Thermal Springs of the United States and Other Countries of the World— A Summary

GEOLOGICAL SURVEY PROFESSIONAL PAPER 492

THERMAL SPRINGS OF THE UNITED STATES AND OTHER COUNTRIES OF THE WORLD

OLD FAITHFUL GEYSER IN ERUPTION, YELLOWSTONE NATIONAL PARK, WYO.

Photographed in 1872 by William H. Jackson, official photographer of the Hayden Survey, 1870–79

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By GERALD A. WARING

Revised by REGINALD R. BLANKENSHIP *and* RAY BENTALL

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ABSTRACT

Thermal springs are widely distributed throughout the world but are most numerous in areas in which there has been volcanic activity in late geologic time. A review of the available literature has revealed much information on the location of the springs, the temperature of the water, the rate of flow, the chemical character of the water and evolved gases, and the uses made of the water. All such information has been tabulated by countries or geographic areas and is presented in the first part of this report. Accompanying the tabulated data for each country or geographic area is a brief description of the geology and a map showing the location of the springs. The second part of the report consists of a list of references, some annotated briefly, to the literature on thermal springs. The references are grouped by countries or geographic areas and within each group are arranged in alphabetical order by author. However, for ease of citation throughout the report, the references have been assigned consecutive numbers.

INTRODUCTION

During his early work with the U.S. Geological Survey, the author was assigned to studies of the mineral and thermal springs of California and Alaska. Later he assisted in the compilation of data on thermal springs throughout the United States. These studies stimulated his interest in the distribution and character of thermal springs in other parts of the world, and during 1954–58 he examined available literature on the subject and compiled an extensively annotated bibliography. Although he planned originally that the bibliography, complete with annotations, would be reproduced in this report, it grew to such size that its publication in full was not feasible. Accordingly, it was decided to place the bibliography in the open file of the U.S. Geological Survey in Washington, D.C., where it may be examined by persons interested, and to publish in this report the titles of the references together with brief annotations of selected references. As published herein, annotations accompany only those titles that either do not of themselves reveal their relevance to the subject of thermal springs or seem not to indicate adequately the scope of the information contained in the publications. Although numbered consecutively (from 1 to 3733) to facilitate citation in the tables of springs and elsewhere, the references are grouped according to the geographic area or political unit to which they pertain, and within each group they are arranged alphabetically by author.

Much information on thermal springs was obtained through examination of the available literature. For ease of presentation in this report, the data on springs have been arranged in tables, each table for a country or a geographic area. Numbers assigned to the individual springs or groups of springs correspond to the numbered locations on the appropriate maps. The boundaries of a few countries may have changed somewhat since the maps were compiled and those shown are not necessarily the political boundaries now recognized officially. Given for each spring or group of springs, if known, are the name or location and information on the temperature of the water, the flow, the chemical character of the water, and the associated rocks. Other pertinent information also is given, and those references that contain data on a spring or group of springs are identified in the tables by their serial numbers.

PERSONNEL AND ACKNOWLEDGMENTS

Most of the reports and articles cited in the present bibliography were examined in the libraries of Stanford University at Palo Alto, Calif., and the University of California at Berkeley, to which access was courteously granted. Through the kindness of Mrs. Florence Yao Chu, of the Stanford library, many publications were borrowed from other university libraries and from the Library of Congress. Many other books and journals were obtained from the library of the U.S. Geological Survey.

Assistance in the translation of a number of Russian publications was given by Dr. Siemon W. Muller, Professor of Geology at Stanford. Articles in Turkish were translated by Miss Sakina Berengian, of the Hoover Institute and Library at Stanford. Articles in German, French, and Spanish were translated with the help of Kathryn Kip (Mrs. G. A.) Waring.

Many of the abstracts in the original bibliography were adapted from the "Bibliography and Index of

Geology Exclusive of North America," issued annually by the Geological Society of America, and from the "Annotated Bibliography of Economic Geology," issued semiannually by the Society of Economic Geologists. Many abstracts of articles on the chemistry of foreign thermal springs, especially in Japan, were adapted from "Chemical Abstracts" of the American Chemical Society. Each of these societies kindly gave permission for its abstracts to be reproduced in the original bibliography, which is in the open file of the Geological Survey.

Specific data on a number of springs in California and Nevada were supplied by Mr. Donald E. White, of the U.S. Geological Survey, and information on several springs in southeastern Oregon was furnished by Mr. Frederick D. Trauger, also of the Survey.

The bibliographic titles were verified by Mr. Blankenship, assisted by Miss Barbara Coate, Mrs. Mollie S. Jablow, Miss Susan D. Smith, and Mrs. Mary Ann Zimmerman, all of the U.S. Geological Survey in Washington, D.C. Mr. Blankenship reviewed the entire manuscript and gave it a preliminary editing; he also rearranged parts of the text and supplied several additional references. To Mr. Bentall fell the major task of making the final revision, shortening the manuscript, and preparing the brief annotations that are included. Mrs. Frances G. Thompson, of the Washington office, made the final rearrangement of the order in which the countries are covered and did the renumbering and crosschecking that were necessary at this stage. Other crosschecking during preparation of the final manuscript was done by Mrs. Mildred P. Martin and Mrs. Dorothy Lamar in the Menlo Park, Calif., office of the Geological Survey, and by Miss Guila C. Darling in the Lincoln, Nebr., office.

As revised, the bibliography unavoidably still contains a few errors and inconsistencies, but these should not detract substantially from its usefulness as a guide to published information on the thermal springs of the world.

BIBLIOGRAPHIC SOURCES

Various geological and chemical bibliographies, some of them annotated, were the source of most of the references listed in this report. The author examined as many of the original publications as were available, abstracted therefrom the pertinent data on thermal springs, and verified the name of the author, date of publication, title, and other bibliographic data. From some of these original publications he obtained references to others, which were similarly examined. The bibliographies consulted are listed below.

American Chemical Society, Chemical Abstracts, 1907–58, 52 v.

American Geophysical Union, Transactions, 1920–57, 38 v.

Geological Society of America, Bibliography and Index of Geology Exclusive of North America, 1933–56, 21 v.

Geological Society of London, Geological Literature Added to the Society's Library, 1894–1933, 37 v.

Royal Society of London, Catalogue of Scientific Papers, 1800–1900, 20 v.

Society of Economic Geologists, Annotated Bibliography of Economic Geology, 1928–56, 29 v.

U.S. Geological Survey, Bibliographies of North American Geology: Bulls. 746 and 747, for 1785–1918; Bull. 823, for 1919–1928; Bull. 937, for 1929–1939; Bull. 1049, for 1940–1949; Bull. 985, for 1950; Bull. 1025, for 1951; Bull. 1035, for 1952–1953; Bull. 1054, for 1954; and Bull. 1065, for 1955.

Publications concerning the therapeutic use of thermal mineral waters deal chiefly with the various spas of Europe. Some of these publications contain analyses of the waters, and most include information on the development and use of the springs. Many pamphlets have been issued by the principal resorts to describe their springs and the bathing and medical facilities, but only a few such publications are included in the geological or chemical bibliographies.

The association of algae and other low forms of plant life with natural thermal waters has received considerable study. The presence of certain types of animal life in thermal springs also has been investigated. Some papers on these subjects, which have been published in journals of botany and of biology, are cited in the bibliography.

The geographic coverage of published information on thermal springs is uneven. Many commercially developed springs at spas and health resorts have been described in great detail, but other springs that may be of equal geological and geochemical interest—but are in remote places—seem to be mentioned only in early books of travel and exploration or in the accounts of missionaries. Many of these rather casual references have been listed in the geological and other bibliographies or have been referred to by later writers. However, an attempt has been made not to extend the present bibliography unduly by including reports that contain only casual mention of springs that are described in detail in other reports.

Most technical papers on specific thermal springs have been published in journals in the countries where the springs are located. The literature on the thermal springs of Europe is the most extensive, for many of the springs there have been developed and used since early medieval times and some were bathing and health resorts as early as the Roman period. The Comptes rendus of the Academy of Sciences, Paris, contain many articles on the thermal and mineral springs of France and her colonies. The principal springs and spas of Germany, Austria, and Czechoslovakia are discussed in the Sitzungsberichte and the Anzieger, Mathematisch-

Naturwissenschaftliche Klasse, Akademie der Wissenschaften, Wien.

Many papers on the geology and geography of parts of Asia and Africa, published in the "Quarterly Journal of the Geological Society of London" and in the "Geographical Journal of the Royal Geographical Society, London," contain descriptions of thermal springs in remote regions. Articles in many other journals and magazines contain significant information and are therefore cited in the present compilation. Some of the listed books and articles were not available for examination but were included in the bibliography because they were thought likely to contain pertinent data on thermal springs. Also included in the bibliography are citations to published abstracts of many of the references.

Most of the books and periodicals cited in the present bibliography are in the library of the U.S. Geological Survey and the Library of Congress, both in Washington, D.C. Most of them are also in the library of the University of California at Berkeley or in the library of Stanford University. Some rare books and periodicals are in the libraries of the U.S. Department of Agriculture, the Catholic University of America, the Smithsonian Institution, and the National Library of Medicine, all in Washington, D.C., and in the libraries of Yale University, New Haven, Conn., and Duke University, Durham, N.C.

FEATURES OF SOME SPRINGS

Many hot springs have been described as remarkably uniform in temperature, flow, and mineral content. Arago (ref. 8) postulated that the temperature of the earth in Algeria had not decreased more than 4° C. in 2,000 years, because the springs near Bône had supplied ancient baths and in 1785 still had a temperature higher than 96.0°C. Little other evidence has been presented to explain why many springs are so constant in character.

Some intriguing areas, especially in Asia, have been brought to notice. For example, Fuchs (ref. 43) mentions the solfatara of Urumchi, in the northeastern part of Sinkiang Province of China, but no additional information on this solfatara has been found in the available literature. No good description of the geysers or spouting springs in southern Tibet, or specific information on the numerous hot springs thought to be in the mountains of Mongolia, seems to be available. Several thermal springs are reported in the Himalayas of Bhutan, but they also do not seem to be described in publications. Marek (ref. 3280) describes the general belief that the site of ancient Troy was near the present village of Bunarbashi in western Turkey and suggests that the springs near that village may be the hot springs mentioned in the Iliad of Homer (ref. 3272). However, no other available literature contains a discussion of the evidence afforded by those springs as to the site of ancient Troy.

The hot springs of Tiberias near the Sea of Galilee doubtless were used in ancient times for their healing qualities. In early Biblical times the town near them was called Hammath (meaning "warm springs") and was mentioned as one of several fenced cities (Joshua 19:35). The town was known later as Emmaus (meaning "hot springs"), but no mention of the medicinal use of these or any other hot springs in the valley of the Jordan River and Dead Sea is found in Biblical or other early records.

The construction during 1919–27 of a siphon and drainage-tunnel system to divert the occasional overflow of hot acid water from the lake in Keloed crater of Kawah Idjèn volcano in eastern Java is mentioned by Tazieff (ref. 94) and is also mentioned and illustrated in the "Bulletin of the Netherlands East Indian Volcanological Survey" (ref. 3724); but no detailed account of the difficulties that must have been encountered in such a project seems to have been published.

CONVERSION FACTORS

On the basis that 1 U.S. gallon equals 3.785 liters and that 1 hectoliter equals 26.420 U.S. gallons, a flow of 1,000 liters per minute is equivalent to 264.20 U.S. gallons per minute, and a flow of 1,000 hectoliters per day (24-hr) is equivalent to 69.444 liters per minute, or 18.347 U.S. gallons per minute.

In each table of this report the water temperature of the springs is shown according to a single scale, either centigrade or Fahrenheit. Any temperatures recorded in the original publications in degrees Réaumur have been changed to centigrade (1°R=1.25°C). Degrees centigrade can be converted to degrees Fahrenheit by multiplying by 9/5 and adding 32; conversely, degrees Fahrenheit can be converted to degrees centigrade by subtracting 32 and multiplying by 5/9. The equivalence of the centigrade and Fahrenheit scales within the normal range of thermal waters is given below.

°C	°F	°C	°F	°C	°F
15	59	45	113	75	167
20	68	50	122	80	176
25	77	55	131	85	185
30	86	60	140	90	194
35	95	65	149	95	203
40	104	70	158	100	212

In early chemical analyses of mineral waters the constituents commonly were reported as concentrations of hypothetical salts, and the concentrations of the constituents generally were expressed in grains per U.S.

gallon or imperial gallon, in grams per kilogram, or in grams per liter. In the annotations prepared originally, most of the analyses are reproduced as given by the author of the article, although a few that were given in grams per kilogram or grams per liter were converted to milligrams per liter. In most reports published since about 1900, results of analyses are stated in parts per thousand, per hundred thousand, or per million, by weight, or in grains per gallon; 1 grain per U.S. gallon (231 cu. in.) is equivalent to 17.12 ppm (parts per million) by weight and 1 grain per imperial gallon (277.41) cu. in., or 1.201 U.S. gallons) is equivalent to 14.25 ppm by weight.

Water containing less than about 7,000 ppm of dissolved solids has a density close to unity, and the concentration values, for practical purposes, are the same whether expressed in parts per million by weight or in milligrams per liter. However, water containing more than about 7,000 ppm of dissolved solids has a density appreciably above unity, and the concentration values expressed in one unit cannot be equated to those expressed in the other. For example, ocean water, which has a density of about 1.026, has a dissolved-solids concentration of about 35,000 ppm, and the concentration values expressed in milligrams per liter are about 2.6 percent greater than if expressed in parts per million by weight.

ABBREVIATIONS

Abbreviations used for citations and for scientific and engineering terms in this report are those listed in "Suggestions to Authors of the Reports of the U.S. Geological Survey," Washington, D.C. (U.S. Govt. Printing Office, 5th ed., 1958).

THERMAL SPRINGS

Strictly defined, any spring or well water whose average temperature is noticeably above the mean annual temperature of the air at the same locality may be classed as thermal. Among European springs that are developed commercially, only those whose temperature is higher than about 20°C are classed as thermal. In the United States, only those springs are called thermal whose temperature is at least 15°F above the mean annual temperature of the air at their localities. In areas where the mean annual air temperature is low, some springs that do not freeze in winter because of natural protective conditions are considered to be thermal; in tropical areas some springs that are only a few degrees warmer than the temperature of the air may be considered thermal.

DISTRIBUTION

The most notable feature of the distribution of thermal springs is their close association with the main belts and areas of volcanoes of present or geologically recent activity. (See fig. 1.)

Thermal springs are common in extensive areas of lava flows of Tertiary and later geologic age—for example, in Yellowstone National Park in Wyoming and in the great lava-covered areas of Idaho, eastern Oregon, and northern California. In the lava of the Auvergne region in France and in areas of volcanic rocks in Italy, thermal springs are more common than in other parts of those countries.

Thermal springs are common also in areas where rocks, regardless of their character and age, have been faulted and intensely folded in geologically recent time. The close relation of thermal springs to structure in such intensely deformed mountain regions as the Alps and the Pyrenees has been commented upon by many writers. In regions of faulted block mountains in the western United States, many thermal springs issue along or close to the fault zones.

ORIGIN

Most investigators of thermal springs believe that almost all the water is of meteoric origin but that some of it may be magmatic. However, few studies have been made of the origin and movement of ground water in areas of thermal springs. As most observations of the temperature and flow of thermal springs have been made at intervals of many years, no trends in their changes have been established. Many thermal springs have been described as artesian, the water rising from deep strata along faults and fissures.

Allen (ref. 120) concluded that steam given off by magma is the source of the heat in all the hot springs he had studied, chiefly in Yellowstone National Park and Lassen Volcanic National Park. He further concluded that the mineral content of the water is derived partly from the adjacent rock and partly from magmatic sources. Intensive studies by Day (ref. 29) seem to prove that volcanoes, hot springs, and mud geysers are phases of one and the same kind of terrestrial activity.

Because nearly all thermal springs are associated with volcanic rocks, most writers on the origin of such springs have tended to assume that the heat was of volcanic origin. However, some writers have suggested that other possible sources of the heat are chemical reactions underground—such as the oxidation of iron pyrite and a few other minerals—and the disintegration of radioactive substances. Many thermal springs, especially in the Alps and Pyrenees, issue in areas of granitic or sedimentary rocks, and probably the water is hot because of the great depth from which it rises. Observations in deep mines and borings indicate that in regions of comparatively uniform and undisturbed rocks the temperature generally increases at the rate of about 1°F for each 50 to 100 feet of depth. Thus, the temperature of artesian water in some areas may indicate the approximate depth from which the water rises. It may be concluded, then, that thermal springs are of two main classes—those that issue in areas where the geothermal gradient is abnormally high because of igneous activity and those that issue where the geothermal gradient is "normal." However, there is a complete gradation between the two classes.

The presence of slight amounts of boron and certain other constituents in thermal water is considered to indicate that the water has come into contact with magma. This hypothesis has received increasing attention during the past half century.

Near many commercially developed thermal springs, borings have been made to supplement the supply of water. It is not always easy to distinguish between the natural and the artificial outlets, and both generally are classed as springs. Many artesian wells and unsuccessful test wells for oil or gas yield thermal water.

MINERAL CONSTITUENTS

The principal mineral substances dissolved in water of thermal springs are the same as are common in other natural waters. Their characteristics have been discussed in numerous publications and are summarized by Collins and others (ref. 129).

Sodium (Na) and potassium (K) are common constituents of many minerals, chiefly the sodium and potassium feldspars. Because many of their compounds are highly soluble, these constituents may be present in considerable amounts in highly mineralized water. In natural water, sodium is much more plentiful than potassium. Lithium (Li) is similar to sodium in chemical action but rarely is present in large amounts. When lithium is determined, it generally is reported as lithium chloride or carbonate.

Calcium (Ca) and magnesium (Mg) are derived mostly from limestone and dolomite and some feldspars. In water from springs the content of calcium generally is two to five times that of magnesium, but in sea water and other very saline water the magnesium content generally exceeds that of calcium. Calcium and magnesium cause most of the hardness of water. Hardness caused by calcium and magnesium equivalent to the bicarbonate (HCO_3) in the water is called "carbonate hardness"; the remainder is called "noncarbonate hardness." These terms are approximately equivalent to the old terms "temporary" and "permanent," which were based on the fact that carbonate hardness is partly removed by boiling the water. Water having noncarbonate hardness may contain in solution the sulfates and chlorides of calcium and magnesium. Barium (Ba) and strontium (Sr) are similar in action to calcium and magnesium, but if present, the amounts are very small.

Except in acid solutions, iron (Fe) and aluminum (Al) are only slightly soluble. The water of many springs contains several parts per million of iron. Generally, the aluminum content is less than that of iron and often is not determined separately. In many analyses the content of both is reported as the oxides Fe_2O_3 and Al_2O_3. An iron concentration higher than 0.5 to 1.5 ppm can be tasted.

Manganese (Mn) is not common, but in natural water it may be present in association with iron in amounts of a few parts per million. Manganese dioxide (MnO_2) has been deposited by a few thermal springs in quantities sufficient to be worked commercially.

Rarely is arsenic found in measurable quantity in natural water, but it has been identified in a few mineral springs, both cold and thermal, and usually is reported as arsenic (As), as arsenic trioxide (As_2O_3), or as arsenic pentoxide (As_2O_5). Also, some thermal waters have been reported to contain minute amounts of gold, silver, copper, lead, zinc, and other metals.

Chloride (Cl) is one of the commonest and most plentiful constituents in solution. It is derived in large part from common salt, sodium chloride (NaCl), and to a lesser extent from magnesium chloride ($MgCl_2$), which is present in small amounts in some rocks.

Sulfate (SO_4) results from the solution of gypsum and anhydrite and is present in considerable amounts in many natural waters. It may be derived also from the oxidation of sulfide minerals, chiefly pyrite and marcasite. A sulfate drinking water is sometimes called a "bitter water." High concentrations of sodium sulfate (Glauber's salt) or magnesium sulfate (Epsom salt) in drinking water are laxative.

Several different forms of sulfides are present in many "sulfur" waters. They are derived principally from the reduction of the sulfate ion (SO_4) and sulfate and sulfide minerals, a process that produces hydrogen sulfide (H_2S); they may be derived also from the solution of natural sulfides. Complex sulfides may give the water a clear greenish-yellow color. "White sulfur" water may contain a finely divided allotropic form of sulfur in suspension. "Blue sulfur" and "black sulfur" water may have slight amounts of iron sulfide in suspension or solution.

Bicarbonate (HCO_3), resulting from the action of dissolved carbon dioxide (carbonic acid) on limestone and dolomite and many other rocks, forms most of the anion content of many waters. Carbonate (CO_3), resulting from the solution of the more soluble carbonates

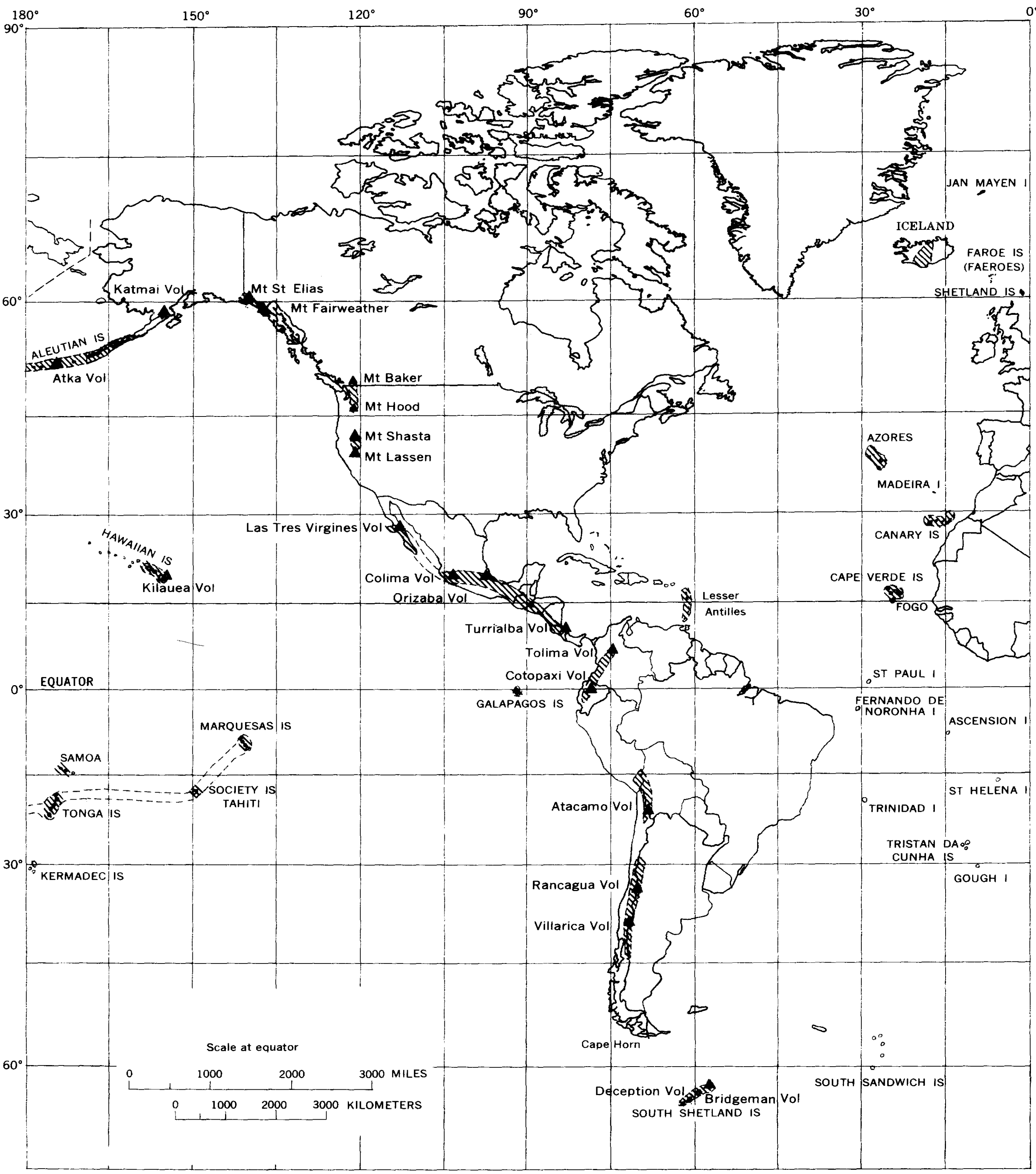
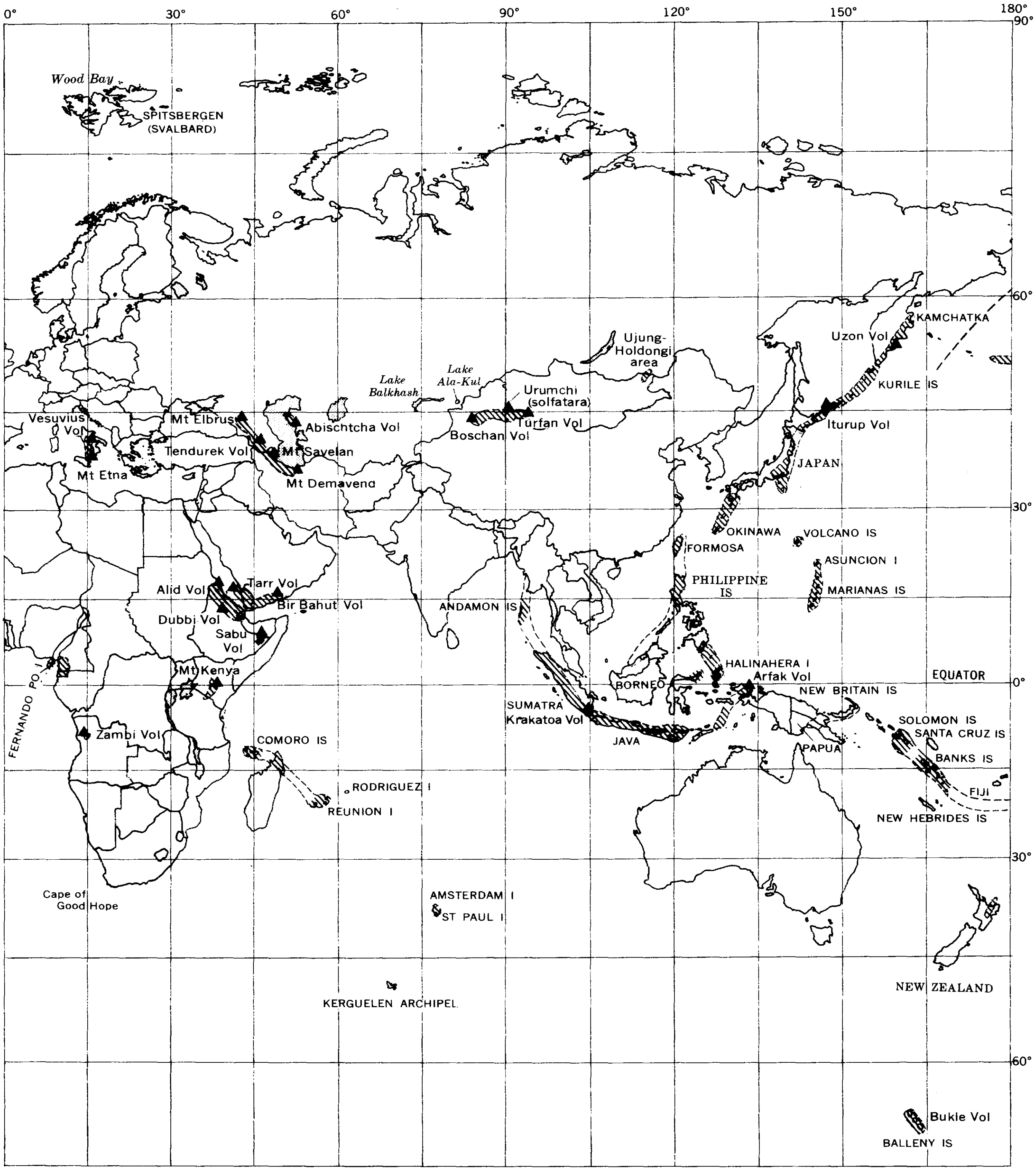


Figure 1.—The world showing principal



volcanic belts and areas. Chiefly from ref. 43.

or from the decomposition of bicarbonate, rarely is present. Bicarbonate and carbonate are reported in many analyses as "alkalinity," which is expressed as calcium carbonate ($CaCo_3$).

Bromide (Br) and iodide (I) are present in very small amounts in a few saline spring waters that are mineralized by solution of marine deposits.

Boron (B) is present in appreciable amounts in many natural waters. As borate (B_2O_3) it is common in vapors from fumaroles and other volcanic vents.

Fluoride (F) is present in small amounts, generally less than 2 ppm, in the water from many springs and wells. However, most early analyses do not record its concentration. A concentration of fluoride between 0.6 and 1.2 ppm is beneficial in reducing the incidence of tooth decay in children, but more than this amount may cause mottling of the tooth enamel.[1]

Phosphate (PO_4) is uncommon but may be taken into solution from phosphate minerals, perhaps chiefly apatite. Generally, the amount present does not exceed a few parts per million.

Ammonium (NH_4) and nitrate (NO_3) may be derived from organic matter and therefore may indicate pollution of the water. However, because they may be derived from inorganic salts also, they are not necessarily evidence of direct contamination.

Silica (SiO_2) is present in nearly all rocks. It is not easily dissolved in water, but generally is present in soluble or colloidal form in comparatively small amounts, ordinarily less than 100 ppm. In the colloidal form it may make the water opalescent. (The same color effect may be caused also by finely divided calcium carbonate in suspension.) In some water analyses the silica is reported as silicate (SiO_3) or as metasilicic acid (H_2SiO_3).

Most mineral-spring water that tastes sour contains free sulfuric acid (H_2SO_4). Nearly all such water contains relatively large amounts of sulfates of iron and aluminium (alums), which give an astringent taste. Water from a few springs contains free hydrochloric acid (HCl).

The water from many springs contains dissolved gases. One of the principal gases given off is carbon dioxide (CO_2). It makes the water slightly acid and gives it a pleasant taste. The carbon dioxide may be derived from the atmosphere or the soil or from chemical action on limestone. Next in importance among the gases is hydrogen sulfide (H_2S), which may be produced by reduction of gypsum and other sulfates or by decomposition of organic matter. This gas accounts for the odor that characterizes many "sulfur" waters. Both hydrogen sulfide and carbon dioxide are common in volcanic exhalations. Nitrogen (N_2), probably derived from air dissolved in the water, has been noted as the chief constituent of the gas evolved by some springs. Similarly, oxygen (O_2) may be present as a constituent of the dissolved air. Slight amounts of argon (A_2) and some other rare inert gases have been found in many thermal springs. Also methane (CH_4), or marsh gas, is given off from some warm springs whose water rises through rocks containing organic matter.

The hydrogen-ion concentration, expressed as the pH, of a water is an index to the possible corrosiveness of the water. The pH is the negative logarithm of the concentration of hydrogen ions, in moles per liter. (A mole, or gram molecule, is the quantity of a compound or element that has a weight in grams numerically equal to its molecular weight.) A solution having a pH of 7.0 is said to be neutral. Progressively lower values of pH indicate increasing concentrations of hydrogen ions (acidity), whereas progressively higher values of pH indicate decreasing concentrations of hydrogen ions or increasing concentrations of hydroxyl ions (alkalinity).

Physicochemical studies of mineral waters, including determinations of their electrical resistivity and radioactivity, are the subject of many papers published during the past half century.

DEPOSITS

Many thermal and some cold springs deposit large amounts of calcium carbonate as hard tufa or travertine, and some springs form similar deposits of siliceous sinter. In places, a mixture of the two forms a silico-calcareous sinter. Numerous papers describe tufa deposits and their method of formation. The deposition of other minerals has been discussed by White (ref. 109), and the formation of siliceous deposits has been studied by White and others (ref. 112).

ORGANIC ASSOCIATIONS

Organic matter, which generally occurs as an impurity derived from vegetal matter, is reported in many water analyses. Reported in some early analyses is the organic substance crenic acid, a pale-yellow uncrystallizable substance believed to be present in vegetable mold and in ocherous material. By oxidation it forms apocrenic acid, which in "chalybeate" waters appears as a brown amorphous deposit. These oxidation products are reported in some early analyses as crenates and apocrenates of sodium, potassium, and iron. Baregine (named from its first recognition at Barèges in France), or hydrosin, is a brownish-yellow residue of nitrogenized organic matter obtained on the evaporation of some sulfur waters. Glairine, or glarin, is a

[1] Welsh, G. B., and Thomas, J. F., 1960, Significance of chemical limits in USPHS drinking water standards: Am. Water Works Assoc. Jour., v. 52, no. 3, p. 289–300.

soft, unctuous amorphous deposit occasionally found in basins where spring water collects. It contains nitrogen and on ignition leaves a siliceous residue.

Sulfur-secreting bacteria, sometimes referred to under the general name "sulfuraria," are minute vegetable organisms and are conspicuous in some thermal springs. Generally, they are green and are common in sulfur waters not hotter than 122°F. They probably secrete silica in addition to sulfur. Bacteria commonly known as *Crenothrix* form the rust-colored gelatinous material found in the water of some cold iron springs, but they seem not to live in distinctly thermal water. These bacteria are colored brownish by iron oxide deposited in their sheaths.

The microscopic siliceous remains of various species of diatoms have been found in and near some hot springs, but it is not certain whether this type of algae actually lives in the water. The most common types of algae found in thermal springs are filamentous. Green species flourish in water having a temperature of about 120° to 140°F (49°–60°C), orange and red kinds in water of about 140° to 160°F (60°–71°C), and white kinds in hotter water. In Yellowstone National Park, Weed (ref. 695) observed algae in spring water having a temperature as high as 185°F (85°C). Some writers refer to certain green filamentous algae as "Confervae."

Several observers have recorded the presence of animal life in thermal springs. In springs of Hammam Meskoutine in Algeria, Blanchard (ref. 2437) noted crabs, frogs, and tadpoles in water at a temperature of 31°C, small fish at 39°C, and ostracodes at 51°C. Brues (refs. 125, 126) examined the fauna of 154 thermal springs in the western United States and found the upper limit for animal life to be about 122°F (50°C), which is about 18°F (10°C) above their normal limit. He found also that the upper limit for plant life is about the same as for animal life.

In the hot springs of Iceland, Tuxen (ref. 1260) found animal life in 37 thermal springs or groups of springs. Of the 6 species found in water above 40°C, only 3 were common. In thermal springs of lower temperature, 46 species were found.

BOILING TEMPERATURES

The boiling point of water decreases with increased elevation above sea level. The rate of decrease is not quite constant, but below altitudes of about 5,000 meters (16,400 ft) the boiling point decreases 1°C for each 303-meter increase in altitude, or 1°F for each 550-foot increase. The approximate boiling point at a few altitudes, as given below, was derived by comparing tables of altitude-atmospheric pressure.[2]

Altitude		*Boiling point*	
Meters	*Feet*	*°C*	*°F*
0	0	100	212
1, 000	3, 280	96. 7	206. 1
2, 000	6, 560	93. 4	200. 1
3, 000	9, 840	90. 1	194. 2
4, 000	13, 120	86. 8	188. 2
5, 000	16, 400	83. 5	182. 3

Below a water surface the boiling point increases rapidly with depth, owing to the increase in pressure resulting from the weight of the overlying water. The boiling point below a water surface at sea level was calculated by Mr. Donald E. White, of the Geological Survey, to be approximately as follows:

Depth below the water surface		*Approximate boiling point*	
Meters	*Feet*	*°C*	*°F*
0	0	100	212
50	164	155	311
100	328	180	356
150	492	196	385
200	656	210	410

Gases in solution lower the boiling point slightly, whereas mineral substances in solution raise the boiling point slightly. Therefore, the effect of gases dissolved in moderately mineralized water is hardly noticeable. The boiling point of ocean water, which has an average mineral content of about 35,000 ppm, is only about 1°F above the boiling point of pure water.

DESCRIPTION OF THERMAL SPRINGS

UNITED STATES

Geologic formations of nearly all ages and types of rocks are present within the 48 conterminous States. Although thermal springs are most numerous in areas of geologically young igneous rocks, some rise from much older rocks of sedimentary origin. The paragraphs that follow are a series of thumbnail sketches of the geologic situations with which thermal springs are associated in the United States.

The Atlantic and Gulf Coastal Plains are underlain chiefly by sands, silts, and clays of Cretaceous and Tertiary ages. In the extreme southeast, much of Florida is underlain by nearly horizontal strata of Tertiary limestone from which many large springs rise in deep pools. In nearly all of them the water is only slightly above the normal ground-water temperature, but at Warm Salt Springs near the west coast, as indicated on figure 3, the water is about 12°F above mean annual temperature.

[2] Hodgman, C. D., editor in chief, 1944, Handbook of chemistry and physics: 28th ed., Cleveland, Ohio, Chemical Rubber Publishing Co., p. 1449–1451.

The Appalachian Mountains and subsidiary ranges extend from western Georgia northward beyond Massachusetts. They are composed chiefly of folded and faulted sedimentary rocks ranging in age from Precambrian through Permian. In an area of faulted Precambrian quartzite in western Georgia several warm springs rise, the most noted group being at Warm Springs.

The Appalachian ranges that form the boundary between Virginia and West Virginia are composed largely of folded and faulted Cambrian and Devonian limestone and sandstone. Several of the numerous thermal springs in this general area have been developed as resorts, one of the most noted being that at Hot Springs, Va. North of the main Appalachians, in areas of ancient schist or limestone, only three small warm springs are reported.

The Mississippi Valley and the bordering plains are, in general, underlain by gently dipping strata of Paleozoic and Mesozoic ages. No thermal springs are reported in this region. In the Ozark uplift in southwestern Missouri and parts of Arkansas and Oklahoma and the Arbuckle Mountains farther southwest, the exposed rocks are mainly Paleozoic limestone. The Ouachita Mountains in western Arkansas and southeastern Oklahoma are also composed of Paleozoic strata which are intensely folded and faulted. Thermal springs at Hot Springs, Ark., issue from Mississippian sandstone on a plunging anticline.

A large area in eastern South Dakota and southeastern North Dakota is underlain by an artesian aquifer. The aquifer, which lies at depths of about 900 to 1,100 feet below the surface, is the Dakota Sandstone of Early Cretaceous age. Since about 1890 several thousand wells of small diameter have been drilled in this area for domestic and farm water supply. The water is distinctly warm, being 20° to 25° above the temperature of the shallow ground water, but no natural thermal springs are present.

The Black Hills in southwestern South Dakota, as indicated on figure 2, have been lifted high above the plains of the Missouri River. The rocks form a broad anticlinal fold, from the higher parts of which the beds have been largely eroded, leaving hogbacks of Carboniferous strata nearly encircling the hills. In the eastern part a core of granite is exposed. No thermal springs break out in the hills, but in the plains near their southern end there are large flows of warm water at the town of Hot Springs.

In northern Montana the Rocky Mountains consist of several nearly parallel ranges, but farther west they are more irregular. They are separated by wide valleys and plains. The rocks are chiefly granite, schist, and other crystalline types overlain by sedimentary strata of Paleozoic through Mesozoic ages. The principal hot springs of Montana are in this region in areas of fractured granite or schist. Several warm springs issue from folded and faulted Paleozoic strata, and others from Cretaceous beds. Warm Springs Creek, which has a water temperature of 68°F and discharges 80,000 gpm, may be the largest natural stream of thermal water in the United States. A few warm springs rise in valleys bordered by Tertiary or Quaternary lava.

The mountains of central Idaho are of granite and ancient sedimentary rocks and contain numerous hot springs, as indicated on figure 4.

Most of southwestern Idaho is underlain by basalt of the Snake River Group (Pleistocene and Recent), which is mantled in some places by lake beds of the Payette Formation (Miocene and Pliocene?). In the valley of the Bruneau River, a southern tributary to the Snake, many warm springs rise through overlying lake sediments or directly from the lava.

The Yellowstone National Park in the northwest corner of Wyoming (fig. 5) embraces a great lava plateau largely of rhyolitic rocks. Detailed geologic studies have shown that the geysers and hot springs of this region derive their heat from magma that underlies the thick lava beds.

Central Wyoming is a region of high plains and small isolated mountains underlain by nearly horizontal Cretaceous and Tertiary strata. There are also hills of eruptive rocks. Several minor thermal springs issue from faulted sedimentary rocks. Other thermal springs are in areas of older rocks. The Big Horn, or Thermopolis, springs issue from faulted Permian and Triassic red beds, but their water probably rises from the Tensleep Sandstone (Pennsylvanian and early Permian). These springs probably rank as the largest hot springs in the country. According to Burk (ref. 575), the largest spring at Thermopolis discharges 12,600 gpm and has a water temperature of 135°F. Outliers of the Rockies in southern Wyoming are composed largely of Mesozoic and older strata in which there are few springs.

The Rocky Mountains have their greatest development in Colorado. The Dakota Sandstone and other formations of Mesozoic age are uplifted along parts of the eastern front, but most of the Rockies are of Paleozoic strata. There are also many areas of granite and other ancient crystalline rocks, and many small areas of Tertiary lava. Thermal springs occur mainly in faulted Paleozoic and Cretaceous rocks.

The southward extensions of the Rockies in New Mexico are largely of ancient crystalline and sedimentary rocks. The Jemez Plateau, farther south, is covered largely by Tertiary lava, which overlies faulted Permian and Triassic strata. Several warm saline springs issue from these beds. Southwestern New Mexico is covered in part by Tertiary lava, from which many warm springs issue.

The Quitman Mountains, largely of Cretaceous rocks, border the Rio Grande in western Texas. Small warm springs issue from Lower Cretaceous sandstone near the south base of these mountains and also 75 miles farther downstream.

The plains of eastern Washington are underlain mainly by the Columbia River Basalt (Miocene and Pliocene?). No prominent thermal springs have been noted in this area. The western part of the State is dominated by the Cascade Mountains, which are composed of granite and ancient sedimentary rocks partly covered by flows of Tertiary lava and are surmounted by a chain of volcanic peaks. In this region are several well-known thermal springs, but none are very hot. Some issue from granite, others from basalt.

The Olympic Peninsula of northwestern Washington is composed mainly of metamorphic and sedimentary rocks of complex structure. In this region two warm springs rise in areas of crushed and altered rocks.

The Blue Mountains in northeastern Oregon consist of ancient metamorphic and sedimentary rocks which are much folded and faulted. Several hot springs issue in this area. (See fig. 6.)

The plateau region of southeastern Oregon is covered largely by the Columbia River Basalt. Many lava flows have been somewhat folded and are broken by faults that have produced extensive tilted block mountains. In the Harney Basin near Burns, and also near Malheur and Harney Lakes, numerous warm and hot springs rise through lake beds or the valley alluvium, probably along faults in the underlying lava. Farther east, warm springs also rise along the valleys of the Malheur and Owyhee Rivers, which are bordered for long distances by basaltic cliffs.

The Cascade Mountains extend southward from Washington, through western Oregon, and include many lava flows and lava peaks. Small warm springs rise at the base of Mount Hood in the north, and small fumaroles issue from Quaternary lava near its summit. Farther south, scalding springs are present at several places in the Tertiary lava.

A large region in southern Utah, northern Arizona, and adjoining parts of Colorado and New Mexico consists of plateaus that are deeply cut by stream canyons. These uplands are composed chiefly of gently dipping strata that range from Paleozoic through Tertiary in age. The principal thermal springs in the region are in the upper part of the Sevier River Valley in Utah along the faulted front of the Sevier Plateau, as indicated on figure 7.

The Wasatch Mountains in northeastern Utah consist largely of Paleozoic strata from Cambrian through Carboniferous in age. The western front of the mountains is traversed by the Wasatch fault which extends northward and southward from Salt Lake City. On or near this fault are several large saline thermal springs, including Utah hot springs, which issue from Cambrian quartzite, and Ogden hot springs, which issue from syenite.

In the plateau region of northern Arizona no important thermal springs are reported. The central and southern parts of the State are occupied largely by mountains composed of crystalline rocks and by folded and faulted ancient marine strata. In many areas these older rocks are covered by Tertiary volcanics, which may account for the heat of some springs.

Most of Nevada is within the Basin and Range province, a region of detached mountains separated by desert valleys. Many of the ranges are composed of granite and ancient metamorphic and sedimentary rocks; others are composed chiefly of lava of Tertiary age. The structure includes much complex folding, but in many places it is dominated by block faulting. As shown in figure 3, many thermal springs are scattered throughout the State. The locations of the springs are shown in more detail on figure 8.

Most of these springs are of moderate temperature and small flow and are closely related to faults. In the northeastern part of Nevada there are several mountain areas of limestone and shale of Paleozoic age from which several hot springs issue. Near the northwest border, several warm to hot springs issue from intrusive granite. The western side of the Black Rock Desert is bordered mainly by hills and plains of Tertiary lava where numerous warm and hot springs rise in close relation to local faults. Farther south, Pyramid and Winnemucca Lakes are partly surrounded by lava hills, and hot springs rise near their bases.

The valley of the Humboldt River east of Winnemucca is bordered largely by hills of lava. In the valley alluvium small warm springs rise at several places and possibly are artesian. In several areas of faulted Triassic or Jurassic strata south of Humboldt River valley, scalding springs deposit much tufa. Boiling springs also issue in several lava areas south of this valley.

In an area of granodiorite and metamorphic rocks a few miles southeast of Reno, the Steamboat springs rise at nearly boiling temperature. Their water has formed extensive layers of siliceous sinter and is noted for the presence of metallic sulfide minerals which are still being deposited.

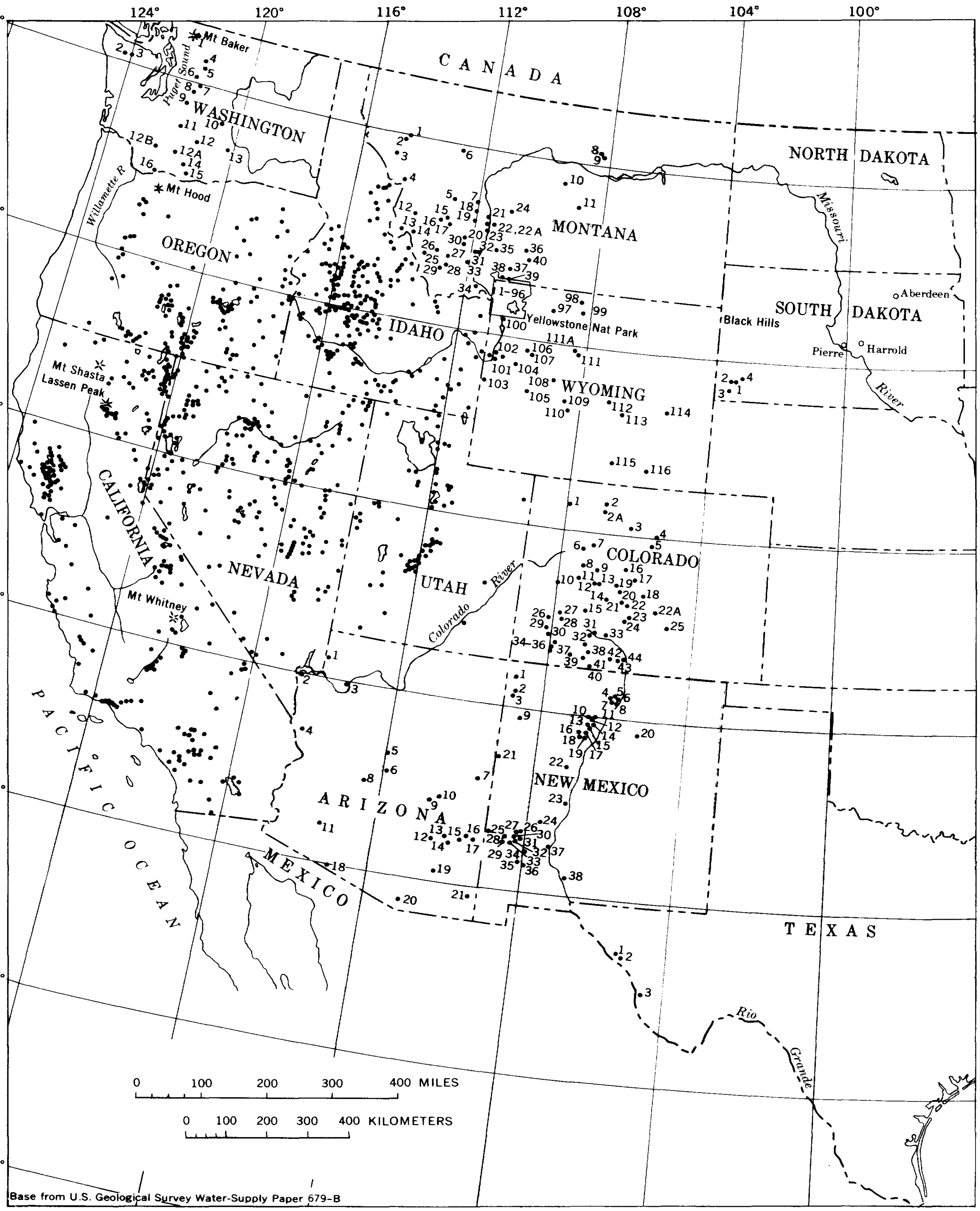


FIGURE 2.—Western part of the conterminous United States showing location of thermal springs. Chiefly from ref. 148.

FIGURE 3.—Eastern part of the conterminous United States showing location of thermal springs. Chiefly from ref. 148.

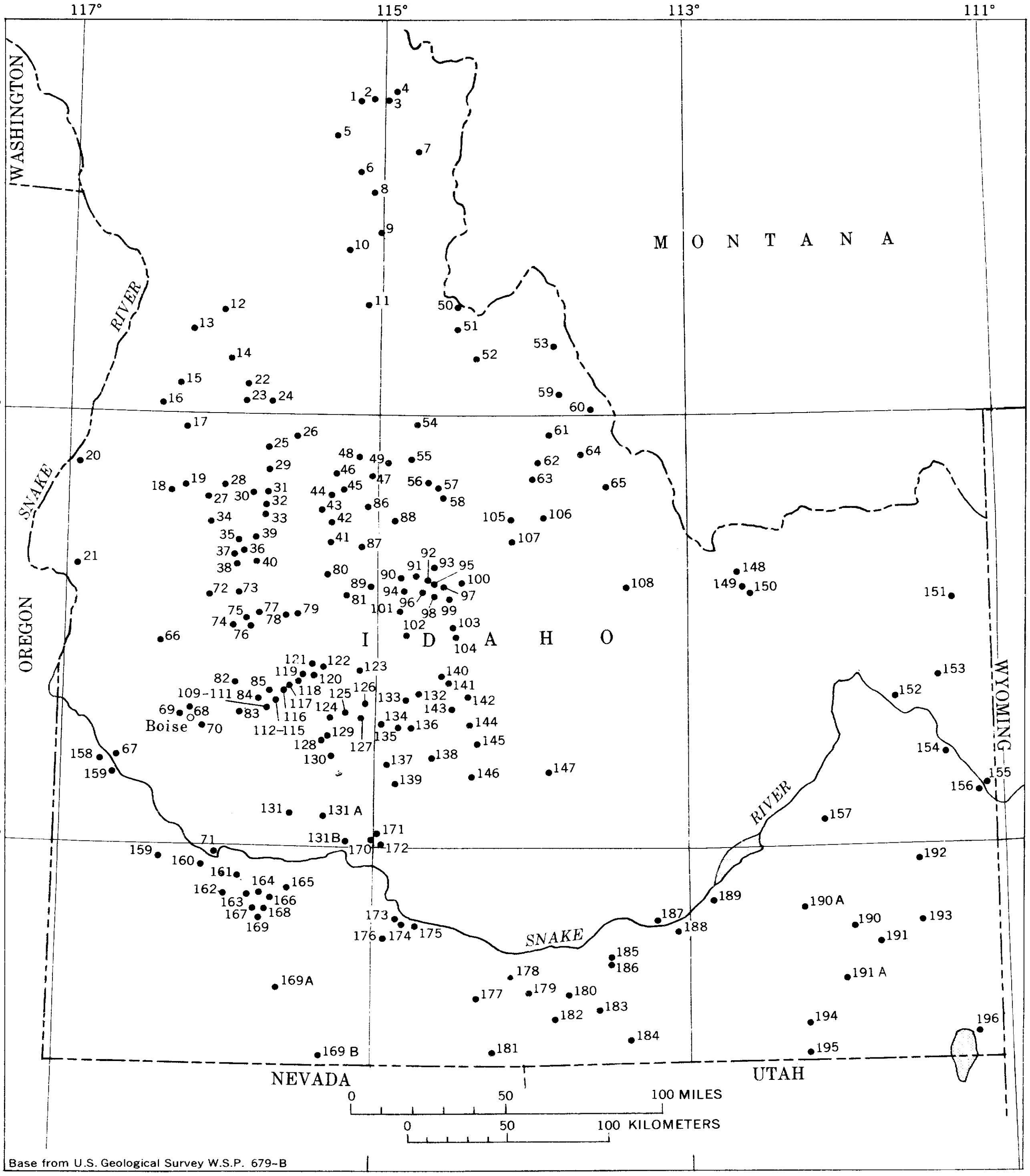


FIGURE 4.—Part of Idaho showing location of thermal springs. From ref. 148.

The Big Smoky Valley in the central part of Nevada is enclosed by mountains that consist largely of strata of Paleozoic age, covered in part by Tertiary lava. Hot springs issue from both kinds of rocks, along the valley border, but probably all rise from Paleozoic strata. Similar conditions are present in Diamond, Steptoe, and White Pine Valleys. Near the south end of the State several wide flat valleys are bordered by mountains of Paleozoic strata, but warm springs in the valley lands may be of comparatively shallow ground water rising under artesian pressure.

Northeastern California is a region largely of Tertiary lava flows. Surprise Valley, on the northeast border of the State, is partly surrounded by lava mountains.

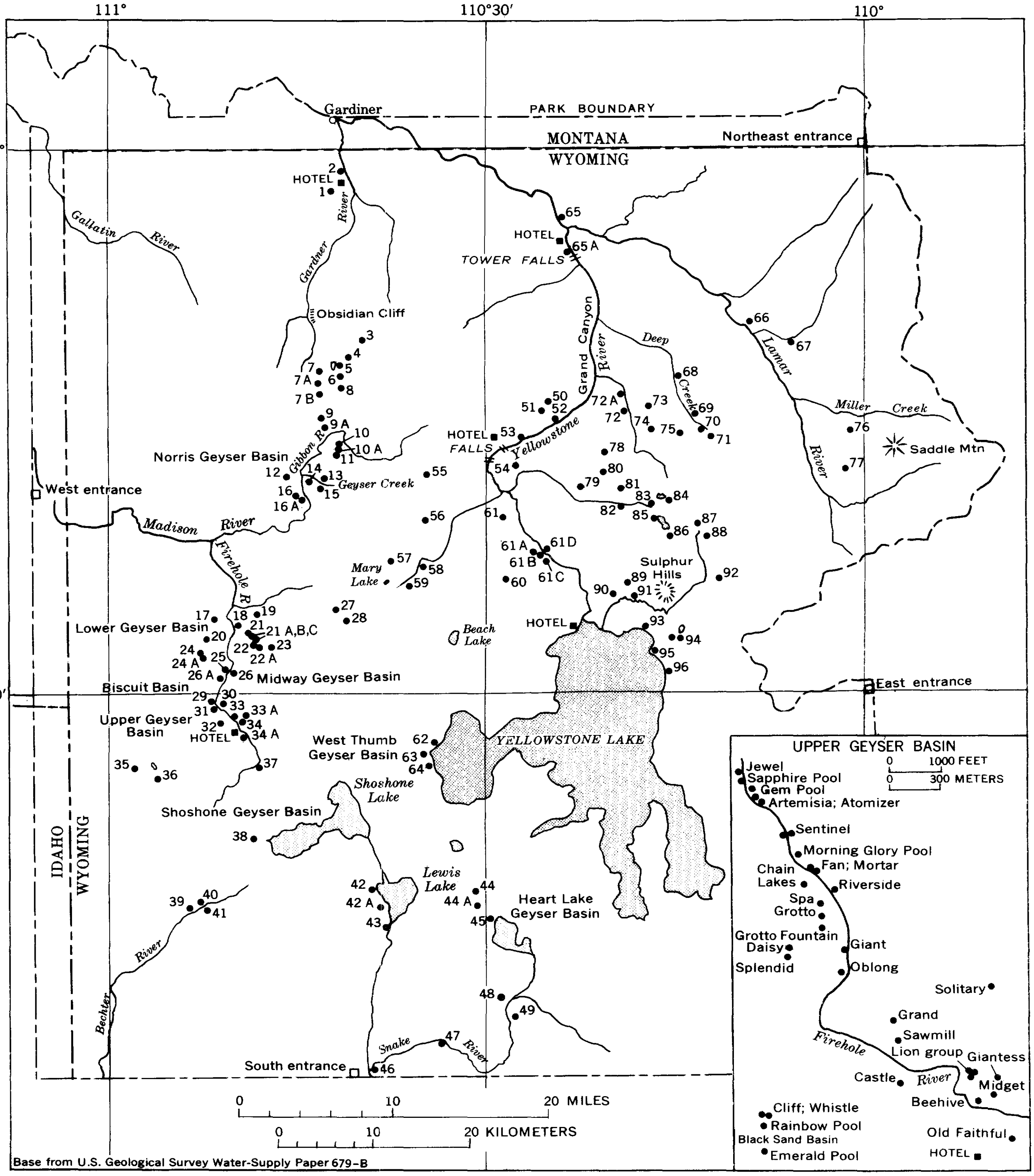


FIGURE 5.—Yellowstone National Park, Wyo., showing location of thermal springs, geysers, and mud pools. From refs. 148, 561, 566, and 637.

Several thermal springs rise in the valley alluvium, probably along buried faults. Other hot springs, some at boiling temperature, are in the Honey Lake Valley farther south, as indicated in figure 8.

The Cascade Mountains of Washington and Oregon extend south into California as far as the Pit River. In California they consist largely of eroded volcanic mountains that do not form a distinct range. Mount Shasta is the most prominent of the lava masses. Near its summit are small hot springs and vapor vents.

South of the deep canyon of the Pit River, the Sierra Nevada forms a great mountain block. Its northern

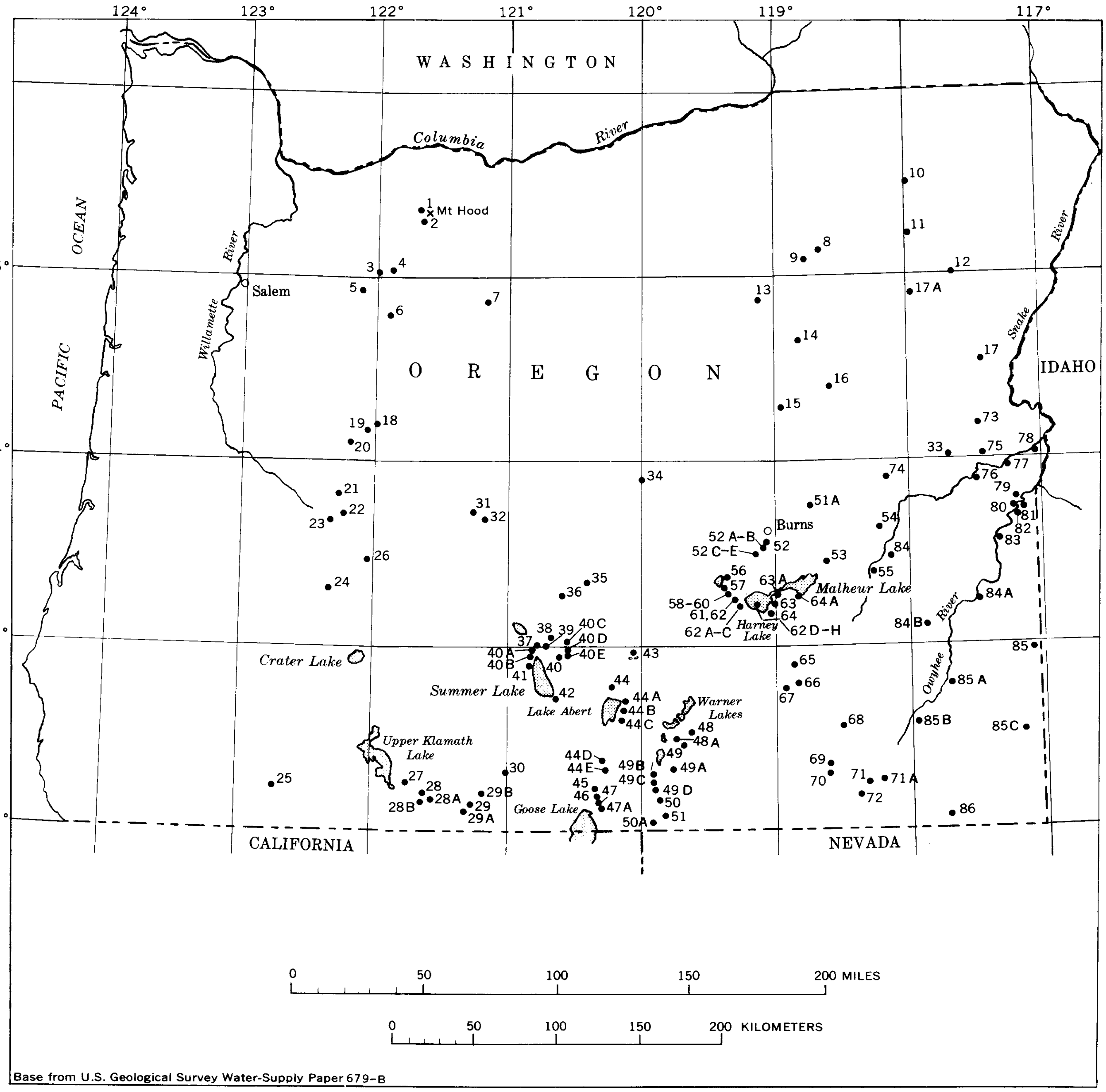


Figure 6.—Oregon showing location of thermal springs. Chiefly from ref. 148.

part is composed mainly of lava, and within this region Lassen Peak had a period of explosive steam activity during 1914–17. This activity did not appreciably affect the large hot springs on its southern slopes.

The crestal part of the Sierra Nevada is composed mostly of granite, and its profoundly faulted eastern front rises steeply from desert valleys of the Great Basin region. Along the east front of the Sierra, hot springs rise chiefly in lava areas near the base of the range.

On the western slope of the Sierra Nevada, wide bands of ancient sedimentary rocks overlie the granite, but there are minor areas of Tertiary lava. No important thermal springs issue on this great slope, but in the southern part of the Sierra warm springs issue at several places from faulted granite or gneiss.

In the coastal ranges of Cretaceous or older rocks north of San Francisco Bay there are many warm springs. These springs generally have a high mineral content but only a small flow. Some of them rise close

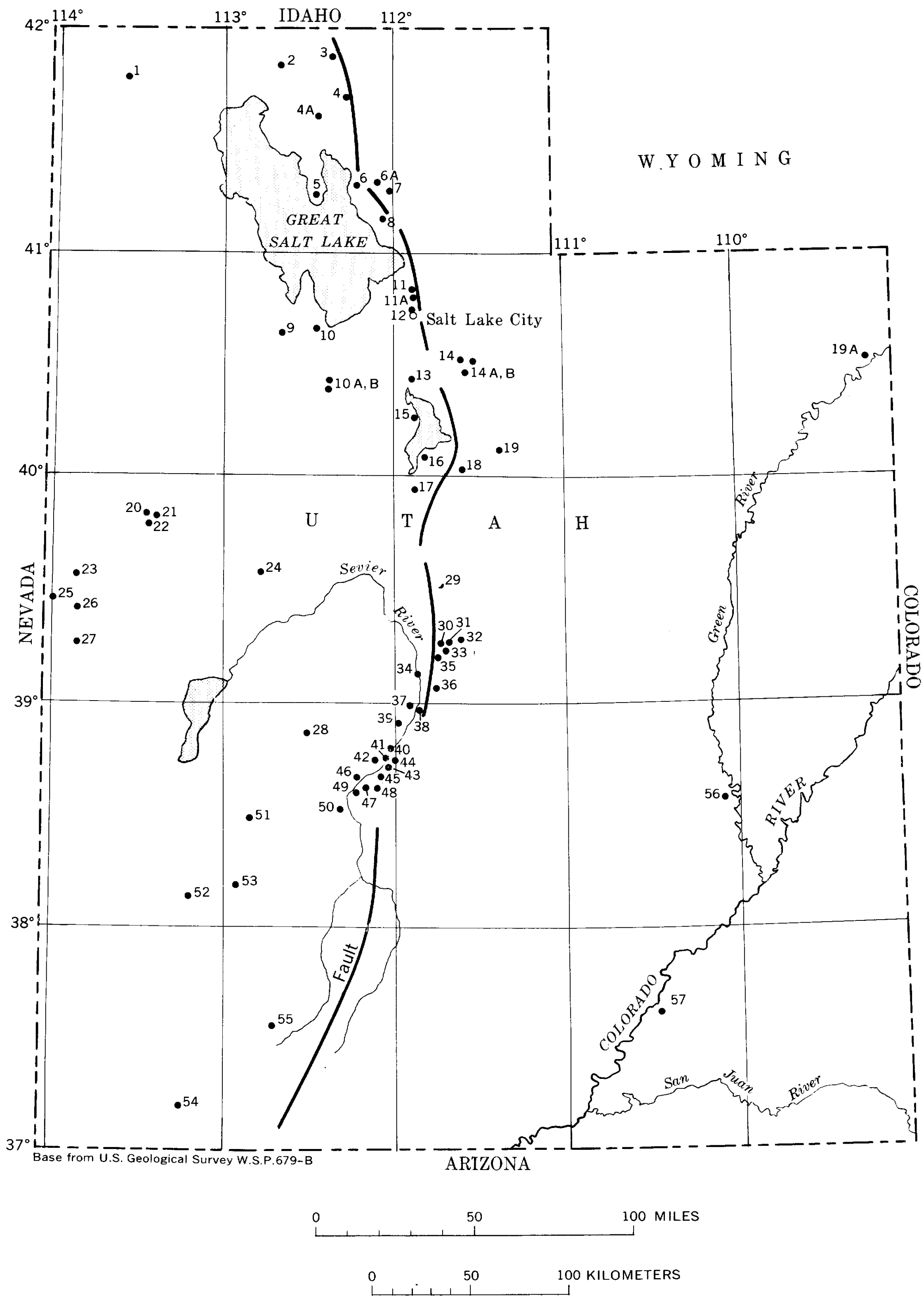


FIGURE 7.—Utah showing location of thermal springs. From ref. 148.

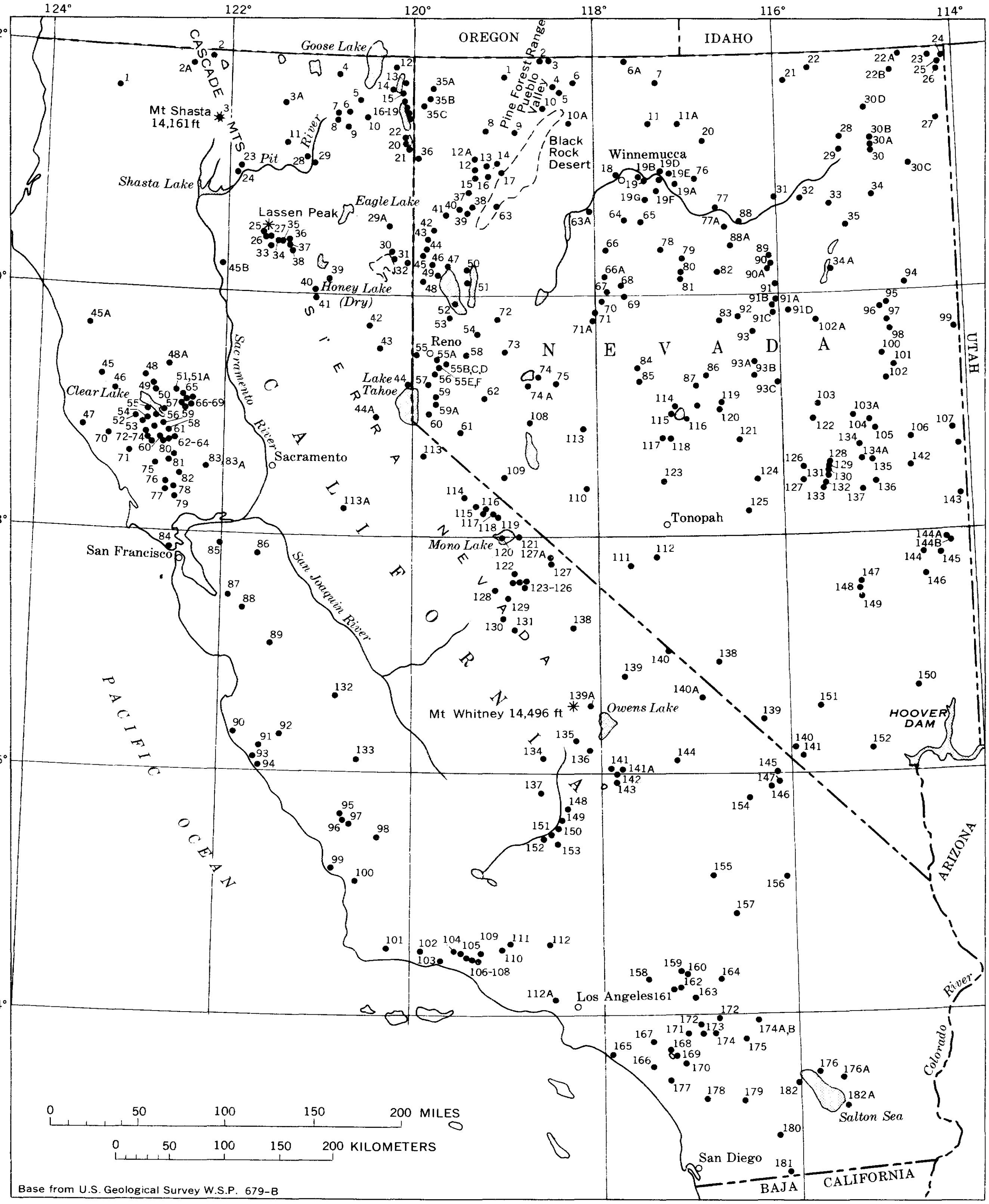


Figure 8.—California and Nevada showing location of thermal springs. Chiefly from ref. 148.

to faults or near volcanic rocks. About 75 miles north of San Francisco an area of faulted metamorphic rocks contains a noted group of hot springs and fumaroles known as "The Geysers," which deposit sulfate minerals.

The coastal ranges south of San Francisco Bay consist largely of granite and of serpentine and marine sedimentary rocks of the Franciscan Formation of Jurassic and Cretaceous age. In large areas these rocks are overlain by Tertiary sandstone and shale. Several warm springs that issue from the serpentine contain considerable quantities of magnesium salts; others from granite or from Tertiary strata are of more usual character.

The San Bernardino and San Jacinto Mountains of southern California are composed largely of granite, which is extensively faulted. On the western slope of the San Bernardino Mountains, Arrowhead hot springs issue at a scalding temperature from fractured granite. Along the western base of these mountains several warm springs rise through Tertiary deposits that overlie the granite.

From Tomales Bay north of San Francisco, the great San Andreas fault extends more than 600 miles southward into the basin of the Salton Sea, and probably beyond. There are no well-known thermal springs along the main part of this fault, but near the southeast border of the Salton Sea are fumaroles and boiling mud pots that are considered to be on a buried extension of the San Andreas fault.

About 1,185 spring localities are given in the following table. Three States—California, Idaho, and Nevada—have about 200 localities each. Of the 140 spring localities listed for Wyoming, all but 21 are within the Yellowstone National Park. Oregon has 126 thermal springs or groups, and there are several dozen in each of the States of Colorado, Montana, New Mexico, and Utah. There is only one thermal spring in each of the States of Florida, Massachusetts, New York, North Carolina, and Pennsylvania. The remaining thermal springs listed in the table are scattered through eight other States—Arizona, Arkansas, Georgia, South Dakota, Texas, Virginia, Washington, and West Virginia.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)

[Data chiefly from ref. 148 and files of U.S. Geol. Survey]

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Arizona (See fig. 2.)					
1	Pakoon (Pahgun) Spring, on tributary of Grand Wash, 18 miles north of Colorado River.	100		Lava (late Tertiary)		Ref. 138.
2	Sec. 23, T. 30 N., R. 23 E., 5 miles south of Hoover (Boulder) Dam.	Hot		Lava (Tertiary)		
3	Lava Warm Springs, near Lava Falls Rapids in the Grand Canyon of the Colorado River.	89	6,700	Granite		Several springs. Refs. 138, 144.
4	Sec. 33, T. 18 N., R. 19 W., 25 miles southwest of Kingman.	Warm		Lava (Tertiary)		
5	Sec. 32, T. 15 N., R. 6 E., 10 miles northeast of Camp Verde.	72	50	Lava (Tertiary) overlying sandstone (Permian).		3 springs. Water used locally.
6	Verde Hot Springs, 0.5 mile northwest of Childs.	104	75	Lava (Tertiary)		Several springs. Resort.
7	6 miles south of St. Johns	74	2	Sandstone (Triassic)		Deposit of tufa.
8	Castle (Monroe) Hot Springs, in sec. 3, T. 7 N., R. 1 W., on Castle Creek, 50 miles south of Prescott.	115–122	280	Lava (Tertiary)	133, 137	2 springs. Water used for bathing. Refs. 144, 187, 194.
9	Salt Banks, in sec. 33, T. 6 N., R. 17 E., 30 miles west of Whiteriver.	Warm		Sandstone (Cambrian)		Large group of springs. Water used locally.
10	Soda Warm Spring, in sec. 13, T. 6 N., R. 19 E., 23 miles west of Whiteriver.	65		Limestone of Supai Formation (Pennsylvanian and Permian).		
11	Agua Caliente Springs, in sec. 19, T. 5 S., R. 10 W., 15 miles northeast of Palomas.	99–104		Lava (Quaternary)	137, 192	Several springs. Resort.
12	Sec. 35, T. 5 S., R. 19 E., 3 miles north of Aravaipa.	90	6	Lava (Tertiary)		Water used for bathing.
13	Near Gila River, 3 miles north of Fort Thomas.			Lake beds (Pliocene)		Do.
14	Indian Hot Springs, 8 miles northwest of Pima.	81–118	300	do	189, 190	5 springs and 1 well 600 ft deep. Resort.
15	Near Bonito Creek, in T. 4 S., R. 27 E., 25 miles east of Fort Thomas.	Warm		Lava (Tertiary)		
16	T. 4 S., R. 28 E., 10 miles west of Morenci.	Hot	Small	do		Ref. 191.
17	Clifton Hot Springs	127–160		do	137, 191	4 springs. Resort. Refs. 188, 328.
18	Aguajito (Quitabaquito), near Mexican border.	Warm		Alluvium near schist		Water used for village supply and irrigation. Ref. 186.
19	Hooker's Hot Springs, in sec. 6, T. 13 S., R. 21 E., 10 miles northeast of Cascabel.	130	40	Faulted granite		2 main springs. Water used for bathing.
20	Agua Caliente Spring, in sec. 13, T. 20 S., R. 13 E., 5 miles east of Amado.	90	50	Gravel (Quaternary) overlying red shale and sandstone (Cretaceous?).		Water used for bathing. Refs. 138, 184, 193.
21	Sec. 7, T. 18, S., R. 31 E., 6 miles southwest of Paradise.			Quartzite dike near lava (Tertiary).		Water used locally.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Arkansas (See fig. 3.)					
1	Rice's Spring, on Mud Creek	82		Limestone (Ordovician)		Resort. Ref. 144.
2	Hot Springs	102–147	165	Hot Springs Sandstone (Mississippian) overlying Arkansas Novaculite (Devonian and Mississippian).	20, 137, 199, 201–204, 207, 209, 210.	46 springs in area of 20 acres. Hot Springs National Park. Army and Navy General Hospital, sanitariums. Refs. 148, 195–198, 205, 206, 208.
3	Big Chalybeate Spring, 5.5 miles northeast of Hot Springs.	79	185	Chert and shale (Ordovician).		Water used locally. Ref. 197.
4	Sec. 17, T. 4 S., R. 27 W., near the Little Missouri River.	74		Arkansas Novaculite (Devonian and Mississippian).		Ref. 197.
5	Sec. 19, T. 4 S., R. 24 W., in bed of Caddo River at Caddo Gap.	96–100		do		Several springs. Refs 197, 205.
6	Sec. 12, T. 5 S., R. 26 W., at Redland Mountain.	77		do		Ref. 197.
	California (See fig. 8.)					
1	Sec. 29, T. 15 N., R. 8 E., 14 miles southeast of Happy Camp.	90	2	Granite		Water used for bathing.
2	Klamath Hot Springs (Shovel Creek Springs), 20 miles northeast of Ager.	100–152	25	Faulted lava (Pliocene)	297	7 springs. Resort. Ref. 284.
2A	4.5 miles northeast of Ager	65–75	6	Lava overlying Cretaceous strata.		Deposit of tufa. Water supply for cattle.
3	Near top of Mount Shasta, 11 miles northeast of Sisson.	150	5	Lava (Tertiary)		2 springs. Ref. 306.
3A	North of Big Glass Mountain	191		Altered volcanic ash		Vapor vents. Ref. 302.
4	Pothole Spring, 35 miles northwest of Alturas.	70	10	Lava (Tertiary)		Ref. 297.
5	Near Rattlesnake Creek, 9 miles west to Alturas.	80	10	do		Do.
6	Essex Springs, in sec. 10, T. 42 N., R. 11 E.	80–92	700	do		5 springs. Water used for bathing and irrigation. Ref. 297.
7	Warm Spring Valley, 15 miles west of Alturas.	81	275	do	297	Water used for domestic supply and irrigation.
8	Kelly's Hot Spring, in sec. 29, T. 42 N., R. 10 E., 4 miles northeast of Canby.	204	325	Alluvium near faulted lava		Water used for domestic supply and irrigation. Ref. 297.
9	Near Canyon Creek, 15 miles southwest of Alturas.	80	100	Faulted(?) lava		Do.
10	1.5 miles southeast of Alturas	72	1	Alluvium overlying lava		Water supply for cattle. Ref. 297.
11	Little Hot Spring Valley, 25 miles northwest of Bieber.	127; 170	225	Basalt		2 springs. Water used for irrigation. Ref. 297.
12	Near Bidwell Creek, 1 mile northwest of Fort Bidwell.	97–108	75	Faulted lava		5 springs. Water used for domestic supply, bathing, and irrigation. Ref. 297.
13	Boyd Spring, on east side of Upper Lake, 12 miles southeast of Fort Bidwell.	70	1,000	Alluvium		Water used for irrigation.
14	Near southwest side of Upper Lake, 4 miles north of Lake City.	120–207	100	do		Several springs at site of spectacular mud eruption in March 1951. Refs. 264, 265, 279, 293, 297, 304.
15	Near south end of Upper Lake, 12 miles northeast of Cedarville.	170–182	80	Faulted Cretaceous strata near andesite dike.		4 springs. Water used for sheep dipping. Ref. 297.
16	Sec. 12, T. 43 N., R. 18 E., near north end of Middle Lake, 12 miles northeast of Cedarville.	140–149	225	Alluvium near faulted lava		3 springs. Water used for irrigation. Ref. 297.
17	Leonard Springs, in sec. 7, T. 43 N., R. 17 E., 11 miles northeast of Cedarville.	150	50	do		3 springs. Water used locally.
18	Sec. 1, T. 42 N., R. 16 E., and sec. 6, T. 42 N., R. 17 E., 5 miles east-northeast of Cedarville.	130	500	do		5 main springs. Water used for bathing.
18A	Cedar Plunge, 5 miles northeast of Cedarville.	180; 208	115	do		2 wells. Water used for bathing. Ref. 302.
19	Benmac Hot Springs, in sec. 18, T. 42 N., R. 17 E., 5 miles east of Cedarville.	120	200	do		Water used for irrigation. Ref. 297.
20	Menlo Warm Springs, in sec. 7, T. 39 N., R. 17 E., 5 miles south-southeast of Eagleville.	117–125	425	do		5 springs. Water used for bathing and irrigation. Refs. 283, 297.
21	Near southwest side of Lower Lake, 8 miles south-southeast of Eagleville.	120	100	Faulted lava		Water used for irrigation. Refs. 283, 297.
22	Bare Ranch, 12 miles south-southeast of Eagleville.	70	5	Alluvium		Refs. 283, 297.
23	Kosk Creek, 65 miles northeast of Redding.	100	5	Porphyritic quartz diorite dike in sedimentary strata.		2 springs. Ref. 297.
24	Big Bend Hot Springs, in sec. 36, T. 37 N., R. 1 W.	100–180	90	do		6 springs. Resort. Ref. 297.
25	Upper Mill Creek, 1 mile northwest of Tophet Hot Springs (No. 26).	120–150	3	Lava (Tertiary)		3 springs. Refs. 239, 307.
26	Tophet (Soupan, Supan) Hot Springs, on southwest side of Lassen Peak, 53 miles northeast of Red Bluff.	175 to boiling	5	do		About 10 springs and mud pots. Deposits of sulfur. Refs. 213, 238, 239, 297, 307, 660.
27	Bumpas Hot Springs, on south side of Lassen Peak, 60 miles northeast of Red Bluff.	Boiling	100	do		About 20 springs. Refs. 213, 239, 240, 258, 297, 307, 660.
28	Bassett Hot Springs, 2.5 miles east-northeast of Bieber.	173	175	Tuffaceous sandstone (late Tertiary).	297	Water used for bathing and irrigation.
29	Stonebreaker Hot Springs, 6 miles east-southeast of Bieber.	110–165	125	do		9 springs. Water used for irrigation. Ref. 297.
29A	Tipton Springs	70	925	Basalt (Tertiary)		Water used for irrigation.
30	Shaffer (Branbecks) Hot Springs, near north shore of Honey Lake.	160–204	250	Faulted(?) alluvium	297	3 springs. Water used for bathing. Refs. 128, 252, 413, 441, 526.
31	Amedee Hot Springs, near Amedee railroad station.	178–204	700	do	297	7 springs. Water used for bathing. Refs. 125, 256, 441.
32	Highrock Spring, 10 miles east-southeast of Amedee.	86	525	Basalt (Tertiary)		Water used for domestic purposes and irrigation. Ref. 297.
33	Morgan Hot Springs, 53 miles northeast of Red Bluff.	90–200	85	do	297	26 springs. Campground. Refs. 239, 307.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
			California—Continued			
34	Devil's Kitchen, 1.5 miles west of Drake Hot Springs (No. 36).	150–205	50	Basalt (Tertiary)	297	About 30 springs. Refs. 213, 239, 240, 307, 660.
35	Hot Spring Valley, 0.5 mile west of Drake Hot Springs (No. 36).	83	8	do		Water is carbonated. Used for drinking. Ref. 297.
36	Drake Hot Springs, 6 miles southeast of Lassen Peak and 70 miles northeast of Red Bluff.	123–148	20	do		4 springs. Resort. Ref. 239, 297.
37	Boiling Spring (Tartarus) Lake, 1 mile south of Drake Hot Springs (No. 36).	170–190	Intermittent	do		10 springs. Refs. 213, 239, 240, 297, 307, 660.
38	Terminal Geyser, 3.5 miles southeast of Drake Hot Springs (No. 36).	120–205	8	do		6 springs. Refs. 239, 297, 307.
39	Kruger Springs, 1 mile east of Greenville	90–106	8	Alluvium overlying faulted granite.		5 springs. Water used for bathing. Ref. 297.
40	Sec. 13, T. 25 N., R. 8 E., 2 miles northeast of Twain.	94	20	Slate (Carboniferous)		
41	Sec. 14, T. 25 N., R. 8 E., on Indian Creek, 1 mile east of Twain.	80–98	35	do		7 springs.
41A	Marble Hot Wells, 5 miles south-southeast of Beckwourth.	125–161	350			3 wells. Water used for domestic purposes, bathing, and irrigation. Ref. 297.
42	McLear Sulphur Springs, 5 miles southwest of Beckwourth.	86	140	Lake Beds (Pleistocene)		8 springs. Water used for domestic purposes and irrigation. Refs. 292, 297.
43	Campbell (Upper Soda, Freys) Hot Springs, 2 miles south of Sierraville.	65–111	80	Faulted andesite		11 springs. Resort. Refs. 284, 297.
44	Brockway (Carnelian) Hot Springs, on north shore of Lake Tahoe and 13 miles southeast of Truckee.	120–140	150	Andesite overlying faulted granodiorite.	137	6 springs. Resort. Ref. 297.
44A	Wentworth Springs	60–75	Small	Granite-slate contact		2 groups of springs. Water is carbonated. Deposits of tufa. Campground.
45	Orrs Hot Springs, 16 miles northwest of Ukiah.	63–104	25	Franciscan Formation (Jurassic and Cretaceous).	263	7 springs. Resort. Ref. 297.
45A	0.5 mile north of Laytonville	70	200	do		Water contains H_2S. Used for bathing.
45B	Tuscan (Lick) Springs	86	50	do		20 springs. Water is saline, contains H_2S. Natural gas. Resort. Ref. 306.
46	Vichy Springs, 3 miles northeast of Ukiah	50–90	30	Sandstone (Franciscan Formation) near lava.	263, 284, 297	7 springs. Resort.
47	Point Arena Hot Springs, 15 miles southeast of Point Arena.	110–112	4.5	Basalt (Tertiary)		2 springs. Resort. Ref. 297.
48	Crabtree Springs, 38 miles north-northeast of Lakeport.	68–105	15	Sandstone (Franciscan Formation).		4 springs. Campground. Ref. 297.
48A	Fouts Springs	60–75	20	Serpentine (Franciscan Formation).		4 springs. Water is saline and carbonated. Resort.
49	Sec. 35, T. 16 N., R. 8 W., 2 miles northwest of Bartlett (cold) Springs.	90	5	do		Water used for bathing.
50	Newman (Soap Creek) Springs, 45 miles west of Williams.	70–92	25	do		9 springs. Water used for bathing. Ref. 297.
51	Complexion Springs, 28 miles west of Willams.	74	1	do	297	30 springs.
51A	Chalk Mountain	67–70	3	Altered lava		3 springs. Water is saline and carbonated. Deposit of tufa.
52	Highland Springs, 6 miles southwest of Kelseyville.	52–82	20	Serpentine (Franciscan Formation).	137, 253, 297	11 springs. Resort.
53	England (Elliott) Springs, 8 miles south-southwest of Kelseyville.	56–76	8	Sandstone (Franciscan Formation).		7 springs. Water used for drinking. Ref. 297.
54	Carlsbad Springs, 5 miles south of Kelseyville.	66–76	4	do	297	4 springs. Water used locally.
54A	Kelseyville	78	10			3 wells. Water used for irrigation.
55	Soda Bay Springs, at base of Mount Konocti.	80–87	400	Lava (Quaternary)	297	5 springs. Resort. Ref. 253.
56	Near southwest shore of Clear Lake, 10 miles east of Kelseyville.	70–100	5	Andesite (Tertiary)		10 springs. Water used for drinking. Ref. 297.
57	Sulphur Bank (Hot Bolata) Hot Springs, 10 miles north-northwest of Lower Lake.	83–120		Basalt near faulted Lower Cretaceous strata.	20, 128, 297, 306	10 springs. Deposits of cinnabar and sulfur. Refs. 214, 225, 244, 245, 252, 260, 274–277, 288, 293, 303, 400, 401, 426.
58	Howard Springs, 28 miles north-northwest of Calistoga.	48–110	135	Sandstone and serpentine (Franciscan Formation).	137, 297	26 springs. Resort. Ref. 284.
59	Seigler Springs, 30 miles north-northwest of Calistoga.	58–126	35	Serpentine (Franciscan Formation).	284, 297	13 springs. Resort. Ref. 253.
60	Gordon Hot Spring, 28 miles north-northwest of Calistoga.	92	5	Lava overlying sandstone (Franciscan Formation).	284, 297	Water used locally. Ref. 216.
61	Spiers (Copsey) Springs, 24 miles north-northwest of Calistoga.	78; 84	15	Serpentine (Franciscan Formation).		2 springs. Water is bottled for drinking. Ref. 297.
62	Castle (Mills) Hot Springs, 25 miles north-northwest of Calistoga.	65; 164		Schist (Franciscan Formation).	297	2 springs. Resort. Ref. 253.
63	Anderson Springs, 22 miles north-northwest of Calistoga.	63–145	7	Lava and schist (Franciscan Formation).	297	9 springs. Resort. Refs. 216, 253, 284, 286.
64	Harbin Springs, 20 miles north-northwest of Calistoga.	90–120	10	Schist (Franciscan Formation).	137, 284, 297	3 springs. Resort. Refs. 216, 253, 284.
65	Deadshot Springs, 28 miles west-southwest of Williams.	65–79	11	Serpentine (Franciscan Formation).		4 springs. Water used for drinking. Ref. 297.
66	Blancks Hot Springs, 27 miles southwest of Williams.	120	4	Sandstone (Franciscan Formation).		2 springs. Water used for bathing. Refs. 246, 297.
67	Jones Hot Springs, 26.5 miles southwest of Williams.	125	2	Serpentine (Franciscan Formation).		Well that flows intermittently. Former resort. Refs. 246, 297.
67A	Manzanita Quicksilver Mine	110–142	4	do		3 springs. Water is saline and sulfurous. Used for bathing. Ref. 246.
68	Wilbur (Simmons) Hot Springs, 26 miles southwest of Williams.	65–140	35	Serpentine and sandstone (Franciscan Formation).	297	12 springs. Resort. Refs. 137, 246, 284.
69	Elgin Quicksilver Mine, 30 miles west-southwest of Williams.	140–153	25	do	297	3 springs. Refs. 109, 216, 246.
70	Hoods (Fairmount) Hot Springs, 15 miles west-northwest of Cloverdale.	100	5	Fractured sedimentary strata (Franciscan Formation) near schist.	297	2 springs. Water used for bathing. Ref 297.
71	Skagg's Hot Springs, 9 miles west-southwest of Geyserville.	120–135	15	Fractured sedimentary strata (Franciscan Formation).	266	3 springs. Resort. Refs. 284, 297.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	California—Continued					
72	The Geysers, 18 miles east-southeast of Cloverdale.	140 to boiling	30–50	Fractured sedimentary strata (Franciscan Formation).	137, 278, 297	About 30 springs, including Iron, Witches' Cauldron, Devil's Teakettle, and Acid. Water is bottled for drinking. Resort. Also wells produce steam for generation of electricity. Refs. 19, 75, 130, 211, 212, 220, 221, 223, 224, 226–230, 233, 237, 241, 242, 267, 284, 285, 288, 296, 306, 400.
73	Sulphur Creek, 21 miles southeast of Cloverdale.	120	5	do		Several springs. Ref. 212.
74	Little Geysers, 22 miles east, southeast of Cloverdale.	110–160	8	do		10 springs. Campground. Refs. 137, 212, 228, 230, 288, 297.
75	Mark West Warm Springs, 7 miles northeast of Fulton.	60–82	30	Lava and tuff (Pliocene)		9 springs. Resort. Ref. 297.
76	Los Guilicos Warm Springs, 3.5 miles southwest of Glen Ellen.	78; 82	5	Franciscan Formation		2 springs. Resort. Ref. 297.
77	McEwan Ranch, 3 miles southwest of Kenwood.	80	50	Lava and tuff (Pliocene)		Water used for irrigation. Ref. 297.
78	Eldridge State Home, 6 miles north-northwest of Sonoma.	72	10	Alluvium overlying lava		Do.
79	Ohms and Boyes Hot Springs, 2 miles northwest of Sonoma.	114–118		Lava and pre-Tertiary sedimentary strata.	297	Pumped wells at site of springs which stopped flowing in 1906. Water bottled for table use. Resort. Ref. 284.
	Fetters Hot Springs, 2.75 miles northwest of Sonoma.	100				4 pumped wells. Resort. Refs. 284, 297.
	Agua Caliente (Aqua Rica) Springs, 3 miles northwest of Sonoma.	97–115	10			5 flowing wells. Resort. Ref. 297.
80	Aetna Springs, 17 miles north of St. Helena	63–92	20	Franciscan Formation	266, 297	6 springs. Water used for drinking. Resort. Refs. 216, 284, 311.
81	Calistoga Hot Springs, 225 yds. east of depot	126–173	8	Faulted tuff (Pliocene?)	270, 297	4 springs and several flowing wells. Water used for bathing. Refs. 212, 267, 276, 284, 285.
82	St. Helena White Sulphur Springs, 2 miles southwest of St. Helena.	69–90	6	Sandstone (Franciscan Formation).	297	5 springs. Resort. Refs. 144, 216.
83	Napa Rock (Priest) Soda Springs, 15 miles east-northeast of St. Helena.	79	15	Altered sandstone and shale (Franciscan Formation).	297	2 springs. Water used for drinking. Ref. 284.
83A	Phillips Soda Springs	68; 76	10	Serpentine (Franciscan Formation).		2 springs. Deposit of $MgCO_3$.
84	Rocky Point Spring, 6 miles northeast of Point Bonita.	100	5	Sandstone (Franciscan Formation).		Ref. 297, 299.
85	Sulphur Springs, 2 miles northeast of Walnut Creek (town).	75–81	5	Faulted sandstone (Tertiary).		6 springs. Water used for domestic purposes. Ref. 297.
86	Byron Hot Springs, 2 miles south of Byron.	72–120	15	Sedimentary strata (upper Miocene).	284, 297	7 springs. Resort. Refs. 137, 216, 253.
87	Warm Springs, 2 miles northeast of Warm Springs (town).	85–90	15	Faulted sedimentary strata (Teritary).		4 springs. Water used for domestic purposes and watering garden. Ref. 297.
88	Alum Rock Park Springs, 7 miles northwest of San Jose.	62–87	15	Folded sedimentary strata (Teritary).	297	17 springs. Water used for drinking and bathing.
89	Gilroy Hot Spring, 14 miles northeast of Gilroy.	110	15	Faulted(?) Franciscan Formation.	297	Water bottled for table use. Resort. Refs. 216, 284.
89A	San Benito Mineral Well, 4 miles southeast of Hollister.	75				Pumped well. Water bottled for table use.
90	North Fork of Little Sur River, 30 miles (by road) south of Monterey.	103; 114		Faulted granite		2 springs. Ref. 297.
91	Tassajara Hot Springs, in sec. 32, T. 19 S., R. 4 E.	100–140	100	Gneiss and granite	297	17 springs. Resort.
92	Paraiso Hot Springs, 8 miles south-southwest of Soledad.	65–111	10	Sandstone (Miocene)	270, 272, 297	5 springs. Resort. Refs. 216, 282.
93	Slate's Hot Springs, in sec. 9, T. 21 S., R. 3 E.	100–121	50	Sedimentary strata (Upper Cretaceous).		10 springs. Resort. Refs. 247, 272, 297.
94	Dolan's Hot Springs, 7 miles from Slate's Hot Springs.	100	5	do		
95	Paso de Robles Mud Bath Springs, 2.5 miles north of Paso Robles.	55–118	100	Sedimentary strata (Pliocene).	297	3 springs. Water bottled for table use; also used for bathing. Ref. 216.
96	Paso de Robles Hot Springs, in southwest part of Paso Robles.	105	1,700	do	270, 272, 284, 297	1 main spring and flowing well. Resort. Ref. 216.
97	Santa Ysabel Springs, 4 miles southeast of Paso Robles.	94	150	do	270, 297	2 springs. Water used for bathing and irrigation.
98	Cameta Warm Spring, 30 miles southeast of Paso Robles.	74	3	Faulted gravel (Quaternary).		Water used for bathing. Ref. 297.
98A	San Luis (Sycamore) Hot Spring, 8 miles south-southwest of San Luis Obispo.	107	50			Well. Resort. Refs. 217, 284, 400.
99	Pecho Warm Springs, 15 miles southwest of San Luis Obispo.	72; 95	17	Folded shale (Miocene)		2 springs. Water used for drinking and bathing. Refs. 217, 297.
100	Newsom's Arroyo Grande Warm Springs, 2.5 miles east of Arroyo Grande.	98	15	Fractured siliceous shale (Miocene).	270, 297	Resort. Ref. 216.
101	Las Cruces Hot Springs, 4 miles north of Gaviota station.	67–97	50	Sandstone (Miocene) faulted(?) against upper Eocene strata.		4 springs. Water used for bathing. Ref. 297.
102	San Marcos (Mountain Glen, Cuyama) Hot Springs, 20 miles northwest of Santa Barbara.	89–108	45	Faulted sandstone (Miocene).		6 springs. Campground. Refs. 262, 297.
103	Montecito (Santa Barbara) Hot Springs, 6 miles northeast of Santa Barbara.	111–118	50	Sandstone (upper Eocene)	297	11 springs. Resort. Source of part of Montecito water supply. Refs. 219, 262, 306.
104	Sec. 4, T. 5 N., R. 25 W., 1 mile east of Mono Creek and 12 miles northeast of Santa Barbara.	90	15	Shale (upper Eocene)		3 springs.
105	Sec. 1, T. 5 N., R. 25 W., 4 miles north of Santa Ynez River and 15 miles northeast of Santa Barbara.	90	10	do		Do.
106	Vicker's Hot Springs, in Matilija Canyon, 9 miles northwest of Nordhoff.	118	5	Faulted(?) sandstone (upper Eocene).	297	3 springs. Ref. 234.
107	Stingley's Hot Springs, 8.5 miles northwest of Nordhoff.	76; 100	4	do		2 springs. Water used for domestic purposes and bathing. Ref. 297.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
				California—Continued		
108	Matilija Hot Springs, 6 miles northwest of Nordhoff.	65–116	45	Sandstone and shale (upper Eocene).	234, 297	4 springs. Resort. Ref. 128.
109	Wheeler's Hot Springs, 7.5 miles north-northwest of Nordhoff.	62–102	40	do	234, 297	4 springs. Resort.
110	Willett Hot Spring, in sec. 31, T. 6 N., R. 20 W., 24 miles north-northwest of Fillmore.	120	50	do		Water used for bathing.
111	Sespe Hot Springs, in sec. 21, T. 6 N., R. 20 W., 22 miles north-northwest of Fillmore.	97–191	125	Faulted granite		4 springs. Campground. Refs. 262, 297.
112	Elizabeth Lake Canyon, 13 miles north-northeast of Castiac station.	100	5	do		Ref. 297.
112A	Encino Ranch (Seminole) Hot Springs	85	5	Shale (Miocene)	262	2 springs. Water is carbonated. Used for domestic purposes and bathing. Refs. 297, 306.
112B	Radium Sulphur Spring, in northwestern part of Los Angeles.	80				Pumped well. Water used for bathing. Ref. 297.
112C	Bimini Hot Spring, in northern part of Los Angeles.	104	100			Flowing well. Water used for bathing. Ref. 297.
113	Grover's Hot Springs, 4 miles west of Markleeville.	128–146	100	Faulted granite		12 springs. Campground. Ref. 297.
113A	Valley Springs	75	1	Miocene(?) strata near contact with Upper Jurassic strata.		2 springs. Water slightly saline. Bottled for table use.
114	Fales' Hot Springs, in sec. 24, T. 6 N., R. 23 E., 13 miles northwest of Bridgeport.	97–141	300	Lava near granite		Several springs. Deposit of tufa. Resort. Refs. 125, 297.
115	Buckeye Hot Spring, in sec. 3, T. 4 N., R. 24 E., 5.5 miles west-southwest of Bridgeport.	140	25	Faulted granite		Water used for bathing. Refs. 282, 297.
116	Sec. 27, T. 5 N., R. 25 E., 1.5 miles southeast of Bridgeport.	121–148	10	Fissured andesite	297	3 main springs. Water used for bathing and sheep dipping. Quarries in onyx marble and travertine nearby. Refs. 235, 236, 251, 282, 302.
117	1.5 miles south-southeast of Bridgeport	70–105	25	do		20 springs. Refs. 282, 297, 305.
118	Warm Springs Flat, 5 miles southeast of Bridgeport.	100	5	Lava (Tertiary)		Water used for cattle supply. Refs. 282, 297.
119	Sec. 20, T. 4 N., R. 26 E., near Mormon Creek, 7 miles southeast of Bridgeport.	100	5	do		Water used for cattle supply. Ref. 297.
120	Paoha Island in Mono Lake	176	100	Lava (Recent)	409	Several springs. Refs. 275, 282, 297, 305, 306.
121	Mono Basin Warm Spring, on east edge of Mono Lake.	90	10	do	128, 137, 282, 297, 409.	
122	Sec. 13, T. 3 S., R. 28 E., 5 miles northeast of Casa Diablo Hot Springs (No. 123).	170	5	Faulted lava (Recent)		Refs. 282, 297.
123	Casa Diablo Hot Springs, in sec. 32, T. 3 S., R. 28 E., on U.S. Highway 395.	115–194	35	Basalt (Quaternary)		20 springs. Small deposit of sinter. Water used for vapor baths. Refs. 282, 297, 305.
124	Casa Diablo Hot Pool, in sec. 35, T. 3 S., R. 28 E., 3 miles northeast of Casa Diablo.	180	Intermittent	Faulted(?) lava (Quaternary)		Ref. 297.
125	The Geysers, in sec. 30, T. 3 S., R. 29 E	120–202	500	Rhyolite (Quaternary)		5 main springs and 2 stream vents. Large deposit of tufa. Ref. 305.
126	Whitmore Warm Springs, in sec. 18, T. 4 S., R. 29 E.	90	306	Faulted lava (Quaternary)		2 main springs. Resort. Ref. 125.
127	Benton Hot Springs, in sec. 2, T. 2 S., R. 31 E., 300 yd northwest of Benton post office.	135	400	Granite near Tertiary volcanic tuff.		Water used for irrigation. Refs. 262, 297, 305, 310.
127A	Bertrand Ranch	70	100	Alluvium		Water used for irrigation.
128	Reds Meadows Hot Springs, 10 miles southwest of Mineral Park.	90–120	10	Granite near lava	297	5 springs. Campground.
129	Fish Creek Hot Springs, in sec. 9, T. 5 S., R. 27 E., at head of Fish Valley.	110	5	Granite		2 springs. Ref. 297.
130	Sec. 16, T. 7 S., R. 27 E., on South Fork of San Joaquin River.	100–112	25	do		4 springs. Campground. Ref. 297.
131	Blaney Meadows Hot Springs, in sec. 10, T. 8 S., R. 28 E.	100–110	40	Gneiss	297	8 springs. Campground.
132	Mercey Hot Springs, 25 miles south of Dos Palos.	79–109	6	Fractured greenstone near Franciscan Formation.	215, 297	3 springs. Water is brackish. Used for bathing.
133	Fresno Hot Springs, on branch of Waltham Creek, 18 miles west of Coalinga.	88–97	20	Faulted sandstone and shale (Miocene?).		5 springs. Resort. Refs. 250, 297.
134	South Fork of the Middle Fork of Tule River, 27.5 miles east-northeast of Portersville.	77	25	Granite		Water is carbonated. Used for drinking. Ref. 297.
135	Jordan Hot Springs, 65 miles north of Kernville.	95–123	75	Gravel near lava		14 springs. Large deposit of tufa. Campground. Ref. 297.
136	Monache Meadows, 14 miles southwest of Olancha.	100	2	Rhyolite (Tertiary)		Water is carbonated. Used for drinking. Ref. 297.
137	California (Deer Creek) Hot Springs	105–126	50	Faulted granite		7 springs. Resort. Refs. 284, 297.
138	Keough Hot Springs, 8 miles south of Bishop.	130	825	Faulted(?) granite		3 springs. Water used for bathing. Resort. Ref. 297.
139	Saline Valley, 10 miles northeast of Saline Valley Borax Mine.	100	5	Alluvium		Ref. 297.
139A	Skinner Ranch	Warm	10	do		Water used for domestic purposes and irrigation.
140	Staininger Ranch (Grapevine) Springs, in Grapevine Canyon, 50 miles northeast of Keeler.	75	30	Lake beds (Tertiary)		Several springs. Water used for domestic purposes and irrigation. Refs. 297, 399.
140A	Keene Wonder Spring, at west base of Funeral Range. Nevares and Texas springs are farther south.	80–93	30	Tertiary strata overlying Paleozoic strata.		1 main and several minor springs. Water contains 3,630 ppm of dissolved solids. Extensive deposit of tufa.
141	14 miles southeast of Haiwee	150–203	Small	Lava (Tertiary)		20 pools and vapor vents. Deposits of sulfur and alum. Refs. 262, 297.
141A	Devil's Kitchen, 2 miles northeast of Coso Hot Springs (No. 142).	180 to boiling	Small	Lava (Recent)		Several small springs and vapor vents. Small deposits of cinnabar. Refs. 248, 275.
142	Coso Hot Springs, 20 miles northeast of Little Lake.	140 to boiling	Small	Lava (Recent) overlying granite.	297	3 main springs. Steam baths. Resort. Refs. 248, 252, 266, 275, 280, 308.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	California—Continued					
143	Near Little Lake, 18 miles south of Haiwee.	80	1	Basalt (Tertiary)	297	Ref. 262.
144	Panamint Valley, 4 miles north of Ballarat.	80	1	Alluvium near granite		Water supply for prospectors. Refs. 261, 297.
145	Yeoman Hot Springs, in sec. 1, T. 21 N., R. 7 E., 5 miles northeast of Zabriskie.	80	100	Alluvium near Tertiary lava.		Several springs. Water used for irrigation. Refs. 289, 290.
146	2 miles north of Tecopa	108; 109	225	Faulted quartzite (Cambrian).		2 springs. Water supply for railroad. Ref. 297.
147	Resting Spring, 5.5 miles northeast of Tecopa.	80	260	do		Water used for domestic purposes and irrigation. Ref. 297.
148	2 miles northeast of Kernville	98; 113	4	Faulted gneiss		2 springs. Water used for bathing. Refs. 262, 297.
149	Neills Hot Spring (Agua Caliente), 7 miles south-southwest of Kernville.	131	115	Faulted granite and gneiss		Water used for domestic purposes, bathing, and irrigation. Refs. 262, 297.
150	Clear Creek (Hobo) Hot Springs, in sec. 25, T. 27 S., R. 32 E.	119	20	Granite		3 springs. Water used locally. Ref. 297.
151	Delonegha Springs, 45 miles northeast of Bakersfield.	104–112	25	Fractured granite		3 springs. Resort. Ref. 297.
152	Democrat Springs, 40 miles northeast of Bakersfield.	100–115	25	Faulted granite		5 springs. Resort. Ref. 297.
153	Williams Hot Springs, 16 miles northeast of Caliente.	60–100	20	Fractured gneiss and quartz.		5 springs. Water contains H_2S. Used for domestic purposes, bathing, and irrigation. Ref. 297.
154	Saratoga Springs, 15 miles west of Sperry railroad station.	82	125	Faulted intrusive diorite	290	4 springs. Water supply for prospectors. Refs. 271, 289, 297.
155	Paradise Springs, 25 miles north of Daggett.	85–106.5	30	Pegmatite	290	Several springs. Water supply for prospectors. Refs. 269, 289, 297.
156	Soda Station Springs, in sec. 14, T. 12 N., R. 8 E.	75	30	Faulted(?) limestone (Precambrian).	290	2 springs. Water used for drinking.
157	Newberry Spring, in sec. 32, T. 9 N., R. 3 E., 600 yd south of Newberry railroad station.	77	300	Alluvium (Quaternary) near tuffaceous lava (Tertiary).		Pumped. Water supply for railroad. Refs. 289, 290, 297.
158	Tylers Bath Springs, in Lytle Canyon, 15 miles northwest of San Bernardino.	92	5	Granite		Refs. 262, 297.
159	Sec. 15, T. 3 N., R. 3 W., in Deep Creek Canyon, 16 miles southeast of Victorville.	80–100	5	do		Several small springs.
160	Sec. 14, T. 3 N., R. 3 W., in Deep Creek Canyon, 15 miles southeast of Victorville.	80–100	5	do		6 springs.
161	Harlem Hot Spring, 5 miles north-northeast of San Bernardino.	120				Pumped well. Water used for bathing. Refs. 268, 297.
162	Waterman Hot Springs, 6.5 miles north-northeast of San Bernardino.	123	5	Fractured granite and gneiss.	297	Several small springs. Water used for bathing. Refs. 262, 284.
162	Arrowhead Hot Springs, 7 miles north-northeast of San Bernardino.	110–187	50	do	137, 268, 284, 297	2 groups of springs. Resort. Ref. 262.
162A	Urbita Hot Springs, 1 mile south of San Bernardino.	80–106	250			6 wells. Water used for bathing. Refs. 268, 297.
163	Sec. 34, T. 1 N., R. 2 W., in Santa Ana Canyon, 12 miles east-northeast of San Bernardino.	90	3	Granite		
164	Near Baldwin Lake, 40 miles southeast of Victorville.	88	5	do		Water used for bathing. Ref. 297.
165	Fairview Hot Spring, 7 miles southwest of Santa Ana.	96	15	Alluvium		Water bottled for table use. Resort. Ref. 297.
166	San Juan Capistrano Hot Springs, 13 miles northeast of San Juan Capistrano.	121–124	35	Faulted(?) granite	297	6 springs. Visited by Francisan friars and mentioned in their records. Ref. 262.
167	Glen Ivy (Temescal) Hot Spring, 11 miles south-southeast of Corona.	102	15	Faulted granite	291, 298	1 main and several minor springs. Resort. Ref. 297.
168	Wrenden (Bundys Elsinore) Hot Springs, 225 yd north of Elsinore depot.	118		Alluvium	291, 297, 298	Originally flowed, now pumped. Resort.
169	Elsinore Hot Springs, 50 yd north of Elsinore depot.	125		Quaternary deposits near faulted Mesozoic rocks.	137, 298	3 springs which originally flowed but now are pumped. Resort. Ref. 297.
170	Murrieta Hot Springs, 4 miles east-northeast of Murrieta.	134–136	75	Faulted granite	284, 291, 297, 298	3 springs. Resort.
171	Pilares Hot Spring, 8 miles northeast of Perris.	100	3	Alluvium overlying faulted bedrock.	298	Water used for bathing. Also drilled well nearby. Ref. 297.
172	Eden Hot Springs, 9 miles southwest of Beaumont.	90–110	30	Faulted granite	291, 298	8 springs. Resort. Refs. 268, 297.
172A	Highland Springs	112 (max)		Granite near San Andreas fault.	291	Several springs. Water used for bathing. Refs. 236, 253.
173	Gilman (San Jacinto, Relief) Hot Springs, 6 miles northwest of San Jacinto.	83–116	20	Alluvium overlying gneiss	291, 297, 298	6 springs. Resort. Ref. 268.
174	Soboba (Ritchey) Hot Springs, 2.5 miles northeast of San Jacinto.	70–111	25	Faulted gneiss	291, 297, 298	6 springs. Water bottled for table use; also used for irrigation. Resort. Ref. 268.
174A	Desert, in sec. 30, T. 2 S., R. 5 E	112–116		Alluvium near San Andreas fault.	291	8 wells about 300 ft deep. Water used for bathing.
174B	Lucky Seven, 2 miles southeast of Desert.	200		Valley alluvium		Drilled well. Water used for bathing. Ref. 302.
175	Palm Springs, 6 miles south of Palm Springs station.	100	5	Faulted granite	232, 291, 297	2 springs. Resort. Refs. 231, 255, 284.
176	Dos Palmas Spring, on northeast side of Salton Sink, 6 miles east of Salton railroad station.	80	25	Alluvium overlying Tertiary strata.	232, 282, 297	Water supply for prospectors. Ref. 262.
176A	Hot Mineral Well	186	900	Alluvium near fault		300 ft deep. Water used for bathing. Refs. 249, 302.
177	Deluz Warm Springs, 20 miles north-northeast of Oceanside.	84–88	5	Diorite dike in granite		3 springs. Water used locally. Refs. 262, 297.
178	Agua Tibia Spring, 30 miles northeast of Oceanside.	92	10	Faulted granite	297	Water used for bathing and irrigation.
179	Warner (Las Aguas Calientes) Hot Springs, in sec. 36, T. 10 S., R. 3 E.	131–139	150	do	137, 232, 297	6 springs. Water used for irrigation. Resort. Ref. 218, 222, 243, 255, 287, 784.
180	Agua Caliente Springs, in secs. 18 and 19, and 19, T. 14 S., R. 7 E.	90	20	do		Several springs. Campground. Refs. 232, 269, 297.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	California—Continued					
181	Jacumba Springs, in secs. 7 and 8, T. 18 S., R. 8 E.	94; 96	15	Fractured granite		2 springs. Water used for bathing and irrigation. Refs. 232, 297.
182	Fish Springs, on west side of Salton Sea, 13 miles south of Mecca.	90	280	Alluvium	232	Several springs, also wells 260–850 ft deep. Water supply for prospectors. Refs. 269, 297.
182A	Salton volcanoes	100 to boiling	Small	Alluvium near fault		4 main groups on southeast-northwest line 2.5 miles long. Refs. 249, 254, 255, 257, 259, 270, 294, 300, 304, 746.
	Colorado (See fig. 2.)					
1	Juniper Hot Springs, in sec. 16, T. 6 N., R. 94 W.	102–105	25	Cretaceous strata	322	Several springs. Resort. Ref. 323.
2	Routt Hot Springs, 7 miles north of Steamboat Springs (No. 2A).	148–150	130	Fractured gneiss near contact with granite.		3 springs. Water used for bathing.
2A	Steamboat Springs	103–150	2,000	Faulted sandstone (Dakota?).	137, 322	150 springs. Deposit of tufa. Resort. Refs. 313, 325–327.
3	Hot Sulphur Springs	90–118	40	Cretaceous strata near granite.	137, 322	25 springs. Strong odor of sulfur. Deposit of tufa. Resort and sanitarium. Refs. 317, 325–327, 513.
4	Moffat (Eldorado) Spring, 12 miles southwest of Boulder.	70	10	Faulted marl (Jurassic)	322	Refs. 325, 327.
5	Hot Soda Springs at Idaho Springs	98–108	50	Fractured syenite near gneiss.	137, 322, 335	Several springs. Resort. Refs. 140, 317, 325, 327, 333, 334.
6	Glenwood Springs	106–150	3,000	Faulted Cretaceous strata	137, 322	Many springs issuing from bank and bed of Colorado River. Resort. Refs. 325, 326, 334.
7	Big Dotsero Spring, on north bank of Colorado River 1.5 miles downstream from Dotsero.	84	400	Limestone (Carboniferous)	322	Water used for bathing.
8	Avalanche Springs, near Avalanche	112–134	200	Diorite intrusion in Carboniferous strata.	322	5 springs issuing along Rock Creek (Crystal River). Water used for bathing. Ref. 324.
9	Conundrum Spring, 16 miles south of Aspen.	100	25	Decomposed granite	322	
10	Alkali Springs, near north end of bridge over the Gunnison River at Austin.	72	5	Sandstone (Dakota?)	322	Several small springs.
11	Sec. 21, T. 13 S., R. 89 W., 10 miles east of Somerset.	90	3	Sandstone (Cretaceous)		4 springs.
12	Ranger (Cement Creek) Spring, 1.5 miles above mouth of Cement Creek.	83	350	Limestone near granite	322	Deposit of tufa.
13	Sec. 18, T. 14 S., R. 84 W., 2.5 miles above mouth of Cement Creek.	100	1,800	Limestone (Cretaceous)		
14	Waunita (Tomichi) Hot Springs, on Hot Springs Creek, 28 miles east of Gunnison.	140–160	1,000	Sandstone (Paleozoic?)	137	2 groups of springs totaling more than 100 individual springs. Resort. Refs. 144, 322.
15	Cebolla (Powderhorn) Hot Springs (Ojo de los Caballos), 6 miles south of Powderhorn.	79–114	100	Granite and gneiss		2 groups of springs totaling about 20 individual springs. Resort. Refs. 322, 330.
16	Rhodes Spring, 8 miles southwest of Fairplay.	79	300	Alluvium	322	Water used locally.
17	Hartsell Hot Springs, 25 miles east of Leadville.	105–134	10	Mesozoic strata near granite	137, 322	5 springs. Resort. Refs. 138, 317.
18	Mound Soda (Currant Creek) Spring, 20 miles northwest of Parkdale.	68		Granite		Refs. 138, 335.
19	Cottonwood (Buena Vista Hot) Springs, 6 miles west of Buena Vista.	120–144	150	Granite near monzonite intrusion.	322	5 springs. Campground.
20	Mount Princeton (Heywood Hot, Chalk Creek Hot) Springs, 3 miles west of Nathrop.	98–150	50	do		4 main and about 30 other springs. Resort. Refs. 322, 325, 335.
21	Poncha Springs	80–168	500	Granite	137	About 100 springs. Water contains 12 ppm of fluorine. Resort. Deposit of tufa. Refs. 109, 315, 317, 322, 325, 326, 331.
22	Wellsville Warm Spring, 5 miles northwest of Howard.	94	150	Carboniferous strata	322	Water used locally. Ref. 138.
22A	Canon City:					
	Near east end of Royal Gorge of Arkansas River.	101				Pumped well 10 ft deep. Ref. 317
	Fremont Natatorium	100	140	Sandstone (Dakota?)		Flowing well 1,665 ft deep.
23	Chamberlain (Mineral) Hot Springs, in sec. 12, T. 45 N., R. 9 E., 6 miles south of Villa Grove.	116–133	50	Lava overlying sedimentary strata.		30 springs. Deposit of tufa. Resort. Refs. 322, 332.
24	Valley View (Orient) Hot Springs, in sec. 31, T. 46 N., R. 10 E., 7 miles southeast of Villa Grove.	72–99	200	Quartzite near granite	332	5 springs. Water used for bathing. Ref. 322.
25	Red Creek (Siloam, Parnassus) Springs, 12 miles southwest of Pueblo.	59–73	5	Contact of Upper Cretaceous strata and gneiss.	322, 328	5 springs. Water used locally. Deposit of tufa.
26	Geyser Warm Spring, at Placerville	94	5	Mesozoic strata	322	Water used for bathing.
27	Orvis (Ridgway, Uncompahgre) Hot Spring, 2 miles southeast of Ridgway.	132	300	Alluvium overlying faulted Pennsylvanian strata.		Water used for bathing and irrigation. Refs. 316, 317, 322, 330.
28	Ouray Hot Springs	100–158	200	Faulted Hermosa Formation (Pennsylvanian).	137, 316	3 groups of springs. Water supply for 2 sanitariums and municipal swimming pool. Resort. Refs. 312, 317, 322, 332.
29	Sec. 33, T. 41 N., R. 11 W., 200 yd southeast of Dunton Store.	110	20	Limestone (Cretaceous)		Water used locally.
30	Iron Spring, 0.75 mile north of Rico	82	30	Sandstone and shale (Permian).	322	Deposit of limonite.
31	Wagon Wheel Gap Springs	132–150	100	Granite cut by dikes	137, 318, 319, 328	3 springs. Large deposit of tufa. Resort Refs. 109, 128, 315, 317, 322, 325.
32	Sec. 26, T. 38 N., R. 1 W., 26 miles northeast of Pagosa Springs.	100; 120	50	Granite		2 springs.
33	Shaw's Spring, 6 miles north of Del Norte	88	10	Sandstone (Tertiary) near igneous rock.	322	Water used locally.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Colorado—Continued					
34	Pinkerton Springs, in sec. 26, T. 37 N., R. 9 W., 14 miles north of Durango.	87–95	8	Sandstone (Paleozoic)	322	5 main and several small springs. Resort.
35	Tripp Springs, 10 miles north of Durango.	90–95	50	Sandstone (Cretaceous)	322	Several springs. Water used for bathing.
36	Trimble Springs, 9 miles north of Durango.	90–110	50	Folded and fractured Paleozoic and Mesozoic strata.		5 springs. Large deposit of tufa. Resort. Refs. 322, 325.
37	Sec. 8, T. 35 N., R. 4 W., 30 miles west of Pagosa Springs (town).	120	3	Limestone (Carboniferous?).		5 small springs. Campground.
38	12 miles northeast of Pagosa Springs (town).	78		Lava overlying shale (Colorado Group).		Ref. 138.
39	Pagosa Springs (town):					
	Pagosa Hot Springs	110–160	600	Fractured shale (Colorado Group).	139, 328	Several springs. Much evolved H_2O, CO_2 Large deposit of tufa. Resort. Refs. 317, 319, 322, 325, 326, 335, 526.
	Well	140	100			Flowing well.
40	3 miles southeast of Pagosa Springs (town).	120	Small	Shale (Colorado Group)		Ref. 138.
41	Warm Sulphur Spring, on the South Fork of the Navajo River, 7 miles east of Chromo.	80	Small	Lava overlying Cretaceous strata.	144, 328	
42	Agua Caliente Spring, in T. 35 N., R. 8 E., 2 miles southwest of Capulin.	90	50	Alluvium near lava (Quaternary).		Refs. 328, 332.
43	McIntyre (Los Ojos) Warm Springs, in sec. 13, T. 35 N., R. 10 E., 8 miles east of La Jara.	62	100	Lava (Quaternary)		Several springs. Water used for irrigation. Refs. 322, 332, 526.
44	Dexter Spring, in sec. 9, T. 35 N., R. 11 E., 12 miles east of La Jara.	71	5	Lava (Tertiary)	332	Ref. 322.
	Florida (See fig. 3.)					
1	Warm (Big) Salt Spring, 8 miles northwest of Murdock.	86	4,900		337, 338	Rises in deep pool 250 ft in diameter. Water used for bathing.
	Georgia (See fig. 3.)					
1	Lifsey (Pine Mountain) Spring, 6 miles south of Zebulon.	77	83	Faulted quartzite and schist (Cambrian or Precambrian).	137, 341, 344, 543	Water used for bathing.
2	Taylor Spring, 2 miles east of Lifsey (Pine Mountain) Spring (No. 1).	75	385	do	341	Supplies pool.
3	Thundering Springs, near Thunder station, 3 miles south of Molena.	74	30	do	137, 341, 344, 543	2 springs. Water used locally. Ref. 339.
4	500 yd south of Thundering Springs (No. 3).	69–72.5	25	do	341	Water used for bathing.
5	Barker Spring, 8 mies south-southeast of Molena.	73	30	do	341	Do.
6	Warm Springs, 0.5 mile west of Warm Springs (town).	87	600	Contact of schist and quartzite.	137, 341, 343, 344, 543.	1 main spring. Resort and sanitarium. Refs. 339, 340, 342.
7	Parkman Spring, 3 miles southeast of Warm Springs (No. 6).	77	20	Faulted quartzite	341	Supplies mill pond.
8	Tom Brown Spring, 2.5 miles northeast of Chalybeate.	69	25	do	341	Supplies pond.
	Idaho (See fig. 4.)					
1	Wier Creek Hot Springs, in sec. 13, T. 36 N., R. 11 E.	Hot	5	Granite		6 springs.
2	Colgate Springs, in sec. 9, T. 36 N., R. 12 E.	105–120	20	do		Do.
3	Jerry Johnson's Hot Springs, in sec. 7, T. 36 N., R. 13 E.	100–130	450	do		3 springs. Water used for bathing. Ref. 383.
4	Horse Creek, 4 miles southeast of Jerry Johnson's Hot Springs.	80	200	do		Ref. 383.
5	Stanley Hot Spring, in sec. 6, T. 34 N., R. 10 E., near Boulder Creek 4 miles upstream from junction with Lochsa River.	Hot	2	do		
6	Stuart Hot Spring, in sec. 4, T. 32 N., R. 11 E., on Link Creek 5 miles upstream from junction with Selway River.	Hot	35	do		
7	Sec. 4, T. 33 N., R. 14 E., 11 miles southwest of Elk Summit ranger station.	Warm	40	do		2 springs.
8	Martin Creek Hot Springs, in sec. 25, T. 31 N., R. 11 E., 3.5 miles west of Wylies Peak.	Hot	15	do		6 springs and seeps.
9	Sec. 14, T. 29 N., R. 12 E., 2 miles south of Grouse Peak.	Hot	10	do		
10	Red River Hot Springs, in sec. 10, T. 28 N., R. 10 E., 10 miles northeast of Red River ranger station.	120	15	do		4 springs. Resort. Ref. 383.
11	Barht's Hot Springs, in sec. 13, T. 25 N., R. 11 E., on Salmon River 200 yds below mouth of Hot Springs Creek.	Hot	200	do		Several springs. Water used locally.
12	Sec. 7, T. 24 N., R. 4 E., 2 miles north of Salmon River.	110	10	do		Water used for bathing.
13	Riggins Hot Spring, in sec. 13, T. 24 N., R. 2 E., 10 miles east of Riggins.	Hot		do		Water used locally.
14	Burgdorf Hot Spring, in sec. 1, T. 22 N., R. 4 E.	113	150	do		Resort.
15	Sec. 13, T. 21 N., R. 1 E., on east side of Little Salmon River 3 miles north of Round Valley.	Hot		do		Water smells of H_2S.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
			Idaho—Continued			
16	Yoghann Hot Sulphur Spring, in sec. 26, T. 20 N., R. 1 E., on west side of Little Salmon River 10 miles northwest of Meadows.	Hot	----------	Columbia River Basalt (Tertiary).	----------	
17	Sec. 22, T. 19 N., R. 2 E., 3 miles northeast of Meadows.	100	50	Granite----------	----------	Water used for bathing.
18	Sec. 2, T. 15 N., R. 1 E., 1.25 miles north of mouth of Warm Spring Creek.	Hot	100	-----do----------	----------	6 springs.
19	Sec. 33, T. 16 N., R. 2 E., 15 miles east of Cottonwood.	Hot	25	-----do----------	----------	8 springs.
20	T. 17 N., R. 5 W., in Snake River Canyon upstream from mouth of Brownlee Creek.	Hot	----------	Columbia River Basalt (Tertiary).	----------	Water smells of H_2S. Ref. 482.
21	T. 11 N., R. 5 W., on Monroe Creek 6 miles northeast of Weiser.	Warm	----------	Payette Formation (Tertiary).	----------	Several springs. Ref. 492.
22	Sec. 11, T. 21 N., R. 5 E., 12 miles west of Shiefers.	Hot	100	Granite----------	----------	10 springs. Water smells of H_2S. Ref. 483.
23	Sec. 15, T. 20 N., R. 5 E., 15 miles southwest of Shiefers.	Warm	5	-----do----------	----------	
24	Sec. 35, T. 20 N., R 7 E., on South Fork of Salmon River 7 miles south of Shiefers.	90–136	100	-----do----------	----------	About 25 springs in 40-acre area.
25	Sec. 25, T. 18 N., R. 6 E., on South Fork of Salmon River 25 miles north of Knox.	Hot	15	-----do----------	----------	10 springs.
26	Sec. 17, T. 18 N., R. 8 E., near mouth of Riordan Creek.	90	2	-----do----------	----------	
27	T. 15 N., R. 3 E., 10 miles north of Cascade.	Hot	----------	-----do----------	----------	Several springs.
28	T. 16 N., R. 4E., on Gold Fork River 25 miles north of Cascade.	Hot	----------	-----do----------	----------	Do.
29	Sec. 1, T. 16 N., R. 6 E., on South Fork of Salmon River 15 miles north of Knox.	Hot	2	-----do----------	----------	2 springs.
30	Sec. 17, T. 15 N., R. 6 E., 6 miles north of Knox.	Hot	100	-----do----------	----------	
31	Sec. 14, T. 15 N., R. 6 E., 6 miles northeast of Knox.	Hot	250	-----do----------	----------	2 springs, 0.5 mile apart.
32	Sec. 11, T. 14 N., R. 6 E., 4 miles east of Knox.	Hot	450	-----do----------	----------	6 springs.
33	Sec. 14, T. 14 N., R. 6 E., 4 miles southeast of Knox.	Hot	100	-----do----------	----------	
34	T. 14 N., R. 3 E., 0.25 mile from Cascade.	Hot	20	-----do----------	----------	2 springs, 0.25 mile north and 0.25 mile south of Cascade. Water supply for town.
35	Sec. 2, T. 12 N., R. 5 E., on Middle Fork of Payette River 12 miles east of Alpha.	Hot	35	-----do----------	----------	
36	Sec. 11, T. 12 N., R. 5 E., near Middle Fork of Payette River.	100	15	-----do----------	----------	
37	Sec. 15, T. 12 N., R. 5 E., near Middle Fork of Payette River.	90	15	-----do----------	----------	
38	Boiling Springs, in sec. 22, T. 12 N., R. 5 E., near Middle Fork of Payette River.	Hot	150	Faulted granite----------	----------	18 springs. Water supply for Forest Service station.
39	Sec. 28, R. 13 N., R. 6 E., near Bull Creek 15 miles east of Alpha.	Hot	15	Granite----------	----------	3 springs.
40	Sec. 31, T. 12 N., R. 6 E., near Silver Creek 15 miles southeast of Alpha.	90	250	-----do----------	----------	4 springs.
41	Sec. 23, T. 13 N., R. 10 E., 0.5 mile southwest of mouth of Bear Valley Creek.	Hot	10	-----do----------	----------	
42	Sec. 30, T. 14 N., R. 10E., 0.25 mile from mouth of Dagger Creek.	Warm	2	-----do----------	----------	
43	Sec. 13, T. 14 N., R. 9 E., on Sulphur Creek.	80–110	7	-----do----------	----------	3 springs.
44	Sec. 34, T. 15 N., R. 10 E., near mouth of Sulphur Creek.	Hot	25	-----do----------	----------	Do.
45	Sec. 26, T. 15 N., R. 10 E., near Middle Fork of Salmon River.	Hot	3	-----do----------	----------	2 springs.
46	Sec. 17, T. 16 N., R. 10 E., on branch of Indian Creek near Chinook Mountain.	Hot	10	Lava (Tertiary) overlying granite.	----------	4 springs.
47	Sec. 20, T. 16 N., R. 12 E., 10 miles north of Greyhound.	Hot	40	Granite----------	----------	2 springs.
48	Sec. 15, T. 17 N., R. 11 E., 8 miles south of Roosevelt.	Hot	50	Lava (Tertiary) overlying granite.	----------	10 springs.
49	Sec. 28, T. 17 N., R. 13 E., on Middle Fork of Salmon River, 2 miles upstream from mouth of White Creek.	Hot	10	-----do----------	----------	3 springs.
50	Sec. 17, T. 25 N., R. 17 E., on Horse Creek 25 miles northwest of Shoup.	110	10	Granite----------	----------	Ref. 383.
51	Sec. 32, T. 24 N., R. 17 E., 17 miles west of Shoup.	Warm	25	-----do----------	----------	5 springs.
52	T. 22 N., R. 18 E., on west side of Copper King Mountain.	Hot	----------	-----do----------	----------	
53	Sec. 22, T. 23 N., R. 22 E., 5 miles north of Carmen.	Hot	80	-----do----------	----------	14 springs.
54	Sec. 26, T. 19 N., R. 14 E., 1 mile east of Mormon Ranch.	Hot	40	-----do----------	----------	
55	Sec. 19, T. 17 N., R. 14 E., near Cache Creek 4 miles upstream from its mouth.	Warm	10	-----do----------	----------	
56	Sec. 10, T. 15 N., R. 14 E., on Warm Spring Creek.	80–190	400	Lava (Tertiary)----------	----------	9 springs.
57	Sec. 1, T. 15 N., R. 15 E., 5 miles northwest of Parker Mountain.	Warm	75	-----do----------	----------	4 springs.
58	Sec. 16, T. 15 N., R. 16 E., near Parker Mountain.	Hot	200	-----do----------	----------	7 springs.
59	Salmon Hot Springs, in sec. 3, T. 20 N., R. 22 E., 7 miles south of Salmon.	Warm	400	Altered lava (Tertiary)----------	----------	Several springs. Water used for bathing and irrigation.
60	Sec. 34, T. 20 N., R. 24 E., 7 miles northeast of Tendoy.	Hot	200	Belt Series (Precambrian)---	----------	
61	T. 18 N., R. 22 E., 27 miles south of Salmon.	Hot	200	-----do----------	----------	2 springs.
62	T. 17 N., R. 21 E., in Kronk Canyon of Salmon River 40 miles south of Salmon.	Hot	100	Belt Series (Precambrian)---	----------	

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
				Idaho—Coutinued		
63	Sec. 18, T. 16 N., R. 21 E., at upper end of Kronk Canyon of Salmon River 3 miles downstream from mouth of Pahsimeroi River.	Hot	100	Belt Series (Precambrian)		6 springs.
64	Warm Spring Creek, 4 miles southwest of Lemhi Indian Agency.	Warm		Lava (Tertiary) overlying Precambrian strata.		Several springs. Ref. 144.
65	Sec. 4, T. 15 N., R. 25 E., 10 miles west of Leadore.	87	3	Belt Series (Precambrian)		Water used for bathing.
66	Sec. 9, T. 7 N., R. 1 E., 1 mile southwest of Sweet.	Hot		Lava (Tertiary) overlying granite.		
67	T. 1 N., R. 3 W., on east side of Snake River 1 mile east of Enterprise.	67		Payette Formation (Tertiary).		Refs. 364, 371.
68	T. 4 N., R. 2 E., on west bank of Squaw Creek 3 miles north of Boise.	Hot	Large	do		Water used locally. Ref. 363.
69	T. 3 N., R. 2 E., on Cottonwood Creek 1 mile west of Boise.	Warm		do		Do.
70	Boise Hot Springs, in T. 3 N., R. 2 E., 4.5 miles southeast of Boise.	90–140	255	Faulted Payette Formation (Tertiary).		About 16 springs. Resort. Refs. 113, 150, 363, 370, 371.
71	Sec. 29, T. 5 S., R. 4 E., near Grand View	109	100	Faulted lava (Quaternary)		Water used for irrigation.
72	Sec. 20, T. 10 N., R. 3 E., 14 miles north of McNish ranger station.	Warm	30	Granite		
73	Sec. 32, T. 10 N., R. 4 E., 3 miles northwest of Garden Valley.	Hot		do		
74	Sec. 6, T. 8 N., R. 5 E., on South Fork of Payette River 10 miles east of Garden Valley.	Hot	20	do		2 springs. Campground.
75	Sec. 2, T. 8 N., R. 5 E., 0.5 mile west of Danskin Creek.	Hot	8	do		
76	Sec. 11, T. 8 N., R. 5 E., 1.5 miles east of Boston & Idaho power plant.	Hot	15	do		2 springs. Water used locally.
77	Sec. 31, T. 9 N., R. 6 E., 0.25 mile west of Pine Flat.	Hot	30	do		Campground.
78	Sec. 31, T. 9 N., R. 8 E., on north side of South Fork of Payette River.	Warm	40	do		
79	Kirkham Hot Springs, in sec. 32, T. 9 N., R. 8 E., on South Fork of Payette River.	90	150	do		5 springs.
80	Bonneville Hot Sprints, in sec. 31, T. 10 N., R. 10 E., on Warm Spring Creek.	100	200	do		6 springs.
81	Sacajawea Hot Springs, in sec. 30, T. 10 N., R. 11 E., near mouth of Bear Creek.	100	200	do		3 springs.
82	T. 5 N., R. 5 E., 6 miles southwest of Idaho City.	110–115	900	do		6 springs. Water used locally. Refs. 133, 144.
83	Nevin Spring, sec. 1, T. 3 N., R. 5 E., near mouth of Cottonwood Creek.	Hot	200	do		
84	Twin Springs, on north side of Middle Fork of Boise River downstream from mouth of Browns Creek.	Hot	350	do		2 main and several smaller springs.
85	Bassett Hot Spring, upstream from Logging Gulch, on north side of Middle Fork of Boise River.	Hot	30	do		
86	Sec. 1, T. 14 N., R. 11 E., 2 miles northwest of Greyhound.	Warm	4	do		
87	Sec. 2, T. 12 N., R. 13 E., 6 miles east of Cape Horn.	Warm	200	do		
88	Sec. 33, T. 14 N., R. 13 E., 10 miles southwest of Casto.	Warm	3	do		
89	Sec. 15, T. 10 N., R. 12 E., near Stanley	Hot	200	do		2 springs.
90	Sec. 36, T. 11 N., R. 13 E., near mouth of Yankee Fork of Salmon River.	Hot	250	do		5 springs.
91	Sec. 20, T. 11 N., R. 14 E., 4 miles east of mouth of Yankee Fork of Salmon River.	Hot	200	do		10 springs.
92	Secs. 22 and 27, T. 11 N., R. 14 E., 6 miles east of mouth of Yankee Fork of Salmon River.	Warm	5	do		
93	Sec. 19, T. 11 N., R. 15 E., on Salmon River 1 mile upstream from Sunbeam Dam.	168	200	do		6 springs.
94	Sec. 3, T. 10 N., R. 13 E., 2 miles south of mouth of Yankee Fork of Salmon River.	Warm	400	do		5 springs.
95	Robinson Bar Ranch Hot Springs, in sec. 34, T. 11 N., R. 15 E., at mouth of Warm Spring Creek.	130	40	do		3 springs. Resort. Also other springs along Warm Spring Creek.
96	T. 10 N., R. 15 E., near mouth of Hot Creek.	134–147		Limestone (Carboniferous)		Several springs along line 0.5 mile long.
97	Loon Creek Hot Springs, in T. 11 N., R. 15 E.	115–136	700	Faulted greenstone		20 springs. Water smells strongly of H_2S.
98	T. 10 N., R. 15 E., near head of Loon Creek	Hot		Granite		Several springs.
99	Sec. 19, T. 10 N., R. 16 E., on Slate Creek 6 miles upstream from its mouth.	Hot	200	Lava (Tertiary) overlying slate (Carboniferous).		10 springs in 2-acre area.
100	Sullivan Hot Springs, in sec. 27, T. 11 N., R. 17 E., on Sullivan Creek 3 miles west of Clayton.	107	5,000	Contact of lava (Tertiary) with limestone (Carboniferous).		Water used locally. Smells strongly of H_2S.
101	Sec. 18, T. 9 N., R. 14 E., on the Salmon River.	105	150	Granite		
102	Pierson Hot Spring, in sec. 27, T. 8 N., R. 14 E.	120	300	do		Resort. Ref. 375.
103	Secs. 30 and 31, T. 8 N., R. 17 E., on East Fork of Salmon River.	70–120	450	Limestone (Carboniferous) near lava.		8 springs.
104	Sec. 6, T. 7 N., R. 17 E., on East Fork of Salmon River.	75–110	300	do		6 springs.
105	Beardsley Hot Springs, in sec. 23, T. 14 N., R. 19 E., on east bank of Salmon River.	123 (max)	1,500	Faulted limestone and quartzite (Paleozoic).		Several springs. Resort.
106	Sulphur Creek Spring, in sec. 26, T. 14 N., R. 21 E., 15 miles northwest of Goldberg.	57	1,500	Paleozoic strata	365	Water used for irrigation.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
			Idaho—Continued			
107	T. 13 N., R. 20 E., on Warm Springs Creek 10 miles southeast of Challis.	Warm	100	Basalt (Tertiary)		Several springs.
108	T. 9 N., R. 27 E., in Little Lost River Valley.	80		Paleozoic strata		Ref. 365.
109	South side of Middle Fork of Boise River, 0.25 mile downstream from mouth of Sheep Creek.	Hot	200	Granite		
110	Sheep Creek Bridge Spring, on Middle Fork of Boise River at Sheep Creek Bridge.	Hot	100	do		
111	Reed Spring, on Sheep Creek near its mouth.	Hot		do		
112	Smith Cabin Springs, on both sides of Middle Fork of Boise River upstream from junction with North Fork.	Hot	900	do		Several springs in 2-acre area.
113	Loftus Spring, on north side of Middle Fork of Boise River downstream from mouth of Loftus Creek.	Hot	100	do		
114	Crevice Spring, on north side of Middle Fork of Boise River downstream from mouth of Vaughn Creek.	Hot	20	do		
115	Vaughn Spring, on south side of Middle Fork of Boise River upstream from mouth of Vaughn Creek.	Hot	200			
116	Ninemeyer Springs, on south side of Middle Fork of Boise River downstream from mouth of Big Five Creek.	Hot	900	do		10 springs.
117	Pool Creek Spring, on north side of Middle Fork of Boise River upstream from mouth of Pool Creek.	Warm	50	do		
118	South side of Middle Fork of Boise River upstream from mouth of Straight Creek.	Hot	180	do		
119	Dutch Frank's Springs, on south side of Middle Fork of Boise River downstream from mouth of Dutch Frank's Creek.	Hot	1,800	do		Many springs in 3-acre area.
120	Granite Creek Springs, on Middle Fork of Boise River, in sec. 4, T. 5 N., R. 9 E., 8 miles east of Narton.	130 (max)	50	do		7 springs.
121	T. 5 N., R. 9 E., on both sides of Middle Fork of Boise River, 0.25 mile upstream from mouth of Granite Creek.	Hot	200	do		About 40 springs in 2-acre area.
122	Sec. 36, T. 6 N., R. 9 E., on south side of Middle Fork of Boise River, 0.5 mile downstream from mouth of Granite Creek.	130 (max)	30			Several springs in 1-acre area. Water used for bathing.
123	Sec. 32, T. 6 N., R. 12 E., 2 miles east of Atlanta.	100-130	50	do		6 springs. Water used for bathing.
124	Sec. 10, T. 3 N., R. 10 E., 0.5 mile northeast of Featherville.	Warm	45	do		Water used for bathing.
125	Sec. 9, T. 3 N., R. 11 E., 7 miles east of Featherville.	Warm	Small	do		
126	Sec. 24, T. 4 N., R. 11 E., on Willow Creek, 10 miles northeast of Featherville.	Hot	45	do		Several springs.
127	Sec. 13, T. 3 N., R. 11 E., on South Fork of Boise River 10 miles east of Featherville.	Hot	30	do		4 springs.
128	Sec. 5, T. 2 N., R. 10 E., 6 miles south of Featherville.	Hot	50	do		12 springs in 5-acre area. Water used for bathing.
129	Sec. 33, T. 3 N., R. 10 E., 4.5 miles south of Featherville.	128	45	do		12 springs in 1 acre area. Water used for bathing. Campground.
130	Sec. 5, T. 1 N., R. 10 E., north of Fishing Falls.	164 (max)		do	144	Several springs. Water used locally. Ref. 138.
131	Hot (Ranch) Springs, in sec. 16, T. 3 S., R. 8 E., 10 miles east of Mountain Home.	103-167	900	Faulted lava		Several springs. Water used for bathing. Refs. 370, 371.
131A	Daugherty's (Lattie's) Hot Spring, 15 miles north of Glenns Ferry.	146	500	do		Water used for bathing and irrigation.
131B	Hot Spring, 1 mile east of King Hill	125	20	do		Also a drilled well. Water used for bathing and irrigation.
132	Sec. 1, T. 4 N., R. 14 E., on Big Smoky Creek 8 miles north of Carrietown.	Warm	10	Granite		
133	Sec. 32, T. 4 N., R. 14 E., on Big Smoky Creek 8 miles northwest of Carrietown.	Hot	20	Granite		About 30 springs.
134	Sec. 18, T. 3 N., R. 13 E., on South Fork of Boise River near mouth of Bear Creek.	Warm	15	do		15 springs.
135	Sec. 30, T. 3 N., R. 14 E., on Little Smoky Creek 8 miles southwest of Carrietown.	Warm	10	do		Ref. 144.
136	Wasewick Hot Springs, in sec. 28, T. 3 N., R. 14 E., 6 miles southwest of Carrietown.	125-150	250	do		About 50 springs. Water used locally. Ref. 375.
137	Wardrop Hot Springs, in sec. 29, T. 1 N., R. 13 E., on Corral Creek 2 miles north of Corral.	Hot	100	Lava (Tertiary)		About 25 springs. Resort.
138	Sec. 14, T. 1 N., R. 15 E., 5 miles north of Blaine.	Warm	15	do		
139	Sec. 34, T. 1 S., R. 13 E., 5 miles south of Corral.	Hot	25	do		20 springs.
140	Russian John Hot Springs, in sec. 33, T. 6 N., R. 16 E., near Wood River 18 miles northwest of Ketchum.	102	50	Lava (Tertiary) overlying Paleozoic strata.		4 springs. Ref. 375.
141	Easly Warm Springs, in sec. 11, T. 5 N., R. 16 E., on south side of Wood River 16 miles northwest of Ketchum.	99	100	do		Do.
142	Guyer Hot Springs, in sec. 15, T. 4 N., R. 17 E., 2.5 miles west of Ketchem.	160	450	Faulted black limestone	376	Several springs. Resort. Deposit of tufa.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
				Idaho—Continued		
143	Sec. 36, T. 4 N., R. 16 E., on Warm Spring Creek 11 miles southwest of Ketchum.	Hot	450	Lava (Tertiary) overlying Paleozoic strata.		6 springs. Water used for bathing. Ref. 144.
144	Clarendon Hot Springs, in sec. 26, T. 3 N., R. 17 E., on Deer Creek 6 miles west of Hailey.	125–150	100	Black limestone (Paleozoic)	376	3 springs. Water used for bathing.
145	Hailey Hot Springs, in sec. 18, T. 2 N., R. 18 E., 2.5 miles southwest of Hailey.	146	50	Slate (Paleozoic)	376	Several springs. Water piped to baths and hotel in Hailey.
146	Lava Creek Hot Spring, in sec. 24, T. 1 S., R. 17 E., near Magic Reservoir.	96	130	Snake River Group (Quaternary overlying rhyolite.)		
147	Condie Hot Springs, in sec. 14, T. 1 S., R. 21 E., near Carey.	124	450	do		2 springs. Water used for bathing and irrigation.
148	Sec. 25, T. 11 N., R. 32 E., 10 miles south of Edie.	80	3,000	Limestone (Carboniferous)		2 springs.
149	Sec. 34, T. 10 N., R. 33 E., 18 miles west of Dubois.	Hot		Lava (Tertiary) overlying limestone (Carboniferous).		
150	Lidy Hot Springs, in sec. 2, T. 9 N., R. 33 E., 16 miles west of Dubois.	124	300	Faulted rhyolite overlying carboniferous strata.		Several springs. Water used for bathing and irrigation.
151	Sec. 6, T. 9 N., R. 44 E., near Warm River	Warm	50	Lava (Tertiary)		3 springs.
152	Heise Hot Spring, in sec. 25, T. 4 N., R. 40 E., on South Fork of Snake River at Heise.	120	400	Faulted lava		Resort. Ref. 373.
153	Pincock (Lime Kiln) Hot Spring, in sec. 6, T. 5 N., R. 43 E., 6 miles south of Canyon City.	Hot	65	Limestone (Paleozoic)		Resort.
154	Sec. 29, T. 1 N., R. 43 E., on Fall Creek 4 miles northwest of Irwin.	Warm		Faulted Paleozoic strata		Several springs. Water used locally. Ref. 373.
155	Alpine Hot Springs, in secs. 18 and 19, T. 2 S., R. 46 E., on east side of South Fork of Snake River 5 miles northwest of Alpine.	120–150	25	Limestone (Carboniferous)		2 main and several small springs. Water smells of H_2S. Deposit of tufa. Resort.
156	Secs. 13 and 24, T. 2 S., R. 45 E., on west side of South Fork of Snake River 3 miles southwest of Blowout.	88–144		Faulted limestone (Carboniferous?).		6 springs. Water used for bathing. Refs. 372, 373, 667.
157	Lincoln Valley Warm Springs, in sec. 36, T. 3 S., R. 37 E., 3 miles south of old Fort Hall.	69–87		Limestone (Carboniferous?)		5 springs. Water used locally. Refs. 138, 144.
158	Enterprise, in T. 1 N., R. 3 W	128	3,000	Payette Formation (Tertiary).		Water used for bathing and irrigation. Refs. 364, 371.
159	Given's Hot Springs, in T. 1 S., R. 3 W., on south side of Snake River near mouth of Reynolds Creek.	98	35	Miocene sediments near Tertiary lava.		2 springs. Water used for bathing. Refs. 133, 137, 144.
159A	Toy Ranch, in sec. 29, T. 5 S., R. 1 E	115–120	50	Alluvium		Several springs. Water used for bathing.
160	Sec. 14, T. 6 S., R. 3 E., on Shoofly Creek near Grand View.	Warm	300	Payette Formation (Tertiary).		2 springs. Water used for irrigation. Deposit of tufa.
161	Rosebrier Spring, in sec. 32, T. 6 S., R. 5 E., on Little Valley Creek 10 miles southeast of Comet.	68	Small	Alluvium near fault in Payette Formation (Tertiary).		Also a drilled well. Water used locally. Ref. 368.
162	Sec. 24, T. 7 S., R. 4 E., near head of Little Valley Creek.	99	135	Payette Formation (Tertiary).		Also 5 drilled wells. Water used for irrigation. Ref. 368.
163	Bruneau Hot Spring, in sec. 21, T. 7 S., R. 6 E., near Hot Springs post office on west side of Bruneau Valley.	105	1,200	do		Water used for bathing and irrigation. Refs. 368, 370, 371.
164	Sec. 22, T. 7 S., R. 6 E., in Bruneau Valley	111	35	do		Water used locally. Ref. 368.
165	Trammel's Hot Springs, in sec. 22, T. 7 S., R. 6 E., in Bruneau Valley.	114	1,000	do		Several springs. Water used for bathing and irrigation. Ref. 368.
166	Sec. 35, T. 7 S., R. 6 E., on east bank of Bruneau River.	Warm	Large	do		Ref. 368.
167	Hot Creek Springs, in sec. 3, T. 8 S., R. 6 E., 11 miles south of Bruneau.	94–98.5	1,800	Basalt (Eocene) overlying tuff.		Several springs. Water used for irrigation. Ref. 368.
168	Sec. 3, T. 8 S., R. 6 E., in Bruneau Valley downstream from mouth of Hot Creek.	100		Payette Formation (Tertiary).		Several springs. Water used locally. Ref. 368.
169	Sec. 29, T. 8 S., R. 7 E., 100 yd downstream from Buckaroo diversion dam in Bruneau Valley.	105		do		Ref. 368.
169A	Indian (Bat) Hot Springs, in sec. 33, T. 12 S., R. 7 E., on West Fork of Bruneau River.	145–158	2,000	Basalt (Tertiary) overlying rhyolite.		2 main springs in deep canyon. Water used for bathing. Refs. 148, 377.
169B	Kitty's Hot Hole, 10 miles southwest of Three Creek.	Hot	Small	Basalt (Tertiary)		Water used for bathing. Ref. 148.
170	White Arrow Hot Springs, in sec. 31, T. 4 S., R. 13 E., near Blanche.	149	1,200	Lava (Pliocene)		4 springs. Water used for bathing and irrigation.
171	Blanche Crater Warm Springs, 1.5 miles northeast of White Arrow Hot Springs (no. 170).	80	Small	Lava (Quaternary)		Maintains Soda (Lye) Lake having area of of 3 acres.
172	Tschannen Warm Springs, 2 miles southeast of White Arrow Hot Springs (no. 170).	110	Small	Lava (Pliocene)		Nearby artesian well flows 200 gpm. Water used locally.
173	Sec. 30, T. 8 S., R. 14 E., on island in Salmon Falls Creek near Austin.	130	5	Lake beds (Tertiary) overlying lava.		Water used for bathing.
174	Ring's Hot Spring, in sec. 31, T. 8 S., R. 14 E., on south side of Snake River.	125	200	Faulted lake beds (Miocene)		Forms pool bubbling with odorless gas. Water used locally.
175	Banbury Hot Springs, in sec. 33, T. 8 S., R. 14 E., on south bank of Snake River 4 miles upstream from mouth of Salmon River.	131	600	do		2 springs and flowing drilled well. Ref. 370.
176	Poison Spring, in T. 9 S., R. 13 E., in canyon of Salmon River 8 miles upstream from mouth of river.	Warm	Small	Lava (Tertiary)		Ref. 370.
177	Sec 10, T. 13 S., R. 18 E., on Rock Creek 10 miles south of Stricker.	90	1,300	do		3 springs
178	Artesian City Hot Springs, in sec. 6, T. 12 S., R. 20 E.	100	Small	do		Also several flowing wells discharging 500 gpm. Water used for bathing and irrigation.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Idaho—Continued					
179	Poulton Warm Spring, in sec. 6, T. 13 S., R. 21 E., 9 miles northwest of Oakley.	72		Limestone (Paleozoic)	367	Also flowing wells. Water used locally.
180	Land Spring, in sec. 7, T. 13 S., R. 23 E., 6 miles northeast of Oakley.	60	2,000	Faulted rhyolite (Tertiary)	367	Water used for irrigation.
181	Thoroughbred Springs, in sec. 21, T. 16 S., R. 19 E.	69	200	Miocene strata overlying faulted Paleozoic strata.		Several springs. Water used locally. Ref. 367.
182	Oakley Warm Spring, in sec. 27, T. 14 S., R. 22 E., 5 miles south of Oakley.	114	10	Quartzite (Carboniferous?)	367	Also flowing well. Water used locally.
183	Sec. 6, T. 14 S., R. 25 E., 1 mile southwest of Elba.	Warm		Carboniferous strata		
184	Frazier Hot Spring, in sec. 23, T. 15 S., R. 26 E., 5 miles southwest of Bridge.	204	120	Alluvium near faulted Carboniferous strata.		Also well 400 ft deep. Water used for irrigation.
185	Bridger Hot Spring, in sec. 11, T. 11 S., R. 25 E., 6 miles northeast of Albion.	120	4	Faulted lake beds (Bridger Formation).		Also 3 flowing wells. Water supply for cattle.
186	Sec. 22, T. 11 S., R. 25 E., 4 miles northeast of Albion.	100	3	do		Water supply for cattle.
187	Sec. 19, T. 9 S., R. 28 E., near Lake Walcott.	70	700	do		5 springs.
188	Fall Creek Warm Springs, in sec. 29, T. 9 S., R. 29 E., 8 miles northeast of Yale.	62	9,000	Lake beds (Eocene) faulted against limestone (Carboniferous).		Several springs. Deposit of tufa.
189	Indian Hot Springs, in sec. 19, T. 8 S., R. 31 E., on south side of Snake River.	140	1,000	Faulted limestone (Paleozoic).		Several springs. Water used for bathing. Resort.
190	Lava Hot Springs, in T. 9 S., R. 38 E., on both sides of Portneuf River 2 miles south of Lava.	100–144	4,200	Faulted quartzite (Paleozoic).		Several springs. Water used for bathing. Resort. Ref. 374.
190A	6 miles northwest of McCammon	Warm	Small	Lava (Tertiary)		Water used for bathing.
191	T. 10 S., R. 40 E., on west side of Bear River at south end of Gentile Valley.	125		Lava overlying Paleozoic strata.	362?	5 springs rising in pools. Ref. 144.
191A	Downata Hot Springs, 4 miles southeast of Downey.	112	470	Gravel (Quaternary)		Water used for bathing and irrigation.
192	T. 6 S., R. 42 E., in canyon of Blackfoot River.	82	Small	Limestone and shale (Carboniferous).		Deposit of tufa. Refs. 366, 374.
193	Bear River Soda (Beer) Springs, in T. 9 S., R. 42 E.	76–88		Limestone (Carboniferous)		Several springs, of which the main spring is Steamboat Spring. Resort. Refs. 366, 374, 413, 625, 666.
194	T. 14 S., R. 36 E., 2 miles southwest of Malad.	85		Carboniferous strata		Several springs. Water used locally. Ref. 144.
195	T. 16 S., R. 36 E., 12 miles southeast of Malad.	Warm		do		Do.
196	Bear Lake Hot Springs, near northeast shore of Bear Lake and 16 miles south of Montpelier.	83–134	150	do		3 springs. Resort. Ref. 124.
	Massachusetts (See fig. 3.)					
1	Sand Spring, 2 miles south of Williamstown	76	400	Schist (Precambrian)	137, 378	Water bottled for table use. Also used in manufacture of soft drinks. Refs. 135, 144, 378.
	Montana (See fig. 2.)					
1	Camas Hot Springs, in sec. 3, T. 21 N., R. 24 W.	110–114		Diorite sill in Belt Series (Precambrian).	137, 385	7 springs. Resort. Ref. 391.
2	Sec. 4, T. 21 N., R. 24 W., 1 mile west of Camas.	Warm		Belt Series (Precambrian)	385	Water used locally. Ref. 391.
3	Sec. 9, T. 18 N., R. 25 W., 4 miles south of Paradise.	114	20	do		7 springs. Water used for bathing.
4	Granite (Lolo) Hot Springs, 8 miles southwest of Woodson.	135	25	Granite	137	3 springs. Resort. Refs. 144, 383.
5	Warm Springs Creek, 6 miles north of Garrison.	Warm		Folded Cretaceous strata		Water used locally. Refs. 144, 148.
6	Sun River (Medicine) Hot Springs, on North Fork of Sun River 30 miles by road west of Augusta.	84	500	do		Resort. Refs. 144, 395.
7	Helena Hot Springs, 2 miles west of Helena.	122;141	30	Lower Paleozoic strata	128, 137 409	2 springs. Water used for bathing. Refs. 133, 393.
8	Big Warm Springs, in sec. 24, T. 26 N., R. 25 E., 6 miles south of Lodgepole.	72–86	10,000	Shale and limestone (Cretaceous).		7 springs. Water used locally.
9	Little Warm Springs, in sec. 32, T. 26 N., R. 26 E., 9 miles south of Lodgepole.	Warm	3,500	do		Water used locally.
10	Warm Spring, in sec. 19, T. 17 N., R. 18 E., on Warm Spring Creek 12 miles north of Lewistown.	68	80,000	Faulted Kootenai Formation (Early Cretaceous).		Water used for mining and milling, also for irrigation. Large deposit of tufa. Refs. 141, 379, 397.
11	Sec. 19, T. 12 N., R. 23 E., on Durphy Creek, 3 miles south of Tyler.	71	15,000	Folded Ellis Formation (Jurassic).		8 springs in area of several acres. Water used for irrigation.
12	Medicine Rock (Weeping Child) Hot Springs, on Weeping Child Creek, 15 miles southeast of Hamilton.	Hot	4,500	Granite		Several springs. Resort. Refs. 382, 383.
13	Sec. 31, T. 1 S., R. 22 W., 4 miles east of Slate Creek station.	Warm	330	do		5 springs.
14	Gallogly (Ross' Hole, Medicine) Hot Springs, in sec. 15, T. 1 S., R. 19 W., 4 miles south of Camp Creek station.	110–125	150	do		3 springs. Resort. Ref. 144.
15	Warm Springs, near Warm Springs railroad station, 10 miles northeast of Anaconda.	Warm		Tertiary strata overlying granite.	137	Resort. Ref. 144.
16	Anaconda Hot Springs, 3 miles east of Anaconda.	Warm		Travertine overlying limestone (Jurassic).		Several springs. Water used locally. Refs. 388, 395.
17	Gregson Hot Springs, 15 miles west of Butte.			Lava (Tertiary) overlying granite.		Several springs. Water used to heat greenhouse. Refs. 144, 395.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Montana—Continued					
18	Alhambra Hot Springs, 17 miles south of Helena.	90–134		Granite	137	22 springs. Resort. Refs. 133, 393.
19	Boulder Hot Springs, 3 miles southeast of Boulder.	125–187	Large	Fissured granite	133, 137, 393	Many springs. Resort. Refs. 109, 395.
20	Pipestone Springs, 20 miles southeast of Butte.	Hot		Granite	137	Several springs. Resort. Refs. 393, 395.
21	Bedford Springs, on north side of Indian Creek 3.5 miles northwest of Townsend.	74	1,400	Gravel overlying Tertiary strata.	384, 387	3 main and several other springs. Water used for irrigation.
22	Kimpton (Warner) Warm Springs, on branch of Crow Creek, 7 miles west of Toston.	65	100	Lake beds (Miocene)	384, 387	2 springs. Water used locally. Ref. 144.
22A	Big Spring, on east bank of Missouri River 4 miles southeast of Toston.	59	29,000	Madison Limestone (Mississippian).	384, 387	Water used for irrigation.
23	Plunket's (Mockel, Nave's Warm) Spring, at head of Warm Creek, 10 miles southwest of Toston.	62	4,000	do	384, 387	Several springs. Water used for irrigation.
24	White Sulphur (Brewer's) Springs	95–125	500	Lake beds (Miocene) overlying Belt Series (Precambrian).	128, 133, 380, 392, 396.	9 springs. Resort.
25	Big Hole Hot Springs, at Jackson	132 (max)	1,500	Tertiary strata overlying Belt Series (Precambrian).		About 100 springs. Resort. Refs. 144, 386.
26	Elkhorn Hot Springs, in sec. 29, T. 4 S., R. 12 W., on Miller Creek 6 miles north of Polaris.	120–150	110	Granite		7 springs. Resort.
27	Ziegler Hot Springs, near Apex	Hot		Folded Cretaceous strata		Several springs. Water used locally. Ref. 391.
28	Lovell Springs, in sec. 21, T. 8 S., R. 9 W., 9 miles southwest of Dillon.	72	1,125	Lava (Tertiary)		4 springs. Water used locally.
29	Brown (Ryan Canyon) Springs, in sec. 30, T. 8 S., R. 9 W., 11 miles southwest of Dillon.	72	360	Lava (Tertiary) overlying limestone (Carboniferous).		6 springs. Water used locally.
30	Barkel's Hot Springs, at Silverstar	Hot	50	Lake beds (Tertiary) overlying granite.		4 springs. Water used for bathing.
31	Clark's Warm (Potosi Hot) Springs, on south branch of Willow Creek, 5 miles south of Pony.	100–120	550	Granite		About 10 springs. Refs. 133, 389.
32	Hapgood (Norris) Hot Springs, on Hot Spring Creek near Norris.	80–122	50	Syenite		5 springs. Water used for bathing. Refs. 138, 388, 389.
33	Puller's Hot Springs, on upper Ruby Creek, 10 miles northwest of Virginia City.	95; 108	150	Schist and gneiss (Precambrian).		2 springs. Resort. Refs. 133, 144.
34	Sec. 18, T. 12 S., R. 1 E., 3 miles southwest of Cliff Lake.	Warm	100	Lava (Quaternary)		
35	Bozeman (Ferris, Matthews) Hot Springs, on West Gallatin River, 7 miles west of Bozeman.	137	250	Tertiary strata	128, 133, 137, 144, 380.	Resort. Ref. 389.
36	Hunter's Hot Springs, 20 miles northeast of Livingston.	148–168	1,500	Faulted Livingston Formation (Upper Cretaceous and Paleocene).	128?, 133, 137, 409?	3 groups, totaling about 25 individual springs. Deposit of gypsum. Resort. Refs. 109, 389, 394, 395.
37	Emigrant Gulch Warm Springs (Chico Spring), on Emigrant Creek near Chico.	102	240	Lava (Quaternary) overlying Precambrian rocks.	128, 144, 409	Water used for bathing.
38	Corwin Hot Springs, in sec. 25, T. 8 S., R. 7 E.	[1] 120 (max)		Lava overlying schist (Precambrian).		Several springs. Resort. Ref. 391.
39	Bear Creek Springs, in sec. 19, T. 9 S., R. 9 E., 3 miles south of Gardiner.	90	30	Lava (Quaternary) overlying Precambrian rocks.		2 springs. Water used locally.
40	Anderson's Spring, in sec. 29, T. 3 S., R. 13 E., near Boulder Creek 3 miles southwest of Hubble.	70	90	Limestone (Cretaceous)		Water used for bathing. Ref. 390.
	Nevada (See fig. 8.)					
1	T. 46 N., R. 27 E., 12 miles west of Pine Forest Range.	108	Small	Lava (Tertiary)		Ref. 441.
2	Bog Ranch Hot Springs, on north side of Thousand Creek Valley 6 miles southwest of Denio, Oregon.	130; 190	20	Intrusive granite (Jurassic)		2 springs. Refs. 144, 403, 441.
3	T. 47 N., R. 31 E., south of Steens Mountain.	178		do		2 springs. Refs. 144, 441.
4	T. 45 N., R. 32 E., 12 miles north of Mason's Crossing of Quinn River.	118	Small	do		
5	T. 45 N., R. 32 E., 11 miles north of Quinn River (town).	130	150	do		Deposit of siliceous sinter. Ref. 440, also field notes by G. A. Waring.
6	T. 45 N., R. 33 E., on west side of King River valley.	76; 80		Lava (upper Tertiary)		2 springs. Water used locally. Refs. 144, 441.
6A	Cordero Mine	118; 138		do		2 pumped wells, 550 and 580 ft deep. Water used at mine. Ref. 451.
7	T. 45 N., R. 41 E., at head of North Fork of Little Humboldt River.	Hot		Lava (Tertiary)		Ref. 144.
8	T. 40 N., R. 25 E., at Soldier Meadows, 15 miles south of old Camp McGarry.	Hot		do		Several springs. Ref. 144.
9	T. 40 N., R. 28 E., west of sink of Quinn River, at west edge of Black Rock Desert.	60		Alluvium near lava		2 springs. Water supply for prospectors. Refs. 144, 418.
10	T. 43 N., R. 31 E., 7 miles west of Mason's Crossing of Quinn River.	155		Lava (upper Tertiary)		Several springs. Ref. 144; also field notes by G. A. Waring.
10A	Near south bank of Quinn River	Warm	Small	Alluvium		Data from field notes by G. A. Waring.
11	T. 41 N., R. 41 E., on bank of Little Humboldt River, 12 miles southeast of Paradise Valley post office.	130		do		
11A	Near North and South Forks of Little Humboldt River, 25 miles east of Paradise Valley.	Hot	Small	do		
12	Double Hot Springs, in T. 37 N., R. 24 E., on west flank of Black Rock Range.	165–191	5	Faulted(?) lava (Tertiary) overlying granite.		Several springs. Refs. 144, 418, 451.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Nevada—Continued					
12A	Near base of west flank of Black Rock Range.	130–150	3	Faulted(?) lava (Tertiary) overlying granite.		3 springs, 1-2 miles apart. Ref. 451.
13	T. 37 N., R. 25 E., on southeast side of Black Rock Range.	Hot		do		Several springs. Ref. 441.
14	T. 37 N., R. 26 E., in arm of Black Rock Desert.	Hot		Alluvium near lava		Ref. 441.
15	Van Riper, in T. 36 N., R. 24 E., on southwest side of Black Rock Range.	145	50	Lava (Tertiary) overlying granite.		3 springs. Ref. 144.
16	T. 36 N., R. 25 E., at south end of Black Rock Range, 10 miles southeast of Division Peak.	Hot		Lava (Tertiary)		Several springs. Ref. 144.
17	Secs. 16, 21, 24, 34, T. 36 N., R. 26 E., on west border of Black Rock Desert.	Hot		Alluvium (Quaternary) near lava (Tertiary).		Several springs. Refs. 144, 438.
18	2 miles north of Winnemucca	Hot	Small	Mesozoic strata		Water used locally. Ref. 386.
19	Golconda Hot Springs, in T. 36 N., R. 40 E.	120–150	250	Alluvium		About 12 springs. Resort. Refs. 109, 144, 422, 437.
19A	Blossom Hot Spring, in sec. 10, T. 35 N., R. 43 E., 8 miles north of Valmy.	107	70	do		Rises in broad deep pool. Water supply for cattle.
19B, 19C, 19D, 19E, 19F, 19G	Humboldt River Valley	Warm	Small	do		Data from field notes by G. A. Waring.
20	T. 39 N., R. 40 E., at head of South Fork of Little Humboldt River.	Hot	Small	Lava (Tertiary)		Ref. 144.
21	Sec. 30, T. 45 N., R. 54 E., 5 miles southeast of Mountain City.	104–106	20	Limestone (Paleozoic)		4 springs. Water used for bathing.
22	Sec. 23, T. 46 N., R, 56 E., 15 miles east of Mountain City.	104	55	Limestone (Paleozoic)		Several springs. Water used locally.
22A	1.5 miles north of Contact	133	5	Lava (Tertiary)		
22B	Mineral (San Jacinto) Spring	78–126	1,200	Lake beds (Tertiary) overlying Paleozoic strata.		Several springs and shallow wells. Water used for bathing.
23	Sec. 22, T. 47 N., R. 68 E., on west side of Goose Creek.	57	850	Cherty limestone (Paleozoic).		Water used locally.
24	Nile Spring, in sec. 30, T. 47 N., R. 70 E., on east side of Goose Creek.	106	6	Alluvium		Forms boggy area at edge of Goose Creek Meadow.
25	Gamble's Hole, in sec. 10, T. 46 N., R. 69 E., on east side of Goose Creek.	103	8	do		Do.
26	Sec. 26, T. 46 N., R. 69 E., at head of main fork of Spring Creek.	62	200	Rhyolite (Tertiary)		Several springs in 1-acre area.
27	T. 41 N., R. 69 E., at south end of Thousand Springs Valley.	Boiling		Carboniferous strata		Ref. 144.
28	Hot Creek mining district in T. 39 N., R. 60 E., on Marys River 15 miles north of Deeth.	110–122	30	do		4 springs. Water used for sheep dipping. Large mound of tufa. Refs. 138, 430; also field notes by G. A. Waring.
29	Cress Ranch, in sec. 14, T. 38 N., R. 59 E., 8 miles north of Deeth.	Hot	Small	Near lava (Tertiary)		Data from field notes by G. A. Waring.
30	Sec. 21, T. 38 N., R. 62 E., in Emigrant Canyon, 4.2 miles north of Wells.	98	50	Faulted quartzite (Carboniferous).		Water contains much H_2S. Used for bathing. Ref. 144, also field notes by G. A. Waring.
30A	5.5 miles north of Wells	113–122	10	Carboniferous strata		3 main springs. Large deposit of tufa. Water supply for cattle. Data from field notes by G. A. Waring.
30B	Metropolis	102	800	Limestone (Carboniferous)		Several springs in canyon. Water used for irrigation. Data from field notes by G. A. Waring.
30C	Johnson Ranch	73	30	Lava (Tertiary)		Water used for domestic supply and for irrigation. Ref. 451.
30D	H. D. Ranch	142–154	600	do		Many springs. Deposit of tufa. Ref. 451.
31	Hot Sulphur Springs, T. 33 N., R. 53 E., 9 miles northwest of Carlin.	98	15	Quartzite (Carboniferous)		3 springs. Water used for bathing. Refs. 138, 144; also field notes by G. A. Waring.
32	Elko Hot Springs, in T. 34 N., R. 55 E., 1 mile west of Elko.	192		Carboniferous strata	137	Several springs. Water used for bathing. Ref. 138.
33	T. 33 N., R. 58 E., 8 miles southwest of Fort Halleck.	Warm		Alluvium near lava		Several springs. Water used locally. Ref. 144.
34	T. 34 N., R. 62 E., near Warm Creek in Independence Valley	Warm	250	Alluvium (Quaternary) near Carboniferous strata.		Water used locally. Refs. 138, 421.
34A	Near east side of Ruby Lake	Hot	Small	Alluvium		Several springs. Refs. 415, 418, 424.
35	Miller's Hot Springs, in T. 30 N., R. 59 E., at northeast end of Franklin Lake.	170		Alluvium (Quaternary) near lava.		Several springs. Refs. 144, 418.
35A	Hill's Warm Spring, in sec. 18, T. 44 N., R. 20 E., 10 miles north of Vya.	83	10	Alluvium		Water irrigates meadow.
35B	Hill's Spring, in sec. 11, T. 43 N., R. 19 E., 5 miles north of Vya.	66	8	do		Do.
35C	Twin Springs, in sec. 4, T. 42 N., R. 19 E., at Vya.	70	200	Lake beds (Pliocene?)		Water used for irrigation.
36	T. 38 N., R. 18 E., at south end of Surprise Valley.	Hot		Lava (Tertiary)		Ref. 441.
37	Wards' (Fly Ranch) Hot Springs, in T. 34 N., R. 23 E., at northwest end of Alkali Flat and 5 miles northeast of Granite Peak.	69 to boiling		Alluvium near granite	128	Many springs in 75-acre area. Largest hot springs in northwestern part of Nevada. Water used for irrigation. Sandy mounds and deposits of tufa. Refs. 144, 409, 418.
38	Gerlach Hot Springs, 1 mile northwest of Gerlach.	188–194		do	144, 409	Many springs. Water used for bathing. Ref. 436.
39	Mud Springs, 2 miles west of Gerlach	Hot		do		Several springs. Ref. 441.
40	Deep Hole Spring, in sec. 25, T. 33 N., R. 22 E., at north end of Smoke Creek Desert.	62	30	Lake beds (Quaternary)		Also several flowing wells. Water used for irrigation. Ref. 441.
41	Wall Spring, in sec. 3, T. 32 N., R. 21 E., on northwest side of Smoke Creek Desert.	Warm		do		Do.
42	Buffalo Spring, in T. 31 N., R. 20 E., on west side of Smoke Creek Desert.	Warm		do		Ref. 441.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Nevada—Continued					
43	Buckbrush Spring, in T. 29 N., R. 19 E., on west side of Smoke Creek Desert.	Warm		Lake beds (Quaternary)		Ref. 441.
44	Rotten Egg Spring, in T. 29 N., R. 19 E., on southwest side of Smoke Creek Desert.	92	10	do		Water smells strongly of H_2S. Ref. 441.
45	Round Hole Spring, in sec. 31, T. 29 N., R. 19 E., on southwest side of Smoke Creek Desert.	Warm		do		Also several flowing wells. Ref. 441.
46	Ross Spring, in T. 28 N., R. 20 E., at south end of Smoke Creek Desert.	Hot		Lava (Tertiary)		Refs. 144, 441.
47	T. 28 N., R. 21 E., near north end of Pyramid Lake.	Hot		do		Several springs. Refs. 144, 441.
48	Fish Spring, in T. 26 N., R. 19 E., 10 miles northwest of Pyramid railroad station.	Warm		do		Ref. 441.
49	T. 26 N., R. 20 E., on northwest side of Pyramid Lake.	206–208		Faulted lava (Tertiary)		Several springs. Refs. 144, 441.
50	T. 27 N., R. 23 E., on northwest shore of Winnemucca Lake.	Warm		Lava (Tertiary)		Several springs. Ref. 441.
51	T. 26 N., R. 23 E., on west shore of Winnemucca Lake.	Warm		do		Do.
52	T. 24 N., R. 22 E., on Anaho Island in Pyramid Lake.	120		do		Several springs.
53	Cottonwood Spring, in sec. 26, T. 23 N., R. 21 E., in Warm Spring Valley 3 miles south of Dewey.	Warm		Lava (Tertiary) overlying granite.		Water used locally.
54	T. 21 N., R. 24 E., in Dead Ox Canyon 12 miles south of Dixon.	Warm		Lava (Tertiary)		
55	Lawton Hot Springs, 6 miles west of Reno.	120	250	Faulted granite	137	2 main springs. Water used for bathing. Resort.
55A	Moana Springs, 2 miles south of Reno	100–200		Metamorphic rocks		Wells. Water used for bathing. Ref. 451.
55B	Huffaker Springs, 5 miles southeast of Moana bathing resort.	79–81	10	Alluvium		Several springs on bank of creek. Ref. 451.
55C	Zoleggi Springs, 3 miles southwest of Huffaker Springs (no. 55B).	103	125	do		Several springs. Ref. 451.
55D	Da Monte Springs, 1.5 miles east of Zoleggi Springs.	130	40	do		On bank of creek. Ref. 451.
55E	Mount Rose, 10 miles south of Reno	Hot		Metamorphic rocks		Erupting wells. Resort. Ref. 451.
55F	Reno Hot Springs, 10.5 miles south of Reno.	Hot		do		Drilled wells. Resort. Ref. 451.
56	Steamboat Springs, in sec. 33, T. 18 N., R. 20 E., 11 miles south of Reno.	167–203	300	Granite	20, 128, 137, 427, 452, 562.	Many springs, including 3 small geysers. Resort and sanitarium. Refs. 400, 401, 404–406, 413, 417, 418, 420, 424, 426, 436, 448–450, 453–456.
57	Bowers Mansion (Franktown Hot) Spring; 10 miles north of Carson City.	115–118	75	Faulted Granite	137	Resort. Ref. 144.
58	T. 19 N., R. 23 E., 10 miles southwest of Wadsworth.	73		Lava (Tertiary)		Water used locally Refs. 144, 418.
59	Carson (Swift's, Shaw's) Hot Springs, 2 miles north of Carson City.	120	75	Metamorphic rocks	137	Water used for bathing. Resort. Ref. 144.
59A	Nevada State Prison	Warm		Lake beds (Pleistocene)		Water used locally.
60	Walley's (Genoa) Hot Springs, 6 miles northwest of Minden.	136–160	Large	Faulted granite	133, 137	Many springs. Resort. Refs. 125, 144, 428.
61	Hind's Hot Springs, in sec. 16, T. 12 N., R. 23 E., near Simpson.	60–143	550	Alluvium overlying granite		Several springs. Water used for irrigation. Resort. Refs. 144, 429.
62	Wabuska Springs, in T. 15 N., R. 25 E., 1 mile north of Wabuska.	138–162		Lava (Tertiary) overlying granite(?).		Several springs. Water used locally. Ref. 144.
63	Butte Spring, in T. 33 N., R. 26 E., at north end of Hot Springs Butte, 25 miles southwest of Sulphur.	182	20	Granite		Refs. 144, 441.
63A	Near Humboldt River, 2 miles north of Mill City.	Warm	Small	Alluvium		Several springs.
64	Leach's (Pleasant Valley) Hot Springs in sec. 35, T. 32 N., R. 38 E., in Grass Valley 25 miles south of Winnemucca.	158–202	200	Alluvium overlying Mesozoic strata.		Several springs. Water used locally. Deposit of siliceous sinter. Ref. 424; also field notes by G. A. Waring.
65	Guthrie (Nelson) Springs, in sec. 36, T. 32 N., R. 38 E., 25 miles south of Winnemucca.	139–204	250	Alluvium near basalt (Quaternary).	412	8 pools in 1-acre area; also several other springs. Water is sulfurous. Used for irrigation. Deposits of tufa and siliceous sinter. Ref. 144 and field notes by G. A. Waring.
66	Kyle's Hot Springs, in sec. 2, T. 39 N., R. 36 E., 25 miles southeast of Humboldt.	100–160	Small	Alluvium		Several springs. Deposit of sinter. Former resort. Ref. 144.
66A	Miller Ranch	58–61	900	do		Several springs. Water used for irrigation. Data from field notes by G. A. Waring.
67	Sec. 1, T. 25 N., R. 36 E., near north end of Salt Marsh (Osobb) Valley.	Hot		Contact of Mesozoic strata with underlying granite.		Ref. 438.
68	Sou (Gilbert's) Hot Springs, in sec. 29, T. 26 N., R. 38 E., near north end of Salt Marsh (Osobb) Valley.	160–185		Faulted(?) lava (Tertiary)		Several springs issuing from tufa mounds in 12-acre area. Refs. 144, 418, 438, 442.
69	Cone Spring, in sec. 26, T. 25 N., R. 38 E., in Salt Marsh (Osobb) Valley.	125	Small	Lava (Tertiary)		
	Sec. 35, T. 25 N., R. 38 E., 0.25 mile from Cone Spring, in Salt Marsh (Osobb) Valley.					
70	T. 24 N., R. 36 E., on northwest side of Salt Marsh (Osobb) Valley.	Warm	Small	Lava (Tertiary) overlying granite.		Ref. 441.
71	T. 23 N., R. 35 E., on northeast side of Pah Ute Mountains.	Hot	Small	Alluvium near granite		Several springs.
71A	5 miles south-southwest of spring No. 71	Warm	Small	Granite		
72	Springer's (Brady's, Fernley) Hot Springs, in sec. 12, T. 22 N., R. 26 E., on U.S. Highway 40.	158–209	50	Lake beds (Quaternary) near lava (Tertiary).	409	Several springs. Deposit of siliceous sinter. Water used for bathing. Also as water supply for auto station.
73	Eagle Salt Works Springs, in T. 20 N., R. 27 E., 15 miles northwest of Fallon.			Alluvium		Several springs. Water used locally.
74	Borax Spring, in T. 17 N., R. 30 E., 3 miles east of South Carson Lake.	178		Alluvium near lava (late Tertiary).		Ref. 144.
74A	Lee Springs, 18 miles south of Fallon	172	25	do		Deposit of siliceous sinter. Also a well. Ref. 451.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
				Nevada—Continued		
75	Sec. 6, T. 16 N., R. 32 E., 20 miles southeast of Fallon.	Hot		Lava (Tertiary)		Several springs. Water smells of H_2S. Ref. 144.
76	Izzenhood Ranch Springs, in T. 36 N., R. 45 E., 25 miles north of Battle Mountain.	83	1,000	do		Water level lowered 4 ft by trenching, thus doubling original discharge. Water used for irrigation. Ref. 425.
77	White Rock Spring, in sec. 8, T. 33 N., R. 47 E., 2 miles west of Rock Creek.	Warm		do		Water used locally. Refs. 144, 434.
77A	Beowawe Geysers, in sec. 5, T. 31 N., R. 48 E., in Whirlwind Valley 8 miles west of Beowawe.	120 to boiling	100	Faulted basalt (Tertiary)	435, 562	About 50 springs and mud pools on hillside tufa terrace 0.75 mile long, also 3 springs in nearby lowland. 2 or 3 springs show true geyser action, 1 spouting to height of 30 ft. Refs. 410, 414, 434, 435.
78	Sec. 24, T. 29 N., R. 41 E., in Buffalo Valley 25 miles southwest of Battle Mountain (town).	130	5	Lava (Tertiary)	446	Several springs. Ref. 438.
79	Mound Spring, in sec. 7, T. 28 N., R. 44 E., in Reese River valley 25 miles south of Battle Mountain (town).	110	3	do		Water used for roadside watering.
80	Sec. 23, T. 27 N., R. 43 E., 1 mile north of Hot Spring Ranch in Reese River valley.	124	450	do	446	Several springs. Water used for irrigation. Ref. 418.
81	Sec. 26, T. 27 N., R. 43 E., at Hot Spring Ranch.	122	50	do	446	Several springs. Water used for domestic purposes and irrigation. Ref. 418.
82	T. 27 N., R. 47 E., 10 miles south of Lander.	Hot		Lava intrusive (Tertiary) in Carboniferous strata.		Water used locally. Refs. 138, 435.
83	T. 22 N., R. 47 E., near north end of Grass Valley.	181		Devonian strata		Water used locally. Refs. 144, 424.
84	T. 18 N., R. 39 E., in Smith Creek valley 6 miles north of Hot Springs.	Warm	Small	Lava (Tertiary)		Water used locally. Refs. 128, 144, 409, 441.
85	Sec. 25, T. 17 N., R. 40 E., on west side of Smith Creek valley.	Hot		do		Several springs. Ref. 144.
86	Spencer Hot Springs, in T. 17 N., R. 46 E., 18 miles southeast of Austin.	117–144	6	do	432	Several springs. Water used locally. Refs. 433, 447.
87	Sec. 14, T. 16 N., R. 45 E., 20 miles southeast of Austin.	Hot	5	do		7 springs. Water used for bathing.
88	Horseshoe Ranch Springs, 1 mile northeast of Beowawe.	125–132	30	Faulted lava (Tertiary)		2 springs. Water used for bathing and irrigation.
88A	Sec. 2, T. 29 N., R. 48 E., in Crescent Valley 12 miles south of Beowawe.	122	40	Lava (Tertiary) overlying Paleozoic strata.		2 springs. Water supply for cattle.
89	Sec. 12, T. 28 N., R. 52 E., at head of Hot Creek, 14 miles north of Mineral.	84	5,900	Lake beds (Pliocene) overlying Paleozoic strata.		6 springs. Water used for irrigation.
90	Carlotti Ranch Springs, in sec. 24, T. 28 N., R. 52 E., 10 miles north of Mineral.	95; 102	100	do		2 springs, 0.25 mile apart. Water used for irrigation.
99A	Bruffey's (Mineral Hill) Hot Springs, in sec. 14, T. 27 N., R. 52 E., 7 miles northeast of Mineral.	108–152	50	do		6 springs. Water used for domestic purposes and irrigation. Ref. 144.
91	Flynn Ranch Springs, in sec. 5, T. 25 N., R. 53 E., in Diamond Valley.	69–78	10	Alluvium		Deep pool and minor springs. Water used for irrigation.
91A	Siri Ranch Spring, in sec. 6, T. 24 N., R. 53 E., in Diamond Valley.	87	300	do		Water used for irrigation.
91B	Sadler (Big Shipley) Springs, in sec. 23, T. 24 N., 52 E., in Diamond Valley.	103–106	5,000	Alluvium near faulted Paleozoic strata.		Several springs. Water used for irrigation. Refs. 138, 144.
91C	Sulphur Springs, in sec. 36, T. 23 N., R. 52 E., on Sulphur Springs Ranch in Diamond Valley.	74	20	do		2 main springs. Water used for irrigation.
91D	Jacobson Ranch Springs, on east side of Diamond Valley.	71–75	900	do		Several springs. Water used for irrigation.
92	Sec. 15, T. 24 N., R. 47 E., on west side of Grass Valley.	Hot	Small	do		Several springs. Water supply for cattle.
93	Sec. 33, T. 24 N., R. 48 E., on east side of Grass Valley.	Hot	Small	do		Several springs.
93A	Bartine Hot Springs, in sec. 5, T. 19 N., R. 50 E., in Antelope Valley 35 miles west of Eureka.	105; 108	10	Lake beds (Tertiary) near faulted Tertiary strata.		2 springs issuing from large mound of tufa. Also a flowing well. Water used locally.
93B	Clobe Hot Spring, in sec. 28, T. 18 N., R. 50 E., in Antelope Valley, 45 miles southwest of Eureka.	142	100	Alluvium near hills of faulted lava.		Water supply for cattle.
93C	Sara Ranch Springs, in sec. 7, T. 16 N., R. 53 E., at head of Fish Creek.	66	4,000	Alluvium		About 20 deep pools in area 0.5 mile in diameter. Water used for irrigation.
94	Collar and Elbow Spring, in sec. 27, T. 26 N., R. 65 E., near north end of Steptoe Valley.	92	20	do	406, 408	Deposit of tufa.
95	Cherry Creek (Young's) Hot Springs, in T. 23 N., R. 63 E., 1.2 miles southwest of Cherry Creek (town) in Steptoe Valley.	118–135	40	Alluvium near Paleozoic strata.	406, 408	3 springs. Water used for bathing.
96	Shellbourne Hot Springs, in T. 23 N., R. 63 E., about 100 ft from Cherry Creek (Young's) Hot Springs (No. 95).	124; 135		do	408	2 springs. Water used for bathing and irrigation.
97	Borchert John Spring, in sec. 16, T. 22 N., R. 63 E., in Steptoe Valley.	66	800	Talus deposit	408	Water used for irrigation.
98	Monte Neva (Goodrich, Melvin) Hot Springs, in sec. 24, T. 21 N., R. 63 E., 1 mile northwest of Warm Springs railroad station in Steptoe Valley.	173–193	625	Alluvium near Paleozoic strata.	406, 408	6 springs issuing from mound of siliceous sinter.
99	T. 21 N., R. 70 E., at east base of Kern Mountains.	Warm		Faulted Paleozoic strata		Ref. 138.
100	Sec. 5, T. 19 N., R. 63 E., 10 miles northwest of McGill.	58–76	200	Carboniferous strata	408	Several springs. Water used for irrigation.
101	McGill Warm Springs, in sec. 21, T. 18 N., [illegible] 64 E., 0.75 mile west of McGill.	76–84	450	Alluvium near Paleozoic strata.	406, 408	3 main springs. Water used for irrigation.
102	[illegible]m Spring, in sec. 10, T. 16 N., R. [illegible], 1.5 miles northeast of Ely.	85	23	do	406	Water used for bathing. Ref. 408.
102A	Moore's Ranch Springs, in T. 23 N., R. 56 E., in Newark Valley.	65–70	200	Alluvium		Several springs. Water used for irrigation.
103	Big Blue Spring, in sec. 23, T. 14 N., R. 56 E., near the north end of White Pine Valley.	Warm		Paleozoic strata	144	Water used for bathing.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
				Nevada—Continued		
103A	Williams Hot Springs, in sec. 33, T. 13 N., R. 60 E., 12 miles northwest of Preston.	124; 128	185	Alluvium		2 springs. Water used for irrigation. Ref. 431.
104	Preston Springs, in sec. 1, T., 12 N., R. 61 E.	72	5,700	Alluvium near Paleozoic strata.		Several springs. Water used for domestic purposes and irrigation. Refs. 407, 421, 431.
105	Lund Spring, in sec. 33, T. 12 N., R. 62 E.	66	2,400	do		Water supply for town. Also used for irrigation. Refs. 407, 421, 431.
106	Warm Sulphur Springs, in T. 11 N., R. 65 E., at head of Warm Creek.	Warm	972	Paleozoic strata		Several springs. Water used for irrigation Refs. 138, 144, 421.
107	Big Spring, in T. 11 N., R. 69 E., in Snake Valley, 15 miles south of Baker.	64	8,000, 12,000	Limestone (Cambrian)		Water used for irrigation. Ref. 141.
107A	Sec. 30, T. 10 N., R. 70 E., at head of Big Springs Creek.	Warm	2,000	Alluvium		Water used for irrigation.
108	Double Spring, in T. 13 N., R. 29 E., 3 miles north of Walker Lake.	Warm		Lava (Tertiary)		Refs. 144, 441.
109	Sec. 4, T. 7 N., R. 27 E., on East Walker River, 20 miles west of Hawthorne.	Hot		Granite near lava		Several springs. Water used for bathing. State reserve.
110	T. 6 N., R. 35 E., at Sodaville	80–101	100	Alluvium		Several springs. Water used locally. Refs. 419, 423.
111	Waterworks Springs, in sec. 22, T. 2 S., R. 39 E., at Silver Peak.	69–118	500	Lava (Tertiary)	432	11 Springs. Water supply for town. Refs. 411, 444, 445.
112	Alkali Spring, in sec. 26, T. 1 S., R. 41 E., 11 miles northwest of Goldfield.	120–140	50	Alluvium near Paleozoic strata.	399, 432, 439	Deposit of tufa.
113	Wedell Springs, in sec. 7. T. 12 N., R. 34 E., 12 miles southeast of Rawhide.	129; 144	60	Alluvium overlying lava (Tertiary).		2 main springs. Water used locally. Refs. 138, 144.
114	T. 14 N., R. 43 E., 1 mile east of McLeod's Ranch in Big Smoky Valley.	Hot		Alluvium near Paleozoic strata.		Issues from large mound. Ref. 432.
115	Gendron Spring, in T. 14 N., R. 43 E., near Millett in Big Smoky Valley.	61	10	do	432	Water used locally.
116	Charnock (Big Blue) Springs, in T. 13 N., R. 44 E., near Charnock Ranch.	80	450	Alluvium overlying lava (Tertiary).		Several springs issuing from large mound. Water used for irrigation. Ref. 432.
117	Sec. 14, T. 11 N., R. 42 E., in Big Smoky Valley, 14 miles south of Millett.	Boiling	600	Faulted lava (Tertiary)		Water used locally. Refs. 144, 432.
118	Darrough Hot Springs, in sec. 17, T. 11 N., R. 43 E., on Darrough Ranch in Big Smoky Valley.	160–207	200	Alluvium near Paleozoic strata.	432	Several springs. Resort. Ref. 433.
119	Sec. 1, T. 14 N., R. 47 E., 2 miles southeast of Potts.	Warm		Lava (Tertiary)		Several springs. Water used locally.
120	Diana's Punch Bowl, in sec. 22, T. 14 N., R. 47 E., 5 miles south of Potts.	Hot	Small	Alluvium (Quaternary) near lava (Tertiary).		
121	Fish Springs, in secs. 26 and 35, T. 11 N., R. 49 E., in Fish Creek valley.	Warm		Lava (Tertiary)		Several springs. Water used locally. Ref. 144.
122	Sec. 32, T. 13 N., R. 56 E., 5 miles north of Duckwater.	Warm	Large	Alluvium		Several springs. Water used for irrigation.
123	Indian Springs, in T. 7 N., R. 42 E., near San Antonio.	Warm		Lava (Tertiary) overlying Paleozoic strata.		3 springs. Water used locally. Ref. 138.
124	T. 7 N., R. 51 E., on Hot Creek 8 miles northeast of Tybo.	Warm		do		Several springs issuing from terrace of tufa.
125	T. 4 N., R. 50 E., near south end of Hot Creek valley.	Boiling		Lava (Tertiary) overlying Silurian and Devonian strata.		2 springs. Ref. 144.
126	Lock's Springs, in sec. 15, T. 8 N., R. 55 E., on west side of Railroad Valley 20 miles southwest of Currant.	93–99	2,000	Alluvium near faulted(?) lava (Tertiary).		2 springs issuing in pools on terrace of tufa and 2 springs in meadow at base of terrace. Water used for irrigation.
127	Chimney Springs, in sec. 16, T. 7 N., R. 55 E., in Railroad Valley 6 miles south of Lock's Springs (No. 126).	130–160	100	Alluvium near faulted(?) lava (Tertiary).		3 springs issuing from mounds of tufa. Water supply for cattle.
128	Blue Eagle Springs, in sec. 11, T. 8 N., R. 57 E., on east side of Railroad Valley 18 miles south of Currant.	82	1,385	Alluvium		2 main springs. Water used for irrigation. Ref. 407.
129	Kate Spring, in sec. 14, T. 8 N., R. 57 E., 0.75 mile south of Blue Eagle Springs (No. 128).	73	14	do		Water used for domestic purposes and irrigation.
130	Butterfield Springs, in sec. 27, T. 8 N., R. 57 E., on east side of Railroad Valley.	64	227	do		2 springs. Water used for irrigation.
131	Bacon Springs, in sec. 34, T. 8 N., R. 57 E., on east side of Railroad Valley.	57	2	do		2 springs. Water supply for cattle.
132	Bullwhacker Spring, in sec. 28, T. 7 N., R. 57 E., on east side of Railroad Valley.	59	10	do		Water supply for cattle.
133	Willow Springs, in sec. 5, T. 6 N., R. 57 E., on east side of Railroad Valley.	60	30	do		2 springs. Water supply for cattle.
134	Mormon Springs, in sec. 33, T. 9 N., R. 61 E., 5 miles west of White River.	100	100	do		Several springs. Water used for irrigation. Ref. 431.
134A	Moon River Springs	92	900	do		Water used for irrigation. Ref. 431.
135	Riordan Ranch (Emigrant) Springs, in T. 9 N., R. 62 E., near White River.	70	200	do		Several springs. Water used for irrigation.
136	White River Valley (Flag, Sunnyside) Springs, in secs. 28, 31, and 32, T. 7 N., R. 62 E., on Whipple and Hendricks Ranches.	65–75	2,000	do		6 springs. Water used for irrigation. Refs. 144, 407.
137	Hot Creek Ranch Springs, in sec. 18, T. 6 N., R. 61 E., in White River valley 8 miles southwest of Sunnyside.	85–90	5,000	do		Several springs. Water used for irrigation. Refs. 144, 407, 431, 443.
138	Hicks Hot Springs, in T. 11 S., R. 47 E., 5 miles north of Beatty.	110	40	Lava (Tertiary) overlying Paleozoic strata.		5 springs. Water used for bathing. Ref. 399.
139	Ash Meadow Springs, in sec. 22, T. 17 S., R. 50 E.	76–94	450	Alluvium near Cambrian strata.		4 springs. Refs. 144, 399.
140	Pahrump Springs, in sec. 14, T. 20 S., R. 53 E., on Pahrump Ranch.	77	2,200	Alluvium near faulted Paleozoic strata.	447	2 springs. Water used for irrigation. Refs. 398, 443.
141	Manse Springs, in sec. 3, T. 21 S., R. 54 E., on Manse Ranch.	75	1,500	do	447	2 springs. Water used for irrigation. Ref. 269.
142	Geyser Ranch Springs, in T. 8 N., R. 65 E., 5 miles east of Patterson.	65–70	50	Alluvium near lava (Tertiary).	407	Several springs. Water used for irrigation. Refs. 138, 144.
143	T. 5 N., R. 70 E., on Hammond Ranch	84		Limestone (Paleozoic)		Several springs. Water used for irrigation. Ref. 407.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Nevada—Continued					
144	Bennetts Springs, in T. 2 S., R. 66 E., 9 miles west of Panaca.	70	Small	Alluvium near limestone (Paleozoic).		2 springs. Water supply for cattle. Ref. 407.
144A	Delmue's Springs, 10 miles north of Panaca	70	200	Lava (Tertiary)		2 springs. Water used for irrigation.
144B	Flatnose Ranch	70	100	do		Water used for irrigation.
145	Panaca Spring, in sec. 4, T. 2 S., R. 68 E.	85–88	2,500	Faulted Paleozoic strata	407	Several springs. Water supply for town.
146	Caliente Hot Spring, in T. 4 S., R. 67 E., 0.25 mile north of Caliente.	110		do		Formerly flowed, now pumped. Water used for bathing.
147	Hiko Spring, in sec. 22, T. 4 S., R. 60 E.	90	4,000	do	407, 441	Water used for domestic purposes and irrigation. Refs. 141, 144.
148	Crystal Spring, 1 mile northwest of Hiko	90	9,000	do		Water used for domestic purposes and irrigation. Ref. 141.
149	Ash (Alamo) Spring, 4 miles south of Hiko.	90–97	9,000	do		6 main springs. Water used for domestic purposes and irrigation. Ref. 141.
150	T. 14 S., R. 65 E., 3 miles west of Moapa	90		Limestone (Paleozoic)		Several springs. Water used for bathing and irrigation. Ref. 407.
151	Indian Spring, in sec. 16, T. 16 S., R. 56 E., 1 mile south of Indian Spring railroad station.	78	410	do	407, 443	Water supply for railroad; also used for irrigation. Ref. 398.
152	Las Vegas Springs, in T. 20 S., R. 61 E., 2 miles west of Las Vegas.	73	2,600	Pleistocene strata	407, 421	2 springs. Water used for domestic and industrial purposes, also for irrigation. Refs. 144, 269.
	New Mexico (See fig. 2.)					
1	Sec. 32, T. 11 N., R. 2 W., 10 miles south of Shiprock.	68	3	Mancos Shale (Upper Cretaceous) intruded by porphyry dike.	144, 328, 460	Water smells of H_2S. Water supply or cattle.
2	Sec. 8, T. 7 N., R. 2 W., 5 miles north of Newcomb.	65	3	do		Do.
3	Sec. 16, T. 7 N., R. 2 W., 4 miles north of Newcomb.	67	7	do		Do.
4	Sec. 23, T. 25 N., R. 8 E., 0.75 mile northwest of La Madera.	80	10	Lake beds (Tertiary)		Several springs.
5	Sec. 24, T. 25 N., R. 8 E., 1 mile northeast of La Madera.	100	5	Granite		
6	Sec. 25, T. 25 N., R. 8 E., 0.25 mile north of La Madera.	90	15	Lake beds (Tertiary)		
7	Sec. 35, T. 25 N., R. 8 E., 1 mile southwest of La Madera.	100	5	Granite		
8	Ojo Caliente Springs, 12 miles northwest of Barranca.	98–113	350	Gneiss intruded by dikes	133, 137, 328, 458, 460, 463, 464.	5 springs. Tufa deposit contains fluorite. Resort.
9	Togay Springs, in sec. 33, T. 19 N., R. 15 W., 20 miles east of Tohatchie.	65	65	Mesaverde Group (Late Cretaceous).		Many small pools. Water supply for cattle.
10	Murray Spring, in sec. 29, T. 20 N., R. 3 E., 15 miles north of Jemez Springs (town).	130	150	Basalt (upper Tertiary)		
11	San Antonio Springs, in sec. 7, T. 20 N., R. 4 E., on San Antonio Creek 20 miles north of Jemez Springs (town).	120	50	do		Refs. 461, 465.
12	Sulphur Springs, in sec. 3, T. 19 N., R. 3 E., 12 miles north of Jemez Springs (town).	76–167	500	Andesite and rhyolite (Tertiary).	461, 466	8 springs. Water smells of H_2S. Refs. 460, 465.
13	Soda Dam Springs, in sec. 15, T. 18 N., R. 2 E., in Canyon de San Diego, 2 miles north of Jemez Hot Springs (No. 15).	75–105	10	Limestone (Carboniferous) faulted against granite.	461, 465	Several springs. Large deposit of tufa. Refs. 457, 460, 466.
14	McCauley Spring, in sec. 4, T. 18 N., R. 3 E., 7 miles north of Jemez Springs (town).	100	110	Lava (upper Tertiary)		
15	Jemez Hot Springs (Ojos Calientes), in sec. 22, T. 18 N., R. 2 E., 12 miles north of Jemez (pueblo).	94–168	200	Faulted Chinle Formation (Triassic).	137, 144, 460, 461, 465, 466.	1 group of 10 and another group of 40 springs. Resort. Refs. 133, 328, 457, 464.
16	Phillips Springs, in T. 16 N., R. 1 W., 10 miles west of Jemez (pueblo) and 1 mile northeast of Rio Salado.	70	Small	Fault contact between Chinle Formation (Triassic) and Carboniferous strata.	466	About 40 springs in 30-acre area. Deposits of travertine. Refs. 457, 461, 465.
17	Indian (Jemez) Springs, in T. 16 N., R. 2 E., 2 miles north of San Ysidro.	120		Faulted Chinle Formation (Triassic).		Several springs. Water used locally. Refs. 457, 461, 465, 466.
18	San Ysidro Hot Springs, in sec. 8, T. 15 N., R. 1 E., 7 miles southwest of San Ysidro.	86 (max)		do	460, 466	40 springs. Water is strongly carbonated. Used locally. Refs. 457, 461.
19	San Ysidro Warm Springs, in secs. 3, 9, 10, T. 15 N., R. 1 E.	68	Small	do	137, 466	Several springs.
20	Las Vegas Hot Springs, 6 miles northwest of Las Vegas.	80–140	100	Contact of Carboniferous strata with Precambrian rocks.	133, 137, 144, 335, 345.	6 springs. Water smells of H_2S. Used for bathing. Refs. 328, 459, 464.
21	Ojo Caliente Springs, in sec. 21, T. 8 N., R. 20 W., 12 miles southwest of Zuni.	80	500	Sandstone and shale (Triassic).	328	2 springs. Water used for bathing and irrigation. Refs. 144, 460.
22	Quelites Mineral Spring, in T. 8 N., R. 2 W., on north side of San Jose River 2 miles northwest of Quelites.	80	3	Sandstone (Cretaceous)	137	Water used locally. Deposit of tufa. Ref. 460.
23	Socorro Warm Springs, 1.5 miles southwest of Socorro.	93	500	Lake beds (Tertiary) near lava.		Several springs. Water supply for Socorro. Refs. 460, 464, 467.
24	Ojo Caliente, in sec. 31, T. 8 S., R. 7 W., 15 miles northwest of Monticello.	85	1,200	Rhyolite (Tertiary)		7 springs. Refs. 144, 460.
25	Sec. 23, T. 12 S., R. 20 W., 1 mile south of Pleasanton.	80–124	50	Lava (upper Tertiary)		8 springs. Water used locally.
26	Sec. 30, T. 11 S., R. 12 W., 1 mile south of DD Bar Ranch.	80	50	Lava agglomerate (Quaternary).		
27	Sec. 19, T. 12 S., R. 13 W., on Diamond Creek near its mouth.	151	30	Lava (Tertiary)		Refs. 138, 144, 460.
28	Sec. 26, T. 13 S., R. 16 W., near Turkey Creek.	80	20	do		

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	New Mexico—Continued					
29	Sec. 3, T. 14 S., R. 16 W., on Turkey Creek 3 miles above its confluence with the Gila River.	Hot	20	Lava (Tertiary)		
30	Gila Hot Springs, in sec. 5, T. 13 S., R. 13 W., on the Gila River near Diamond Creek.	90-100	900	do		4 springs. Water used for bathing. Refs. 138, 144, 460.
31	Sec. 3, T. 13 S., R. 13 W., on the Gila River.	Hot	30	do		Water used locally.
32	Sec. 20, T. 13 W., R. 13 W., on the Gila River.	Hot	30	do		
33	Sec. 16, T. 14 S., R. 14 W., on the Gila River.	Hot	20	do		
34	Hudson's Hot Springs, 4 miles northwest of Mimbres.	142		do	133	Several springs. Water used for bathing. Refs. 135, 144.
35	Apache Tejo Warm Springs, 7 miles north of Whitewater.	97	2,000	Alluvium near lava		Several springs. Water used locally. Refs. 138, 144.
36	Faywood Hot Springs, in T. 20 S., R. 11 W., 6 miles northeast of Faywood.	142	120	Lava (Tertiary)	345	Several springs issuing from mound of tufa. Resort. Ref. 526.
37	Hot Springs (Palomas), near Truth or Consequences.	90-105	10	Limestone (Pennsylvanian) faulted against granite.	137	Several springs and wells. Water used for bathing. Resort and State Hospital for crippled children. Refs. 460, 468.
38	Radium Hot Springs, near Radium Springs railway station 17 miles north of Las Cruces.	165; 185	Small	Rhyolite (Tertiary)		2 springs. Water is brackish. Used for bathing and heating hotel. Refs. 133, 137.
	New York (See fig. 3.)					
1	Lebanon Warm Spring, 27 miles southeast of Albany.	76	500	Faulted limestone (Paleozoic).	137, 144, 469, 471	Water bottled and marketed. Resort since colonial times. Refs. 469–472.
	North Carolina (See fig. 3.)					
1	Hot Springs, on French Broad River 40 miles northwest of Asheville.	92-117	30	Shady Dolomite (Cambrian).	137, 144, 473, 476, 478, 543.	About 20 springs issuing at river edge. Resort. Refs. 473–478.
	Oregon (See fig. 6.)					
1	Sec. 29, T. 2 S., R. 9 E., in crater of Mount Hood.	120–194		Lava (Quaternary)		Many fumaroles emitting steam and gases, including H_2S. Refs. 479, 484, 485.
2	Mount Hood Warm Springs, in sec. 24, T. 3 S., R. 8½ E., on south side of Mount Hood.	60–80	25	do		Several small springs in 3-acre area. Resort.
3	Sec. 25, T. 6 S., R. 6 E., on the Clackamas River.	188 (max)		Columbia River Basalt (Tertiary).		Several springs. Water used locally. Ref. 481.
4	Carey (Austin) Hot Springs, in sec. 30, T. 6 S., R. 7 E., on the Clackamas River.	176–196		do		Several springs. Water smells of H_2S. Used for bathing. Ref. 481.
5	Bagsby Hot Springs, in sec. 26, T. 7 S., R. 5 E., on Hot Springs Creek 4 miles south of Thunder Mountain.	Hot	50	do		8 springs in 5-acre area. Campground. Ref. 481.
6	Breitenbush Hot Springs, in sec. 20, T. 9 S., R. 7 E., on the Breitenbush River.	140–198	900	do		About 40 springs in 10-acre area. Resort. Ref. 481.
7	Warm Springs, in secs. 19 and 20, T. 8 S., R. 13 E., on Warm Springs River 9 miles north-northeast of Warm Springs Indian Agency.	138–145	Large	Lake beds (Tertiary) overlying lava.		Many springs for 2 miles along river. Water smells of H_2S. Campground. Refs. 133, 483.
8	Lehman Hot Springs, in sec. 1, T. 5 S., R. 33 E., on Camas Creek.	Hot	75	Columbia River Basalt (Tertiary).		10 springs. Resort.
9	Hideaway Springs, in T. 5 S., R. 33 E., 7 miles southwest of Lehman Hot Springs (No. 8).	Hot		do		Several springs. Water smells of H_2S.
10	Sec. 6, T. 1 S., R. 39 E., 2 miles northeast of Summerville.	Warm		do		Several springs. Water used locally. Ref. 144.
11	Hot Lake, in T. 4 S., R. 39 E., 10 miles southeast of La Grande.	180	175	do		Water used for bathing.
12	Medical Springs, in sec. 24, T. 6 S., R. 41 E., 20 miles north-northeast of Baker.	140	50	Greenstone (Carboniferous).	482	2 springs. Water used locally.
13	Ritter (McDuffee) Hot Spring, sec. 8, T. 8 S., R. 30 E., on north bank of Middle Fork of John Day River.	110	35	Faulted Columbia River Basalt (Tertiary).		Resort. Refs. 109, 480.
14	Hot Sulphur Spring, in sec. 35, T. 10 S., R. 32 E., on Camp Creek 6 miles south of Susanville.	120		do		Resort. Refs. 144, 482.
15	Bear Gulch Spring, in sec. 11, T. 15 S., R. 31 E., near Canyon Creek 10 miles south of Canyon City.	Warm	2	Lava (upper Tertiary)		
16	Blue Mountain Hot Springs, in sec. 13, T. 14 S., R. 34 E., near mouth of Reynolds Creek 10 miles south of Prairie City.	Hot		Carboniferous strata		Several springs. Water used locally. Ref. 482.
17	Sam-O Mineral Springs, in sec. 2, T. 12 S., R. 43 E., 4 miles southeast of Durkee.	80		Faulted(?) Jurassic or Triassic strata.	481	2 springs. Water used locally. Ref. 482.
17A	Radium Hot Spring, in sec. 28, T. 7 S., R. 39 E., 10 miles northwest of Baker.	135	Small	Jointed diorite		Also 2 flowing wells. Water used for bathing.
17B	Sam-O Spring, in sec. 16, T. 9 S., R. 40 E., near Baker.	80	400	Alluvium overlying Tertiary volcanic and sedimentary rocks.		Water used for irrigation.
18	Belknap Hot Springs, in sec. 11, T. 16 S., R. 6 E., 6 miles east of McKenzie Bridge.	147–180	75	Conglomerate near lava (upper Tertiary).	133, 481	3 main springs. Water used for bathing. Resort. Refs. 137, 488.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
				Oregon—Continued		
19	Foley Springs, in sec. 28, T. 16 S., R. 6 E., 4.5 miles southeast of McKenzie Bridge.	162–174	25	Columbia River Basalt (Tertiary).	137, 144	4 springs. Resort. Ref. 481.
20	Sec. 7, T. 17 S., R. 5 E., on the South Fork of McKenzie River, 8 miles southwest of McKenzie Bridge.	130 (max)	60	do		4 springs.
21	Wall Creek Hot Springs, in sec. 26, T. 20 S., R. 4 E., 10.5 miles northeast of Oakridge.	98	3	do		3 springs. Water used locally.
22	Winino (McCredie) Springs, in sec. 36, T. 21 S., R. 4 E., 11 miles east of Oakridge.	Hot	20	do		15 springs in 1-acre area. Resort.
23	Kitson Springs, in sec. 6, T. 22 S., R. 4 E., 8 miles southeast of Oakridge.	114	35	do		2 main springs. Resort.
24	Umpqua Warm Spring, in sec. 20, T. 26 S., R. 4 E., on Umpqua River 5 miles south of Potter Mountain.	105	5	Andesite (Tertiary)		2 springs.
25	Jackson (Bybee) Hot Springs, 2 miles northwest of Ashland.	104 (max)	70	Granite		8 springs. Resort.
25	Sec. 31, T. 24 S., R. 5½ E., in Summit Lake Valley.	Warm		Lava (Pliocene)		Several springs. Water used locally. Ref. 144.
27	Klamath Hot Springs, at Klamath Falls	185	150	do		Water used for bathing. Also several wells supplying hot water for heating of residences. Refs. 113, 150.
28	0.5 mile northeast of Olene	130	8	Lava (Tertiary)		Several springs. Water from one is used for domestic purposes.
28A	Taylor Warm Spring, 2 miles east of Olene.	75	500	do		Water used for irrigation.
28B	Crystal Springs, 1 mile south of Olene	76	1,350	do		Water used for bathing and irrigation.
29	Oregon (Turner) Hot Springs, in sec. 10, T. 40 S., R. 13 E., 10 miles southeast of Bonanza.	148	35	Lake beds (Tertiary)		Water supply for sanitarium. Water used for bathing. Resort.
29A	Smith's Hot Spring, in sec. 10, T. 40 S., R. 13 E., 9.5 miles southeast of Bonanza.	146	5	do		Water used for bathing. Also water supply for cattle.
30	Wilkerson's Warm Springs, in sec. 6, T. 40 S., R. 14 E., 13 miles southeast of Bonanza.	76	20	Lava (Tertiary)		2 springs. Water used for domestic purposes and irrigation.
31	Robertson's Springs, in sec. 18, T. 38 S., R. 15 E., in Horsefly Valley 8 miles south of Bly.	Hot		Lava (upper Tertiary)		Several springs. Water used locally. Ref. 144.
32	Paulina Springs, in sec. 26, T. 21 S., R. 12 E., near north shore of Paulina Lake.	65; 70	10	Andesite and tuff (upper Tertiary).		2 springs. Ref. 487.
33	East Lake Hot Springs, in sec. 29, T. 21 S., R. 13 E., on south shore of East Lake.	110–141		Lake beds (Tertiary) near lava (Tertiary).		Many small springs. Water used for bathing. Ref. 487.
34	Sec. 36, T. 19 S., R. 32 E., near Twelvemile Creek 20 miles southwest of Paulina.	60–87		do		Several springs. Water used locally. Ref. 487.
35	Sand Springs, in sec. 35, T. 25 S., R. 19 E., 5 miles northeast of Fossil Lake.	62	30	Alluvium overlying lake beds.		3 springs, of which the southernmost is called Mound Spring. Water supply for cattle. Ref. 490.
36	Sec. 32, T. 26 S., R. 18 E., on west shore of Christmas Lake.	62	3	do		Water used for domestic purposes. Ref. 490.
37	Ana River Springs, in sec. 6, T. 30 S., R. 17 E., 7 miles north of Summer Lake post office.	66	48,000–75,000	Lake beds overlying faulted basalt.	489	5 springs. Water supply for Summer Lake Irrigation District. Refs. 489, 490.
38	Buckhorn Creek Springs, in sec. 5, T. 30 S., R. 17 E., 9 miles north of Summer Lake Post Office.	68	1,000	do		Several springs. Water used for irrigation. Ref. 490.
39	Johnson Creek Springs, in sec. 34, T. 29 S., R. 17 E., 12 miles northeast of Summer Lake post office.	56	9,000	do		Do.
40	Thousand Springs, in sec. 19, T. 30 S., R. 18 E., on east side of Summer Lake Valley.	66	200	do		Many small springs. Water used for irrigation. Ref. 490.
40A	R. C. Foster's Spring, 2 miles southwest of Ana River.	66	2,500	do		Water used for irrigation. Ref. 489.
40B	W. O. Grisel's Spring	60.5	10	Faulted lake beds (Pliocene).		Water used for domestic purposes and irrigation. Ref. 489.
40C	Russell Emery's Spring	64.5	2	do		Water used for domestic purposes; also water supply for cattle. Ref. 489.
40D	J. G. Foster's Spring	65	50	do		5 springs. Water used for irrigation. Ref. 489.
40E	Lost Cabin Spring	67.5	100	do		Water supply for cattle. Ref. 489.
41	Pardon Warm Spring, in sec. 35, T. 30 S., R. 16 E.	76	40	Lake beds (Pliocene) near faulted lava.		Water used locally.
42	Summer Lake (Woodward; J. W. Farleigh's) Hot Spring, in sec. 11, T. 33 S., R. 17 E.	116	21	Lake beds (Pliocene)	489	3 main springs. Water smells of H_2S. Used for bathing and irrigation. Deposit of siliceous sinter. Ref. 490.
43	Sec. 12, T. 30 S., R. 22 E., on west shore of Alkali Lake.	59	25	Alluvium overlying lake beds (Pliocene).		Water used for domestic purposes; also water supply for cattle. Ref. 490.
44	Sec. 22, T. 32 S., R. 21 E., on XL Ranch 3 miles north of Abert Lake.	63	10	Lake beds (Pliocene) overlying basalt.		Water used for domestic purposes and irrigation. Ref. 490.
44A	Northeast shore of Abert Lake	65	20	Lake beds (Pliocene) near faulted lava (Tertiary).		Water supply for cattle.
44B	East shore of Abert Lake	68	10	do		Do.
44C	Southeast shore of Abert Lake	80	30	Lake beds (Pliocene)		Do.
44D	White Rock Ranch Springs, 10 miles north of Lakeview.	63; 71	10	Basalt (upper Tertiary)		2 springs. Water used for domestic purposes and irrigation.
44E	Russell Bean's Spring	69	Small	Alluvium		Water used for domestic purposes; also water supply for cattle. Ref. 489.
45	Hunters Hot Springs, 2 miles north of Lakeview.	128–162	600	Faulted lake beds (Pliocene).		12 main springs, also a flowing well 200 ft deep and discharging 120 gpm. Water from well used to heat hotel. Resort. Ref. 490.
46	Leo Hank's (Leithead, Joyland Plunge, Lakeview) Hot Spring, 1.5 miles south of Lakeview.	157	50	Faulted lava (Tertiary)	489	Water smells of H_2S. Used for bathing. Refs. 133, 144.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
			Oregon—Continued			
47	Gus Allen's (Barry Ranch, Down's, Lakeview) Hot Springs, 2 miles south of Lakeview.	175–185	50	Faulted lava (Tertiary)	489	3 springs. Water smells of H_2S. Used for irrigation.
47A	F. S. Longfellow's Spring	63	20	do		Water used for domestic purposes and irrigation. Ref. 489.
48	Sec. 16, T. 35 S., R. 26 E., on upper Rock Creek 4 miles east of North Warner Lake.	105–115	50	Interbedded tuff and lava (Miocene).		Several springs. Water supply for cattle. Refs. 144, 491.
48A	Antelope Spring	104	30	Faulted alluvium	489	Water used for bathing. Deposit of tufa.
49	Hart Mountain Hot Spring, in sec. 7, T. 36 S., R. 26 E., on the north side of Hart Mountain about 200 ft below crest.	Hot	Small	Interbedded tuff and lava (Miocene).		Water supply for cattle.
49A	Fisher's Spring	144	20	Lake beds (Pliocene) near lava.		Water smells of H_2S. Used for bathing. Ref. 489.
49B	W. D. Moss Ranch, on west side of South Warner Lake.	72; 83	500; 30	Faulted lava (Tertiary)		2 main and several smaller springs. Water used for irrigation. Ref. 489.
49C	Charles Crump's Spring	104	5	Faulted lake beds (Tertiary).	489	Water smells of H_2S. Water supply for cattle. Deposit of tufa.
49D	Warner Valley Ranch	98; 107; 164	20; 2; 10	do		3 springs. Deposit of siliceous sinter. Also a pool of sulfurous water. Ref. 489.
50	Adel Hot Spring, in sec. 23, T. 39 S., R. 24 E., 1 mile east of Adel post office.	160	10	do		Water used locally.
50A	Pat Hallinan's Spring, 1 mile southwest of Houston Spring (No. 51).	1.3	20	Lake beds		4 springs. Water smells of H_2S. Water supply for cattle. Ref. 489.
51	Houston Hot Springs in sec. 27, T. 40 S., R. 24 E., 3 miles east of Warner Lake post office.	160	5	Faulted tuff and basalt		Water smells of H_2S. Used locally. Deposit of siliceous sinter. Ref. 489.
51A	Sec. 14, T. 22 S., R. 32½ E., 17 miles northeast of Burns.	72	225	Alluvium	486	Water contains 72 ppm of dissolved solids. Used for irrigation; also water supply for cattle.
52	Millpond Spring and other springs in secs. 35 and 36, T. 23 S., R. 30 E.	73–80	1,200	Interbedded tuff and basalt (Quaternary).	486	3 springs. Water contains 121 ppm of dissolved solids. Flow maintains log pond for saw mill. Refs. 371, 491.
52A	0.75 mile south of Millpond Spring (No. 52).	78	300	do		Water used for irrigation; also water supply for cattle.
52B	Goodman Spring, 1 mile south of Millpond Spring (No. 52).	Warm	300	do		Do.
52C	3.5 miles southwest of Millpond Spring (No. 52).	64	75	Lake beds, tuff, and rhyolite.		Water supply for cattle.
52D	1.5 miles east of spring No. 52C	72	485	do		Water contains 113 ppm of dissolved solids. Used for irrigation; also water supply for cattle.
52E	Baker Spring, 1.5 miles southeast of spring No. 52D.	62–70	50	do		5 springs. Water supply for cattle.
53	Crane Hot Spring, in sec. 34, T. 24 S., R. 33 E., near Crane Creek Gap 4 miles northwest of Crane.	122–126	180	Alluvium overlying lake beds (Pliocene).	486	2 main springs. Water contains 427 ppm of dissolved solids. Used for bathing. Refs. 371, 487, 491.
54	Sec. 23, T. 22 S., R. 36 E., on the west side of Middle Fork of Malheur River 8 miles northwest of Riverside.	138–144	90	Faulted interbedded tuff and basalt.		Several springs. Water used for bathing and irrigation. Ref. 491.
55	Sec. 16, T. 25 S., R. 36 E., on the west side of South Fork of Malheur River 8 miles north of Venator.	104–108	300	Faulted(?) lava (upper Tertiary).		Several springs. Water used for irrigation. Ref. 491.
56	Sec. 12, T. 26 S., R. 27 E., near south shore of Silver Lake.	68	45	Alluvium		Water used for irrigation. Ref. 491.
57	Sec. 33, T. 26 S., R. 28 E., 3.5 miles east of Iron Mountain.	68	10	do		Water supply for cattle. Ref. 491.
58	Double-O Spring, in sec. 34, T. 26 S., R. 28 E., 1.5 miles west of Double-O Ranch.	74	5,350	Interbedded tuff, rhyolite, and lake beds (Pliocene).		Water used for irrigation; also water supply for cattle. Refs. 141, 486, 491.
59	Double-O Barnyard Spring, in sec. 33, T. 26 S., R. 28 E., on Double-O Ranch.	72	1,750	do		Water used for irrigation; also water supply for cattle. Ref. 486.
60	Basque (East Double-O) Springs, in sec. 31, T. 26 S., R. 29 E., 1 mile southeast of Double-O Ranch.	67–74	1,800	do	486	Several springs. Water used for irrigation; also water supply for cattle. Ref. 491.
61	Johnson Springs, in sec. 5, T. 27 S., R. 29 E., 2.5 miles southeast of Double-O Ranch.	72	900	do		Several springs. Water used for irrigation; also water supply for cattle. Refs. 486, 491.
62	Hughet (Crane Creek) Spring, in sec. 8, T. 27 S., R. 29 E., 3 miles southeast of Double-O Ranch.	68	5,900	do		Water used for irrigation; also water supply for cattle. Refs. 141, 486, 491.
62A	Sizemore Upper Spring, in sec. 9, T. 27 S., R. 29 E., 5 miles southeast of Double-O Ranch.	67	1,160	do		Water used for irrigation; also water supply for cattle. Ref. 486.
62B	Sizemore Lower Spring, in sec. 15, T. 27 S., R. 29 E., 0.5 mile southeast of Sizemore Upper Spring (No. 62A).	66	410	do		Do.
62C	Hurlburt Spring, in sec. 15, T. 27 S., R. 29 E., 1 mile southeast of Sizemore Lower Spring (No. 62B).	Warm	25	Alluvium		Water supply for cattle. Ref. 486.
62D	Between high- and low-water boundaries of Harney Lake.	66–108	30	do		Several springs in southern and eastern parts of lake. Ref. 486.
63	Lynch Spring, in sec. 8, T. 27 S., R. 30 E.	65	25	do		Water smells of H_2S. Ref. 486.
63A	Dunn Spring, in sec. 4, T. 27 S., R. 30 E., on south side of Mud Lake.	65; 70	10; 25	do		2 springs 0.5 mile apart. Water supply for cattle. Ref. 486.
64	Sec. 36, T. 27 S., R. 29½ E., 0.5 mile from southeast shore of Harney Lake.	154	180	Lake beds, tuff, and rhyolite (Pliocene).	486	Refs. 371, 491.
64A	Sodhouse (Springer) Spring	54	1,800–5,200	Lake beds and playa deposits.		Water contains 226 ppm of dissolved solids. Used for irrigation; also water supply for cattle. Refs. 486, 491.
65	Hoghouse Spring, in sec. 13, T. 31 S., R. 32 E., on west side of Donner and Blitzen River valley.	78–80	1,800	Alluvium near faulted basalt (Tertiary).		Water used for irrigation. Refs. 486, 491.
66	Sec. 5, T. 32 S., R. 32½ E., 1 mile northeast of P Ranch.	83	100	do		Water supply for cattle. Refs. 486, 491.
67	Sec. 12, T. 32 S., R. 32 E., 1 mile southwest of P Ranch.	89	500	do		Water used for irrigation. Refs. 486, 491.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Oregon—Continued					
68	Sec. 33, T. 34 S., R. 34 E., on west border of the Alvord Desert 6 miles south of Alvord Ranch.	168–177	135	Faulted lava (lower Tertiary).		Several springs. Water used locally. Refs. 144, 491.
69	Sec. 15, T. 37 S., R. 33 E., 2 miles south of Alvord Lake.	160	6	Lake beds (Pleistocene) near fault zone.		Several springs. Ref. 491.
70	Sec. 15, T. 37 S., R. 33 E., at old borax works 2.5 miles south of Alvord Lake.	97	900	Lake beds (Pleistocene)		Several springs. Water supply for abandoned borax works. Ref. 491.
71	Sec. 24, T. 38 S., R. 37 E., 5 miles northeast of Flagstaff Butte.	96–100	30	Interbedded tuffs and lava (Miocene).		4 springs. Water supply for cattle. Ref. 491.
71A	5 miles southwest of Whitehorse Ranch	114	10	do		Water used for bathing.
72	Sec. 16, T. 39 S., R. 37 E., on north side of Trout Creek 0.5 mile downstream from mouth of Little Trout Creek.	128	45	do		Several springs. Water supply for cattle. Ref. 491.
73	Sec. 4, T. 16 S., R. 43 E., near Willow Creek 20 miles northwest of Vale.	Hot		Payette Formation (Miocene and Pliocene?).		Also a nearby drilled well. Ref. 492.
74	Sec. 11, T. 19 S., R. 37 E., in Warm Creek valley near Beulah.	185	Small	do		Several springs. Water used locally. Ref. 371.
75	Neal Hot Spring, sec. 9, T. 18 S., R. 43 E., 12 miles northwest of Vale.	168	24	Faulted(?) Payette Formation (Miocene and Pliocene?).		Water used locally. Also a small warm spring nearby. Refs. 371, 492.
76	Sec. 18, T. 19 S., R. 43 E., on the Malheur River 15 miles southwest of Vale.	Hot		Payette Formation (Miocene and Pliocene?) near lava.		Several springs. Ref. 492.
77	Vale Hot Springs, in sec. 20, T. 18 S., R. 45 E., on the south side of the Malheur River 0.5 mile east of Vale.	198	20	Payette Formation (Miocene and Pliocene?).		Also a nearby well 140 ft deep. Water used for bathing. Resort. Ref. 371.
78	Sec. 31, T. 17 S., R. 47 E., on the Malheur River 3 miles west of Ontario.	164		do		Water used locally. Refs. 144, 667.
79	Mitchell Butte Hot Springs, in sec. 12, T. 21 S., R. 45 E., on the Owyhee River.	122–141		do		3 main springs. Water used locally. Ref. 492.
80	Deer Butte Hot Spring, in sec. 14, T. 21 S., R. 45 E., on the Owyhee River.	115		Interbedded tuff and lava		Water used locally. Refs. 371, 492.
81	North Black Willow Spring, in sec. 25, T. 21 S., R. 45 E., on the Owyhee River near Sniveley's Ranch.	67		Faulted Payette Formation (Miocene and Pliocene?).		Water used locally.
82	South Black Willow Spring, in sec. 35, T. 21 S., R. 45 E., on the Owyhee River.	71		do		Water used locally. Ref. 492.
83	Sec. 10, T. 23 S., R. 44 E., on the Owyhee River 2 miles downstream from mouth of Dry Creek.	Hot		Alluvium overlying lava (upper Tertiary).		Several springs. Ref. 492.
84	Sec. 20, T. 24 S., R. 37 E., near South Fork of Malheur River 5 miles south of Riverside.	106–143	60	Faulted(?) lava (upper Tertiary).		Several springs. Water used for irrigation. Ref. 491.
84A	Sec. 18, T. 27 S., R. 43 E., on the Owyhee River 30 miles northwest of Jordan Valley.	Hot	Large	do		
84B	Near north end of Saddle Mountain 25 miles northwest of Rome.	Warm	Small	do		
85	Canter's Hot Springs, in sec. 2, T. 30 S., R. 46 E., 0.5 mile west of Jordan Valley.	120	10	Lava (lower Tertiary)		3 main springs. Water used for bathing. Ref. 144.
85A	Scott's Springs, 6 miles southwest of Rome	68	5,000	Basalt (Tertiary)		Several springs. Water used for irrigation.
85B	Tudor's Springs, 24 miles southwest of Rome.	68	6,000	do		Do.
85C	South Fork of Owyhee River, 40 miles south of Jordan Valley.	88–95	1,000	Basalt overlying rhyolite (Tertiary).		About 15 springs within a distance of 0.5 mile.
86	Sec. 36, T. 40 S., R. 42 E., 6 miles north of McDermitt, Nev.	130	200	Faulted lava (Tertiary)		Several springs. Water used for irrigation. Ref. 144.
	Pennsylvania (See fig. 3.)					
1	Perry County Warm Spring, near Sherman Dale 14 miles northwest of Harrisburg.	72	90	Folded Paleozoic strata	493	Water used locally. Former resort.
	South Dakota (See fig. 2.)					
1	Hot Springs, in western part of Hot Springs (town).	80–90	5,000	Deadwood Formation (Late Cambrian and Early Ordovician).	133, 137, 500	8 springs, including Minnekahta and Kidney. Resort, sanitarium, U.S. Army hospital. Refs. 145, 148, 496, 498, 501.
2	Hot Brook, 3 miles west of Hot Springs (town).	90	50	do		Water used for irrigation. Refs. 148, 496.
3	Cascade Springs, at head of Cascade Creek 10 miles southwest of Hot Springs (town).	68	7,200	do	499	3 springs. Water used for irrigation. Refs. 145, 498, 501.
4	Buffalo Gap Springs	Warm	Small	Carlile Shale Member of Colorado Shale (Cretaceous).		Ref. 498.
	Texas (See fig. 2.)					
1	Near bank of the Rio Grande, at south end of Quitman Mountain.	100		Faulted(?) Trinity Group (Early Cretaceous).		Water used for bathing. Ref. 144.
2	Near bank of the Rio Grande, 2 miles east of the south end of Quitman Mountain.	118		do		Pool on river flat. Overflowed until earthquake in 1922. Water used for bathing. Ref. 144.
3	Hot Spring Creek, 5 miles east of the Rio Grande and 7 miles northeast of Ruidosa.	114	45	Alluvium (Quaternary) overlying faulted(?) Cretaceous strata.		Water used for bathing. Refs. 73, 138, 502–504.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Utah (See fig. 7.)					
1	Warm Springs in sec. 20, T. 12 N., R. 15 W., 17 miles north-northwest of Terrace railroad station.	Warm	900	Alluvium		Water used for irrigation. Ref. 508.
2	Blue (Honeyville) Springs, in T. 13 N., R. 5 W., 18 miles southeast of Snowville.	86		do	508	6 springs. Refs. 144, 521.
3	Udy's Hot Springs, near the Malad River 2 miles southwest of Plymouth.	90–122	3,500	Carboniferous strata near Wasatch fault.		8 main springs. Water is saline. Used for bathing. Resort. Refs. 144, 508.
4	Crystal Springs, in T. 11 N., R. 2 W., 12 miles north of Brigham City.	121–134		do	508	About 30 springs. Water used locally. Refs. 124, 133, 144, 505, 521.
4A	Near south end of Little Mountain, 7 miles west-northwest of Corinne.	Warm	Small	Paleozoic strata	508	
5	T. 6 N., R. 5 W., on east side of Promontory Point.	84		Faulted(?) schist and gneiss (Precambrian).		Ref. 144.
6	Utah (Bear River) Hot Springs, in T. 7 N., R 2 W., 8 miles northwest of Ogden.	131–144	110	Faulted quartzite (Cambrian).	20, 133, 137, 144, 409, 522.	12 springs. Water is saline and ferruginous. Ref. 138.
6A	Clay's Hot Springs, 10 miles north of Ogden.	140	50	Quartzite on Wasatch fault		2 springs. Water is saline and ferruginous. Used for bathing. Ref. 512.
7	Patio Spring, 12 miles northeast of Ogden	68	200	Lake beds (Quaternary)		Water used for bathing.
8	Ogden Hot Springs, in T. 6 N., R. 1 W., at mouth of Ogden Canyon.	121; 150	Small	Syenite on Wasatch fault	522	2 springs. Water used for bathing. Refs. 138, 144, 418, 505.
9	Big Springs, in T. 2 S., R. 8 W., on the west side of Stansbury Range.	74		Carboniferous strata near fault.		2 springs. Water is brackish. Ref. 144.
10	Grantsville Warm Springs, 5 miles northwest of Grantsville.	74–91	50	Wasatch Formation (Eocene).		6 springs. Water is brackish; used for bathing. Deposit of calcareous tufa. Refs. 138, 144, 508.
10A	Morgan's Warm Springs, 4 miles southwest of Stockton.	80	500	do		Water is ponded. Used for bathing and irrigation.
10B	Russell's Warm Springs, 4.5 miles southwest of Stockton.	90	200	do		Water is ponded. Used for irrigation.
11	Beck's Hot Springs, 4 miles north of Salt Lake City.	128		Paleozoic strata on Wasatch fault.	128, 133, 137, 418.	Several springs. Water smells of H_2S. Resort. Refs. 124, 144, 511, 512, 521, 686.
11A	Warm Springs, 2 miles north of Salt Lake City.	118	350	do	525	Water used for bathing. Refs. 137, 511–513, 523.
12	Wasatch Springs, in the northwestern part of Salt Lake City.	130	350	Limestone (Carboniferous) near Wasatch fault.	525	Water used for bathing. Sanitarium. Refs. 133, 137, 144, 513, 523.
13	Crystal Springs, in T. 4 S., R. 1 W., 4 miles southwest of Draper.	70		Alluvium		Several springs. Water used for bathing. Refs. 138, 144, 523.
14	Schneitter's Hot Pots, 4.5 miles northwest of Heber.	85–116	20	Wasatch Formation (Eocene) near Carboniferous limestone.	133, 137	20 main springs. Water used for bathing. Extensive deposit of tufa. Refs. 138, 144, 418, 514, 526.
14A	Luke's Hot Pots, 4 miles northwest of Heber.	78–110	30	do		Several springs. Water used for bathing. Ref. 514.
14B	Buhler's Springs, 3.5 miles northwest of Heber.	80–108	10	do		Several springs. Water used for bathing. Extensive deposit of tufa. Refs. 137, 510, 514.
15	Saratoga Springs, on northwest shore of Utah Lake.	111	211	Wasatch Formation (Eocene).		Several springs. Water used for bathing. Resort. Ref. 523.
16	T. 8 S., R. 1 E., on south shore of Utah Lake 8 miles northwest of Payson.	88	200	Alluvium		Water used locally. Ref. 523.
17	T. 10 S., R. 1 E., near the north end of Long Ridge 2 miles east of Goshen.	70	2,000	Faulted Carboniferous strata.		Several springs. Water used locally. Ref. 523.
18	Castilla Mineral Springs, in T. 9 S., R. 3 E., in Spanish Fork Canyon 15 miles south of Provo.	111; 145		Carboniferous strata near Wasatch fault.		3 springs. Resort. Refs. 138, 144, 526.
19	Sec. 14, T. 8 S., R. 5 E., on Diamond Creek 15 miles east of Springville.	Warm	700	Wasatch Formation (Eocene).		2 springs. Water smells of sulfur.
19A	12 miles northeast of Jensen, in canyon of Green River.	90	10	Paleozoic or Mesozoic strata.		2 springs issuing at river edge.
20	Hot Springs, in T. 11 S., R. 14 W., at north end of Fish Springs Mountains and 3 miles north-northeast of Fish Springs (town).	74–78		Alluvium near faulted Paleozoic strata.		Several springs. Water used locally. Refs. 138, 144, 506, 515, 520.
21	Big Spring, in T. 11 S., R. 14 W., 1 mile southeast of Hot Springs (No. 20).	85		do		3 springs. Refs. 144, 506, 520.
22	Fish Springs, in T. 11 S., R. 14 W., 4 miles southeast of Hot Springs (No. 20) and 3 miles east of Fish Springs (town).	80–140		do	406	7 springs. Water smells strongly of H_2S. Large deposit of tufa. Refs. 144, 406, 506, 515, 520.
23	Sec. 33, T. 14 S., R. 18 W., on Miller's Ranch 8 miles south of Trout Creek.	64	500	Alluvium		Several springs rising in pools. Water used for irrigation. Refs. 506, 520.
24	Abraham Springs in T. 14 S., R. 8 W., on Fumarole Butte, 19 miles north-northwest of Delta.	100–205	1,200	Fractured lava (Tertiary)	507	20 springs. Deposit of manganese. Refs. 109, 144, 509, 512, 516, 520.
25	Sec. 31, T. 15 S., R. 19 W., in Snake Valley 1 mile west of Gandy.	82	Large	Limestone (lower Paleozoic)		Several springs. Water used for irrigation. Deposit of tufa. Ref. 520.
26	Sec. 9, T. 16 S., R. 18 W., in Snake Valley 2 miles south of Foote's Ranch.	68	1,000	Alluvium		Several springs rising in pools. Water used for irrigation. Refs. 144, 520.
27	Knoll Springs, in sec. 11, T. 18 S., R. 18 W., in Snake Valley 12 miles southeast of Smithville.	68–71		Alluvium near Carboniferous strata.		Several springs. Water smells of H_2S. Used locally. Refs. 144, 520.
28	Sec. 24, T. 22 S., R. 6 W., 3 miles northwest of Hatton.	94	Large	Interbedded tuff and lava (Tertiary).		Water used for irrigation. Ref. 520.
29	Brewer's Springs, in secs. 13 and 24, T. 15 S., R. 2 E., 1 mile northwest of Wales.	57–62	400	Alluvium near faulted Wasatch Formation (Eocene).		3 springs. Water used for domestic purposes and irrigation. Ref. 524.
30	Lowry's Spring and Squires' Spring, in sec. 23, T. 18 S., R. 2 E., 3 miles south of Manti.	59; 62	40	Faulted Wasatch Formation (Eocene).		Water used for irrigation. Ref. 524.
31	Livingston Warm Springs, in sec. 13, T. 18 S., R. 2 E., 1 mile south of Manti.	62; 73	285	do		2 main springs. Water used for domestic purposes and irrigation. Ref. 524.
32	Manti Springs, in sec. 17, T. 18 S., R. 3 E., 2 miles southeast of Manti.	59; 65	30	do		Do.
33	Morrison Spring, in sec. 35, T. 18 S., R. 2 E., 2 miles northeast of Sterling.	61	2,500			Water used for irrigation. Ref. 524.
34	Gunnison Spring, in sec. 18, T. 19 S., R. 1 E.	61	8	Alluvium		Water supply for cattle. Ref. 524.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Utah—Continued					
35	Ninemile Warm Spring, in sec. 4, T. 19 S., R. 2 E.	72	900	Alluvium near faulted Wasatch Formation (Eocene).		Water used for domestic purposes and irrigation. Ref. 524.
36	Sec. 32, T. 20 S., R. 2 E., 8 miles northeast of Redmond.	58	15	Faulted Wasatch Formation.		Water used for irrigation. Ref. 524.
37	Redmond Springs, in secs. 11 and 12, T. 21 S., R. 1 W., near Redmond.	70	6,000	do		Several springs. Water used for domestic purposes and irrigation. Ref. 524.
38	Salt Spring, in sec. 17, T. 21 S., R. 1 E., 2 miles northeast of Salina.	72	2	Faulted Jurassic strata		Ref. 524.
39	Oak Spring and Christianson Spring, in sec. 1, T. 22 S., R. 2 W., 2 miles west of Aurora.	60	20	Faulted lava (Eocene)		Water supply for cattle. Ref. 524.
40	Herrin's Hole Spring, in sec. 23, T. 23 S., R. 2 W., 1 mile north of Glenwood.	63	450	do		Water used for irrigation. Ref. 524.
41	Cove Springs, in sec. 27, T. 23 S., R. 2 W., 1 miles west of Glenwood.	60	4,000	do		Several springs. Water used for irrigation. Ref. 524.
42	Richfield Hot Springs, in sec. 26, T. 23 S., R. 3 W.	74	1,500	Faulted limestone (Eocene)		Several springs. Water supply for town; also used for irrigation. Ref. 524.
43	Indian Spring and Parcel Creek Spring, in sec. 25, T. 23 S., R. 2 W., near Glenwood.	60	130	Faulted lava (Eocene)		Water used for domestic purposes and irrigation. Ref. 524.
44	Sec. 5, T. 24 S., R. 2 W., 2 miles southeast of Richfield.	52–61	4,500	Lava (Tertiary)		Several springs. Water used for irrigation. Ref. 524.
45	Sec. 25, T. 24 S. R. 3 W., 6 miles south of Richfield.	59	25	Alluvium overlying Wasatch Formation (Eocene).		Water used for domestic purposes and irrigation. Ref. 524.
46	Jericho Spring, in sec. 6, T. 25 S., R. 3 W., 2 miles northeast of Joseph.	65	700	Alluvium		Water used for irrigation. Ref. 524.
47	Johnson Spring, in sec. 27, T. 25 S., R. 3 W., 2 miles southeast of Monroe.	80	200	Faulted lava and tuff (Eocene).		Do.
48	Cooper Hot Springs, in sec. 15, T. 25 S., R. 3 W., 0.5 mile east of Monroe.	144–156	100	Faulted tuff (Tertiary)	524	Several springs. Water used for irrigation.
49	Joseph Hot Springs, in sec. 23, T. 25 S., R. 4 W., 1 mile southeast of Joseph.	135–146	30	Lava (Tertiary)		Several springs. Water used for irrigation. Deposit of tufa. Ref. 524.
50	Sevier Spring, in sec. 32, T. 25 S., R. 4 W.	59	100	Alluvium		Water used for domestic purposes; also water supply for cattle. Ref. 524.
51	Roosevelt (McKean's) Hot Spring, in T. 27 S., R. 9 W., on west slope of Mineral Mountains 15 miles northeast of Milford.	192	10	Granite	518	Water smells strongly of H_2S. Water supply for cattle. Deposits of tufa and sinter.
52	Warm Springs, secs. 21 and 28, T. 30 S., R. 12 W., 2 miles south-southwest of Thermo railroad siding.	90–175	20	Alluvium near faulted(?) lava (Tertiary).	518	About 16 springs issuing from a low ridge. Deposits of dense calcareous tufa. Water supply for cattle.
53	Radium (Dotson's) Warm Springs, in sec. 7, T. 30 S., R. 9 W., 1 mile east of Minersville.	97	57	Quartzite	518	3 springs. Water used for bathing and irrigation.
54	La Verkin Hot Springs, on Rio Virgin 2 miles north of Hurricane.	108–132	1,000	Faulted Triassic strata		Several springs. Refs. 133, 144.
55	T. 37 S., R. 7 W., 25 miles southwest of Panguitch.	Warm		Lava (Tertiary) overlying Wasatch Formation (Eocene).		Ref. 138.
56	Undine Springs, in T. 25 S., R. 17 E., in Labyrinth Canyon of the Green River.	Warm		Sandstone (Triassic)		Many small springs. Deposit of tufa. Ref. 138.
57	Warm Spring Canyon near its junction with "Narrow Canyon" or "Dark Canyon" of the Colorado River.	91		do		Ref. 138.
	Virginia (See fig. 3.)					
1	Limestone Springs, near Compton	61–66		Folded or faulted Paleozoic strata.		3 springs. Water used locally. Refs. 133, 538, 541.
2	Warm Spring, 1 mile south of Bridgewater	64	500	do		Water used locally. Ref. 538.
3	Dice's Spring, 1 mile southeast of Burketown.	65	1,500–2,000	do		Do.
4	Fitzgerald Spring, near Middle River Bridge, 2.25 miles west of Fort Defiance.	61	60	do		Do.
5	Bragg Spring, 2.25 miles northeast of Bolar	75	50	do		Do.
6	Bolar Spring, 3 miles northeast of Bolar	72	1,500	do		Do.
7	Warm Sulphur Springs, at Warm Springs (town).	91–96	1,200	do	133, 144, 541, 543	4 springs. Resort. Refs. 529, 538.
8	Hot Springs, at Hot Springs (town)	72–106		do	20, 128, 133, 137, 144, 409, 541, 543.	7 springs. Resort. Refs. 529, 538, 542.
9	Healing (Rubino Healing, Sweet Alum) Springs, at Healing Springs (town).	82–88		do	133, 137, 139, 144, 409, 543.	4 springs. Water bottled and marketed. Resort. Refs. 538, 541.
10	Mill Mountain Springs, at Panther Gap 1.5 miles west of Goshen.	60; 65; 66	50; 800; 500	do		3 springs. Water used locally. Refs. 538, 541.
11	Rockbridge (Rockbridge Alum, Strickler's) Springs at Rockbridge Baths 10 miles north of Lexington.	72		do	137, 139	3 springs. Resort. Refs. 144, 529, 538, 541.
12	Layton (Keyser's) Springs, on the Jackson River 2 miles south of Falling Spring (No. 13).	63; 72	200	do		2 springs issuing on opposite banks of the river. Water used locally. Refs. 538, 541.
13	Falling Spring, 8 miles south of Healing Springs (No. 9).	74	7,000	do		Water used locally. Refs. 538, 541.
14	Sweet Chalybeate Springs, 3 miles north of Sweet Chalybeate.	63–68	280	do	133, 144, 541	3 springs. Resort. Ref. 538.
15	Lee Carter Spring, 1.5 miles northeast of Sweet Chalybeate.	63	20	do		Water used locally.
15	C. B. Hunter Spring, 0.5 mile north of Sweet Chalybeate.	60	10	do		Do.
15	R. O. Stone Spring, at Sweet Chalybeate	73	100	do		Do.
15	Sweet Chalybeate Spring, at Sweet Chalybeate.	76	1,000	do		Do.
16	Lithia (Wilson Thermal), on Mill Creek 3.25 miles east of Gala.	65	300	do	541	Water used locally. Ref. 538.
17	Blueridge (Buford's Gap) Springs, at Buford's Gap.	66–75		do		3 springs. Water used locally. Refs. 138, 541.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Virginia—Continued					
18	New River White Sulphur Springs, at Eggleston.	85	3	Folded or faulted Paleozoic strata.		3 springs. Resort. Refs. 144, 541.
19	Hunter's Pulaski Alum Springs, at Sassin, 8.5 miles north of Pulaski.	72		do		2 springs. Resort. Ref. 133.
20	McHenry's Spring, near the North Fork of the Holston River.	68		do	144, 541	Water used locally.
	Washington (See fig. 2.)					
1	Baker Hot Spring, in sec. 30, T. 38 N., R. 9 E., on east side of Mount Baker.	108	7	Lava (upper Tertiary) overlying granite.		
2	Sol Duc Hot Springs, in sec. 32, T. 29 N., R. 9 W., 14 miles (by road) southwest of Crescent Lake.	100–132	50	Metamorphic rocks (pre-Tertiary).		3 main and 8 smaller springs in 1-acre area. Resort.
3	Olympic Hot Springs, in sec. 27, T. 29 N., R. 8 W., 11.5 miles (by trail) southwest of Elwha post office.	120–125	135	do		17 springs in 5-acre area. Resort.
4	Sulphur Creek Spring, in sec. 30, T. 32 N., R. 12 E., 1 mile north of Sulphur Creek Shelter.	98	4	Granite		
5	White Chuck Hot Springs, in sec. 1, T. 30 N., R. 12 E., near the White Chuck River.	100–110	30	do		4 springs. Water used for bathing. Deposit of iron-stained tufa.
6	San Juan Hot Springs, in sec. 25, T. 28 N., R. 11 E., on the North Fork of Skykomish River 5 miles east of Galena.	100	25	do		3 springs. Ref. 548.
7	Scenic (Great Northern) Hot Springs, in sec. 28, T. 26 N., R. 13 E., 5 miles west of Scenic.	122	30	do	546, 548	Several springs. Water is sulfurous; is piped 2 miles to hotel. Resort.
8	McDaniels Hot Springs, in sec. 15, T. 23 N., R. 11 E.	114–127	30	do		4 springs. Resort.
9	Hot Springs, in sec. 21, T. 20 N., R. 9 E., at Hot Springs railroad station.	120–122		Basalt (Tertiary)	548	5 springs. Resort.
10	Clerf Spring, in sec. 5, T. 17 N., R. 20 E., 8 miles east of Ellensburg.	68	1,100	Basalt (Tertiary) overlying sandstone (Miocene).		Water used for irrigation. Refs. 544, 549, 550.
11	Ohanapecosh Hot Springs, in sec. 4, T. 14 N., R. 10 E., near south base of Mount Rainier.	109–120	60	Basalt (Tertiary)		5 springs. Resort and sanitarium. Ref. 660.
12	Sec. 9, T. 11 N., R. 15 E., on the North Fork of Simcoe Creek.	90	40	do		Several springs. Water used for bathing. Ref. 546.
12A	North slope of Mount St. Helens	142–190		Lava (Quaternary)		Small fumaroles. Ref. 547.
12B	Crater of Mount Adams	Hot		do		Steam vents and small fumaroles. Ref. 547.
13	Nicolai Spring, in sec. 15, T. 11 N., R. 23 E., 10 miles north of Sunnyside.	66	300	Ellensburg Formation (Miocene).		Water used for irrigation. Ref. 551.
14	Sec. 16, T. 6 N., R. 13. E., 5 miles southeast of Glenwood	76	Large	Basalt (Tertiary)		Several springs. Gas rises with water. Water used for irrigation. Ref. 546.
15	Blockhouse Mineral Springs, in sec 12, T. 4 N., R. 14 E., 8 miles west of Goldendale.	67	50	do	137, 546	2 springs. Resort.
16	Cascade Warm (Moffet's Hot) Springs, in sec. 16, T. 2 N., R. 7 E., near Cascade.	96	20	do	137	4 springs. Resort. Refs. 133, 546.
	West Virginia (See fig. 3.)					
1	Manacea (Irondale) Spring, at Irondale	63.6		Allegheny Formation (Pennsylvanian).	554	Water marketed for table use.
2	Gillis (Iron Magnesium) Spring, at Terra Alta.	64	40	Chemung Formation Devonian).	do	Formerly the source of water supply for Terra Alta. Ref. 552.
3	Berkeley Springs, at Berkeley Springs (town).	73.5	1,000–1,230	Oriskany Sandstone (Early Devonian).	133, 137, 144, 554, 555.	2 springs. Source of water supply for town of Berkeley Springs. State Park. Sanitarium. Refs. 538, 541, 552.
4	Swan Pond Spring, 5 miles east of Martinsburg.	72	100	Ordovician strata		Ref. 552.
5	North Branch of Walker Spring, 1.5 miles south of Harpers Ferry.	62	36	Cambrian strata		Do.
6	Shannondale Springs, 5 miles southeast of Charles Town:					
	Blue (Black) Sulphur Spring	64	1	Waynesboro Formation (Early Cambrian).	554	Former resort.
	Red Sulphur Spring	64	1	do	554	
7	Everett Fruit Farm, 5 miles southeast of Romney.	64	20	Devonian strata		Ref. 552.
8	Cold Stream Run, 1 mile west of Cold Stream (town).	64	700	do		Water is slightly cloudy. Ref. 552.
9	Capon (Cacapon) Springs, at Capon Springs (town).	64	170	Oriskany Sandstone (Early Devonian).	133, 137, 144, 554	4 springs. Water marketed for table use; also used for bathing. Resort hotel. Ref. 552.
10	Warm (Boiling) Spring, 4 miles south of Wardensville.	61	100	Devonian strata		Ref. 552.
11	Big Spring, 0.5 mile southwest of Harman	61	2,290	Carboniferous strata		Do.
12	Trout Rock Spring, 3 miles south of Hopeville.	61	510	Silurian strata		Do.
13	Arbogast Farm, 3 miles north of Onego	61	500	Carboniferous strata		Do.
14	Roaring Springs, 1 mile north of Onego	61	850	do		Do.
15	Roaring Springs, at Circleville	65	5,500	Silurian strata		Several springs. Ref. 552.
16	Near mouth of Thorn Creek, 2 miles south of Franklin.	71	7,700	Devonian strata		Ref. 552.
17	Big Spring, on Big Spring Fork 2 miles west of Linwood.	63	1,140	Carboniferous strata		Ref. 552.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	West Virginia—Continued					
18	Dunmore Drinking (Reece Prichard) Spring, 0.8 mile southeast of Dunmore.	63	30	Contact of Bossardsville Limestone (Silurian) and Helderberg Limestone (Early Devonian).	554	Refs. 538, 552.
	Meadow Spring, 0.5 mile east of Dunmore	66	200	do	554	Ref. 552.
	Upper Spring, at Dunmore	62.5		do	554	Water used for bathing, also used for growing water cress. Ref. 552.
19	Mill Run Spring, 2.5 miles southwest of Frost.	65	400	Devonian strata		Several small springs. Ref. 552.
20	Guy Run, 4 miles southwest of Frost	69	240	do		Do.
21	Peter McCarthy Springs on Browns Creek, 5 miles northeast of Huntersville.	63.5	230–300	Bossardsville Limestone (Silurian).	554	2 springs. Ref. 552.
22	S. P. Curry (Nap's Creek) Spring, at Huntersville.	64	230	Silurian or Devonian strata		Refs. 538, 541, 552.
23	Ruckman Run, 6 miles east of Huntersville.	62	300	do		Several springs. Ref. 552.
24	Minnehaha Springs, at Camp Minnehaha, 4 miles southeast of Huntersville.	72	550–600	Marcellus Shale (Middle Devonian).	554	Water used for bathing. Hotel. Refs. 538, 552.
25	Piercy's Cave Spring, 2 miles northwest of Asbury.	68	1,630	Carboniferous strata		Ref. 552.
26	White Sulphur Springs (town):					
	Black Sulphur Spring	62.5	25	Marcellus Shale (Middle Devonian).	554	Water used for medicinal drinking and bathing. Resort hotel. Ref. 538.
	White Sulphur Spring	64	30	do	133, 137, 144, 541, 554.	
	White Sulphur Chalybeate Spring	64	5	do	554	Water bottled and marketed for table use.
	Big Spring	62	840			Ref. 552.
	Sterett Spring	61	610			Do.
27	Old Sweet Springs, at Sweet Springs (town).	73	Large	Stones River Limestone (Middle Ordovician).	133, 137, 144, 541, 554.	Water used for bathing. Resort. Ref. 538
28	Salt Sulphur Springs (town):					
	Salt Sulphur Spring	61	50	Greenbrier Limestone (Mississippian).	554	Water used for bathing. Hotel.
	Iodine Spring	61.5	50	do	554	Water used for drinking.
29	Right Fork of Trout Branch, 6 miles southeast of Gap Mills.	64	310	Ordovician strata		Several springs. Ref. 552.
30	Upstream from Ewin Run (cold) Spring, 7 miles southeast of Gap Mills.	72	66	do		Do.
	Wyoming (See figs. 2, 5.) [Data for Nos. 1–96 are chiefly from ref. 562; in those areas in Yellowstone National Park where thermal springs are numerous and closely spaced, only the more noteworthy are listed]					
1	Boiling (Hot) River, 0.8 mile north-northeast of Yellowstone Park Headquarters.		10,000		562	Several springs, the flows combining to form stream, 6–8 ft wide, flowing into Gardiner River. Refs. 592, 625–628, 672.
2	Mammoth (White Mountain) Hot springs, 0.5 mile southwest of Yellowstone Park Headquarters.	160 (max)	225–1,152	Rhyolite overlying Mesozoic strata.	562	Several springs. Extensive deposits of travertine. Refs. 140, 557, 558, 574, 608, 617, 620, 625, 628, 634, 636, 637, 642, 645, 655, 664, 667, 679, 692, 697, 698.
3	3 miles east of Obsidian Cliff		Small	Rhyolite (Tertiary)		
4	Northeast base of The Landmark		Small	do		
5	Near east side of Lake of the Woods		Small	do		
6	0.5 mile southeast of Lake of the Woods		Small	do		
7	Amphitheater Springs, 0.8 mile west of Lake of the Woods.	135–196		do	562	Also solfataras.
7A	Clearwater Springs, 1 mile southwest of Amphitheater Springs (No. 7) and 0.5 mile northwest of Roaring Mountain.	178–198		Clay	562	Several boiling springs and fumaroles. Ref. 562.
7B	Pool in crater of Semi-Centennial Geyser, near Obsidian Creek 0.6 mile south of Clearwater Springs (No. 7A).	Hot		Rhyolite (Tertiary)		Erupted violently in August 1922, but ceased geyser action soon thereafter. Refs. 637, 667.
8	Whiterock Springs, 1 mile south-southeast of Lake of the Woods.	149–156	Small	do	562	2 springs. Ref. 561.
9	Bijah Spring, 0.4 mile northwest of Fryingpan Springs (No. 10).	184	58.5	do	562	Rises in large clear pool. Ref. 561.
9A	Fryingpan Springs, 2 miles northwest of Norris Junction.			do	562	Many bubbling vents on both sides of Mammoth-Norris Junction Road.
10	Congress Pool, 0.3 mile southwest of Norris Junction.			do		Muddy pool, sometimes boiling and sometimes quiescent.
10A	Crater of Monarch Geyser, near Congress Pool (No. 10).			do		Formerly erupted to height of 100–200 ft. Ceased activity in 1913. Ref. 637.
11	Geysers in Norris Geyser Basin:					
	Ebony Geyser			do		Erupts to height of 25–50 ft at intervals of 8–48 hr. Ref. 637.
	Echinus Geyser			do		Erupts to height of 75–100 ft at intervals of 1–1.5 hr. Ref. 637.
	Emerald Spring			do	562	Erupts occasionally to height of 20–30 ft. Ref. 637.
	Fan Geyser			do		Erupts to maximum height of 25 ft at intervals of 7–19 hr. Ref. 637, 647.
	Ledge Geyser			do		Erupts to height of 60–75 ft several times a day. Ref. 637.
	Mud Geyser			do		Erupts to height of 8–60 ft at intervals of 20 min. Ref. 637.
	Steamboat Geyser			do		Erupts to height of 25–30 ft at intervals of 2–5 min. Ref. 637.
	Valentine Geyser			do		Erupts to height of 60–75 ft at intervals of 18–72 hr. Ref. 637.
	100 ft northwest of Valentine Geyser			do		Erupts to height of 20–35 ft several times an hr. Ref. 637.
	Vixen Geyser			do		Erupts to height of 18–30 ft several times a day. Refs. 566, 637.
	Whirligig Geyser			do		Erupts to height of 8–15 ft once or twice a day. Refs. 576, 637.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Wyoming—Continued					
12	Sylvan Springs, in Gibbon Meadows 3.5 miles southwest of Norris Junction.	190 (max)	Small		562	Several springs and fumaroles; also large shallow pool. Ref. 561.
13	Gibbon Hill Geyser, near east side of Gibbon Meadows at foot of southwest side of Gibbon Hill.	188–198		Rhyolite (Tertiary)	562	Erupts to height of 15–25 ft several times a day. Ref. 637.
14	Artists Paintpots, at foot of northwest side of Paintpot Hill.	178–199	149	do	562	Pools of bubbling mud; also fumaroles. Ref. 576.
15	Geyser Springs, at foot of east side of Paintpot Hill.			do		Several springs including an unnamed geyser that erupts to height of 25 ft at intervals of 6 min. Ref. 637.
16	Monument Geyser in Monument Geyser Basin 1 mile west-southwest of Painpot Hill.	197	5,400	do	562	Erupts to height of 4–9 ft almost constantly. Also several springs issuing from small cones. Barren area 240 yd long and 50 yd wide.
16A	Beryl Spring, 1.5 miles north of Gibbon Falls.	197	54	do	562	Pool 20 ft in diameter. Water in constant ebullition. Ref. 576.
17	Queen's Laundry (Red Terrace) Spring, 1.5 miles southwest of Fountain Ranger Station.	160		do	562	Large pool. Terraces of sinter. Ref. 561.
18	River Group Springs, on both sides of Firehole River 1.5 miles south of Fountain Ranger Station.	119–203		do	562	Numerous springs including 6 that are superheated and 3 small geysers. Ref. 561.
19	Morning Mist Springs, near Nez Perce Creek 1.2 miles east-southeast of Fountain Ranger Station.	201 (max)	Small	do		Numerous springs.
20	Fairy Springs, 2.7 miles south-southwest of Fountain Ranger Station.	184-202			562	4 groups of springs Includes Boulder Springs, the water of which is in constant ebullition. Ref. 561.
21	Fountain Paintpot			Rhyolite (Tertiary)	562	Large cauldron of white, pink, and pale orange clay. Ref. 557.
21A	Clepsydra Geyser			do		Erupts to height of 5–25 ft at intervals of 3 min. Refs. 576, 637.
21B	Fountain Geyser, 2.2 miles southeast of Fountain Ranger Station.			do		Erupts to height of 50–75 ft at intervals of 6–12 hr. Refs. 557, 576, 637, 665.
21C	Morning Geyser, near Fountain Geyser (No. 21B).			do		Erupts to height of 50–60 ft at intervals of 2 5 days. Refs. 576, 637.
22	Great Fountain Geyser, 1 mile south-southeast of Fountain Geyser (No. 21B).	204	22	do	562	Erupts to maximum height of 90 ft at intervals of 8–15 hr. Large deposit of sinter. Refs. 557, 637.
22A	Pink Cone Geyser			do		Erupts to height of 12–17 ft once a day. Sinter cone is 18 in. high and 5 feet in diameter. Ref. 637.
23	White Dome Geyser, 0.8 mile south of Fountain Geyser (No. 21B).			do		Erupts to height of 18–30 ft at intervals of 20–30 min. Ref. 637.
24	Spray Geyser, at base of south end of Twin Buttes 4 miles southwest of Fountain Ranger Station.		72	do		Erupts to height of 5–20 ft at intervals of 2–31 min. Ref. 637.
24A	Pool in crater of Imperial Geyser, 0.2 mile west of Spray Geyser.		690	Rhyolite (Tertiary)	562	Began erupting in 1928 to height of 100–125 ft; ceased erupting in 1929. Ref. 637.
25	Prismatic Lake in crater of Excelsior Geyser, about midway between Upper Basin Ranger Station and Fountain Ranger Station.	146	2,700	do	562	Formerly the largest geyser in Yellowstone Park but dormant since 1888. Lake is 370 ft long and water is blue-green. Much steam. Turquoise and Opal Pools nearby, also several hot springs. Refs. 557, 576, 587, 611, 617, 637.
26	Flood Geyser, 0.5 mile southeast of Prismatic Lake (No. 25).	201	18	do	562	Erupts to height of several ft at irregular intervals. Ref. 637.
26A	Rabbit Creek area, 1 mile east-southeast of Prismatic Lake (No. 25).	201 (max)		do	562	Several springs and large pool of blue water; also paintpots and fumaroles. Ref. 637.
27	Tributary of Juniper Creek, 6.5 miles east of Fountain Ranger Station.			do		
28	Juniper Creek Springs, 1.1 miles southeast of No. 27.			do		
29	Biscuit Basin, 2.2 miles northwest of Old Faithful Inn:					
	Jewel Geyser	190		do	562	Erupts to height of 12–22 ft at intervals of 5–10 min. Ref. 637.
	Sapphire Pool (Soda Geyser)	201		do	562	Erupts to height of 4–12 ft at intervals of 10–20 min. Water is exceptionally clear. Ref. 637.
30	1.7 miles northwest of Old Faithful Inn, on northeast side of Firehole River:					
	Gem Pool			do		Water is clear and quiescent.
	Artemisia Geyser			do	562	Erupts to height of 15–35 ft at intervals of 24–30 hr. Ref. 637.
	Atomizer Geyser			do		Erupts to height of 20–40 ft once a day. Ref. 637.
30A	1.2 miles northwest of Old Faithful Inn, on northeast side of Firehole River:					
	Sentinel Geysers	201		do	562	2 geysers. Erupt to maximum height of 20 ft at intervals of 2–3 days. Ref. 637.
	Morning Glory Pool	171		do	562	Refs. 576, 677.
	Fan Geyser	198		do		Erupts to height of 6–100 ft two or three times a year. Refs. 637, 612.
	Mortar Geyser	198		do		Erupts to maximum height of 30 ft two or three times a year. Ref. 637.
	Riverside Geyser			do	562	Erupts obliquely to height of 80–100 ft at intervals of 6–9.5 hr. Refs. 637, 665.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Wyoming—Continued					
31	1 mile northwest of Old Faithful Inn, on southwest side of Firehole River:					
	Chain Lakes (Bottomless Pit) Geyser			Rhyolite (Tertiary)		Erupts to height of 35–75 ft at intervals of 2–3 weeks. Refs. 566, 637.
	Spa Geyser			do		Erupts rarely to maximum height of 50 ft. Ref. 637.
	Grotto Geyser			do		Erupts to height of 20–30 ft at intervals of 2–8 hr. Refs. 576, 644, 647, 651, 655, 660, 661, 677, 689.
	Grotto Fountain			do		Erupts to maximum height of 65 ft at intervals of 6–12 hr. Ref. 637.
	Daisy Geyser	198		do	562	Erupts obliquely to maximum height of 75 ft at intervals of 1.5–3 hr. Ref. 637.
	Splendid Geyser	200		do	562	Erupts rarely to height of 125–150 ft. Ref. 637.
	Giant Geyser	205		do	562	Erupts to height of 150–180 ft at intervals of 6–16 days; sometimes inactive for long periods. Refs. 574, 579, 637, 648, 649, 652, 655, 665, 672, 679, 689.
	Oblong Geyser	202		do	562	Erupts to height of 20–40 ft at intervals of 5–8 hr. Ref. 637.
32	0.5 mile north-northwest of Old Faithful Inn, on northeast side of Firehole River:					
	Grand Geyser			do	562	Erupts to height of 180–200 ft at intervals of 8–80 hr. Refs. 579, 637, 652, 663, 672.
	Turban Geyser			do		Erupts to maximum height of 25 ft simultaneously with nearby Grand Geyser. Refs. 645, 663.
	Sawmill Geyser			do	562	Erupts to height of 17–32 ft at intervals of 3 hr. Refs. 637, 652.
32A	0.3 mile north of Old Faithful Inn, on northeast side of Firehole River:					
	Lion (Niobe) Geyser	201		do		Erupts to height of 50–60 ft several times a day. Refs. 576, 637.
	Lioness Geyser	203		do	562	Erupts rarely to maximum height of 80 ft; sometimes inactive for long periods. Refs. 637, 645.
	Big Cub Geyser	201		do		Erupts rarely to maximum height of 30 ft; sometimes inactive for long periods. Refs. 637, 645.
	Little Cub Geyser			do		Ref. 645.
	Giantess Geyser	202		do	562	Erupts rarely to height of 150–200 ft; sometimes inactive for long periods. Refs. 579, 626, 637, 647, 652, 665, 672, 679, 689.
	Midget Geyser			do		Erupts rarely to maximum height of 30 ft. Ref. 637.
	Beehive Geyser			do	562	Erupts to height of 200–220 ft two or more times a week. Refs. 579, 637, 645, 647, 649, 652, 661, 664, 672, 689.
32B	Solitary Geyser, 0.6 mile north of Old Faithful Inn.	200		do	562	Erupts to maximum height of 25 ft at intervals of 2-6 min. Ref. 637.
33	Black Sand Basin, 0.8 mile west of Old Faithful Inn:					
	Cliff Geyser	190		do	562	Erupts to height of 40–50 ft once a day. Ref. 637.
	Whistle Geyser	149		do		Erupts infrequently to maximum height of 40 ft. Ref. 637.
	Rainbow Pool	151		do		Erupts to maximum height of 40 ft at irregular intervals; sometimes inactive for long periods. Ref. 637.
	Sunset Lake	169		do		Pool 45 yd in diameter.
	Emerald Pool	158		do		
33A	Castle Geyser, 0.4 mile northwest of Old Faithful Inn.			do	562	Erupts to height of 65–100 ft at intervals of 12–16 hr. Large deposit of sinter. Refs. 587, 617, 637, 644, 647, 648, 652, 655, 661, 665, 689.
34	Old Faithful Geyser, near Old Faithful Inn.			do	610	Erupts to height of 116–171 ft at intervals of 65 min. Large mound of gray sinter. Refs. 106, 563, 566, 576, 579, 590, 599, 617, 637, 648, 652, 659, 660, 677, 688, 689, 692.
34A	Pipeline Creek Springs, 0.5 mile southeast of Old Faithful Inn.			do	562	
35	1 mile west of Summit Lake and 7 miles west-southwest of Old Faithful Inn.			do		15 shallow, muddy springs. Deposit of sulfur. Ref. 561.
36	0.5 mile south-southeast of Summit Lake			do		
37	Lone Star Geyser, 2.7 miles south-southeast of Old Faithful Inn.			do		Erupts to maximum height of 25 ft at intervals of 20–180 min. Cone of geyserite 12 ft high. Refs. 587, 637.
38	Shoshone Geyser Basin, 7.5 miles south-southeast of Old Faithful Inn:					
	Bead Geyser			do		Erupts to height of 10–20 ft. Abundant "geyser eggs." Ref. 637.
	Lion Geyser			do		Erupts to height of 10–12 ft. Ref. 637.
	Little Giant Geyser			do		Erupts to height of 10–50 ft twice a day. Ref. 637.
	Minute Man Geyser			do		Erupts to maximum height of 20 ft at intervals of 1–3 min. Ref. 637.
	Union Geyser			do		3 cones erupting simultaneously several times a week. Maximum height of eruption is 66 ft for northern cone, 114 ft for center cone, and 3 ft for southern cone. Ref. 637.
39	Bechter River Springs, 12.5 miles south-southwest of Old Faithful Inn.			do		

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Wyoming—Continued					
40	Three River Junction Springs, near confluence of Phillips, Littles, and Ferris Forks of Bechter River.			Rhyolite (Tertiary)		
41	Tendoy Falls Springs, on Ferris Fork of the Bechter River.			do		
42	Near northwest shore of Lewis Lake	Hot				Large pools. Ref. 561.
42A	0.5 mile west of west shore of Lewis Lake	190–198	Small			Several springs. Ref. 561.
43	Near south outlet of Lewis Lake	154 (max)	Small			Do.
44	Deluge Geyser, near Witch Creek in Heart Lake Geyser Basin.			Rhyolite (Tertiary)		Erupts to height of 10–15 ft. Ref. 637.
44A	Spike Geyser, near Witch Creek in Heart Lake Geyser Basin.			do		Erupts almost continuously. Ref. 637.
45	Rustic Geyser, 0.25 mile west of north end of Heart Lake.	201		do		Erupts to maximum height of 30 ft at intervals of 26–90 min. Ref. 637.
46	Near confluence of Snake and Lewis Rivers, 0.5 mile north-northeast of South Entrance to Yellowstone National Park.	158 (max)		Limestone		
47	Snake Hot Springs, near the Snake River 5 miles upstream from confluence with Lewis River.	120–163		Limestone near rhyolite	562	Several groups of springs. Terraces of travertine. Refs. 561, 621.
48	Near mouth of Basin Creek, 3 miles south of Heart Lake.					
49	Near Snake River, 0.5 mile downstream from mouth of Basin Creek.			Rhyolite overlying limestone.		
50	Washburn Hot Springs, 1.8 miles southeast of Dunraven Pass Ranger Station.	178–198		Basaltic gravel or breccia	562	Several springs, including Inkpot Spring, and fumaroles in marshy area. Water from Inkpot Spring is black. Deposits of iron sulfide. Ref. 561.
51	Sulphur Creek Springs, 1.3 miles upstream from mouth of Sulphur Creek and 2 miles south-southeast of Dunraven Pass Ranger Station.			Rhyolite (Tertiary)		
52	Near mouth of Sulphur Creek, 3 miles south-southeast of Dunraven Pass Ranger Station.			do		
53	0.5 mile northeast of Inspiration Point, on both sides of Yellowstone River.			do		
54	Forest Springs, 1.2 miles east-southeast of Canyon Lodge at the Yellowstone River Falls.			do		2 large mudpots and several small springs. Ref. 561.
55	0.5 mile south of Norris-Canyon Road and 4 miles west-southwest of Canyon Ranger Station.			do		
56	Violet Springs, on tributary of Alum Creek 6 miles southwest of Canyon Ranger Station.	Hot	740	do	561, 562	Deposit of sulfur.
57	Highland Hot Springs, on tributary of Alum Creek 3.5 miles southwest of Violet Springs (No. 56) and 1.1 miles north-northeast of Mary Lake.			do	561, 562	
58	Alum Creek Springs, 2 miles east of Highland Hot Springs (No. 57).	194 (max)	Large	do		Ref. 561.
59	1 mile southeast of Highland Hot Springs (No. 57) and 1 mile northeast of Mary Lake.			do		2 springs, one rising in shallow basin and the other a small geyser. Ref. 561.
60	Elk Antler Creek Springs			do		
61	Sulphur Spring (Crater Hills Geyser), 1 mile west of Yellowstone River and 4 miles south of Canyon Ranger Station.	194	Small	do	562	Pool 20 ft in diameter; erupts to height of 5–6 ft at short intervals. Deposit of sulfur. Refs. 561, 576.
61A	Crater Hills Mudpots, on Lake-Canyon Road near mouth of Elk Antler Creek.			do		5 small mud pools. Ref. 561.
61B	Dragon's Mouth Spring, on Lake-Canyon Road 6 miles (by road) northwest of Fishing Bridge.	160		do	562	Pulsating pool of clear water. Ref. 561.
61C	{Mud Volcano, near Dragon's Mouth Spring (No. 61B).	185 (max)		do	562	Pool 30 ft in diameter. Ref. 561.
	{Mud Geyser			do		Erupts to maximum height of 12 ft every few sec. Ref. 561.
61D	Sulphur Caldron, on northeast side of Yellowstone River nearly opposite Dragon's Mouth Spring (No. 61B).			do		Pool. Water contains much sulfur in suspension. Ref. 637.
62	Near west shore of West Thumb of Yellowstone Lake, 2 miles north of Thumb Ranger Station.			do		
63	Near west shore of West Thumb of Yellowstone Lake, 1.5 miles north-northwest of Thumb Ranger Station.	200		do		
64	Near Thumb Ranger Station, on west shore of West Thumb of Yellowstone Lake:					
	Thumb Paintpots	200 (max)		do	562	Pools of pink and white mud. Also several small geysers. Refs. 561, 576, 637.
	King Geyser			do		Spouts to maximum height of 6 ft at irregular intervals. Refs. 561, 637.
	Lakeshore Geyser			do		Erupts to height of 15–25 ft at intervals of 35 min when lake level is low and at intervals of 2–4 days when submerged by lake water. Refs. 561, 637.
	Occasional Geyser			do		Erupts to height of 25–60 ft at irregular intervals. Refs. 561, 637.
	Twin Geysers			do		2 geysers erupting to height of 100–125 ft at intervals of 4–5 hr. Refs. 561, 637.
	Fishing Cone Spring, offshore from Thumb Paintpots.			do		Refs. 561, 637.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Wyoming—Continued					
65	Near Yellowstone River, 1 mile downstream from mouth of Lamar River.			Rhyolite (Tertiary)		
65A	Calcite Springs, in canyon of Yellowstone River 1 mile downstream from mouth of Tower Creek.	156–01		Breccia of andesitic and basaltic fragments.	562	Issue near veins of calcite and gypsum. Also fumaroles. Deposit of sulfur. Ref. 561.
66	Near Lamar River, 1 mile north-northwest of mouth of Cache Creek.			Rhyolite (Tertiary)		
67	Wahb Springs, in Death Gulch 2.2 miles upstream from mouth of Cache Creek.			do		Much Co_2. Ref. 637.
68	Near Deep Creek, 0.4 mile upstream from mouth of Shallow Creek.	Hot	100	do		Several springs. Ref. 561.
69	Near Deep Creek, 3 miles upstream from mouth of Shallow Creek.			do		Do.
70	Near Deep Creek, 4 miles upstream from mouth of Shallow Creek.			do		Do.
71	Near Deep Creek, 5 miles upstream from mouth of Shallow Creek.			do		Do.
72	Whistler Geyser, near west bank of Broad Creek 3 miles upstream from its mouth.	198		do	562	Erupts frequently. Ref. 637.
	Joseph's Coat Springs	Hot		do		Several springs. Scorodite deposited as coating on siliceous sinter. Refs. 609, 611, 620, 637, 702.
73	Near head of tributary to Broad Creek, 1.5 miles east of Whistler Geyser and Joseph's Coat Springs (No. 72).			do		
74	Near head of tributary to Broad Creek, 2 miles southeast of Whistler Geyser and Joseph's Coat Springs (No. 72).			do		
75	Hot Springs Basin, 1.5 miles north of Wapiti Lake.			do		Numerous fumaroles. Ref. 561.
76	Near tributary of Miller Creek, 2.7 miles northwest of Saddle Mountain.			do		
77	Near tributary of Lamar River, 2.6 miles west-southwest of Saddle Mountain.			do		
78	Near head of Moss Creek, 3 miles south-southwest of Whistler Geyser and Joseph's Coat Springs (No. 72).			do		
79	Bog Creek Springs, near head of Bog Creek, a tributary of Sour Creek.			do		
80	Head of unnamed tributary of Sour Creek, 1.5 miles northeast of Bog Creek Springs (No. 79).			do		
81	Along unnamed tributary of Sour Creek, 2 miles east of Bog Creek Springs (No. 79).			do		
82	Sour Creek Springs, 2.3 miles west of Fern Lake.			do		
83	Ponuntpa Springs, 0.6 mile southwest of Fern Lake.	113–180		do		Ref. 561.
84	Near east end of Fern Lake		Small	do		Do.
85	Near northwest end of White Lake	Warm	Small	do		Do.
86	Near southeast end of White Lake	Warm	Small	do		Do.
87	The Mudkettles, near Pelican Creek 1.5 miles east of southeast end of White Lake.			do		
88	The Mushpots, 1 mile southeast of the Mudkettles (No. 87).			do		
89	Near west end of Sulphur Hills, 1.8 miles south of Stonetop Mountain.	196		do		
90	Ebro Springs, 2.5 miles south-southwest of Stonetop Mountain.			do		
91	Vermilion Springs, near Pelican Creek, 2.3 miles south of Stonetop Mountain.			do		
92	Pelican Springs, at confluence of Pelican and Raven Creeks.			do		
93	Beach Springs, on shore of Mary Bay of Yellowstone Lake.			do		
94	Turbid Springs, near south end of Turbid Lake.	Hot	Small	do	562	Deposit of sulfur. Also boiling mud pots 0.5 mile west. Ref. 561.
95	Steamboat Springs, on northeast shore of Yellowstone Lake at Steamboat Point.	186–198		do	562	Also powerful steam vents. Ref. 576.
96	Butte Springs, on northeast shore of Yellowstone Lake, 1.5 miles southeast of Steamboat Point.	190 (max)	10	do	562	Several deep pools of clear water in area 300 yd long and 250 yd wide. Ref. 561.
97	DeMaris (Cody) Hot Springs, 4 miles southwest of Cody.	76–100		Deadwood Formation (Late Cambrian and Early Ordovician) or Tensleep Sandstone (Pennsylvanian and Permian).	137, 564, 598	Several springs. Deposit of sulfur. Resort and sanitarium. Refs. 144, 592, 594, 597, 703.
98	T. 55 N., R. 94 W., in Sheep Canyon of the Bighorn River near mouth of Five Springs Creek.	Warm		Folded Carboniferous or Triassic strata.		Several springs. Water used locally. Ref. 597.
99	T. 53 N., R. 94 W., near upper end of Black Canyon of the Bighorn River.	Warm	Small	Folded Carboniferous or Triassic strata.		Ref. 597.
100	Sec. 8, T. 48 N., R. 115 W., near the Snake River 2 miles south of boundary of Yellowstone National Park.	Hot	100	Lava (Tertiary) overlying shale (Cretaceous).		Refs. 144, 373, 564.
101	T. 39 N., R. 116 W., near the Snake River 4 miles downstream from mouth of Hobak River.	94	100	Chugwater Formation (Permian and Triassic) near fault.		Several springs. Water smells of sulfur. Used for bathing and irrigation.
102	Granite Hot Springs, in sec. 6, T. 39 N., R. 113 W.	110	360	Wasatch Formation (Eocene) near granite.		2 springs.
103	Near west bank of Salt River, 2.5 miles north of Auburn.	68–140	38	Limestone (Triassic or Jurassic).	676	Many springs. Water is salty. Deposit of tufa. Ref. 144.
104	Sec. 2, T. 38 N., R. 110 W., on the Green River near Wells.	Warm	Large	Limestone (Carboniferous)		6 springs.

Thermal springs and wells in the United States (excluding Alaska and Hawaii)—Continued

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	References on chemical quality	Remarks and additional references
	Wyoming—Continued					
105	T. 32 N., R. 107 W., near Fremont Butte.	Hot	Small	Granite		Water used for bathing. Ref. 514.
106	Near Warm Spring Creek 4 miles northwest of Dubois.	84 (max)		Tertiary strata overlying limestone (Carboniferous).		Several springs. Deposit of tufa. Refs. 144, 442.
107	Near mouth of Little Warm Spring Creek, 3 miles southwest of Dubois.	68		Carboniferous strata near granite.		Do.
108	Fort Washakie Hot Springs, in sec. 2, T. 1S., R. 1 W., 24 miles west of Riverton.	110	2,000	Chugwater Formation (Permian and Triassic).	137, 564	Several springs rising in deep pools. Resort. Refs. 126, 144, 592, 594, 646.
109	T. 30 N., R. 97 W., 4 miles southwest of Hailey.	100–120	100	do		Several springs. Water smells of H_2S. Used for irrigation. Refs. 144, 564, 594, 623.
110	T. 29 N., R. 96 W., near Sweetwater River 12 miles southwest of Myersville.	Warm		Sandstone (Oligocene)		Several springs. Water used locally. Ref. 623.
111	Big Horn (Thermopolis) Hot Springs, on the Bighorn River at Thermopolis.	135	>12,600	Tensleep Sandstone (Pennsylvanian and Permian).	137, 575, 585, 597, 598.	1 large spring and several small springs. Large deposit of tufa. Resort. Refs. 126, 144, 148, 564, 577, 586, 592, 638, 646, 704.
111A	3.5 miles northwest of Thermopolis, near sulfur deposits.	Hot	Small	Red beds (Triassic)		Deposits of tufa and sulfur. Flow formerly much greater. Ref. 704.
112	Sec. 35, T. 32 N., R. 86 W., on Horse Creek near Independence.	Warm	Large	Oligocene strata near Chugwater Formation (Permian and Triassic).		Several springs. Water used locally. Refs. 144, 623.
113	Alcova Hot Springs, in T. 30 N., R. 83 W., in Fremont Canyon of the North Platte River.	139	75	Faulted Upper Cretaceous strata.	564	Several springs. Resort. Refs. 144, 623.
114	T. 31 N., R. 71 W., near the North Platte River 9 miles south of Douglas.	Warm		Folded Oligocene strata		Water used for bathing and irrigation. Ref. 564.
115	Saratoga Hot Springs, in T. 17 N., R. 84 W.	120	10	Sandstone (Tertiary)	564	6 springs. Resort. Ref. 144.
116	10 miles northwest of Laramie	74		Faulted Mesaverde Group (Late Cretaceous).		Refs. 124, 144.

Although Alaska and Hawaii have recently been admitted as States, their geographic separation from the 48 conterminous States warrants their consideration here as separate entities. Alaska may be divided broadly into five geographic provinces: (1) the Pacific mountain region, which includes the coastal mountain ranges and islands of the southeastern "panhandle," the Alaska Range and subsidiary ranges in the southern part of the State, and the southwestern extension consisting of the Alaska Peninsula and the Aleutian Islands; (2) the Central Plateau region, which is mostly within the basins of the Yukon and Kuskokwim Rivers; (3) the Rocky Mountain region, embracing subsidiary ranges in the northern part of Alaska; (4) the Arctic Mountain region, consisting of the Brooks Range and subsidiary ranges, all nearly parallel with the Arctic coast; (5) the Northern Plateau, which descends to a broad coastal plain that extends north to the Arctic Ocean.

The thermal springs in the southeastern part of Alaska are generally associated with shear zones in granitic rocks which are present as batholiths or intrusives of Mesozoic or later ages in the Coast Ranges. Few hot springs are known in the Alaska Range and other ranges in the southern part of the main area, although the rocks of that region are intensely folded and faulted. Nearly all the known hot springs in the Alaska Peninsula and Aleutian Islands are associated with volcanic rocks, and most of them are near volcanoes that are still active.

Several thermal springs in the Yukon River basin are in three general areas: between Circle and Fairbanks; the Hot Springs-Rampart area; and north of the Yukon, between Ruby and Fort Hamlin. These are areas of intrusive granitic rocks, of Mesozoic and possibly later age, fractured by post-Eocene movements. On the Seward Peninsula are also several hot springs in areas of intrusive rocks of Mesozoic or Tertiary age. Although Quaternary volcanic rocks are present at numerous places in the Yukon River basin and Seward Peninsula, no thermal springs seem to be associated with these rocks.

Information concerning the various thermal springs is given in the table below. The locations of the springs and volcanoes are shown on figure 9.

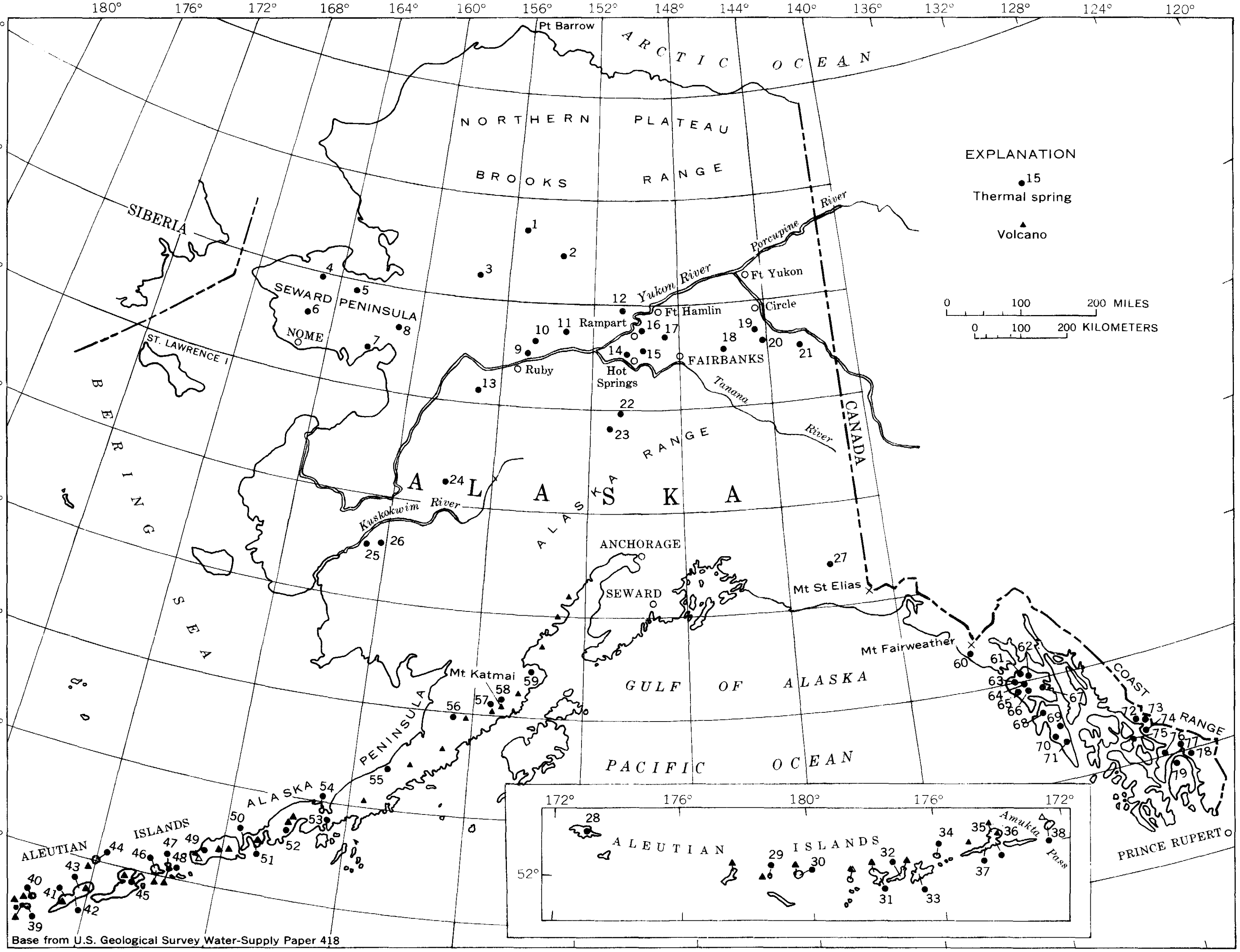


FIGURE 9.—Alaska showing location of thermal springs and volcanoes. Springs from ref. 178; volcanoes from ref. 172.

Thermal springs in Alaska

[Data chiefly from refs. 172 and 178. Principal chemical constituents are expressed in parts per million]

No. on fig. 9	Name or location	Temperature of water (°F)	Flow (gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Near head of Reed River	100				Probably schist	Pool 20 ft in diameter. Small deposit of tufa. Ref. 176.
2	On upper course of Alatna River.	Warm	Large			Paleozoic schist and limestone.	Numerous springs near river channel.
3	Near head of Selawik River	Warm				Probably Mesozoic or older strata.	
4	Arctic, on Hot Springs Creek	150	10			Probably granite intrusive in gneiss.	Several springs issuing along creek for distance of 0.5 mile. Small amount of H_2S. Large mounds of tufa. Bath cabin. Refs. 154, 165.
5	Near Inmachuk River	100	Large			Crystalline limestone	Ref. 170.
6	Kruzgamepa, 70 miles north of Nome.	100; 156	8	[1] 5,955	SiO_2 (87); Ca (545); Na (1,587); K (61); SO_4 (25); Cl (3,450); small amount of free H_2S.	Alluvium overlying granite.	2 main springs; also much seepage. Small deposit of salt. Water used for bathing and irrigation. Ref. 165.
7	Near Kwiniuk River	Hot				Probably Paleozoic strata	2 small groups of springs. Free H_2S.
8	On tributary of Sweepstake Creek.	Hot				do	
9	Horner, 0.75 mile north of Yukon River.	86–120	45	[2] 292	SiO_2 (29); Na+K (58); HCO_3 (22); CO_3 (32); SO_4 (45); Cl (39); small amount of free H_2S.	Fractured granite	1 main and 7 smaller springs. Temperature of water from main spring, 117°F. Water used for domestic supply and irrigation.
10	Melozitna, 16 miles north of Kokrines.	131	130	442	SiO_2 (78); Na+K (107); SO_4 (61); Cl (92); small amount of free H_2S.	Granite, probably intruded into Paleozoic strata.	Issues on creek bank. Small deposits of tufa and sulfur. Bath cabin.
11	Little Melozitna, 27 miles north of Hub roadhouse.	82–99.5	60	[1] 350	SiO_2 (80); Na; HCO_3; Cl; free CO_2, H_2S.	Granite intrusive in schist	Main and 4 smaller springs. Water from main spring is hottest. Bathing pool.
12	On Ray River, 35 miles above its mouth.	130				Granite intrusive	Free H_2S. Water used for bathing and irrigation.
13	On tributary of Innoko River.	Hot	Moderately large			Probably Mesozoic strata	
14	Baker, near north bank of Tanana River.	101–136	145	417	SiO_2 (59); Na (121); HCO_3 (86); SO_4 (48); Cl (120).	Granite intrusive	3 springs. Analysis is for water having temperature of 125°F. Water used for bathing and irrigation.
15	Hutlinana, 8.5 miles east of Eureka post office.	114	50	634	SiO_2 (44); Na+K (208); HCO_3 (494); SO_4 (67); Cl (38); free CO_2.	Lower Cretaceous quartzite.	Bathing pool; cabins.
16	Near Little Minook Creek	Hot	Small			Granite, probably intruded into Paleozoic strata.	
17	Near Tolovana River	130	Small			Granite intrusive in schist	Water tastes alkaline. Free CO_2, H_2S.
18	Chena, 62 miles east-northeast of Fairbanks.	72–153	220	338	SiO_2 (77); Na+K (94); HCO_3 (118); SO_4 (78); free H_2S.	do	10 main springs. Analysis is for water having temperature of 149°F. Water used for bathing and irrigation.
19	42 miles southwest of Circle	100–134	130	[1] 813	SiO_2 (82); Na (248); HCO_3 (173); SO_4 (98); Cl (252); free CO_2.	do	11 main springs. Small deposits of tufa, sulfur, alum. Water used for bathing and irrigation.
20	On Big Windy Creek, in canyon.	Hot	Moderately large			Granite intrusive	2 main and several smaller springs. Free H_2S.
21	On upper Flat Creek	Warm				Schist	
22	About 20 miles north of Glacier.	Warm				Gravel, probably overlying granite.	Supplies pool which does not freeze over in winter.
23	About 8 miles west of Glacier.	Warm				Quaternary gravel overlying gneiss.	Do.
24	On Otter Creek, 10 miles southeast of Iditarod.	Warm				Granite, at contact with slate.	Several springs; flow all winter. Iron oxide stains on rocks.
25	Near Tuluksak River, in Whitefish Lake area.	Hot				Probably granite intrusive in Cretaceous strata.	Several springs. Free H_2S.
26	Near head of Ophir Creek, in Whitefish Lake area.	150	Large			Granite intrusive in Carboniferous volcanic tuff.	Small amount of free H_2S. Water used for bathing. Large mound of siliceous sinter 13.5 miles farther southeast marks site of former thermal springs.
27	On Twelvemile Creek	Hot				Altered Paleozoic strata	
28	Attu Island	Warm				Lava	Water rises in pools. Ref. 177.
29	Little Sitkin Island	Hot				do	Near solfataric volcano. Ref. 171.
30	Semisopochnoi (Semiseisopochnoi) Island.	Hot				do	Ref. 171.
31	At Hot Springs Bay on Tanaga Island.	Hot				do	Ref. 172.
32	At base of volcano on Kánaga Island.	[3] 219				do	Hot springs and fumaroles. Water used for cooking food. Refs. 160, 166.
33	Near White volcano on Adak (Adakh) Island.	Hot				do	Refs. 155, 160, 166, 171.
34	Great Sitkin Island	190–208				do	12 main springs, also mud pots and fumaroles, at altitude of 2,000 ft. Refs. 153, 171, 173.
35	Near Conical volcano on Atka (Athka) Island.	Hot				do	Mud pools, some boiling. Water is sulfurous. Ref. 155.
36	Near Kliuchef volcano on Atka (Athka) Island.	Hot				do	Ref. 160.
37	About 5 miles from Koróvin Bay on Atka (Athka) Island.	167				do	Ref. 155.
38	Seguam Island	Hot				do	Springs and hot mud pools. Ref. 160.
39	At base of volcano on Chuginadak Island.	Hot				do	Ref. 160.
40	Kagamil Island	Hot				do	Springs and fumaroles. Ref. 160.

See footnotes at end of table.

Thermal springs in Alaska—Continued

No. on fig. 9	Name or location	Temperature of water (°F)	Flow (gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
41	Northeast of Vsevidof volcano on Umnak Island.	43–68	52,000			Lava	16 springs, including 1 geyser; also fumaroles. Water contains as much as 159 ppm of B_2O_3. Refs. 83, 153, 171.
42	Central part of Umnak Island.	214		1,377	SiO_2 (150); Ca (39); Na (350); HCO_3 (29) SO_4 (130); Cl (483); B_2O_3 (157).	do	Small geyser.
43	Near Hot Springs Cove on Umnak Island.	95–215		2,282	SiO_2 (88); Ca (164); Na (606); HCO_3 (67); SO_4 (88); Cl (1,133); B_2O_3 (92).	do	28 springs, including several small geysers. Analysis is for water having temperature of 192°F. Ref. 153.
44	Bogoslof and New Bogoslof Islands.	Hot				do	Intermittent and steady jets of steam from many vents. Refs. 156, 157, 160, 169, 175, 177.
45	Makushin volcano on Unalaska (Unalashka, Oonalashka) Island.	94				do	Several springs. Solfataras in the crater. Refs. 155, 160, 166, 168, 171.
46	Akutan Island, including springs at head of Long Creek and in Hot Springs Bay valley.	[3] 181		[1] 952	SiO_2 (129); Ca (10); Na (288); HCO_3 (192); SO_4 (39); Cl (350); B_2O_3 (36).	Lava	Several springs and steam vents. Refs. 152, 155, 159, 171.
47	Islet northwest of Akutan Island.	Hot				do	Ref. 160.
48	Islet southeast of Akutan Island.	Hot				do	Several springs issuing on beach between tide levels. Ref. 155.
49	Near Pogromni volcano on Unimak Island.	Hot				do	Many springs; also hot marshes. Refs. 160, 166.
50	Near Morzhovoi (Morshevoi) village.	Hot				do	Water is sulfurous. Refs. 160, 171.
51	Amagat Island, near Morzhovoi Bay.	Hot				do	Refs. 155, 160, 166.
52	Near Pavlov volcano	140	Large			do	Several main springs; also fumaroles on southwest slope of Mount Hague.
53	Near Balboa Bay	Hot					Ref. 160.
54	Port Moller	150–180				Recent lava overlying limestone.	1 main and several minor pools. Water tastes alkaline. Much free gas. Refs. 160, 166.
55	Near Port Heiden	Hot				Probably Cretaceous strata.	Water issues near shore.
56	Southwest shore of Becharof Lake near base of Mount Peulik.					Jurassic sandstone probably intruded by lava.	
57	Near Katmai Pass	Hot	Large			Lava	Much free H_2S. Deposits of ocher and sulfur. Refs. 161, 174.
58	Near Mount Katmai, including those in Valley of Ten Thousand Smokes.	Hot				Lava and tuff	Several springs and many fumaroles. Refs. 119, 151, 158, 161, 163, 164, 182, 183.
59	West Fork of Douglas River, 25 miles west of Cape Douglas.	Hot	Large			Jurassic strata	
60	Near shore of Lituya Bay	Warm				Tertiary strata	
61	Near head of Mud Bay	Hot				Paleozoic strata	
62	Near Nika Bay	Hot				do	
63	North shore of Lisianski Inlet.	Hot				do	
64	4 miles above head of Tenakee Inlet.	81–179	10	[1] 592	SiO_2 (119); Na (137); SO_4 (226); Cl (33); free H_2S.	Diorite intrusive in granite.	12 springs issuing near creek Small deposits of tufa.
65	Hooniah, 75 yd from shore	84–111	30	[1] 276	SiO_2 (96); Na + K (59); HCO_3 (18); CO_3 (25); SO_4 (35); Cl (42); small amount of free H_2S.	Schist	3 springs. Water used for bathing.
66	Near North Arm of Peril Strait.	101–103	3	[4] 786	Na (206); SO_4 (329); Cl (133)	Fractured diorite	4 main springs issuing on shore between low and high tide levels.
67	Tenakee, on north shore of Tenakee Inlet.	56–106	22	[1] 787	SiO_2 (94); Na (201); SO_4 (302); Cl (99); free CO_2, H_2S.	Granite intrusive in gneiss	10 main springs. Bathing resort. Ref. 180.
68	3 miles east of head of Fish Bay.	62–117	25	[1] 393	SiO_2 (110); Na + K (69); HCO_3 (43); CO_3 (63); B_4O_7 (34); small amount of free H_2S.	Faulted schist	24 springs issuing along bank of small creek. Water used for bathing.
69	Baranof	60–122	80	[1] 268	SiO_2 (96); Na + K (58); HCO_3 (93); SO_4 (49).	Faulted granite and diorite.	9 springs. Bathhouses; cabins. Ref. 180.
70	Sitka, near shore 16 miles south of Sitka.	95–149	13	[1] 4,877	SiO_2 (96); Ca (378); Na (1,440); SO_4 (88); Cl. (2,745); free H_2S.	Granite cut by diabase dikes.	3 main springs, 124°–149°F. Bathing resort. Ref. 166, 180.
71	Near north side of Gut Bay	Warm				Paleozoic limestone and schist.	Water is sulfurous.
72	North side of Stikine River, 18 miles northeast of Wrangell.	Hot	Small			Alluvium overlying intrusive granite.	
73	Shake's, 20 miles northeast of Wrangell.	[3] 125	100	[1] 409	SiO_2 (108); Na (87); HCO_3 (43); SO_4 (142).	Granite	Several springs. Bathhouse.
74	South side of Stikine River, 8 miles north of Wrangell.	Hot	Small			Probably Paleozoic strata, near granitic batholith.	
75	South end of Vank Island, 8 miles west of Wrangell.	Hot				do	Issues on beach between low and high tide levels.
76	Bailey Bay	145–191	83	413	SiO_2 (142); Na + K (54); HCO_3 (27); CO_3 (52); small amount of free H_2S.	Granite	9 main springs. Analysis is for water having temperature of 186°F. Water used for bathing. Ref. 180.
77	North bank of Unuk River	Warm	Small			do	Ref. 181.
78	5 miles southeast of Saks Cove.	150	10			do	
79	Bell Island	109–162	10	[1] 674	SiO_2 (105); Na + K (201); SO_4 (129); Cl (188); small amount of free H_2S.	Granite cut by pegmatite dikes.	Temperature of water from 5 main springs ranges from 125° to 162°F. Bathhouse.

[1] Hottest.
[2] Main spring.
[3] Maximum.
[4] Coolest.

The eight main islands and several smaller islands that constitute the State of Hawaii are composed almost entirely of volcanic materials, overlain in a few places by deposits of coral limestone and alluvial material. Active volcanism is limited to the largest and easternmost island, Hawaii, which includes the great volcanic craters of Kilauea and Mauna Loa, both of which erupt occasionally with the outpouring of molten lava. Because the volcanic materials of all the islands are largely fragmental and porous, the water table is, in most places, only a few feet above sea level and springs are not common.

The location of thermal springs and wells is shown on figure 10, and information concerning them is presented in the table below.

Thermal springs and wells in Hawaii

[All issue from or tap Tertiary or Quaternary lava]

No. on fig. 10	Name or location	Temperature of water (°F)	Remarks and references
	Maui County		
1	West part of Molokai Island.	93	Drilled well. Water contains Ca (393 ppm), Mg (395 ppm), Na+K 820 ppm), HCO_3 (44 ppm), Cl (2,890 ppm). Ref. 359.
2	Mouth of Ukumehame Canyon on Maui Island.	95	Drilled well. Ref. 357.
	Hawaii County		
1	On shore at Kawaihae	Warm	Ref. 347.
2	Near shore at Kailua	Warm	Water vapor but no definite flow. Deposit of Glauber salt ($Na_2SO_4 \cdot 10H_2O$). Ref. 347.
3	In and near crater of Mauna Loa volcano.	Hot	Steam issuing from crevices. Incrustations of sulfur. Refs. 347, 348, 358.
4	Crater of Kilauea volcano.	Hot	Steam issuing from crevices on north edge; used as vapor baths. Also solfataras in bottom of crater. Refs. 345, 346, 348–351, 353–355, 358.
5	0.5 mile northwest of Puu Kukae.	83	Small spring-fed pool at foot of fault scarp. No outflow. Ref. 350 and personal communication from G. A. Macdonald to G. A. Waring (1950).
6	Near north base of Puu Kukae hill.	84	Small flow. Ref. 350.
7	On shore 3 miles south of Kapoho.	91	Do.
8	Near Waiwelawela Point	Warm	Small flow. Probably on southwest rift zone of Kilauea volcano. Refs. 350, 356, and personal communication from G. A. Macdonald to G. A. Waring (1950).

OTHER NORTH AMERICAN COUNTRIES

CANADA

More than half the area of Canada slopes gently to Hudson Bay, but the two main streams of the country have other outlets. The St. Lawrence River flows northeastward to the Atlantic Ocean, and the MacKenzie River flows northwest to the Arctic Ocean. Most of the eastern part of Canada is within the great region of Precambrian rocks known as the "Canadian Shield." Farther west the broad plains are underlain by gently dipping Paleozoic and Mesozoic strata which rise through foothills to the Rocky Mountains, where the strata are upthrust, faulted, and folded, and the underlying granitic and metamorphic rocks are exposed. In the western Coast Ranges the rocks are largely granitic and metamorphic. These are overlain by ancient sedimentary strata in many areas.

No thermal springs have been recorded in eastern Canada; a number are present in the southwestern part of the country, where they seem to be associated chiefly with faults in ancient sedimentary strata or with fissures and fractures in the granitic and metamorphic rocks.

Data on the thermal springs are presented in the table below. The locations of the springs are shown on figure 11.

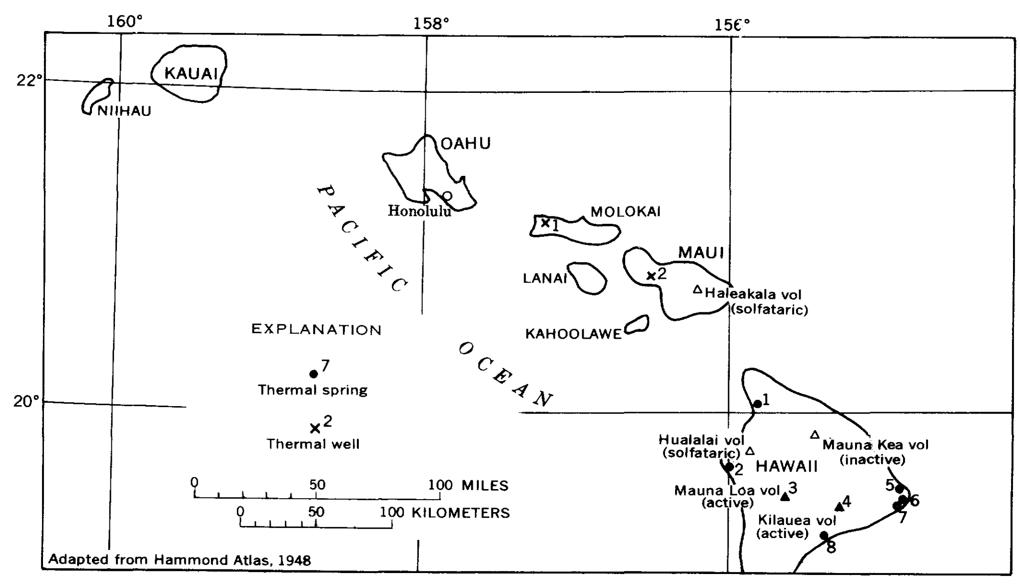


FIGURE 10.—Hawaii showing location of thermal springs and thermal wells. From refs. 347, 350, and 357–359.

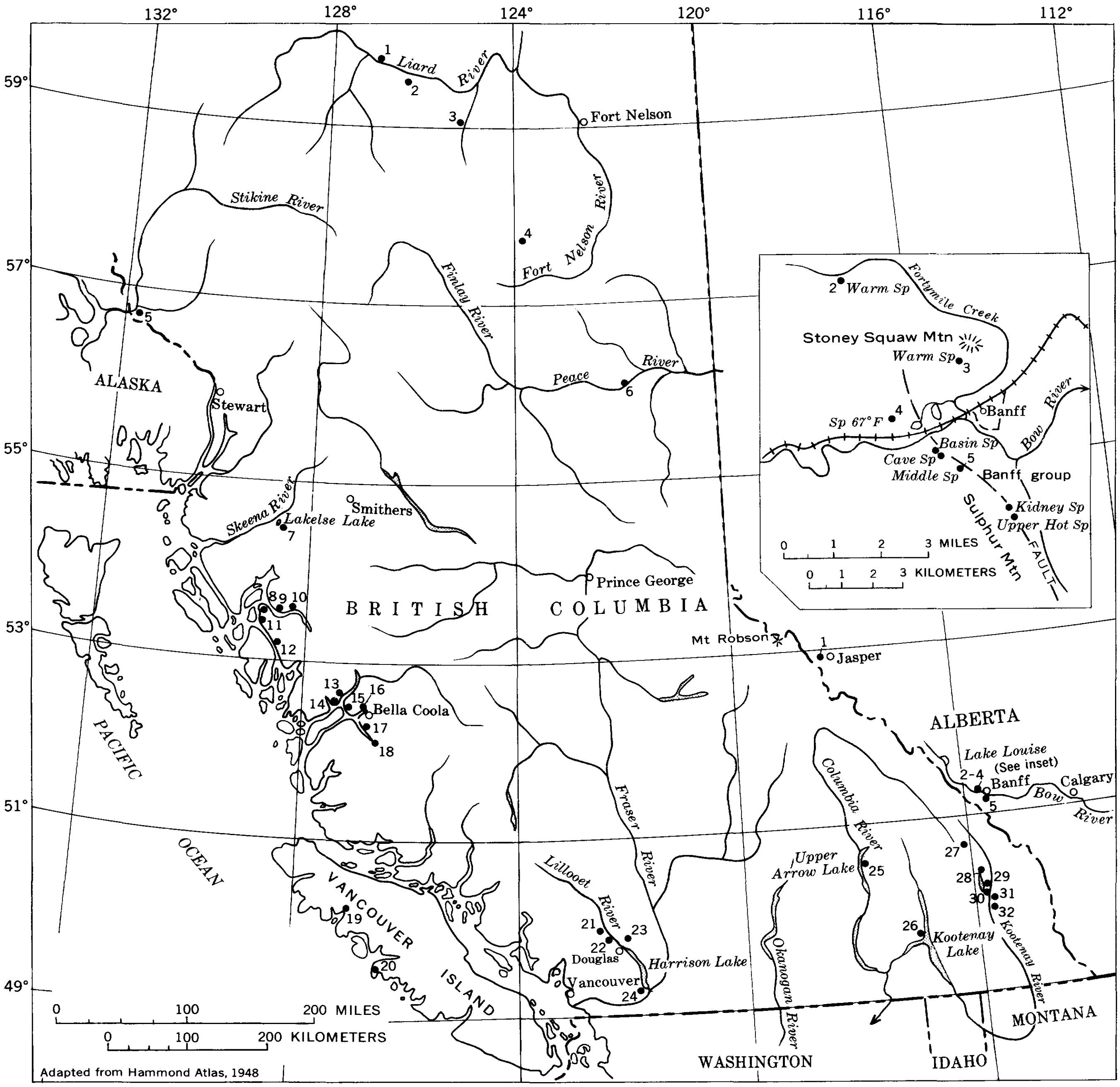


FIGURE 11.—Part of southwestern Canada showing location of thermal springs. Chiefly from refs. 711 and 712.

Thermal springs in Canada

[Data chiefly from refs. 711, 712. Principal chemical constituents are expressed in parts per million]

No. on fig. 11	Name or location	Temperature of water (°F)	Flow (imperial gallons per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
					Alberta		
1	Jasper (Miette), on Sulphur Creek, 10 miles from Jasper Park Station.	70-120		503; 1,825	Ca, SO_4; free H_2S.	Paleozoic strata.	6 main springs. Resort. Refs. 708, 709.
2	Bank of Fortymile Creek, 4 miles northwest of Banff.	Warm	Small			Upper Banff Shale (Mississippian).	Ref. 723.
3	Near south base of Stoney Squaw Mountain, 2 miles north of Banff.	Warm	Small			Pennsylvanian strata.	Do.
4	Auto Road, near Vermillion Lake, 3 miles northwest of Banff.	67	100	434	Ca (95); Mg (23); HCO_3 (155); SO_4 (147); Cl (42).	Upper Banff Limestone (Mississippian).	Refs. 710, 722, 723.

Thermal springs in Canada—Continued

No. on fig. 11	Name or location	Temperature of water (°F)	Flow (imperial gallons per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
					Alberta—Continued		
5	Banff:						
	Basin, near valley floor	94	150	1,905	Ca (400); Mg (71); HCO_3 (175); SO_4 (1,120); gas, 97 percent N_2.	Triassic strata faulted against Devonian limestone.	Piped to bathhouse. Refs. 710, 711, 722, 723.
	Cave, near valley floor	85	250	1,107	Ca (217); Mg (39); HCO_3 (140); SO_4 (580); gas, 97 percent N_2.	do	Refs. 710, 711, 722, 723.
	Kidney, on northeast flank of Sulphur Mountain.	101	20	1,064	Ca (230); Mg (39); HCO_3 (154); SO_4 (587).	do	Piped to swimming pool. Refs. 710, 711, 722, 723.
	Middle, on northeast flank of Sulphur Mountain.	92	100	1,059	Ca (228); Mg (39); HCO_3 (128); SO_4 (610); gas, 97 percent N_2.	do	Issues in small cave. Refs. 710, 711, 722, 723.
	Upper Hot, on northeast flank of Sulphur Mountain.	115	130	1,098	Ca (239); Mg (40); HCO_3 (133); SO_4 (634); gas, 98 percent N_2.	do	Piped to bathhouse. Refs. 710, 711, 722, 723.
					British Columbia		
1	North bank of Liard River, 2 miles below mouth of Coal River.	Warm	Small				Ref. 717.
2	Bank of Liard River, 1 mile northwest of bridge on Alcan Road.	121–125		1,195 (hottest)	SiO_2 (57); CaO (292); MgO (68); SO_3 (505); Cl (23).		Water issues in tufa-lined basins. Refs. 717, 724.
3	West bank of Toad River, 1.5 miles above its junction with Racing River; 8 miles from Alcan Road.	Hot					About 15 springs. Refs. 717, 720, 724.
4	South bank of Prophet River, 35 miles west of Alcan Road	Hot					Several springs. Deposits of tufa Ref. 717.
5	East side of Stikine River, nearly opposite Great Glacier.	120–150	700	800	$CaSO_4$ (202); Na_2SO_4 (154); NaCl (423).	Fractured schist and granite.	18 main springs. Ref. 714.
6	North bank of Peace River at Hudson Hope.	Hot					Several springs. Large deposits of tufa. Ref. 717.
7	0.5 mile east of southeast corner of Lakelse Lake and 10 miles south of Terrace.	185					Several springs; probably the hottest in Canada. Resort. Ref. 718.
8	West side of Bishop's Cove on Ursula Channel.	112				Fissured quartz diorite	Ref. 707.
9	Near Gardiner Canal, 12 miles above Desolation Channel.	112	Small			Schist	Do.
10	Near southeast bank of Brim River, 200 yd above mouth of river.	100				Fissured quartz diorite	Do.
11	Shore of Ursula Channel	112	Small			do	Do.
12	Head of Klekane Inlet	112		8,640	Na, Cl	do	Do.
13	Shore of Nascall Bay	Warm					Several springs.
14	Shore of Eucott Bay on west side of Dean Channel.	130		192	SO_4	Fissured quartz diorite	Ref. 707.
15	Shore of Brynildsen Inlet on Labouchere Channel.	Warm					
16	Northwest of Bella Coola	Warm					Several springs.
17	Shore of South Bentinck Arm, 25 miles south of Bella Coola.	Warm	Large			Fissured quartz diorite	Water used for bathing. Ref. 707.
18	Head of South Bentinck Arm.	Warm					Ref. 707.
19	1 mile from Fair Harbour on Kyuguot Sound, Vancouver Island.	Hot					Several springs. Ref. 706.
20	Sharp Point, between Sydney Inlet and Refuge Cove, west side of Vancouver Island.	125	100	483	SO_4 (47); Na (137); Cl (217)	Fractured diorite	May be mixed with sea water. Refs. 706, 713.
21	Skookumchuck, 20 miles northwest of Douglas.	130		1,280	Ca (169); Na (119); SO_4 (413); Cl (338).		
22	Bank of August Jacob's Creek, 11 miles northwest of Douglas.	120	Small	367	Ca (32); Mg (41); SO_4 (162); Cl (39).	Metamorphic rock	
23	Bank of Sloquet Creek, 10 miles above junction with Lilooet River.	160	Large	742	Ca (94); Na (108); SO_4 (360); Cl (63).	Sedimentary strata (Jurassic?).	
24	Harrison, near south end of Harrison Lake.	140; 145		1,285; 1,367	Ca, Na, SO_4, Cl	Fractured ancient sedimentary rocks.	2 main springs. Water is radioactive. Resort.
25	Halcyon, on east shore of Upper Arrow Lake.	120–128		788	Ca (57); Na (161); HCO_3 (48); SO_4 (433).	Gneiss	3 main springs. Water is radioactive. Resort; sanatorium. Ref. 716.
26	Ainsworth, on west shore of Kootenay Lake.	101.5 (max)	60	1,766	Ca (150); Na (290); HCO_3 (1,144).	Metamorphosed sedimentary and volcanic rocks.	Several springs. Large deposit of tufa. Resort. Ref. 721.
27	Radium (Sinclair)	114–116	330	696	Ca (140); HCO_3 (216); SO_4 (306).	Fractured Jubilee Formation (Cambrian).	Several springs. Water is strongly radioactive. Resort. Ref. 705.
28	Fairmont, 1.5 miles northeast of north end of Columbia Lake.	86–113		1,218	Ca (228); Mg (75); HCO_3 (230); SO_4 (570).	Cambrian(?) strata	2 main springs (91° and 113°F) and 4 smaller springs. Analysis is for water having temperature of 91°F. Water is radioactive. Deposits of tufa. Resort. Ref. 705.
29	Bedrock, on west bank of Kootenay River 9.5 miles northeast of Canal Flats.	Warm	Small			do	Extensive deposits of tufa. Probably several springs.
30	East shore of Columbia Lake, 2 miles north of Canal Flats.	Warm	Small			Jubilee(?) Formation (Upper Cambrian).	Do.
31	Bank of Lussier (Sheep) River, 11 miles east-southeast of Canal Flats.	108 (max)				Beaverfoot Limestone (Upper Devonian).	Several springs. Water is sulfurous. Used for bathing. Ref. 715.
32	Bank of Ram Creek, 13 miles southeast of Canal Flats.	90–100				Jubilee Formation (Upper Cambrian).	Many small springs. Deposit of tufa. Water is alkaline. Ref. 715.

MEXICO

The main part of Mexico consists of a great plateau region bordered on the east and west by mountain chains and comparatively narrow bands of lowland between the mountains and the coasts. In the northwest a chain of barren mountains traverses nearly the entire length of Baja California. These mountains have steep eastern slopes but a gentler descent to the Pacific coast on the west. In southeastern Mexico there is a detached mountain region, but in the extreme southeast the greater part of Yucatan consists of low sandy plains. In the main plateau region the Valley of Mexico near Mexico City and the Bolson de Mapimi in the States of Chihuahua and Coahuila, are floored by deposits of former lakes, of which many small lakes and marshy lagoons are remnants.

Most of the eastern and central parts of the plateau region are underlain by Cretaceous strata. In western Mexico much of the upland region is covered by Tertiary volcanic rocks, which also extend nearly to the east coast in the southern part of the plateau region. Farther south much of the upland is of ancient crystalline rocks. Marine Tertiary strata form bands along much of both coasts and along a large part of Baja California.

Popocatepetl volcano southeast of Mexico City, and several other great volcanic peaks, are along a nearly east-west line.

Some of the craters are still semiactive. The new volcano of Parícutin, which began to develop in February 1943, is in the western part of this band, about 60 km northwest of Jorollo volcano, which developed in a similar way beginning in September 1759.

Most of the thermal springs of Mexico seem to be concentrated in or near the middle part of the principal band of volcanic activity, which extends westward across the country from Orizaba volcano 120 km west of Vera Cruz.

The table below is a summary of the available data on thermal springs in Mexico. The locations of the springs and the principal volcanoes are shown on figure 12.

Thermal springs and wells in Mexico

[Data chiefly from ref. 744. Principal chemical constituents are expressed in parts per million]

No. on fig. 12	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Aguascalientes						
1	Ojo Caliente (Cantera), 4 km southwest of Aguas Calientes.	28–30	Moderately large				Several springs. Water used for bathing. Refs. 732, 750.
2	In valley east of Aguas Calientes.	40					Refs. 727, 750.
	Baja California						
1	East border of Laguna Salada (Laguna Maquata).	44–53	Moderately large	24, 890	$CaSO_4$ (5,222); NaCl (21,960)	Alluvium	Several springs. Ref. 746.
2	West side of Volcano Lake, at base of Cerro Prieto.	42–77	Moderately large			do	Several springs and mud volcanoes in northwest-trending band 1 mile long and 0.5 mile wide. Refs. 746, 759, 770.
3	Volcan, 8 km east of El Marmol onyx quarries.	Warm	Small				Several springs in ravine. Large deposits of tufa. Ref. 768.
	Chihuahua						
1	Ojo Caliente	Warm	Moderately large			Phonolite	Issues at base of hill. Refs. 740, 784.
2	Several km north of Llanos	Hot	Moderately large				Ref. 740.
3	6.5 km east of Santa Rosalia	Hot	Moderately large				6 springs issuing at base of bluff. Water is sulfurous. Used for bathing. Ref. 749.
	Colima						
1	Barcena volcano, on San Benedicto Island.	Hot				Recent lava	Many steam fumaroles produced by eruption in August 1952. Refs. 754, 769.

Thermal springs and wells in Mexico—Continued

No. on fig. 12	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
				Durango			
1	Near Agua Caliente railway station.	Warm					
				Guanajuato			
1	Comanjilla, 20 km west of Guanajuato.	104 (max)	Moderately large			Decomposed fractured granite.	Group of spouting springs and several small geysers, including Geyser Humboldt. Large amount of H_2S. Deposits of sinter and opaline silica. Refs. 727, 771.
2	Aguas Buenas, 20 km southeast of Comanjilla.	45 (max)	Moderately large	High	SiO_2; Na_2SO_4; free H_2S	Tertiary conglomerate faulted against Triassic slate; near basalt and andesite.	Several springs. Deposit of siliceous sinter. Water used for bathing. Refs. 727, 771.
3	Tupataro, 50 km west of Salamanca.	Warm				Lava	Water used locally. Ref. 771.
4	San Gregorio, 14 km northwest of Cuitzeo de Abasolo village.	Tepid	Large	960	SiO_2 (79); Na_2O (246); K_2O (50); SO_3 (165); Cl (176).	Basalt and rhyolite	Water used for irrigation. Ref. 763.
5	Munguia, 10 km east of San Gregorio.	Hot	Small			do	Water is muddy.
6	Cuitzeo de Abasolo	75	2,900	604	SiO_2 (81); Na_2O (167); K_2O (95); SO_3 (54); Cl (80).	do	2 main springs. Water used for irrigation. Ref. 763.
7	Pueblo Nuevo	Warm	Small			do	Ref. 771.
				Jalisco			
1	Atotonilco, 2 km from Huejucar.	Hot					Water used locally.
2	Embocadero and Zapotan, 75 km west of Ameca.	Warm; hot					2 springs. Water used locally.
3	Laguna de Magdalena	25		119	Ca, HCO_3; free CO_2		Several springs. Water used locally.
4	Agua Caliente, near Teuchitlan.	Hot					1 main and 2 smaller springs. Water is sulfurous. Used locally.
5	Tala municipio:						
	Agua Caliente Grande, 28 km east of Tala.	45	Small				Water used locally.
	20 km from Tala	Hot	Small				2 springs. Water used locally.
	10 km from Tala	Warm	Small				Water used locally.
6	Agua Caliente Chica, near Zapopan.	Hot	Small				Do.
7	Agua Caliente, 4 km from Zapotlanejo.	Warm	Moderately large				4 springs. Water used locally.
8	Near Ixtlahuacan, 22 km northeast of Guadalajara.	Warm	Moderately large				2 groups of springs. Water used locally.
9	Agua Caliente de la Cofradia, near Cuquio.	Warm	Moderately large	139	Ca, CO_3; free CO_2		Water used locally.
10	Agua Caliente de la Cuna, 20 km from Yahualica.	Warm					Do.
11	El Terrero, 8 km west of Tlajomulco.	Hot					Water used for drinking.
12	Tototlan municipio	Warm					3 springs. Water used locally.
13	12 km west of Atemjac	Hot	Small				Water used for drinking.
	5 km northwest of Atemjac	Hot	Small				Do.
14	Near Santa Ana Acatlan:						
	Ojo de Agua Caliente	Warm	Moderately large				Water used for bathing.
	Baño de Guerrero	Warm	Moderately large				Do.
15	Ixtlahuacan de los Membrillos municipio.	Warm					2 groups of springs. Water used locally.
16	Agua Tibia, at Chapala	Warm	Moderately large				2 groups of springs. Water used for bathing.
17	Tacotan, in Union de Tula municipio.	Hot					Water probably sulfurous. Used for drinking.
18	Agua Caliente, 8 km from Ejutla.	Warm					Water used locally.
19	Agua Caliente, in Juchitlan municipio.	Warm					Water used for drinking.
20	Agua Caliente, in Chiquilistlan municipio.		Moderately large	Low	Ca, CO_3		Water used locally.
21	Agua Caliente, south of Amacueca.	Hot					Do.
22	North of Manatla pueblo	Warm					Water is mineralized; used locally.
23	San Cristobal de Barranca municipio.	Warm					2 springs. Water used locally.
24	Atoyac municipio:						
	Isla Grande	Warm	Moderately large		SO_4; free H_2S		Bathhouse.
	Isla Chica	Warm	Moderately large				Do.
	Molino	Warm	Moderately large				Do.
25	San Sebastian municipio	Warm	Small				2 groups of springs. Water used locally.
26	Apazulco, 4 km from the coast.	Hot	Moderately large				Water used for bathing.
	Atotonilco, 60 km from Purificacion municipio.	Hot	Moderately large				Do.
	Achiotes, 20 km from Purificacion municipio.	Warm	Moderately large				Do.
	San Miguel, 16 km from Purificacion municipio.	Warm	Moderately large				Do.

Thermal springs and wells in Mexico—Continued

No. on fig. 12	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
					Jalisco—Continued		
27	Near base of Colima volcano	Hot				Recent basalt	Many large fumaroles. Ref. 743.
28	Pihuamo municipio	Warm	Small			Probably lava	2 groups, 4 and 8 km from town. Water used locally.
					Mexico and Distrito Federal		
1	Guadalupe Hidalgo, north of Mexico City:						
	Pozito	21.5	Small	603	Na_2CO_3 (193); NaCl (108); KCl (108); free CO_2.		Water used for drinking.
	Artesian well	21					Water used for bathing.
2	Baños de Aragon, south of Guadalupe Hidalgo.	25	Moderately large	345	Ca, Na, HCO_3		Near early Paseo Grande. Water used for bathing. Ref. 750.
3	Baños de Peñon, 4 km northeast of Mexico City.	47.5	Moderately large	2,216	SiO_2 (152); $CaCO_3$ (404); $MgCO_3$ (429); Na_2CO_3 (183); K_2CO_3 (294); NaCl (737); gas, 63 percent CO_2, 29 percent N_2.	Limestone and shale	Water used for bathing by Aztecs; now supplies modern bath establishment. Refs. 731, 751, 753.
4	Popocatepetl volcano	92 (max)				Recent lava	7 main fumaroles exhaling water vapor, some with considerable force; also about 60 solfataras. Refs. 726, 743, 749.
5	Between Ixtapan de la Sal and Tonatico.	35–40	Moderately large	6,500	Ca (646); Mg (83); Na (1,615); K (86); CO_3 (890); SO_4 (894); Cl (2,200); BO_3 (105); free CO_2.		Several springs. Water contains 11 ppm of Li, 8.6 ppm of Fe_2O_3+Al_2O_3, 7.6 ppm of As, and 6.2 ppm of Br. Large deposits of tufa. Source of salt supply for local residents. Ref. 747.
					Michoacan		
1	Agua Caliente, near Yurecuaro municipio.	30					Water used for drinking.
	El Nacimiento, 6 km from Yurecuaro municipio.	20					Do.
	La Buena Huerta, 4 km from Yurecuaro municipio.	25			Na, SO_4		Do.
2	Near Ixtlan de los Hervores:						
	Pozo los Baños	88				Trachyte	Refs. 728, 755, 758, 762, 766, 767.
	Pozo del Carbón	98				do	Spouts to height of 3 meters. Refs. 728, 755, 758, 762, 766, 767.
	Poze del Coyote (Pozo Grande).	100.5		18,000	Ca $(HCO_3)_2$ (7,287); Mg $(HCO_3)_2$ (5,896); $NaHCO_3$ (935); NaCl (3,437).	do	Spouts to height of 2 meters at intervals of 2 hr. Refs. 728, 755, 758, 762, 766, 767.
	Other hot springs, including Pozo Blanco, Geyser de Salitre, Geyser Tritubular, Pozo Verde; also hot pools and well.					do	Refs. 728, 755, 758, 762, 766, 767.
3	Agua Caliente, 30 km south-southeast of La Piedad.	Tepid					Water used for drinking.
4	Agua Caliente, 16 km from Angamacutiro.	Hot	Large				Do.
5	Near Puruándiro	64–86	Moderately large				4 springs, some distance apart. Water is sulfurous. Refs. 728, 763, 771
6	Near Huaniqueo, 48 km northwest of Morelia.	Warm	Moderately large				2 springs. Water used for bathing.
7	Near west end of Lake Cuitzeo:						
	Baño de las Arenas	37–41	Large		$CaCO_3$ (36); $CaSO_4$ (14); free H_2S.		Water used for bathing.
	Chamiquel and Tricuiluca.	Hot	Moderately large		Ca, SO_4		2 springs. Water used for bathing.
	San Sebastian	45	Large				Water used for bathing.
8	Near southwest shore of Lake Cuitzeo:						
	Baño Prieto, 4 km from San Augustin.	Hot	Moderately large				Water is sulfurous. Used for bathing.
	4 km from Hacienda Huandacareo.	Hot	Moderately large				Do.
	San Juan Tararameo, near Cuitzeo village.	Hot	Moderately large				Water is sulfurous. Used for bathing. Ref. 758.
9	Zinapecuaro municipio, 8 km south of east end of Lake Cuitzeo.	30–34	Small				4 springs. Water used for drinking. Refs. 728, 758.
10	4 km south of Ucareo	Hot	Small				3 springs. Water used for bathing.
	Sierra Ucareo	Hot	Small	High	Fe, Ca, Na, SO_4		Several springs and solfataras. Refs. 728, 742.
11	Ojo de Agua de Arumbaro	Hot	Moderately large				Water used locally.
12	Ojo de Agua Caliente, 8 km from Los Reyes.	Warm	Moderately large				Water used for bathing.
13	Paricutin volcano	Hot				Recent lava and tuff	Many fumaroles. An estimated 17,000 tons of water per day emitted as steam. Refs. 734–737, 751, 761.
14	Agua Tibia, in Taretan municipio, 18 km southeast of Uruapan.	Warm	Moderately large				Water used for drinking.
15	Atzizindaro, near northeast shore of Lake Patzcuaro.	Warm	Moderately large				Water is sulfurous.

Thermal springs and wells in Mexico—Continued

No. on fig. 12	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Michoacan—Continued						
16	Arumbaro, near Morelia municipio.	Hot	Moderately large	2,040	Na, SO_4, Cl		Water is saline and sulfurous. Used locally.
	Barreno, near Morelia municipio.	26	Moderately large	130			Water is sulfurous. Used for bathing.
	Cuincho, 10 km northwest of Morelia municipio.	37.5	Moderately large				Water used for drinking.
17	Pila de Agua Caliente, 25 km south-southwest of Morelia municipio.	Warm					Water used locally.
18	Tajimarao municipio:						
	Agua Fria, 20 km south of Ucareo.	Warm	Moderately large				3 springs. Water used for drinking.
	Los Hervideros, 10 km from Tajimarao.	Warm	Moderately large				Evolved gas causes ebullition. Water used for bathing.
19	Baños de Purua, 50 km southeast of Morelia municipio.	34	Moderately large	Moderately high	HCO_3; SO_4; free CO_2, H_2S		Water used locally.
20	2 km northeast of San Fernando.	Hot.					Water used for drinking.
21	Rancho Salitre, west of Jorullo volcano.	Hot					Water used for drinking. Some H_2S. Ref 727.
22	Huacana municipio, 55 km south of Uruapan.	Hot					2 springs. Water used for drinking. Some H_2S.
23	Hacienda Agua Fria, at north base of Cerro de las Humaredas.	88–102	Moderately large			Decomposed rhyolite	Many hot springs, fumaroles, and solfataras. Refs. 762, 765.
	Baños del Chino, west of Hacienda Agua Fria.	70–89	Moderately large	High		Lava	3 main springs, 1 of which is a geyser that spouts to height of 2 meters; also fumaroles. Some H_2S. Refs. 729, 765.
	Laguna Verde, north of Baños del Chino.	28	Small			do	Many sulfurous vents on border of lagoon 80 by 200 meters. Refs. 729, 758, 762, 765.
	Nopal, near Baños del Chino.	85	Small			do	Saline pool 6 by 8 meters; viscous mud thrown to height of 10 meters. Refs. 729, 765.
	Pozos de Gallo, in Marítaro area.	80–100	Small			Decomposed basalt	2 groups of vapor vents and boiling springs. Refs. 729, 758, 765.
	Pozos de Marítaro, near Laguna Verde.	92–111	Small			do	Crater with hot muddy lagoon and many fumaroles. Vapor from largest vent rises to height of 20 meters. Free H_2SO_4, HCl. Refs. 729, 765.
	Station de Huingo	Warm	Small			Lava	Several springs. Common salt extracted from adjacent soil. Ref. 765.
24	Chiflador (Chillador), near north base of Cerro de Azufre.	82–91	Small			do	Several springs and fumaroles. Water vapor and sulfurous gases emitted with such force that stones are cast out. Refs. 728, 756, 762, 765.
	Curritacao (Currutaco), on north flank of Cerro de Azufre.	90–100	Small			do	Crater with lagoon of boiling mud. Sulfurous vapors. Refs. 729, 756, 765.
	La Tacita, in and near Laguna de Azufre on south slope of Cerro de Azufre.	50–86	Small			do	Evolved gas contains H_2S, SO_2. Refs. 762, 765.
	Baños de Azufre, 3 km south of Cerro de Azufre.	44–55	Small			do	Ref. 765.
	Taximaroa (Taximarca?), several km south-southwest of Cerro de Azufre.	89 (max)	Small			do	Lagoon in crater; also several springs. Water is acid. Near former sulfur workings. Refs. 729, 756.
25	El Salitre, near Tuzantla	Hot			Ca, SO_4		Water used locally.
26	Quetzerio, 50 km northeast of Huetamo.	Hot					Water used for drinking.
27	Jaripeo, 4 km from Huetamo.	Hot					Do.
28	Itucuarillo and La Salada, 30 km south of Tacambaro.	Hot					2 springs a few km. apart. Water used for drinking.
	Morelos						
1	Agua Hedionda, 3 km northeast of Cautla.	25.3–26.1	Moderately large	2,130	$CaSO_4$ (1,200); $CaCO_3$; $MgSO_4$; NaCl.		Water used for bathing.
2	Pozo Hediondo, in Xochitepec city.	22	do	High			Free H_2S, CO_2. Water used for bathing.
3	At Atotonilco, 6 km from Jonacatepec.	30–38					Water is sulfurous. Used locally.
4	Baños de Tula, 3 km from Amacusac.	Warm	Moderately large				Water is sulfurous. Used for bathing.
	Nuevo Leon						
1	Topo Chico (San Bernabe), 8 km north of Monterrey.	98	Moderately large		Na, Cl, SO_4; gas, 97.5 percent N_2, 2.5 percent CO_2.		Bathing resort. Tepid "arsenic" spring nearby. Ref. 749.
2	Carmen, 20 km northeast of Linares.	Warm	do				Water used for bathing.
3	San Ignacio, 20 km east of Linares.	Hot					Free H_2S. Water used for bathing.

Thermal springs and wells in Mexico—Continued

No. on fig. 12	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
				Oaxaca			
1	La Chivela Pass, above ford of Rio Verde.	36.6 (max)	Moderately large			Limestone	Several springs. Water is sulfurous. Ref. 757.
2	On coastal plain, half a mile from base of mountains.	33 (max)	do			do	Several springs. Deposit of tufa. Water is slightly saline. Free H_2S. Water used for bathing. Refs. 741, 757.
				Puebla			
1	Chiguahuapan municipio, 4 km east of Tlacomulco.	33			$CaCO_3$ (618); free CO_2, H_2S		Water used locally.
2	Orizaba volcano	Hot					Several fumaroles in main crater. Water is sulfurous.
3	Paseo Bravo and San Pablo, 1 km west of Puebla city.	Hot	Moderately large	1,800	$CaCO_3$ (547)		Water used for bathing. Ref. 733.
4	Ojo de San Pablo, 4 km from Tecapa.	34	Moderately large		Ca, HCO_3		Water used locally.
5	Axocopan, 5 km from Puebla city.	20	Large	339	Na, HCO_3, SO_4, Cl; gas, 93 percent CO_2, 7 percent N_2.		Water used for bathing.
6	Ojo de Rancho Colorado, in San Hueyotlipan municipio.	Warm	Moderately large				Do.
7	Colucan and San Vicente, 12 and 16 km from Izucar.	Warm; hot			Ca, SO_4		Water used locally.
8	Chichipico and Ojo de Agua, 6 and 8 km from Tehuizingo.	Warm			Ca, SO_4		Do.
9	2 km from Huehuetlan	35			Ca, SO_4		2 springs. Water used locally.
10	Ojo de Agua de Tlancualpican, in Chiautla municipio.	Warm					Water used locally.
11	Los Hornos and Ixtatlala, in Teotlalco municipio.	Warm; hot	Moderately large				Water used for bathing.
12	Agua Santa, at Xixingo village.	Warm					Water used locally.
				Queretaro			
1	Hacienda Montenegro, 25 km north of Queretaro: El Salto	32	Moderately large			Basalt	Ref. 764.
	Two wells	26; 29				do	Pumped wells. Water reached at depth of 50 meters. Ref. 764.
	Pueblo Santa Rosa	27					Ref. 764.
2	Near Pate, 70 km east-southeast of Queretaro.	96	Moderately large			Porphyry	Ref. 727.
				San Luis Potosi			
1	El Gato, 40 km south of San Luis Potosi.	41	316,000	500		Lake beds in area of faulted rhyolite.	Water is strongly radioactive. Used for bathing, irrigation, and generation of electric power. Also flowing wells 200–600 meters deep. Refs. 752, 772.
				Sonora			
1	Agua Caliente, between Tepustetes / and Piedras Verdes.	Hot	Moderately large				Ref. 740.
				Vera Cruz			
1	Near Amatlan	70	Large				Ref. 730.
				Zacatecas			
1	Las Pastoras and La Almoloya, in Rio Grande municipio.	Warm	Small				Water used for bathing.
2	Atotonilco de los Martinez, 50 km southwest of Nieves.	Hot			Na, SO_4		
3	La Tinaja, 5 km south of Sain Alto.	Warm	Moderately large			Basalt	Issues at west base of hill. Water used for bathing. Ref. 738.
4	Bocas (El Vergel), near Chalchihuites.	Hot	Moderately large				Water used for drinking.
5	Near San Andreas de Teul	Warm-hot	Moderately large				6 springs. Water from some is potable, from others too highly mineralized for drinking. Water used locally.
6	Santa Cruz, 12 km southwest of Fresnillo.	Warm	Moderately large			Trachyte porphyry	Small bathing resort. Ref. 727.

Thermal springs and wells in Mexico—Continued

No. on fig. 12	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
				Zacatecas—Continued			
7	Baño de Atotonilco, 3 km southwest of Valparaiso.	48	Moderately large	Moderately high.			Water used for bathing.
8	Ojo Caliente, 35 km southeast of Zacatecas.	35	Moderately large	162			Water is slightly alkaline. Small bathing resort.
9	Agua Caliente, near Momax.	Warm					Water used locally.
10	Agua Tibia, 2 km west of Sanchez Roman.	Warm	Moderately large	193			Free CO_2. Bathing resort.
11	Ojo de Agua de la Higuera, in Huanusco municipio.	Warm	Small				Water used for drinking.
12	Near Jalpa	Warm	Moderately large	60			Free CO_2. Small bathing resort.

CENTRAL AMERICA

(Costa Rica, El Salvador, Guatemala, Nicaragua, and Panama)

The western Sierra Madre of Mexico swings southeastward, parallel to the Pacific coast, and forms the southernmost highlands of that country. South of Jorullo volcano in Mexico there are very few prominent volcanic peaks in this range, but in its extension into Central America the mountains of this range are predominantly volcanic and there are numerous cones, some of which are still active or semiactive (solfataric).

East of the main mountain chain, which is composed mainly of volcanic rocks, most parts of Central America that have been mapped geologically are underlain by marine sedimentary rocks of Cretaceous and Tertiary ages; but Paleozoic strata and a few small, scattered areas of sandstone and clay containing plant remains that indicate Triassic age are exposed in northern Guatemala. Structurally, Central America does not seem to form a direct connection between South America and the main part of North America because the sedimentary beds genarally are folded along nearly east-west lines, oblique to the trend of the isthmus. The deep depression that contains Lakes Nicaragua and Managua may be a graben. Extensive volcanism began in the main ranges near the close of the Cretaceous period and has continued to the present. The lava and ash are chiefly andesitic and basaltic.

Nearly all the thermal springs recorded in Central America are in areas of lava, and most of them are on or near geologically Recent volcanoes. No thermal springs seem to be reported in British Honduras and Honduras, which are east of the zone of volcanism.

Costa Rica has considerable lowland along each coast and extensive plains in the northeast. The northwestern part of the main volcanic chain is formed largely by a succession of volcanic cones. Farther east the chain is partly divided into two cordilleras separated by a central plateau, beyond which the chain swings farther eastward, nearer the median part of the isthmus.

El Salvador has a narrow coastal plain which is bordered by the main cordillera. Much of the country consists of irregular plateau areas which are interrupted by many volcanic peaks in notable alinement but in several broad groups. Most of the volcanoes are probably of Pliocene age.

In Guatemala the Pacific Coastal Plain is nearly 80 km wide. The Sierra Madre rises steeply from the coastal plain, and along its southern base are numerous volcanic peaks, several of which are still active. The main ranges of the chain have lesser ranges branching from them and are interrupted by several depressions. North of the main chain of the Sierra Madre there is a region of high valleys enclosed by minor ranges, beyond which the country slopes to the Caribbean Sea through the undulating plains of El Peten, which occupy nearly one-third of the country.

The Pacific coast of Nicaragua is bordered by the volcanic cordillera which extends into, and is interrupted by, a great depression that is in part occupied by Lakes Nicaragua and Managua. This depression is bordered on the northeast by a minor range which is in part of volcanic rocks, and from it the land surface descends northeast and east to a wide swampy coastal belt along the Caribbean Sea.

Panama has a main range which extends eastward through the central part of the isthmus nearly to the low pass at the Panama Canal. Chiriqui volcano, quiet since the 16th century, is near the western border of the country, and there are other volcanic peaks farther east. East and south from the canal, a lower range of mountains continues nearly to a minor transverse range that forms the boundary with Colombia. Though mineral springs are common, only a few are noticeably thermal.

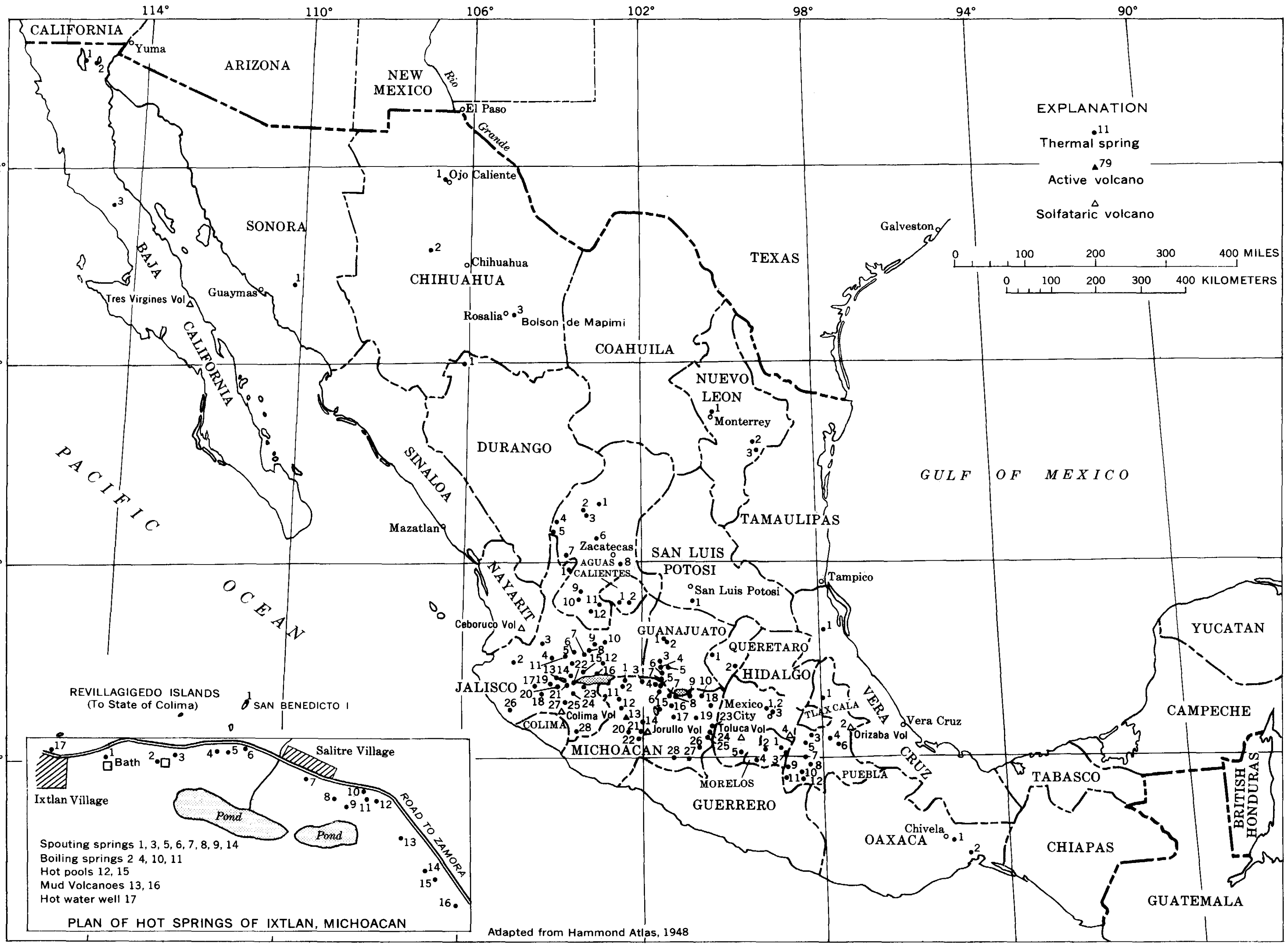


FIGURE 12.—Mexico showing location of thermal springs and principal volcanoes. Chiefly from ref. 744.

The table below summarizes the available information on the thermal springs in the several countries of Central America. The locations of the springs and principal volcanoes are shown on figure 13.

Thermal springs in Central America

[Data chiefly from refs. 783, 800, 808, 809, 811. Location of unnumbered springs not identified]

No. on fig. 13	Name or location	Temperature of water (°C)	Remarks and additional references
	Costa Rica		
1	Rincon de la Vieja volcano	Hot	Mud pots on southwest flank and hot springs 8 km farther south. Ref. 813.
2	Hacienda la Cueva, near Liberia.	Warm	
3	Near Bagaces, 23 km southeast of Liberia.	71 (max)	Hot springs near Salitral and warm springs near Santa Ana.
4	Hornillos des Miravalles	Hot	Solfataras in crater; also mud pots on southwest flank. Ref. 813.
5	Muchucatale, 16 km southeast of Castillo.	38.8	Water used locally.
6	On bank of Río Pocosol, several km above its junction with Río San Juan.	Warm	Do.
7	Las Cañas, near head of Río Avangares.	Warm	Do.
8	On bank of Río Peña Blanca, 25 km above its junction with Río Fortuna.	Hot	Do.
9	Agua Caliente de la Trinchera, on bank of Río Barranca 8 km north of Esparto.	Warm	Do.
10	Poas volcano	Hot	Lake in lower crater; hot water and steam thrown to great heights at intervals of 12 to 20 min. Also boiling springs on flank of volcano. Refs. 21, 774, 804.
11	On coast near Hafen Caldera	Warm	Small flow from several springs.
12	Near San Mateo, 50 km west of San José.	Warm	Water used locally.
13	Ojo de Agua, 5 km south of Alajuela.	Hot	Water used for bathing. Ref. 779.
14	San Pablo Turrubures, 40 km southwest of San José.	51.5 (max)	Several springs. Water used for bathing.
15	On or near Río Grande:		
	Salitral del Rayo	Warm	Several saline springs.
	Agua Caliente de Cangrejal, 4 km west of Salitral del Rayo.	Warm	Water used locally.
	Near junction of Río Virilli with Río Grande.	Warm	Do.
	Paso del Alumbre	60–66	Several saline springs.
16	Near Río Atarrazu below its junction with Río Candelaria.	Tepid	Small flow.
17	San Antonio de Desamparados, 5 km southeast of San José.	45.6–46.2	Several springs issuing from Miocene sandstone. Principal chemical constituents: Ca, Cl. Water used for bathing. Deposit of tufa.
18	El Salitre, 2 km east of San José.	29	Water is saline. Ref. 790.
19	Irazu volcano	Hot	Springs, fumaroles, and solfataras on north slope. Refs. 21, 774, 804.
20	Turrialba volcano	Hot	Fumaroles and solfataras.
21	Near Río Parita	36.6 (max)	Several springs. Water used locally.
22	Near Salitral, 1.5 km south of Cartago.	Hot	Several springs. Small deposit of iron oxide. Refs. 790, 822.
23	Agua Caliente, 3 km south-southeast of Cartago.	50	Principal chemical constituents: $CaCO_3$, Na_2SO_4, NaCl. Water used for bathing. Refs. 790, 822.
24	San Cristobal, 10 km south-southwest of Cartago.	66–68	Several springs. Water used for bathing.
25	Near Orosi:		
	Orosi Convent	34.5–51.5	2 springs. Water used for bathing. Ref. 822.
	Hacienda Navarro	24.5–38	Several springs. Total dissolved solids, 500 ppm. Principal chemical constituents: Ca, HCO_3, SO_4. Deposit of tufa. Water used for bathing. Ref. 822.
26	Near Río Macho	50–56	Several springs. Water used for bathing.
27	El General, 80 km southeast of San José.	17–36	Small flow from several springs. Water is saline.
28	Near Pejivalle, on north side of mouth of Río Diquis.	40–50	Several springs issuing from Tertiary strata. Principal chemical constituents: Na, SO_4, Cl.

Thermal springs in Central America—Continued

No. on fig. 13	Name or location	Temperature of water (°C)	Remarks and additional references
	Costa Rica—Continued		
29	North side of Pico Blanco, near Río Uren.	Warm	Water used locally.
30	Near Río Jurquin	Warm	Not developed.
	Coris	51–61	4 springs issuing from sandstone. Principal chemical constituents: SO_4, Cl. Large deposit of tufa. Ref. 812.
	Hualcalillo	23.5; 34	2 main springs. Total dissolved solids, 7,500 ppm. Large deposit of tufa.
	Los Hervideros	28–46	3 springs. Principal mineral constituents: SO_4, Cl. Ref. 812.
	Mount Hato Viejo, Río Viejo Gorge.	70	
	Near Río La Paloma	Warm	
	El Salvador		
	[Data chiefly from refs. 786, 787, 798, 800, 808, 809. For general information on ausoles of Ahuachapán area, see also refs. 789, 796, 801, 807, 819, 821]		
1	Near Tejutla pueblo	29–42	4 small springs.
2	Hervideros de El Obrajuelo, near Agua Caliente pueblo.	72–82	2 main springs issuing from fracture in decomposed lava. Ref. 807.
3	West border of El Paraiso pueblo.	37	Water used locally.
3	Bank of Río Grande de San Francisco, 2 km south of El Paraiso pueblo.	45–58	Several large springs. Water used locally.
4	Ahuachapán area:		
	Playon de Salitre, 8 km northeast of Ahochapan.	70 (max)	3 springs feeding small lake. Combined flow 200–300 liters per second. Refs. 778, 806.
	Ausol Valdiviseo, 6 km northeast of Ahuachapán.		1 clear and several mud springs. Refs. 778, 806.
	Playon de Ahuachapán, 3 km east of Ahuachapán.		Small lakes from which outflow is 220 liters per minute. Refs. 797, 799.
	Ausoles de Agua Shuca, 3 km southeast of Ahuachapán.		Flow 20 liters per minute. Refs. 797, 799.
	Ausol de Barreal, north of Cerro San Lazaro.		9 main springs and several vapor vents. Water is sulfurous. Ref. 806.
	Ausol El Zapote, southeast of Cerro San Lazaro.	95–98	Mud crater 6 meters in diameter. Noted for clouds of steam. Refs. 787, 806.
	Ausol La Labor, southwest of Cerro San Lazaro.		Vapor vents and pools of boiling black mud. Refs. 791, 795, 806.
	Ausol San José, 2 km northwest of Laguna Verde volcano.	96 (max.)	Ref. 799.
	Ausol San Carlos, 1 km east of Ausol San José.	97	Springs of clear water, mud pools, and vapor vents. Ref. 799.
	Ausol Cerro Branco, 1 km northwest of Laguna Verde volcano.	93 (max)	Weak vapor vents. Ref. 799.
	Ausol El Sauce, between Ausol San Carlos and Ausol San José.	86–97	Mud pools and vapor vents.
	Ausol de Amaya		3 main gas vents issuing from decomposed lava. Deposits of sulfur. Refs. 778, 780.
	Ausol Los Termopilas	93–97	Vapor vents issuing from decomposed basalt. Refs. 778, 780.
5	Ausoles de Cuyanausul		Springs and vapor vents. Refs. 778, 780, 799.
6	Izalco volcano (active)	Hot	Many fumaroles. Refs. 778, 780.
7	Laguna de Coatepeque, at east base of Santa Ana volcano.	Hot	Springs along shore of small lake in crater. Ref. 823.
8	Lake Chammico, at base of Javal volcano.	Hot	Small springs along border of lake.
9	Ausol El Boqueron (Quezaltepeque), 16 km northwest of San Salvador.	Warm	Several springs in ravine. Refs. 778, 780, 807.
10	Ilopango volcano	Hot	Several springs on flank of subsidiary Santa Ana volcano. Ref. 823.
11	Infiernillos on northeast flank of San Vicente volcano.	99 (max)	Gas and vapor jets and pools of acid mud. One, called El Infiernillo, spouts boiling water. Deposits of sulfur. Refs. 778, 780, 795, 806, 807, 817, 819–821.
12	Hervideros de Carolina, near Río Torola 3 km northwest of Carolina.	100 (max)	Springs, including a geyser, and vapor vents.
13	Bank of Río Araute, 2 km northwest of El Rosario.	50–59	Several springs issuing from decomposed basic lava. Water used for bathing.

Thermal springs in Central America—Continued

No. on fig. 13	Name or location	Temperature of water (°C)	Remarks and additional references
	El Salvador—Continued		
14	Los Ausoles, 3 km northeast of Santa Rosa de Lima.	89 (max)	
	Pozos Tibios, on margin of Río Pasaquina near south border of Santa Rosa de Lima.	37	Water used for bathing.
15	Tecapa volcano:		
	Laguna de Alegria	Warm	Sulfurous water in small crater lake. Refs. 789, 807, 819, 820.
	El Tronador	Hot	Fumarole having high pressure. Refs. 785, 787, 817, 819, 820.
16	Falda volcano	Hot	Fumaroles and solfataras.
17	Infiernillos de Chinameca, at northwest base of Chinameca volcano.	Hot	2 main steam vents (Hervedor and Boqueron): also lesser vents and mud pools. Free H_2S. Deposits of pyrite crystals. Refs. 778, 799, 807.
18	El Limbo volcano	Hot	Fumaroles and solfataras. Ref. 807.
19	San Miguel volcano	57–90	Fumaroles around crater. Deposits of sulfur and alum. Refs. 778, 817.
20	Laguna Agua Caliente, 7 km northeast of Jucuaran.	96–98	Springs and vapor vents near border of lagoon. Ref. 786.
21	Conchagua volcano	Hot	Fumaroles and solfataras.
22	Playita, at southeast base of Conchagua volcano.	32–69	Springs and steam fumaroles issuing along fracture line.
	Guatemala [Data chiefly from refs. 800, 808, 809]		
1	Salcaja, 8 km northeast of Quezaltenango.	Hot	Several springs. Water used locally.
2	Santa Maria volcano	Hot	Fumaroles and solfataras.
3	Almolonga, on Cerro Quemado volcano 6 km southwest of Quezaltenango.	Hot	1 main spring and several fumaroles. Water used for bathing. Refs. 775, 778, 821.
4	Zunil volcano, 15 km southeast of Quezaltenango:		
	Las Fuentes Georginas	45	Total dissolved solids, 2,212 ppm. Principal chemical constituents SiO_3 (380 ppm): Na (123 ppm); SO_4 (1,450 ppm). Refs. 777, 799.
	Las Aguas Amargas	45	Total dissolved solids, 2,186 ppm Principal chemical constituents: SiO_3 (340 ppm): Na (106 ppm) SO_4 (1,490 ppm). Refs. 777, 799.
5	Agua Caliente, near Lake Atitlan at north base of Atitlan volcano.	Hot	Springs and fumaroles: also fumaroles in main crater. Refs. 778, 821.
6	La Canoa, near Río Montagua, 30 km southwest of Salama.	Hot	Water used locally. Ref. 775.
7	About 4 km from San José, 20 km northeast of Guatemala City.	Hot	Large flow of very sulfurous water. Ref. 781.
8	Acatenango volcano	Hot	Fumaroles and solfataras.
9	El Fuego volcano	Hot	Fumaroles and solfataras. Ref. 778.
10	Lake Amatitlan	Warm-hot	Several springs near lakeshore. Much steam. Refs. 775, 780.
11	Pacaya (Pecul) volcano, 10 km southeast of Amatitlan.	Hot	Fumaroles and solfataras near the crater. Refs. 778, 780.
	Nicaragua [Data chiefly from refs. 800, 808, 809, 818]		
1	Coseguina volcano	Hot	Fumaroles and solfataras.
2	El Viejo volcano	91 (max)	1 main spring and 3 craters with fumaroles. Ref. 773.
3	Chichigalpa volcano	Hot	Fumaroles and solfataras. Ref. 83.
4	Near Telica volcano:		
	San Jacinto, at south base of volcano.	Hot	Several pools of varicolored clay and boiling water. Free H_2S. Deposits of sulfur and various salts. Refs. 784, 796.
	Tisate, farther west	Hot	Thick mud in ebullition. Ref. 784.
5	Axusco, 3 km south of Leon	Tepid	Large flow of water into large pool at bottom of ravine.
6	Momotombo volcano	Hot	Fumaroles and many solfataras.
7	Tipitapa, at outlet of Lake Managua.	Boiling	Large flow. Free H_2S. Deposits of sulfur. Ref. 784.
8	Masaya-Nindiri volcano	Warm	Vapor vents.
9	Lago de Apoyo, near east base of Masaya-Nindiri volcano.	Warm	Small springs. Water used locally.

Thermal springs in Central America—Continued

No. on fig. 13	Name or location	Temperature of water (°C)	Remarks and additional references
	Nicaragua—Continued		
10	Ometepe (Concepción) volcano, on island in Lake Nicaragua.	Warm	Fumaroles and solfataras near the crater.
------	Near Tottoa village	Hot	Water used for cooking.
	Panama		
1	Caldera on southeast flank of Chiriqui volcano.	Hot	Fumaroles and solfataras. Refs. 809, 815.
2	Agua de Salud, near Calobre village.	Warm	Several springs. Ref. 815.

WEST INDIES

The West Indies consist of three main groups, or chains, of islands. The Bahama Islands in the north are mainly low coral islands in which no thermal springs have been reported. The Greater Antilles, consisting of Cuba, Hispaniola (Haiti and Dominican Republic), Jamaica, and Puerto Rico, are composed of various kinds of sedimentary and crystalline rocks and have thermal springs in a few places. The Lesser Antilles, in the southeast, form a curving line trending southeast and south toward the coast of South America, as shown on figure 14.

The curving band of islands was considered by Suess [3] to be divisible into three zones. The inner zone is formed by the Lesser Antilles, the middle zone embraces the Greater Antilles, and the outer zone includes the Bahamas and several islets farther east.

The Greater Antilles generally are considered to be the upper parts of a submerged mountain chain which divides in Hispaniola, one branch extending through Cuba and the other through Jamaica.

Cuba has mountainous regions in the extreme east, in the central part, and in the westernmost part, and there is much rolling to flat country between the uplands. The north coast is bordered largely by hilly lands, but much of the south coast is swampy. Both coasts are bordered by many islets and coral reefs. Metamorphic and igneous rocks (pre-Cretaceous?) form parts of the range that borders the south coast near the east end of the island. Cretaceous limestone underlies many areas, but the greater part of Cuba is underlain by early Tertiary limestone which is uplifted and folded in many areas. There is little evidence of volcanic activity. Thermal springs at several places in the Habana (Havana) area have been developed as resorts, but few others seem to be recorded. Cold mineral springs are more widespread, and several have been developed as resorts.

[3] Suess, Edward, 1904, The face of the earth: v. 1, p. 542–552.

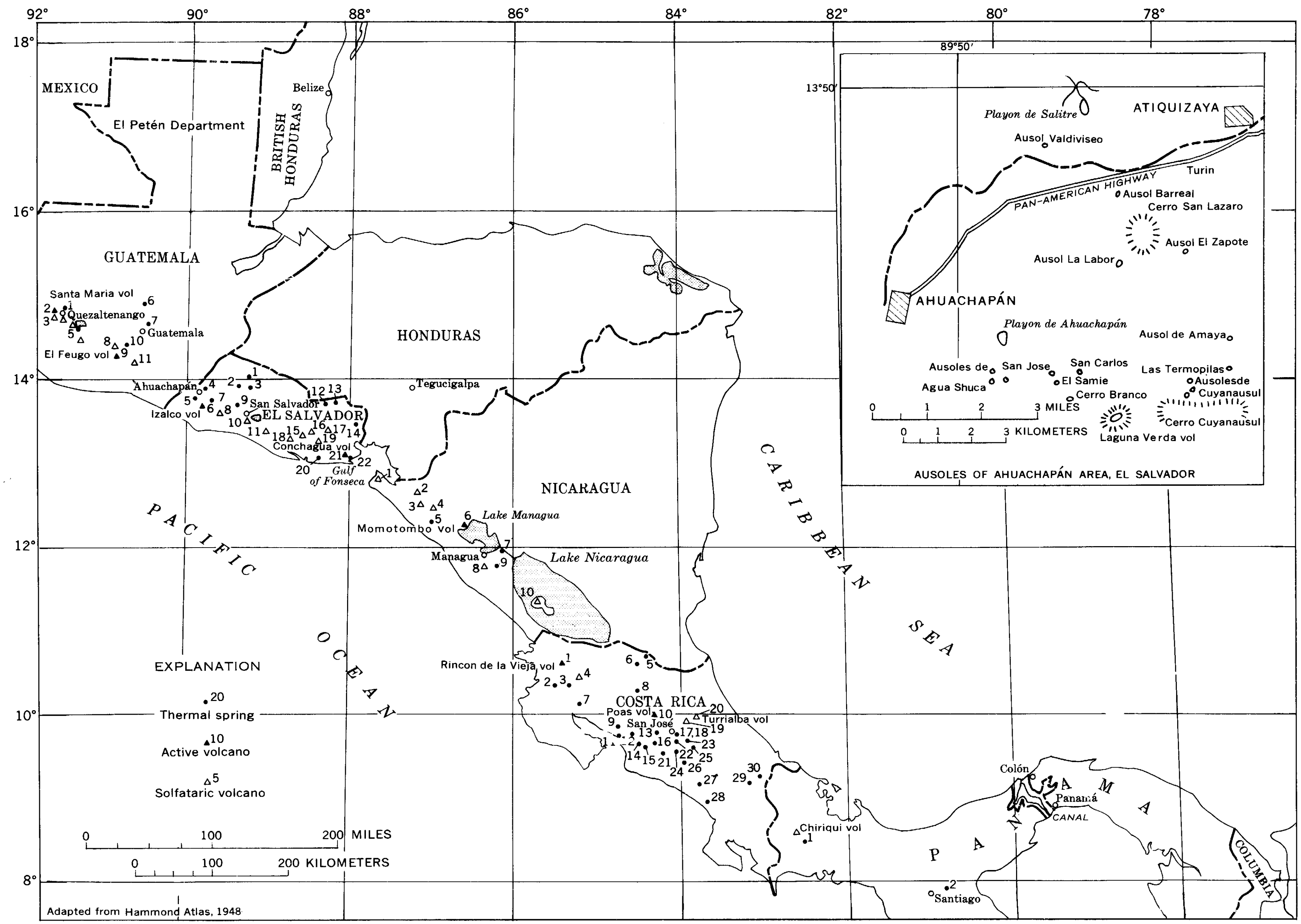


FIGURE 13.—Central America showing location of thermal springs and principal volcanoes. Chiefly from refs. 806, 808, 809, and 818.

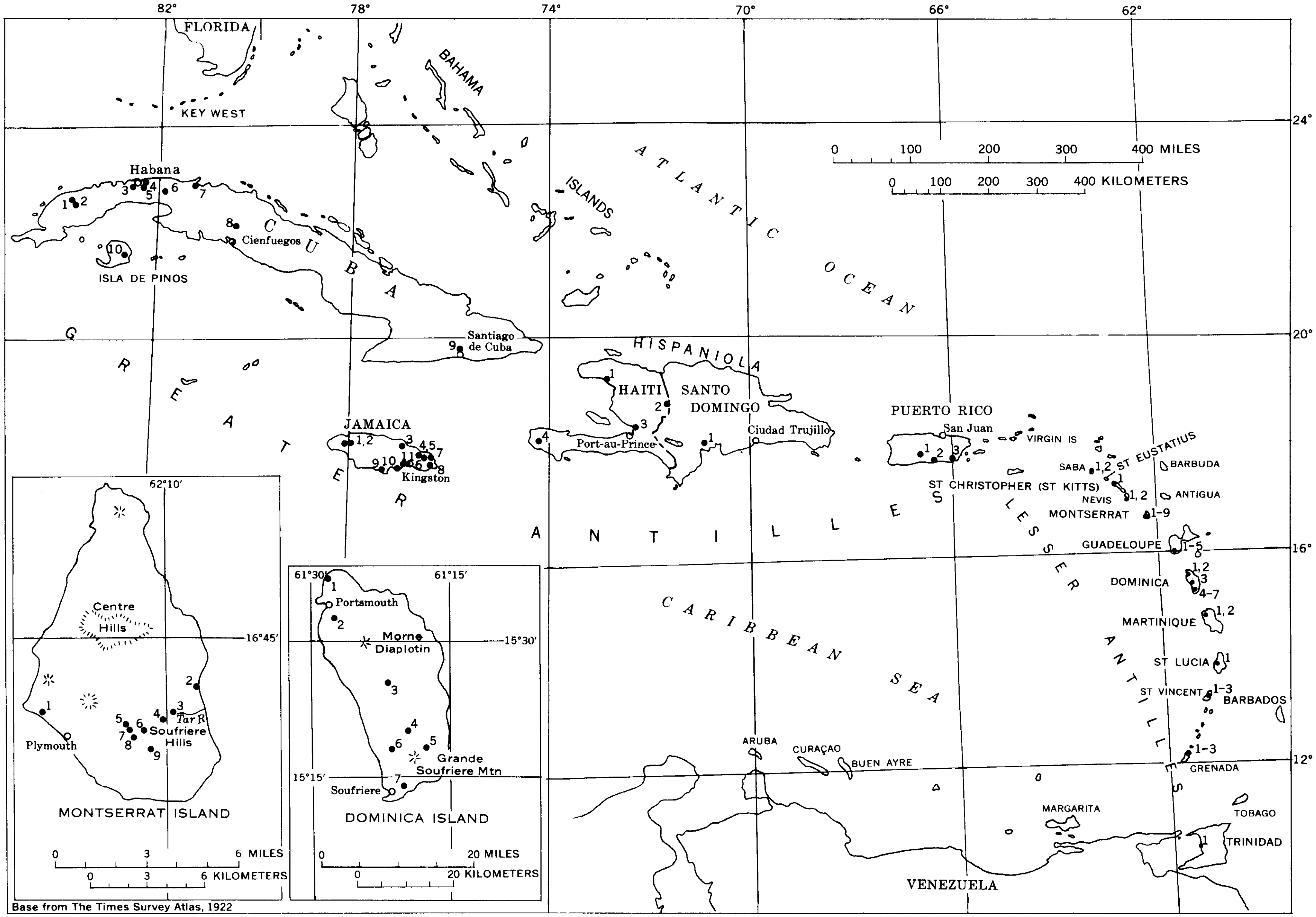


FIGURE 14.—Part of the West Indies showing location of thermal springs in the Antilles. Cuba from refs. 832 and 834; Haiti from refs. 829 and 830; Jamaica from refs. 839 and 840; Puerto Rico from ref. 837; and Lesser Antilles chiefly from refs. 869–878.

Hispaniola is separated from the eastern extremity of Cuba by a passage about 60 miles wide. The island comprises the republics of Haiti and Santo Domingo (Dominican Republic) and is largely mountainous. There are three nearly parallel east-west ranges. The northern range rises steeply from the coast; the central range is broader, with gentler slopes; the southern range also rises steeply, but there is a wider lowland along its eastern part. Between the three ranges are considerable areas of plain and lowland, and a lake of considerable size is in the southern part of the island. A wide central east-west core of pre-Tertiary igneous and metamorphic rocks extends throughout the island. This core is bordered chiefly by Tertiary deposits of Miocene age, but in the west it is bordered in part by Cretaceous sedimentary rocks. Most of the lowlands are underlain by Quaternary deposits, including a large area of coralline beds in the extreme northwest. An area of Mesozoic basalt forms uplands southward from Port-au-Prince and also farther west, but there is no evidence of Tertiary or later volcanic rocks. An early study by Tippenhauer (ref. 843) indicated that the lava might be of post-Tertiary age, but later studies class it as Upper Cretaceous. In the western part of the island four localities of thermal springs are well known, and one warm spring has been reported in the eastern part.

Jamaica lies about 90 miles south of the eastern part of Cuba and has a central east-west range and subsidiary ridges branching from it. The mountains are highest in the east and merge westward with hills of a plateau region that occupies two-thirds of the island. There are some wide plains along the south coast. Schist and other metamorphic rocks are exposed in the eastern mountains, but most of the uplands are of Upper Cretaceous limestone which is generally much folded and extensively overlain by lower Tertiary marl and limestone. These rocks cover the greater part of Jamaica in large areas of hills and valleys. In the northwestern part there is much sinkhole country. Shallow-water Miocene and Pliocene deposits underlie most of the coastal lowlands, and geologically Recent uplift has produced coastal terraces and raised beaches. Tuffs and other volcanic rocks indicate early Tertiary volcanic activity. There were some plutonic intrusions in Oligocene time, but no recent volcanism. Thermal and cold mineral springs issue from the older rocks in a few places.

Puerto Rico, about 70 statute miles beyond the east extremity of Hispaniola, has a main east-west mountain range which lies somewhat south of the median part of the island. At each end of this range the mountains descend steeply to the sea. The south flank also descends steeply to a belt of coastal plain. The north flank of the range is less steep, and numerous spurs descend to a belt of lowland. Thermal springs have been reported in only three places, all on the southern coastal plain.

The Lesser Antilles extend from a few miles east of Puerto Rico eastward and southward to near the coast of South America. (See fig. 14.) Some of these islands are considered to be related geologically to the mainland, as they are composed of schist, crystalline limestone, and other ancient rocks similar to those found in northeastern Venezuela. In other islands the older rocks are overlain by Cretaceous and later marine sedimentary strata, similar to those found on the mainland. Several smaller islands are composed largely or entirely of Tertiary to Quaternary volcanic rocks.

Saba Island, near the northwest end of the Lesser Antilles, has an area of about 5 square miles. It is formed by a single volcanic cone that rises to an altitude of 2,800 feet. The town of Saba is in the old crater and is reached by steps cut in the mountainside. St. Eustatius Island, about 8 square miles in area, is composed of several volcanic hills, but no thermal springs have been reported. St. Christopher (St. Kitts) is about 23 miles long. It has a central volcanic range and considerable areas of lowland. Nevis, which is separated from St. Christopher by a passage only 2 miles wide, is almost circular, about 8 miles in diameter, and is formed by a single volcanic cone that rises with moderate slopes to an altitude of 3,200 feet. Montserrat, about 40 miles farther southeast, is 11 miles long and about 7 miles wide. It is composed of a group of volcanic peaks, of which Soufrière Mountain is the highest. Guadeloupe, 40 miles farther southeast, consists of a high western part of old eruptive rocks overlain by Recent volcanic materials and of a low eastern part of Tertiary deposits of conglomerate and shell limestone. Dominica is separated from Guadeloupe by a passage 25 miles wide. It has a north-south range of high mountains, including Morne Diablotin in the north and Boiling Lake on the side of a mountain in the south. Martinique is composed chiefly of volcanic mountains. A group of mountains in the north is dominated by Mount Pelée. There is another group in the south, and a belt of upland connects the two groups. St. Lucia is largely mountainous and steep slopes rise directly from the coast, but it also has large areas of cultivated plains. In the southwestern part of the island are two pitons, which are conspicuous pyramidal peaks that are not a definite part of the main mountain system. A few miles east of them is the Soufrière in a depression that sometimes has been called a volcanic crater.

St. Vincent has a central range of volcanic hills that culminate in Soufrière volcano in the north. Grenada is the southernmost of the truly volcanic islands of the Lesser Antilles. It has a north-south mountain range, considerable lowland in the southeastern and northwestern parts, and a raised limestone beach at the north end. The oldest rocks exposed are of schist, porphyry, and sandstone, which are overlain by much basalt. In the central part of the island is Grand Etang Lake, which occupies 13 acres in an old crater where a sanatorium and health resort have been established. In the northeastern part is the larger Lake Antoine, also in an old crater near sea level.

Trinidad is formed for the most part of three nearly parallel ranges that trend north of east and two intervening wide areas of lower lands. The Northern Range borders the coast, where high cliffs rise from the sea. The greater part of this range consists of the Caribbean series of schistose rocks, which probably are of Mesozoic and Paleozoic ages. Also, there are a few small areas of marmorized and siliceous limestone of Jurassic and Cretaceous ages, and one small area of basic intrusive rock. The Central and Southern Ranges are underlain by marine sedimentary strata of Eocene through Pliocene ages; Cretaceous sandstone and shale are exposed in a few places.

The available information on thermal springs in the West Indies is summarized in the table below. The locations of the thermal springs are shown on figure 14.

Thermal springs and wells in the West Indies (Greater and Lesser Antilles)

[Principal chemical constituents are expressed in parts per million]

No. on fig. 14	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Cuba [Data chiefly from refs. 832, 834, 835]						
1	San Diego de los Baños	34–38	875	1,280	$CaCO_3$ (141); Mg $(HCO_3)_2$ (230); $CaSO_4$ (808); free H_2S.		3 main springs (Fl Tigre, El Templado, La Paila) on bank of Rió Caiguanabo. Water has fetid odor. Used for drinking and bathing. Refs. 831, 836, 844.
2	San Vicente, 3 km north of Vinales.	Warm			$CaSO_4$ (143); Na_2SO_4 (39); CaS (679); free H_2S, CO_2.		6 main and 2 small springs. Bathing resort.
3	San Antonio de los Baños	Warm					Several springs. Bathing resort. Ref. 836.
4	Guanabacoa (Santa Rita)	17.5–26	13	1,378 (hottest)	Mg $(HCO_3)_2$ (323); $CaSO_4$ (197); $MgSO_4$ (261).	Tertiary limestone and sandstone; serpentine.	1 main and 3 smaller springs. Resort. Refs. 828, 844.
5	Santa Maria del Rosario	19–22	6	1,440	$CaSO_4$ (147); Na_2SO_4 (406); NaCl (389).	Volcanic tuff near serpentine.	4 main springs. Resort. Ref. 828.
6	Madruga	22–25	25	675–772	$CaCO_3$, $MgCO_3$, $CaCO_4$, NaCl.	Serpentine	3 main springs (Paila, Castilla, Tigre). Bathing resort. Refs. 828, 844.
7	San Miguel de Guamacaro	Tepid	100	780		do	3 main springs. Water is alkaline; used as table water.
8	Ciego Montero	Warm					Shallow wells. Water used for bathing.
9	Las Delicias de San Antonio, 2 km north of Santiago de Cuba.	22	10	1,722	Mg $(HCO_3)_2$ (273); $NaHCO_3$ (636); Na_2SO_4 (196); free CO_2.	Tertiary sandstone	Shallow wells. Water used for table water and bathing.
10	Sante Fe, on east side of Isla de Pinos (Isle of Pines).	28			$CaCO_3$, $CaSO_4$, $CaCl_2$, NaCl, SiO_2.		Several springs. Resort.
	Dominica [Data chiefly from ref. 874]						
1	North of Portsmouth	Warm	Small			Lava	Several springs. Water is sulfurous.
2	Slope of Morne Diablotin, near Portsmouth.	Warm	Small			do	Several springs. Water is sulfurous. Ref. 836.
3	Ravine d'Or	Warm	Small			do	Do.
4	Near Laudat, north of Grande Soufrière Mountain.	Warm	Small			do	Do.
	Grande Soufrière Mountain:						
	Boiling Lake	88	Large			do	Lake in crater, 60 meters in diameter; water usually turbulent; contains sulfur in suspension. Much vapor. Refs. 847, 853, 856, 863, 864, 867.
5	Middle Lake	40–80	Large			do	Lake in crater fed by 1 spouting spring and several other springs. Deposit of sulfur. Ref. 867.
	Western Crater, 0.5 mile southwest of Boiling Lake.	83–96	Large			do	4 groups of springs; also large mud spring. Refs. 856, 864, 867.
6	Wotten Waven, 1.25 miles east of Roseau.	83; 96.5	Large				1 mud spring, 1 sulfur spring; also several small warm springs.
7	East of Soufrière village	48–92	Moderately large				Several springs; also fumaroles. Deposit of sulfur.
	Dominican Republic (Santo Domingo)						
1	35 km southwest of Azua	Tepid	230				1 main and several smaller springs. Water tastes and smells of sulfur. Ref. 843.

Thermal springs and wells in the West Indies (Greater and Lesser Antilles)—Continued

No. on fig. 14	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Grenada [All data from ref. 869]						
1	Near Peggy's Whim	44.4	Small		Ca, Na, K, HCO_3	Lava	
2	Hampsack, east of Tufton Hall.	24.4–48.9	Small			do	7 springs. Water from hottest spring carries clay in suspension.
3	Near Lake Antoine	Warm	Small			do	Several springs. Free H_2S.
	Guadeloupe [Data chiefly from ref. 876]						
	Soufrière Mountain:						
1	Crater	85–98				Lava	3 main fumaroles along a fissure. Refs. 836, 850, 852, 856.
2	Lac du Soufre, on upper part of north slope.	Warm				do	Water contains sulfur in suspension. Also several fumaroles. Refs. 836, 850, 852, 856.
3	Lower part of north slope.	76–89				do	3 main fumaroles. Refs. 836, 850, 852, 856.
4	South slope	95				do	Several fumaroles. Refs. 836, 850, 852, 856.
5	Lowland south of Soufrière Mountain.	80–90	Large			do	Several springs (1 spouting) and mud pools. Source of Jaune Matylise stream. Refs. 850, 852, 856.
	Haiti [Data chiefly from refs. 829, 843]						
1	Eaux Boynes (Terre Neuve), 30 km northwest of Gonaives.	45–49	200	403	Ca (51); Na+K (56); HCO_3 (277); SO_4 (68); Cl (36).	Faulted upper Eocene limestone.	6 springs. Former sanatorium and military hospital. Refs. 826, 827, 830.
2	Los Pozos	31.5–42	Small	1,214	Ca (118); Na+K (223); HCO_3 (260); SO_4 (62); Cl (464); free H_2S.	Faulted(?) Oligocene limestone.	5 springs. Ref. 826, 827, 830.
3	Sources Puantes (Arcahaie), west coast at foot of Mount Terrible.	32.7	2,000	12,684	Ca (397); Mg (299); Na+K (3,930); HCO_3 (610); SO_4 (872); Cl (6,627); free H_2S.	Faulted Miocene strata	2 main springs. Possibly contaminated by sea water. Refs. 826, 830, 842, 843.
4	Grand River of Jérémie:						
	Les Irois (Anse d'Hainault), near head of Right Fork.	Warm	Small			Tertiary strata	Ref. 842.
	Tiburon (La Cahouane), near head of Left Fork.	34; 37.5	Small			do	2 springs. Water used for bathing. Ref. 842.
	Jérémie (Dame-Marie, Dalmarie), 8 km downstream from Tiburon.	35–40	Small	515	Ca (26); Na+K (135); HCO_3 (93); SO_4 (117); Cl (121).	Cretaceous basalt	2 springs. Water used for bathing. Refs. 826, 842.
	Jamaica [Data chiefly from refs. 840, 841]						
1	Near head of Cabarita River	Warm				Black shale	Water is chalybeate. Heat may be due to decomposition of pyrite.
2	Bank of White River, in Hanover Parish.	Warm				do	Heat may be due to decomposition of pyrite.
3	Quebec Estate, in St. Mary Parish.	Hot					
4	Bank of branch of Back River, in Portland Parish.	Warm					
5	Golden Dale Estate in Portland Parish.	Hot					Water is sulfurous.
6	Bed of east branch of Guard (Guava) River, in Portland Parish.	55			Ca, CO_3 SO_4	Manganese veins	Water jets from riverbed; contains Fe, Mg.
7	Near mouth of Priestman's River.	Hot					Water is saline.
8	Bath of St. Thomas, the Apostle, in gorge near Sulphur River.	52–55	230	441	$CaSO_4$ (71); $NaSO_4$ (91); NaCl (197).	Slate and limestone (pre-Cretaceous).	Several springs. Resort. Refs. 833, 836, 839.
9	Milk River Bath, 2 miles upstream from river mouth.	33		29,650	$CaCl_2$ (1,500); $MgCl_2$, (4,120); Na_2SO_4 (3,100); NaCl (20,770).	Miocene limestone	Issues a few feet above river level. Water used for bathing. Refs. 836, 838, 839.
10	Shore of Manati Bay	26					Several springs. Water is saline. Ref. 839.
11	Port Henderson, near entrance to Kingston Harbour.	Warm	Small				2 springs. Ref. 839.
	Martinique						
	Mount Pelée:						
1	3 miles southwest of main crater.	Hot	Small			Recent lava	Refs. 851, 861, 868, 877.
2	2 miles south-southwest of main crater.	Hot				do	Crater having area of 2 acres. Refs. 851, 855, 857, 861, 868, 877.

Thermal springs and wells in the West Indies (Greater and Lesser Antilles)—Continued

No. on fig. 14	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Montserrat [Data chiefly from ref. 866]						
1	Hot Pond, near coast about 1 mile northwest of Plymouth.	Hot	Small				Several springs feeding pond. Refs. 866, 872.
2	Mulcair soufrière, on east coast.	Warm					Sulfurous vapor. Ref. 866.
	Cow Hill, in Tar (Tow?) River district:						
3	Old soufrière	Hot	Small				2 springs; also vapor vents.
4	New soufrière	Hot					Vapor vents.
5	Gage's lower soufrière	Hot					Large group of vapor vents.
6	Gage's upper soufrière	Hot					Vapor vents. Ref. 865.
7	Semiactive soufrière	Warm					Several vapor vents.
8	Spring Ghaut soufrière	Warm					2 main vapor vents.
9	Galway's soufrière	34.2–93.2					13 main springs, 1 spouting. Refs. 862, 867, 872.
	Nevis						
1	0.5 mile south of Charleston	36	Moderately large				Several springs. Water is sulfurous. Used for bathing. Refs. 836, 838, 873.
2	0.25 mile south of farm estate.	50 (max)					Several solfataras. Refs. 836, 873.
	Puerto Rico [Data chiefly from ref. 837]						
1	Quintana, 15 km north of Ponce.	34		791	Ca (85); Na (265); SO_4 (125); Cl (163).	Sedimentary strata near lava.	Water used for bathing. Ref. 836.
2	Baños de Coamo	44		1,604	Ca (420); Na (149); SO_4 (609); Cl (132); $CaCO_3$ (18).	Faulted conglomerate and volcanic tuff, near post-Eocene volcanic crater.	Issue 50 ft above bed of Coamo River. Bathing resort. Ref. 836.
3	Virella	30		5,827	Ca (1,688); Na (819); SO_4 (460); Cl (1,358); $CaCO_3$ (1,065).	Coastal plain deposits	Water is unpotable.
	Saba						
1	North end of island	Warm	Small			Lava and volcanic tuff	Ref. 875.
2	Southwest shore	54.2	Small			do	Contaminated by sea water. Ref. 875.
	Saint Christopher (Saint Kitts)						
1	Near and on Mount Misery.	93.2–95.8	Small			Lava and volcanic tuff	Springs, fumaroles, and solfataras. Refs. 838, 856, 867, 873.
	Saint Lucia						
1	La Soufrière (Qualibou), 3 miles south-southwest of Soufrière village.	22–92.5	Moderately large			Decomposed volcanic rocks.	10 main springs, 6 pools, and vapor vents in area of 3 acres. Much H_2S. Small deposit of sulfur. Refs. 836, 838, 849, 856, 864, 871.
	Saint Vincent [Data chiefly from ref. 878]						
1	La Soufrière Mountain	Hot				Lava	Solfataras in crater and fumaroles on east slope of mountain. Water is clear to black; highly malodorous. Refs. 838, 846, 847, 855, 857, 863, 878.
2	Head of Larikai River valley.	Hot				do	Small fumaroles. Deposits of sulfur. Refs. 870, 878.
3	Petit Wallibou Valley	Hot				do	Small fumaroles. Deposits of sulfur. Ref. 847.
3	Rouseau Valley	Hot				do	Small fumaroles. Deposits of sulfur. Ref. 870.
	Trinidad						
1	Plaisance, 1 mile north of Pointe-à-Pierre.	43	600	226	SiO_2 (28); Na+K (76); HCO_3 (146); Cl (54).	Faulted Tertiary strata	Stopped flowing in 1941 when deep water wells were drilled nearby. Refs. 860, 879.

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SOUTH AMERICA

ARGENTINA

The ancient granite and other crystalline rocks exposed in the Andes Mountains and the associated tablelands of northwestern Argentina are overlain in part by Tertiary and Quaternary volcanic rocks. The region includes many volcanic mountains and extensive saline flats in the tablelands between the main ranges. Farther south, the eastern slopes of the Andes are largely of marine Paleozoic and Mesozoic strata. Folded continental Tertiary beds underlie the lower slopes and extend eastward beneath great plains that reach to and beyond the Parana River. The lower lands are covered by Quaternary deposits, but some hills of ancient basement rocks rise above the plains. Misiones Territory, in the extreme northeastern part of Argentina, is within a great region of Mesozoic basalt and intrusive rocks that includes much of southern Brazil. The arid uplands of Chubut and Santa Cruz Territories in the far south are underlain mainly by ancient crystalline and metamorphic rocks, but these are covered in many areas by Cretaceous and Tertiary continental deposits and Quaternary gravel.

The locations of thermal springs in Argentina are shown on figures 15 and 16. Sketch maps of the Río Hondo and Copahue areas, which are noted for their thermal springs, are presented on figures 17 and 18. The available information on the numerous thermal springs in Argentina is summarized in the table below.

Thermal springs and wells in Argentina

[Data chiefly from refs. 926, 929, and Geological map of South America, scale 1:5,000,000 (Geol. Soc. America, 1950). Principal chemical constituents expressed in parts per million. Locations of unnumbered springs not identified]

No. on fig. 15	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	El Oratorio, at Guera	35	Small			Quaternary lava	Water is slightly saline. Used for bathing.
2	Río Jordan, 30 km southeast of Tilcara.	36	Large	2,689	Na, SO_4, Cl; free H_2S	Folded Tertiary strata	Water used for bathing.
3	San Lucas, 10 km east of Río Jordan.	48	Large	830	Na, SO_4	do	Water contains 28.7 ppm of Al. Used for bathing.
4	Caimancito, 8 km northeast of railway station.	41–59	Large	1,080	Na, SO_4, Cl	do	4 main springs. Analytical data for spring having temperature of 57° C. Water used for bathing.
5	Quinta, 20 km east of Yuto railway station.	38	Moderately large	372	Ca, HCO_3	do	1 main and several smaller springs. Water used for bathing.
6	Volcan, 1 km west of railway station.	41	Moderately large	444	Ca, Na, HCO_3; free H_2S	Lava(?) near Precambrian rock.	2 main and 4 smaller springs. Water contains sulfur in suspension. Used for bathing.
7	Near Quemado railway station.	40–45	500	13,936 (hottest)		Folded Tertiary strata	3 drilled wells (Quemado, Peña, Moralito). Water is strongly saline. Used for bathing.
8	Palo a Pique, on bank of Río San Francisco.	22		1,924	Na, HCO_3, Cl	do	2 main springs. Water used for bathing.
9	Arroyo el Rabon	20–43	Large			Tertiary strata near Tertiary lava.	6 main and several smaller springs. Water used for bathing.
10	El Palmar, 4 km south of Rabon.	25–49.5	Moderately large	3,577 (hottest)	Na, SO_4	do	5 main springs. Water used for bathing.
11	Chorro	34–53	Large	838 (coolest)	Ca, SO_4	Upper Cretaceous strata	4 main springs. Water used for bathing.
12	Los Reyes, 20 km west of Jujuy.	28.5–52	Moderately large	895 (hottest)	Na, SO_4	Tertiary trachyte overlying Paleozoic strata.	5 springs in 2 groups (Los Reyes and El Bajo). Bathing resort.
13	San Roque, 12 km southeast of Jujuy.	19	Large	424	Na, HCO_3	Tertiary strata	Water used for bathing.
14	Angosto de Cachipunco	31.5; 40	Large	970	Ca, Na, SO_4	Tertiary strata overlying Upper Cretaceous deposits.	2 main springs. Small deposits of sulfur. Water used for bathing.
15	Agua Salada, 3 km west of San Antonio.	24	Small	3,043	Na, HCO_3, SO_4, Cl	Tertiary strata	3 springs. Water used for bathing.
16	Near San Antonio	27	Moderately large	226	Ca, Na, HCO_3, SO_4	do	Rises in large pool. Much gas. Water used for bathing.
17	El Carmen (El Molino), 26 km south of Jujuy.	28	Large	208	Ca, Na, HCO_3	do	Water used for bathing.
18	Agua Caliente de El Molino, 31 km southeast of Perico railway junction.	22–30	Large	207–340	Na, HCO_3	do	7 main springs. Bathing resort.
	Puerta del Chanar, in Jujuy	21			Na, HCO_3, SO_4, Cl		
	Pozo Moralito, in Jujuy	40			Na, HCO_3, SO_4, Cl		Flowing well.
	Pozo Peña, in Jujuy	40			Na, HCO_3, SO_4, Cl		Do.
19	Near Antuco	20–35	100	21,030	CaO (682); SO_3 (1,023); NaCl (14,909).	Probably Tertiary lava	3 drilled wells.
20	Agua Caliente, on border of Salina de Antofalla.	Warm	Small			do	Several springs. Water is saline.
21	Salina de Aguas Calientes, at south base of Cerro Aguas Calientes.	Warm	Small			do	Do.
22	Vega de Agua Caliente, near Río Agua Caliente.	Warm	Small			do	Do.
	Inchachuli, in Los Andes	45–46			Na, HCO_3, SO_4, Cl		
	Pompeya, in Los Andes	38–50	8	4,180	NaCl (2,312)		4 flowing wells.
	Río Tugle, in Los Andes	38–53	80	4,840	NaCl (4,080)		4 flowing wells. Water used for bathing.
	Tucomar, in Los Andes	35–63	50	2,736	NaCl (1,355)		4 flowing wells.
23	Río Lipeo (Lipion)	Warm	Small	422	CaO (40); CO_2 (185); NaCl (101); Fe_2O_3; free H_2S.	Devonian slate	4 main springs. Water contains 20 ppm of $Fe_2O_3+Al_2O_3$. Used for bathing.

Thermal springs and wells in Argentina—Continued

No. on fig. 15	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
24	Fuente de El Sauce (Paraiso), 10 km northwest of Campo Santo.	18–31	300	9,504 (hottest)	Na, SO_4, Cl; free H_2S, CH_4	Tertiary limestone	5 springs. Water contains 14 ppm of Fe. Bathing resort. Ref. 927.
25	Termas de Inti (Aguas Calientes del Molino), 18 km northeast of Güemes.	22–30		207	Ca, Na, HCO_3, SO_4, SiO_2 (24)	Tertiary and Upper Cretaceous strata.	7 main springs. Water used for bathing. Refs. 906, 920, 927.
26	Luracatao	47		1,770	$CaCl_2$, NaCl	Precambrian(?) rock	Water contains 6 ppm of F. Ref. 910.
27	Near Juramento railway station.	34–38	Small			Tertiary and Upper Cretaceous strata.	Several springs. Water is sulfurous.
28	Near Lumbrera railway station.	Warm	Small				Ref. 919.
29	Ojo de Agua, 7 km southeast of Galpón village.	35–50	Small	692	SO_3 (96); NaCl (284); SiO_2 (40)	Cretaceous(?) strata	Several springs. Water contains 16 ppm of $Fe_2O_3 + Al_2O_3$. Used for bathing. Refs. 919, 923.
30	Rosario de la Frontera, at base of Sierra de la Candelaria 10 km southeast of Rosario, in Salta:						
	Agua Salada Alta	89		26,090		Faulted Cretaceous marl and limestone.	Water is radioactive. Used for bathing. Combined flow 420 liters per minute. Refs. 896, 904, 919, 920, 923.
	Silicosa	62		980			
	Sulfurosa	84		1,154			
	Ferruginosa	80		1,320			
	Several others	28–94					
31	Ceibal (Puesto de Aguas), 20 km east of Candelaria.	22–28	Moderately large	207 (hottest)	Ca, Na, HCO_3	Precambrian(?) rock	3 springs. Water used for bathing.
	Baños de Fleming, in Salta.	29			Ca, Na, HCO_3		
	Cuchiyaco, in Salta	52			Na, HCO_3, SO_4, Cl		Ref. 908.
	Inti and Porongal, in Salta.						
	Quebrada de Luingo, in Salta.	80					
32	Agua Salada de Timbo, 25 km south-southeast of Trancas.	Tepid		317,000	SO_3 (10,400); NaCl (299,300)	Tertiary strata overlying Precambrian rock.	
33	Las Cejas, 30 km east of Tucuman.	20.7; 32		High	Na, HCO_3, Cl	Quaternary deposits	2 flowing wells.
34	Near south base of Agua Caliente Peak.	Warm	Small			Tertiary and Jurassic lava.	
35	Villa Vil	55–64	Moderately large	903 (hottest)	Na, HCO_3	Pliocene strata	4 main springs. Water used for bathing. Ref. 908.
36	Cura Fierro, 2 km southwest of Villa Vil.	21	Small	4,934	Na, HCO_3; free CO_2	do	Medicinal drinking water. Ref. 908.
37	Llampa, 10 km south-southwest of Villa Vil.	30	Small	1,889	Na, HCO_3	do	Do.
38	Nacimientos de Hualfín, 8 km east of Llampa.	37–39	Large	1,144 (hottest)	Na, HCO_3	do	4 main and several smaller springs. Water used for bathing. Ref. 908.
39	La Colpa, 10 km southwest of Llampa.	27	27	2,247	Na, HCO_3; much free CO_2	do	Water deposits sodium bicarbonate. Used for bathing. Ref. 908.
40	Agua de Dionisio, 30 km southeast of Villa Vil.	24	Moderately large	1,943	Na, SO_4, Cl	do	Several springs. Medicinal drinking water. Refs. 889, 908.
41	Fuente de Vis-Vis and Nacimiento de Vis-Vis.	34–38	Small	1,225	Na, SO_4, Cl	Precambrian crystalline rock.	Several springs. Water used for bathing. Ref. 908.
42	Choya de Andalaga (Yacochuyo).	19	Small	1,220	Na, SO_4	do	Water used for domestic purposes. Ref. 908.
43	Ciénaga, on bank of Río Haulfín.	30	Large	393	Na, SO_4 Cl	do	Water used for bathing. Ref. 908.
44	Fiambala	54–58	Moderately large	480	Na, HCO_3	Granite	Water used locally.
45	Suriyaco, at border of saline flat.	34	Moderately large	High	Na, HCO_3	Quaternary deposits	Water used for bathing.
46	Chanampas	25–31	Moderately large	Low	Na, HCO_3	do	Do.
47	Las Higueritas, 15 km southwest of Tinogasta.	30	Moderately large	Low	Na, HCO_3	Tertiary strata overlying Precambrian rock.	Do.
	Adentro and Palmas Viejas, in Catamarca.						
	Saugil, in Catamarca	21			Ca, Na, SO_4, Cl		
48	Along Rio Hondo (see also, fig. 18):						
	Inti-Yacu	38–42				Tertiary strata	20 springs on island in river. Refs. 881, 892.
	Las Termas					do	Several springs. Bathing resort. Ref. 881.
	Condor-Huasi		Large			do	Several springs. Ref. 881.
	Totora Yacu		Large			do	Do.
	Atacama	31 (max)	390	370	SiO_2 (30); Na (93); K (27); CO_2 (70); SO_4 (80); Cl (50).	do	4 main springs. Refs. 881, 892.
	Trigo-Chacra	20–35				do	Several springs. Ref. 881.
	Alto de las Gatitas	20–30				do	Do.
49	Atacama (Vichy) and Isca Yacu.	31	400	500–572	Na, HCO_3, SO_4, Cl	do	3 main springs and several smaller ones. Water used for bathing.
50	Near Lavalle railway station	29.5–35.5	Moderately large		Ca, Na, SO_4, Cl	do	3 flowing wells.
	Remate Hill, in Santiago del Estero.	Warm					Ref. 917.
51	Agua Caliente	60	Moderately large	Low		Quaternary and Tertiary strata.	Water used for bathing.
52	Santa Terezita (Mazan), 15 km southeast of Agua Caliente.	35–37		417–572	Na, HCO_3	do	6 main springs. Water used for bathing.
53	Fuente de El Chocoy, near Famatina.	27 (max)	Large	1,200		Probably Precambrian intrusive rock.	Several springs. Water contains 30 ppm of $FeCO_3$; much ocher deposited. Ref. 907.
54	40 km northeast of La Rioja	23	Moderately large		Na, HCO_3	Precambrian(?) strata	Water collected in reservoir for drinking by cattle.

Thermal springs and wells in Argentina—Continued

No. on fig. 15	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
55	El Saladillo de los Colorados	34	Moderately large	4,560	Na, SO_4, Cl	Precambrian(?) strata	1 main spring and several small flowing wells.
56	Surgente de Copai de Guayapa, 15 km southwest of Patquia.	22	Large	8,270	Na, SO_4, Cl	do	Flowing well. Water used for drinking by cattle.
------	Totoritas, in La Rioja	26			$NaHCO_3$		Water used for bathing.
57	Pismauta, 8 km west of Jachal.	40; 45		400; 356	Na, SO_4; free H_2S	Paleozoic strata	2 main springs. Water contains much Fe_2O_3 and Al_2O_3. Ref. 912.
58	Quebrada de Huaco (Hedionda).	21–25	100	2,300–2,868	Na, SO_4; much free H_2S	Paleozoic limestone	Several springs. Deposits of sulfur. Water used for bathing. Ref. 905.
59	El Volcan	27.1		Moderately high	Na, SO_4, Cl; free H_2S	Tertiary(?) deposits	Water used locally.
60	Near bank of Río Blanco	50		8,674	NaCl (6,327)	Probably Jurassic lava	
61	Talacasto	25.5				Tertiary strata	
62	Baños de la Laja, 28 km north-northeast of San Juan.	24–27	Moderately large	6,610	Na, SO_4, Cl; free H_2S	do	3 main springs. Bathing resort. Ref. 928.
63	Baños de El Salado (San Bernardo), 5 km east of Baños de la Laja.	21.3–27	240	9,234	$Ca(HCO_3)_2$ (397); $Mg(HCO_3)_2$ (350); $CaSO_4$ (418); $MgSO_4$ (523); Na_2SO_4 (766); K_2SO_4 (492); NaCl (6,329).	do	Water used for bathing. Ref. 928.
64	Salados Albardon, 20 km northeast of San Juan.	Warm	Small			Quaternary and Tertiary strata.	Water is saline.
65	Zonda, 25 km southwest of San Juan.	23.2				Quaternary deposits overlying Paleozoic strata.	2 main and several smaller springs. Free H_2S. Water used for bathing.
66	Baños del Inca (Puente del Inca), near Trans-Andean Railway and border of Chile.	35–38	Large	16,350	Ca (1,028); Na (5,552); HCO_3 (743); SO_4 (1,838); Cl (7,100).	Jurassic lava and Paleozoic limestone.	5 main springs near Bridge of Incas, a natural bridge. Resort. Refs. 886, 891, 895, 899, 904, 911, 914, 915, 918.
67	Cañada del Monte (Carrizal de Arriba).	21.5	Large	500	Na, SO_4	Mesozoic or Paleozoic strata.	Water used for bathing and irrigation.
68	Villa vicencio	26.4–36.8	Large	1,200	$NaHCO_3$ (876); Na_2SO_4 (309); KCl (126); free CO_2.	Tertiary strata overlying Permian strata. Water may rise from Devonian graywacke.	2 groups of 5 springs each. Water bottled and sold. Bathing resort. Refs. 882, 883, 914.
69	La Peña (Cascada), south of Río La Peña.	21	Moderately large	1,604	Na, SO_4	Tertiary strata	Water used for bathing.
70	Higuerita de Callao	18.5; 20.2	Large	1,056	Na, HCO_3, SO_4	Tertiary strata overlying Triassic or Permian strata.	2 springs. Bathing resort.
71	Zapata, 15 km northeast of Mendoza.	22.4	Large	980	Ca (108); Na (183); SO_4 (468); Cl (121).	Quaternary and Tertiary strata.	Several flowing wells 25–30 meters deep. Water used for bathing and irrigation.
72	Borbollon, 14 km northeast of Mendoza.	24.5; 25	6,000	1,061	Na, K, SO_4	Quaternary and Tertiary strata.	2 springs. Water used for bathing and irrigation.
73	Las Totoras, about 10 km northeast of Mendoza.	19.3 (max)	Moderately large	871	Ca (111); Na (125); HCO_3 (50); SO_4 (408); Cl (99).	do	Several springs. Water used for bathing and irrigation.
74	Cacheuta, on right bank of Río Mendoza.	35.6–50.1	Large	1,540	SiO_2 (48); Ca (131); Na (387); HCO_3 (97); SO_4 (525); Cl (368).	Granitic rock	4 main springs. Water is radioactive. Used for bathing. Refs. 894, 913, 921.
75	Alto Verde, 15 km north of Tunuyan.	23.4	Moderately large	334	Ca, Na, SO_4	Folded Tertiary strata	Water used for bathing.
76	Baños de Capis and Serafim Dias, 15–20 km northeast of San Carlos.	26	Large	410	Na+K (62); HCO_3 (49); SO_4 (130).	do	2 groups of springs. Water used for bathing and irrigation.
77	Las Peñas	19	Moderately large	5,970	Na (1,825); HCO_3 (1,229); Cl (870)	do	2 main springs. Deposits of salt and ocher. Ref. 925.
78	Agua Poca	29	Small	620	Na, SO_4	do	
79	El Salado	29	Large	7,900	Na (2,845); SO_4 (1,059); Cl (3,403).	Permian strata	Water contains 7 ppm of Br. Used for bathing.
80	La Vigorosa	20.5	Large	12,260	Na (4,789); HCO_3 (1,258); Cl (5,254); free CO_2.	Triassic or Permian strata	Water used for bathing. Ref. 925.
81	Paloma, 2 km southwest of Vigorosa spring.	21.4	Moderately large	2,780	Na, SO_4	do	Water used for bathing.
82	Arroyo del Tigre	30.4 (max)	Large	578	Na, SO_4, Cl	Upper Permian strata	Several springs. Water used for bathing.
83	Cerro Bola, in bed of Río Cañada Seca.	19	Large	4,840	Ca (500); Na (363); SO_4 (3,265); Fe (58); Al (115); Mn (44).	Jurassic volcanic rock	Water used for bathing. Ref. 925.
84	Los Burros	21.2 (max)	Large	520	Na (149); SO_4 (155)	Paleozoic strata	4 springs. Water used for irrigation.
85	Sosneado	31; 33	24,000	10,205	Ca (972); Na (3,127); HCO_3 (218); SO_4 (2,184); Cl (3,690); much free H_2S.	Tertiary volcanic rock	2 main springs. Water contains 14 ppm of Al. Deposit of sulfur. Bathing resort.
86	Agua Caliente, 5 km northeast of Sosneado village.	Warm	Small			Quaternary deposits	Water is potable.
87	Volcan Peteroa (Baños de Azufre), at east base of the volcano.	20.3–49.5	Large	640	Na, HCO_3	Quaternary lava	8 main springs. Analytical data for spring having temperature of 38°C. Water contains 8 ppm of Fe. Bathing resort.
88	Aguas Amarillas	20	Large	1,030	Ca (293); HCO_3 (836); SO_4 (460); free H_2S.	Carboniferous schist	Deposits of sulfur.
89	Peralito, in canyon of Río Salado.	32.5–46	Large	42,254 (hottest)	Ca (1,210); Na (15,176); HCO_3 (146); SO_4 (2,644); Cl (22,365).	Lower Cretaceous strata	6 springs. Bathing resort.
90	Los Molles, 2 km below Peralito springs.	36–49.5	Large	55,100 (hottest)	Ca (1,324); Na (21,785); HCO_3 (113); SO_4 (2,930); Cl (29,900).	do	4 main springs. Bathing resort
91	La Kiki, on left side of Río Salado 12 km east of Los Molles.	22	Small	2,966	Ca (625); Na (163); HCO_3 (113); SO_4 (1,636); Cl (167); much free H_2S.	Upper Cretaceous strata	1 main spring. Deposit of tufa. Water used for bathing.
92	Alfalfalito, on left side of Río Salado, 18 km east of Los Molles.	26; 35.5	Moderately large	832 (hottest)	Ca (70); Na (277); HCO_3 (45); Cl (389); free H_2S.	do	2 springs 2 km apart. Water used for bathing and irrigation.
93	La Vista, 33 km southeast of Las Molles.	25	Moderately large	11,370	Ca (780); Na (3,103); HCO_3 (158); SO_4 (2,134); Cl (4,963); free H_2S.	do	Water used for bathing.
94	Cajon Grande (Companario)	51 (max)	Large	1,300	Na, SO_4, Cl	Tertiary volcanic rock overlying Lower Cretaceous strata.	Many springs in area of 600 sq mi. Deposits of salt and ocher. Water contains 12 ppm of Fe. Used for bathing.

Thermal springs and wells in Argentina—Continued

No. on fig. 15 or 16	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
95	Quebrada de Zapallar	28	Moderately large	High	Na, HCO_3, SO_4, Cl	Quaternary deposits	
96	San Marcos, on right bank of Río San Marcos.	21	Moderately large	2,203	Na, HCO_3	Precambrian(?) rock	Deposits of opaline silica and iron oxide. Water contains 4 ppm of Fe. Used for bathing.
97	La Magdalena, at Barreto railway station.	28	450	1,127	Na, SO_4	Quaternary deposits	Flowing well 221 meters deep. Water used for drinking by cattle.
98	Barreto, 10 km east of railway station.	32	6,000	522	Na, SO_4	do	Flowing well 320 meters deep. Water used for drinking by cattle.
99	Salto Argentino	21	8	3,283	Mg, Na, SO_4	do	Flowing well 100 meters deep. Bottled and sold as mineral water.
100	Villa Albertina, 10 km south of Buenos Aires.	21.5	140	3,863	Na, SO_4, Cl	do	Flowing well 88 meters deep. Bottled and sold as mineral water. Contains 2.5 ppm of Mn.
101	Punta Lara, on bank of Río de la Plata.	Warm	Moderately large	7,050; 7,524	Na, SO_4, Cl	do	2 flowing wells 84 and 87 meters deep. Bathing resort.
No. on fig. 16							
102	Alsina de la Noria, at west end of Lake Alsina.	21.5	3	15,864	Na (4,455); SO_4 (6,267); Cl (4,020)	Plio-Miocene strata	Flowing well. Bathing resort.
103	Viticola, 27 km north of Bahia Blanca.	55	800	704	Na, HCO_3	Quaternary deposits overlying Plio-Miocene strata.	Flowing well 654 meters deep. Water used locally.
104	Argerich, at National Fish Hatchery.	63.7		1,017	Na, HCO_3, SO_4	do	Flowing well 711 meters deep Water used locally.
105	Puerto Militar, 20 km southeast of Bahia Blanca.	55		9,466	Na, (2,786); SO_4 (1,138); Cl (4,902).	do	Flowing well 787 meters deep.
106	Ombucta:						
	Depth of 300–304 meters	32		13,337			
	Depth of 568–570 meters	33		28,865	Na (8,886); SO_4 (3,800); Cl (12,400).		Flowing well 850 meters deep tapping 3 water-bearing zones.
	Depth of 840–847 meters	63		4,264			
107	Los Gauchos, at Villalonga railway station:						
	Depth of 884 meters	77				Quaternary deposits overlying Plio-Miocene strata.	Oil test well yielding water at rate of 1,200 liters per minute. Water from upper zone is saline. Water from lower zone contains 387 ppm of Br and 5 ppm of I. Used to supply bathing pool.
	Depth of 1,085–1,115 meters.	80		144,560	Ca (4,240); Mg (2,069); Na (44,294); SO_4 (1,535); Cl (83,425).		
108	Chacra, 2 km northwest of Chos Malal village.	20	Small	2,373	Na, SO_4, Cl; free H_2S	Lower Cretaceous strata	Water used for bathing.
109	Agua Hedionda, 4 km northeast of Chos Malal.	18	Small	560	Na, HCO_3, SO_4; free H_2S	do	Do.
110	Baños de Copahue, in National Reserve on east slope of Cerro Copahue (see also fig. 18, showing):						
	Aguas de Fierro	68		396	SiO_2 (118); Na (35); HCO_3 (130)	Quaternary andesite and trachyte.	Water contains 10 ppm of Fe, 13 ppm of Al.
	Norte del Correo	67				do	
	Two other main and several smaller springs; also a few fumaroles.	18–63		838	SiO_2 (116); Ca (72); SO_4 (572)	do	Analysis is for spring having temperature of 40°C. Water contains 23 ppm of Fe, 8 ppm of Al.
111	Las Mâquinas and Las Maquinitas, on both sides of Arroyo Blanco, 2.5 km south-southeast of Baños de Copahue (see also fig. 18).	28–95	Moderately large	High		do	3 main and several small springs; also fumaroles. Water used for bathing. Ref. 903.
112	Laguna del Volcan, 7 km southwest of Baños de Copahue (see also fig. 18).	35	Moderately large	6,941	Na, SO_4, Cl	do	Lake having area of 3 hectares in crater 0.5 km in diameter. Water contains 25 ppm of NH_4, 33 ppm of Fe, 195 ppm of Al, is heated by escaping gases. Used for bathing. Deposits of sulfur.
113	Chanchoco, south of Laguna del Volcan.	26.5	Small	200	SO_4 (97); SiO_2 (35)	do	2 main springs. Water used for bathing.
114	Cerro del Domuyo, south of Chanchoco.	90 (max)				Quaternary lava	Sulfurous fumaroles on hillsides. Escaping gases contain SO_2 and H_2S.
115	Plaza Huincul, near Huincul railway station.	35		88,000		Upper Cretaceous strata	Well No. 23. Thermal water encountered at three main horizons. Analytical data for strongly saline water from depth of 805–857 meters. Ref. 912.
116	Colluco (Huechu-Laufquen), 2 km south of small lake.	60 (max)	Small	2,000	Ca, Na, HCO_3, SO_4, Cl	Probably Cretaceous intrusive rock.	Many small springs issuing from mounds of tufa. Water used for bathing.
117	Queni, west and south of small lake.	Warm	Large			Alluvium overlying Cretaceous intrusive rock.	Several springs. Water used for irrigation.
118	Southwest of Telek village	Warm	Small			Probably Quaternary basalt.	Several springs and shallow wells near area of smoking ground (solfataras?). Ref. 916.
119	Gran Bajo, 18 km north of San Julian.	Warm	Large			Probably Eocene-Oligocene strata.	Several springs on north border of lowland. Water is potable. Used for irrigation. Also a few saline springs on lowland.

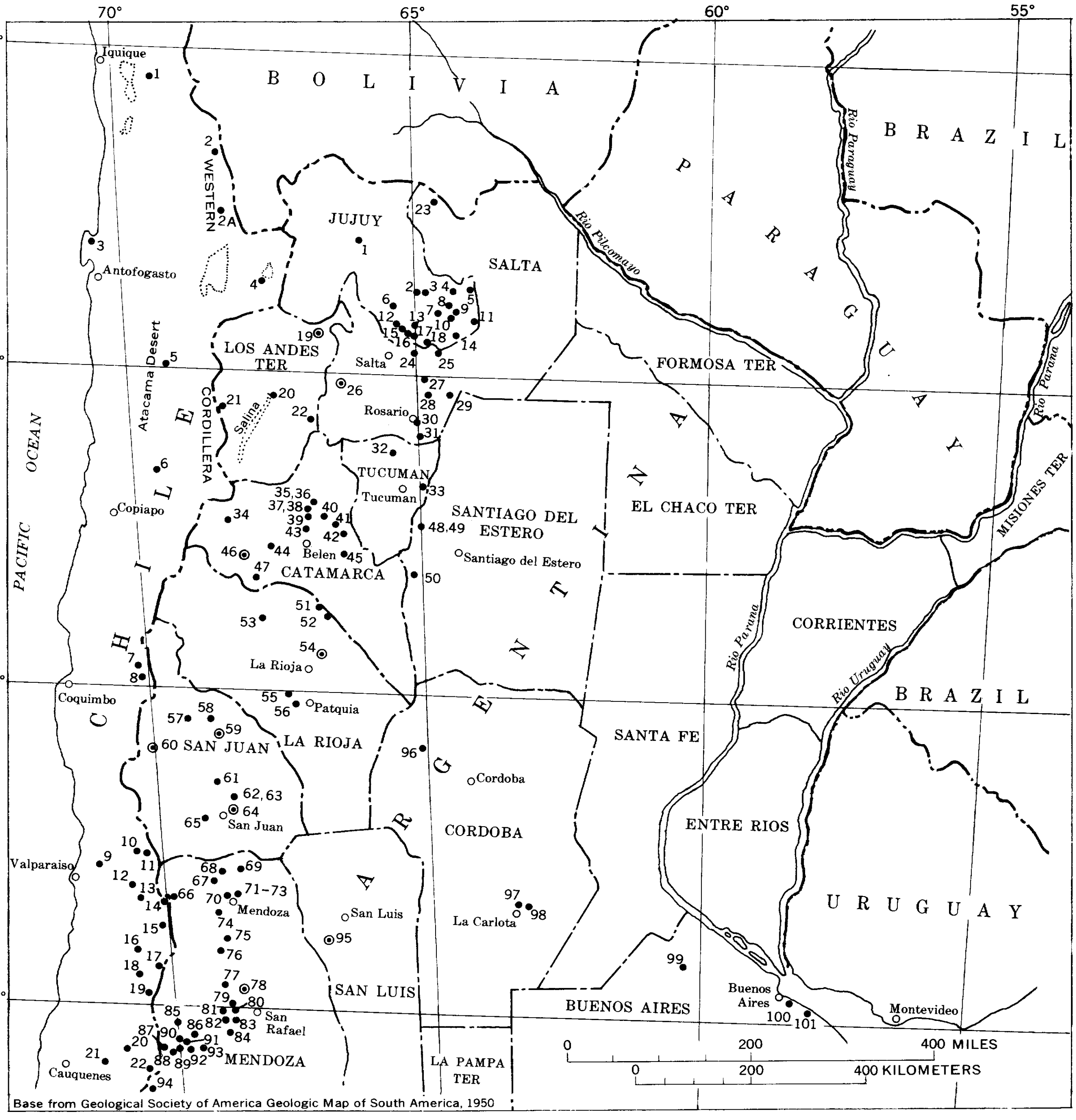

Figure 15.—Northern parts of Argentina and Chili showing location of thermal springs. Argentina chiefly from ref. 926; Chile chiefly from ref. 1002.

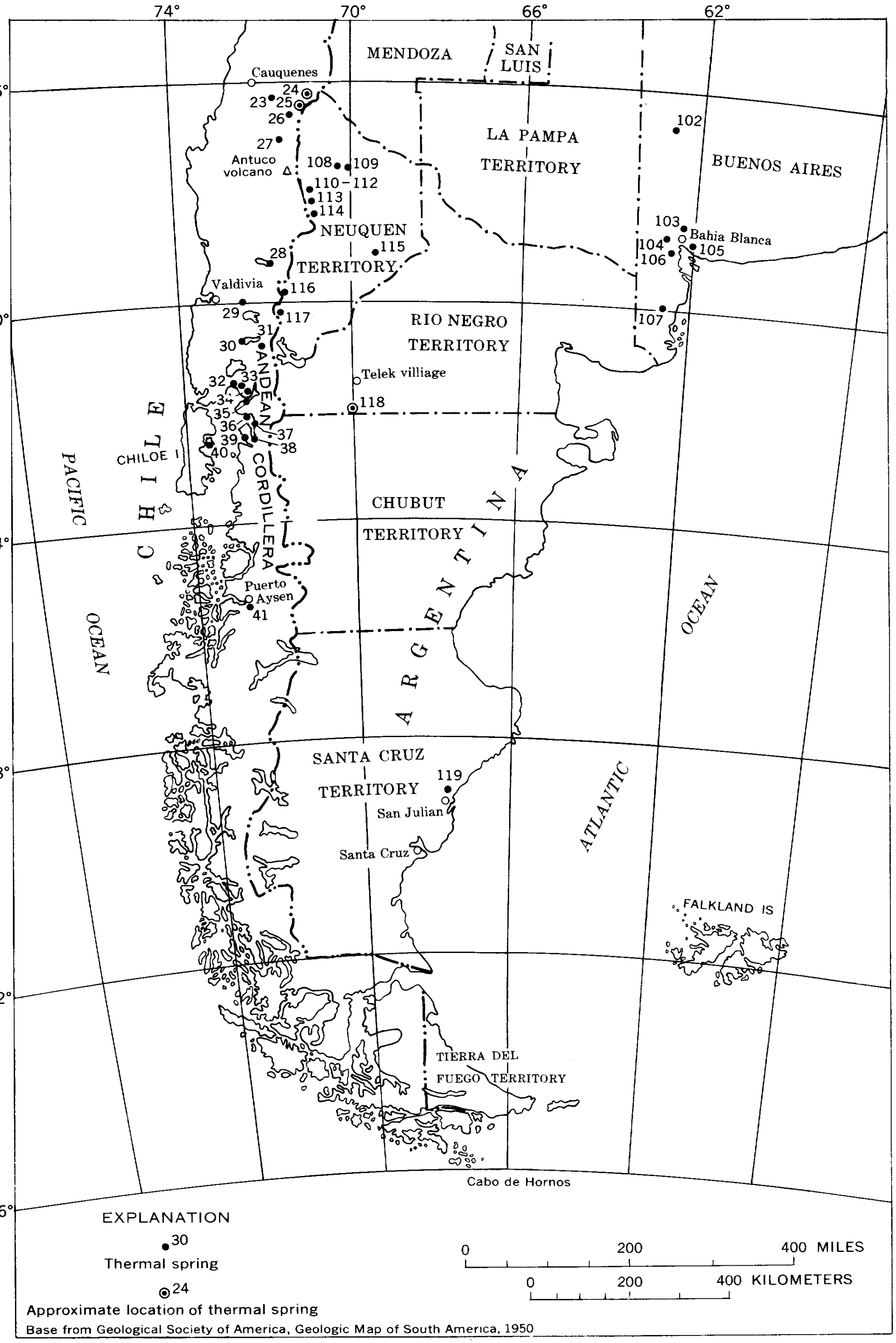

FIGURE 16.—Southern parts of Argentina and Chile showing location of thermal springs. Argentina chiefly from ref. 926; Chile chiefly from ref. 1002.

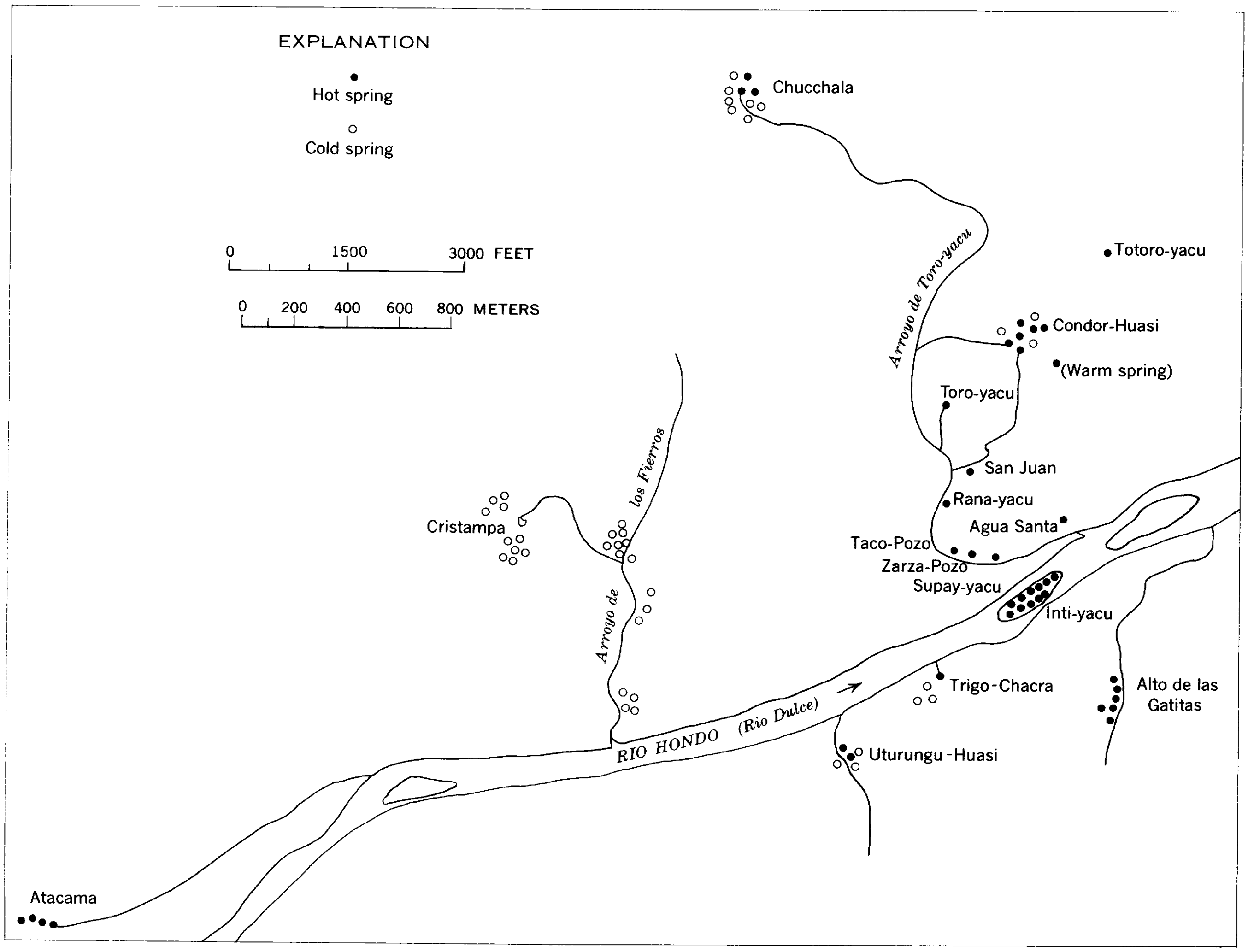

FIGURE 17.—Río Hondo area, Santiago del Estero Province, Argentina, showing location of springs. From ref. 881.

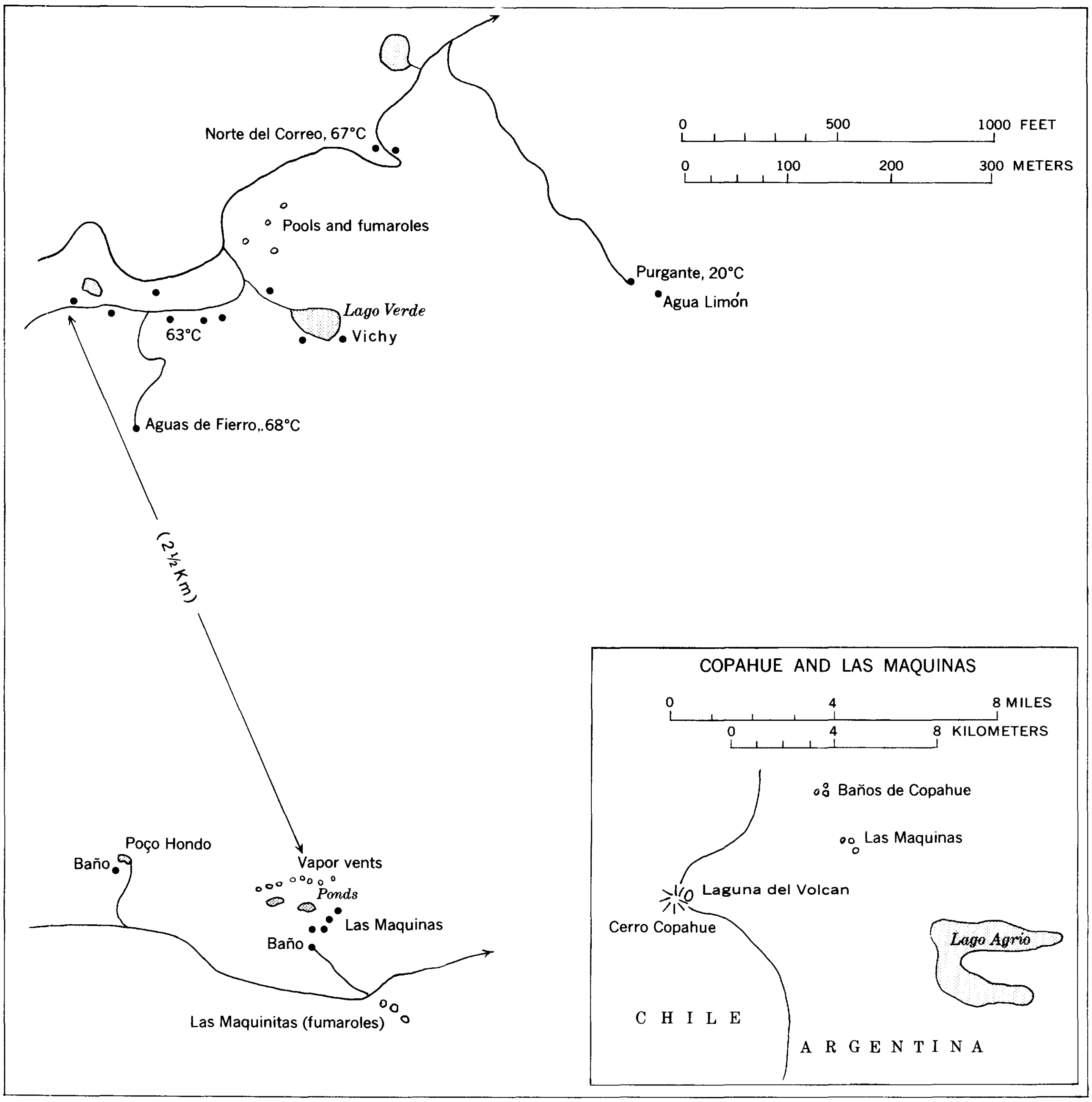

Figure 18.—Copahue area, Neuquén Territory, Argentina, showing location of springs. From ref. 903.

BOLIVIA

The Western (Occidental) and Eastern (Oriental) Cordilleras of Peru extend southeast and south through western Bolivia where they are separated by a wide plateau region that is called the Central Cordillera, or Cordillera Real (Royal). The Central Cordillera extends southward from Lake Titicaca and contains many large saline flats. The Western Cordillera is composed largely of marine Jurassic and Cretaceous rocks overlain in part by volcanic materials. Nearly all the volcanic mountains of Bolivia are in this belt; two on the southwest border are solfataric. The northern part of the Eastern Cordillera is chiefly of Devonian and Carboniferous rocks; the southern part is of Cambrian and Ordovician rocks and some intrusive granite. The great upland between the two cordilleras is underlain by continental Tertiary beds covered largely by Quaternary deposits. Much of this region may have been a lake basin.

More than one-half of Bolivia lies east of the Andes and within the basin of the Río Mamore which is tributary to Río Amazonas. The extreme southeastern part of the country drains southward to the Río Paraguay. Within this part are large areas of ancient crystalline and metamorphic rocks which are overlain by Devonian and Silurian rocks similar to those of the Eastern Cordillera.

Thermal springs are common in the central mountainous regions. The locations of those which have been recorded are shown on figure 19. The information concerning them is presented in the table below.

Thermal springs in Bolivia

[Data chiefly from refs. 931, 932. Location of unnumbered spring not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 19	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Putina, 15 km east of Cojata	Warm				Cretaceous strata faulted against Devonian slate.	Deposits of sulfur and pyrite.
2	Charasani	Warm				do	
3	Chuma	Warm				do	
4	Ilabaya	Warm				do	
5	Bank of Río Suches, 4 km from Escoma.	Warm				Cretaceous strata	
6	Carabuco, 5 km from Matilde mine.	65				do	
7	Poquea, east of Ancoraimes	Warm				Quaternary deposits overlying Devonian strata.	
8	San Francisco, south of Ancohuma.	Warm				Faulted Devonian strata	
9	Viscachani, near La Paz-Oruro railway.	26	Moderately large			Devonian(?) strata	Much free CO_2. Water used for bathing.
10	Urmiri, near Sapahaque	42–73	Large	1,794	SiO_2 (73); Na (310); K (65); SO_4 (629); Cl (64).	Devonian strata	14 springs. Large deposit of tufa and small deposits of gypsum, sulfur, and pyrite; incrustations of hyalite, realgar, cinnabar. Water used for bathing.
11	Chiguacato, near Río Caracato.	40	Small			do	In area of antimony mines.
12	Aguas Calientes, 20 km north of Quime.	Warm				do	
13	Valle Colquiri, near junction of Ríos Colquiri and Ayopaya.	Warm				do	
14	Kami, on bank of Río Ayopaya.	Very hot	Small			do	Water is sulfurous.
15	Lanza, 5 km below Leque	69	240,000			do	Water is sulfurous and alkaline.
16	Liriuni, at base of Tunari Mountain.	Warm	Moderately large			do	Water is sulfurous and alkaline. Used for bathing.
17	Incuyo, 10 km south-southwest of Tapacari.	Warm				do	
18	Putina, between Suticollo and Parotani.	Warm				Upper Cretaceous sandstone.	
19	Cayacayani, east of Santivanez.	Warm	Moderately large			Probably Upper Cretaceous strata.	Water used for bathing.
20	Aguas Calientes, near Oruro-Cochabamba railway.		Moderately large			do	Do.
21	Colcha, near Colcha railway station.	Warm				Upper Cretaceous sandstone.	
22	Near Arque	Warm				Devonian strata	Water is sulfurous and alkaline. Near antimony mines.
23	Carapari, in bed of Río Grande.	Warm				do	
24	Paja, east of Totora	Warm				do	
25	Base of Pomarape volcano	Hot				Quaternary lava	Several springs and solfataras.
26	Capachos, 12 km east of Oruro.	Warm				Devonian(?) strata	
27	Obrajes, near Paria	71	Moderately large			Devonian strata	Issues from pyrite-bearing vein. Water is sulfurous. Used for bathing.
28	Machacamarca, 26 km southeast of Oruro.					do	Issues from quartz vein.
29	6 km from Huanuni	Warm				Probably Quaternary deposits overlying Devonian strata.	
30	East of Poopó	Warm	Moderately large			Faulted Devonian strata	Water used for bathing.

Thermal springs in Bolivia—Continued

No. on fig. 19	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
31	North of Pazna					Faulted Devonian strata	
32	Urnuri, near Pazna	55				do	Water is saline; contains Fe.
33	Ajata, southeast of Condor	71				do	Water is sulfurous and alkaline. In area of antimony mines.
34	2 km south of Challapata	Warm				do	Water is strongly saline; contains Fe.
35	Mojotoro, in Río Chico	Warm				Probably Upper Cretaceous strata overlying Devonian slate.	
36	Compania, 30 km north of Sucre.	Warm	Moderately large			do	Water used for bathing.
37	Huata, north of Sucre					do	
38	Talulu, in bed of Río Pilcomayo near Quila Quila.					Upper Cretaceous sandstone.	
39	Aguas Calientes, in valley of Catavi.	68				Probably Quaternary rhyolite overlying Devonian strata.	Near an antimony mine.
40	Catavi, near Victoria mining mill.	Warm	Moderately large			do	Deposits of tufa, pyrite, and manganese dioxide. Water is sulfurous and alkaline. Used for bathing.
41	Uncia, 3 km below Uncia tin mine.	60	600			Folded Devonian slate	Several springs. Large deposits of tufa and small deposits of opal, calcite, barite, limonite, psilomelane, wolframite. Similar deposits 2 km north of Uncia. Water is slightly saline. Free CO_2, H_2S. Ref. 937.
42	Río Huntuma, 30 km southwest of Uncia.					do	Deposits of $CaCO_3$, MnO_2.
43	Luluni, in valley of Río Blanco.	68–75	Large			do	Several springs. Large deposits of tufa.
44	Near Chiuta	Warm				do	Several springs.
45	Chayala, in bed of Río Grande.	Warm				do	
46	Tacarani, in bed of Río Grande.	Warm				Probably Upper Cretaceous strata overlying Devonian slate.	
47	Zepelin, 2 km from Luluni	Warm				Devonian strata	Water is sulfurous and alkaline. In area of antimony mines.
48	Guadalupe, southeast of Colquechaca.	Warm				do	Water is sulfurous. In area of antimony mines.
49	Yurimata, 12 km downstream from Maragua.	45				do	In area of antimony mines.
50	Churiña, in bed of Río Salinas de Macha.	79				Probably Quaternary rhyolite.	Water is sulfurous. In area of antimony mines.
51	Tinguipaya, near Tacopapa	Warm				Probably Quaternary rhyolite overlying Upper Cretaceous strata.	
52	Miraflores, near Potosí	Warm	Large			Upper Cretaceous strata faulted against Devonian slate.	Large deposit of tufa. Much free CO_2. Bathing resort. Ref. 936.
53	Tarapaya (San Tomás), near Potosí.	24–34	Large			do	Several springs. Deposit of tufa. Ref. 935.
54	Totora, near Potosí	Warm				do	Water contains Fe.
55	Tirispaya, near Bartolo	Warm	Moderately large			Upper Cretaceous sandstone.	Water is sulfurous. Bathing resort. Ref. 934.
56	Don Diego, near Potosí-Sucre railway.	48	Moderately large			do	Water is slightly sulfurous. Used for bathing.
57	Chaqui, north of Cotagaita	80				Probably Tertiary intrusive in Devonian shale.	Several springs. Deposits of sulfur. Ref. 934.
58	Río Mulatos, in riverbed near railway station.	Tepid				Folded Tertiary(?) strata	Much free CO_2.
59	Río Mulatos-Potosí, at km 20 on the railway.	Tepid				Probably Quaternary rhyolite.	Do.
60	Río Yura, near its headwaters.	Warm				do	Deposits of tufa.
61	Carma, in bed of Río Agua Castilla.	Warm				Devonian strata	
62	Near Cayza	Warm				do	2 groups of springs. Water is sulfurous. Near antimony workings.
63	Asiento, southeast of Río Mulatos.					Probably Quaternary rhyolite.	
64	Pulacayo, in Veta Tajo mine	59	Moderately large			Devonian(?) strata	Issues from silver-lead-zinc vein at depth of 500 meters.
65	Near Caite, on shore of Salar de Empexa.	62–79	Moderately large	18,608	CaO (869); MgO (373); SO_3 (2,370); Cl (9,376); Al_2O_3 (216); free H_2SO_4 (1,578).	Probably Quaternary deposits overlying Tertiary lava.	3 main springs. Analysis is for spring having temperature of 74°C.
66	Touca, west of Caite	Warm				do	Water is saline.
67	Empexa, southwest of Caite	Warm				do	Water is saline and sulfurous.
68	Near shore of Salar de Laguna	Warm	Moderately large			do	Do.
69	At north base of Ollca volcano.	Hot	Moderately large			Quaternary lava	Several springs and solfataras.
70	Chocaya, 15 km west of Chocaya la Vieja.	Warm	Moderately large			Folded Tertiary deposits overlying Devonian strata.	Deposits of tufa, partly aragonite.
71	In bed of Río San Juan, 15 km below Esmaraca.	Warm				Devonian strata	Deposits of sulfur.
72	Near Sud Lopez Mountains	Warm	Moderately large			Quaternary deposits overlying Tertiary lava.	Several springs issuing on saline flats and also in shallow lake.
	Chinchillani						

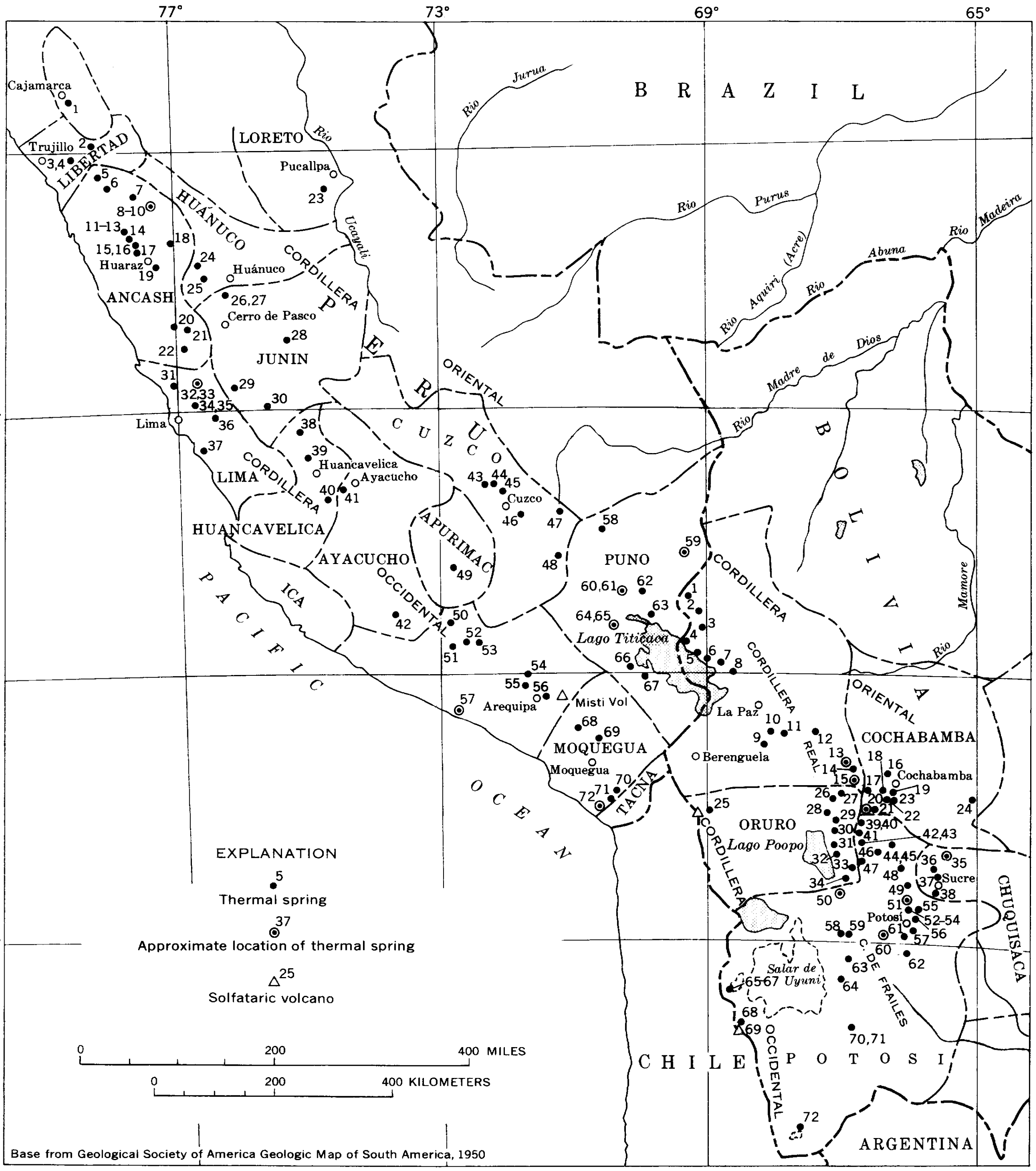

FIGURE 19.—Western Bolivia and central and southern Peru showing location of thermal springs and principal volcanoes. Bolivia chiefly from refs. 931 and 932; Peru from refs. 1061 and 1066.

BRAZIL

The principal mountain ranges in Brazil are in the eastern and southeastern parts; some of them rise abruptly from the coast. They are composed largely of granite, gneiss, and other crystalline and metamorphic rocks, all probably of Precambrian age. These rocks also underlie most of northeastern Brazil, where they are covered by continental Upper Carboniferous beds in the basins of Rio Tocantins and Rio Parnaiba and by marine Cretaceous limestone and sandstone in some upland areas. Most of the Amazon River basin in northern and northwestern Brazil is underlain by

Tertiary deposits that are covered largely by Quaternary alluvium that extends to the bordering uplands of ancient basement rocks. On both sides of the middle and lower parts of the Amazon River valley, marine Cambrian to Carboniferous strata overlying crystalline rocks are exposed.

Cretaceous formations extend far south along the highlands in eastern Brazil, but in the main valleys of Rio São Francisco and its tributaries, marine Silurian deposits and also Cambrian and Precambrian strata, including the iron-bearing Minas quartzite, are exposed. South of the area of outcrop of the marine Cretaceous deposits is a region of Mesozoic basalt and some intrusive rocks. This region is bordered on the east and south by Paleozoic and Mesozoic deposits which lap against the coastal mountains of gneiss and granite. No areas of Tertiary or later volcanic rocks have been recorded in Brazil.

The locations of thermal springs in Brazil are shown on figure 20, and the available information concerning them is summarized in the table below.

Figure 20.—Brazil showing location of thermal springs. Chiefly from refs. 940–949 and 964.

Thermal springs and wells in Brazil

[Data chiefly from ref. 964, and Geological Map of South America, scale 1:5,000,000 (Geol. Soc. America, 1950). Principal chemical constitutents in parts per million]

No. on fig. 20	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	25 km west of Xapury	Warm	Moderately large			Tertiary strata	Water is saline.
2	Uricurituba municipio, on south side of Rio Amazonas.	Warm-hot				Quaternary deposits	Several shallow wells. Free H_2S. Small deposit of iron oxide.
3	Everé, 8 km west of Monte Alegre.	35	Moderately large			Tertiary strata	Water is saline Free H_2S. Water used for bathing.
4	Near Marcanan	Warm	Small			do	Several springs. Water is potable.
5	Itaituba, on west bank of Rito Tapajos.	38	140	912	Ca (63); Na (20); K(29); CO_3 (60); Cl (434).	Upper Cretaceous strata	Test well for oil. Water used locally.
6	3 km southwest of Itaituba	Warm		5,500		do	Test well for oil. Water is saline.
7	1 km south of Conceição do Araguaia.	Warm	Moderately large			Pliocene-Miocene strata	Water is brackish. Free CO_2. Water used locally.
8	Rosario	Warm	Small			do	Water is moderately mineralized. Used locally.
9	Caxias municipio	Warm	Small			Upper Carboniferous strata.	Free H_2S. Water used locally.
10	Fervedouro da Fstiva, 2 km northeast of Riachão.	Tepid	Small			Upper Cretaceous sandstone.	1 main spring. Much free H_2S. Other springs reported a few kilometers farther west. Refs. 967, 976, 988.
11	12 km south of Terezina	Warm	Small			Upper Carboniferous strata.	Water is potable. Used locally.
12	About 30 km west of São Benedicto.	Warm	Small			do	Do.
13	5 km west of Palma	Warm	Small			Granitic(?) rock	Water is potable. Free CO_2. Water used locally.
14	Aguas do Pagé, 45 km southeast of Sobral.	31.5	Moderately large			do	2 springs. Free H_2S. Water used for bathing.
15	Near Brejo dos Santos	Warm	Small			do	Several springs. Water is brackish Free CO_2. Water used locally.
16	Olho d'Agua do Milho (Aguas Termais do Apody), 7 km west of Caraúbas.	39	Moderately large			Upper Cretaceous strata	Water is brackish. Used for bathing.
17	42 km south of Touros	Warm	Small			do	Water is potable. Used locally.
18	Macaiba	Warm				Teritary strata	Several shallow wells. Water is brackish.
19	Brejo das Freiras, 9 km from Antenor Navarro.	38	100	522	SiO_2 (33); Na (179); SO_4 (26); Cl (124); free CO_2.	Lower Cretaceous sandstone faulted against quartzite.	Spring; also 3 wells drilled in 1933 and 1 in 1939. Water used for bathing. Refs. 947, 953, 954, 957, 976.
20	At base of Serra do Sabá, 13 km from Custodia.	25.5	20	68	Na (22); Cl (28); free CO_2	Precambrian sandstone.	Water marketed for table use. Ref. 978.
21	Brejo de Madre de Deus (Conceição).	30	20	1,478	Na (405); SO_4 (262); Cl (599)	Granite	Water used for bathing.
22	In and near Ribieropolis	Warm				Tertiary strata	Many shallow wells. Water is potable.
23	Caldas do Bamburral, 20 km north of Aracajú.	35	Small			do	Free H_2S.
24	Near Salgado railway station.	29	Large	261	Ca, Mg, Na, HCO_3, SO_4	Upper Cretaceous strata	Water used for bathing.
25	180 km north-northeast of Mato Grosso.	Warm	Large			do	Several springs supplying Rio Agua Quente. Ref. 962.
26	Baía do Frade, on left side of Rio Cuyabá near Tamandaré.	30; 42	17	104	SiO_2 (49); CaO (14); SO_3 (19); Cl (74).	Minas series (Precambrian).	2 main and 2 smaller springs supplying lake 10 km long. Water high in Fe, Mg. Water used for bathing. Ref. 962.
27	Palmeiras (Serro de Paulista).	30–41	280	86	SiO_2 (57); CaO (7); SO_3 (8)	Granite-porphyry	8 main springs within area 30 meters in diameter. Water used locally. Ref. 962.
28	Termas do Poúro, on north side of Rio Poúro 20 km north of São Lourenço.	32–42	2,100	82	SiO_2 (29); CaO (12); SO_3 (13)	Devonian quartzite	3 groups of springs. Ref. 962.
29	Tardariau	40	Large			do	Ref. 962.
30	Paikidjagure, 18 km northeast of Tardariau springs.	Warm	Moderately large			do	Do.
31	Near Registro de Araguaia, on west bank of Rio Araguaia.	Warm	Small			Precambrian crystalline rock.	Water is sulfurous. Used locally. Ref. 962.
32	18 km from Barreiro Grande.	Warm	Large			Devonian strata	Water used locally. Ref. 962.
33	25 km north of Coxim	Warm	Small			do	Water is potable. Used locally.
34	Agua Santa, 120 km south of Coxim.	Warm	Small			do	Do.
35	Near west bank of Rio Aporé.	Warm	Small			Probably Mesozoic lava	Several springs supplying small lake. Ref. 962.
36	30 km south of Boa Vista de Tocantins.	Warm	Moderately large			Triassic deposits	Several springs. Water is brackish. Free H_2S.
37	60 km east of Conceição do Norte.	Warm	Moderately large			Precambrian rock	Water is brackish. Free H_2S. Water used locally.
38	Near Cavalcante	Warm				do	3 shallow wells. Water is potable. Free H_2S. Water used locally.
39	On bank of Riberão de Crixa, several km northeast of Formosa.	Warm	Moderately large			Upper Cretaceous strata	3 springs. Free H_2S. Water used for bathing.
40	Salobro	Warm				Precambrian rock	
41	Capellina Santa Bárbara, 1 km north of Goiaz.	22	2	78	Ca, SO_4	Gneiss	Water used for bathing. Ref. 955.
42	Caldas Velhas	27	10,500	39	Ca, Na, HCO_3	Precambrian schist	Bathing resort. Refs. 961, 979.
43	Caldas Novas, 12 km east of Caldas Velhas.	36–45	120	65	Ca, Na, HCO_3	Precambrian gneiss	23 main springs. Bathing resort. Refs. 961, 979, 989.
44	Caldas de Pirapetinga, 8 km northeast of Caldas Novas.	42–51	900	128	Ca, Na, HCO_3	Precambrian schist	9 main springs supplying pool beside Rio Pirapetinga. Bathing resort. Refs. 961, 979.
45	3 km from Pires do Rio railway station.	Warm	Small			Upper Cretaceous strata	Water moderately mineralized. High Mg content. Ref. 950.

Thermal springs and wells in Brazil—Continued

No. on fig. 20	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
46	Right bank of Rio Corrente	38	Small			Tertiary or Triassic strata	Water is potable. Used for bathing.
47	Near Rio Apuré	38	Small			do	Do.
48	Near Pilão Arcado	Warm	Moderately large			Precambrian rock	Water is brackish. Free CO_2. Water used locally.
49	Campo Formoso Antonica	Warm	Moderately large			do	Several springs. Water is brackish. Free CO_2. Also shallow warm-water wells at Lagoa de Rocha and Panellas.
50	Near Tucano village	Warm	Small			Upper Cretaceous strata	Several springs. Water is brackish. Used locally.
51	Caldas do Cipó, 45 km northwest of Itapicurú.	33–40	Large	1,685	Ca (354); Mg (56); Na (817); HCO_3 (43); Cl (955); gas 98 percent N_2.	do	4 main springs. Water used for bathing. Refs. 941, 947, 960, 976, 990, 992.
52	Cajazeiras, 21 km northwest of Itapicurú.	33–37	30	3,987	Na, Cl	do	3 main springs. Water used for bathing. Also several small springs 5 km farther south. Ref. 941.
53	Fervente, 2 km southeast of Itapicurú.	33	840			Probably Upper Cretaceous strata.	Water is slightly saline. Free gas. Water used for bathing. Refs. 941, 976, 990.
54	3 km north of Soure	Warm				Tertiary strata	Water is brackish. Free H_2S. Water used for bathing.
55	Tareco, 36 km from Morro do Chapeo.	Warm	Small			Granite	Water issues at base of hill.
56	Agua Quente, 15 km from Paramirim.	Warm	Moderately large			Cambrian strata	2 springs. Water is saline. Used for bathing.
57	Santarem and Barra, 30 km from Paramirim.	Warm	Moderately large			do	2 springs. Water is brackish. Used for bathing.
58	3 km north of Monte Alto village.	Warm	Small			do	Water is brackish. Free CO_2. Water used locally.
59	Agua Quente, 60 km north of Rio Pardo city.	29	2,000	111	Na, HCO_3	Precambrian crystalline schist.	Water used locally.
60	Serra Negra, 19 km east of Patrocinio.	23.5	Moderately large	5,595	Na_2CO_3 (3,339); $NaHCO_3$ (151); K_2CO_3 (1,898); Na_2SO_4 (214).	Precambrian nepheline rock.	Water marketed for table use. Also used for bathing. Ref. 994.
61	Tapira (Sacramento), 50 km northeast of Araxá.	16–26	Moderately large		Na, HCO_3	Precambrian rock	3 springs. Soda extraction works. Ref. 970.
62	Araxá	21.7–34.1	840	4,470 (hottest)	Na_2CO_3 (2,352); $NaHCO_3$ (1,583); Na_2SO_4 (218); K_2SO_4 (368).	Faulted Minas series (Precambrian).	10 main springs. Water is radioactive. Bathing resort. Refs. 940, 942, 946, 976, 982–984, 994.
63	Agua Quente, 63 km northwest of Ibiracy.	21	Small			Minas series (Precambrian).	Ref. 951.
64	Agua Salus, 40 km west-southwest of Belo Horizonte.	24	60	180	Ca (34); Mg (12); CO_3 (75)	do	Water used for bathing. Ref. 977.
65	Bebedouro, 3 km from Salitre railway station.	20.3	Small		Na, HCO_3, SO_4; free CO_2	do	Deposit of barite. Ref. 988.
66	Fontes do Girâu, in Municipio de Presidente Vargas.	Warm	Small	Low		do	Ref. 949.
67	Agua Quente, 13 km from Itabirito.	28.7	2,000			do	Water used for bathing. Ref. 951.
68	Aguas Santas (Santa Luzia de Carangola).	21–27	15			Granite	8 springs. Water is potable. Used locally.
69	São Sebastião do Paraiso	30 (max)	Moderately large	62	Ca, HCO_3, SiO_2	Minas series (Precambrian).	5 springs. Water used for bathing.
70	Itaú, between São Sebastião and Jacuí.	Warm	Small	Low	Ca, Na, HCO_3	do	3 groups of springs. Water is slightly radioactive. Used locally. Ref. 971.
71	Thermopolis, 12 km east of Jacuí.	30	Small			do	Water marketed for table use.
72	Aguas Santas de Tiradentes, 13 km from São João del Rey.	21–28	770	46	SiO_2 (13); CaO (8); MgO (8); Na_2O (7); HCO_3 (35); Cl (4).	Quartzite and phyllite of Minas series (Precambrian).	4 main springs. Water used for bathing. Ref. 968.
73	Poços de Caldas, 25 km northwest of Caldas.	41–46	290	575	$NaCO_3$ (345); $NaHCO_3$ (123); Na_2SO_4 (57).	Minas series (Precambrian).	7 main springs, including Pedro Botelho, Chiquinha, Mariquinha, and Macacos. Water marketed for table use. Bathing resort. Refs. 956, 960, 965, 966, 976, 986–988, 993–996.
74	Poçinhos, 4 km west of Caldas.	24	Moderately large	Low	Ca, HCO_3	do	Several springs. Water used for bathing. Ref. 994.
75	Lambarí	21 (max)	Moderately large	Low	Ca, HCO_3	do	6 main springs. Water marketed for table use. Also used for bathing. Refs. 956, 965, 976, 986, 988, 994–996.
76	Caxambú	21–29	Moderately large	494	CaO (113); Na_2O (55); K_2O (63)	Minas series (Precambrian) intruded by pegmatite dikes.	9 springs. Water is radioactive. Marketed for table use. Bathing resort. Refs. 947, 956, 959, 963, 965, 966, 969, 976, 986–988, 994–996.
77	Contendas, 4 km east of Conceição do Rio Verde.	20–22	Moderately large			Minas series (Precambrian).	4 main springs. Free H_2S. Water used locally. Ref. 995.
78	Baependy	20–23	Moderately large			do	Several springs. Marketed for table use. Refs. 959, 987.
79	São Lourenço (Aguas de Vianna), near Pouso Alto:						
	Five main springs, including Fonte Vichy.	17.5–19		1,407	SiO_2 (38); Ca (87); Mg (50); Na (115); K (90); HCO_3 (990); free CO_2.	do	Water marketed for table use. Also used for bathing. Refs. 945, 947, 948, 973, 976, 987, 988, 994.
	Well 21.75 meters deep	22	7				
	Well 45.7 meters deep	22	6				
80	Salvaterra, 12 km from Juiz de Fora.	23.5 (max)	Moderately large	380	Ca, Na, HCO_3	Granite and gneiss	4 main springs. Water used locally.
81	Cambuqueira	20–21.4	20	Low	Ca, Na, HCO_3; free CO_2	do	4 main springs. Water marketed for table use. Bathing resort. Refs. 956, 958, 966, 976, 986–988, 994, 995.

Thermal springs and wells in Brazil—Continued

No. on fig. 20	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
82	Marimbeiro, 4 km from Cambuqueira.	19–20	Moderately large	2,194	Ca, Na, HCO_3	Probably Minas series (Precambrian).	3 springs. Water marketed for table use. Refs. 988, 994.
83	Cubatão, 11 km west of Itaperuna.	Warm	8			do	Water used for bathing.
84	Muribeca, near Santa Maria Magdalena.	Warm	Small			do	Water used locally.
85	Inge, near Niteroi	20–24	75	145–807	Ca, Na, HCO_3	Gneiss	4 springs. Water marketed for table use.
86	São Jorge, 18 km north of Franca.	Warm	Small	Low	Ca, Na, HCO_3	Syenite	Water marketed for table use.
87	Valley of Riberão Canoas	Warm	Small	Low	Ca, Na, HCO_3; free H_2S	do	Several springs. Water used for bathing.
88	Ibiracy	Warm	2,800	Low	Ca, Na, HCO_3; free H_2S	Nephaline syenite	2 springs. Water used for bathing.
89	Fonte Seixao, at Ibira	Warm	7			Upper Cretaceous strata	Water used for bathing.
90	4 km north of Mococa	Warm	Small	Low		Syenite	Water marketed for table use.
91	Agua de Java, 3 km from Java railway station.	22	Small	118	Na, HCO_3	Triassic strata	Water marketed for table use Ref. 975.
92	7 km from Lindoia	27; 28.5	1,000	52	$CaCO_3$ (7); $CaPO_4$ (14); $MgCl_2$ (24).	Lower Permian strata	2 springs. Water is radioactive. Marketed for table use. Also used for bathing. Refs. 939, 974, 999.
93	6 km from São Pedro	30	28	1,982	Na_2CO_3 (356); Na_2SO_4 (186); NaCl (1,262); free H_2S.	Jurassic and Triassic strata.	Oil test well 350 meters deep; drilled in 1932. Water used for bathing.
94	Near Gioconda, in Piracicaba municipio.	Warm	Moderately large			do	Test well for oil ("Aragua 112"). Water moderately mineralized; high Mg content. Used for bathing.
95	Near Boa Vista, in Itapira municipio.	26	Small	176	Ca, Na, HCO_3	Metamorphic rock	Water marketed for table use.
96	Campinas	Warm	Small			Precambrian rock	Water is radioactive. Ref. 972.
97	Sonia	21	Small	90	Ca, Na, K, HCO_3	do	Water marketed for table use. Bathing resort. Also similar springs at Juventude, Santa Teresa, Sete Quedas, and Tres Barras.
98	San Antonio, at Serra Negra	Warm	Small	Low		Faulted Minas series (Precambrian.	4 springs. Bathing resort. Refs. 940, 988.
99	Poço Quilombo, near Pedreneiras.	29	Moderately large	192	Na_2O (109); HCO_3	Jurassic strata	Water used for bathing.
100	Santa Bárbara do Rio Pardo	27 (max)	480			Triassic basalt	1 main and 6 smaller springs. Bathing resort. Ref. 938.
101	Cerqueira Cesar (Esmeralda), 5 km south of Santa Bárbara.	22	600			do	Water is potable. Used locally. Also well 9 meters deep. Ref. 938.
102	Piaol, near Prata railway station.	22	35	2,370	$MgSO_4$ (60); NaHCO (1,977); Na_2SO_4 (169); NaCl (44).	Nepheline syenite intruded into schist and quartzite.	2 springs. Water marketed for table use. Also used for bathing. Group of 3 other springs about 3 km distant. Refs. 974, 976, 999.
103	Platina, 4 km from Prata	24–31.5	Small	694	Na, HCO_3	Metamorphic rock	Water used for drinking. Refs. 974, 999.
104	12 km south of Bofete village	Warm	Moderately large			Upper Carboniferous deposits.	Test well for oil drilled in 1896. Water is saline. Used for bathing.
105	Serrito, 20 km from Itapetininga.	Warm		510		Precambrian bituminous(?) schist.	Pumped well. Free H_2S. Water used for bathing.
106	Colonia Teresa, near Rio Ivaí.	30	Small			Upper Cretaceous strata overlying Triassic basalt.	Several springs. Also similiar springs of Goio-En and Serra Azul.
107	4 km south of Piraí	29	Moderately large		Na, HCO_3	Devonian(?) strata	Water moderately mineralized; high conent of Fe_2O_3. Used for bathing.
108	Agua Mineral Paraná, at Castro.	20	Moderately large	826	Ca, Na, HCO_3	Lateritic diabase	Flowing well 36 meters deep. Water marketed for table use. Also used for bathing.
109	Near Rio Cavernoso:						
	Lourdes	30	Small	154	Ca, Na, HCO_3	}Triassic basalt	Water used locally.
	Candoi	30.5	Small	216	Ca, Na, HCO		
110	Along Rio Jordão	29–31.5	Small	405	Na, K, HCO_3	do	3 main springs: Jacu, Santa Clara, Boa Vista. Other springs in same district reported at Algodõeiro, Araras, Igrejinha, Juquia, Reserva, São Pedro, and Sobrado. Ref. 952.
111	30 km north of Clevelandia	Warm	Small			do	Water is saline; high content of Fe_2O_3. Free H_2S. Water used for bathing.
112	80 km north of Palmas	Warm	Small			do	Several springs. Water is brackish. Free H_2S. Water used for bathing.
113	On left bank of Rio Chapecó (Xapecó), 9 km above junction with Rio Uruguai.	31.3–34.2	75	732	Ca; Na; SO_4 (448); Cl (143)	do	3 main springs. Also 3 other similar springs (Ilha Redonda, Prata, and Tarquaruçu) in same district.
114	Caldas de Imperatriz, 24 km southwest of Florianopolis.	35–39.5	Moderately large	97 (hottest)	$Ca(HCO_3)_2$(16); $NaHCO_3$ (17); $KHCO_3$ (10).	Pegmatite dike intruded into granite, gneiss, and schist.	4 main springs. Water is highly radioactive. Marketed for table use. Bathing resort. Refs. 943, 944, 947, 998.
115	Aguas Mornas (Caldas do Sul), 5 km southwest of Imperatriz springs.	30	Moderately large			Precambrian rock	Bathing resort. Ref. 943.
116	30 km north of Imaruí	Warm	Small			do	Water is bitter; high content of $MgSO_4$. Free H_2S. Water used for bathing.

Thermal springs and wells in Brazil—Continued

No. on fig. 20	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
117	Sangra Morta	34-40	Small		Na, HCO_3	Quaternary deposits overlying Precambrian rock.	Several springs. Water moderately mineralized. Used for bathing.
118	12 km east of Tubarão	32-40	Small		Na, HCO_3	do	Do.
119	Near Rio Bravo	35-40	Small		Na, HCO_3	do	Water moderately mineralized. Used for bathing. Also 3 other springs (Bittencourt, Cubatão, and Santo Anjo da Guarda) in same district.
120	Fontes de Iraí (Aguas do Mel), near Rio Uruguai.	24.5-36.5	280	1,324 (hottest)	$NaHCO_3$ (353); Na_2SO_4 (457); NaCl (442).	Triassic basalt	4 main springs. State bath establishment.
121	Prado	20.8-31	Large			do	Water moderately mineralized. Used for bathing.

CHILE

The Western Cordillera, which forms the boundary between Bolivia and northern Chile, approaches the coast as it extends southward. The main parts of the ranges are chiefly of Mesozoic intrusive granite and other crystalline rocks, but there are some altered volcanic rocks. These older materials are covered in many areas by Tertiary lava. Farther south, the older rocks constitute both the coastal mountains and the numerous islands offshore, including Horn Island (Cape Horn). The northern and middle parts of the main Andean Cordillera along the east side of Chile are covered largely by Miocene to Quaternary lavas and contain many volcanic mountains, but in some places the underlying marine Mesozoic strata are exposed. Valleys between the mountain chains generally are underlain by Quaternary deposits. In the far south, ancient crystalline and metamorphic rocks form the principal mountain ranges.

The locations of thermal springs in Chile are shown on figures 15 and 16, and the available data concerning them are summarized in the table below.

Thermal springs in Chile

[Data chiefly from ref. 1002 and Geological map of South America, scale 1: 5,000,000, (Geol. Soc. America, 1950). Locations of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 15 or 16	Name or location	Temperature of water (° C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Aguas de Pica, east and south of Aldea de Pica.	22-35	Large			Quaternary rhyolite	5 main springs. Water is potable. Used for irrigation.
2	Ojos de Agua de Ascotan	Warm				Quaternary lava	Several springs near small lake. Water contains borate.
2A	Tatio, near head of Río Salado.	Boiling	7,000			do	Many small springs and fumaroles.[1]
3	Termas de Mejillones, on harbor shore.	37	Moderately large			Granitic intrusive rock	Issues at high-tide level. Water is more saline than sea water.
4	Lago Aguas Calientes, at southwest border of Salar Agua Caliente.	Warm				Quaternary lava	
5	Salina de Aguas Calientes, on border of small saline flat.	Warm				Quaternary deposits	Ref. 1007.
6	Aguas Termales, 50 km north-northwest of Salar de Pedernales.	Warm				Jurassic volcanic rocks	Do.
7	Baños del Toro (Estero de Los Baños).	26-60	Moderately large	4,800	Ca, Na, HCO_3, SO_4, Cl; free CO_2.	Granite near kaolinized sedimentary strata.	4 main and several small springs. Deposits of tufa and salt. Bathing resort. Ref. 1004.
8	Aguas del Volcan, 17 km southeast of Baños del Toro.	22	Small			Jurassic volcanic rocks	3 springs. Water is brackish. Used for bathing.
9	Agua de Catapilco, 10 km north of Quillota.	19				Pyritiferous Mesozoic marl.	Water used for bathing.
10	Baños de Jahuel, 20 km east-northeast of San Felipe.	20.7; 21.8	400			Metamorphic rocks	2 main and 5 smaller springs. Bathing resort.
11	Baños de Higuera, 5 km east of Baños de Jahuel.	18.9				Porphyry and metamorphic rocks.	Large deposit of tufa. Water used for bathing.
12	Baños de Colina (Peldehue), 30 km north of Santiago.	26; 32	Moderately large	428	$CaSO_4$ (120); $CaCl_2$ (77); Na_2SO_4 (89); NaCl (142).	Jurassic volcanic rocks	2 main springs. Bathing resort. Ref. 1009.
13	Baños de Apoquindo, 10 km east of Santiago.	17.7-23.3	48	2,743 (hottest)	$CaCl_2$ (1,665); NaCl (1,008)	do	4 main springs. Bathing resort. Ref. 1009.
14	Termas de Tupungato (Río Colorado).	38.5; 44.6	Moderately large			do	2 main springs. Water is saline. Much free CO_2. Deposit of iron oxide. Bathing resort.
15	Salinas de Maipu, on Río Maipu.	41.2 (max)				do	Water is saline. Used for bathing.
16	Baños de Cauquenes, 20 km east-southeast of Rancagua.	40-50	Moderately large	3,032	$CaCl_2$ (2,168); NaCl (1,031)	Faulted porphyry and altered sedimentary rocks.	4 main springs. Bathing resort. Refs. 1001, 1003, 1008, 1009.
17	Los Bañitos, 70 km southeast of Rancagua.	61 (max)				Jurassic strata	Several springs. Large deposit of tufa.
18	Aguas de la Muerte, 38 km southwest of Los Bañitos.	28 (max)				Jurassic volcanic rocks	Several springs. Water is astringent. Deposit of ochre.
19	Baños de San Fernando (Tinguiririca).	70-96				Porphyry	Many small springs on riverbank.

[1] 3 groups, 100 km south of No. 2, have total of 72 fumaroles, 40 geysers, 62 thermal springs, 13 solfataras, 5 mud springs; total flow of 7,000 liters per minute (Zeil, Werner, 1959, Das Fumarolen- und Geysir-Feld westlich der Vulcangruppe des Tatio, Provinz Antofogasta, Chile: Bayer. Akad. Wiss., Math.-Naturw. Kl. Abh. no. 96, p. 5-14).

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Thermal springs in Chile—Continued

No. on fig. 15 or 16	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
20	Baños de Mondaca, on west side of Descavezada volcano.	Warm	Moderately large			Gravel overlying Quaternary lava.	Several springs. Water used for bathing.
21	Baños de Panimávida, 25 km east-northeast of Linares.	32–33	Moderately large	380	SiO_2 (34); $CaCO_3$ (22); $CaSO_4$ (80); Na_2SO_4 (134); NaCl (92); KCl_4 (14).	Jurassic volcanic rocks	5 springs. Bathing resort. Water marketed for table use. Ref. 1006.
22	Aguas de los Volcanes, east of Cauquenes.	28–44		Low		do	Several springs. Deposit of sulfur.
23	Baños de Catillo, 30 km east-southeast of Parral.	20–36	Moderately large			do	4 springs. Bathing resort.
24	Baños de San Lorenzo (Vilicura), near base of Sierra Velluda.	Warm				do	Water used for bathing.
25	Baños de Trapa Trapa, on tributary of Río Pinco.	Warm				do	Do.
26	Baños de Longavi	66–71	340			do	Many springs in 10 groups. Water is sulfurous. Much CO_2. Deposit of ocherous tufa. Bathing resort.
27	Baños de Chillan, 75 km southeast of Chillan.	40–62	Moderately large			Quaternary lava	5 main and several minor springs; also fumarole. Bathing resort.
28	Termas de Villarica, at base of Villarica volcano.	Warm	Large			do	2 main springs.
29	Termas de Ranco, near west end of Laguna de Ranco.	Hot	Moderately large			Quaternary deposits overlying Quaternary lava.	4 springs. Water is sulfurous. Used for bathing.
30	Baños de Puyehue, 10 km south of Laguna Puyehue.	55.5–70	Moderately large			do	5 springs. Bathing resort.
31	Termas de Rupanco (Llanquihue), on east shore of and in laguna.	45–70	Moderately large			do	Several springs.
32	Baños de Petrohue, 15 km east of Puerto Montt.	60	Moderately large			Quaternary deposits	Issues below high-tide level. Water is potable. Used for bathing.
33	Termas de Sotomó, on northwest bank of Estero Reloncavi.	22.5; 41.7				do	2 springs issuing near tide level. Water is potable. Free CO_2, H_2S.
34	Termas de Ralun (Llaulhaupi), on east bank of Estero Reloncavi.	32.2 (max)				do	Several springs issuing below high-tide level. Water is potable. Much free H_2S.
35	Termas de Cochamo, on east bank of estero 10 km south of Ralun.	25; 28.7	Moderately large			do	2 springs issuing near tide level. Much free H_2S. Water used for bathing.
36	Terma de Llancahue, on north shore of island.	58	Moderately large		Na, SO_4, Cl; free H_2S	Metamorphic rocks	Water is moderately mineralized.
37	Termas de Cahuelmo, on east bank of Estero de Camau.	55	Large		Ca, HCO_3	do	Water is moderately mineralized; cements adjacent sand with calcium carbonate.
38	Terma de Leteu, on west shore of Enseñada de Leteu.	Hot	Large			do	Issues above low tide level.
39	Terma de Renihue, south of Boca Camau.	Hot	Moderately large			do	
40	Termas de Quinchao, on Quinchao Island.	Warm			Ca, Na, SO_4, Cl	Quaternary deposits	
41	Baños de Aysen, on shore of Enseñada de Aysen.	Warm	Small			Cretaceous intrusive rocks	Several springs; others on nearby islets. Water used for bathing.
	Termas de Yungai, at Itatinos, near Río Papal.	Warm					Water used for bathing.
	Termas de Cuptana, at base of Cerro de Cuptana.	Warm					Do.
	Baños Morales	Hot					Ref. 1005.

COLOMBIA AND VENEZUELA

Colombia and Venezuela comprise the northernmost part of South America, extending from the Pacific Ocean, along the south border of the Caribbean Sea, to the Atlantic Ocean. This great region was the subject of studies by several early scientific observers, some of whose reports on the natural phenomena describe thermal springs in parts of both countries.

Western Colombia is traversed by three cordilleras of the Andean mountain system, many of whose peaks are covered perpetually with snow. The cores of the ranges are chiefly of granite, gneiss, and schist, but the western and central cordilleras are largely of Paleozoic intrusive rocks and pre-Cretaceous metamorphic rocks. The low mountains along the west coast and the narrow western and northern coastal plains are underlain

Thermal springs in Colombia

[Data on associated rocks mainly from Geological Map of South America, scale 1:5,000,000 (Geol. Soc. America, 1950). Principal chemical constituents are expressed in parts per million]

No. on fig. 21	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
1	Near Cabo Corrientes	Warm				Cretaceous strata	
2	Termales de Ruiz, on Ruiz volcano:						
	Near hotel on west slope	45–69.4		15,740	SiO_2 (1,065); SO_3 (6,448); NaCl (1,843); $Al_2O_3+Fe_2O_3$ (5,838); much gas.	Quaternary lava	Several springs. Analysis for water having temperature of 59° C. Water used for bathing. Refs. 1013, 1019.
	1 km west of hotel	45				do	10 small springs. Ref. 1015.
3	Tolima volcano:						
	Agua Caliente, near east base.	Hot				do	Issues near deposit of sulfur. Ref. 1017.
	Azufral Quindiú, on slope.	35.5				do	Issues at altitude of 1,955 meters. Fumaroles emit CO_2 and H_2SO_4. Ref. 1012.
	Azufral San Juan, on upper slope.	32–50				do	Several springs and fumaroles at altitude of 4,000 meters. Fumaroles emit CO_2 and H_2SO_4. Refs. 1012, 1013.
4	8 km east of Santa Rosa de Cabal:						
	Acimaipa	57–67	410			Pre-Cretaceous metamorphic rocks.	15 springs. Large deposit of stained travertine. Ref. 1016.
	Caleras	53.6–61	907			do	15 springs. About 100,000 tons of travertine available for agricultural use. Ref. 1016.
	Termales	61–72	227	1,488	SiO_2 (249); Ca (72); Mg (48); Cl (479).	do	7 springs. Ref. 1016.
	El Disparate, 2 km east of Termales.	61				Diorite porphyry	Fumaroles exhaling aqueous vapor, H_2S, CO_2. Ref. 1016.
5	Near Río Coello (Toche)	32				Probably Cretaceous strata.	2 main springs. Free CO_2, H_2S. Deposit of iron-stained tufa. Ref. 1017.
6	Tabio, 30 km north of Bogotá.	45.5				Quaternary deposits overlying Cretaceous strata.	Water used for bathing. Ref. 1017.
7	Suba, 15 km north of Bogatá	Warm				do	Do.
8	Caqueza, 25 km south of Bogatá.	65				Cretaceous strata	Water is sulfurous. Much gas. Water used for bathing. Ref. 1017.
9	Puracé (Coconuco) volcano:						
	Near quarry at base	36	Large			Trachyte	Deposit of tufa. Ref. 1013.
	Cobalo (Coconuco), at base.	72.8		7,430	$NaHCO_3$ (690); Na_2SO_4 (3,890); NaCl (2,750).	do	Refs. 1012, 1013.
	Azufral, on slope	86.5				Quaternary lava	Ref. 1013.
		50				do	Water is saline. Free CO_2 and sulfurous vapor. Refs. 1013, 1038.
	Grand and Petit Vinaigres, east of Azufral.	Hot		2,959	$CaSO_4$ (248); NaCl (232); $Al_2(SO_4)_3$ (1,343); free H_2SO_4 and HCl.	do	3 springs. Ref. 1013.
10	Pasto volcano	101.6 (max)	Small			do	Several springs and many fumaroles. Deposit of aluminum sulfate. Refs. 1013, 1023.
11	Pandiaco, 2 km northwest of Pasto village.	20–37	Moderately large			do	Group consists of El Tablon and 6 other springs at altitude of 2,571 meters. Water is saline; much CO_2. Large deposit of iron-stained tufa. Water used for bathing. Refs. 1012, 1023.
12	Tuquerres volcano:						
	Lake in crater	27				do	Lake is 150 by 500 meters in size. Free H_2SO_4 and HCl. Deposit of aluminum sulfate. Ref. 1013.
	Guachal, on slope	70				do	1 main spring and several acid fumaroles. Free H_2SO_4 and CO_2. Ref. 1013.

largely by Quaternary deposits of sandstone and marl. The Cordillera Oriental [Eastern range] is chiefly of folded marine Cretaceous strata, but some older rocks are exposed in the crests of anticlines. Nearly one-half of the country lies east of this mountain chain and is within the basins of the Orinoco and Amazon Rivers, in a region of continental Tertiary deposits which are covered largely by Quaternary alluvium.

The western border of Venezuela is marked by a branch of the Andean mountain system. Another branch swings northeast and north, along the north coast, and separates the basin of Lake Maracaibo from that of the Orinoco River. The cores of these mountains consist chiefly of gneiss, crystalline schist, and ancient sedimentary strata. Both flanks of the western mountains and the south flank of the eastern range are composed largely of Lower Cretaceous sandstone and shale and of Middle Cretaceous limestone. These strata are overlain in some areas by marine Tertiary deposits.

Nearly four-fifths of Venezuela is within the Orinoco River basin, whose great plains and rolling uplands are underlain by marine Tertiary strata that are covered in large part by continental Quaternary deposits. There is a great region of swampland in the Orinoco River delta.

The southern and southeastern parts of Venezuela are within the region of the Guiana Highlands, which consist of granite, gneiss, and other crystalline rocks overlain in part by continental Triassic deposits. The Triassic rocks are exposed just south of the Orinoco River, which marks the areal boundary between them and the overlying Tertiary and Quaternary deposits farther north.

Several thermal springs are scattered through the mountainous parts of both countries. Data concerning them are given in the two tables below, and the locations of the springs are shown on figure 21.

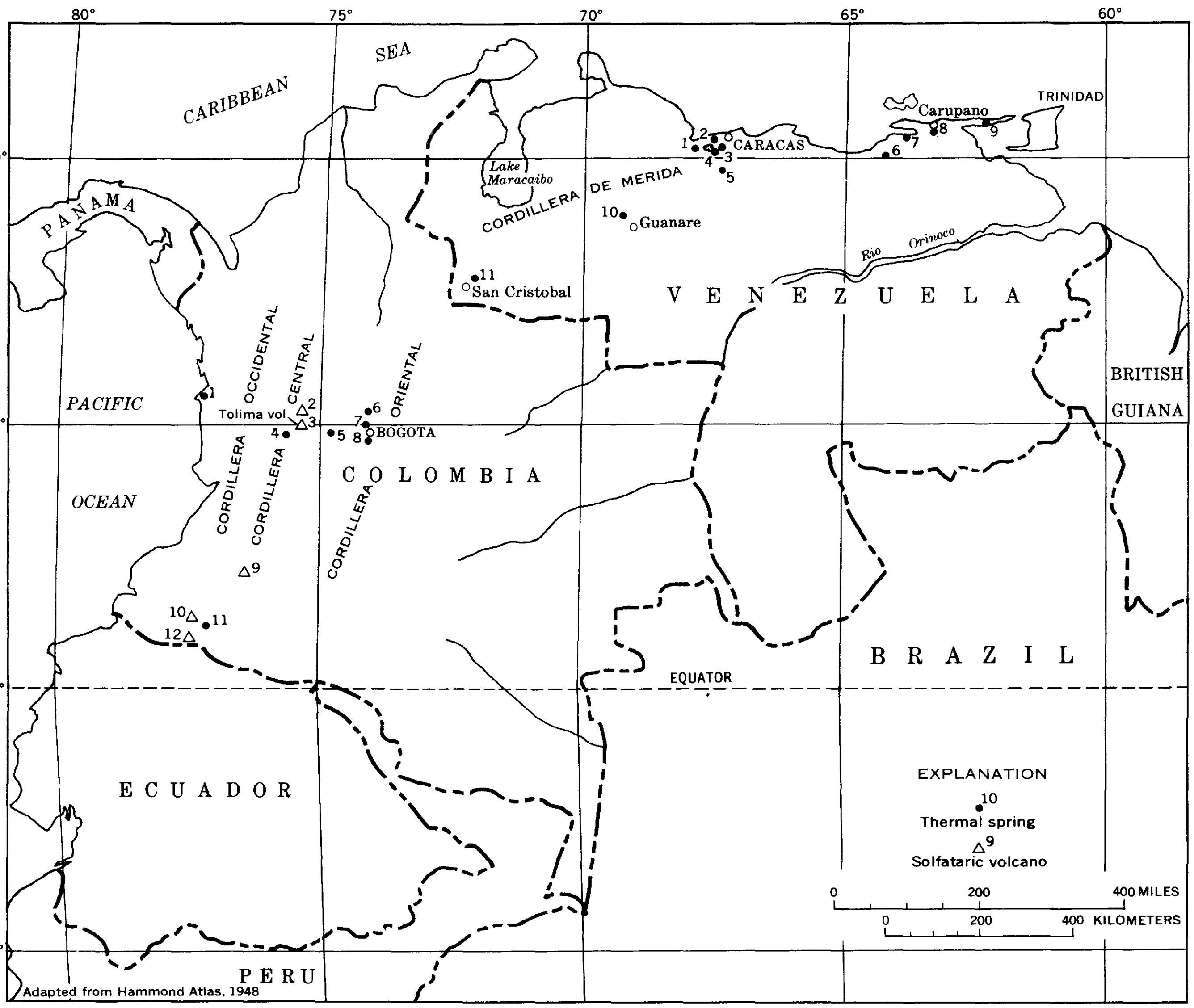

FIGURE 21.—Colombia and Venezuela showing location of thermal springs and solfataric volcanoes. Colombia chiefly from refs. 1013 and 1015–1017; Venezuela from refs. 1012, 1018, 1019, 1021, and 1022.

Thermal springs in Venezuela

[Data chiefly from ref. 1018 and Geological Map of South America, scale 1:5,000,000 (Geol. Soc. America, 1950). Locations of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 21	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Las Trincheras, near Puerto-Cabello.	90–97				Mica schist and coarse-grained granite.	Several springs issuing in ravine near sea level. Water is moderately mineralized. Free H_2S. Refs. 1012, 1020, 1026.
2	Onoto, between Turmero and Maracay.	44.5				Mesozoic metamorphic rocks.	Issues at altitude of 702 meters. Water is moderately mineralized. Free H_2S. Water used for bathing. Ref. 1012.
3	Aguas Calientes, 5 km north of Mariara (Mariana?).	56–64				do	Several springs at altitude of 476 meters. Water is moderately mineralized. Free H_2S. Refs. 1012, 1024
4	Plain near Lake Maracay (Valencia)	42				do	Supplies pool 5 meters in diameter Water used for bathing. Ref. 1024.
5	San Juan de los Morros	37	115	541	SiO_2 (81); Na_2CO_3 (127); Na_2SO_4 (86); NaCl (29); NaHS (31); $Na_2B_4O_7$ (47); gas 82 percent N_2.	Faulted Cretaceous limestone.	Water used for bathing. Refs. 1022, 1027.
6	Aguas Calientes de Bergantin, 35 km east-southeast of Barcelona.	43.2				Quartzose sandstone overlying limestone (Miocene).	Water is moderately mineralized. Free H_2S. Deposit of sulfur. Ref. 1024.
7	Gulf of Cariaco	Hot				Cretaceous(?) strata	Several springs issuing from sea bottom in area about 250 meters in diameter. Ref. 1024.
8	18 km south of Carúpano:						
	Chaguaramal (Provisor)	90	Small			Cretaceous limestone	Several springs. Deposits of tufa and sulfur. Ref. 1024.
	Azufral Grande (Salse of Cumatar), 1 km from Chaguaramal.	Hot				Cretaceous sandstone	Several solfataras. Deposits of sulfur and silica. Refs. 1010, 1011, 1024, 1026.
9	Irapa, at northeast end of New Andalusia.	Hot	Small			Mesozoic metamorphic rocks.	
10	Santa Ana de los Baños, 25 km northwest of Guanare.	32; 37	6; 30	608 (hottest)	SiO_2 (33); Na (180); K (70); HCO_3 (250); CO_3 (58).	Quaternary deposits overlying Miocene(?) strata.	2 springs. Water contains 8 ppm of PO_4; 12 ppm of F. Water used for bathing. Ref. 1019.
11	Agua Caliente (Sierra Nevada of Merida), 28 km northeast of San Cristobal.	26–62	1,000	331 (hottest)	SiO_2 (29); Ca (50); Na (42); HCO_3 (167); SO_4 (95); Cl (12).	Miocene sandstone and shale overlying Cretaceous limestone; faulted.	About 50 springs. Refs. 1021, 1024.
	La Cuiva						Water changes in color and temperature; has peculiar taste. Ref. 1024.
	Cabrera						Possibly the same as spring No. 1 or 2. Ref. 1024.

ECUADOR

The Andes Mountains in Ecuador consist of a Cordillera Oriental and a Cordillera Occidental, each of which trends nearly north-south. Many peaks have perpetual snow far down their slopes, and there are several active or solfataric volcanoes. Between the mountain chains are extensive plateaus which become lower toward the south. The higher parts of the Cordillera Oriental are largely of gneiss, schist, and other metamorphic rocks that are overlain in some areas by Tertiary and Quaternary volcanic materials. The Cordillera Occidental has some areas of Mesozoic eruptive rocks, but is composed chiefly of Cretaceous sedimentary rocks. The plateau regions between the mountain chains are covered largely by Tertiary and later volcanic rocks. The coastal zone is widest in the northern and central parts, where it is underlain by marine Tertiary deposits and alluvium. Northeastern Ecuador extends east of the Andes far into the basin of the Amazon River, where continental Tertiary deposits are overlain extensively by Quaternary alluvium.

The location of thermal springs in Ecuador is shown on figure 22, and information concerning the various springs is presented in the table below.

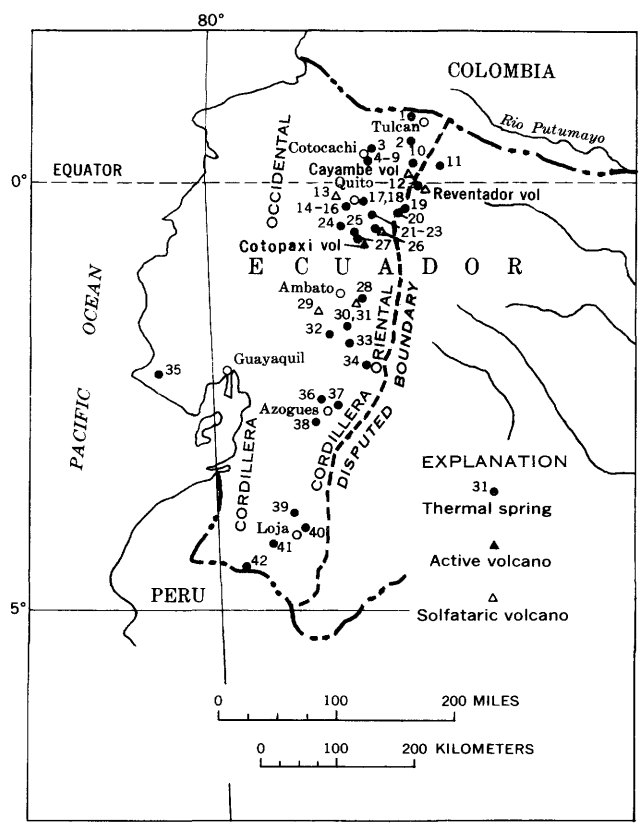

FIGURE 22.—Ecuador showing location of thermal springs and principal volcanoes. From refs. 1036, 1046.

Thermal springs and wells in Ecuador

[Data chiefly from refs. 1036, 1046, and Geological Map of South America, scale 1:5,000,000 (Geol. Soc. America, 1950). Locations of unnumbered springs not identified. Chemical constituents are expressed in parts per million]

No. on fig. 22	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Near Tulfino village, west of Tulcan.	50	400			Quaternary lava	Water rises in walled basin; used for bathing.
2	El Baño, 12 km from San Gabriel.	21.5	Small	1,311	Ca; Mg; HCO_3; NaCl (123); free CO_2.	do	Water used for bathing.
3	Near Cotocachi, 10 km north of Otavalo:						
	El Tinte (Yana-yacu)	19.5–27	Moderately large	2,734	Ca; Mg; Na; HCO_3; $FeHCO_3$ (146).	do	Several springs. Water used for bathing.
	Quebrada Caparossa	28.7		3,728	Na, HCO_3	do	Water used for bathing.
	Potrero	25		2,630	Na, HCO_3	do	Do.
	San Antonio, near Río Pomasqui.	20		889		do	Water is weakly alkaline, ferruginous. Used for bathing. Ref. 1029.
4	El Neptuno, at Otavalo	19	Large			do	Deposit of iron oxide. Bathing resort.
5	Yana-yacu, near Otavalo	26.2	Large	1,957	Ca; Mg; Na; HCO_3; $FeHCO_3$ (36).	do	Water supply for municipal bathhouse. Ref. 1029.
6	Termas de Peguche, 2 km from Otavalo.	20	Large	High		do	Several springs. Water used for bathing.
7	Rio Blanco (Bosque de Pinto), 4 km from Otavalo.	27.1	Moderately large			do	Water is alkaline, bicarbonate, ferruginous.
8	El Salado, beside Río Blanco, 6 km north of Otavalo.	26–31	Moderately large	5,474	Ca; Mg; HCO_3; NaCl (641)	Lava(?)	
9	Tangli (Cachi-yacu), beside Río Blanco 15 km from Otavalo.	26.7	2,200			Quaternary lava	Water is calcic bicarbonate, ferruginous. Free CO_2. Water used for bathing.
10	Laguna San Marcos, 25 km north-northeast of Cayambe volcano.	46.1–65.5	400			Gravel overlying metamorphic rock.	Several springs at south end of lake. Free H_2S. Gravel is iron stained. Refs. 1044, 1045.
11	Agua Caliente, near south bank of Río San Pedro 40 km east of Cayambe volcano.	Warm	300			Cretaceous(?) strata	Issues from cave at base of cliff. Free H_2S. Deposit of tufa. Water used for bathing. Ref. 1045.
12	Reventador, near west base of El Reventador volcano.	Warm	Moderately large			Quaternary lava	Ref. 1045.
13	Pichincha volcano (Guagua-Pichincha).	Hot				do	Fumaroles. Ref. 1035.
14	Palmira, near Lloa and 10 km west-southwest of Quito.	30–40	Moderately large	2,098	Ca; Na; HCO_3; NaCl	do	Several springs. Water is ferruginous.
15	Ura-urcu, near Lloa	Warm	Small			do	
16	Fuente de San Juan, 10 km southwest of Quito.	25.6	Small	5,892	Ca, Mg, Na, HCO_3, Cl; free CO_2	do	
17	Guangopolo (Cumbaya?), 13 km east of Quito.	27	2	519	SiO_2 (77); Ca (130); Na (37); S (17); Cl (99); free H_2S.	do	Ref. 1037.
18	Cunuc-yacu, on bank of Río Tumbaco 15 km east of Quito.	27	Large	436	Ca, HCO_3, SO_4, Cl; free CO_2	do	Water supply for municipal baths. Ref. 1029.
19	Salados de la Calera (Cachi-yacu), on river plain.	20.7; 23		4,520; 3,610	Ca, Mg, Na, HCO_3, Cl; free CO_2	Matamorphic rocks	Water is turbid. Deposit of iron oxide.
20	El Quitasol, 8 km from Aloag.	23		1,928	Ca, Mg, Na, HCO_3; free CO_2	do	Water used for bathing.
21	San Pedro del Tingo, 24 km east-southeast of Quito.	38–42	180	1,657	Ca, Mg, Na, HCO_3, Cl; free CO_2	Quaternary lava	4 springs. Water supply for municipal baths. Ref. 1040.
22	La Merced (Alangasi, Los Belermos), 24 km south-east of Quito.	35	Moderately large	1,546	Ca, Mg, Na, HCO_3	do	Ref. 1029.
23	La Calera, on bank of Río San Pedro 25 km southeast of Quito.	20.7–26.2		3,609–5,892	Ca, Mg, Na, HCO_3	do	
24	Near Macachi (Machachi), 40 km south-southwest of Quito:						
	Guitig (Hervedero, Ferruginosa).	24.3	Moderately large	1,622	Ca, Mg, Na, HCO_3, $FeCO_3$	Probably Quaternary lava	Also flowing artesian well. Water used for drinking and bathing. Refs. 1029, 1043.
	Hacienda Tesalia (Santa Emelia, Timpuc).	22	Moderately large	2,710	Mg, Na, HCO_3, Cl	do	Refs. 1029, 1042.
25	Sillunchi, at west base of Pasochoa volcano 30 km south of Quito.	Warm	Moderately large		Ca, Mg, Na, HCO_3, Cl; free CO_2	Quaternary lava	Several springs; also drilled wells. Water used for drinking and bathing.
26	Antisana volcano:						
	Tysco (Lysco?), on west slope.	27.2	Moderately large			do	Much free CO_2. Deposit of iron-stained tufa. Ref. 1013.
	In crater					do	Solfataras. Ref. 1035.
27	Belermos, on west slope of Cotopaxi volcano.	36.7	Moderately large			do	Also fumaroles in crater of volcano. Refs. 1012, 1035.
28	Near Banos village, at northeast base of Tungurahua volcano:						
	Agua Santa	54.5		7,440		do	Free CO_2. Water used for bathing. Ferruginous deposit. Refs. 1029, 1041.
	Badcung	44		6,252		do	Water is saline. Used for bathing. Refs. 1029, 1041.
	Cumanda	23		781		do	Free CO_2. Water used for bathing. Ref. 1041.
	Salado de Badcung (El Salado).	35.5		1,466	Mg, Na, HCO_3	do	
	Santa Clara (Cangrejo, Pangora).	22		848		do	Free CO_2. Water used for bathing. Ref. 1041.
	Upper valley of Badcung.	44		6,252	Ca, Mg, Na, SO_4	do	

Thermal springs and wells in Ecuador—Continued

No. on fig. 22	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
29	Cunuc-yacu, at northwest base of Chimborazo volcano.	46				Decomposed andesitic tuff.	Water used for bathing. Ref. 1035.
30	Cubijies, on bank of Rio Guano 10 km northeast of Riobamba.	Warm				Quaternary lava	Water used for bathing.
31	Los Elenes, on bank of Río Guano 13 km from Riobamba.	22.5				do	Water is alkaline and radioactive Bathing resort. Ref. 1030.
32	Cicalpa (Cunuc-pugyo), 8 km west of Riobamba.	Hot	Small			do	
33	Pungola, 20 km southeast of Riobamba.	50	Small			Probably Quaternary lava.	
34	Quillu-yacu, 3 km northeast of Alausi.	20.1	Small	4,136	SO_4; Al_2O_3 (1,085)	Decomposed Quaternary andesite.	Several springs near Tixon sulfur mine. Water is astringent and acid.
35	San Vicente, 20 km east of Santa Elena:						
	Main springs	32–40	80	14,083 (hottest)	$CaCl_2$ (7,304); NaCl (4,720); KCl (991); NaBr (783); gas chiefly CH_4 and C_2H_6.	Quaternary deposits overlying nearly vertical Cretaceous strata.	Several springs and 3 large pools. Water used for bathing. Refs. 1029, 1034, 1039.
	El Volcancito, 100 meters from main springs.	30.8	Small	22,400	$CaCl_2$ (11,520); NaCl (7,590); NaBr (3,010).	do	Mud volcano having cone of hardened mud 30 ft in diameter and 6 ft high. Water is turbid and saline; traces of petroleum. Refs. 1034, 1039.
36	Aguas de Guapan, 3 km from Guapan.	45.2	Moderately large			Tertiary limestone	Water is saline, strongly alkaline. Free CO_2. Water used for bathing. Ref. 1032.
37	Aguas de Opar (Chaquimaillana), 3 km northeast of Azogues.	20.1	150	3,644	Ca, Na, HCO_3; free CO_2	do	Water used for drinking.
38	Fuentes de Baños, 9 km from Cuenca del Tomebamba.	87	Large	2,300	Ca, Na, HCO_3, SO_4, Cl	Tertiary(?) strata near Quaternary lava.	Bathing resort.
39	Cullqui-yacu, north of Loja	Warm	Moderately large			Probably metamorphic rocks.	Water used for bathing. Ref. 1041.
40	Agua Hedionda, 5 km northeast of Loja.	25	Large	High	Ca, Na, SO_4, S; free H_2S	Metamorphic rocks near Tertiary strata.	Water supply for municipal baths.
41	Cerro de Colambo, 7 km from the cerro.	25	Moderately large			Probably Quaternary lava.	Water used for bathing.
42	1 km from Cariamanga	20–22	10		Ca, HCO_3, SO_4	Cretaceous strata	Small deposits of tufa, gypsum, ochre, and sulfur. Water used for bathing.
	Chinangachi, in Yaruqui						Ref. 1028.
	Chufata, Cubi, and El Chico, in Perucho.						Do.
	Cuchibianda and Pilgaran, in Atahualpa.						Do.
	Hacienda Cachuca, in Pueblo llaro.						Do.
	Irubi, in San Jose de Minas						Do.
	Oyacachi						Water is sulfurous and ferruginous. Ref. 1028.
	Papallacta						Do.
	Pueblo Tumbaco, in Chichi						Ref. 1028.

PERU

Peru has a Cordillera Oriental, a lower Cordillera Occidental, and a wide coastal belt. Between the ranges are plateaus and mountainous country. The eastern part of Peru is drained by the Río Ucayali and other tributaries of the Amazon River.

The Cordillera Occidental is composed largely of marine Cretaceous strata and much intrusive granite. It also includes a long belt of volcanic mountains, several of which are still active. The Cordillera Oriental is chiefly of Devonian and Silurian slates and pre-Cretaceous metamorphic rocks. It is flanked on each side by marine Lower Cretaceous strata. The two cordilleras merge southward into a wide series of ranges. The northeastern part of Peru extends far into the upper basin of the Amazon River.

The available information on the various springs is summarized in the table below, and the locations of the springs are shown on figure 19.

Thermal springs in Peru

[Data chiefly from refs. 1050, 1061, 1066, and Geological Map of South America, scale 1:5,000,000 (Geol. Soc. America, 1950). Principal chemical constituents are expressed in parts per million]

No. on fig. 19	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Los Baños del Inca, 5 km east of Cajamarca.	62; 74	Moderately large	725	SiO_2 (392); $CaCO_3$ (84); $CaSO_4$ (30); NaCl (172); free H_2S.	Sandstone and limestone (Lower Cretaceous).	2 main springs. Water used for bathing. Ref. 1055, 1067, 1071.
2	Cachicadan, 8 km from Santiago de Chuco.	71 (max)	Large	302	$CaSO_4$ (59); $MgSO_4$ (27); Na_2SO_4 (28); NaCl (103); Fe_2O_3; free CO_2.	Trachyte intrusion in Lower Cretaceous strata.	2 large springs. Deposit of iron oxide. Water used for bathing. Refs. 1067, 1071.
3	Pampa, 50 km east of Trujillo.	24	Small			Lower Cretaceous strata	
4	Huaranchal, near Pampa spring.	75	Small	418	$CaCO_3$ (60); $CaSO_4$ (41); $MgCO_3$ (30); $MgSO_4$ (30); NaCl (214); Fe_2O_3 (28); free CO_2, H_2S.	do	
5	Tablachaca, on river bank at Pallasca.	53	Moderately large	1,257	$CaSO_4$ (75); Na_2SO_4 (325); NaCl (760); KCl (39).	do	Small deposit of iron oxide. Water used for bathing.
6	Ninabamba and Pacatqui	60–80	Large			Probably intrusive rock	Several springs issuing from tufa mound. Much free CO_2.
7	Jocos (Sihuas), on river bank 30 km northwest of Pomabamba.	40; 43	Moderately large	Low		Limestone (Lower Cretaceous).	2 main springs. Deposits of tufa, gypsum, sulfur. Water used for bathing.
8	Santa Clara, on bank of Rio Rupac.	Tepid	Large	866	$CaCO_3$ (75); $CaSO_4$ (306); $MgSO_4$ (132); $MgCl_2$ (102); NaCl (85).	Lower Cretaceous strata	Water is light yellow.
9	Andaimayo	38	Moderately large	Low		Sandstone (Lower Cretaceous).	Free H_2S. Deposit of sulfur.
10	Pomabamba, on right bank of river.	22–52.5	Moderately large			do	3 main springs. Free H_2S. Deposit of iron oxide. Water used for bathing.
11	Shangor, 6 km from Caraz	36.5	Small	801	$CaCO_3$ (95); $CaSO_4$ (65); Na_2SO_4 (30); NaCl (554); Fe_2O_3 (19).	Probably Lower Cretaceous strata.	Water used for bathing.
12	Colca, 6 km below Shangor	Warm	Small			do	Free CO_2. Deposits of tufa and iron oxide.
13	Pato, 12 km from Caraz	Warm	Small	950	NaCl	do	
14	Santa Julia, near Mancos	50	Moderately large	5,565	$CaCO_3$ (236); $MgCl_2$ (280); NaCl (4,319); KCl (454); free CO_2, H_2S.	Sandstone (probably Lower Cretaceous).	Much tufa above present outlet. Small deposits of iron oxide and common salt.
15	Tactabamba, 4 km from Carhuaz.	Warm		300	$CaCO_3$ (37); $CaCl_2$ (33); NaCl (164); LiCl (26); Fe_2O_3 (12); free CO_2.	do	
16	Near Río Chancos, 4 km above Carhuaz:						
	Aguas de Chancos	70; 74.5	25	3,340 (cooler)	$CaCO_3$ (208); $CaSO_4$ (174); NaCl (2,592); KCl (212); much free CO_2.		2 main springs. Large deposits of tufa. Water used for bathing. Refs. 1055, 1067, 1069, 1071.
	Monte Rey	47.8	225	3,424	Na (772); K (303); HCO_3 (549); Cl (1,729).	do	Ref. 1069.
17	Brioso, 5 km northwest of Huaraz.	Warm	125	3,500	$CaCO_3$ (90); NaCl (3,278); KCl (76); Fe_2O_3 (18); much free CO_2, small amount free H_2S.	do	Several springs. Deposits of iron oxide. Water used for bathing. Refs. 1067, 1071.
18	Chavin, on river bank near Chavin de Huantar.	45.5	Large			Steeply dipping sandstone (Lower Cretaceous).	Small deposits of sulfur, alum, iron sulfate, and common salt.
19	Olleros (La Ceuva), 18 km southeast of Huaraz.	19.2–46.2	35	14,068 (hottest)	Mg (1,757); Na (1,782); K (3,241); HCO_3 (1,860); SO_4 (1,334); Cl (3,899).	Probably Lower Cretaceous strata.	3 springs. Ref. 1069.
20	Near Río Chiquian, 2 km above Llaclla.	49.2	Small			Folded Tertiary sandstone.	2 springs. Water is brackish. Small amount of free gas. Small deposits of iron oxide and common salt.
21	Oyon	Warm	Small	1,674	Ca (350); HCO_3 (467); SO_4 (501); Cl (273).	do	
22	Churín	34	Large	956	$CaCO_3$ (275); $CaSO_4$ (136); $MgSO_4$ (162); NaCl (257); much free CO_2, H_2S.	Gravel overlying Tertiary lava.	Several springs, 2 of which issue from tufa mounds. Water used for bathing, irrigation. Ref. 1055.
	Andages	55	Moderately large	1,869	Ca, Na, SO_4, Cl	Probably Tertiary lava	Deposit of iron oxide.
	Tingo de Huacho	58	Moderately large	2,135	Ca, Na, SO_4, Cl	do	Ref. 1055.
23	Near Agua Caliente village and oil field, 40 km south of Pucallpa.	Warm	Small			Tertiary deposits overlying Lower Cretaceous strata.	Ref. 1068.
24	2 km south of Aquamiro	41	Moderately large		Ca, HCO_3	Conglomerate overlying Lower Cretaceous strata.	Deposit of tufa. Water used for bathing.
25	Bank of Río de Nupe 3 km north of Baños.	56; 61	Moderately large			Sandstone (probably Lower Cretaceous).	2 springs. Water is slightly brackish. Much free H_2S. Water used for bathing.
26	Chaccha, near Caina	Warm	Moderately large	4,363	$CaCO_3$ (290); $CaCl_2$ (116); $MgCl_2$ (252); NaCl (3,678).	Probably Lower Cretaceous strata overlying Devonian slate.	Water used for bathing.
27	Cocha, near Tangor	Warm	Moderately large	500	$CaSO_4$ (284); $MgSO_4$ (210)	do	Water used locally.
28	Near Río Perene	Hot	Moderately large			Sandstone (Lower Cretaceous).	Several springs. Ref. 1051.
29	Near Yauli	38–52	Moderately large	2,396 (hottest)	$CaSO_4$ (176); $MgSO_4$ (167); Na_2SO_4 (958); NaCl (958); LiCl (93).	Sandstone (probably Lower Cretaceous).	5 springs, 1 known as the Hervidero. Ref. 1072.
30	Acaya, 5 km from Lloclla pampa.	30	Small			Lower Cretaceous strata	Water is saline. Free H_2S. Large deposit of tufa and small deposit of sulfur. Ref. 1073.
31	Chiuchín, in Checra district	Warm	Moderately large	2,791	$CaCO_3$ (344); $CaSO_4$ (1,166); $MgSO_4$ (432); Na_2SO_4 (104); NaCl (689); free H_2S.	Intrusive rocks (Cretaceous).	2 main springs. Water used for bathing. Ref. 1071.
32	San José de los Baños	Hot	Moderately large	1,030	$CaCO_3$ (88); $CaSO_4$ (73); $MgSO_4$ (127); Na_2SO_4 (260); LiCl (23).	do	Several springs. Deposit of calcareous concretions containing iron oxide and trace of arsenic. Water used for bathing.
33	Santa Catalina, in Pacraos district.	Warm	Moderately large	1,146	$CaCO_3$ (196); $CaSO_4$ (160); $MgCl_2$ (92); NaCl (584); LiCl (22).	do	Water used for bathing.

Thermal springs in Peru—Continued

No. on fig. 19	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
34	Tingo, 2 km from Casapalca	Tepid	Moderately large	2,456	$CaCO_3$ (290); $CaSO_4$ (235); Na_2SO_4 (638); NaCl (1,080); LiCl (119).	Red sandstone (probably Lower Cretaceous).	Water used for bathing.
35	Agua Caliente, 3 km from Casapalca.	31	Moderately large			Red sandstone (Lower Cretaceous).	Several springs. Water is slightly brackish. Free H_2S. Water used for bathing.
36	Near Tambo-Viso	31	Moderately large	903	$CaSo_4$ (94); $MgCo_3$ (151); $MgSO_4$ (183); NaCl (300); KCl (90); Fe_2O_3 (25).	Intrusive rock (Cretaceous).	Water used for bathing.
37	Bellavista, on bank of Río Rimac above Chilea.	33	Moderately large	Low	$CaCO_3$ (8); $CaSO_4$ (60)	do	Do.
38	Bank of Río Mantaro, 12 km from Coris.	43.2	Moderately large			Probably Lower Cretaceous strata.	Issues from large mound of iron-stained tufa. Water is brackish and astringent. Used for bathing
39	San Cristobal (Potochi), near Huancavelica.	28; 29	Moderately large	873 (hottest)	$CaCO_3$ (75); $CaSO_4$ (313); $MgSO_4$ (75); MgCl (118); NaCl (264).	do	2 springs. Water used for bathing. Ref. 1071.
40	4 km south-southwest of Julcamarca.	25.2 (max)	Moderately large			Steeply dipping limestone in region of Tertiary lava.	Water used locally.
41	Niñobamba, 40 km southwest of Ayacucho.	43.3 (max)	Moderately large			Porphyry in region of Tertiary lava.	Several springs. Water is slightly astringent and ferruginous. Free CO_2. Water used for bathing.
42	Sancos, near Pueblo de Sancos.	20	Small	Low		Sedimentary rock in region of Tertiary lava.	Several small springs. Much free H_2S. Large deposit of sulfur.
43	Colpani, near right bank of Río Vilcanota.	59	Moderately large	3,048	$CaCO_3$ (350); $MgCl_2$ (120); NaCl (2,360); KCl (120); free CO_2, H_2S.	Probably Cretaceous intrusive rock.	Deposit of iron-stained tufa. Water used for bathing.
44	Andiguela, at Yanatilde	35; 42.5	Moderately large	1,335 (hottest)	$CaCO_3$ (250); K_2SO_4 (152); NaCl (791); free CO_2.	Slate or Cretaceous intrusive rock.	2 springs. Small deposit of tufa. Water used for bathing.
45	1 km southwest of Lares	30–45	Moderately large	3,165	$CaCO_3$ (551); $CaSO_4$ (442); $MgCO_3$ (165); $MgCl_2$ (245); NaCl (1,599).	Igneous intrusive rock (Cretaceous?) in Permian strata.	Several springs. Small deposits of iron-stained tufa. Water used for bathing. Ref. 1071.
46	300 meters from Yaurisque	32	Moderately large	3,890	$CaSO_4$ (146); $CaCl_2$ (2,787); $MgCl_2$ (60); NaCl (856).	Tertiary conglomerate	Water used for bathing.
47	1 km from Marcapata	60–75	Moderately large			Alluvium overlying Devonian(?) slate.	Several springs. Main spring issues from mound of iron-stained tufa. Free H_2S. Water is brackish. Used for bathing.
48	1 km from Posta de Agua Caliente.	41.5–55	Large	4,220	$CaCO_3$ (532); $CaSO_4$ (765); Na_2SO_4 (65); NaCl (2,719); Fe_2O_3 (15); much free CO_2.	Permian strata	3 main springs. Deposits of iron-stained tufa.
49	Quelcata, between Antabamba and Oropesa.	75 (max)	Moderately large		Ca, Mg, HCO_3; free CO_2, H_2S	Jurassic(?) strata	Several springs issuing from tufa mound. Water is moderately mineralized. Used for bathing.
50	Lucha, 3 km from Catahuasi	34–45	Moderately large	1,000	NaCl (500); free CO_2	Quaternary lava	3 main springs. Small deposits of iron-stained tufa. Water used for bathing.
51	Antaura, 15 km west of Viraco.	49.2	Large			Quaternary trachyte	Free H_2S. Deposit of sulfur. Water used for bathing.
52	Viques, 3 km north-northwest of Viraco.	26	Moderately large			do	Water is slightly astringent. Free CO_2. Deposit of iron-oxide. Water used for irrigation.
53	Taparza, 8 km east of Viraco.	46.6–50.3	Moderately large			Steeply dipping Cretaceous sandstone near Tertiary lava.	2 main and several smaller springs. Deposits of sulfur and alum. Water used for bathing.
54	Agua Caliente (Ullupampa), 12 km north of Yura.	Warm	Moderately large			Tertiary lava	Water used locally.
55	Chachani volcano:						
	Termas de Yura, 28 km northwest of Arequipa.	29.6–33.9	340	1,054	$CaCO_3$ (149); $MgCO_3$ (326); Na_2CO_3 (124); NaCl (198); free CO_2, H_2S.	Cretaceous strata near Tertiary lava.	5 main springs including El Tigre and Fierro Viejo. Analysis for water having temperature of 32°C. Deposits of tufa and iron oxide. Water used for bathing. Refs. 1054–1058, 1064, 1067, 1071.
	Aurora, at Socosani 5 km downstream from Yura.	30–35	145	3,187	SiO_2 (222); Ca (205); Mg (125); Na (304); Cl (222); much free CO_2.	do	Water is bottled. Refs. 1056, 1067.
56	Baños de Jesús, on slope of Misti and Pichupichu mountains 7 km east of Arequipa.	22–23	330	2,511	Ca (127); Na (364); HCO_3 (400); SO_4 (155); Cl (794).	Tertiary lava	Several springs including Pozo Negro. Water used for bathing. Refs. 1053–1056, 1058, 1059, 1062, 1067, 1071.
57	Chucani, 8 km from Carineli.	27.5	Moderately large			Pre-Cretaceous metamorphic rock.	Water used for bathing.
58	Near Ollachea	66; 69.4	Moderately large	280	Na_2CO_3 (60); Na_2SO_4 (42); NaCl (173); small amount of free H_2S.	Devonian strata intruded by porphyry.	2 springs. Water used for bathing.
59	Near Cuyo-Cuyo	44.8 (max)	Moderately large			Devonian slate	Several springs. Water is slightly brackish. Free CO_2, H_2S. Water used for bathing.
60	Fraylima, 8 km from Azangaro.	36.1	Moderately large	2,562	$CaSO_4$ (1,564); $MgSO_4$ (296); Na_2SO_4 (445); NaCl (220); free CO_2.	Probably Cretaceous strata overlying Devonian slate.	2 springs. Water used for bathing.
61	Putina-Punco, 4 km west of San José.	70	Small			Sandstone (probably Cretaceous).	Free H_2S. Deposit of iron-stained tufa.
62	Putina	37–49.1	Large	4,439	$CaSO_4$ (768); $MgSO_4$ (135); Na_2SO_4 (287); NaCl (3,195); Fe_2O_3 (15); free CO_2.	Steeply dipping red sandstone (Cretaceous).	4 main springs issuing from silicocalcareous tufa. Water used for bathing.
63	Near Huancane	18	Large	Low		Cretaceous sandstone	Issues at base of a hill. Water is potable. Used for bathing.
64	Near Ayaviri	36	Moderately large	4,975	$CaCO_3$ (909); $CaSO_4$ (216); $MgSO_4$ (730); Na_2SO_4 (654); NaCl (2,380); Fe_2O_3 (19); much free CO_2.	Steeply dipping red sandstone (Cretaceous).	Small amount of free H_2S. Deposit of iron oxide. Water used for bathing.
65	Near Ocubiri	37.8	Moderately large			Probably Devonian strata	Water is brackish. Free CO_2, H_2S. Deposit of iron oxide.
66	Tangolaya, 12 km west-southwest of Puno.	18.2 (max)	Moderately large	1,037	$CaCl_2$ (220); $MgCl_2$ (278); NaCl (210); free CO_2.	do	Several springs. Water used for bathing.

Thermal springs in Peru—Continued

No. on fig. 19	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
67	Near Acora	69 (max)	Moderately large	1,307	$CaSO_4$ (317); $MgCl_2$ (131); NaCl (736).	Limestone (Cretaceous) and intrusive lava.	Main spring near antimony mine; several small springs 1½ km farther northwest. Water used for bathing. Ref. 1047.
	Omate	71; 74	Moderately large			Quaternary lava	2 main and several smaller springs. Water is sulfurous.
68	Oleocan	32.8		2,011	$CaCO_3$ (187); $CaSO_4$ (227); $MgCO_3$ (50); $MgCl_2$ (1,488); Fe_2O_3 (19).	do	Deposit of iron-stained tufa.
69	Putina (Carumas), 55 km southeast of Arequipa.	Near boiling	Moderately large	1,939	$CaCO_3$ (91); $CaSO_4$ (121); Na_2SO_4 (403); NaCl (1,120); free CO_2.	do	Several spouting springs. Deposits of silico-calcareous tufa and iron oxide. Water used for bathing. Refs. 1048, 1071.
70	Caliente, on Río Candarve 12 km above Candarve springs.	Boiling	Moderately large	1,141	SiO_2 (140); $CaSO_4$ (150); Na_2SO_4 (168); NaCl (591); much free CO_2	Pliocene strata overlying trachyte (Quaternary).	Several springs, including 5 geysers. Deposits of siliceous sinter and iron oxide. Water used for bathing. Ref. 1048.
71	Candarve, at base of Yucumani volcano.	42.7; 44	Moderately large	3,305 (hottest)	SiO_2 (160); $CaSO_4$ (245); Na_2CO_3 (386); NaCl (2,456); free CO_2.	do	2 springs. Water used for bathing.
72	4 km from Ticaco	49.8	Moderately large	1,768	$CaSO_4$ (559); Na_2SO_4 (539); NaCl (601).	Diorite or Pliocene-Miocene strata.	Water used for bathing.

ATLANTIC REGION

AZORES

One principal group of islands in the eastern Atlantic is the Azores. This group comprises 9 main and 2 minor islands about 830 to 1,200 statute miles west of Portugal. There are hot springs in four of the islands, as shown on figure 23.

All the islands are volcanic, with generally precipitous coasts, and rise to high peaks, several of which have erupted within the past few hundred years. The main hot springs are in São Miguel Island (fig. 24) and are chiefly in the Valley of the Furnas (fig. 25).

The available data on the several springs are summarized in the table below.

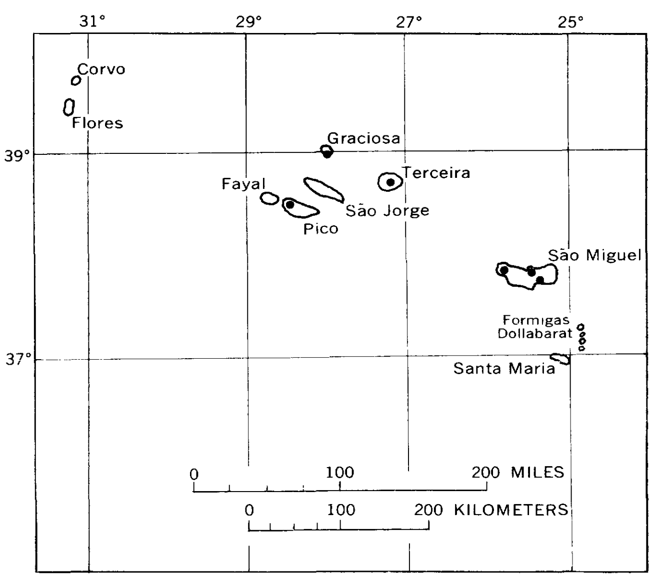

Figure 23.—Azores showing location of thermal springs.

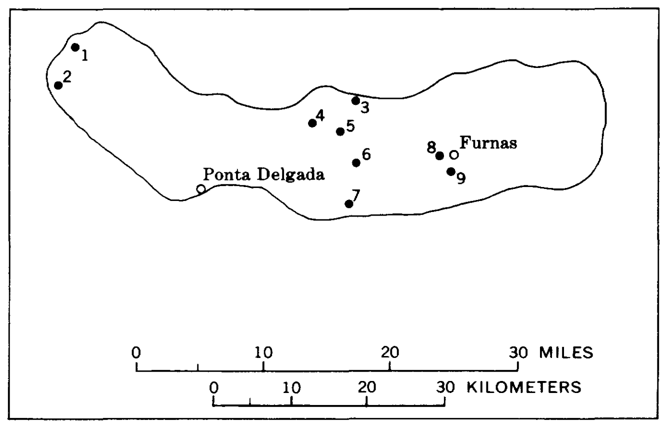

Figure 24.—São Miguel Island, Azores, showing location of thermal springs. From ref. 2272.

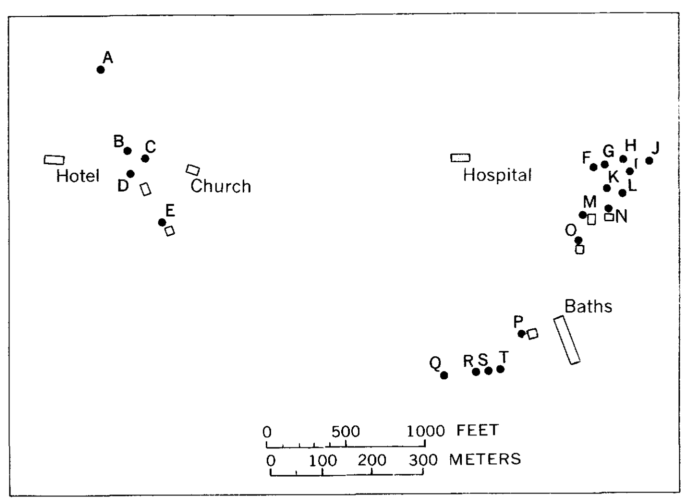

Figure 25.—Springs at Furnas, São Miguel Island, Azores. From ref. 2272.

Thermal springs in the Azores

[Chemical constituents are expressed in parts per million]

No. on fig. 24	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
	São Miguel Island [Data chiefly from refs. 2271, 2272]					
1	Mosteiros	38; 44		5,500–10,000		Lowest mineral content at low tide. Small bathhouse. Ref. 2272.
2	Ferraria	62.5		20,960	Na, Cl	Near rocky shore; mixed with sea water. Ref. 2272.
3	Ladeira da Velha	30.3	46	354	Na, HCO_3, SiO_2	Saline, carbonated; free CO_2; pH 5.30. Water bottled for table use. Small bathhouse.
4	Ribeira Grande	62.1; 65				2 walled pools. Sulfurous. Small bathhouse.
5	Caldeira Velha	90.2		1,118		Water and mud in ebullition; sulfurous. Nearby spring flows 300 liters per minute; temperature 25.2° C. Ref. 2272.
6	Lombadas	Warm				Carbonated. Water bottled for table use.
7	Castelinhos	Warm				Do.
8	Lagoa de Furnas	81.2; 89.9; 96.2				3 main caldeiras near northeast margin of small lake. Sulfurous.
9	Furnas:					
Letter on fig. 25						
A	Agua de Comarca	14				Slightly saline. Free CO_2.
	Helena	15				
B	Agua Ferrea	30.3				Free CO_2. Source of supply for mineral bath.
C	do	39				Do.
D	Agua Dr. Bruno	19				Free CO_2.
E	"New" spring	48.5				Supplies bath.
F	Agua Prata	Cold	4.7			Slightly sulfurous.
G	Agua Miguel Henriques	16	3.3			Free CO_2.
H	Caldeirão	75.4	32	633	Na, HCO_3, SiO_2	Actively boiling. Contains 5.5 ppm H_3BO_3; pH, 6.36. Ref. 2272.
I	Agua Santa	Cold				
J	Agua Azeda	15.5	15.2			Slightly saline; much CO_2.
K	Caldeiras de Inhames	95.2				Siliceous, sulfurous; free CO_2. Sulfur deposits.
	Vimes	92				
	Esquicho	96				
L	Caldeira Pero Botelho	Hot				Mud pool.
M	Caldeira Grande	99	61	2,064	Na, HCO_3, Cl	Supplies bath. pH, 8.34.
	Caldeira Pequena					Supplies bath.
N	Caldeira do Asmodeu	94.4				Do.
O	Agua do Padre Jose	68.9	1.1			Saline, bicarbonate. Supplies bath.
P	Quenturas	24–59.5	166	1,364	Na, HCO_3, SiO_2	Saline, sodic bicarbonate; pH, 6.45. Supplies bath.
Q	Agua de Morangueira	43		2,032	Na, Cl, SO_4	
R	Agua do Torno	39				
S	Grutinhas	41.5; 43.5; 44.5				
T	Ernesto	44		1,600	Na, Cl, SO_4, HCO_3	
	Graciosa Island (fig. 23)					
	Southeast coast	50				Issues from base of cliff. Ref. 2272.
	Terceira Island (fig. 23)					
	In the caldeira	90				Water vapor and much CO_2 and H_2S. Deposits of sulfur. Rocks greatly decomposed. Ref. 2272.
	Pico Island (fig. 23)					
	Small crater at summit					Water vapor and much CO_2 and H_2S. Ref. 1080.

GREENLAND

Greenland, the largest island in the world (839,800 sq mi), is sometimes called a continental island. It is separated from Ellesmere Island of North America by a narrow strait. Except along the coasts, Greenland is covered by a thick ice sheet whose surface forms a great plateau. Seismic exploration in recent years indicates that the bedrock surface is irregular; it has deep valleys that extend below sea level and probably divide the region into two or more bedrock islands.

Ancient gneiss and schist underlie most areas that are bare of ice. Sedimentary rocks are exposed in some places. Marine sedimentary strata of Silurian age are exposed on the northwest coast, Devonian strata in the southwest, and Jurassic and Cretaceous strata at several places. Marine Miocene sandstone and shale have been recognized in Disco (Disko) Island, off the central part of the west coast. Basalt is associated with schist along the shore of Scoresby Sound on the east coast. The five recorded thermal-spring localities in Greenland are given in the table on page 98. The three principal ones are shown on figure 26.

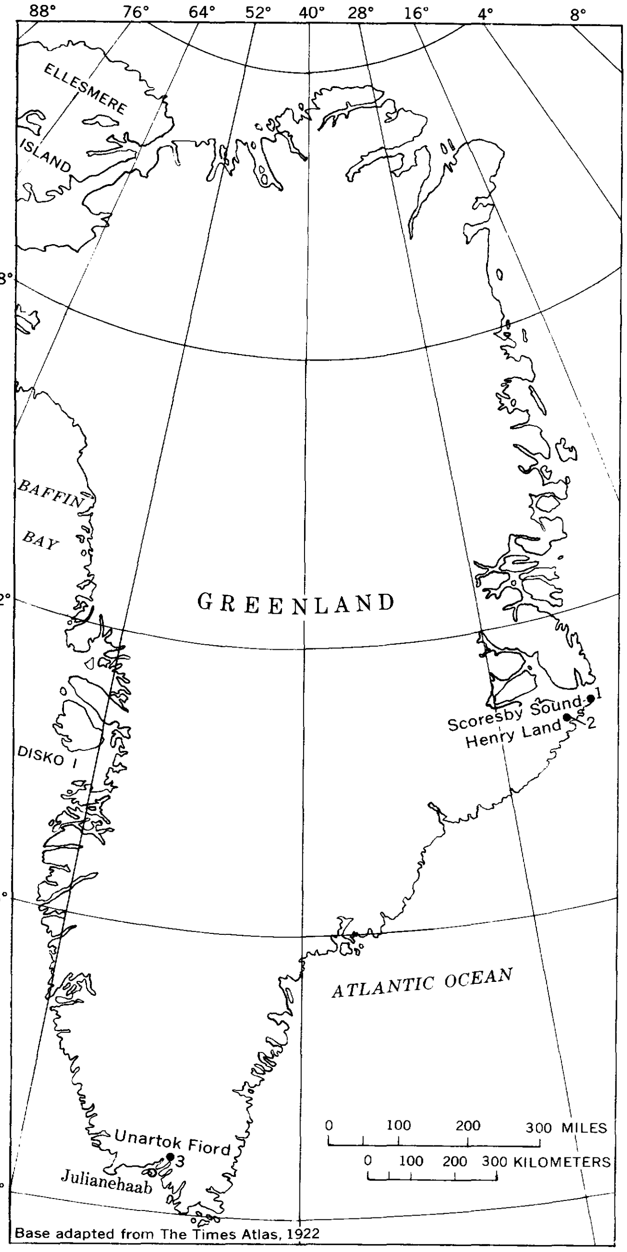

FIGURE 26.—Greenland showing location of thermal springs.

ICELAND

The eastern coast of Iceland is about 500 statute miles beyond the northern tip of Scotland and 600 miles from the coast of Norway. The island is nearly 300 miles long east-west, and about 200 miles broad north-south through its central part. It consists mainly of mountains and plateaus and comparatively little lowland. Around most of the coast are deep fiords which extend far inland, and beyond their limits, narrow valleys extend still farther into the uplands. Except in the southeastern part, where small mountains of gabbro are present, the island is composed chiefly of basaltic lava of early Tertiary age. This lava is considered to be part of vast subaerial effusions that took place over an extensive region in the North Atlantic, including the Hebrides Islands, Faroe (Faeroe) Islands, and parts of Greenland. After a long period of relative quiescence, fissure flows and volcanic activity began in the early Pleistocene Epoch, and have continued to the present.

Great amounts of brecciated volcanic material and palagonite (altered volcanic tuff) were ejected beneath ice sheets and are interbedded with later lava flows. Palagonite, breccia, and tuff cover nearly one-third of the island and overlie earlier lava. Large areas are covered by Quaternary lava, which extends in a broad band from the southwest coast northeastward and northward across the island. A great lava field in the east-central part has been built up by many eruptions from more than 20 volcanoes, of which Askja, the largest, was active in 1875. Mount Hekla, in the southwestern part, has had many eruptions during historic time. Some narrow valleys are underlain by glacial deposits. Higher plateaus are covered by great snowfields or by glaciers, from which many tongues of ice extend to lower lands.

Hot springs issue in nearly all parts of the island, but they are most numerous in the western part, as shown on figure 27. They are especially numerous in the

Thermal springs in Greenland

[Location of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 26	Name or location	Temperature of water (°C)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
------	On Disco Island----------	14	------------	--------------	--------------	Several springs. (Encyclopedia Britannica, 11th ed., article on "Greenland.")
------	Cape Hold-with-Hope----	Warm	------------	--------------	Basalt and tuff-	Several springs. Refs. 1095, 1096.
1	Scoresby Sound:					
	East side of Cape Tobin.	45. 5–62	6, 667	--------------	Gneiss-------	4 springs near shore. Small siliceous deposit. Refs. 1095, 1096.
	2 km northeast of Cape Tobin.	34. 7; 41. 8	5,441; 6,666; 8,902	Na, Cl------	--------------	Some gas. Refs. 1095, 1906.
2	Henry Land-------------	------------	------------	--------------	--------------	Several springs. Refs. 1095, 1096.
3	Unartok Island, near Julianehaab.	32. 5–41. 9	1,024; 1,080	Na, Ca, Cl, SO_4.	Granite------	7 springs. Small deposits of calcareous-siliceous sinter. Refs. 1092–1094.

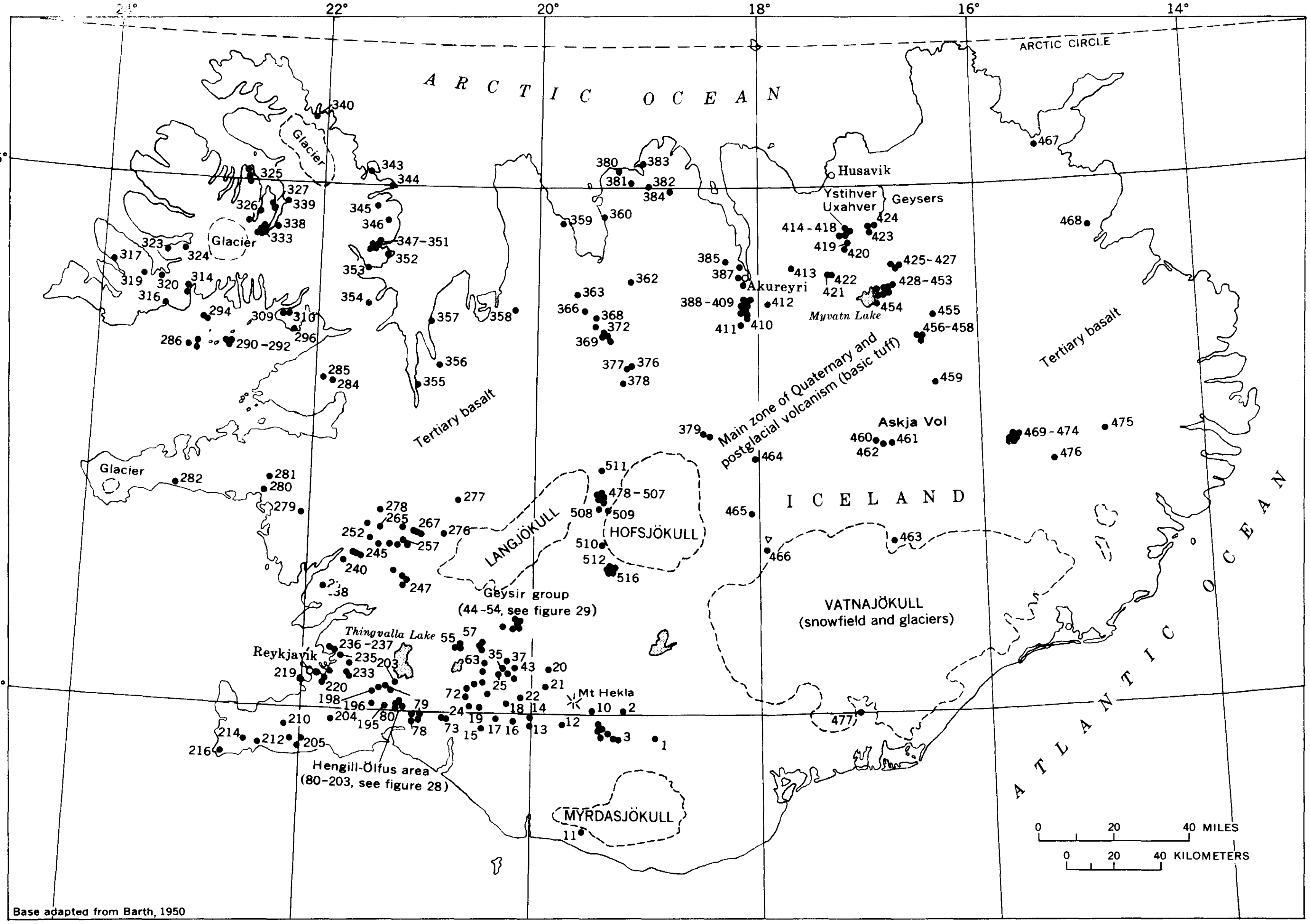

FIGURE 27.—Iceland showing location of principal thermal springs and geysers. From ref. 1115. A, main groups of acid springs.

Hengill-Ölfus area, about 50 km east-southeast of Reykjavik, as shown on figure 28.

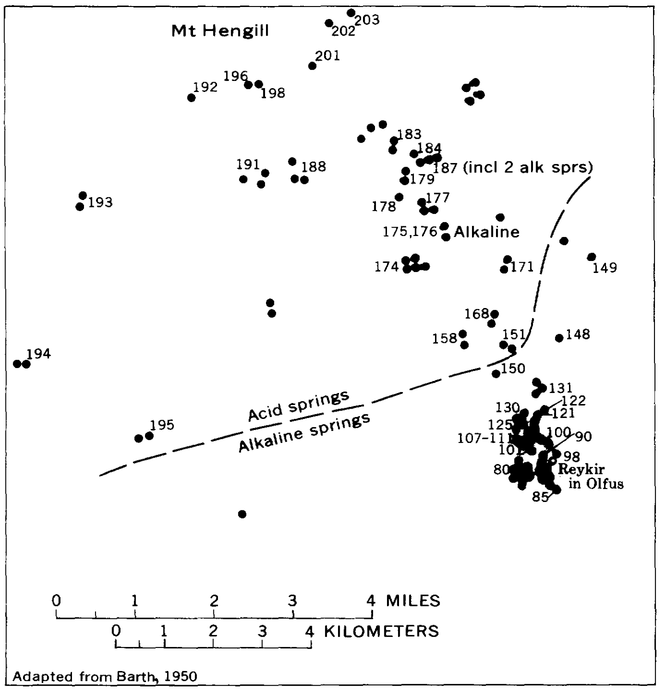

FIGURE 28.—Hengill-Ölfus area of thermal springs, Iceland. From ref. 1115.

One of the earliest descriptions of the principal geysers was by Olafsen (ref. 1206), in an official report of a study of the resources of Iceland, published in Danish. A condensed edition in English was published in 1805 as "Olafsen's Travels," with some of the original illustrations, including a curious representation of Geysir or the Great Geyser.

Geysir (The Gusher, or Spouter)—from whose name all other intermittently erupting hot springs have been called geysers—is in Haukadalur (Hawk Valley), about 80 km east-northeast of Reykjavik, in a group of other hot springs as indicated on figure 29.

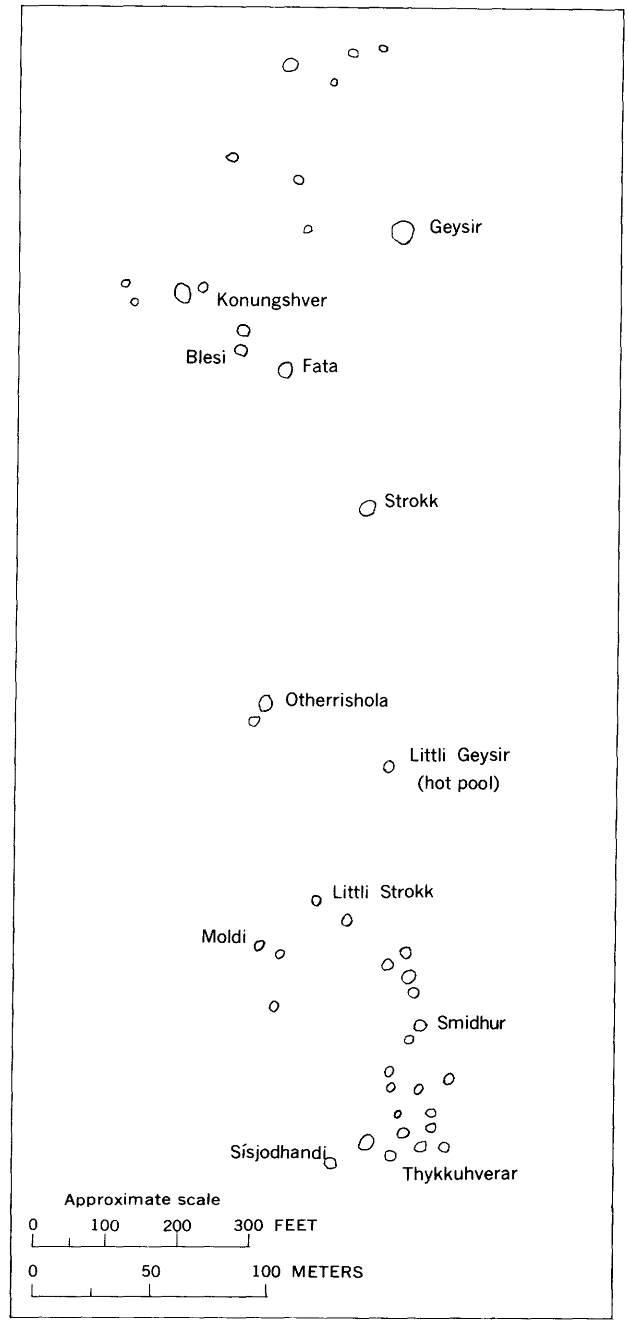

FIGURE 29.—Geysir group, Haukadalur, Iceland. From ref. 1115.

The available data on the principal thermal springs and geysers in Iceland are summarized in the table below.

Thermal springs and wells in Iceland

[Data from Barth, 1950, ref. 1115. Some of Barth's map locations are of extinct springs, which are not included in the present table; not all localities are numbered on fig. 27. See also refs. 1109-1114, 1152, and 1283. Locations of unnumbered springs not identified.]

No. on fig. 27	Name or location	Temperature of water (°C)	Flow (liters per second)	Remarks and additional references
1	Hitalaugar, southeast of Svartahnuksfjökull.	41–70		About 10 springs.
2-4	Southeast side of Laugahraun, near Storihuer.	50–72		About 20 springs, including Kaffihola. Also fumaroles, solfataras, and mud pools. Large deposit of sulfur. Refs. 1136, 1165.
5	Along Bóykjadalir, north of Hrafntinnuhraun.			Many mud pools and sulfur springs. Refs. 1136, 1165.
6	Southeast of Hrafntinnuhraun.			Many boiling springs, roaring steam vents, and solfataras. Refs. 1136, 1165.
11	Seljavallalaug, near Seljavellir.	50		Well.
13	Svinhagi	30		4 springs.
15	Thjórsártun	Warm	Small	
	Heidhi	Warm	Small	
	Marteinstunga	Warm	Small	
16	Hjallenes	Warm		Several springs.
18	Near Búdhafoss on the Thjórsá (near Vindás).	49–58		5 springs. Some formerly were geysers.
19	Kaldárholt			
22	Thjórsárholtslaug	32.4		
23	Reykir, in Skeidh	62		Water formerly boiled.
24	Húsatoptir	38		Well.
	Hlemmiskeidh	32		Do.
25	Hellisholtahverar	60		Several springs. Water from one is used for laundering.
26	Gravarhver	100.3	3	Water used for heating the Gröf farm.
31	Vadhmálahver	99		Constantly boiling.
33–45	Básahverar	Boiling	10–15	3 large basins of quietly boiling water. Water from one is used for heating the Hvam farm.
36	Draugahver	Boiling		Small basin of boiling water.
37	Laugarhver	Boiling	1	Formerly a geyser. Water used for laundering. Deposit of siliceous sinter.
39	Jötulaug	20		Well.
40	Skipholstlaug	Warm		
41	Hiljalaek	39	2	Large amount of gas.
42	Hrunalaug	43	2	Water used for bathing.
43	Horgsholt	Warm		
44–54	Near Haukadalur:			
(fig. 29)	Geysir (Stori Geysir)	100	2.5	Spouts irregularly to a height of as much as 60 meters. Circular basin is 14 meters in diameter. Best known of Iceland's geysers; the word "geyser" originated at this site. Water contains SiO_2 (519 ppm); Na (254 ppm); SO_4 (108 ppm); Cl (144 ppm); CO_3 (207 ppm). Refs. 65, 106, 1098, 1101, 1107, 1111, 1118, 1119, 1126, 1127, 1129, 1130, 1132, 1134, 1137, 1138, 1140–1148, 1150–1152, 1154, 1156, 1160–1162, 1165, 1174, 1178, 1182, 1185, 1188, 1190, 1195, 1197, 1198, 1200, 1202, 1203, 1205, 1206, 1208–1210, 1213, 1217, 1227, 1234, 1235, 1242, 1250, 1254, 1257, 1258, 1260, 1262, 1265.
	Konungshver	89		Formed in 1896. Formerly a geyser, now inactive.
	Blesi	70	6	2 round basins. Formerly a geyser. Refs. 1138, 1210, 1234.
	Fata	99.8		Elliptic basin, 2 meters across, filled with quietly boiling water.

Thermal springs and wells in Iceland—Continued

No. on fig. 27	Name or location	Temperature of water (°C)	Flow (liters per second)	Remarks and additional references
44–54	Near Haukadalur—Con.			
	Strokk	70		Formerly a spectacular geyser shooting a solid column of water to height of 60 meters. Refs. 106, 1098, 1107, 1126, 1127, 1129, 1130, 1134, 1137, 1138, 1143, 1144–1148, 1156, 1160, 1178, 1182, 1188, 1190, 1196, 1197, 1205, 1208–1210, 1234, 1235, 1242, 1250.
	Otherrishola	100		Jets to height of 4 meters several times a day. Can be induced to erupt by clogging orifice with turf.
	Littli Strokk	100		Constantly boiling, producing large quantity of white foam. Erupts irregularly. Refs. 106, 1098, 1137.
	Moldi			
	Smidhur			Constantly boiling, producing large quantity of white foam. Erupts irregularly.
	Sísjódhandi	98–100		Constantly boiling, erupting occasionally. Water contains SiO_2 (222 ppm); Na (107 ppm); SO_4 (118 ppm); Cl (83 ppm); CO_3 (69 ppm).
	Thykkuhverar			Constantly boiling, erupting occasionally.
	Many other springs			Includes Stjarna and Littli Geysir, both formerly active geysers.
55	Hjálmastadhalaugar, north of Laugavatn.	58–76		Several springs.
56	Utey, on southeast shore of Laugarvatn.	93–94		Several springs, including Efrihver and Nedhrihver. One of the springs formerly was a geyser. Refs. 1137, 1147.
57	Laugarvatn (farm), on west side of Laugarvatn.			Several springs, including Reykjalaug and Vigdalaug. Site of mass baptisms in A.D. 1000, when Icelanders were converted to Christianity. Ref. 1147.
57	Littlúhverir, 100 meters south of Laguarvatn farm.			Several springs, two of which are boiling.
58	North end of Apavatn	Warm		
59	Efri Reykir	75-80	Small	Large deposit of siliceous sinter.
60	Sydhri Reykir	97	30	Boils constantly; formerly a geyser.
61, 62	Reykjavellir	84	Large	2 springs.
63	Reykholtshver, at Reykholt, near Tungufljót.	97–100	2	Boils constantly; spouts to height of 1 meter.
65	Spoastadhir	55		
	Laugaras, near confluence of Hvítá and Stóra-Laxa:			
66	Draugahver	95–100		Refs. 1181, 1192.
67	Thvottahver	94.5–96		
68	Hildarhver	94		
69	Sudhuhver	98.5		
70	At and near Reykjanes:			
	Brandhahver			Water used in breadmaking.
	Tjörnhver			
	Rimahver	68		Large pool; some gas.
	North of Rimi	50		
	Thórlakshver, on east side of Brúará.	96		Several other hot springs nearby.
71	South of Hverakot, on north side of Hestvatn:			
	Eyvík	55	Large	
	Ormsstadhir	40	Small	
	Klausturhólar	34		
	Near Sudhurkot	50		
	Vadhnes	50		
	Kidhjaberg, near southwest end of Hestvatn.			
72	Hverakot, 2 km southwest of confluence of Brúará and Hvítá.	94	60	Main spring in group. Much gas. Group also includes Littla Laug.
73	Laugar, near Stóru Reykir.			
74	Laugardaelir	29		Water formerly much warmer.

Thermal springs and wells in Iceland—Continued

No. on fig. 27	Name or location	Temperature of water (°C)	Flow (liters per second)	Remarks and additional references
75	Thorleifskot	48		Do.
76	Sölvholt			
77	Laugarbakkar, on north bank of Ölfusa.	50	.7	Well. Water used for bathing.
78	Selfosslaug, on south bank of Ölfusa.	57		
80	West side of Varmá near Reykir:			
	Hveragardhi			10 springs, including a geyser spouting to height of 2 meters. Issue from large deposit of sinter. Water used for heating houses and a dairy. Described in many old legends. Water contains SiO_2 (324 ppm); Na (236 ppm); Cl (173 ppm). Refs. 1140, 1141.
	Fagrihvamm			Water used to heat large greenhouse.
81	Fosshver, near Reykjafoss.			Also several submerged springs.
98	East and west of Varmá:			
	Littli Geysir, near Reykir.	100		Quiet springs that formerly was one of the best known geysers in Iceland. Water used for heating a sanatorium. Ref. 1231.
99	Tungardhshver			Formerly a geyser.
100	Ljotu-hverar	80.2		Several muddy springs.
107	Bogi I		1	Formerly a quiet spring; now an artificial geyser.
108	Badhstofuhver	99		Well-known geyser. Several other hot springs nearby. Water contains SiO_2 (263 ppm); Na (188); SO_4 (48); Cl (155). Refs. 1140, 1141.
121	Svadhi	100		Geyser having circular basin 9 meters in diameter.
122	Stekkjatunshver	74–75		2 circular basins. Large deposit of siliceous sinter.
125	Gryla	97		Geyser jetting to height of 6 meters. Also several other springs nearby.
	Baulufoss	76; 89		2 springs issuing near diabase dike.
130	Eldhólshver	92		Quiet spring in circular basin 2 meters in diameter.
131	Spytir	100.5		Circular basin of spurting boiling water. Bubbles as large as 5 cm in diameter. Several other hot springs nearby.
	Between Reykjakot and Dalafell:			
150	Reykjakotshver, at Reykjakot.	65	3.9	
151	Brennisteinstindar, on southwest slope of Tindar.	100		Numerous steam jets and boiling mud pots. Large deposit of clay.
158	Hofmannaflöt, on south slope of Dalafell.	31–99.6		Several springs and solfataras. Deposits of clay and sulfur.
168	Hveramoahver and other springs on west side of Graendalsá.	90		Geyser, steam vents, and mud pots. Deposits of clay and sinter.
	Havera Kjalkur:			
175, 176	South slope	97–100	2.5	20 to 30 springs, some of which are in bed of stream. Much gas. Deposits of sulfur.
	East slope	84–98	.8	Several boiling pools and mud pools. Much gas.
	North slope, at and near Falkaklett.	97–100		Many boiling pools and mud pools. Much gas.
184–187	Divide between Reykjadalsá and Thverá drainages and north side of Ökelduhnukur.	97		Many springs, mud pools, and fumarols. Much gas. Deposits of clay and sinter.
	Upper Hengladadalsa drainage basin:			
188–190	Fremstiddalur	60–90		Several springs. Deposits of clay and sulfur.
191	Midhdalur	98.5		Several small springs and steam vents. Deposits of clay.
192	Innstidalur		Large	Large spring issuing at bottom of pool. Also many small springs, fumaroles, and solfataras. Former site of powerful steam vent that could be seen and heard for miles.

Thermal springs and wells in Iceland—Continued

No. on fig. 27	Name or location	Temperature of water (°C)	Flow (liters per second)	Remarks and additional references
193	Sleggjubeinsdalus	99		Several steam vents. Deposits of clay and sulfur.
194	Hveradalir, at west end of Hellisheidhi.	97		Several springs.
195	Hverahlidah, on south side of Hellisheidhi.	96		Steam vents and mud pools. Large deposit of clay.
196	Nesjavallalaugar, at Nesjavellir.			
197	Kaldalaugargil			Fumaroles. Steam clouds can be seen from a great distance.
198–202 (fig. 28)	Northern and eastern slopes of Mount Hengill.			Solfataras andmud volcanoes.
204	Brennisteinsfjöll	26–78		Springs and solfataras. Large deposits of sulfur.
205	Seltun, 3 km north Krisuvik.			Many solfataras, powerful steam vents, and mud pools. Water from Nýihver contains SiO_2 (290 ppm); Al (58 ppm); Fe (35 ppm); Ca (129 ppm); SO_4 (665 ppm). Water from spring at old sulfur mine contains SiO_2 (399 ppm); Al (190 ppm); Fe (168 ppm); Mg (60 ppm); Ca (132 ppm); SO_4 (1,603 ppm). Large deposits of sulfur. Refs. 1133, 1161, 1195, 1197, 1208, 1217, 1234, 1250
214	Svartsengi			Gas and steam vent in lava field.
216	Cape Reykjanes: Brennisteinshverar, on northern slope of Skálarfell.	High		
217	Gunna			Several springs and mud pools. Refs. 1181, 1195.
218	Geysir	Boiling		Formerly jetted to height of 6 meters; now a pool. Water contains SiO_2 (124 ppm); Mg (105 ppm); Ca (1,862 ppm); Na 13,470 ppm); K (1,409 ppm); SO_4 (250 ppm); Cl (25,740 ppm). Refs. 1181, 1195.
219	Hlidhslaug, on Álfanes peninsula.			Issues between high- and low-tide levels.
220	Breidhholtslaugar	25–36		Several springs.
221–223	Laugarneslaugar (Thvottalaugar).	40–88	15	3 main springs and 2 wells. Water used by laundry. Water from 1 spring contains SiO_2 (153 ppm); Na (62 ppm); SO_4 (15 ppm); Cl (30 ppm). Refs. 1140, 1141, 1147, 1159, 1185–1187, 1192.
	Raudhará	30		
224	Grafarlaug, near Grafarholt.	20	Small	
	Nordhur Reykir:			
225	Northernmost spring.	79		
228	Brendihver	76		Much gas.
229	Northwest of Brendihver.	48		
230	South of Nordur Reykir.	57		
231	Sudhurá	83		
232	Aesustadhalaug, near Nordhur Reykjaá.	77		
	Sudhur Reykir:			
233–235	South of Sudhur Reykir.	37.4–55.0		4 springs, including Hornlaug. Water from 1 spring contains SiO_2 (22 ppm); SO_4 (14 ppm); Cl (12 ppm); CO_3 (35 ppm).
	Near Reykjahvoll	21–80		3 springs.
	Adhalhver	78		
	Braudhahver	81.5		
	Along Varmá	31.3–79.5		7 springs, including Blomvanglaug, Bensillaug, Brúarlandhver, and Loalaug.
	Amsterdamlaug	44.5–83.0		4 springs. Water used at Álafoss mill.
236	Kollarjardharlaug	56		
238	North side of Reykjadalsá south of Deildartunga.	99	250; 50	2 springs forming 2 boiling streams that flow into the Reykjadalsá.
	Kleppjarnsreykir (Klephúsreykir), on south side of Reykjadalsá.	99	150	Several springs. Water used for heating a hospital, a farm and, a greenhouse.

Thermal springs and wells in Iceland—Continued

No. on fig. 27	Name or location	Temperature of water (°C)	Flow (liters per second)	Remarks and additional references
	Sturbureykir			Several springs, one of which jets to height of 0.5 meter.
	Árhver (Aahver, Vellineshver), in bed of Reykjadalsá.	Boiling		Several springs, one a geyser that jets to height of 1 meter. Refs. 1165, 1167, 1217.
	Badhlaugahver			
	Fundahús			
	Kópareykir	80–94		6 springs, one of which jets to height of 15 cm. Large deposit of sinter.
238	Leira	53		Ref. 1192.
	Fitgar, near east end of Skorradalsvatn.		Small	
	Sydhstufossar near west end of Skorradalsvatn.	50	4.5	
	Snartastadhir	40	Small	
	Brautarunguhver	100	2.5	
	Krosslaug	43		Reported to have been site of baptisms about A.D. 1000.
	Reykir	Tepid		3 springs.
240–243	Fossatún	48		4 springs.
245	Langholt	82		Mentioned in Sturlunga Saga.
	Baer	56		Do.
247	Englandsshver	74; 89	3	2 springs.
252	South side of Reykjadalsá at Klettur.	50–73		3 springs.
	Stórikroppur	87		
257	Skrifla, near Reykholt	97	8	Water supplied Snorralaug (Snorri's bath) in 13th century. Water contains SiO_2 (166 ppm); Na (71 ppm); K (26 ppm); SO_4 (66 ppm); Cl (81 ppm); CO_3 (106 ppm). Refs. 1160, 1165, 1188, 1233.
263	Haegindi (Haegindakot).	80–96	6	4 springs.
	Ulfstadhir, east of Reykholt.	30		Large deposit of sinter.
264	Stafholtsveggir	99.5	10	Several springs called Veggalaug. Water used for bathing. Ref. 1165.
	Lundahver	80		
	Brúarreykir	37	16	
265	Hurdarbak	92;100	50	2 springs.
	Sidhumúli	65		Water reported to have been boiling in 18th century.
266	Suddalaug, near Hvítá between Sidhumúli and Nordhurreykir.	60	Small	
267	Nordhurreykir	70–97		30 springs.
	Sudhurhverir	80–97		20 springs.
268	Dynk, 40 m south of Skrifla.	94	.5	Jets to height of 1 meter. Large gas bubbles burst with thumping sound.
269	Strokk			Jets to height of 0.5 meter.
272	Stóri ás	76	30	Large amount of N_2.
276	Near Húsafell	51	1	Several springs. Temperature and flow are for the largest spring.
277	Haedaspordh, near Nordhlingafljót.			
278	Giljar	Tepid	Small	
279	Stadharhraun	Warm		
280	Hrútsholtslaug, on Haffjardhára.	46		
	Near Landbrot	52	1	
281	Sydri Raudamelur	40		
	Bárdharlaug, 2 km northwest of Hellnar.	25		Well.
282	Lysuhólslaug, 8.5 km east-northeast of Búdhir.	32	0.5	Large deposit of siliceous sinter. Refs. 1165, 1182, 1192.
283	Hamrar, in Haukadalur	Warm		Water is saline.
284	Laugar in Saelingsdalur	40–50		Several springs. One at Saelingsdalstunga is mentioned in several Icelandic sagas. Water formerly used for bathing.
286	Near Oddbjarnarsker Island in Breidhafjördhur.			Several submarine springs.
287	At and near Laugaland	57–66		Several springs: one near farm, two on seashore, and several below sea level.
	Drápsker Island:			
288	Drápskershver	100		Issues on shore between high and low tide levels.
	Drápsker Island—Con.			
289	Near Drápskershver.	Tepid		Well. Water used for bathing.
290	East of Drápskershver.	Tepid		Several wells.
291	On low rock north of island.	Boiling		Exposed only at low tide.
292	Small uninhabited islands near Flatey Island in Breidhafjördhur.	Boiling		Ref. 1165.
293	Near Sandey Island in Breidhafjördhur.	100		Submarine spring. Water boils noisily; much steam.
295	Near Reykey and Urdholmur Islands in Breidhafjördhur.			Submarine springs. Steam rises from sea surface.
310	Gjörfudal			
	West side of Vatnsfjördhur:			
314	Near Hella farm	29–31		3 springs.
315	South of Hella farm	Tepid		Several springs.
316	Mórudalur:			
	1 km west of Kross	30.5		Much gas.
	Near head of valley			2 springs.
317	Stori Laugardalur			2 springs, one known as Gvöndarlaug.
319	Dufansdal	Tepid		Several springs.
320	Reykjarfjördhur	48–55		3 springs.
323	Laugaból	Tepid		Several small springs.
324	Dynjandi	Tepid		Well.
325	Laugaból	Hot		
335	Muli			
339	Nauteyri	30–42.5		Several springs.
340	Reykjafjördhur	50 (max)		Do.
343	Near Krossnes	50–70		3 wells.
344	2 km northeast of Gjögur.	65–69		
345	Veidhileysa, at head of Veidhileysufjördhur.	68.5–73		
346	Hveratunga	70–72		Several springs.
347	Bjarnarfjardhara Valley	Warm		
348	Klúka	39.5–42.5		3 springs.
349	Svansholl			
350	Godhdalur			
351	Asmundarnes	31		
352	Kaldrananes	28; 32		2 springs.
353	Shore of Hveravik	76		Several springs. Water is salty. Deposit of siliceous sinter.
355	Reykir, on east side of Hrútafjördhur.	56–96.5		Several springs near shore. Hottest water is used for bathing and heating farmhouse.
356	Reykir, at head of Midhfjördhjur.	72		
357	Nordur Reykir, near Ytri and Kárasstadhir on east side of Midfjördhur.	73		
358	Reykir, 2 km west of west end of Svinavatn.	56		
359	Reykir á Reykjaströnd, on west side of Skagafjördhur.			Issues from basalt. Water formerly used for bathing.
361	Reykir, in Hjaltadalsá	40–90		Several springs and 5 wells. Water used for laundering.
363	Fosshver, near Reykjavelir, in Skagafjördhur.	65		Much gas.
368	Reykjahóll, 2 km north of Vidhimyri in Skagafjördhur.	50–89		Large group of springs. Site of 13th century baths and laundry building.
369	Skídhastadhir, 1 km northwest of Reykir in Skagafjördhur.	67		Several springs.
377	Godhdalir, on both sides of river in Vesturdalur.	55–65		
378	Hofsdal, in Hofsdalur	Hot		2 groups of springs.
379	Near Laugakvisl	49–53		Several springs.
380	Laugaland			
381	Bardh, 1 km east of Flókadalsvatn.	65		
382	Stóri Reykir, on east side of Flókadalsá.			
383	Lambanesreykir	41		
384	Reykir, in Olafsfjördhur	40–42		Several springs.
385	Laugaland, in Horgardalur.	20–30	Small	2 springs. Large deposit of siliceous sinter nearby.
387	Glerárgilslaugar, near Akureyri.	40	2.5	Several springs issuing from wall of gorge. Water used for bathing.

735–914 O—65——8

Thermal springs and wells in Iceland—Continued

No. on fig. 27	Name or location	Temperature of water (°C)	Flow (liters per second)	Remarks and additional references
388	Gislaug, on slope west of Sydhra-Gil.	48.4	.4	Much gas.
	West side of Eyjafjardhara:			
389	Reykhúsalaugar	42.5	.2	2 springs. Water used for laundering.
394	Kristneslaug	61		Much gas. Water used for bathing.
395	Grisarárlaug			
396	Hrafnagilslaugar	40	.2	Mentioned in Sturlunga Saga as early as 13th century. Water used for bathing. Ref. 1207.
404	Botnslaug	49.3	.1	
	East side of Eyjafjardhara:			
405	Grýtulaug	33	Small	Some gas.
406	Brunhúsalaug, at Klauf.	64.1		Water used to heat greenhouse.
407	Laugalandslaug	54		
408	Hóllslaugar, at Háagerdhi.	37.5–47.5		8 springs.
409	Bjarkarlaugar, at Bjork.	20		Pools of water.
410	Gardhsárlaug, in Gardhsárdalur.	20		
411	Holsgerdhislaugar, in Eyjafjördhur, 20 km south of Akureyri.	23–44		Several springs.
412	Reykir, on west side of Fnjóská River, 3.5 km southeast of Illugastadhir.	88–89		Do.
413	Stórutjarnir, 1 km west of Ljósavatn.	26–53		Do.
416	Strútshver	85–86		Pool flooded by brook. Also boiling mud pots. Water contains SiO_2 (110 ppm); Na (85 ppm); SO_4 (51 ppm); CO_3 (91 ppm).
417	Uxahver		5	Geyser spouting to height of 2 meters. Known as the Ox Spring. Water contains SiO_2 (160 ppm); Na (30 ppm); SO_4 (50 ppm); Cl (20 ppm); CO_3 (24 ppm). Refs. 1106, 1160, 1165, 1192, 1206, 1207.
418	Ystihver (Badhstofuhver, Nordhurhver).	98.8	50	Largest geyser in northern Iceland. Jets to height of 12 meters. Circular basin of siliceous sinter 10 meters in diameter and 8 meters deep. Water in basin boils continuously. Subsidiary vent (Strokk). Ref. 1160.
419	Thvottahver	92.1	.1	Water contains SiO_2 (125 ppm); Na (102 ppm); SO_4 (73 ppm); Cl (70 ppm) CO_3 (49 ppm).
421	Stóru-Laugar, 3 km southeast of Breidhamýri.	48–57	1.8	Several springs. Water used for irrigation of meadows, for heating hotel, and for swimming pool in hotel.
423, 424	Theistareykir, on northwest slope of Baejarfjall.			Several solfataras and pools of mud.
425, 426	Near Helviti, west and southwest of Krafla, and along east slope of Leirhnúk.			Several steam vents and small springs near Twin Lakes. Refs. 1133, 1138, 1165, 1221.
433, 434	East slope of Namáfjall and Hverarönd (Hlidharnámar) at base of slope.	87–94		Many mud pots. Water from one mud pot contains SiO_2 (214 ppm); Al (344 ppm); Fe (310 ppm); Mg (74 ppm); Ca (94 ppm); Na (24 ppm); SO_4 (4,023 ppm). Much gas. Refs. 1138, 1156.
435	West slope of Namáfjall			Several springs. Water from one spring contains SiO_2 (417 ppm); Al (50 ppm); Fe (30 ppm); Mg (215 ppm); Ca (374 ppm); Na (87 ppm); K (61 ppm); SO_4 (2,812 ppm).
436, 437	Jardhbadhshólar (Bjarnarflag).			Many vapor vents and solfataras in craters. Southernmost crater named Hitur. Ref. 1265.
438	Stóragjá, near Reykjahlidh.	25–43		Water used for bathing.
456	Ketildyngja			Many solfataras. Large deposit of sulfur.
459	Hrúthálsar (Hrútshálsar).			Several fumaroles and solfataras.
460	Crater of Askja volcano			Many hot springs and fumaroles on inner wall of Rudloffkrater of Öskjuvatn.
463	Kverkfjöll, near edge of Vatnajökull.			Several craters exhaling water vapor and gases.
464	Hitalaug, 1 km west of Hrauna River.	33		Several springs at altitude of 660 meters.
465	Marteinsflaedha	35.5		Altitude of 720 meters.
466	Gaesavötn	1–7		Several springs at altitude of 900 meters.
467	Gunnarstadhir	Warm		
468	Both sides of Selá River, 1.5 km south of Hróaldsstadhir.	30–44		
472	Laugarvalladal	14.5		Several springs. Deposit of sinter. Ref. 1165.
475	Near Hrafnekilsstadhir, on east side of Jokulsá Leirur.			
476	Near Laugafell	51		Altitude of 500 meters.
477	Near Jökulfell, on west side of Morsardalur.	50–60		Several springs. Ref. 1125.
	Hveravellir:			
481	Bóluhver	95		Formerly a noisy steam vent. Deposit of sulfur. Ref. 1250.
486	Goshver	97.5		Jets to height of 20 cm. Ref. 1250.
491	Eyvindarhver	Boiling		Formerly a geyser. Water used by Mountain-Eyving, an outlaw, for cooking in 18th century. Ref. 1250.
492	Öskuhóll	98.5		5 noisy steam vents. Deposit of sulfur. Ref. 1250.
493	Bláhver	Boiling		Deep-blue water in circular basin 8 meters in diameter.
494	Graenihver (Meyjarauga).	Boiling		Light-blue water in circular basin 4 meters in diameter.
496	Fagrihver	90		Small geyser spouting from cone of silica.
497	Braedhrahverir			2 springs 6 meters apart. One is a geyser.
503	Djupihver			
510	Beljandarkvislar, 10 km north of Hveravellir.	Boiling		4 springs, one of which spouts to height of 0.5 meter.
511	Nauthagi and Blágnýpaver, 20 km south of Hveravellir.			Several springs.
512–516	Hveradalir			Myriad springs, solfataras, and fumaroles. One steam vent called Öskran'ki is extremely noisy. Deposits of sulfur and gypsum. Ref. 1165.
	Near Hofsós	58		
	Upper part of Thverá drainage basin.			Powerful and noisy fumarole, many solfataras, mud volcanoes, and mud pots.
	Near head of Torfatindar.			Refs. 1136, 1165.

MINOR ISLANDS—CANARY, CAPE VERDE, FAROE (FAEROE), JAN MAYEN, AND SPITSBERGEN (SVALBARD)

In addition to the Azores and Iceland, several other volcanic islands or groups of islands are situated on the mid-Atlantic Ridge, which is considered by some geologists to extend, with interruptions, from Jan Mayen Island in the north to the South Sandwich Islands east of Cape Horn, as indicated on the map of the world showing volcanic zones (fig. 1).

The Canary Islands, about 60 miles west of the coast of northern Africa, form a group of seven small islands and several islets, as shown on figure 30. All the islands

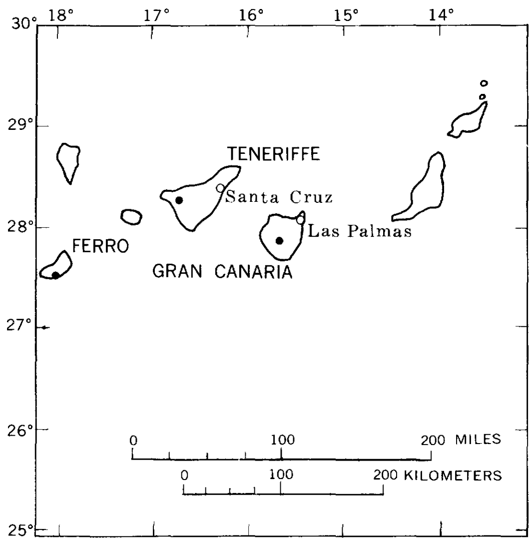

FIGURE 30.—Canary Islands showing location of thermal springs.

are of volcanic rocks, chiefly basalt and trachyte. The easternmost two islands and several islets rise from a submarine platform. The five western islands rise as separate peaks from the deep ocean.

The Cape Verde Islands, off the west coast of northern Africa, are an archipelago of 10 islands that are spread over an area about 200 miles in diameter. (See fig. 1.) The principal islands are about 320 to 350 miles west of Cape Verde; all are volcanic. Fogo Island, next to the most southwestern of the group, is nearly circular, about 15 miles in diameter with a volcanic caldera and a large active inner crater.

The Faroe (Faeroe) Islands comprise 21 small volcanic islands and several islets, about 300 miles southeast of Iceland. (See fig. 1.) Most of the islands in the group are hilly and rocky and are bordered by sea cliffs interrupted by fiords. Thick sheets of basalt interbedded with tuffs are intruded by dolerite and, on some of the islands, are overlain by clay, sandstone, and beds of brown coal. Barth (ref. 1115) stated that Noe-Nygaard (ref. 1274) examined a spring of water, 20°C, on the east coast of Ostero Island. It is the only reported thermal spring in the islands, but is not considered to be of volcanic origin.

Jan Mayen Island is about 370 statute miles north-northeast of the northeast tip of Iceland, as shown on figure 1, and is about 9 by 34 miles in extent. A volcanic mountain in its northeastern part has been observed at times in eruption, and deLaunay (ref. 30) noted that there are hot springs. There also may be fumaroles and solfataras.

Spitsbergen (Svalbard) lies north of Norway and northeast of Iceland. (See fig. 1.) It consists of four islands of unequal size and several other much smaller islands. West Spitsbergen, the largest island, is deeply indented by fiords, and Wood Bay occupies Wood Fiord in the north end of this island. The surface of Spitsbergen is very rough, because there are several large glaciers on the island and because the rocks are much folded and faulted. The island is underlain by rocks which range in age from Precambrian through Tertiary, but the largest areas are underlain by rocks of Precambrian and Triassic age. The Wood Bay area is underlain by rocks of Silurian and Devonian ages, which are faulted on the west against rocks of Precambrian through Ordovician ages. The hot springs of Wood Bay and Rock Bay, an inlet of Wood Bay, issue in nearby areas close to the faultline.

OTHER SMALL ISLANDS

Ascension Island (fig. 1) is 1,700 statute miles south-southeast of the Cape Verde group and is about 6 by 7½ miles in extent. It consists of a volcanic mass on a submarine platform and contains numerous volcanic cones, one of which has a great elliptical crater. Hot springs or fumaroles have not been reported but may be present.

Gough Island in the South Atlantic is about 4 by 8 miles in extent. It is mountainous and volcanic, but no thermal springs seem to have been reported.

St. Helena Island, about 8 by 10 miles in extent, is on the Atlantic Ridge, 800 statute miles southeast of Ascension Island. St. Helena is composed of volcanic rocks, chiefly basalt, andesite, and phonolite, and is deeply weathered and eroded. The culminating summit is the remnant of the north rim of a large crater. The island receives considerable rain. Springs of fresh water are plentiful, but no thermal springs seem to be present.

South Sandwich Islands form a scattered group about 1,600 statute miles east of Cape Horn. They probably are volcanic, and thermal springs may issue in one or more of them.

Trinidad Island, 700 statute miles east of the Brazilian coast, is 2 by 4 miles in extent and is composed of volcanic rocks. It has fresh-water springs, but none is reported to be thermal.

Tristan da Cunha Islands comprise three small volcanic peaks in the South Atlantic, about 2,000 statute miles west of the Cape of Good Hope and 4,000 miles northeast of Cape Horn. These islands rise from the same submarine platform as the Azores and Ascension Island. Sea cliffs in the Tristan da Cunha group expose several varieties of lava, chiefly basalt, andesite, palagonite, and dolerite. Tristan Island, the largest and northernmost, is 7 miles in diameter and contains a volcanic cone in whose crater is a small fresh-water lake

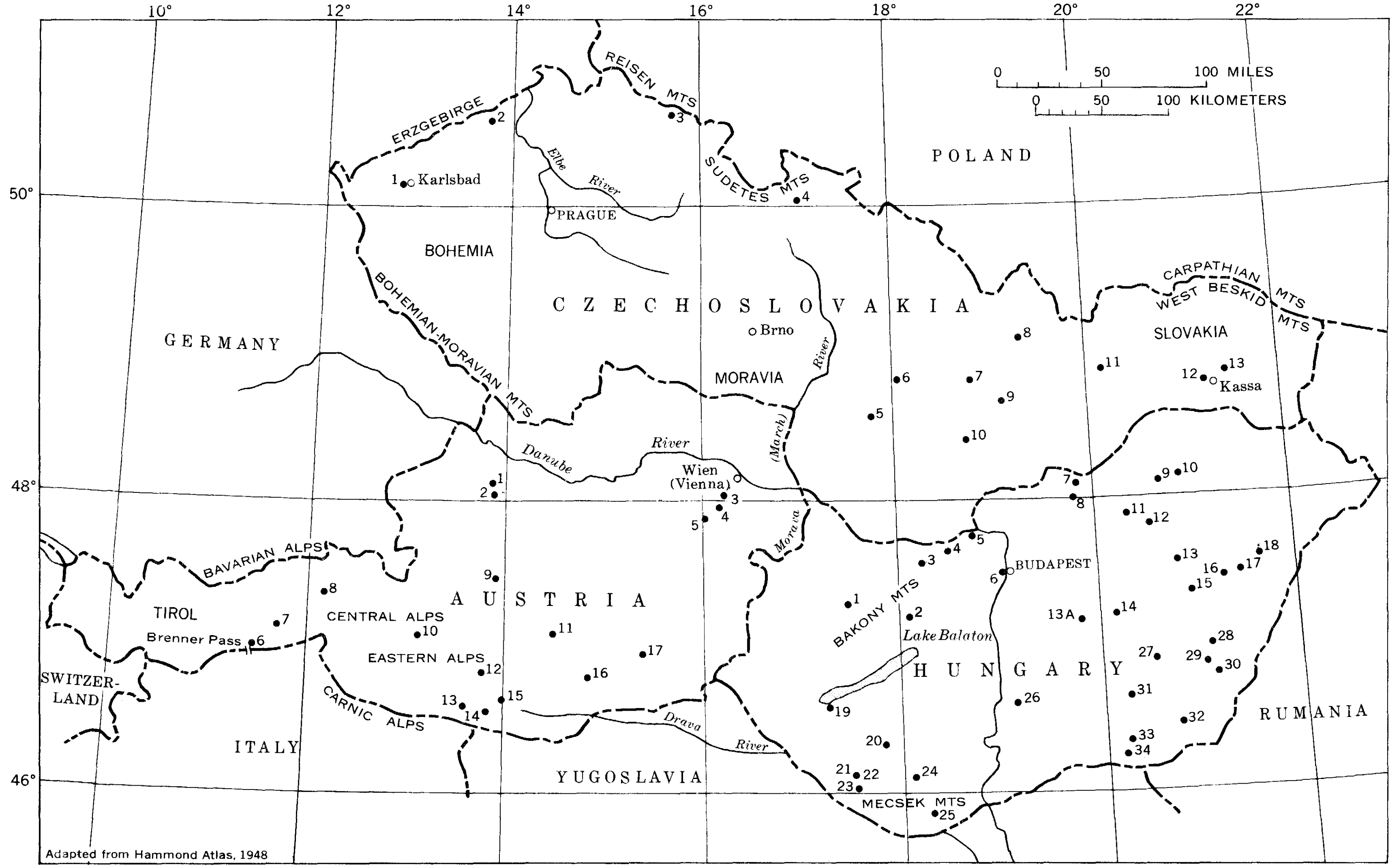

Figure 31.—Austria, Czechoslovakia, and Hungary showing location of thermal springs and thermal wells.

that is reported never to freeze. Hot springs and fumaroles may issue there. [A volcanic eruption in late 1961 necessitated the evacuation of all the residents of the island.]

EUROPE

AUSTRIA

Most of Austria is mountainous. Part of the western border with Germany is formed by the Bavarian Alps. The eastern part of the Central Alps and the Eastern Alps occupy much of central and eastern Austria. (See fig. 31.) These ranges form a wide belt of intensely folded and greatly faulted rocks. The central core of the mountains is of gneiss and schist and infolded Paleozoic sedimentary rocks. On each side are Triassic beds of marine limestone and minor areas underlain by Jurassic and Cretaceous limestone, marl, and sandstone. All these beds are intensely folded in higher areas, but deformation is less on the lower slopes. In the Tirol region in the westernmost part of the country large areas are underlain by faulted igneous rocks. The Carnic Alps along part of the southern border are composed chiefly of Triassic rocks, but they contain some Jurassic and Cretaceous strata. In the northeast, along the valley of the Danube River, are some wide areas of lowland.

Numerous mineral springs issue throughout the mountain areas. It is estimated that more than 1,500 individual springs are present, but only a few have temperatures noticeably above the mean annual temperature, which ranges from about 10°C in the Danube Valley at Vienna to less than 8°C in the populated higher areas. All the principal thermal springs and many of the cold mineral springs have been developed for bathing, the water from the cold springs being heated artificially. The mineral springs are used also for medicinal drinking.

The location of the thermal springs is shown on figure 31, and information concerning them is presented in the table below.

Thermal springs and wells in Austria

[Data chiefly from ref. 1304. Principal chemical constituents are expressed in parts per million]

No. on fig. 31	Name or location	Temperature of water (° C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Scharten						Ref. 1828.
2	Schallerbach	36.6	8,640	564	Sulfide; gas, 78.8 percent N_2, 21.2 percent H_2S and CO_2.		1 main spring. Ref. 1310.
3	Baden:						
	11 main springs	27–35.7		1,978 (hottest)	Ca, SO_4, Na, Cl, HCO_3; gas, 98 percent N_2.	Triassic dolomite	On extension of Fischau-Voslau thermal zone. Resort; sanatorium. Refs. 1310, 1336, 1339, 1342, 1345, 1347, 1355, 1358.
	Well near Krozingen	40.3	70,000	4,016		do	Do.
4	Voslau	20; 23.3		686	Ca, CO_3; gas, 95 percent N_2.	Contact of Tertiary breccia with underlying Triassic dolomite.	2 main springs. Resort. Refs. 1298, 1324, 1335, 1344.
5	Fishau	21		426		Tertiary strata	1 main spring. Developed A.D. 865 as bathing resort.
6	Brennerbad:						
	Main spring	21.6		476		Near contact of ancient limestone with schist.	In use about 600 yr as bathing resort. Radioactive. Ref. 1316.
	Others	22.8 (max)					
7	Hintertux	22.5	15,550	204		Limestone and schist	1 main spring. In use about 700 yr as bathing resort. Radioactive. Refs. 1297, 1316, 1337.
8	Haring (Francisbad)	38.8		2,371	$CaSO_4$	Tertiary strata including brown coal.	Resort.
9	Mittendorf	23.4		26,000	Ca, Mg, SO_4, HCO_3		Shallow well. Resort. Ref. 1306.
10	Bad Gastein	24.4–49.4	2,600	398	Na, SO_4, HCO_3	Crystalline schist	18 springs, from galleries. Developed A.D. 678 as resort. Also supplies baths at nearby Hofgastein. Refs. 1296, 1301–1305, 1307–1309, 1312, 1319–1321, 1323, 1325, 1326, 1328–1330, 1332, 1337, 1338, 1350, 1353, 1356, 1359.
11	Linod						
12	Kathrininbad bei Kleinkircheim.	22.5	900	247		Carboniferous dolomite	Early developed as bathing resort. Ref. 1337.
13	Bleiberg	Warm				Triassic dolomite	In gallery of tin mine on Bleiberg graben. Ref. 1311.
14	Warmbad Villach	24–29		561	Ca, HCO_3	Conglomerate overlying Triassic limestone.	Several springs; Aquae Villacenses of the Romans. Resort. Springs of Bad Villach nearby are cold. Refs. 1346, 1349, 1350.
15	Reifnitz-am-Worthersee	16.8 (max)	Small	Low	Ca, HCO_3		Locally classed as thermal. Ref. 1313.
16	Weisenbach	25		2,250	Na, Ca, HCO_3; free CO_2	Schist and crystalline limestone.	Resort. Minor chemical constituents: Cl, SO_4.
17	Tobelbad	27.8–36.3	6,900	663		Upper Tertiary strata overlying Devonian limestone.	Several springs; earthy, acidulous. Known to the Romans. Resort.

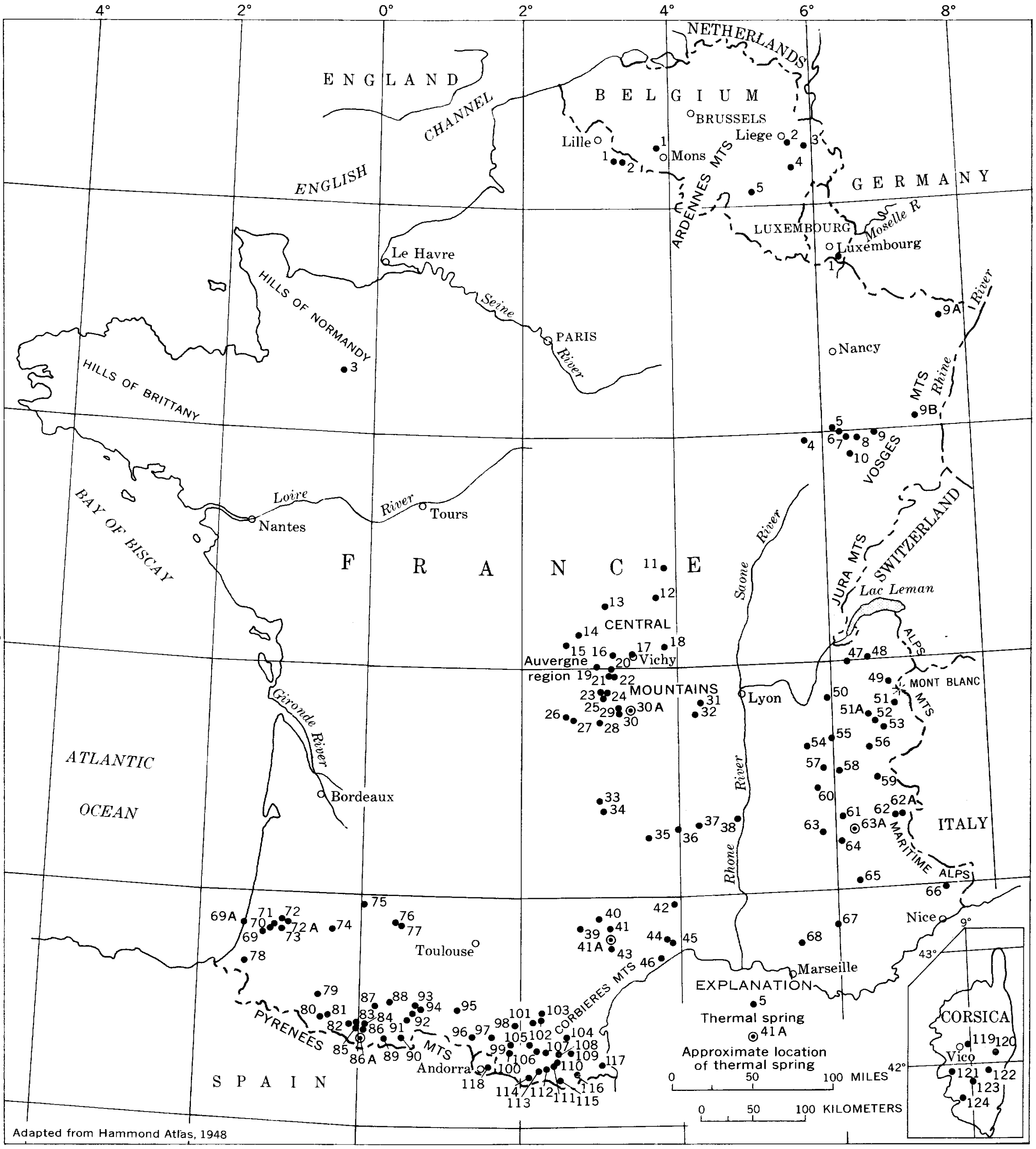

FIGURE 32.—Belgium, France, and Luxembourg showing location of thermal springs and thermal wells. Belgium chiefly from ref. 1368; France chiefly from ref. 1685; Luxembourg from refs. 1361 and 1365.

BELGIUM AND LUXEMBOURG

Belgium, for the most part, is underlain by marine Cretaceous and Tertiary strata. These strata lap onto older rocks exposed in the Ardennes Mountains in the southeastern part of the country. Along the north side of these mountains, coal beds and other rocks of Carboniferous age are faulted and infolded with strata of Devonian age.

The southeast flanks of the Ardennes Mountains descend to the hilly lands of Luxembourg, which is drained mainly by tributaries of the Moselle River, which marks part of the eastern boundary of the country. Throughout most of Luxembourg the outcropping rocks are of Devonian, Triassic, and Jurassic age. In some of the lower areas, however, sedimentary deposits of Tertiary and Quaternary age overlie the older rocks. In places, the older rocks are greatly faulted, the fault systems trending northeast-southwest.

In Belgium, thermal springs have been recorded at five places, and in Luxembourg one deep well that yields thermal water has long been in use. Their locations are shown on figure 32.

The available information on the several thermal water supplies is summarized in the table below.

Thermal springs in Belgium and thermal well in Luxembourg

[Data chiefly from ref. 1368. Principal chemical constituents are expressed in parts per million]

No. on fig. 32	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
				Belgium			
1	Sirault, 13 km northwest of Mons.	31.25					Water temperature measured in 1779. Apparently has ceased flowing or has been covered.
2	Chaudefontaine, 8 km southeast of Liege.	32–35	Large	352–488	Ca, Na, HCO_3, Cl	Condruzien strata (Upper Devonian).	Several springs and shallow wells early developed. Large bathing resort. Refs. 1362–1364, 1369, 1371.
3	Juslenville, 25 km southeast of Liege.	17.5–21.5	Large		$CaCO_3$ (144); $MgCO_3$ (35); Na_2SO_4 (36); NaCl (19); SiO_2 (27).	do	6 springs. Chemical analysis made in 1827. Used as source of waterpower for mill.
4	Ernonheid, 5 km east of Ferrieres.					Coblentzien strata (upper part of Lower Devonian).	
5	Epgrave, 5 km southwest of Rochefort.					Condruzien strata (Upper Devonian).	Several springs at foot of mountain; much vapor in cold weather.
				Luxembourg			
1	Mondorf-les-Bains, 15 km southeast of city of Luxembourg.	24.5	670	14,460	NaCl (9,400)	Permian	712 meters deep. Temperature of water from lowest strata 28°C. Drilled in 1946 to replace well drilled in 1844, which had become clogged. Original well, 730 meters deep, flowed 600 liters per minute; water temperature 25°C. Refs. 1361, 1365, 1366, 1370, 1372.

BRITISH ISLES

In Scotland and the northern part of England, the ancient sedimentary and crystalline rocks exposed are greatly folded and faulted in some areas and intruded by volcanic rocks of Mesozoic to early Tertiary age. In these districts no thermal springs have been recorded. Part of the northern half of England is occupied by the great anticline of the Pennine Hills, whose core of Lower Carboniferous strata is flanked by the Coal Measures and Permian and Triassic formations. Triassic beds also cover extensive areas in the Midlands region. A thick succession of Jurassic and Cretaceous rocks is exposed in eastern and southern England, but these rocks are overlain by Tertiary deposits in the London and Hampshire (Hants) synclinal basins. Sedimentary rocks of Cambrian to Devonian age and some gneiss and ancient volcanic rocks occupy much of Wales and southwestern England. Nearly all the thermal springs reported are in areas of Carboniferous or younger marine strata.

The locations of thermal springs and wells in the British Isles are shown on figure 33. Data on these springs and wells are given in the table below.

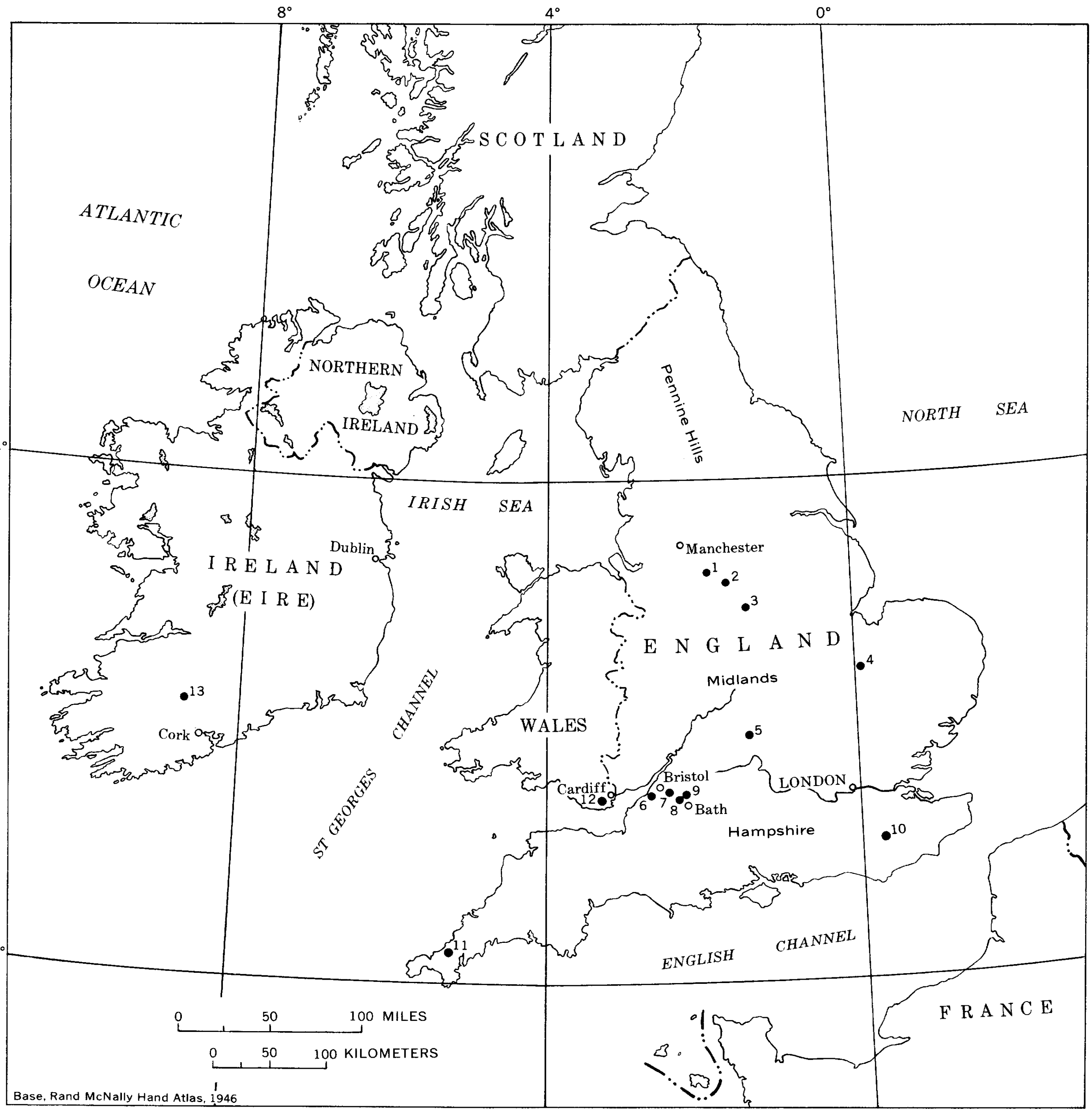

FIGURE 33.—Part of the British Isles showing location of thermal springs and thermal wells.

Thermal springs and wells in the British Isles

[Principal chemical constituents are expressed in parts per million]

No. on fig. 33	Name or location	Temperature of water (°F)	Flow (imperial gal per min)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
	England						
1	Buxton, 20 miles southeast of Manchester.	82 (max)	129.5	378	Ca, Na, HCO_3, Cl	Carboniferous limestone, probably faulted.	Originally 9 springs. Bathing resort. Refs. 1374, 1391, 1403, 1413, 1416, 1435, 1442, 1443, 1450, 1452–1454, 1456–1459, 1468, 1474–1477, 1490.
2	Bakewell, 25 miles southeast of Manchester.	60–62	Variable			Carboniferous limestone	Water quality similar to springs at Buxton. Bathing resort. Refs. 1468, 1490.
3	Matlock, 37 miles southeast of Manchester.	68	415	478	Ca, Mg, Cl	do	3 main springs. Resort. Refs. 1391, 1403, 1421, 1443, 1456–1458, 1468, 1490.
4	Chatteris, 12 miles northeast of Huntingdon.	69–74					Shallow wells in fenland. Water may be from deep-seated source. Refs. 1406, 1407, 1462, 1489, 1490.
5	Stoney Middleton, 15 miles north of Oxford.	63	20	230	Mg, Na, SO_4	Carboniferous limestone	Bathing resort. Refs. 1468, 1490.
6	Clifton Wells, on bank of Avon River, 2 miles west of Bristol.	76		660	Mg, Na, HCO_3, SO_4, Cl		Bathing resort. 2 original springs, temperature 66° F and 72° F, were at St. Vincent's Rocks in the Avon River gorge. Refs. 1403, 1404, 1450.
7	Bristol hot well, in Bristol	76		1,092	Ca, SO_4	Carboniferous limestone	Original spring near river: temperature, 76° F; total dissolved solids, 630 ppm; principal chemical constituents, Ca, Na, HCO_3, SO_4, Cl. Refs. 1381, 1382, 1391, 1409, 1437, 1439, 1450, 1457, 1471, 1487, 1490.
8	Bath	110–117	350	1,820	Ca, Na, SO_4. Gas, 96 percent N_2.	Contact of Keuper marl (Jurassic) with Triassic strata. Water probably rises, along faults, from Carboniferous strata.	3 main springs. Developed by Romans. Large bathing resort. Refs. 1373, 1377, 1378, 1381, 1383–1391, 1393, 1395, 1396, 1398–1405, 1408–1410, 1412, 1415, 1419, 1422, 1424, 1427–1429, 1433, 1434, 1436, 1438, 1440, 1441, 1444, 1446–1449, 1455–1457, 1461, 1463, 1465–1469, 1478–1484, 1486, 1488–1490.
9	Batheaston, 3 miles northeast of Bath.	Tepid	Moderately large			Coal Measures (Upper Carboniferous).	Chalybeate. Water issues in coal shaft. Refs. 1411, 1489, 1490.
10	Tunbridge Wells, 30 miles southeast of London.	57			Ca, Ng, Ma, SO_4, Cl	Cretacous strata. Water may rise from Jurassic strata.	Originally 2 small springs. Bathing resort. Refs. 1376, 1380, 1426, 1457, 1458, 1473.
11	Redruth, 28 miles southwest of Bodwin.	125	150	9,200	Ca, Na, Cl	Contact of granite porphyry with ancient slate.	Water issues in Weal Clifford copper mine, at depth below 1,500 ft. Refs. 1430, 1431, 1464.
	Wales						
12	Taafe's (Taff's) well, near Cardiff.	65–70		137	Mg, SO_4. Gas, more than 95 percent N_2.	Coal Measures (Upper Carboniferous).	Bathing resort. Refs. 1472, 1490.
	Ireland (Erie)						
13	Mallow, 18 miles north-northwest of Cork.	70–71		212	Ca, SO_4, Cl	Carboniferous limestone near contact with Devonian sandstone.	1 spring and 2 shallow wells at base of hill. Bathing resort. Refs. 1414, 1445.

BULGARIA

Bulgaria has the Danube River for most of its northern boundary and the Black Sea for its eastern boundary. The Rhodope Mountains, with sharp peaks and steep slopes, extend along part of its southern border. Smaller ranges form most of the western border. Through the central part of the country the Balkan Mountains, with rounded crests and generally moderate slopes, extend east–west. Northward from these mountains, long and gentle slopes interrupted by hills descend to the Danube, along whose lower course are extensive plains. In the southeastern part of the country, the wide plain of eastern Rumelia extends southward from the Balkan Mountains.

According to Bourchier (ref. 1494), Archean gneiss and crystalline schist form most of the Rhodope Mountain area and also underlie much of the Rumelian plain. Carboniferous rocks overlain by marine Triassic and Jurassic strata are exposed in the western Balkans, and

Permian sandstone occupies parts of the Sofia basin. Lower to Upper Cretaceous strata cover nearly the whole extent of northern Bulgaria, from the crest of the Balkans to the Danube. Eocene deposits form both flanks of the eastern Balkan Mountains, and late Tertiary strata underlie lands near the Black Sea. Most of the Danube plain is covered by loess of Quaternary age. Some intrusive masses of granite and other coarsely crystalline rocks, also lavas, are present in the Balkan Mountains and in the Sredna Gora Mountains in the southwestern part of the country. Most of the thermal springs are in the southwestern part, as shown on figure 34. Available information on the springs is given in the table below.

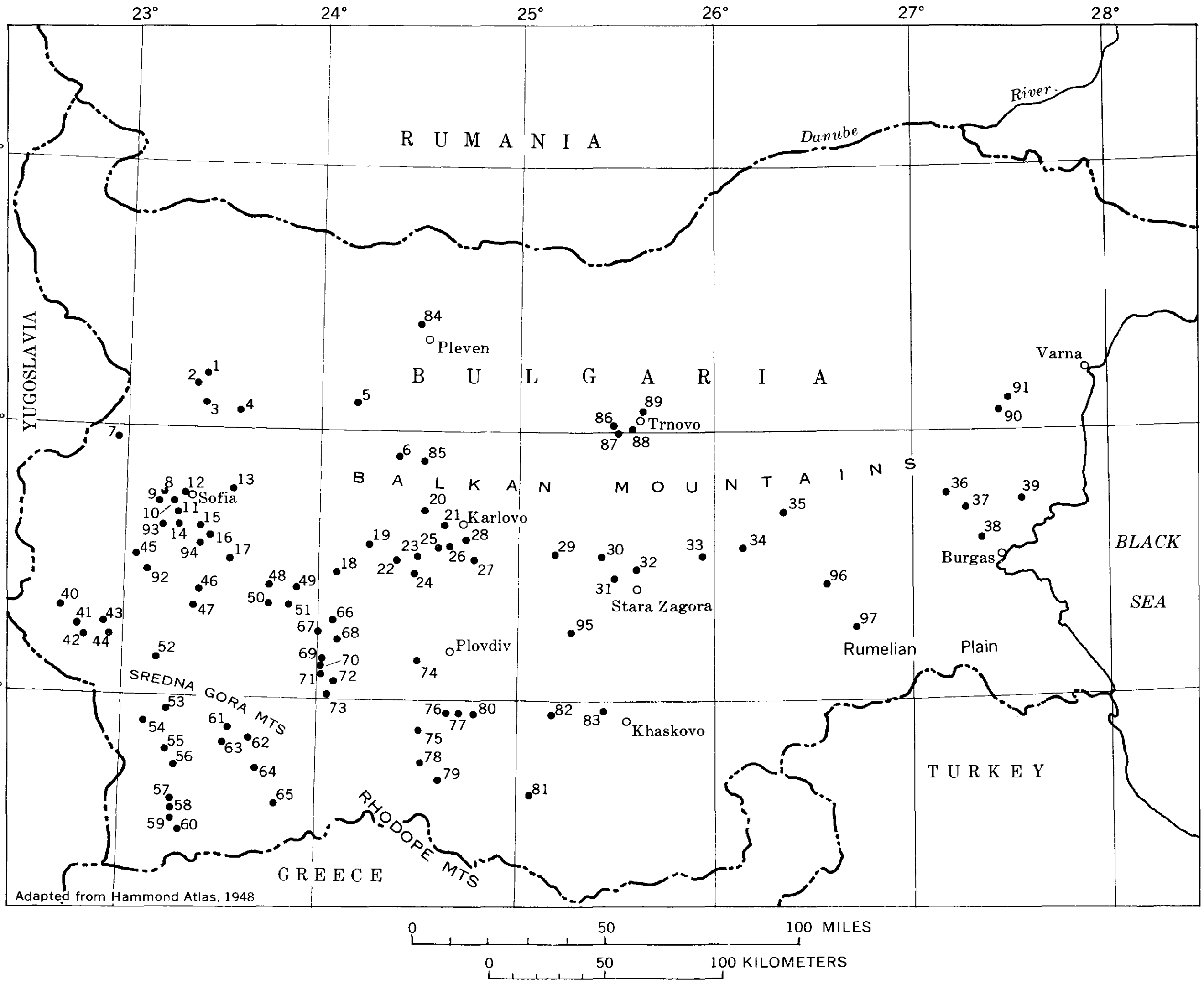

Figure 34.—Bulgaria showing location of thermal springs. From ref. 1493.

Thermal springs in Bulgaria

[Springs numbered in accordance with ref. 1493. Data chiefly from refs. 1493, 1502, and 1506. Nearly all are developed for bathing. Principal chemical constituents are expressed in parts per million]

No. on fig. 34	Name or location	Temperature of water (°F)	Flow (U.S. gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
				Balkan Mountain area			
1	Vrshets (Vershetz)	98	90	172		Faulted granite	Ref. 1494.
2	Zanozene	68	9				
3	Lataknik	86	4				
4	Jelenovdol	80	55				
5	Glava-Panega	72	45				
6	Shipkovo	77	40				
7	Vladislavtsi	70					

Thermal springs in Bulgaria—Continued

No. on fig. 34	Name or location	Temperature of water (°F)	Flow (U.S. gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Balkan Mountain area—Continued						
8	Bankya (Banki)	99	300	245		Pliocene strata overlying faulted andesite.	Refs. 1495, 1507.
9	Malko-Bucino	73					
10	Gorna-Banya (Gornia-Bania).	68-106	50	135		Faulted alluvium	Refs. 1495, 1501.
11	Knyazhevo (Kniajevo)	72-97	60			do	Do.
12	Sofia	117	170	262		do	Refs. 1494, 1505.
13	Cepinci	89	55				
14	Kladnitsa	81	55				
15	Pancharevo	118	35		CO_3 (411)	Faulted Triassic limestone	
16	Zheleznitsa	77	260			Faulted granite	
17	Kalkovo	77	15				
18	Pangyurishte	111	250				
19	Strelcha	104	50			Faulted granite	
20	Karasarli	90	55				
21	Stoletovsk	93	30			Faulted alluvium	
22	Bota-Banya	106-111	450				Issues from fault zone.
23	Starosel	81	25				
24	Krasnovo	88-127	15		Sulfide, H_2S	Faulted granite	
25	Khisar (Hissar; Kuptchez bath).	121	280	191		do	Refs. 1500, 1501, 1507.
26	Davadzhov	98	45	200	Sulfide, H_2S	do	
27	Pesnopoi	86					
28	Karlovo-Banya	124	260				Refs. 1498, 1499.
29	Pavel	122	80			Faulted granite	
30	Ovoshtnik	109	15		HCO_3 (323); SO_4 (690)	Faulted alluvium	
31	Sulica	115	160				
32	Gorno-Panicherevo	120	65		HCO_3 (259)	Faulted granite	
33	Korten	71-129	105		SO_4 (467)	Faulted schist and granite	
34	Dzhinovo	110	70				
35	Sliven (Slivno)	112	90		SO_4 (736); CO_2 (2,370); Fe_2O_3 (40).	Faulted Cretaceous strata near andesite.	Water used for bathing. Ref. 1495.
36	Markovo-Banya	73	40		HCO_3 (977)		
37	Aitos	107	500			Faulted andesite	
38	Burgas (Bourgas)-Banya	106	360 (max)				Water used for laundering. Refs. 1491, 1495.
39	Medovo	75	8				
	Rhodope Mountain area						
40	Kyustendil	164	500		Sulfide, H_2S	Faulted schist	
41	Katrishte	68					
42	Nevestino	122					
43	Kadin Most		65				Issues from fault zone.
44	Chetirtsi	122					
45	Rakovets	90	40				
46	Baltchin	102	120			Alluvium overlying faulted strata.	
47	Saparevo (Zaparevo)	187	25		Sulfide, H_2S	Faulted schist	Hottest spring water in Bulgaria. Refs. 1491, 1494.
48	Pchelin	163	170			Faulted granite	
49	Solu-Dervent (Momina Banya).	150	270			do	Radioactivity 560 emans per liter. Refs. 1491, 1500, 1501.
50	Dolna-Banya	126	35		Sulfide, H_2S	Faulted schist	
51	Kostenets	107	70		do	Faulted granite	
52	Gorna-Djumaya	95-131	155		HCO_3 (620), sulfide, H_2S	Faulted schist	
53	Osenova	154					
54	Simitli	108-140	150		Sulfide, H_2S	Faulted schist	
55	Hustava	140					
56	Gorna-Gradeschnitsa	109	50				
57	Sveti Vrach	142-182	115		Sulfide, H_2S	Faulted schist	Ref. 1496.
58	Polenitsa	120-143	30			do	
59	Levunovo	130-134	140				
60	Marikostenovo	145	260		Sulfide, H_2S	Faulted Tertiary strata	
61	Gulina-Banya	98	470	321	Small amount of H_2S	Alluvium overlying schist	Local water supply.
62	Eleshnitsa	100-133	200			Faulted schist	
63	Dobrinishki	100-104	225		Small amount of H_2S	do	
64	Kanina	109	175				
65	Bashnitsa	100	130				
	Elli Dere River area						
66	Vetren	147	80				
67	Malo Belov	75	600			Marble	Issues at base of bluff.
68	Varvara	90-150	140			Faulted schist and gneiss	
69	Korovo	129	17				
70	Kamênitsa (Kamenitza)	172	135	698		Faulted granite	Refs. 1500, 1501.
71	Velyuva-Banya	111	85				Issues from fault zone.
72	Ludzhene	128-140	90	2,565			Do.
73	Tshepino	119	50				

Thermal springs in Bulgaria—Continued

No. on fig. 34	Name or location	Temperature of water (°F)	Flow (U.S. gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
				South-Central Bulgaria			
74	Krichim	81	210			Faulted schist	
75	Leskovo	104	25				Issues from fault zone.
76	Lilkovo	149	30				
77	Kosovo						
78	Beden	84	5				
79	Shiroka-Lika	124–140	25				
80	Narechen	86	50		HCO_3 (636); SO_4 (770); CO_2 (357).	Crystalline schist	
81	Ilidza	107	40				
82	Breszovo	136	400				
83	Khaskovo	130–137	1,340		HCO_3 (620); Fe_2O_3 (58)	Faulted andesite	
84	Makhalata						
85	Shipkoveni	74	50				Noted resort.
86	Elensko						Pumped. Water for medicinal use.
87	Manoya						Local water supply.
88	Vonestcha	56	60		Small amount of H_2S	Coarse sandstone	
89	Bryeznik	66	2		Much iron	Tuff (tufa?) and limestone	
90	Tutrakantsi		15				
91	Mirovo		8		Saline; H_2S		Salt works nearby.
92	Dolni-Rakovets	72–86	575			Limestone	
93	Kladnichi	81	60			Syenite	
94	Zheleznitsa	72–90	120			Alluvium overlying granite	
95	Chirpan	82	Large				Town water supply.
96	Yambol	76	80	1,700	Ca, Mg, Na, HCO_3		
97	Stefan Karadzhovo		Large		Small amount of H_2S	Marble	Noted resort.

CZECHOSLOVAKIA

The western part of Czechoslovakia consists of the province of Bohemia, which formerly was a part of Austria. This province is chiefly rolling upland drained by the Elbe River and its tributaries. It is nearly enclosed by mountain ranges—the Erzgebirge on its northwestern border, the Riesengebirge and other ranges of the Sudetes (Sudeten) Mountains on the northeast beyond the valley of the Elbe, and the Bohemian-Moravian Mountains on the south and southwest. All these ranges are formed chiefly of marine Paleozoic strata, much folded and faulted, but the central basin is underlain largely by Cretaceous deposits. Moravia, in the central part, also formerly a part of Austria, consists mainly of a plateau area that descends southward from the Sudetes Mountains and is drained chiefly by the Morava, or March, River, which is a tributary of the Danube. The province of Slovakia in the east, which formerly was a part of Hungary, consists largely of hilly lands that extend southward from the Beskid Mountains. The region is drained by several large tributaries of the Danube River.

In the mountains of Czechoslovakia there are numerous mineral springs, but only a few are thermal. The springs on which published data were found are shown on figure 31, and data concerning them are given in the table below.

Thermal springs and wells in Szechoslovakia

[Data chiefly from ref. 1304. Principal chemical constituents are expressed in parts per million]

No. on fig. 31	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Karlsbad (Carlsbad; Karlovo Vary).	42–71.1	25,000+	6,353	Na, HCO_3, SO_4, Cl; much free CO_2.	Ancient granite; Tertiary strata including brown coal.	4 main springs in north-south line 1,325 meters long; also 7 wells. Developed in 13th century. Bathing resort. Refs. 1511, 1514, 1515, 1517, 1521–1525, 1533–1535, 1537–1540, 1542, 1548–1551, 1554, 1556, 1557, 1562, 1564, 1568, 1570, 1572.
2	Teplitz (Toeplitz)-Schonau	49 (max)	30,000	1,058	Na, HCO_3	Porphyry near Cretaceous strata.	Used by the Romans; redeveloped A.D. 762. Bathing resort. Radioactive. Refs. 1509, 1519, 1520, 1526, 1536, 1541, 1544, 1549, 1555, 1558, 1563, 1565–1567, 1569, 1573.
3	Johannisbad	29.6	10,000	354		Schist and dolomite	Used since about A.D. 1000. Resort. Refs. 1304, 1571, 1892.
4	Gross Ullersdorf	25.3–36		3,650	$NaHCO_3$ (1,195); H_2SiO_3 (1,187); gas, 94 percent N_2.	Schist and gneiss	3 springs; hottest has small flow. Developed A.D. 1576. Bathing resort. Ref. 1543.
5	Pistany (Pistyan)				Sulfur		Thermal mud baths. Radioactive. Refs. 1510, 1513, 1515, 1546.

Thermal springs and wells in Czechoslovakia—Continued

No. on fig. 31	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
6	Trencin (Trencsen, Trenčianské, Trentschin)-Teplice.	36–52	90,000	2,450	Gas, 76 percent N_2	Mesozoic strata	Radioactive mud baths. Refs. 1515, 1516, 1545, 1559.
7	Sztubnya (Stubnya-fürdö, Lower Stubnya, Bad Stuben).	40-43.7			SO_4		5 main springs. Bathing resort. According to ref. 1293, includes Rajecz Toplice in Rajecer Mts., temperature 33°C; contains iron and alum.
8	Lucky-les Bains						
9	Szliacs (Sliac)	33			Much free CO_2		Bathing resort. Refs. 1515, 1547.
10	Schemnitz (Selmeczbanya):						
	Skleno (Glashuette)	49				Rhyolite	Bathing resorts, 5 km apart. Water deposits much tufa. Ref. 1531.
	Vichnye (Eisenbach)	38				do	Do.
11	Kiralyl	Warm					Earthy calcic.
12	Banko, 5 km north of Kassa	Warm					Alkaline ferruginous water. Bathing resort.
13	Rank-Herlany (Rank Herlein).	23	Intermittent	4,504	Na_2CO_3, NaCl; much free CO_2		Well 404 meters deep. Used for municipal supply. Refs. 1512, 1552, 1553, 1574.

FRANCE

The Maritime Alps, along the southeast border of France, consist partly of granite and other ancient crystalline rocks but chiefly of intensely folded and faulted marine Paleozoic and Mesozoic strata. Farther north along the border, the Jura Mountains of Paleozoic strata are flanked by extensive areas of Mesozoic rocks. Beyond them the Vosges Mountains are largely of crystalline rocks, their flanks covered by marine Permian through Jurassic strata. The Ardennes Mountains on the northern border are lower and largely of Mesozoic strata. Lower ranges of ancient sedimentary rocks form the mountainous uplands and woodlands of Normandy and Brittany in the northwest. Along the southwest border of France, the Pyrenees Mountains have a core consisting chiefly of Paleozoic rocks that are greatly folded and faulted. More gently dipping Cretaceous and Tertiary strata are on the northern flanks. The Central Mountains, or plateau region of the Auvergne, sometimes called the Central Massif, is largely of ancient crystalline rocks. Extensive areas of these rocks are overlain by lava of Tertiary age. Some craters probably are the result of volcanic activity in Pleistocene time. The northern and western lowlands of the basins of the Seine, Loire, and Gironde Rivers, and also the valley of the Rhone River in the southern part of the country, are underlain by gently dipping Cretaceous and Tertiary formations.

Nearly all the thermal springs and also cold mineral springs in France are grouped in the four principal mountain areas—the Alps, the Vosges, the Pyrenees, and the Central (Auvergne) Mountains. No thermal springs seem to be recorded in either the Jura Mountains or the main part of the Ardennes, although there are some cold springs in these areas. Only one thermal spring of note (Bagneres-de-l'Orne) issues in the mountainous part of Normandy. The similar highland region in Brittany has no recorded thermal springs.

The northeastern part of the island of Corsica consists chiefly of schist, with some marine coastal deposits of Cretaceous to Recent age. No thermal springs have been recorded in this part of the island. The southern and western parts are underlain almost entirely by granitic rocks.

The locations of the springs are shown on figure 32, and information concerning them is presented in the table below.

Thermal springs and wells in France

[Data chiefly from refs. 1685 and 1745. Some geologic data from Internat. Geol. Map of Europe, scale 1:1,500,000. Principal chemical constituents are expressed in parts per million. Chemical classification: A, sodic bicarbonate; B, bicarbonates of earthy bases; C, sodic sulfide; D, sodic sulfide, "degenerees"; E, calcic sulfurous, "accidentelles"; F, sodic sulfate; G, calcic and magnesian sulfate; H, sodic chloride; I, ferruginous of all classes, and bicarbonate sulfate (nearly all cold)]

No. on fig. 32	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Chemical classification of water	Associated rocks	Remarks and additional references
	Ardennes Mountain area							
1	Meurchin	42	1,200			E		2 oil test wells:
		26	500					240 meters deep (1865). Resort.
2	St. Amand:							
	Fontaine Bouillon	25	3,400			G, F	Carboniferous limestone	
	Vielle-Chapelle	25	1,450				do	Known to Romans. Resort.
	2 smaller springs	25	950					

Thermal springs and wells in France—Continued

No. on fig. 32	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Chemical classification of water	Associated rocks	Remarks and additional references
	Normandy							
3	Bagnoles-de-l'Orne:							
	Grand Source	27	4,000			H, F	Faulted Paleozoic sandstone or underlying granite.	Resort. Refs. 1627, 1718, 1722.
	4 other springs	21–41						
	Vosges Mountain area							
4	Bourbonne-les-Bains	42–65	5,000			F	Triassic strata; granite may be present at shallow depth.	3 main springs; several galleries. Resort; military hospital. Refs. 1699, 1727.
5	Fontaines Chaudes	25.4–27.5	Large			F	do	3 main springs. Resort. Ref. 1606.
6	Bains (Bains-les-Bains).	33–50	2,000	Low		F, H	do	3 main springs; 5 smaller springs. Resort. Ref. 1627.
7	La Chaudeau	22–23	2,000			F	do	Several springs. Not developed. Ref. 1606.
8	Plombières	27–70	7,300			F	Granite	About 45 springs. Large resort. Refs. 1576, 1605, 1607, 1608, 1627, 1632, 1638, 1691, 1699.
9	Chaude Fontaine	23.6	Moderate			F	Porphyry; granite	Much gas. Resort.
9A	Niederbronn	18	3,180	5,400	Na, Cl, HCO_3; gas, 94.7 percent N_2, 5.3 percent CO_2.	H	Muschelkalk limestone. (Upper Triassic).	2 wells. Resort. Springs known to Romans. Wells sunk here for brine in A.D. 1565.
9B	Rappoltsweiler (Carolabad).	16.9; 18.2	10,000	2,150	Na, Ca, HCO_3, SO_4; free CO_2.	G, B	do	2 shallow wells. Resort. Developed in early 15th century.
10	Luxeuil	21–52.5	6,300			H, F	Triassic strata	15 springs; several ferruginous. Large resort. Refs. 1691, 1699.
	Central (Auvergne) Mountains							
11	St. Honore-les-Bains	25–31				H, B	Faulted Jurassic strata	5 main springs. Known to Romans. Large resort. Ref. 1600.
12	Bourbon-Lancy	43.5–56.5	4,020			H, B	do	5 main springs. Large resort. Refs. 1592, 1627.
13	Bourbon l'Archambault.	53	3,000			H, A	Jurassic strata overlying Permian strata.	Resort; military sanatorium. Ref. 1639.
14	Néris	50–53	10,100			A, H	Granite; gneiss	6 main springs. Roman ruins. Large resort. Refs. 1589, 1621, 1627, 1640, 1641, 1643, 1699, 1708.
15	Evaux	28.8–56.7	Moderate			F	do	14 main springs. Roman ruins. Large resort. Refs. 1621, 1640, 1641.
16	Jenzat	21	144			A	Granite; gneiss	3 springs.
17	Vichy	22.5–44	4,000			A	Faulted granite and lava	Several springs and wells. Tufa and siliceous sinter deposits. Large resort; military hospital. Refs. 1576, 1593, 1602, 1623, 1625, 1633, 1652, 1681, 1699, 1700, 1725, 1735–1737, 1768.
17	Cusset, Hauterive, and St. Yorre groups.	22–24						Refs. 1581, 1602, 1625.
17	Vaisse (Vesse)	31.4		5,136	Na_4CO_3 (3,490)	A	Granite	Artesian well. Ref. 1602.
18	Sail-les-Bains (Chatteau Morand).	23–34	11,500			A	do	5 main springs. Resort. Refs. 1707, 1710.
19	Chateau-Neuf	20–38.2	11,200			A	do	22 main springs. Resort. Also cold mineral springs. Refs. 1600, 1683, 1701.
20	Rouzat (Beauregard-Vendon).	31	3,000			B	do	Resort. Ref. 1600.
21	Prompsat	22.5	Small			B	Oligocene strata	Water similar to that of Gimeaux.
22	Châtel-Guyon	27–33	9,000			B	Faulted granite	6 main springs. Large resort. Refs. 1581, 1600, 1612, 1645, 1649, 1713.
23	Gimeaux	24–25		3,700	Ca, Na, HCO_3, Cl.	B, H	Basalt	5 main springs. Tufa deposits. Little used.
24	Clermont-Ferrand:							
	St. Ayre spring	24	236			B, I	Contact of Miocene strata and basalt.	15 springs in 3 groups. Much tufa. Resort. Ref. 1600.
	Other springs	22–24						
25	Royat:							
	Eugenie spring	34.2	14,400			A, H	Faulted Oligocene strata, near lava.	4 main springs. Tufa deposits. Large resort. Refs. 1595, 1600, 1672, 1680, 1697, 1702, 1710, 1760.
	3 other springs	20.3–34						
26	La Bourboule:							
	2 wells	19	10,600			A, H	Granite or schist	5 wells 75–137 meters deep; 2 flow, 3 are pumped. Resort. Refs. 1600, 1672, 1710, 1717, 1766, 1799.
	3 wells	53–60						
27	Mont-Dore	35–45	3,500			A	Faulted granite and trachyte.	5 main springs. Large resort. Refs. 1576, 1590, 1600, 1642, 1656, 1669, 1672, 1677, 1688, 1700, 1723, 1799.
28	St. Nectaire	18–46	4,000			A, H	Faulted granite, near basalt.	5 main springs and many small springs. Resort. Refs. 1591, 1595, 1679.
29	St. Maurice	18–32		[1] 7,100	NaCl (2,269); $NaHCO_3$ (2,043); $Ca(HCO_3)_2$ (1,157).	A, B, H	do	3 springs and artesian well.

See footnotes at end of table.

Thermal springs and wells in France—Continued

No. on fig. 32	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Chemical classification of water	Associated rocks	Remarks and additional references
	Central (Auvergne) Mountains—Continued							
30	Martres-deVeyre	15.2–24.8				A, H	Faulted granite, near basalt	5 springs. Ref. 1683.
30A	Martres d'Artieres	31				A, H	Oligocene strata	Oil test well 415 meters deep. Water is radioactive; contains much CO_2. Refs. 1625, 1649, 1673, 1678, 1710.
31	Salt-en-Donzy	Warm				A	Basalt or Cretaceous strata	Not developed.
32	Montrond-geyser	26	2,520	4,824	$NaHCO_3$ (4,577)	A	Cretaceous strata, near basalt.	
33	Chaudes-Aigues	53–81.5	6,300			A	Granite; gneiss	3 main springs; total about 25. Much gas. Resort. Refs. 7, 1587, 1588, 1599, 1600, 1642, 1669, 1733.
34	La Chaldette	31	Small			A	Granite	1 main spring. Resort.
35	Bagnoles-les-Bains	[2] 42	Large		Free H_2S	A	Faulted gneiss	Several springs. Resort. Ref. 1642.
36	St. Laurent	53.5	540			A	Gneiss; schist	Resort.
37	Néyrac (Meyras)	27	4,000			A, I	Gneiss	1 thermal, several cold springs. Resort. Refs. 1703, 1704.
38	Celles-les-Bains	25	1,000	1,887	Na_2CO_3 (531); $CaCO_3$ (905).	A, B	Cretaceous strata, near basalt.	Artesian well. Resort.
39	Lacaune	22–24	4,000			B	Paleozoic strata, near gneiss	Several springs. Resort.
40	Sylvanes	34; 36	450			B, I	Paleozoic or Mesozoic strata	2 main springs. Resort.
41	Avene	27	5,000	Low		B	Paleozoic strata, near basalt	Resort.
41A	Capus	Warm				A	Paleozoic strata	
42	Fonsanges	23.5				E	Oxfordian limestone (Jurassic), faulted against Cretaceous marl.	Resort.
43	Lamalou-les-Bains	23.7–47	Small			A	Paleozoic strata	Several springs in 3 groups and 1 artesian well. Well water, 30°C. Resort. Ref. 1617.
44	Foncaude	25.5	1,296	286	$CaCO_3$ (188)	B	Miocene or Mesozoic strata	Resort.
45	Montpellier-geyser	35		1,646	$Ca(HCO_3)_2$ (618); $CaSO_4$ (377); NaCl (279).	B, G, H	Cretaceous strata	Artesian well 25 meters deep. Ref. 1750.
46	Balaruc-les-Bains	48	3,000			H	Mesozoic near Miocene strata.	Also minor spring. Resort. Refs. 1578, 1586, 1617, 1676.
	Western and Southern Alps							
47	La Caille	[2] 30				E	Miocene or Cretaceous strata	Several springs; H_2S. Resort.
48	Petit-Bornand	20				C	Alluvium	Sulfureted, equivalent to 21.8 ppm Na_2S.
49	St. Gervais	38.5–39.5				H, G	Granite	3 springs. Resort. Refs. 1622, 1629, 1671, 1699, 1751–1753, 1757.
50	Aix-les-Bains:							
	Source Soufre	45	10,300		Free H_2S	D	Faulted Cretaceous limestone.	2 main springs. Large resort. Refs. 1596, 1617, 1618, 1628, 1692, 1699, 1716, 1737, 1754, 1758, 1759, 1781–1789, 1794, 1795.
	Source Alun	47	20,000					
51	Bonneval (Bourg-St. Maurice).	37.5	1,000			H, G	Paleozoic strata	Resort.
	Lavey, at St. Maurice bridge.							Ref. 1658.
51A	La Lechére-les-Bains (Notre Dame de Briançon).	53		High		G, H	Triassic gypsiferous shale	Highly radioactive. Ref. 1709.
52	Saline-Moutiers	34; 34.5	35,000			H	Paleozoic strata	2 springs. Strongly saline. Resort. Refs. 1596, 1627, 1630, 1695.
53	Brides-les-Bains	35	4,000			H, G	do	Resort. Refs. 1630, 1695.
54	L'Echaillon de Veurey	19.1				H, G	Cretaceous or Miocene strata	
55	Valle du Gresivaudan:							
	Combettes a la Terrasse.	19				E, G, H	Faulted Triassic strata	From gallery; resort.
	Spring near Laval	21.7						Not developed.
	Spring near Domene	46	Moderate					Do.
	Allevard spring in Breda Valley.	16.9	1,300					Well 6 meters deep, pumped. Resort. Ref. 1671.
56	L'Echaillon (Savoie)	30	936			H, G	Paleozoic strata	Several springs.
57	Uriage-les-Bains	27	4,200		Free H_2S	H, E	Alluvium	Gallery. Strongly saline. Resort. Refs. 1594, 1620, 1671, 1739–1741.
58	La Garde	Tepid	Moderate	5,258	$MgSO_4$ (2,000); Na_2SO_4 (1,540); NaCl (1,310); free CO_2, H_2S.	H, G	Schist or Paleozoic strata	2 springs.
59	Le Monestier-de-Briançon (Barrançon).	30; 45				G, H	Alluvium	2 springs. Resort.
60	La Motte-les-Bains	56; 61	3,760			H, G	Liassic limestone	2 springs. Large resort. Ref. 1671.
61	St. Bonnet	33	1,000			E	Jurassic strata	
62	Plain-de-Phazy	28–36			Gas, 79.5 percent N_2, 20.5 percent CO_2.	G, H	Triassic strata	Several springs. Resort. Refs. 1598, 1737, 1796.
62A	Réotier	Warm				G, H	do	Ref. 1598.
63	Aspres-les-Veynes	[2] 34		5,980	NaCl (3,270); $CaSO_4$ (2,270).	H, G	do	Several springs.
63A	Serre Ponçan	49	345,600			F, H	Liassic limestone	Gallery at depth of 60 meters. Ref. 1693.
64	La Saulce	16–23	Small	2,516	NaCl (2,135); $CaCO_3$ (237).	H	Alluvium	Several springs.
65	Digne	35–43	2,200			E, H	Upper Triassic strata	Ref. 1631.
66	Berthemont-Roquebilliere (St. Martin Lantosque).	29.5; 30.5	864			C	Cretaceous or Jurassic strata	2 springs having equal flow; baregine deposit. Resort.
67	Gréoux	37	17,000; 300			E, H	Upper Triassic marl	2 springs. Resort. Ref. 1631.
68	Aix	36.5	3,700	Low		B	Oligocene strata	Sextius spring. Resort. Refs. 1624, 1634–1637.

See footnotes at end of table.

Thermal springs and wells in France—Continued

No. on fig. 32	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Chemical classification of water	Associated rocks	Remarks and additional references
				Pyrenees Mountain area				
69	Saubusse	24–38		Low		H, G	Oligocene or Miocene strata	Several springs. Resort.
69A	Fosse de Capbreton	29				H, G	do	Refs. 1647, 1648.
70	Tercis	37.5	980			H, G	do	Resort. Ref. 1778.
71	Dax:							
	Fontaine Chaude	61	15,000			H, G	Faulted Triassic marl	Resort. Refs. 1576, 1627, 1644, 1647, 1651, 1738, 1778, 1790, 1801.
	Bastion spring	59	5,000					
	Smaller springs	38–54.3	1,000					
72	Prechacq des Landes	52–63	20,000			H, G	do	Resort. Refs. 1647, 1778, 1801.
72A	Garmarde	Warm		613	SO_4, Cl	H, E	Triassic strata	Ref. 1801.
73	Pouillon	20	Large	1,951	NaCl (1,359); $CaSO_4$ (492).	H, G	Triassic marl	Ocher deposit.
74	Eugenie-les-Bains	20	800			E	Micoene strata	Also wells, 16°–19.5°C. Resort. Ref. 1778.
75	Barbotan	31.2–38.7	2,500			E	do	5 main springs; also ferruginous spring 21° C. Resort. Refs. 1647, 1684, 1801.
76	Castera-Verduzan	23.5; 23	1,339; 1,037			E, I	Tertiary strata	2 springs. Resort. Refs. 1684, 1801.
77	Lavardens	19		467	$CaCO_3$ (190); SO (138).	B, G	do	
78	Cambo-les-Bains	21.8	432		SO_4, free H_2S	G, D	Cretaceous strata	Resort. Refs. 1657, 1760, 1778.
79	Ogeu	22				G, B	do	Resort. Ref. 1760.
80	Eaux Chaudes	24.2–36.2	1,492			C	Triassic-Cretaceous fault contact.	6 springs. Resort. Refs. 1604, 1699, 1804.
81	Eaux Bonnes	22–32.7	700			C, H	Triassic strata	8 springs. Resort. Used for table water. Ref. 1699.
82	Cauterets	30–56	13,000			C	Alluvium over granite and schist.	22 springs, for 3 km along valley. Large resort. Refs. 1675, 1699, 1724, 1726, 1770, 1798.
83	Labeourat	22				C	Schist	2 springs, 3 km apart; much CO_2; reported arsenic. Resort.
84	Barèges	24–45			Na_2S(40)	C	Paleozoic strata	12 springs; baregine deposited. Resort; military hospital. Refs. 1620, 1631, 1667, 1674, 1699, 1724, 1726, 1737, 1743, 1744, 1776, 1777.
85	St. Sauveur	34.3; 22	1,450; 180			C	do	2 springs. Resort. Refs. 1620, 1699, 1714, 1724, 1726.
86	Barzun	29			Gas, chiefly N_2	C	do	Resort. Ref. 1620.
86A	Bagnères de Labassère	Warm			Na_2S(50)	H, C	do	Refs. 1663, 1674.
87	Bagnères-de-Bigorre	18.7–51.2	33,700			G	Faulted Triassic strata	16 main springs; also galleries; more than 50 outlets. Large resort. Refs. 1610, 1617, 1627, 1699, 1778.
88	Capvern	24	17,400			G	do	Resort. Refs. 1734 1778.
	Bouride, 3 km from Capvern.	21.8	8,000	1,968	Ca, SO_4			Former resort. Ref. 1734.
89	Tramezaigues	28				C	Cambrian strata	1 spring. Resort.
90	Bagnères-de-Luchon	35–64.5	[3] 3,720		Na_2, S(54)	C	Granite; schist	19 springs; baregine deposited. Refs. 1576, 1609, 1611, 1619, 1662–1665, 1674, 1699, 1710–1712, 1715, 1763, 1765.
91	Ferrere	21				A, G, H	Mesozoic strata	Resort.
92	Barbazan	[2] 19.6				G	do	3 springs. Resort.
93	Labarthe-Riviere	21	300			G	do	Resort.
94	Encausse	19.5				G, H	do	2 springs. Resort.
95	Audinac (St. Girons-les-eaux):							
	Main spring	21.5	2,000			G	do	3 springs. Water is radioactive. Resort. Ref. 1748.
	2 other springs	16; 20						
96	Aulus	14.5–20	Small			G	Paleozoic strata	5 main springs. Resort.
97	Ussat	38	8,200			G	do	1 spring; also pumped wells. Large resort.
98	Foncirgue	20	Small			B	Cretaceous limestone	Resort.
99	Ax-les-Thermes	25.7–77.6	13,300			C	Paleozoic schist	About 55 springs in 3 groups. Silica unusually high. Large resort. Refs. 1603, 1627, 1646, 1797, 1802.
100	Merens	36–45				C	Faulted schist	3 springs.
101	Campagne:							
	Main spring	26	3,000			H, G	Cretaceous marl	3 springs. Water bottled for table use. Resort.
	2 other springs	20.4; 22						
102	Rennes-les-Bains	36.6–46	16,500			H, G	do	3 main springs; also well 14 meters deep, 39°C.
103	Alet:							
	Source Rocher	29	6,000			B	Senonian sandstone (Upper Cretaceous).	Resort. Ref. 1673.
	Source Buvette	32	2,000					
104	Lesquerde	25				G	Cretaceous strata near granite.	1 spring. Resort.
105	Usson	19.8–26.5				C	In or near granite	3 main springs. Resort. Ref. 1742.
106	Carcanieres	35.3–59				C	do	About 12 springs. Resort.
107	Escouloubre	21.2–49				C	do	5 main springs. Resort.
108	Molitg:							
	Main spring	37.5	1,150			C	do	Resort. Ref. 1580.
	4 other springs	33–36						
109	Nossa	20; 22.4				C	do	2 springs. Resort.
110	Le Vernet	34.8–66				C	do	11 springs. Resort. Refs. 1580, 1710.
111	Canaveilles	36.8–60				C	do	Several springs; sulfureted, equivalent to 5.2 ppm Na_2S. Resort. Ref.
112	Les Graus-d'Olette (Thuès).	27–79.4	22,000			C	do	About 42 springs in 3 groups; baregine deposited. Resort. Refs. 20, 1287, 1580?, 1710, 1755, 1802.

See footnotes at end of table.

Thermal springs and wells in France—Continued

No. on fig. 32	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Chemical classification of water	Associated rocks	Remarks and additional references
	Pyrenees Mountain area—Continued							
113	St. Thomas	48-60	Large			C	do	3 springs; sulfureted, equivalent to 27.5 ppm Na_2S.
114	Les Escaldas	18.3-42.3	11,600			C	do	5 springs. Resort. Refs. 1580, 1710.
	Dorres, 1 km from Les Escaldas.	40.4						Not developed. Ref. 1580.
115	La Preste	44				C	Granulite	2 springs. Resort. Ref. 1580.
116	Amélie-les-Bains	40-63.5	12,000			C	do	9 springs. Resort; military hospital.
117	Sorede (Font Agre)	20.9		967	$CaCO_3$ (607); much CO_2.	B	Schist near basalt	Ferruginous.
118	Las Caldas (in Andorra).	Warm				C	Silurian strata near granite.	
	Corsica							
119	St. Antoine de Guagno.	37; 51	93; 864			C	Granite, probably along fault.	2 springs; H_2S. Resort; military hospital.
120	Guitera	37	864			C	Granite and porphyry	Resort.
121	Caldaniccia	38.7	200			C	Granite	Resort.
122	Pietrapola	35-58	3,000			C	Granite and sandstone	8 springs. Resort. Ref. 1774.
123	Urbalacone (Bains de Taccana, Zigliara?).	32				C	do	Resort.
124	Caldane de Baracci (Olmeto).	32				E	Granite	Sulfuration from peat deposit. Baths.

[1] Main spring. [2] Maximum. [3] 12 springs.

GERMANY AND POLAND

Germany formerly included Silesia as one of its eastern provinces. The area became a part of Poland after World War II; but as it contains the only recorded thermal springs within the boundaries of Poland as of 1958, and the literature concerning them is in publications on Germany, the two countries are considered together.

The most mountainous parts of Germany are along its south and southeast borders, where the ranges are of ancient gneiss and schist, and of granite and other cystalline rocks. These rocks are present also in the Black Forest region in southwestern Germany. They probably are of Archean age. Northward from these areas Paleozoic sedimentary rocks form the hilly and mountainous areas. They are considerably folded in belts that extend from east-northeast to west-southwest. Along the north border of the folded area is the Rhur coal basin of Carboniferous strata, and the similar basin of the Saar coal fields farther south.

In the south and west, between the valley of the Rhine River and the mountains southeast of it, a great area that is underlain by Triassic sandstone and shale extends from approximately Stuttgart northward to some distance south of Bremen. In most places the rock strata are nearly horizontal, but they are faulted in many districts, especially along the east and west borders of the area. Along its southern and eastern parts the Triassic area is bordered by a wide belt of Jurassic rocks, which are present also along the north border of the Triassic area.

In the upper basin of the Ems River in the west and of the Elbe River in the northeast, large areas are covered by Cretaceous deposits that directly overlie Paleozoic strata. The great plains region of north and northeast Germany is underlain chiefly by marine Tertiary beds, which are largely covered by Quaternary deposits that are in part of glacial material. Much of the plain of the Danube River in the extreme southeast, and also the valley of the Rhine from Basel in Switzerland to Mainz, are covered by Tertiary and Quaternary deposits. Considerable areas of Tertiary volcanic rocks, including craters that are possibly of Quaternary age, cover small areas between Mainz and Cologne.

Most of the thermal springs in Germany are in its southwestern part. Many are in areas of Paleozoic and Mesozoic sedimentary rocks, and some are in areas of Tertiary volcanic rocks. Some deep wells, sunk originally to obtain brine for salt production, have also been developed as thermal bathing resorts.

Western Poland includes mountainous areas of ancient crystalline rocks that are considerably folded and faulted. Within this area are four developed groups of thermal springs.

The locations of the theimal springs and wells in Germany and western Poland are shown on figure 35, and the available information on them is summarized in the two tables below.

735-914 O—65——9

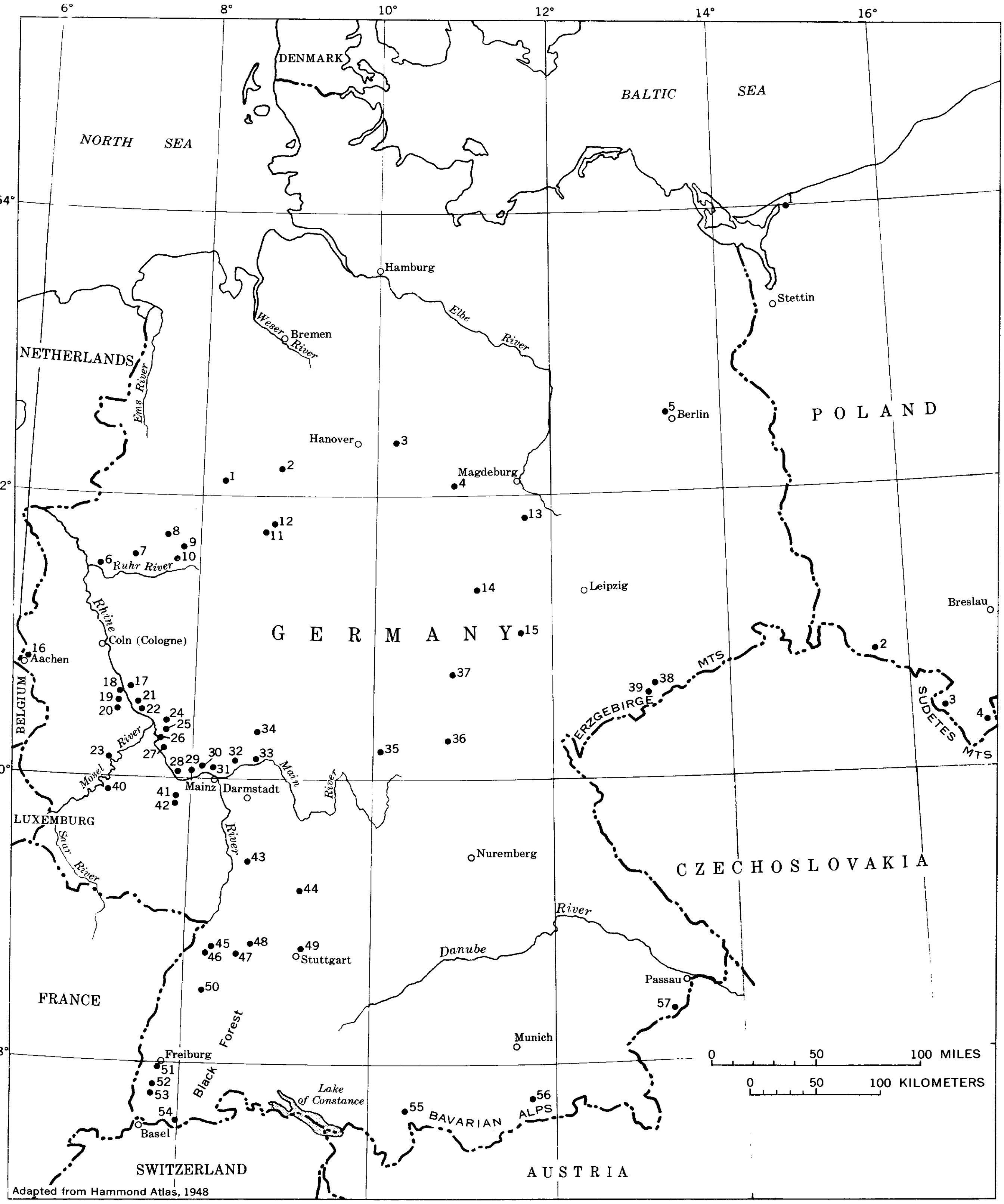

FIGURE 35.—Germany and western Poland showing location of thermal springs and thermal wells. Germany chiefly from ref. 1914.

Thermal springs and wells in Germany

[Data chiefly from refs. 1914, 1922. Some geologic data from International Geologic Map of Europe, scale 1:1,500,000. Chemical classification: A, simple thermal; B, alkaline; C, saline; D, bitter; E, iron; F, sulfur]

No. on fig. 35	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Chemical classification of water	Associated rocks	Remarks and additional references
1	Rothenfelde	18	1,200	61,250	NaCl; free CO_2	C	Turonian limestone (Upper Cretaceous).	2 springs. Baths.
2	Oeynhausen: 5 wells	24.2–33.4	21,500 (largest)	44,850 (hottest)	NaCl; free CO_2	C	Muschelkalk formation (Upper Triassic).	620–707 meters deep. Salt production. Baths. Refs. 1822, 1876–1878, 1887, 1956, 1961.
	2 wells	30					Keuper formation (Lower Triassic).	Pumped. Refs. 1822, 1876–1878, 1887, 1956, 1961.
3	Olheim	18.4		89,670	NaCl; free CO_2	C	do	Oil test well; pumped. Baths.
4	Schoeningen	18.8		265,400	Gas, 98 percent N_2	C	do	Well of salt works. Pumped. Resort.
5	Hermsdorf	20		39,250	Na, Cl	C	Middle Liassic limestone	Well 320 meters deep; pumped.
6	Alstaden (at coal mine).	25.5 (max)	16,000	1,712	Na, Cl	C	Carboniferous sandstone	Several wells 289–330 meters deep at coal mine; pumped. Baths.
7	Eickel-Wanne	35		110,700	Na, Cl; free CO_2	C	do	Issues from fault at depth of 600 meters in Pluto mine. Baths.
8	Werne	28.7	26,000		Na, Ca, Cl; free CO_2	C	Triassic chalk	Well 550 meters deep. Resort.
9	Bad Hamm	33	1,300	82,600	Na, Cl; free CO_2	C	do	Well 650 meters deep; original flow 7,500 hectoliters per day.
10	Königsborn-Unna					C	do	Several brine wells and springs. Water for baths piped 27 km from Bad Hamm. 2 hospitals.
11	Inselbad	18.1	2,592; 270	1,614	Na, Cl, HCO_3; free CO_2.	C	do	2 shallow wells. Baths; sanatorium.
12	Lippspringe	20.8	259	2,624	SO_4 (1,048 ppm); Ca; gas, 86.9 percent N_2, 13.1 percent CO_2.	D	do	Baths. Ref. 1838.
13	Bernburg	26		268,000	Na, Cl	C	Zechstein formation (Upper Permian).	Well of salt works. Baths.
14	Frankenhausen: Spring	20		7,172	Na, Cl, SO_4; free CO_2	C	do	Baths.
	Well (or spring?)	20		265,000	Na, Cl	C	do	
15	Sulza	20–25	2,500	50,750	Na, Cl; free CO_2	C	Muschelkalk (Upper Triassic), Bunter (Lower Triassic), Zechstein (Upper Permian) formations.	7 brine wells, 250–890 meters deep. Analysis is for well having temperature of 21° C. Salt production since early 10th century. Baths.
16	Aachen (Aix-la-Chapelle)-burscheid.	32.8–73.2	39,000	4,740 (hottest)	Na, Cl, HCO_3; free H_2S.	F	Upper Devonian limestone	33 springs; many wells, 1,570–2,200 meters deep. Large baths. Refs. 1809–1811, 1815, 1817, 1837, 1882, 1935, 1936, 1945, 1960, 1964, 1978, 1984, 1985, 2008, 2013.
17	Honnef am Rhein	18	9,600	8,020	Na, Cl, HCO_3; free CO_2.	B	Lower Devonian slate	Well 250 meters deep. Baths.
18	Bodendorf	32	40	1,530	Na, HCO_3	A	Lower Devonian quartzite	Well 65 meters deep.
19	Apollinaris-brunnen	22		4,000	Na, HCO_3; free CO_2	B	Graywacke	2 wells 15 meters deep; pumped Ref. 1824.
20	Neuenahr: Grosser Sprudel (90 meters deep).	40	7,200	2,093–2,342	Na, HCO_3; free CO_2	B	Graywacke and quartz	5 wells 90–377 meters deep. Refs. 1824, 1965, 1966.
	4 other wells	29–36	10,000					
21	Hoenningen am Rhein.	22.5; 32	7,200	6,413	Na, HCO_3; free CO_2	B	Graywacke	2 wells 50 and 150 meters deep; 38° C at bottom. Baths.
22	Arienheller Sprudel	22.4	8,640	4,900	Na, HCO_3; free CO_2	B	Lower Devonian slate	Well 390 meters deep. Baths.
23	Bertrich	32; 32.9	4,460	2,394	Na, HCO_3, SO_4; gas, 92.2 percent N_2, 7.8 percent CO_2.	B	Lower Devonian quartzite, slate.	2 springs. Known to Romans. Baths.
24	Ems	29.9–50	864	3,742–3,895	Na, Cl, HCO_3	B	do	9 springs. Iron spring: 21.3° C; total dissolved solids 564 ppm. Several large wells, large flow. Water used for drinking and baths. Refs. 1827, 1850, 1851, 1854–1857, 1859, 1860, 1864, 1865, 1879, 1884, 1913, 1924, 1952, 1996, 2001, 2003.
25	Oberlahnstein am Rhein.	24.8	4,320	4,865	Na, HCO_3, Cl; free CO_2.	B	Graywacke and slate	Well 200 meters deep. Water used for drinking.
26	Rhens am Rhein	22.1; 23.2	1,200; 2,705	4,053	Na, HCO_3, Cl, SO_4; free CO_2.	B	Lower Devonian quartzite, slate.	2 wells 375 and 337 meters deep. Water used for drinking.
27	Salzig	18–31	350	7,546	Na, HCO_3, Cl, SO_4; free CO_2.	B	do	Springs; also well 263 meters deep. Water temperature at bottom of well, 31°C.
28	Assmannshausen am Rhein.	31.1 (max)		11,265	Na, Cl, HCO_3; free CO_2.	C	do	5 springs or wells. Baths developed in Middle Ages. Refs. 1861, 1868.
29	Kiedrich	24.3	1,500–1,700	8,900	Na, Cl, much Li; gas, 86.7 percent N_2, 13.3 percent CO_2.	C	Gneiss	Well 184 meters deep.
30	Schlangenbad: Schachtquelle	31	806	378–422	Na, Cl; gas, 77.4 percent CO_2, 22.6 percent N_2.	A	Lower Devonian quartzite	Refs. 1863, 1866, 1892, 1942.
	Romerquelle	30.5	417					
	7 other springs	17–30						

Thermal springs and wells in Germany—Continued

No. on fig. 35	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Chemical classification of water	Associated rocks	Remarks and additional references
31	Wiesbaden:							
	Kochbrunnen	65.7	5,472	8,567 (hottest)	Na, Cl; gas, 79.8-83.2 percent N_2, 20.2-16.8 percent CO_2.	C	Jurassic limestone and Triassic slate.	27 springs and wells. Used by Romans. Large bathing establishments. Refs. 1827, 1831, 1848, 1849, 1851, 1852, 1858, 1867, 1869, 1871–1875, 1883, 1893–1905, 1907–1912, 1915–1919, 1931, 1942, 1943, 1946, 1948, 1959, 1973–1975, 1979, 1982, 1983, 2000, 2005.
	Alderquelle	64.4	2,124					
	Schutzenquelle	49.2	2,304					
	Other springs	40–49						
32	Soden am Taunus:							
	Main well	32	2,809	17,800	Na, Cl; gas, 97.8 percent CO_2, 2.1 percent N_2.	C	Triassic slate	Numerous springs. 5 wells, maximum depth 230 meters. Baths developed in 16th century. Refs. 1820, 1891, 1900, 1909, 1910, 1920, 1943, 1944, 1958, 1981, 1986, 1997, 1998.
	4 other wells	20–30						
33	Offenbach am Main	19.2	1,440	4,543	Na, HCO_3, Cl; free CO_2.	B	Lower Permian sandstone	Well 275 meters deep.
34	Nauheim:							
	3 springs	17.2–20.1	2,000	1,307–18,000	Na, Cl	C	Tertiary strata	Baths. Refs. 1816, 1826, 1832, 1835, 1890, 1900, 1910, 1921, 1923, 1943, 1949–1951, 987–1991, 2006, 2007, 2011.
	3 wells	30–34.4	24,000	25,000–33,600	Na, Cl	C	Devonian quartzite	
35	Kissingen:							
	Well 96 meters deep.	18.1	15,000 (max)	14,976	Na, Cl, HCO_3, SO_4	C	Bunter sandstone (Lower Triassic).	Refs. 1830, 1840, 1843, 1889, 1927, 1994.
	Well 584 meters deep.	19.2	15,000	13,789	Na, Cl, HCO_3, SO_4	C	Zechstein formation (Upper Permian).	
36	Bad Kolberg	22–36		17,000–50,000	Na, Cl, SO_4	C	Bunter sandstone (Lower Triassic).	Wells 354–780 meter deep. Ref. 1839.
37	Plaue	19; 22	430	3,287–5,539	Na, Cl, SO_4	C	do	2 wells. Sanatorium.
38	Warmbad bei Wolkenstein.	25.7–31.2	2,160	Low	Na, Cl, HCO_3	A	Quartzite and gneiss	12 main springs. Developed for bathing in 14th century. Ref. 1992.
39	Wiesenbad	20.2	3,240	522	Na, HCO_3	A	do	Well 14 meters deep. Used since early 16th century. Ref. 1992.
40	Wildstein and Wildbad-Trarbach.	35–36.2	12,000	364	Na, HCO_3; free CO_2	A	Quartz veins in slate	2 springs from gallery. Also piped 3 km to Wildbad-Trarbach. Ref 1823.
41	Kreuznach	17–22.8		11,900	Na, Cl	C	Quartz porphyry	5 wells 200–300 meters deep; pumped for salt production. Large bathing establishments. Refs. 1847, 1880, 1900, 1934, 1939, 1943, 1976, 1977.
42	Munster am Stein:							
	Hauptbrunnen	30.6	180	7,224	Na, Cl; gas, 79.1 percent N_2 and CH_4, 20.9 percent CO_2.	C	do	Wells 28–66 meters deep. Salt production since early 15th century. Refs. 1847, 1976, 1977.
	Brunnen No. 2	31.2	880					
	4 other wells							
43	Heidelberg	Warm				C	Muschelkalk formation (Upper Triassic).	Several wells about 1,000 meters deep. Refs. 1805, 1880.
44	Jagstfeld	20		264,000	Na, Cl	C	do	Well 155 meters deep.
45	Rothenfels	19.3	29	5,079	Na, Cl; free CO_2	C	Red sandstone, in coal formation.	Well 95 meters deep.
46	Baden-Baden	44.4–68.6	8,000	2,852	Na, Cl; free CO_2	C	Slate, near gneiss	11 wells. Analysis is for well having temperature of 62.8° C. Refs. 1808, 1901, 1980, 1995, 2002.
47	Wildbad	34.5–39.5	10,000	706–732	Na, Cl, HCO_3; free CO_2.	A	Triassic beds over granite and gneiss.	36 springs; wells 5–56 meters deep. Refs. 1833, 1892, 1943, 1995, 2009.
48	Liebenzell	23.6–26.7	140	1,257	Na, Cl, HCO_3	C	do	3 springs; 3 wells 50–60 meters deep. Ref. 1845.
49	Berg:							
	Spring	20.1	21,160	5,477		C	Muschelkalk formation (Upper Triassic).	Spring on island in Neckar River. Well 30 meters deep. Resort. Ref. 1834.
	Well	20.5	24,000					
	Cannstatt	18.4–21.2	Large	3,663–6,556			do	7 main wells, 70 meters deep. 4 springs developed by Romans. Refs. 1834, 1844, 1947.
50	Sulzbach	20; 21	360	2,060	Na, HCO_3, SO_4; free CO_2.	B	Granite and porphyry	2 springs.
51	Bad Krozingen	Warm				B	Gneiss	Refs. 1805, 1836.
52	Sulzburg	18.5	144		Na, SO_4, HCO_3	D	do	Several wells.
53	Badenweiler	26.4	16,000	379	Na, Ca, HCO_3, SO_4; gas, 93.8 percent N_2, 6.2 percent O_2.	A	Muschelkalk formation (Upper Triassic).	From gallery. Known to Romans. Resort.
54	Saeckingen	29.6	605	3,294	Na, Cl	C	Triassic or Jurassic strata, near granite.	Several minor springs from depth 6 meters. Ref. 1828.
55	Romerbad Kunzing (Bad Salzbrunn).	19		1,310		C	Oligocene strata	Iodide, 0.51 ppm. Ref. 1805.
56	Bad Weissee	17.1; 21		13,490	Na, Cl, HCO_3	C	Triassic or Jurassic strata	2 springs. Iodide 35 ppm. Hydrocarbon gas. Refs. 1805, 1870, 2008.
57	Fussing	52	22,600	1,271	Na, Cl, HCO_3	C	Massenkalk formation (Jurassic).	Oil test well: water at 916 meters; crystalline rock at 1,142 meters. Refs. 1805, 1963.

Thermal springs in Poland

[Data chiefly from ref. 1914]

No. on fig. 35	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Cammin (Kammin)	18.1	6,264	32,000	Na, Cl	Middle Liassic sandstone	Flowing well 325 meters deep. Salt production. Baths.
2	Warmbrunn	24.5–43.1	7,200	621–735	Na, HCO_3, SO_4; gas, 65.2 percent N_2; 32.9 percent CO_2; and 1.9 percent O_2.	Granite	6 wells; maximum depth, 167 meters. Developed in 12th century. Baths. Ref. 1892.
3	Reinerz	18.4 (max)	5,000	2,881	Ca, Na, HCO_3; free CO_2	Schist and gneiss	Several springs. Water contains 11.5 ppm Fe. Baths. Refs. 1543, 1885, 1892, 1934, 1937, 1957, 2014.
4	Bad Landeck	19.5–29.6	8,000	183–223	Na, HCO_3, SO_4, SiO_2; gas, about equal parts CO_2 and N_2.	Gneiss. Gypsum-bearing strata nearby.	5 springs. Developed in 16th century. Baths. Ref. 1543.

GREECE AND ALBANIA

The mainland of Greece, which forms the southern part of the Balkan Peninsula, has many mountain chains that are dominated by the great chain of the Pindus Mountains. The irregular coastline is characterized by many bays and inlets. A few small valleys lie between the mountain ranges and a few plains extend along the lower courses of the main streams, most of which are small and flow rapidly. Several large streams in areas of limestone disappear underground for considerable distances.

In the eastern part of the country the general strike of rock strata is east-west; in the western part the strike is north-northwest to south-southeast. There is considerable folding in rocks of Carboniferous through Eocene ages. In the Pindus range and in the Peloponnesus region in the south, Triassic limestone has been thrust over Cretaceous and Eocene strata, which are much folded. Neogene deposits along the coast and in some valleys are not extensively folded, but they have been greatly uplifted by faulting. In some places along the coast the land has risen perceptibly in historic times. Earthquakes are of common occurrence along several fault zones.

Most of Crete is occupied by four main groups of mountains. In its western part are metamorphic and basic igneous rocks, overlain in some places by ancient sedimentary rocks and in other places by rocks of Triassic and Jurassic ages, including much dolomite and gypsum. Lower to Upper Cretaceous limestone and schist underlie extensive areas in other parts of the island. In the mountain ranges all these older rocks are considerably folded, uplifted, and, in places, thrust faulted. Miocene and later deposits in the coastal lowlands are comparatively undisturbed. No volcanic rocks seem to be reported in Crete and the nearby small islands.

The mountains of northwestern Greece extend into southern Albania to the basin of the Simen River, which flows west to the Adriatic Sea. Northern Albania includes a southeastern prolongation of the Alpine mountain system. These mountains form part of the watershed between the Adriatic and Aegean Seas. The valleys of the larger streams are underlain by Quaternary and alluvial deposits. The bordering hills, chiefly in the southwest, are of marine Miocene strata. By far the greater part of the plateau and mountain areas are of Cretaceous strata, largely of limestone.

Many thermal springs in the mainland of Greece are closely related to volcanism or to faults. In some of the volcanic islands thermal springs issue close to the shore, and are sulfureted and generally saline from the infiltration of sea water. No good description of mineral and thermal springs in Albania seems to be available. Official topographic maps of the country indicate about 20 principal springs, 3 of which are thermal.

The locations of the thermal springs in Greece and Albania are shown on figure 36; data on the springs are presented in the two tables below.

Thermal springs in Greece

[Data chiefly from refs. 2024, 2033, 2040. Principal chemical constituents are expressed in parts per million]

No. on fig. 36	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Cavassila	30				Upper Cretaceous strata	Sulfurous.
2	Vromoneri	28			Na, Cl; free CO_2	do.	
3	Lotrochorion (Vodena)	20.5		997	$Ca(HCO_3)_2$ (359); $Mg(HCO_3)_2$ (218); NaCl (308).	Probably Triassic strata	
4	Pozar	41.5				do.	
5	Giannes Metallikon (Kokotsh).	17.5		2,205	$Ca(HCO_3)_2$ (1,407); $Mg(HCO_3)_2$ (557); Na_2SO_4 (98).	Quaternary deposits overlying gneiss.	
6	Singeli	[1] 40				do.	
7	Sidiro Kastro	45			Na, HCO_3; free CO_2	do.	
8	Nigrita (Litza)	51–55.8		[2] 3,597	$Ca(HCO_3)_2$ (515); $Mg(HCO_3)_2$ (746); $NaHCO_3$ (1,688).	Gneiss	
9	Langaza, 18 km from Salonika.	37–39.4	840	785	Ca)$HCO_3)_2$ (248); Na_2SO_4 (255).	Lake sediments overlying faulted crystalline schist.	3 springs. Bathing resort. Ref. 2035.
10	Nea Apollonia (Egri Bouzak).	48.5–49.8		[3] 1,147	$Ca(HOC_3)_2$ (87); $NaHCO_3$ (409); Na_2SO_4 (482).	Crystalline schist	
11	Hagia Paraskevi	25–35		[4] 7,973	$Ca(HCO_3)_2$ (2,143); $Mg(HCO_3)_2$ (937); NaCl (4,359).	Miocene strata overlying crystalline schist.	
12	Souroti	19.6		2,384	$Ca(HCO_3)_2$ (1,047); $Mg(HCO_3)_2$ (618); NaCl (337).	do.	
13	Elefterai	41.5–43		[4] 2,804	$Ca(HCO_3)_2$ (1,031); Na_2SO_4 (118); NaCl (1,030).	Gneiss	3 springs.
14	On north shore of Thasos Island.	25				Crystalline schist.	
15	Thermae Psarotherma, Samothrace Island.	45–59.4		[2] 20,753	$CaCl_2$ (1,576); NaCl (9,361); KCl (1,048).	Volcanic rock	Several springs. Baths. Analysis is for spring having temperature of 59°C.
16	Traianopolis (Pherrai)	48.5–50.6		[2] 8,380	$CaSO_4$ (656); $CaCl_2$ (1,006); NaCl (5,883); free CO_2.	Probably marine Tertiary strata.	
17	Chanopolo (Kounouple; Arta).	16.4		2,718	Mg $(HCO_3)_2$ (207); $CaSO_4$ (1,270 (1,270); NaCl (1,129).	Eocene strata	Ref. 2020.
18	Bani	25–32				Quaternary deposits overlying Eocene strata.	Sulfurous.
19	Choteni	[1] 23				Eocene or Upper Cretaceous strata.	Do.
20	Kremasta Vatto	28				do.	Do.
21	Privintzi	[1] 23				do.	Do.
22	Kremasta Chonis	[1] 35				do.	Do.
23	Loutra Stachtis (Stranoma)	15.7		406	$Ca(HCO_3)_2$ (357); free CO_2	Probably Upper Cretaceous strata.	Refs. 2022, 2030.
24	Psani (Naupacte)	21.4		924	$Ca(HCO_3)_2$ (92); $NaHCO_3$ (574); NaCl (169); free CO_2.	do.	Ref. 2020.
25	Smokovo Solanoa	29.3–40.2	370	311	$NaHCO_3$ (101); H_2SiO_3 (83)	Eocene flysch	5 main springs. Bathing resort. Analysis is for spring of largest flow, temperature 39.6°C. Ref. 2037.
26	Platystomo	25.5–33.6		[2] 409	Na_2CO_3 (41); NaCl (415); H_2SiO_3 (61).	do.	No free gas. Ref. 2020.
27	Hypate	33.5		7,703	$Ca(HCO_3)_2$ (1,117); $Mg(HCO_3)_2$ (1,300); $CaCl_2$ (1,347); NaCl (3,704); free CO_2.	do.	Refs. 2015, 2039.
28	Thermopylae	28–41			Free H_2S	Quaternary deposits	Water is sulfurous and deposits white salts. Ref. 2015.
29	Mylas Koniavita (Kamena Vourla).	20–34	100	10,078	$Mg(HCO_3)_2$ (654); $CaCl_2$ (1,253); NaCl (7,129); free CO_2.	do.	2 main and several minor springs. Analysis is for spring flowing 77 liters per minute, temperature 32.7°C. Refs. 2035, 2039.
30	Gialtra, Euboea Island, 80 m from sea.	44	Strong	39,149		Upper Cretaceous strata	Water is saline. Ref. 2019.
31	Aedipsos	34.5–78.2		[2] 32,937	Free CO_2	Lower Cretaceous strata	6 groups: 4 main springs. Water is strongly saline. Refs. 2017–2019.
32	Kournou, Lemnos Island	35			Na, HCO_3; free H_2S	Tertiary lava	
33	Gavatha (Telonia)	25			Mg, Na, So_4, Cl	Probably Tertiary strata	Ref. 2038.
34	Efthalou, near Molyvo village.	46.5	83	5,810	$CaSO_4$ (629); $CaCl_2$ (564); NaCl (4,082).	Tuffaceous andesite	Refs. 2038, 2039.
35	Thermi	46.9	246	35,479	$CaCl_2$ (4,698); NaCl (26,187)	Probably Tertiary lava	Iron oxide deposited. Bathing resort since ancient times. Ref. 2038.
36	Jera (Golfed Iera), near seashore.	39.8	[5] 200–600	1,685	Mg $(HCO_3)_2$ (283); $CaCl_2$ (186); NaCl (973).	do.	Bathing resort. Ref. 2038.
37	Kourdji, at Metelin village	34.8–38.5	110	1,762	NaCl (889); Ca; Mg; HCO_3	do.	5 springs. Bathing resort since ancient times. Ref. 2038.
38	Hagia Melani	21			Ca, Na, SO_4, Cl	do.	Ref. 2038.
39	Lisborion (Lisvoriou; St. Joannis).	69			Na, Cl; free CO_2	do.	Do.
40	Polychnitos	65.5–87.6	1,000	11,179	$CaCl_2$ (1,475); NaCl (8,496)	do.	5 springs. Baths. Ref. 2038.
41	Panaghia Krypti	44				do.	Ref. 2038.

See footnotes at end of table.

Thermal springs in Greece—Continued

No. on fig. 36	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
42	Keramou	67			Na, HCO_3; free H_2S	Probably Tertiary strata	
43	Iolissos	67			Na, HCO_3; free H_2S	do	Water contains considerable iron. Ref. 2035.
44	Langada	28–30				do	
45	Hagia Hellenis	[1] 38			Na, HCO_3; free CO_2	do	
46	Conopeli (Orta?)	28			Free H_2S	Quaternary deposits overlying Pliocene strata.	
47	Killinis	21–25			Free H_2S	do	3 main springs.
48	Phrasinias	21			Free H_2S	do	
49	Pournari	20			Na, HCO_3	do	
50	Kaiapha	27.4–35.6	[3] 22,600 [6] 4,700	5,492–16,523	Na, Cl; free H_2S	Fault contact between Upper Cretaceous strata and Eocene limestone.	Bathing resort. Refs. 2020, 2034.
51	Vromeneri	[1] 25				Pliocene strata	
52	Loutraki	19.5–31.5			Na, HCO_3, Cl	Upper Cretaceous strata	3 main springs, temperature, 29°–31°C; several minor springs. Ref. 2022.
53	Sousaki, near Corinth	Hot			CO_2, SO_2, H_2S	Tertiary marl near intrusive gabbro.	Solfataras, at north end of Aegean volcanoes. Ref. 2043.
54	Epidaurus, near temple of Aesculapius.	Warm				Upper Cretaceous strata	At ruins of ancient baths. Ref. 2015.
55	Therma, Aegina (Egine) Island.	25.5		12,824	$MgSO_4$ (1,161); $CaCl_2$ (1,051); NaCl (9,424); free CO_2.	Probably trachyte	
56	Kato Moska	[1] 20			Na, HCO_3; free CO_2	Trachyte	
57	Methana	28.5–41.2	20,000	14,186	$Mg(HCO_3)_2$ (1,812); $CaCl_2$ (1,188); NaCl (9,356); much free H_2S.	Upper Cretaceous strata near dacite.	Several springs. Analysis is for spring having temperature 31° C. Bathing resort since ancient times. Refs. 2020, 2033, 2043.
58	Glyphad (Voliagmeni)	[1] 20			Na, Cl; free H_2S	Pliocene deposits overlying crystalline schist.	
59	Hagia Anagyron, Kythnos Island.	38; 52			Na, Cl	Crystalline schist	2 springs.
60	On Nikaria Island	33.5–55.7		High	Na, Cl	Probably lava	8 springs. Water is highly radioactive. Refs. 2017, 2019, 2041.
61	Prassa, Kimolos Island	32		High	Na, Cl	do	
62	Adamantos, Melos (Milo) Island.	[1] 35			Free H_2S	do	Ref. 2032.
63	Halikis, Melos Island	[1] 30		Moderate	Na, Cl	do	
64	Atherma, Santorin (Thera) Island:						
	Near shore	16–26			Na, HCO_3	Quaternary lava	
	Near base of volcanic cone.	45–60			Na, Cl	do	Several springs: also fumaroles. Refs. 2023, 2025.
65	Plakas, Santorin Island	32			Na, HCO_3	do	
66	On south shore of Cos (Kos) Island.	Hot			Na, HCO_3; free CO_2	Probably Cretaceous limestone.	Springs issue at two places below high-tide level. Refs. 2028, 2030.
67	On Nisyros Island	Hot			CO_2, SO_2	Quaternary lava	Several fumaroles. Refs. 2027, 2029, 2030.
68	Lenta, Crete Island	22.5			Na, HCO_3	Paleozoic strata	

[1] Approximately.
[2] Hottest.
[3] Main spring.
[4] Coolest.
[5] Seasonal range.
[6] Other springs.

Thermal springs in Albania

[Data from ref. 2031]

No. on fig. 36	Name or location	Associated rocks	Remarks
1	1 km west of Peskopija	Lower Tertiary marl and sandstone overlying Paleozoic slate and schist.	Sulfurous.
2	10 km north of Rogojna	Upper Tertiary sandstone	Do.
3	Lixha; 9 km south of Elbasan.	Lower Tertiary marl and sandstone.	Sulfurous. Large resort.

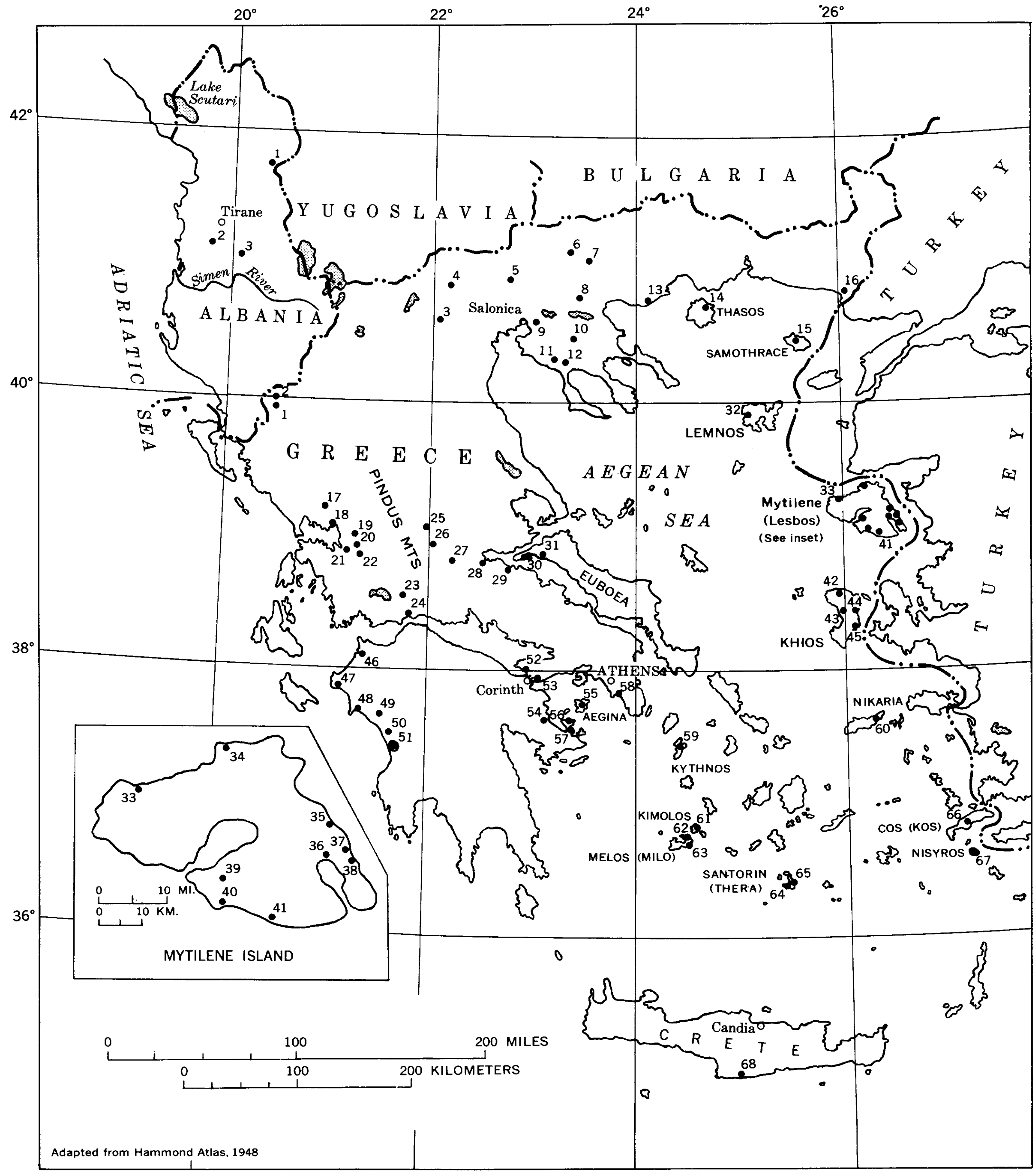

Figure 36.—Greece and Albania showing location of thermal springs. Greece from refs. 2024, 2038, and 2040.

HUNGARY

Hungary is bordered on the northwest in part by the Danube River and on the north and northeast chiefly by southern outliers of the Carpathian Mountains. The great curve of these mountains to the east, south, and southwest forms the boundary of the Transylvanian region, whose eastern portion was ceded to Rumania after World War I. The Drava River marks part of the southern boundary of Hungary. The western boundary with Austria extends across uplands.

Hills in the north and northeast are chiefly of Mesozoic strata, but on the higher slopes of the Carpathians older rocks are exposed. The Bakony Mountains in the northwest extend to the Danube at Budapest, and southward to Lake Balaton. They are mainly of Triassic limestone with some Jurassic and Cretaceous strata, but there are considerable areas of volcanic rocks. The Mecsek Mountains in the southwest are also chiefly of Mesozoic rocks, with some volcanic areas. Much of the country is occupied by the great Central Plain which is crossed by the Danube River and several large tributaries to that stream. Most of the plain is underlain by Tertiary rocks, and brackish-water Miocene strata are exposed around the borders. Large parts of the surface are covered by Quaternary deposits, including Recent loess and alluvium. The locations of thermal springs and wells recorded are shown on figure 31, and data on them are given in the table below.

Thermal springs and wells in Hungary

[Data chiefly from refs. 2045, 2065. Locations of unnumbered springs not identified]

No. on fig. 31	Name or location	Temperature of water (°C)	Flow (hectoliters per min.)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
1	Papa	18–20				Ref. 2057.
2	Pet	22.5	480			Several springs.
3	Tata-Tovaros:					
	7 springs	19–22	1,700			Ref. 2055.
	Well	20	2,880			
4	Dunalmaas:					
	2 wells	20	12	723; 728	Ca, Mg, SO_4, HCO_3	Travertine quarries. Ref. 2050.
	Springs	24				
5	Estergom (Gran):					
	17 springs	20–25	1,025			Ref. 2047.
	Well	29	1,040			323 meters deep. Ref. 2047.
6	Budapest:					
	60 springs	21–63.8	193			Issue from Cretaceous dolomite. Resort. Refs. 2044, 2046, 2056, 2059, 2063, 2067, 2068, 2070–2072, 2074, 2076, 2077, 2083–2085.
	Several wells	79.5 (max)				Refs. 2044, 2051, 2053, 2054, 2058, 2063, 2069, 2072, 2076, 2081, 2083, 2085.
7	Bukkszik	39.4	33.5			2 wells.
8	Parad	Tepid				Spring.
9	Diosgyor	22.5		Low		
10	Gorombolv-Topolca (suburb of Miskolc).	26–31	208	600	Ca, HCO_3	8 wells tapping Triassic limestone.
11	Eger:					
	6 springs	28.6–30.7	167	350–500	Ca, HCO_3; gas 93 percent N_2	Ref. 2075.
	2 wells	32	140			228 and 248 meters deep. Ref. 2075.
12	Mesokovesd	70	50			Well.
13	Tisza-Ors	48	3			Do.
13A	Cegled		20			Do.
14	Szolnok	54	5			Well 967 meters deep.
15	Karcag	70	20			Well.
16	Kaba		2.4			Do.
17	Hajduszoboszlo	74	20	5,145	Na, Cl, HCO_3	Well 1,090 meters deep. Resort. Refs. 2048, 2073.
18	Debrecen	65	26			Well.
19	Balaton-Heviz:					
	Several springs	38–39			Ca, HCO_3, Cl, SO_4	Resort.
	Well	38	60			
20	Kaposvar					
21	Csokonya-Visenta		3.5			Well.
22	Nagyatad	45	2.8			Do.
23	Labod	70	7			Do.
24	Sikonda	35.6	15			Well. Ref. 2082.
25	Harkany	62	15	1,016	Na, HCO_3	Springs; well. Combustible gas. Refs. 2049, 2079.
26	Kecs (Kecel?)	22.5–23	210			5 springs.
27	Szarvas		2.5			Well.
28	Szeghalom	43	2.3			Do.
29	Mezobereny		1.3			Well 420 meters deep.
30	Bekes (Borsod-Tapolcza?):					
	2 springs	18; 24	Large			Slightly sulfurous.
	Well	43	2.5			733 meters deep.
31	Szentes		7.8			Well 330 meters deep.
32	Totkomlos		2.2			
33	Algyo (Algyogy)	30–35				Alkaline. Ref. 2076.
34	Szeged	50	5.7			Well.
	Atya	25				Alkaline. Ref. 2076.
	Alsokeked	24	4.6			2 springs; alkaline earth; slightly sulfurous. Resort.
	Alvacza (Also-Vacza)	28–36	1.2	1,065 (hottest)	Na, Ca, Mg, Sl, SO_4, H_2S	5 springs; sulfureted. Issue from strata containing brown coal. Ref. 2066.
	Feredo Gyorgy	31.8				Earthy calcic. Ref. 2076.
	Punkasfurdo		18			Well 553 meters deep.

ITALY

The mountains that bound Italy on the north are parts of the several Alpine chains. They include areas of granite and other crystalline rocks, notably in Mont Blanc and other outstanding mountain masses. From the Western or Maritime Alps of southeastern France, the Apennine Range extends southward throughout nearly the entire length of Italy and forms the backbone of the country. The Apennines are generally considered to be in three parts: the Northern, Central, and Southern ranges, though these are not sharply divided. In their northern and central parts,

FIGURE 37.—Italy and Switzerland showing location of thermal springs. Italy chiefly from ref. 2105; Switzerland from ref. 2384.

these mountains consist almost wholly of marine sedimentary rocks of Mesozoic and Tertiary ages. In the south, granite and other ancient crystalline and metamorphic rocks form considerable parts of the mountains, especially in the Calabrian Peninsula, which forms the "toe" of Italy. In addition to the ancient crystalline rocks, lava of Tertiary and later ages covers considerable areas, chiefly in four districts: (1) the Euganean Hills, forming an area about 25 km in diameter in northeastern Italy about halfway between Verona and Venice; (2) the district in the west-central part near Rome, including the Alban Hills; (3) the volcanic areas west of Naples, including the Phlegraean Fields, part of the Campanian Plain, and the island of Ischia; and to the east, the Apulian area, dominated by Mount Vesuvius; (4) the district of Monte Volture north of Potenza in the province of Basilicata in southern Italy.

Many of the principal thermal springs, whose location is shown on figure 37, are closely related to the volcanic areas; others are in areas of sedimentary strata that possibly are underlain by igneous rocks. A few hot springs issue in areas of faulted crystalline and metamorphic rocks.

The extensive plains of Lombardy and other lowland parts of the Po River basin in the north are underlain by a great thickness of marine and fresh-water deposits of Pleistocene and Recent ages. Only a very few thermal springs are in that area.

Hot springs and vapor vents within an area of 100 square kilometers in Tuscany have been the subject of considerable attention. At Larderello (fig. 38), wells were drilled as early as 1837 in attempts to obtain natural steam for developing power. Other attempts to use the steam for the generation of electric power were made in 1897, but the first successful plants were not established until about 1904. Turbogenerators were installed successfully in 1916. Boric acid and ammonium sulfate are obtained as byproducts, and carbon dioxide is also recovered. Some of the other main fumarole localities also are shown on figure 38.

The Tuscany area is underlain by a complex of Permian to Eocene rocks, which are much folded and broken as the result of volcanism and faulting that took place at the close of Pliocene time. Most of the hot springs and vapor vents are alined either along lines of geologic contacts, which may be either stratigraphic or tectonic, or along faults. The boric acid, ammonia, and perhaps other substances in the vapor exhalations, may be derived from laccolithic masses, or from volcanic rocks, or even from basic rocks intruded into schist.

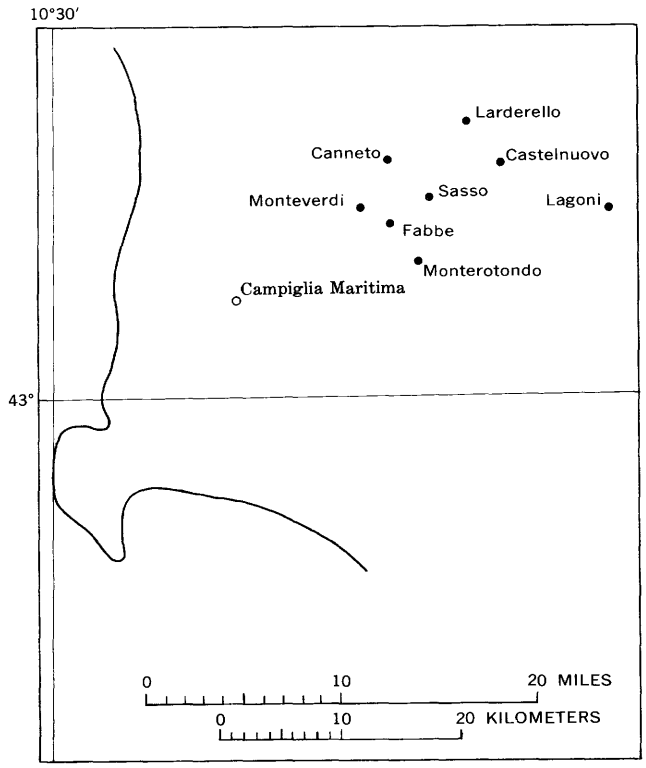

FIGURE 38.—Tuscany area, Italy, showing fumarole localities. From ref. 2171.

On Ischia Island near the Bay of Naples, are several localities of thermal springs and fumaroles, as shown on figure 39. Information on the principal thermal springs in Italy is summarized in the table below.

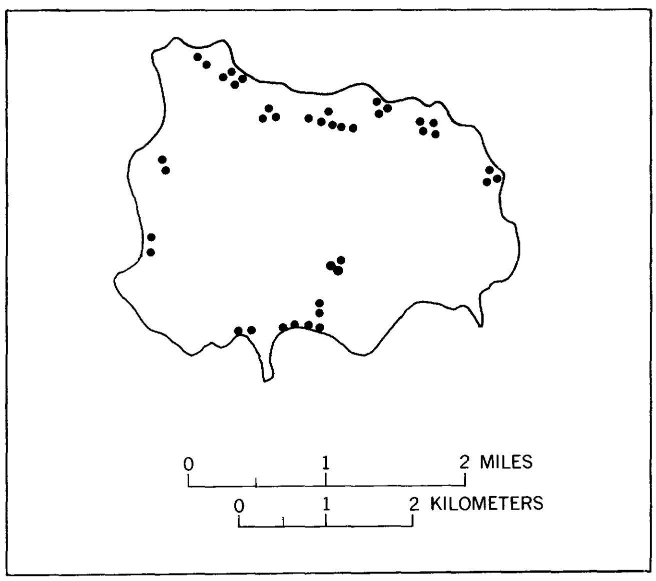

FIGURE 39.—Ischia Island, Italy, showing location of thermal springs. From refs. 30 and 2105.

Thermal springs and wells in Italy

[Data chiefly from refs. 2105, 2141, 2168]

No. on fig. 37	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Italian peninsula and small islands						
1	Pre-St. Didier (San Desiderio).	35	288	320	HCO_3, SO_4, Cl		Resort.
2	Courmayeur	17–24		3,500	HCO_3, SO_4		4 springs. Resort. Refs. 2138, 2191, 2261.
3	Craveggia (Comano)	27					
4	Masino	38.2	864	589	SO_4	Granite	Resort.
5	Bormio	35–40	288	1,000	HCO_3, SO_4		7 springs. Resort. Refs. 2088, 2089, 2097, 2144, 2188.
6	San Pellegrino	27	10,000	1,500	HCO_3, SO_4, Cl	Triassic dolomite	3 springs. Resort. Ref. 2256.
6A	Comano	27.5	720	298	Ca, HCO_3	Eocene limestone	Resort. Refs. 1297, 1304, 1316.
7	Monfalcone	37.9		12,715	Ca, Na, HCO_3, SO_4, CO_2	Cretaceous limestone	Resort. Refs. 1304, 2127, 2128, 2147, 2173.
8	Sirmione, in Lago di Garda.	63.5	2,736	2,500	SO_4, Cl		Resort.
9	Caldiero	28	288	400	HCO_3, Cl	Basalt	Wells; 2 springs. Ref. 2205.
10	Abano Bagni	80–87	10,000	5,500	Na, SO_4, Cl, H_2S	Tertiary lava	Several springs. Resort. Refs. 2095, 2104, 2109, 2114, 2129.
11	Battaglia	58–78	Large	4,920	Na, SO_4, Cl	Lava	3 springs. Resort. Refs. 2098, 2104, 2114.
12	Montegrotto	Hot			CO_2, H_2S, CH_4, N_2		Gases indicate deep source. Refs. 2104, 2114, 2121, 2178.
13	Monteortone	63	960	3,700	Na, SO_4, Cl		Resort. Ref. 2104.
14	Val Calaono	Hot		880	Na, SO_4		3 springs. Ref. 2095.
15	Lampiano	Warm					
16	Montafia	Warm					
17	Calliano	Warm					
18	San Nazario di Burgundi (Sannazzaro).	28	17,000				
19	Casteggio	Warm					
20	Voghera (Rivanzzano)	Warm					
21	Vinadio	30–60	43	500	Na, SO_4, Cl		Several springs. Resort.
22	Valdieri	38–64	300	100–290	Na, SO_4, Cl		7 springs. Resort. Ref. 1285.
23	Acqui	45–73	14,400	1,168–3,372	Na, SO_4, Cl		3 springs. Resort. Refs. 2113, 2176, 2245.
24	Acqua Santa (Liguria Province).	22	240	510	HCO_3, SO_4, H_2S	Serpentine	Resort.
25	Salso Maggiore	20 (max)					Several springs. Strongly saline. Ref. 2162.
26	Peglio	Warm					
27	Sant'Andrea di Medesano	20	324	1,330–44,000			3 springs, 2 of which are strongly saline and the other sulfurous. Resort. Ref. 2263.
28	Fornovo di Taro	Warm					
29	Lesignano de Bagni	Hot					Ref. 2150.
30	Miano	Warm					
31	Tabiano	20					Resort.
32	Corniglio	40					Saline. Ref. 2149.
33	Equi, Fivizzano commune	26	86,400	4,847	SO_4, Cl, H_2S		Several springs. Resort.
34	Castel San Pietro	20 (max)			Na, SO_4, Cl		3 springs. Resort.
35	Imola	Warm					
36	Riolo	Warm					
37	Pieve Fasciana	Warm					Issues along fault. Refs. 2123, 2219.
38	Torrite	32–35	123	7,000	Ca, Na, HCO_3, SO_4		4 springs. Resort. Ref. 2125.
39	Porretta	27–38	14,600		Na, HCO_3, SO_4, Cl		6 saline and 4 sulfurous springs. Resort.
40	Bagni di Lucca	37–54	1,080		HCO_3, SO_4, Cl	Eocene limestone	5 springs. Resort. Refs. 1285, 2093, 2168, 2175.
41	Montecatini	24–33	50,000	4,000–22,000	Na, SO_4, Cl, CO_2	Liassic and Upper Cretaceous strata.	3 main springs. Temperature of water from 18 small springs ranges from 14° to 19°C. Resort. Refs. 2103, 2137, 2143, 2168, 2200.
42	Monsummano	22–35				Liassic limestone	Resort, vapor baths. Ref. 2224.
43	San Giuliano	33.5–41	4,320	2,140–2,390	SO_4, Cl	do	12 springs. Resort.
44	Agnano Pisano	17.8; 30			Ca, HCO_3		2 springs. Resort. Ref. 2231.
45	Vicascio	23		3,330	Ca, HCO_3	Limestone	Resort.
46	Pomarance (Val de Cecina)	28–50	200	500–3,000	HCO_3, SO_4, H_2S		5 sulfurous and 2 bicarbonate springs. Ref. 2168.
47	Montepisani	20–41				Quartzitic schist	Several springs. Ref. 2231.
48	Casciana (Montevaso)	36	25,920	3,000	Ca, SO_4	Mesozoic strata	Refs. 2115, 2158, 2202.
49	Uliveto	23–34	2,376	2,500–4,000	HCO_3, SO_4		Several springs. Resort.
50	Mammialla bei Volterra (Fenga).	Warm				Eocene strata	
51	Maggiona	Warm					
52	Bagno di Romagna	43		1,300	Na, HCO_3, H_2S		Several springs. Resort.
53	San Marino	Warm					
54	Citta di Castello	Warm					
55	San Vittore	Warm			H_2S		Resort. Ref. 2235.
56	Gubbio	Warm					
57	Larderello district	Hot					8 areas of fumaroles and steam wells. Boric. Developed for electric power. Refs. 2091, 2092, 2111, 2112, 2134, 2163, 2185–2187, 2190, 2194, 2230, 3554.
57	Montecerboli, 18 km south of Volterra.	44					Fumaroles. Boric. Commercially developed.
58	Campiglia Marittima	31–43	Large			Mesozoic strata	2 groups. Ref. 2168.
59	Frassine (Casale)	26			CO_2, H_2S		
60	Montioni (Grosseto)	32					
61	Gavorrano	34.1			SO_4	Mesozoic strata	Refs. 2168, 2172.
62	Elba Island (northeast part).	Warm					Ref. 2207.
63	Caldanello	35.5					Ref. 2168.
64	Poggetti di Montepescali	35–44					

Thermal springs and wells in Italy—Continued

No. on fig. 37	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Italian peninsula and small islands—Continued						
65	Roselle (Boccnaggio)	35–44				Mesozoic strata; much tufa	
66	Casaccie	Warm	Small		SO_4	Rhaetic limestone (Upper Triassic).	
67	Talamone	32				do	
68	Ponte a Macereto	38				Mesozoic strata	
69	Rapolano	28–40	6, 720	2, 000–4, 000	HCO_3, SO_4, Cl	Pliocene overlying Mesozoic strata; much tufa.	4 main springs. Resort.
70	Mont'Alceto (Armaidlo)	31 (max)	1, 824	2, 500	Ca, HCO_3, SO_4	do	Several springs. Resort.
71	Petriolo (Montaigne)	25. 5–45		2, 650	HCO_3, SO_4, Cl	Mesozoic strata	Several springs. Resort. Ref. 2168.
72	Bagni Vignone	36–52	43, 200	4, 690	Ca, HCO_3, SO_4, Cl	Eocene strata; much tufa	Several springs. Resort. Refs. 2168–2170.
73	Chianciano	21–39	Large	3, 250–3, 500	Ca, HCO_3, SO_4	Pliocene overlying Mesozoic strata.	3 bicarbonate springs; 1 sulfur spring, water temperature 39°C. Resort.
74	San Filippo	26; 53	Large	2, 190–3, 660	Ca, HCO_3, SO_4	Eocene strata	2 springs. Resort. Refs. 2142, 2168.
75	San Casciano dei Bagni	34–42	5, 400	720–1, 970	HCO_3, SO_4, Cl	Pliocene overlying Mesozoic strata.	43 springs in area of 2 sq km. Resort.
76	San Vito	Warm					
77	Saturnia	37. 5	34, 500	3, 447	Ca, HCO_3, SO_4, BO_2, H_2S	Mesozoic strata near trachyte; much tufa.	Spring and solfataras. Refs. 2168, 2203, 2204, 2255.
78	Acqua Fitusa (San Giovanni Gemini).	28	72	2, 500	Na, Cl, H_2S	Limestone	Resort.
79	Acquasanta (Ascoli Piceno Province).	24. 5–36	52, 000–104, 000	4, 000	Na, HCO_3, SO_4, Cl, CO_2, H_2S.		Resort. Refs. 1737, 2236.
80	Canino	39				Mesozoic lava; much tufa	Resort. Ref. 2168.
81	Viterbo	30–56. 4	156	2, 420	HCO_3, SO_4, CO_2, H_2S	Lava	Several springs. Resort. Refs. 2161, 2253.
82	Civita Vecchia	56	2, 018	2, 510	Ca, HCO_3, SO_4, Cl, CO_2, H_2S.		Several springs. Resort.
83	Bassano di Sutri (Il Laghetto).	Tepid			CO_2, H_2S		Mud pool, 50 meters in diameter. Ref. 2234.
84	Vicarello (Terme Apollinari).	45 (max)	300		Na, HCO_3, SO_4, Cl, CO_2		Several springs. Resort.
85	Claudia, beside Lago Bracciano.	20. 2	960	765	HCO_3, CO_2		Resort.
86	Stigliano	19–56		970–9, 860	Na, HCO_3, Cl, H_2S		6 springs. Resort
87	Acqua Albule	23–24	1, 720, 000	2, 240	Ca, HCO_3, SO_4, CO_2, H_2S		Several springs; travertine quarries. Resort. Ref. 2181.
88	Acqua Vergine (Laziali Colli), in Alban hills.	20 (max)				Lava	Resort. Ref. 2174.
89	Albano, near Lago Albano	20					
90	Palena	35–48					Several springs.
91	Sujo (Suio)	29–45	18, 000		Ca, HCO_3, SO_4, Cl		Many springs for 5 km along valley.
92	Telese	20–22	240, 000	2, 179	Ca, Mg, Na, HCO_3, Cl, CO_2		Several springs on Mount Pugliano. Resort.
93	Ischia Island:						
	Porto	52–55	Large	7, 000	Na, SO_4, Cl		Several springs.
	Lago Ameno	41–66	Large	4,770–19,000	Na, SO_4, Cl		6 springs.
	Casmicciola	30–70	Large	5, 000	Na, SO_4, Cl		Several springs. Refs. 2100, 2101, 2151, 2206, 2210, 2211, 2215, 2223, 2241–2244.
94	Procida Island	Hot					Several springs. Ref. 2211.
95	Phlegrean Plain	Hot					Several springs. Resort. Refs. 2167, 2211.
96	Pozzuoli and Solfatara	40–43	Large		Na, HCO_3, Cl		Several springs. Resort. Refs. 2119, 2120, 2133, 2146, 2194, 2251.
97	Agnano, 3 km southeast of Solfatara.	20–95			Na, HCO_3, SO_4, Cl		Several springs. Resort. Refs. 2167, 2183, 2267.
98	Bagnoli	40–50	Large		Na, HCO_3, SO_4, Cl		7 shallow wells near seashore. Refs. 2167.
99	Mount Vesuvius crater	Hot					Several springs, 14°–26°C; and fumaroles. Refs. 2102, 2141, 2167, 2238, 2239, 2266.
100	Atrio del Cavallo on northeast side of Vesuvius crater.	100 (max)			H_2S		Solfatara del Atrio and 27 main fumaroles. Refs. 2177, 2214.
101	Torre Annunziata near south base of Vesuvius	30 (max)	3, 600	4, 500	Na, HCO_3, Cl	Lava	3 springs. Resort. Refs. 2117, 2221.
102	Castellammare di Stabbia	20 (max)			Na, HCO_3, Cl		7 springs. Resort. Ref. 2139.
103	Villamaina	35	48		Ca, HCO_3, CO_2, H_2S	Limestone	Resort.
104	Monticchio, on west slope of Monte Vulture.	20 (max)	660	2, 300	Ca, HCO_3, CO_2		Also several cold springs. Resort.
105	San Cataldo	20	Large		SO_4		Resort.
106	Contursi	23–42			SO_4, CO_2, H_2S		3 main springs. Resort. Refs. 2106, 2220, 2253.
107	Latronico (Bagni della Calda).	22; 23	30, 000	500	HCO_3, SO_4, Cl, H_4S		2 main springs. Resort.
108	Santa Cesarea	21–32	Large	4, 430	Ca, Na, HCO_3, SO_4, Cl, CO_2, H_2S.	Limestone	4 springs in grottos. Resort. Ref. 2264.
109	Cassano al Jonio	26	Moderate		SO_4, CO_2, H_2S		3 springs. Resort.
110	Lungari	20					Ref. 2233.
111	Acquapessa (Terme Luigiane).	39–42	17, 300		Na, H_2S	Paleozoic limestone	2 springs. Resort. Ref. 2257.
112	Caccuri	32–33					Several springs.
113	Gimigliano	35					
114	Sambiase	39. 6	1, 250	2, 400	Ca, SO_4, CO_2, H_2S		Resort.
115	Galatro	37–39	960		SO_4, Cl, H_2S		3 springs. Resort.
116	Antonimina-Gerace (Acque Sante).	18. 3–36. 4	4, 000	5,510–11,670	Ca, Na, SO_4, Cl		4 springs. Resort.
117	Stromboli Island	Hot				Lava	Fumaroles. Temperature of gases exceeds 230°C. Refs. 2087, 2239, 2266.

Thermal springs and wells in Italy—Continued

No. on fig. 37	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Italian peninsula and small islands—Continued						
118	Filicuri Island	Hot				do	Several springs. Ref. 2207.
119	San Calogero, on Lipari Island.	35–58		Large	Na, HCO_3, SO_4, Cl	do	Several springs. Refs. 2099, 2107, 2135, 2154.
120	Vulcano Island	Hot					Many fumaroles in lava crater. Steam. Temperature of gases and acid fumes exceeds 300°C. Gases contain H_3BO_3. Refs. 2043, 2122, 2131, 2132, 2250, 2266.
	Sicily						
121	Alcamo	Warm					
122	San Lorenzo, near Roccameno.	38.5			HCO_3, SO_4		Ref. 2152.
123	Montevago	31	9,760				
124	Sciacca, near the city:						
	Molinelli	28	230	12,500	Na, Cl	Limestone	Resort. Refs. 2116, 2148, 2240.
	Acqua Santa	32	57	5,820	Na, HCO_3		
	Solfurea	52	720	20,500	Na, SO_4, Cl		
125	Acqua Calda, near Trabia.	26					
126	Termini Imerese, near seashore.	42; 43	1,584; 432	14,500; 18,030	Na, SO_4, Cl, CO_2	Triassic strata	2 springs. Resort. Ref. 2184.
127	Sclafani	33; 35	6,712		Na, SO_4, Cl, H_2S		2 main springs. Resort.
128	Cefalu-Diana	38					
129	Castroreale	32; 25	360; 72	5,350; 3,900	Na, HCO_3	Gneiss	2 springs. Resort.
130	Ali-Marina, on sea coast:						
	5 springs	28–36	Small		HCO_3, SO_4 Cl, H_2S		Sulfur water. Resort. Refs. 2192, 2193, 2232.
	2 springs	26; 28	Small	2,160	HCO_3, CO_2		Bicarbonate water.
131	Mount Etna, on south and east slopes.	Hot				Lava	Many fumaroles. Refs. 2239, 2266.
132	Acireale (Santa Tegla)	20 (max)			SO_4, H_2S		Resort.
133	Grammichelle (Acqua Calda; Mineo).	22–35					Ref. 2145.
134	Pantelleria Island on northwest coast.	30–75	432	3,680–7,980	Na, Cl	Lava	4 springs. Also hot springs and and fumaroles in crater.
	Sardinia						
135	La Crucca	Warm					
136	San Martino	25	29	3,000	HCO_3, Cl	Lava	Several springs. Resort; table water. Ref. 2229.
137	Ploagre	20 (max)					
138	Thiese	Warm					
139	Mesumundu	Warm					Ref. 2225.
140	Benetutti	34–46					Do.
141	Orani	Warm					Do.
142	Conone	Warm					Ref. 2207.
143	Casteldoria (Castel Dora)	70–75			Ca, Na, Cl, H_2S	Granite porphyry	Several springs. Refs. 2195, 2196, 2225, 2228.
144	Fordongianus	54					Water is saline. Refs. 2225, 2227.
145	Sardara	50–60	10,000	2,500	Na, HCO_3, SO_4, Cl, CO_2	Schist near basalt	5 springs. Resort. Refs. 2228, 2229.
146	Villasor (Acqua Cotta)	40; 62			Ca, Na, HCO_3	Contact of granite and trachyte.	2 main springs. Refs. 2225, 2226, 2228.
147	San Saturnino	34–43					3 springs. Ref. 2228.
148	Is Bangius	44					Ref. 2228.
149	Caddas	55	2,160				Do.
	Unidentified locations (data from ref. 2141)						
------	Bano dell'Osa	32					
------	Beveretto	23	46,600				
------	Bulgherano	22–25					
------	Florinas	20 (max)			HCO_3, SO_4		Alkaline.
------	Monte de Castona	29–42					
------	Sigona Grande	23	35,400				
------	Siligo	20 (max)			HCO_3, SO_4		Do.
------	Solofrano Torrent	21–25					
------	Uria Torrent	22–25					

PORTUGAL

Portugal occupies an area about 300 miles long, north-south, and 100 miles wide, east-west, on the west side of the Iberian Peninsula. The country is traversed by mountain ranges that trend east-west and are continuations of ranges in Spain. Most streams flow westward to the Atlantic. The Minho River forms part of the northern boundary; the Guadiana River forms part of the southeastern boundary. The greater part of Portugal is underlain by rocks of Archean and Paleozoic ages, cut by eruptive rocks of later dates, like the syenite laccolith of Serra de Monchique in the south. In the south also are extensive areas of Lower Carboniferous sandstone and conglomerate, with coal beds. Mesozoic deposits, chiefly of Jurassic age and less extensive areas of Cretaceous rocks, are present in lower areas. The plain of the Tagus River and other large areas near the coast are covered by Tertiary deposits. Great eruptions of basalt and tuff in early Tertiary time are covered in part by marine deposits of Oligocene and Miocene age. The mountains of northern Portugal are mainly of plutonic rocks flanked by Paleozoic sedimentary strata. Thermal springs are not common, though 34 localities are recorded, as shown on figure 40. Most of them have been developed as bathing resorts.

Information on the various springs in Portugal is presented in the table below.

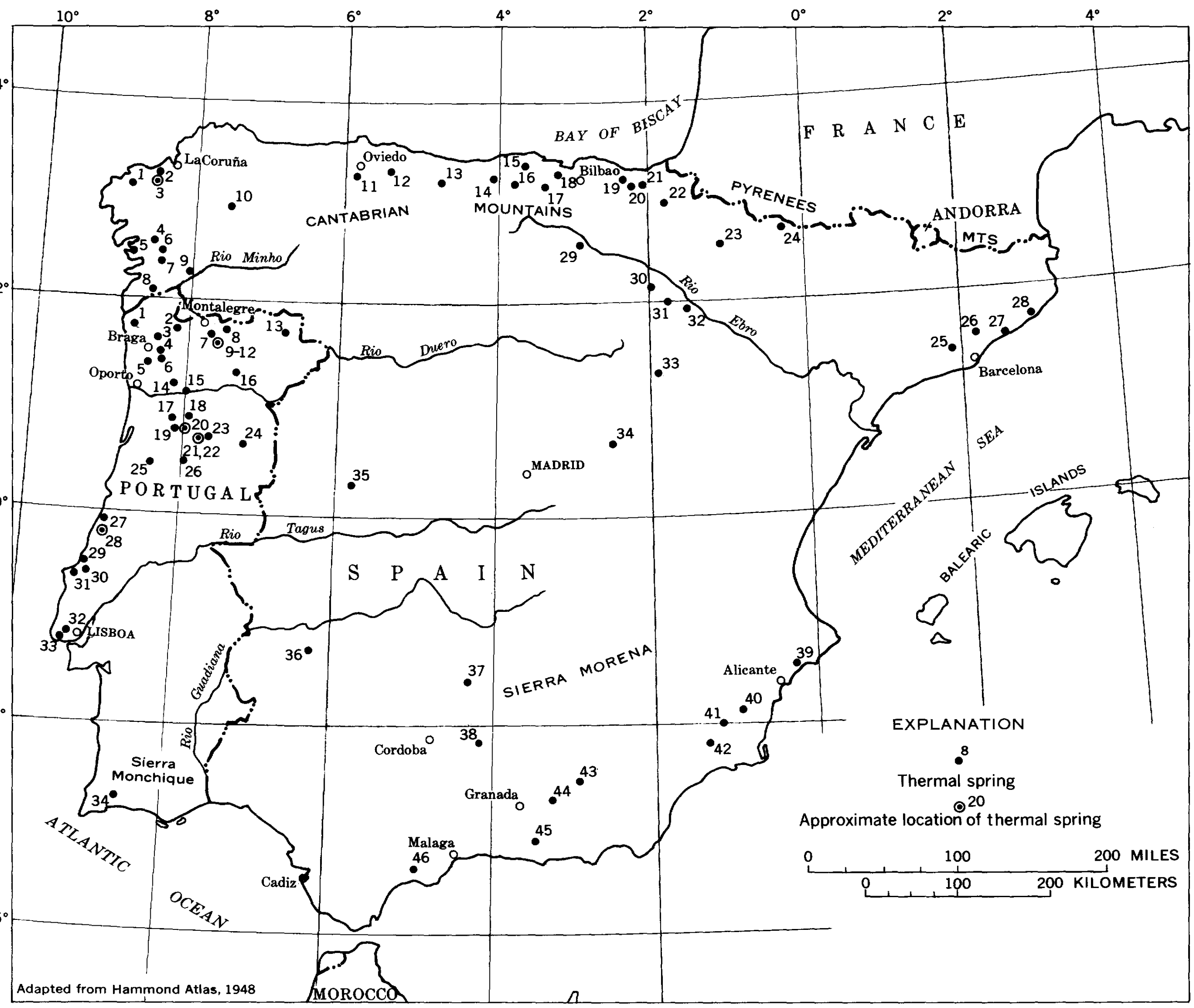

FIGURE 40.—Portugal and Spain showing location of thermal springs. Portugal from refs. 2268 and 2272; Spain chiefly from ref. 2346.

Thermal springs in Portugal

[Data chiefly from refs. 2268, 2272. Locations of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 40	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Monção (Valaderes de Minho).	20			Na, SO_4		Strongly radioactive. Resort. Ref. 2274.
2	Geres (Fonte da Bica)	42.5		282	Na, HCO_3	Granite, faulted	Used since Roman times. Strongly radioactive and high in fluoride. Resort. Refs. 2283, 2292, 2295, 2296.
3	Caldelas	21.5; 31.2		81; 110	HCO_3 (60); SO_4 (11 ppm)		2 springs. Strongly radioactive; fluoride, 3 ppm. Resort. Refs. 1760, 2276, 2284, 2285.
4	Taipas	28.7		188	Na, SO_4		Strongly radioactive. Resort. Ref. 2276.
5	Caldas da Saude (Caldinhas)	27			Na, Cl, SO_4		Strongly radioactive. Resort. Refs. 2273, 2283.
6	Vizela and Mourisco	54; 62.4		324	Na (92); HCO_3 (79); Cl (30); fluoride (23.6).		2 springs. Radioactive. Resort. Temperature of nearby spring, 31° C. Ref. 2283.
7	Carvalhelhos	21		205			Slightly saline and radioactive. Resort. Ref. 2276.
8	Chaves	69			Na, HCO_3		Faulted zone of Rio Tamega. Resort. Refs. 2291, 2306.
9	Vidago	Warm					Faulted zone of Rio Tamega. Resort. Ref. 2291
10	Cabres	Warm					Do.
11	Vilarelho	Warm					Do.
12	Pedras Salgadas	Warm					Do.
13	Alfaião (Bragança)	15				Contact of schist and amphibolite.	Bathing. Ref. 2281.
14	Canavezes	35.3		268	Na, NCO_3, SO_4		Weakly radioactive. Resort. Ref. 2276.
15	Aregos	61			Na, SO_4		Strongly radioactive. Resort. Refs. 2283, 2300.
16	São Lourenço	31.1	92.5	251	Ca; Na; Cl (35.5); SiO_2		Strongly radioactive. pH, 8.1. Resort. Also small warm sulfur spring at Caldas Velhas 2 km distant. Ref. 2302.
17	Moledo	Warm			Na, SO_4		Weakly radioactive. Resort.
18	Carvalhal (Castro Daire)	21–29.5	25	292	SO_4; free H_2S	Granite	Saline, alkaline, radioactive. Resort. Ref. 2276.
19	São Pedro do Sul	67					Strongly radioactive. Resort. Ref. 2283.
20	Fonte Santa (Manteigas)	Hot			Na, SO_4		Resort.
21	São Gemil	Hot			Na, SO_4		On bank of Rio Dao. Resort.
22	Alcafache	50			Na, SO_4	Granite	Do.
23	São Paulo	Warm			Na, SO_4		Weakly radioactive. Resort.
24	Caldas do Cro	Warm			Na, SO_4		Resort.
25	Luso:						
	Main Spring	27.2	283	42			Much gas. Both water and gas strongly radioactive. Resort.
	São João de Luso	20.5	3,600	35			Radioactive. Bathing. Refs. 2298, 2299, 2303, 2304.
26	Felgueira	Warm			Na, SO_4		Highly radioactive. Resort.
27	Monte Real	19.2		252	Ca, Mg, SO_4		Resort. Ref. 2301.
28	Piedade	25–27.5			HCO_3, Cl		Weakly radioactive. Resort.
29	São Martinho (Aguas de Salir).	27–29	Large		Ca, Na, HCO_3, Cl	Faulted Jurassic strata	Resort.
30	Aguas Santas	Warm			Ca, Cl, SO_4		Do.
31	Caldas da Rainha	33.4 (max)	1,390	3,169	Ca, Na, HCO_3, SO_4, Cl		5 main springs. High fluoride content; pH, 6.9; radioactive. Developed in Roman times. Resort. Refs. 2271, 2277, 2279, 2283, 2290, 2305.
32	Cucos	31.5–40			HCO_3, Cl		4 springs. Strongly radioactive. Resort. Ref. 2285.
33	Estoril	32.7		4,520	Na (1,290); Ca (234); HCO_3 (284); SO_4 (290); Cl (2,260).		Strongly radioactive. Resort.
34	Caldas de Monchique (S. João, Chagas, Fonta Santa).	30–32.1	330	3,558	Na, HCO_3, SO_4, Cl	At border of granitic laccolith.	5 main springs. pH, 9.6. Bathing. Refs. 2271, 2278, 2290, 2293.
------	Caldas de Carlão	Warm			Na, SO_4		Radioactive. Ref. 2268.
------	Monfortinho	28					Ref. 2276.

RUMANIA (ROMANIA)

Rumania extends northwest and west from the Black Sea and includes parts of the Carpathian and Transylvanian Mountains and high plateaus beyond. The Danube River forms most of the southern boundary of the country, and the Pruth River forms most of its northeastern boundary. The higher parts of the Transylvanian Mountains are largely of schist and other metamorphic rocks, which are flanked on the south by marine Jurassic and Cretaceous strata overlain on the lower slopes by flysch of Late Cretaceous and early Tertiary ages. These formations also extend along the east base of the Carpathians, being overlain in a trough farther east by flat-lying to strongly folded Miocene salt-bearing beds. In the south-central part of the country are oil-bearing beds of Tertiary age. Along the lower parts of the Pruth and Danube Rivers are extensive areas of marsh and lagoons. Farther up the Danube the adjacent lands are somewhat higher, and in some places, hills of crystalline rocks rise above the Quaternary deposits.

Many mineral springs issue in the mountains and uplands, but most of them are cold. Thermal springs are found at numerous places, as indicated on figure 41. Nearly all principal springs have been developed as bathing resorts, some having been in use since Roman times.

Very little information is available on most of the springs, as shown in the table below.

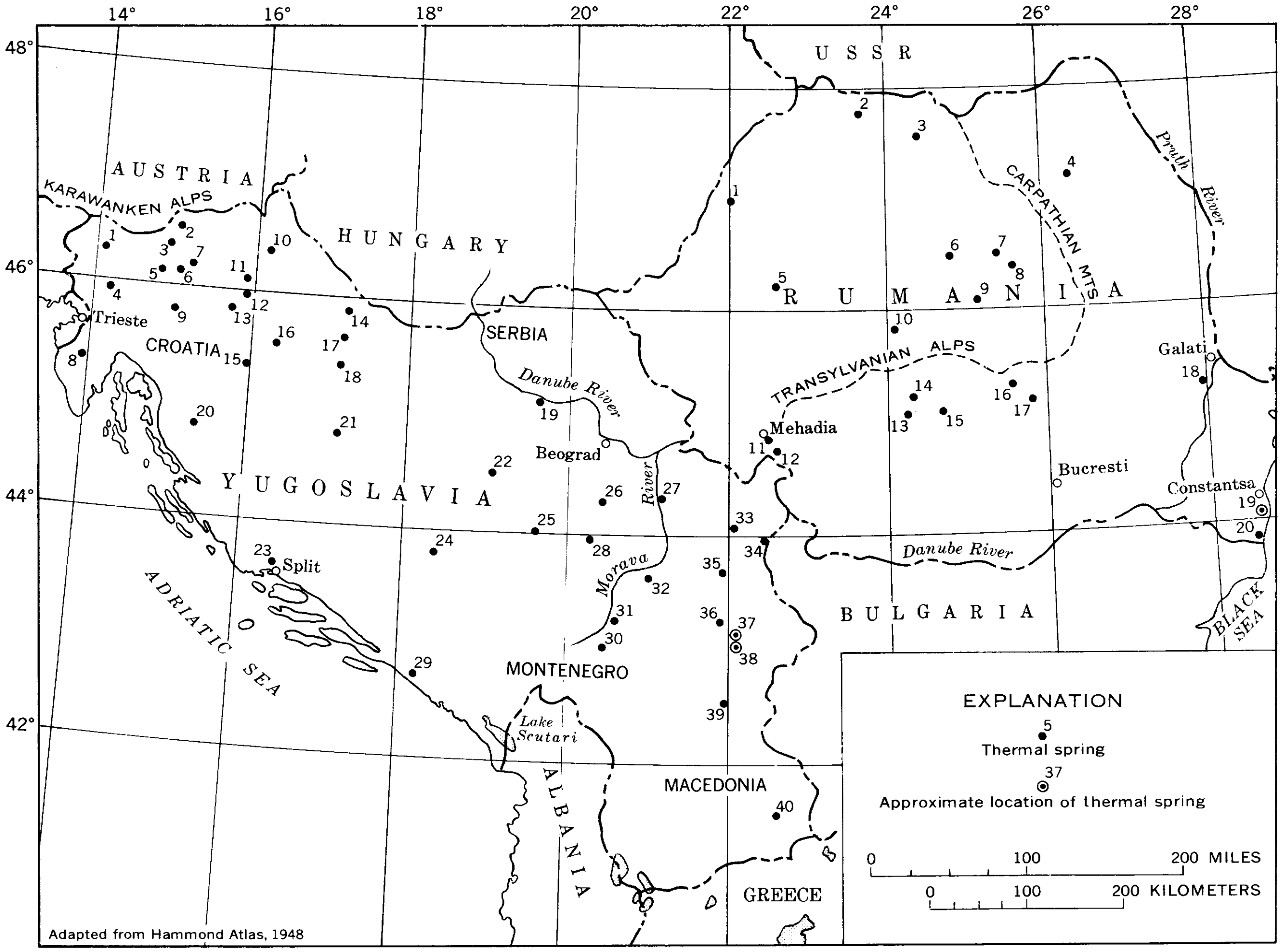

FIGURE 41.—Rumania and Yugoslavia showing location of thermal springs.

Thermal springs and wells in Rumania

No. on fig. 41	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and references
1	Félixfürdö (Felix baths), 8 km southeast of Oradea:					
	Well	48	170,000	812	Ca, SO_4, CO_3	47 meters deep. Ref. 2328.
	2 springs	41.3; 48.2		927; 947	Ca, Na, HCO_3, SO_4, CO_2.	Refs. 2320, 2330, 2331.
2	Felsobanya, near Sighet					Baths.
3	Borsod Tapolcza					Resort.
4	Baltzatesti (Baltatestii), near Targu-Neamtu.					Resort. Ref. 2308.
5	Korosbanya (Altenburg)	Warm				Weakly sulfurous. Ancient "Thermae Pannoniae." Ref. 1293.
6	Hebe, in Sângeorz-Băi region.					Ref. 2333.
7	Csikszereda (Katalin)	10.7		868	Ca, Na, HCO_3, SO_4, CO_2.	Ref. 2330.

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Thermal springs and wells in Rumania—Continued

No. on fig. 41	Number or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and references
8	Tusnad (Ilona)	21; 22.5		5,254		Ref. 2330.
9	Caciulata					Mineralized. Ref. 2308.
10	Vizakna	28.7–45				Saline, iodine.
11	Herculesbad (Mehadia):					
	Elizabeth					Radioactive. Water temperature, 25°–62.5°C. Ancient "Thermae Herculis ad aquas." Refs. 2309, 2323, 2325, 2327, 2329.
	Hygea					
	Hercules	46	38,400	3,440	Na, Ca, Cl; gas, 40 percent N_2.	
	Ileana					
	Regina Maria					
	Others					
12	Bahna (Basna)					Baths. Ref. 2318.
13	Govora					Resort. Ref. 2308.
14	Calimanesti (Calimanescii)					Do.
15	Curtea de Argesh					Used by Romans. Ref. 2308.
16	Sinaia					Resort. Ref. 2308.
17	Slanic					Saline mine water. Baths. Refs. 2308, 2314.
18	Lake Sarat (near Braila)					Ref. 2308.
19	Tekir Ghiol, near Constantsa.					Do.
20	Mangalia					Radioactive. Refs. 2315, 2319.

SPAIN

Spain occupies about five-sixths of the Iberian Peninsula, which consists mostly of a great plateau, limited on the north by the Pyrenees Mountains and the Cantabrian Mountains and on the south by the Sierra Morena. The plateau is traversed by four minor mountain ranges which separate the drainage basin of the Ebro River from that of the Duero River. The Ebro drains the northeastern part of the country and empties into the Mediterranean Sea; all the other main streams flow southwestward or westward to the Atlantic.

The plateau region and bordering mountains are underlain by a massif of ancient rocks, complexly folded and faulted, and form a part of the Hercynian tectonic region of southern Europe. Archean granite, gneiss, and schist form much of the Pyrenees Mountains. Paleozoic sedimentary rocks constitute other main mountain masses. Sedimentary strata of Mesozoic age border most areas of older rocks and also cover large areas in south-central Spain. In the north, northeast, and southeast, large areas of older rocks are overlain by marine Tertiary strata. Volcanic rocks are present in only minor areas. The locations of thermal springs are shown on figure 40, and the available information on them is given in the table below.

Thermal springs in Spain

[Data chiefly from ref. 2346. Location of unnumbered spring not identified]

No. on fig. 40	Name or location	Temperature of water (° C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Carballo:						
	Baños Viejos (Old Baths).	33–40		404–418		Granite	3 springs. Bathing.
	Baños Nuevos (New Baths).	26		342; 375	Na, SO_4	do	2 springs. Bathing. Refs. 2342, 2343.
2	Ortejo	28–42		651–2,009	Na, SO_4		4 springs. Resort. Ref. 2343.
3	Aguas de Bejo	25		261			Ref. 2343.
4	Caldelas de Reyes	39.4 (max)		Low	Na, Cl, SO_4		4 springs. Resort. Ref. 2344.
5	La Toja, on island of same name.	60 (max)	400	Low			Several springs. Resort. Ref. 2344.
6	Caldas de Cuntis	60 (max)		Low			Several sprigns. Resort.
7	Puente Caldas, 15 km east-southeast of Pontevedra.	30		Low			Includes nearby warm spring of San Justo de Sacos. Resort. Ref. 2344
8	Caldas de Tuy	47–50		Low			Several springs in bed of Río Miño. Resort. Ref. 2344.
9	Carballino	28	100	(1)	Na, SO_4		Resort. Ref. 2344.
	Polgras	24	Small				
	Parada de Achas	32	Small				
10	Lugo	43	120	(1)	Na, SO_4	Silurian strata	Resort.
11	Caldas de Oviedo	43	Large	(1)	HCO_3	Carboniferous limestone	Contains nitrogenous matter. Resort
12	Buyeres de Nava	21–25	62.5		Ca, SO_4		3 springs. Resort.
13	La Hermida	50–60	Large		Na, Cl	Contact of Triassic strata with Carboniferous limestone.	Several springs. Resort.

See footnote at end of table.

Thermal springs in Spain—Continued

No. on fig. 40	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
14	Puente Viesgo	35	34; 910	(1)	Na, HCO_3, Cl		2 springs. Resort.
15	Alceda	27	2,550		Ca, SO_4	Jurassic strata near Carboniferous limestone.	Resort.
16	Solares:						
	Main spring	29.8		(1)	Na, HCO_3		Resort
	Small spring				Na, Cl		
17	Ontaneda	27.2	1,186			Jurassic strata overlying Carboniferous limestone.	Do.
18	Molinar de Carranza	30–35	2,150		Na, HCO_3, Cl	Cretaceous limestone	Several springs. Resort.
19	Uberuaga de Ubilla	27	544	(1)			3 springs. Water contains nitrogenous matter. Resort. Ref. 1293.
20	Alzola	30.5			Ca, HCO_3		Water contains small amount of lithium. Bathing. Ref. 1293.
21	Cestona	27; 31	Large	(1)	Na, Cl		2 springs. Bathing. Ref. 1642.
22	Betelu	24			Na, SO_4		3 springs. Bathing.
23	Tiermas	22–42		(1)	Na, SO_4, Cl		Several springs. Bathing.
24	Panticosa	26–31		(1)		Granite	5 main springs. Water contains nitrogenous matter. Resort. Ref. 1576.
25	La Puda de Montserrat	27–29.3	387	(1)	Na, SO_4		4 main springs. Resort.
26	La Garriga	60		(1)	Na, Cl		Bathing.
27	Caldetas (Baños de Titus)	38.5	208	(1)	Na, Cl		Do.
28	Vichy Catalan	60	180		Na, HCO_3, Cl		Do.
29	Porvenir de Miranda	22.5	200		Ca, Na, HCO_3		3 springs. Resort.
30	Arnedillo	52.5 (max)	130		Na, Cl	Lower Triassic strata	Several springs. Resort.
31	Fitero, Baños Viejos	47.5	1,080			Quartzitic sandstone	Flows from gallery. Resort.
32	Fitero, Baños Nuevos	48	10,000		Na, Cl	Jurassic strata	Resort.
33	Alhama de Aragon	34	16,000		Na, SO_4, Cl		Strongly radioactive. Also several small springs, 29°–37°C. Ref. 2339.
34	Trillo and Carlos III	23–30			Ca, Na, SO_4, Cl		6 main springs in two groups of differing chemical character. Bathing.
35	Montemayor	42	164		Na, SO_4	Ancient (crystalline?) rocks	Water contains small amount of lithium. Resort. Ref. 2291.
36	Alange	28	216		Ca, HCO_3	Miocene strata	Bathing. Ref. 2291.
37	Fuencaliente	25–50		170	Ca; HCO_3; H_2SiO_3 (52 ppm); Fe_2O_3.	Siliceous rocks	7 springs. Resort. Ref. 2338.
38	Marmolejo	21			Na, HCO_3		Bathing.
39	Busot	39			Ca, SO_4		3 springs. Bathing.
40	Fortuna	52.5	3,000		Na, Cl		Bathing.
41	Archena	55.5 (max)	Large		Na, SO_4, Cl	Miocene strata	Bathing. Refs. 1285, 1576.
42	Alhama de Murcia	45		(1)	Ca, SO_4		4 springs. Resort.
43	Zujar	38	5,300		Na, SO_4, Cl		4 main springs. Resort.
44	Graena	43	Large	(1)	Ca; HCO_3; Fe_2O_3		Developed by the Romans.
45	Lanjaron	16–30					7 springs. Resort.
46	Fuente Amargosa	21		(1)			Water contains nitrogeneous matter. Bathing.
	Puertollano					Ordovician strata	Ref. 2348.

[1] Results of chemical analysis given in ref. 2349.

SWEDEN

A detailed study of springs throughout Sweden was made by Wahlenburg (ref. 2353), who used the term "Quellen-Warme" to refer to their temperature. His report has therefore been included in some bibliographies on thermal springs. Although some springs were found to be perceptibly above the mean annual temperature of the air at their localities, nearly all were below 10°C, and none were considered to be truly thermal. No other reports on thermal springs in other parts of the Scandinavian Peninsula seem to be recorded.

SWITZERLAND

The southern part of Switzerland is bordered by the main chain of the Alps and the western part by the Jura Mountains. Between them are the Bernese Alps lying entirely in Switzerland. The valley of the Rhine River from the Lake of Constance and that of the Rhone River in the south are deep and narrow, but the basin of the Aar River and the smaller one of the Thur River contain wide areas of valleyland which form more than one-half the total area of the country. Most of the mountains are composed of belts of marine sedimentary rocks of Mesozoic age, greatly folded and faulted in the Alps but less disturbed in the Jura Mountains. In the central plain that forms much of the basin of the Aar, the bedrock deposits, chiefly of Tertiary age, are partly marine and partly brackish-water and fresh-water. These older materials are largely covered by glacial material and stream alluvium.

The extensive folding and faulting in the mountain areas would seem to be favorable to the presence of thermal springs. However, only a very few of the great many mineral springs are recorded as thermal; but perhaps only those which have been developed commercially have received attention. Those springs for which descriptions have been found as shown on figure 37, and information concerning them is presented in the table below.

Thermal springs and wells in Switzerland

[Data chiefly from ref. 2384. Principal chemical constituents are expressed in parts per million]

No. on fig. 37	Name or location	Temperature of water (°C)	Flow (cubic meters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Hauenstein tunnels	Warm	Large			Mesozoic strata	In 2 railway tunnels crossing west extension of Baden thermal zone. Ref. 2365.
2	Zurzach:						
	Well	27.7	20–29	1,011	Na (293); HCO_3 (262); SO_4 (263); Cl (146); free gas, 90 percent N_2.	Bunter sandstone (Lower Triassic).	404 meters deep. Used for bathing. Ref. 2362.
	Well	38	300			Gneiss	416 meters deep.
3	Bad Schinznach	34; 36	720	2,971	Ca (365); Na (434); HCO_3 (288); SO_4 (1,076); Cl (604); dissolved CO_2 and H_2S.	Fault between Jurassic limestone and Triassic strata.	2 springs, developed A.D. 1658. Resort. Refs. 1285, 1291, 1687, 1699, 2366, 2367, 2386, 2387.
4	Baden-Aargau, in Aar River Valley and bed of Limmat River.	46–48	550–850	4,666	Ca (517); Na (798); HCO_3 (481); SO_4 (1,418); Cl (1,200); free gas, 69 percent N_2, 30 percent CO_2.	Keuper formation (Upper Triassic).	About 20 main springs; flow varies with the season. Several resorts. Refs. 1699, 2368, 2379–2381, 2386, 2391.
5	Reuss River Valley, a few km southwest of Baden.	Warm				Probably Keuper limestone.	Bathing.
6	Baden-bei-Zurich	48	7,800			Probably Tertiary molasse	Several wells about 1,000 meters deep. Resort. Ref. 1285.
7	Yverdon at south end of Lake Neuchatel.	24	540	413	Ca (31); Na (54); HCO_3 (215); Cl (60); and HS (5); free CO_2, H_2S.	Morainal gravel	2 shallow wells, developed 1903–05. Water may rise from considerable depth. Resort. Refs. 1293, 1294.
8	Weissenburg	24–28.7	42	1,628	Ca (340); Mg (77); HCO_3 (125); SO_4 (1,040); dissolved CO_2 and O.	Triassic strata	Water contains 10 ppm Sr. Resort. Refs. 30, 1687.
9	Heustrich, near Lake Thun.	24				Probably crystalline schist	Resort. Ref. 30.
10	Pfaefers (Pfafers)	35–40	5,760	428	Ca (55); Na (29); HCO_3 (236); SO_4 (30); Cl (34); dissolved N_2.	Mesozoic schist and limestone.	Resort; water also piped 4 km north to Ragaz (Ragatz) resort. Refs. 30, 1285, 1291, 1669, 1687, 1699, 1892, 2369, 2386.
11	Lavey-les-Bains	45–47.3	40	1,148 (hottest)	Ca (52); Na (275); HCO_3 (112); SO_4 (423); Cl (181).	Base of alluvium overlying schist.	Water obtained from wells. Radioactive. Small amount of free oxygen. Resort. Refs. 30, 1687, 2354, 2355, 2363, 2376.
12	Bovernier	21		Low		Crystalline rock	Bathing.
13	Saxon	25	200–800	760		Mesozoic strata	Flow varies with the season. Bathing. Ref. 1687.
14	Leukerbad (Loeche-les-Bains).	39–51.3	10,000–12,000	2,028 (hottest)	Ca (460); Mg (60); HCO_3 (149); SO_4 (1,285); free gas, 98 percent N_2.	Dogger limestone (Middle Jurassic).	The Ca and SO_4 probably are derived from Triassic gypsum; moderate radioactivity from underlying granite. Resort. Refs. 30, 571, 1285, 1291, 1669, 1687, 1699, 2364, 2373, 2375.
15	Ehemalig (former Brigerbad.)	30		650		Crystalline rocks	Bathing.
16	Acquarossa	25.3	430	2,551	Ca (500); Mg (105); HCO (530); SO_4 (1,303); dissolved gas, chiefly CO_2.	Triassic dolomite	Resort. Ref. 1293.
17	Vals	25	600	2,075	Ca (473); Mg (60); HCO_3 (459); SO_4 (1,040); free and dissolved CO_2.	do	2 wells, bored in 1899 to depths of 80 and 130 meters. Refs. 1293, 1294.
18	Innerferrera	24			$CaSO_4$	Probably crystalline	Mineral character probably derived from strata overlying schist. Local use.

YUGOSLAVIA

Yugoslavia includes Serbia, Croatia, Montenegro, and Macedonia and covers the northwestern part of the Balkan Peninsula. The Karawanken Alps extend along the northwestern border, and most of the country forms an upland area between these mountains and minor mountains along its southeastern border. In the east the Morava, or March, River cuts through the mountains. Along the Danube River, which forms part of the eastern boundary, there is much low swampy land. The mountain regions are composed largely of granite and other crystalline rocks flanked by marine Paleozoic formations; but some areas between the mountain ranges are of Cretaceous limestone that forms a karst topography. In these areas there are many springs, some of which are slightly thermal; but the principal thermal springs of the country are in the more mountainous areas, as shown on figure 41. Information on the several springs is given in the table below.

Thermal springs and wells in Yugoslavia

[Data chiefly from refs. 1304, 2410, 2414. Principal chemical constituents are expressed in parts per million]

No. on fig. 41	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Veldes	26.6					Bathing. Ref. 1293.
2	Topolschitz	31 (max)	3,000	351	Ca, HCO_3	Pliocene coal-bearing beds overlying Triassic limestone.	In Bad Neuhaus thermal zone. Resort; sanatorium. Ref. 1304.
3	Bad Neuhaus bei Cilli	26.5–37	475	444	Ca, HCO_3	Tertiary limestone overlying Mesozoic dolomite.	Known to the Romans. Resort. Refs. 1304, 2431.
4	Vhrinka	Warm					Resort.

Thermal springs and wells in Yugoslavia—Continued

No. on fig. 41	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
5	Gallenegg	26 (max)		363	Ca, Mg, HCO_3	Miocene strata overlying Triassic limestone.	Developed A.D. 1687. Resort. Ref. 1304.
6	Römerbad	36.3		2,808	Ca, Na, HCO_3, SO_4, Cl. (Reported H_2SiO_3, 1,128).	Paleozoic schist	2 springs; known to the Romans. Refs. 1304, 1310.
7	Franz Josef-bad (Tuffer)	37.5		452	Ca, Mg, HCO_3	Tertiary strata and andesite tuff overlying Triassic limestone.	Bathing resort. Ref. 1304
8	San Stefano	37 (max)	360	3,053	Ca, Na, HCO_3; Cl (1,467)	Eocene flysch near karst limestone.	3 springs; known to the Romans. The water is radioactive. Resort. Refs. 30, 1304, 2420.
9	Sutinskie Toplice	36.2 (max)	1,100	386	Ca, HCO_3	Jurassic limestone	Resort. Ref. 2431.
10	Varaždinske (Warasdin) Toplice.	57			Ca, Na, HCO_3, SO_4, Cl	Tertiary molasse	Ancient Aquae Jassae. Sulfur spring baths. Refs. 2394, 2431.
11	Krapinske Toplice	41.8; 43		Low			Sulfur baths. Ref. 2431.
12	Stubicke Toplice	49.8		470	Ca, Na, HCO_3, SO_4		Water contains Zn, Cu. Resort. Refs. 2392, 2412, 2431.
13	Samobar	Warm			Ca, Mg, HCO_3		Sulfur baths. Refs. 2402, 2431.
14	Bukovicka Banja	25			Ca, Na, HCO_3		Bathing resort. Refs. 2399, 2407.
15	Topusco	50–60.5		440	Ca, HCO_3, SO_4	Tertiary sandstone	3 main springs. Resort. Refs. 2425, 2431.
16	Sisak	Warm					Water has high fluoride content. Resort. Ref. 2393.
17	Daruvar	42.2; 46.6		Low			2 springs; water has high fluoride content. Ancient Aqua Balissae. Resort. Refs. 2393, 2404.
18	Lipik	64			Ca, HCO_3, SO_4, Cl		Water has high fluoride content. Resort. Refs. 2393, 2401, 2405, 2431.
19	Vrdnik	Warm		886	Ca, Na, HCO_3, SO_4		Resort. Ref. 2406.
20	Lešce	34			Ca, Mg, HCO_3, SO_4		Resort. Ref. 2411.
21	Luka Banja	Warm					Bathing resort.
22	Smadran Bara	Warm					Sulfurous. Resort. Ref. 2399.
23	Spalato (Split)	22	1,400	35,350	Na (10,877); Cl (18,780)	Eocene flysch	Known to Romans. Resort; sanatorium. Ref. 1304.
24	Ilidza	Warm					Resort. Ref. 2409.
25	Rogatsch (Rogaška Slatina)	Warm					Resort. Refs. 2400, 2415, 2421–2424.
26	Arandjelovac	16			Na, HCO_3		Classed as slightly thermal. Resort. Ref. 2426.
27	Velika Plana	Warm					Resort. Ref. 2403.
28	Čačak (Tchatchak)	Warm					Sulfurous. Resort. Ref. 2399.
29	Mokosica	22.5				Bituminous chalk	Resort. Ref. 2408.
30	Ribarska Banja	35–37.5					Slightly sulfurous. Bathing resort. Refs. 2399, 2431.
31	Raska	Warm					Bathing.
32	Vranjacke Banja	Warm					Bathing resort. Ref. 2431.
33	Brestovacka Banja	Warm					Do.
34	Hamsigrad (Gamsigrad)	30			HCO_3		On bank of Timok River. Resort. Ref. 2399.
35	Soko Banja	Warm					Water is radioactive. Bathing resort. Refs. 2395, 2418, 2431.
36	Niska Banja (Niss)	41–46	425 (main spring)				Ruins of Roman baths. Resort. Refs. 2398, 2399.
37	Wrntze	27					Much free CO_2. Bathing. Ref. 2399.
38	Yochanitza	76–78					Bathing. Ref. 2399.
39	Vranje Banja	87.5					Bathing resort. Ref. 2399.
40	Strumicka Banja	72–72.8			Na, SO_4		More than 20 wells. Bathing resort. Ref. 2397.

AFRICA

ALGERIA AND TUNISIA

Algeria and Tunisia, which comprise much of northern Africa, border the south side of the Mediterranean Sea. The two countries have similar climatic and geologic conditions and may conveniently be considered together.

The rugged range of the Maritime Atlas, or Kabylia Mountains, closely borders most of the coast of Algeria, and cliffs or hills rise abruptly from the seashore. The mountains are composed almost entirely of metamorphic rocks, the most ancient in Algeria. Along the northeastern part of the coast the mountains recede a few miles, and there are some low sandy areas. To the south, and nearly parallel with the coastal range, the Tellian Atlas Mountains extend eastward from Morocco.

The Tellian Atlas ranges are composed chiefly of folded Mesozoic and Tertiary strata. South of these mountains is a broad high plateau region containing many undrained saline lakes and marshes. The rocks in this region are somewhat folded and much faulted, for there are both downwarps and horst blocks. The rocks of these uplands consist mainly of marine deposits of Cretaceous and later ages, but include some continental deposits. Beyond the plateau belt is the Saharan Atlas Range composed of folded Tertiary strata. The southern front of this range descends steeply to the Sahara Desert, a vast expanse of plains underlain chiefly by Miocene and Pliocene deposits. Tertiary volcanic rocks are present at many places in the mountain areas.

The northern and northwestern parts of Tunisia are mountainous and well watered. The central plateau

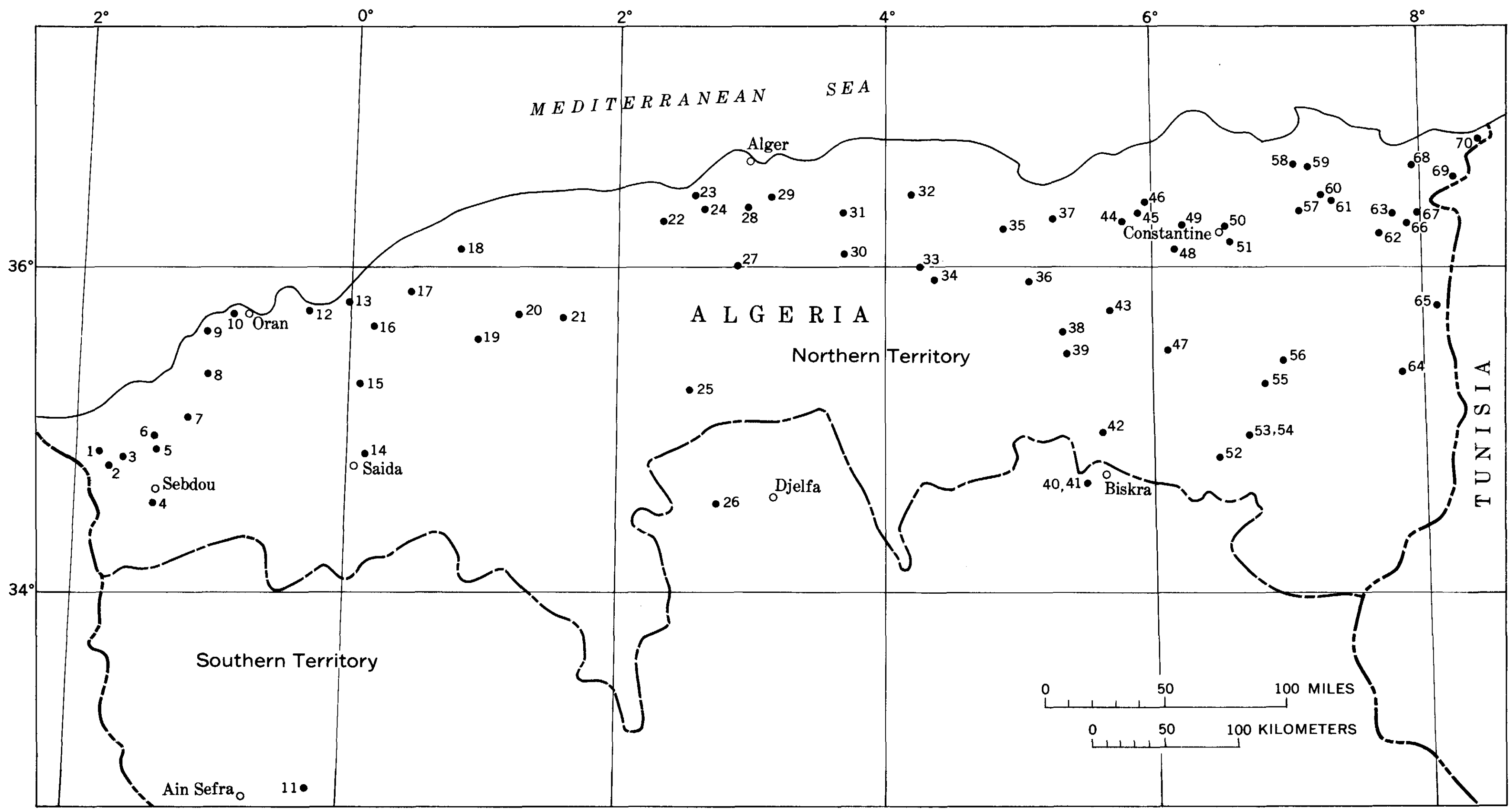

Figure 42.—Northern part of Algeria showing location of thermal springs. From refs. 2448, 2449, 2455.

region farther south is more arid and is crossed by an eastern extension of the Saharan Atlas Mountains. Another branch of the range extends southeastward. The northern part of the eastern coastal belt is a lowland region 50 to 100 km wide, which is fertile and fairly well watered. In its middle part are several oases, but the belt narrows southward, where there are brackish marshes and shallow intermittent lakes. The southern part of the country is within the Tunisian Sahara, but there are some upland areas, chiefly in the extreme southeastern part.

The northern mountains are composed chiefly of marine strata of Late Triassic through Jurassic ages. Much of central Tunisia is underlain by Lower Cretaceous formations. Upper Cretaceous strata are exposed near the coast, and Miocene and Pliocene beds of sandstone and marl underlie most lowland areas. The Tunisian Sahara is underlain largely by Quaternary sand and gravel.

Many noted thermal springs rise in Algeria. Several were developed as bathing places during Roman times, and they are still well-patronized resorts. According to Hanriot (ref. 2455), there are 77 groups of mineral springs in Algeria; of these, 64 are classed as thermal.

There are several groups of thermal springs in the mountainous belt that crosses northern Tunisia. The most accessible of these springs were developed in ancient times as bathing resorts and have been in nearly continual use down to the present. Another region of thermal springs is in the south-central part of Tunisia where numerous springs, both thermal and of normal temperature, issue along the borders of saline flats, especially at Shat-el-Jerid. These and the northern springs are described in a comprehensive report by Berthon (ref. 2436).

Information on the thermal springs in Algeria and Tunisia is summarized in the two tables below. The locations of the springs are shown on figures 42 and 43.

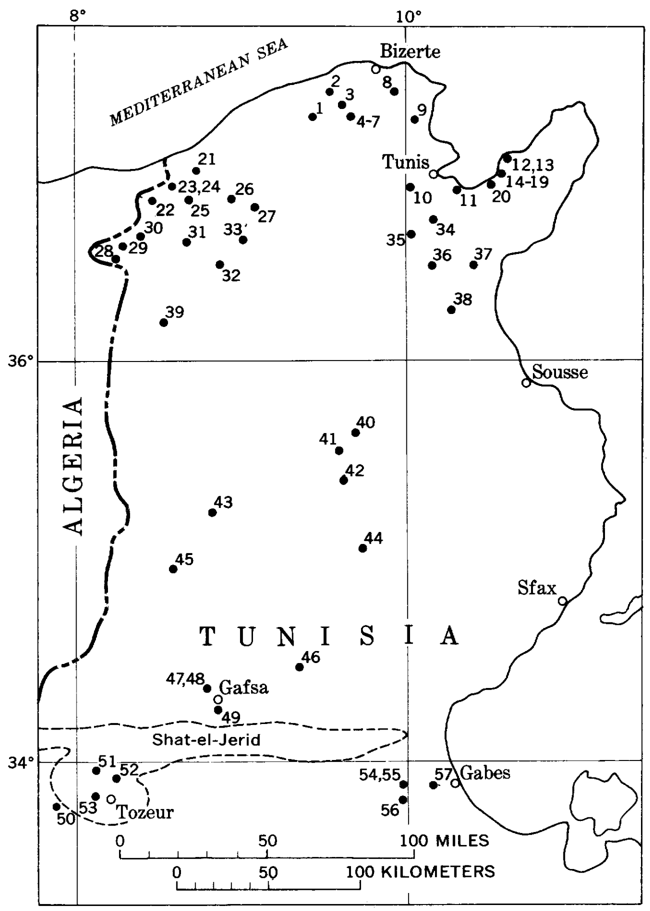

FIGURE 43.—Northern part of Tunisia showing location of thermal springs. From ref. 2436.

Thermal springs and wells in Algeria

[Data chiefly from refs. 2448, 2449, 2455. Location of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 42	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Hammam Ben Chiguer (Sidi Chirgh).	26.3–33	40	3,075	Ca, Na, HCO_3, Cl	Faulted Miocene strata	Many springs. Water used for bathing.
2	Hammam Bou Ghrara (Ghara).	43.4–45.7	720	404	Ca, Na, HCO_3, Cl		4 springs. Water used for bathing. Ref. 2432.
3	Ain Bel Kheir	35	200	1,090	Ca, Na, HCO_3, SO_4, Cl		Water used for bathing.
4	Hammam de Sebdou	22.5	Large	450	Ca, Mg, HCO_3, Cl		Several springs. Water used for bathing.
5	Hammam Tihammamine	21.8	Large	392	Ca, Mg, Na, HCO_3		Water used for bathing.
6	Hammam Tahammamit (Ouled Raou).	31.2		381	Ca, Mg, Na, HCO_3		4 springs. Water used for bathing.
7	Hammam Ouled Sidi Abdelli (Les Abdellys).	33.3–33.7	500	237	Ca, HCO_3, Cl; free H_2S, CO_2.		3 main springs. Water used for bathing. Ancient Roman baths.
8	Hammam Bou Hadjar	19–75	Large	3,414–4,890	Ca, Na, HCO_3, Cl	Quaternary deposits overlying Triassic(?) strata.	30 springs. Main spring (75°C) flows 210 liters per minute. Tufa deposited in mounds. Resort and infirmary. Refs. 2432, 2477, 2486.
9	Ain Madagre	30.7	20	2,126	Ca, Na, HCO_3, SO_4, Cl		Water contains 1.1 ppm of As_2O_3. Used for bathing.
10	Hammam Sidi Dederop (Bains de la Reine).	55	60	10,223	Na, Cl		Water contains 64 ppm Br. Resort. Ref. 2432.
11	Ain el Ourka	42.5; 46.5		5,609	Ca, Na, SO_4, Cl	Faulted Triassic strata	2 springs. Water used for bathing. Ref. 2461.
12	Hammam Selama	35; 37	38	14,260	Ca, Na, HCO_3, SO_4, Cl		2 oil test wells. Gypsum penetrated at depth of 272 meters. Water contains 50 ppm of BO_3. Tufa deposited. Resort.

Thermal springs and wells in Algeria—Continued

No. on fig. 42	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
13	Ain Nouissy	20.2	10	14,765	Na, Cl		Water used for bathing. Ref. 2432.
14	Hammam Ouled Khaled (Nazereg).	45–49	480	1,833	Ca, Na, SO_4, Cl; free H_2S, CO_2.	Faulted Jurassic marl	Many springs. Water used for bathing.
15	Hammam Bou Hanifia, (Hanéfia, Sidi Hanefiah).	42–66	600	1,314	Ca, Na, HCO_3, Cl	Lower Eocene marl	20 springs in 3 groups. Resort. Ancient Roman baths. Refs. 2432, 2433.
16	Ain Keberta	24.5	5	4,319	Ca, Na, SO_4, Cl; free H_2S	Cretaceous limestone	Water used for bathing.
17	Hammam Sidi Bou Abdallah.	44.5–50.5	40	1,025	Ca, Na, HCO_3, Cl; free H_2S		4 groups of springs. Water used for bathing.
18	Ain Mekeberta	20.5	10	6,658	Ca, Na, SO_4, Cl		Resort. Ancient Roman baths.
19	Hammam Sidi Mohamed	30.4	700	23,076	Ca, Na, K (595), SO_4, Cl		Water used for bathing.
20	Ain Mentila (Mentilla, Mentil).	33	13	59,522	Ca, Na, SO_4, Cl; free H_2S	Upper Cretaceous marl	Several springs. Water used for bathing. Ref. 2486.
21	Hammam Ouled Ghalia (Beni-Hindel).	36–40	100	2,444	Ca, Na, SO_4, Cl; free H_2S	Cretaceous marl	2 main springs. Water used for bathing.
22	Hammam Righa (R'hira, Rira, Rirha, Merega).	37–67	120	2,466	Ca, Na, SO_4, Cl	Miocene strata	10 springs. Resort and military hospital. Aquae Callidae Colonia of Romans. Refs. 2432, 2445, 2486, 2487.
23	Source Leblanc	24	10	1,610	Ca, Na, HCO_3, Cl	Pliocene strata	Well 80 meters deep.
24	Ain Garca	17	1	1,710	Ca, Na, HCO_3, SO_4		Water used for drinking.
25	Hammam Zerguin	25–42	Small	6,350	Ca, Na, SO_4, Cl; free CO_2	Eocene(?) limestone	Water used for bathing.
26	Hammam de Djelfa	28–41		1,632	Ca, Na, HCO_3, SO_4, Cl		13 springs. Water used for bathing.
27	Hammam Berrouaghia (Berrouaguia).	35; 44	60	1,508	Na, HCO_3, SO_4, Cl	Cretaceous sandstone	2 springs. Water used for bathing. Ref. 2432.
28	Hammam Melouane, 34 km south of Alger (Algiers).	27–39.5	1,220	29,422	Ca, Na, SO_4, Cl	Faulted Cretaceous marl	3 springs. Resort. Refs. 2432, 2477, 2486.
29	Ain M'ta Melah	18	20	12,800	Na, Cl		Water used for bathing.
30	Hammam Ksenna	38–70	Large	5,466	Ca, Na, SO_4, Cl; free H_2S	Upper Cretaceous strata	4 springs. Resort.
31	Ain Ben Haroun	19	50	3,312	Ca, Na, HCO_3, SO_4, Cl; free CO_2.	Upper Cretaceous marl	Water used for drinking. Ref. 2432.
32	Ain Souk el Arba	19	60	120	Fe_2O_3 (31)		
33	Hammam el Biban (Oued Chebba).	80–90	60	15,435	Ca, Na, SO_4, Cl; free H_2S	Upper Cretaceous marl	Water used for bathing.
34	Hammam Mansourah (Azigal).	25; 26	20		HCO_3; free H_2S	Faulted Miocene strata	2 springs. Water used for bathing.
35	Hammam Guergour (Sidi el Djoudi).	41.2–48	Large	3,521	Ca, Na, SO_4, Cl	Faulted Triassic strata	13 springs. Resort. Ancient Roman baths. Refs. 2432, 2473.
36	Hammam Bou Sellam (Ouled Yelles).	38.5–49	18	1,399	Ca, Na, SO_4, Cl; free H_2S	Fault between Cretaceous and Triassic strata.	Water used for bathing.
37	Source Takitount (Ain Hamza).	18–21.7	12,500	2,210	Ca, Na, HCO_3, Cl	Upper Cretaceous strata	Water used for drinking. Ref. 2432.
38	Hammam Bou Taleb (Thaleb, Ouled Sefian).	49–50	20	3,150	Ca, Na, SO_4, Cl	Triassic strata	5 main springs. Water used for bathing. Ref. 2432.
39	Hammam Gosbate (Gridjima).	40.8	Large	4,968	Ca, Na, HCO_3, Cl; free H_2S		Water used for bathing.
40	Hammam Salahine (Salahin).	43–44.9	1,380	9,159	Ca, Na, HCO_3, SO_4, Cl; free H_2S.	Cretaceous clay	Tufa deposited. Resort. Refs. 2432, 2468.
41	Hammam G. Rule, 0.5 km southeast of Hammam Salahine.	21.3	Large				Free H_2S.
42	Hammam Sidi el Hadji	Warm		3,020	Mg, Na, SO_4, Cl		Water used for bathing.
43	Ain Sokhna (Sukhna)	42.6–45.4	Small	2,018	Ca, Na, SO_4, Cl; free H_2S	Pliocene strata overlying Triassic strata.	Several springs. Water used for bathing.
44	Hammam Bou Akkaz	39.5	50	2,724	Ca, Na, HCO_3, SO_4, Cl	Upper Cretaceous limestone	Large deposits of tufa. Water used for bathing. Ruins of Roman baths.
45	Hammam Beni Cuecha (Rocher Rouge).	40.7–53.2	15	16,876	Ca, Na, SO_4, Cl; free H_2S	Oligocene and Miocene sandstone.	3 main springs. Large deposits of tufa.
46	Hammam Bou Hallouf	45	85	3,260	Ca, SO_4, Cl		Water used for bathing.
47	Hammam Bou Hilip (Ain Kasserou).	33.9	600	500	Ca, Na, HCO_3, Cl; free H_2S		Do.
48	Hammam Grous	33–37.6	Large	1,160	Ca, Na, SO_4, Cl	Fault between Cretaceous and Triassic strata.	Do.
49	Ain Djebel Leckhal (Lekhal, Tinn).	31.7	Large	553	Ca, HCO_3, SO_4	Cretaceous limestone	Do.
50	Ravin du Rummel	29.5–31	4,000	785	Ca, Na, HCO_3, SO_4, Cl		Do.
51	Source du Hamma (Le Hamma).	33.5–36.5	Large	729	Ca, Na, HCO_3, Cl	Cretaceous limestone	3 main springs. Ref. 2443.
52	Hammam Chaboura	39	Large	1,430	Ca, Na. HCO_3, SO_4, Cl; free H_2S.		Sulfur deposited. Water used for bathing.
53	Ain Tamersit Keirgis	25.6	100	1,197	Ca, Na, HCO_3, SO_4, Cl; free H_2S.		Water used for bathing and irrigation.
54	Ain Tamersit Guerbir	25.6	90	1,320	Ca, Na, HCO_3, SO_4, Cl; free H_2S.		Sulfur deposited. Water used for bathing.
55	Hammam Kinif	45	Small				Vapor vents. Much free CO_2; deposits of $BaCO_3$.
56	Hammam des Amamrhas	58–65		2,190	Ca, Na, HCO_3, SO_4, Cl; free H_2S.	Lower Cretaceous quartzite	Water contains 7.3 ppm of Li. Water used for bathing. Aqua Flaviana of Romans.
57	Hammam Meskoutine (Hammam Meskouten, Hammam-Mez-Koutin, Ham-am-escoutin, Bains Maudit), 18 km from Guelma.	72–98	6,000	1,466	$MgCO_3$ (257); $MgSO_4$ (176); $MgCl_2$ (416); NaCl (416); KCl (79); gas, 97 percent CO_2, 2.5 percent Na, 0.5 percent H_2S.	Faulted lower Eocene strata	8 main springs; hottest flows 1,800 liters per minute. Water contains 6.5 ppm As. Large deposits of tufa containing pisolites of aragonite. Cloud of steam. Bathing resort. Aquae Tibilitnae of Romans. Refs. 30, 1568, 2432, 2433, 2435, 2437, 2438, 2440, 2447, 2453, 2454, 2461, 2464, 2466, 2467, 2470, 2474, 2476, 2477, 2486, 2492, 2493–2495.
58	Hammam Oued Hamimine	40.5–47.2	Large	2,391	Ca, Na, HCO_3, SO_4		13 springs. Resort. Refs. 2463, 2486.
59	Hammam du Djendel	42–43		2,242	Ca, Na, SO_4, Cl; free CO_2, H_2S.		Water used for bathing. Ancient Roman baths.
60	Hammam Oued Ali (Hammam des Biban), 12.4 km northwest of Guelma.	49.7–56.7; 90	Large	1,264	Ca (272); CO_3, (480); SO_4 (618); gas, 80.4 percent, N_2, 19.6 percent CO_2.		2 groups of springs. Water used for bathing. Ref. 2475.

Thermal springs and wells in Algeria—Continued

No. on fig. 42	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
61	Hammam Bradaa (Braada, Ain Berda), at northeastern end of Mount Debahr.	28–29.4	8,000	371	$CaCO_3$ (200); $MgCO_3$ (37); Na_2SO_4 (53); NaCl (22); gas, 86 percent N_2, 17 percent CO_2, 2 percent O_2.	Faulted Upper Cretaceous marl.	Tufa deposited. Water used for irrigation. Ancient Roman baths. Refs. 2462, 2492, 2494, 2495.
62	Hammam N'Bails (Nador)	30–42	500	5,839	Ca, Na, HCO_3, SO_4, Cl	Fault between Cretaceous and Triassic strata.	Large deposits of tufa. Water used for bathing. Ancient Roman baths. Ref. 2432.
63	Hammam Reguema	49.8		1,090	Na, HCO_3, SO_4, Cl		Water used for bathing. Ancient Roman baths.
64	Hammam Youks les Bains	33.5–35	50	430	Ca, HCO_3, SO_4; free H_2S	Upper Cretaceous limestone	Do.
65	Hammam Sidi Yahia	34.6	Small	10,378	Na, Cl		Water used for bathing.
66	Hammam Tassa	39–40.6	Large	1,992	Ca, Na, HCO_3, Cl; free H_2S	Upper Cretaceous limestone	Water used for bathing. Ruins of Roman baths.
67	Hammam Zaid	39–41.4	Large	1,015	Ca, Na, HCO_3, Cl; free H_2S	Fault between Eocene and Triassic rocks.	4 main springs. Resort.
68	Hammam Sidi Djaballah	31.6; 37.1		986	Na, SO_4, Cl		2 springs. Water used for bathing. Ref. 2432.
69	Hammam Sidi Trad	60.7; 63.9		424	Ca, Na, HCO_3, Cl		Do.
70	Ain Sidi el Adjene	34.9; 35.6	50	512	Ca, Na, HCO_3, SO_4, Cl		2 springs. Water used for irrigation.
	Ain Djeraba						Water is sulfurous.
	Ain Kçar el Tir	Warm					
	Ain Sfa	Warm					
	Hammam de la Barbinais						Do.
	Hammam Boughara	29		405	Ca, Na, HCO_3, Cl		
	Hammam Bou Ilef	40					
	Hammam Dalsaa	35					Water is sulfurous.
	Hammam Ibaïnen	35–50					Water is saline.
	Hammam Oued Kçob (Sidi Larbi).	30–35					Water is sulfurous.
	Hammam Ouled Tebben	Hot					Water is ferruginous.
	Hammam Sidi M'Cid (Mescid).	33		778	Ca, Na, HCO_3, Cl		Several springs. Water used for bathing. Ref. 2437.
	Megris	30					

Thermal springs and wells in Tunisia

[Data chiefly from ref. 2436]

No. on fig. 43	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Hammam Ahmed ben Medjoub.	27	0.2		Ca, Na, SO_4, Cl	Lower Eocene strata	
2	Ain Zitouna	22	Small		Ca, Mg, SO_4, Cl	Lower Cretaceous strata	
3	Hammam el Atrous	47	Small		Na, Cl	Cretaceous dolomite	Several springs.
4	Hammam ben Abbes	27	Small		Ca, Na, SO_4, Cl	Faulted Cretaceous dolomite.	
5	Hammam Abd el Kader	27	Small		Ca, Na, SO_4, Cl	do	
6	Hammam el Dherab	27	Small		Ca, Na, SO_4, Cl	do	
7	Hammam el Chfaa	27	Small		Ca, Na, SO_4, Cl	do	
8	Hammam el Tella Merzoug	20.5	42	10,960	Ca, Na, SO_4, Cl	Upper Miocene strata	
9	Ain el Hammam, at ruins of Utica.	34	Large	1,840	Na, Cl	Alluvium	Source of water supply. Ref. 2480.
10	Ain Oued El-Lil	21.5	96	4,004	Ca, Na, HCO_3	Upper Cretaceous strata	
11	Hammam Lif (Leef)	43; 50	245	14,825	Na, SO_4, Cl	Jurassic strata	2 springs. Refs. 2432, 2454, 2459, 2487, 2489, 2491.
12	Ain Kalaa Srira (Fguil)	42; 45	108	11,200	Ca, Na, SO_4, Cl	Faulted upper Eocene strata	2 springs on seashore.
13	Ain el Atrous	60	1,150	11,140	Ca, Na, SO_4, Cl	Upper Eocene strata	
14	Ain Chefa, at Korbous	58	75	11,567	Ca, Na, SO_4, Cl	do	Ancient Roman baths.
15	Ain Kebira (Kelbia), at Korbous.	50	557	11,500	Ca, Na, SO_4, Cl	do	Ref. 2469.
16	Ain Haraga, at Korbous	45.5	25	11,030	Ca, Na, SO_4, Cl	do	
17	Ain Sbia, at Korbous	50.2	42	11,010	Ca, Na, SO_4, Cl	do	
18	Ain Fakroun, 1 km north of Korbous.	25	114			do	On seashore.
19	Ain Sidi Messaoud	45	60			do	Do.
20	Ain el Okteur, 5 km southwest of Korbous.	22	1.6	2,475	Na, Cl	do	Source of water supply.
21	Ain el Hammam (Tabarka)	35	180		Ca, Na, Cl	Quaternary strata	
22	Bordj el Hammam	39–48.5	92		Ca, Na, Cl; free H_2S	Upper Eocene strata	3 springs. Water used for bathing.
23	Kef el Hammam	39–51	325			do	3 springs.
24	Ain el Hammam (Kof)	29	21			Alluvium	
25	Hammam Salahine (Gouaidia).	46.5; 70	66		Ca, Na, Cl; free H_2S	Upper Eocene strata	2 springs.
26	Hammam des Ouled ben Salem.	30–40	Small		Ca, Na, Cl	Lower Eocene strata	
27	Hammam Seiala, 8 km southwest of Beja.	46	.5		Ca, Na, SO_4, Cl	Lower Miocene strata	Water supply for town.
28	Hammam des Ouchtetas	44.5	240			Upper Eocene strata	Water is sulfurous. Used for bathing.
29	Hammam des Ouled Ali	40	30		Na, Cl	do	At Colonia Thuburnica of ancient Romans.
30	Hammam el Fouzoua	30	180		Ca, HCO_3, SO_4	Lower Miocene strata	Water used for irrigation.
31	Hammam de Bulla Regia, 9 km morth of Souk el Arba.	26	300		Ca, Na, Cl	Lower Eocene strata	Water supply for town.
32	Hammam Biada	45	120		Na, SO_4, Cl	Triassic strata	2 springs. Water used for bathing.
33	Hammam des Ouled Abbed	44	18		Ca, Na, Cl	Eocene strata	
34	Ain Ziga	22	360		Ca, SO_4, Cl	Lower Eocene strata	Part of water supply for Tunis. Ref. 2469.
35	Ain Djebel Oust	54.5	9	17,847	Ca, Na, SO_4, Cl	Faulted Cretaceous strata	Large deposits of tufa. Ancient Roman baths.

Thermal springs and wells in Tunisia—Continued

No. on fig. 43	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
36	Hammam Zriba	46	360	5,472	Ca, Na, SO_4, Cl	Upper Cretaceous strata	Large deposits of tufa. Resort. Ref. 2469.
37	Hammam Jedidi (Djdidi)	61	830	19,310	Ca, Na, SO_4, Cl	Faulted Triassic strata	2 springs and shallow well. Water used for bathing. Ref. 2469.
38	Ain Garci	22	18		Ca, Mg, Cl	Upper Cretaceous strata	
39	Hammam Mellegue	38	40		Ca, Na, Cl	Middle Cretaceous strata	
40	Source du Trozza Nord	Warm	Small			Lower Cretaceous strata	Water is sulfurous. Ref. 2454.
41	Source du Trozza Sud	Warm	Small			do	Do.
42	Hammam Sahline	65	66		Na, Cl	Quaternary strata	Water used for bathing.
43	Hammam Zebbess	35	150		Ca, Mg, SO_4, Cl	Upper Miocene strata	Do.
44	Ain Rebaou	28	4,000			Contact of Eocene strata with underlying Cretaceous strata.	Water used for irrigation.
45	Ain Feriana	Warm	Large			Alluvium	Water used for irrigation. Refs. 2480, 2491.
46	Hammam Djebel Meich	36.5	Large		Ca, Na, SO_4, Cl	do	Water used for irrigation.
47	Ain Sidi Ahmed Zaroug	26.5; 29	420		Ca, Na, SO_4, Cl	Cretaceous strata	2 springs. Water used for bathing.
48	Ain Dar-el-Bey, at Gafsa	31–37.5	9,000	335	Ca, Mg, Na, HCO_3, SO_4, Cl.	Upper Miocene strata	3 main springs. Water used for irrigation. Ancient Roman baths. Refs. 2454, 2456, 2458, 2459, 2480, 2487, 2491.
49	Ain Faouara	31	1,800		Ca, Mg, Na, HCO_3, SO_4, Cl.	do	Water used for irrigation. Refs. 2487, 2491.
50	Ain Nefta	27.5–30	70,000	405	Ca, Mg, Na, HCO_3, SO_4, Cl.	do	Water used for irrigation. Ref. 2454.
51	Ain el Hamma du Djerid	30; 45	Large		Ca, Mg, Na, HCO_3, SO_4, Cl.	do	2 springs. Water used for irrigation.
52	Ain El Oudiane	30	360			do	Water used for irrigation.
53	Ain Tozeur (Touzer)	27.5–30	60,000	312	Ca, Mg, Na, HCO_3, SO_4, Cl.	do	Water used for irrigation. Ref. 2454.
54	Ain el Bordj	47	10,800	3,405	Ca, Na, SO_4, Cl	do	Water used for irrigation. Ref. 2454.
55	Ain Seba, in El Hamma oasis.	39–47.5	Large	1,920	Ca, Na, SO_4, Cl	do	Much free gas. Water used for irrigation. Ref. 2459.
56	Ain el Hamma	37–57	Large	3,369	Ca, Na, SO_4, Cl	do	Spring and wells. Water used for irrigation. Refs. 2436, 2439.
57	Ain Saada	29–30	Large			do	Spring and wells. Water used for irrigation. Ref. 2454.

ANGOLA

Angola has a rather arid coastal plain 50 to 150 km wide bordering the Atlantic Ocean. From this plain the country rises in irregular steps to rolling well-watered plains of the central African plateau. The northeastern part drains to the Congo River, and the southeastern part consists largely of sandy desert within the basin of the Zambezi River. The highest lands are in the district of Benguela in the southwestern part.

The central plateau is chiefly of ancient crystalline rocks, which include granite in some areas. These older rocks are overlain largely by Paleozoic sandstone and conglomerate, and wide areas are covered by laterites. An upland zone, approximately parallel to the coast, is largely of granite and other crystalline rocks which are covered in many areas by ancient sedimentary rocks. The coastal zone is largely of Cretaceous and Tertiary formations overlying pre-Cretaceous red sandstone. Recent eruptive rocks form hills at several places in the district between the cities of Benguela and Mossamedes not far from the coast. A volcanic mountain called Coculo-Cabaza, south of the Kwanza (Cuanza) River, probably is the Zambi volcano of Fuchs (ref. 43). There probably are other areas of volcanic eruptions and lava flows.

The available data on the several thermal springs in the southwestern part of Angola are summarized in the table below. The locations of the springs are shown on figure 44.

Thermal springs in Angola

[Data from refs. 2497, 2498]

No. on fig. 44	Name or location	Temperature of water (°C)	Remarks
1	Andulo	Hot	In volcanic district of Bihi.
2	Chieuca	Hot	Do.
3	Ochilesa, on banks of Quime	45 (max)	Several springs issuing from fault. Water is alkaline. Terraces of tufa deposits.
4	Montipa, 50 km northwest of Lubango (Sã de Bandeira).	Warm	
5	Kitewe, 40 km northwest of Lubango (Sã de Bandeira).	Warm	On south side of Lunda anticlinal axis between Massamedes and Montipa.
6	North of Pediva	Warm	At foot of escarpment.
7	Kambeno, 10 km north of Kunene River and 85 km above river mouth.	Warm	Small amount of H_2S.

FIGURE 44.—Part of southern Africa showing location of thermal springs in Angola, Bechuanaland Protectorate, Burundi, Kenya, Mozambique, Northern and Southern Rhodesia, Nyasaland, Republic of the Congo, Rwanda, Tanganyika, and Uganda.

BELGIAN CONGO (REPUBLIC OF THE CONGO) AND RUANDA-URUNDI (REPUBLIC OF RWANDA AND KINGDOM OF BURUNDI)

The Belgian Congo or, since gaining its independence in 1960, the Republic of the Congo, occupies a large part of south-central Africa and is nearly all within the basin of the Congo River, which forms a part of the western border of the country. A comparatively small area in the northeast is tributary, through Albert Edward Nyanza [Lake] and Lake Albert, or Albert Nyanza, to the Nile River. Cliffs several thousand feet high along the western shores of Lake Tanganyika and Lake Kivu mark the great Western Rift Valley.

The Mfumbiro, or Kirunga, Mountains consist of many volcanic peaks, and north of Lake Kivu are lava flows that extend across the Western Rift Valley and form the drainage divide between the basins of the Congo and the Nile Rivers. The highest peak rises to an altitude of nearly 15,000 feet; this and several other high peaks are snow-covered during part of the year. In the southeastern part of the colony are several minor ranges. The coastal area at and near the mouth of the Congo River is bordered by highlands through which the Congo passes in rapids to the ocean. Nearly all the remainder of the great river basin is of rolling uplands that form part of the central African plateau.

Ruanda-Urundi or, since June 1962, the Republic of Rwanda and Kingdom of Burundi occupy a part of the plateau on the east side of the Western Rift Valley between Lake Tanganyika and Lake Kivu. It includes a part of the valley and its eastern escarpment and also a part of the lava area along the south flank of the Mfumbiro Mountains.

Crystalline and metamorphic rocks considered to be of Archaean age are exposed in the mountains of the southeastern part of the Republic of the Congo and also near the coast. In both regions the basal rocks are overlain by sandstone and grit intercalated with thick layers of lava. These rocks may be part of the thick Karroo system of Permian through Jurassic ages. Nearly all the plateau region also is underlain by the Karroo beds. Near the coast are marine strata of Cretaceous and Tertiary ages.

Data on the thermal springs in the Republics of the Congo and Rwanda and in Burundi are given in the table below. The locations of the springs are shown on figure 44.

Thermal springs in the Belgian Congo (Republic of the Congo) and Ruanda-Urundi (Republic of Rwanda and Kingdom of Burundi)

[Data chiefly from ref. 2508. Location of unnumbered spring not identified]

No. on fig. 44	Name or location	Remarks and additional references
	Belgian Congo (Republic of the Congo)	
1	Vicinity of Lake Albert:	
	Kaswa	Water is hot and sulfurous. Deposits of sulfur.
	Vicinity of Lake Albert—Con.	
	Mount Laba	Water is hot and sulfurous.
	Goda	Water and petroleum.
	Pandju	Water is saline.
2	Semliki River valley:	
	Zumbia (Kwaniwa?), on west side of valley.	Ref. 2590.
	East side of valley near base of Mount Ruwenzori:	
	Molinglingo	Water is sulfurous.
	Katuka	Water is sulfurous.
	Vyatungo	Water is sulfurous.
	Mutwanga	Water is sulfurous.
3	Bitagoha (Rutchuru), near Lake Edward.	
4	Lowa River basin	14 springs.
5	Lake Kivu volcanic area:	
	Sake	
	Katana (Kakondo), on border of lake.	Large deposits of tufa.
	Luiro	
	Near Kahusi volcano	Water, 60°C, rises in bathing pool. Much free CO_2. Large deposit of tufa. Ref. 2501.
6	Ulindi (Ilindi) River basin:	
	Nyaluindja	Water is sulfurous.
	Lualatshi	Water is sulfurous.
	Lubuka	Water is sulfurous.
	Eight other springs	
7	Ruzizi River valley:	
	Luwangi	
	Luvungi	
	Mokindwa	
	Minyove	
8	Elila River basin:	
	Mount Kasongo	Water is saline.
	Pene Kabonde	Water is saline.
	Tchavula	Water is saline.
	Kitutu	Water is sulfurous.
	19 other springs	
9	Lualaba River valley near Kibombo:	
	Kibimbi	
	Lufubu, on left bank of river.	Water is saline. Ref. 2506.
	Piani Mimba (Pene Sipo) group, 12 km west of Lufubu spring.	Water issues from schist. Total dissolved solids, 33,360 ppm. Principal chemical constituents: $CaSO_4$ (1,791 ppm); $CaCl_2$ (3,747 ppm); NaCl (18,494 ppm). Ref. 2506.
10	Luama River basin:	
	Basikabusi	Water is sulfurous.
	Basimakule	Water is sulfurous.
	15 other springs	
11	Luika River basin:	
	Muesse	
	Kilenga	
12	West side of northern part of Lake Tanganyika:	
	Uvira	Water is sulfurous.
	Mutambula	Water is sulfurous.
13	Pakundi, in Lukuga River basin.	
14	Tshapona, between Lomami and Luembe Rivers.	

Thermal springs in the Belgian Congo (Republic of the Congo) and Ruanda-Urundi (Republic of Rwanda and Kingdom of Burundi)—Continued

No. on fig. 44	Name or location	Remarks and additional references
	Belgian Congo (Republic of the Congo)	
15	Luvua River basin:	
	Kisabi	Water is saline.
	Luona	
	Mbalai	
	Sanga	
	Luiboso	
16	West side of southern part of Lake Tanganyika:	
	Rutuku	Water is saline. Ref. 2502.
	Kayungwa	
	Kakonta	
	Kianza, near Tampa	
	N'Ganza	
17	Vicinity of Lake Upemba:	
	Kafungwe	Water is sulfurous.
	Katapena	
	Konkula	
	10 other springs	
18	Lufira River basin:	
	Moashia	
	Tanda Mukola	
	Kashiba	
	Basumba	
------	Manjakito fault	Several springs. Water temperature about 60° C. Much free CO_2. Ref. 2501.
	Ruanda-Urundi (Republic of Rwanda and Kingdom of Burundi)	
1	Mashiosa, in Lake Kivu volcanic area	
2	Ruzizi River valley:	
	Kisange	
	Luha	

EGYPT, LIBYA, AND SUDAN

Egypt, Libya, and Sudan comprise a large part of the desert region of northeastern Africa.

The northwest coast of Egypt is bordered largely by cliffs, which rise to an uneven plateau on which are depressions occupied by minor oases. Nearly all the remainder of the country west of the Nile River is occupied by the Western, or Libyan, Desert. In this desert region are several large oases, notably those of Dakhla and Kharga, within which are natural springs. Water also is obtained from bored wells sunk to depths of 100–150 meters in sandstone. Flowing artesian water is obtained in some places.

The eastern part of Egypt is traversed for its entire length by the Nile River. The narrow Nile Valley below the Aswan (Assouan) dam, the Fayum area west of the Nile, and the Nile delta lands are supplied by irrigation canals from the river; these agricultural lands, however, constitute only about 3 percent of the total area of the country. The remainder is desert.

Between the Nile River and the Gulf of Suez, the Eastern, or Arabian, Desert consists chiefly of stony plateaus of Tertiary and Cretaceous strata. Older rocks are exposed in a few places. A mountain chain that borders the west shore of the gulf is largely of granitic rocks and is flanked on the coastal side by a narrow band of Tertiary strata that contain thick masses of gypsum in some places. Farther south, between Aswan and the Red Sea, the coastal mountains are largely of crystalline schist with intrusions of granite, diorite, and porphyry. The uplands west of Aswan are underlain largely by Nubian sandstone that is considered to be chiefly of Cretaceous age. In northeastern Egypt, the northern part of the Sinai Peninsula is composed largely of Cretaceous and older strata that are somewhat folded and are bordered by Tertiary strata. The surface rises southward to the high granitic mountains that form the backbone of the peninsula.

Part of the coast of northwestern Libya is low and sandy, and other parts that border the Gulf of Sidra are low; but much of the shore is bordered by cliffs that rise to coastal mountain ranges. These extend some distance inland to the plateau areas of Cyrenaica, or Barca, in the northeast, and Tripolitania in the northwest. From the eastern uplands the surface descends to the Libyan Desert, which occupies most of the southeastern part of the country. From the Red Hammada of the western plateau region, the country descends more steeply to the depression of Fezzan, which occupies the west-central part of Libya. Much of this area is below sea level, but rises southward to the higher lands of the Sahara Desert. The Barca plateau region is chiefly of Miocene limestone whose strata are somewhat folded. The northwestern uplands are largely of Cretaceous rocks, but Recent eruptives are reported in some places, including Takut (Tekuk) and Manterus volcanic peaks. Rocks of late Paleozoic age have been found in the Fezzan depression.

In the Cretaceous uplands are several oases with water of good quality at shallow depths. There are springs and flowing artesian wells at Ghadames and perhaps in other oases, but none are classed as thermal. Some oases with shallow water are in a long depression south of the Barca plateau. In the higher southeastern region, especially the Kufrah district, several large oases are spaced along a zone that extends for 300 km northwest-southeast. Water of only normal temperature is reported to be obtained in these places.

The entire length of the Sudan is traversed by the Nile River, but away from this stream and its main tributaries water is very scarce. The Nubian Desert in the northeast is a southern extension of the Arabian Desert of Egypt. Much of the northern region is an area of rocky mountains and plateaus of crystalline rocks which are overlain in many places by Nubian sandstone of Cretaceous(?) age. West of the Nile, a great plateau region forms part of the Libyan Desert. This region contains several oases, but water from the wells in these oases is reported to have only normal temperature.

Several hot or warm springs are present in Egypt. Three localities of warm springs have been reported in Libya, and warm springs issue at one place in the valley of the Nile near the north border of Sudan.

The available data on thermal springs in Egypt, Libya, and Sudan are summarized in the table below. The locations of the springs are shown on figure 45.

Thermal springs and wells in Egypt, Libya, and Sudan

[Data chiefly from ref. 2521. Principal chemical constituents are expressed in parts per million]

No. on fig. 45	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
				Egypt			
1	Ain el Sira, near Cairo	40		120,000	Mg, Na, SO_4, Cl	Eocene limestone	Water level in pool varies with height of Nile River; no surface outflow. Ref. 2516.
2	Helwân (Helouan les Bains), 25 km south of Cairo and 4 km east of Nile River.	23–34	165	4,890–25,126	Ca, Na, SO_4, Cl	Pleistocene deposits overlying faulted middle Eocene limestone.	3 main springs and 15 wells. Springs developed before 1600 B.C.; wells drilled in recent years. Bathing resort. Refs. 2510, 2517, 2523, 2525.
3	Ain Sukhna, 50 km southwest of Suez and 2 km from shore of gulf.	33	6,800	8,840	CaO (750); MgO (424); SO_3 (981); NaCl (6,142).	Upper Cretaceous limestone and Jurassic sandstone; faulted.	Springs rise in several pools near base of fault scarp. Ref. 2526; also field notes of G. A. Waring.
4	Ayun Musa, 25 km southeast of Suez:						
	No. 1	17	40	3,250	SiO_2 (60); CaO (476); MgO (94); SO_3 (483); NaCl (1,755).	Alluvium overlying marine Tertiary clay.	Issue from sand dunes. Known as "Springs of Moses." Water used for irrigation and refreshment of caravans. Refs. 2512, 2544; also field notes of G. A. Waring.
	No. 2	17		5,600	SiO_2 (24); CaO (640); MgO (97); SO_3 (555); NaCl (3,919).		
5	Hammam Faraun, on gulf shore.	71 (max)	Large	16,480	CaO (1,760); Mg (544); SO_3 (598); NaCl (14,320); free H_2S.	Faulted Eocene sandstone and limestone.	Many springs for 400 meters along shore, at base of cliffs. Known as "Baths of Pharoah." Water has petroliferous odor; may be partly sea water. Deposits of sulfur. Refs. 2512, 2522, 2524, 2805.
6	Hammam Saidna Musa (Moussa), 3 km north of Tor.	25	Small	9,330	$CaCO_3$ (1,034); H_2SO_4 (1,036); NaCl (6,347).	Faulted Cenomanian marl and limestone (Upper Cretaceous).	Several springs at base of hill. Known as "Baths of Moses, the Master." Water used for irrigation. Ruins of ancient baths. Refs. 2512, 2515.
7	Bowitti, near El Kasr in Bahariya Oasis (Oasis Parva).	33.7; 34.2	Moderate			Nubian sandstone (pre-Cretaceous?).	2 springs. Water used for irrigation. Refs. 2528, 2805.
8	Ain Dalla, 60 km west of Farafra Oasis.	Warm	Considerable			Cretaceous strata	Water issues from top of sandy mound in center of depression; sulfurous but palatable. Ref. 2511.
9	Near El Kasr (Qasr), on north border of Dakhla Oasis.	39				Cretaceous sandstone	Probably Ain Sheikh Mawhub, 10 km west of El Kasr. Refs. 2528, 2805.
				Libya			
1	Duga, near crest of Tarhuna Mountains and 75 km southeast of Tripoli.	Warm					Water is ferruginous. Ref. 2527.
2	Wadi Dernah	Warm					Extensive deposit of tufa. Ref. 2519.
3	Marada Oasis:						
	Ain el Braghi	29–30					Ref. 2513.
	Ain ez Zauia	Warm					
				Sudan			
1	Akasha	54			Na_2SO_4, NaCl		Several springs. Water used for bathing. Ruins of ancient baths. Refs. 2514, 2518, 2520.

Figure 45.—Northern Africa showing location of thermal springs in Egypt, French Equatorial Africa, French West Africa, Libya, Morocco, and Sudan.

ERITREA, ETHIOPIA, FRENCH SOMALILAND, AND SOMALI REPUBLIC

Eritrea, Ethiopia, French Somaliland, and the Somali Republic form the easternmost part of Africa.

The northern part of Eritrea, which forms a relatively narrow band along the southwest coast of the Red Sea, widens to include a plateau region west of the coastal range, but the southern half is limited chiefly to a belt of hills and coastal plain less than 80 km wide. This southern part, which lies within the great East African Rift Valley zone, contains large areas of arid plains in which are several lakes. Much of the drainage from regions farther south and west ends in salt plains and basins in this region, some basins being below sea level. In this part of the rift zone are also many lava flows and volcanic mountains. Southeast of Asmara a great lava field extends north and south from Alid volcano; farther southeast are several volcanoes that have been active in recent years. The mountains of the northern part of Eritrea are chiefly of gneiss and schist, whereas the plateaus farther west are largely of thick formations of sandstone and limestone, probably of Cretaceous age.

The western half of Ethiopia is a region of high plateaus above which rise several mountain ranges. Drainage is chiefly to the Blue Nile River and its tributaries. This high region is limited on the east by a remarkably straight north-south escarpment that marks the west side of the great East-African Rift Valley zone. Within this wide depressed belt much of the country is hilly. The Harar Hills form an east-west range that separates the drainage northward toward the Red Sea from that of the lower region, sometimes called Abyssinian Somaliland, whose streams flow south and southeast to the Indian Ocean. In the higher mountains of the northwest, Archaean gneiss and schist form the cores of the principal ranges which are flanked by Triassic(?) and Jurassic limestone and shale. Large parts of the plateau regions are covered by igneous rocks of Mesozoic age. The Harar Hills are largely of Tertiary limestone. Along the Rift Valley zone are many areas of Tertiary to Recent volcanic rocks.

French Somaliland is a comparatively small area at the entrance to the Red Sea and consists chiefly of elevated arid plains, mainly within the great East-African Rift Valley zone. Volcanic rocks border the west end of the Gulf of Tajura on whose shore is the seaport of Djibouti. A chain of saline lakes inland receives the flow of the principal river in a depression that is more than 100 meters below sea level. The saline lake of Bahr Assal is in this low area.

The Somali Republic, which formerly was British Somaliland and the Somaliland Trust, forms a scissor-like band between the eastern section of Ethiopia on the west and the Gulf of Aden and Indian Ocean on the north and east, respectively. In the northwestern part, along the Gulf of Aden, is a coastal plain of considerable width underlain by marine Cretaceous and Tertiary strata. This plain is bordered by a coastal range, and farther inland another range rises to altitudes of more than 3,000 meters, then lowers southward to plateau areas. In the northeastern extremity a high range borders the gulf coast and a rocky coast borders the Indian Ocean. Farther inland in this area are high plateaus. Most of the mountain ranges are of granite cut by quartz veins. The plateaus are underlain mainly by thick formations of sandstone and limestone, probably of Cretaceous or earlier age. The central part also consists chiefly of plateau above which rise several high mountains. The southern part includes much lowland along the valleys of the Juba and Shebeli Rivers. The region from the inland plateaus to the seacoast is underlain by granite, gneiss, and crystalline schist. Several areas of Tertiary volcanic rocks are in the southwestern part.

Notes on thermal springs in Eritrea and Ethiopia are scattered through publications of early explorers. More recent information is available on several springs in the northwestern part of the Somali Republic, and a detailed report on the hot springs in French Somaliland was issued by Aubert de la Rüe (ref. 2530). No reference has been found to thermal springs in the eastern part of the Somali Republic bordering the Indian Ocean, though the character of the rocks and the geologic structure in the northern and central parts seem favorable to the presence of thermal water along faults and fractured folds.

The available information on thermal springs in Eritrea, Ethiopia, French Somaliland, and the Somali Republic is presented in the table on page 152. The locations of the springs are shown on figure 46.

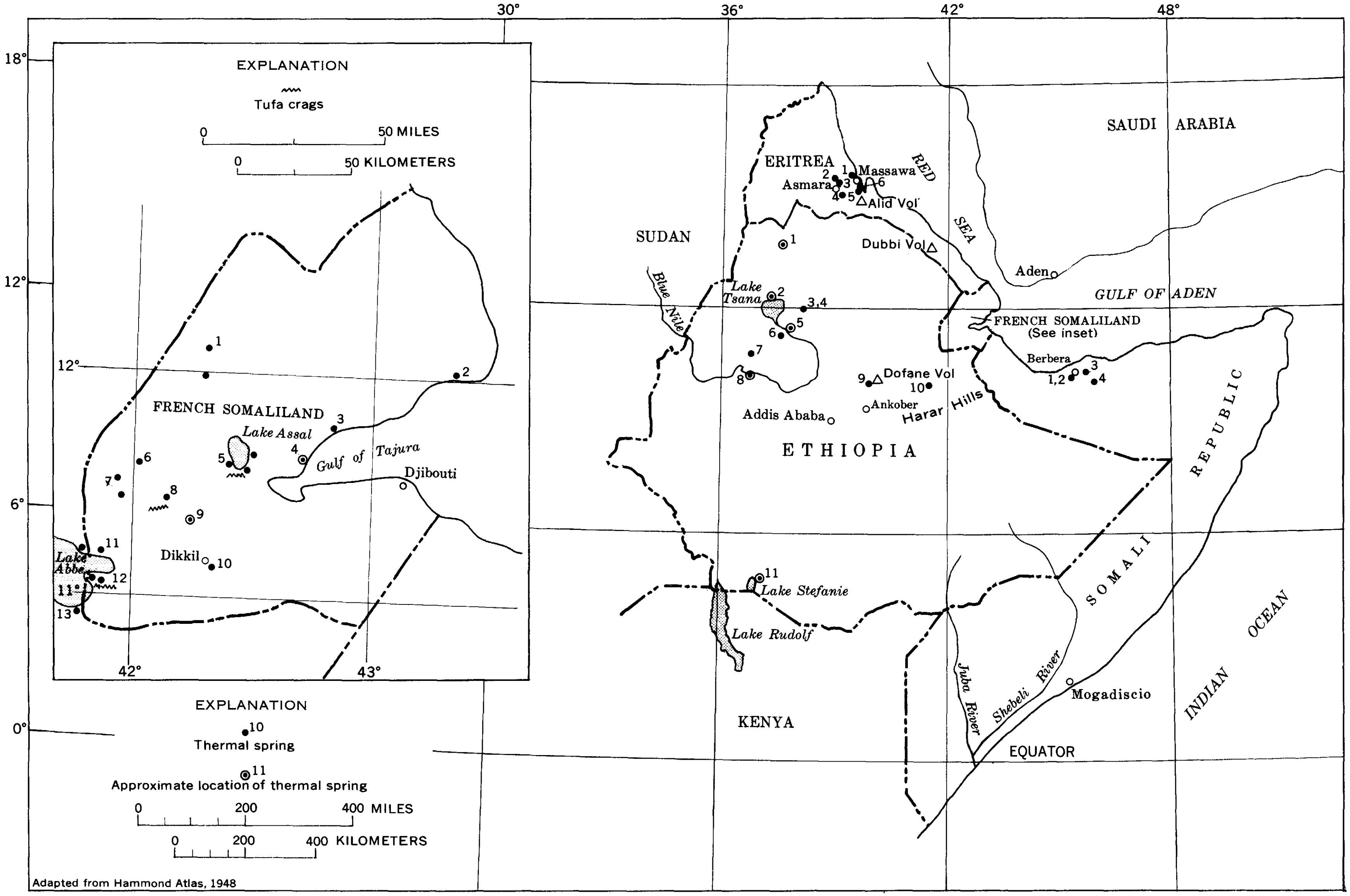

Figure 46.—Eritrea, Ethiopia, French Somaliland, and Somali Republic showing location of thermal springs.

Thermal springs and wells in Eritrea, Ethiopia, French Somaliland, and Somali Republic

[Locations of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 46	Name or location	Temperature of water (°C)	Flow	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Eritrea						
1	Momoullou, 4 km west of Massawa.	34.3					Shallow wells. Ref. 2549.
2	Ailet (Ailate, Heylâte), 36 km west of Massawa.	50–67.4		833	SiO_2 (88); Na (196); HCO_3 (411); SO_4 (33); Cl (77); free CO_2.	Schist and quartzite intruded by basalt.	3 main springs. Water is radioactive. Used for bathing. Refs. 2544, 2546, 2549–2551.
3	Ali-Hasa, 15 km southwest of Ailet.	52.5–60		745	SiO_2 (81); Na (168); HCO_3 (276); SO_4 (102); Cl (80).	Schist intruded by igneous rock.	2 main springs. Water is radioactive. Used for bathing. Refs. 2550, 2552.
4	Atzfut, at Hatefete, 3 km from ruins of Adulis and 0.5 km from seashore.	44			$NaSO_4$, $MgSO_4$	Cellular lava	Refs. 2534, 2549.
5	Guel, 3 km east of Adulis and near seashore.	58.4–69.8				Lava	18 springs issuing at base of extinct volcano. Inundated by high tide. Refs. 2433, 2549.
6	Komali (Komalyi), near Annesley Bay and 10 km from Zula.	Warm					Shallow wells. Ref. 2534.
	Ethiopia						
1	Bend of Casam River	65					Several springs flowing into grove of palms. Water used for bathing. Ref. 2539.
2	West shore of Lake Tasana (Tsana, Tana, M'-Woutan).	Hot					25 springs in large crater. Water is sulfurous. Refs. 30, 2549.
3	Goramba, near Mahadera Mariam.	52.5					Ref. 2546.
4	Wirrus Aggie and Sat Allenga, 15 km from Goramba.	40; 60					2 springs. Ref. 2546.
5	Wayra, in Nile River valley below Korata.	Hot					Several springs. Ref. 2546.
6	Agitta	Hot					Do.
7	Dûbbi, on east bank of I'sser River.	Warm					Many springs. Water is slightly saline; much free CO_2. Ref. 2533.
8	Dembitcha (Dembecka), in Nile River valley.	Warm					Several springs. Ref. 2546.
9	St. Abbo (Sidano?) and Holy Virgin, near Dofane volcano and 80 km north-northeast of Ankober.	37					2 springs. Water is tasteless and odorless. Refs. 2532, 2545.
10	Sirke (Sirge), at base of the Galla Hills near Errur (Erer).	Hot					Several springs. Refs. 2531, 2545.
11	Lake Stefanie	Hot	Large				Several springs. Water is brackish. Ref. 2538.
------	Near Aito Hill	45–48				Red sandstone	4 wells (Aragawi, Selassie, Mariam, Abbo). Small amount of H_2S. Water used for bathing. Ref. 2539.
------	Foot of Finfini Mountains	Hot					3 wells. Water is sulfurous. Ref. 2540.
------	Ta'hou, between Owssa and Gondah.	Hot					Several springs spouting to height of several ft. Deposit of hard white material (siliceous sinter?) around outlets. Ref. 2541.
	French Somaliland [Data chiefly from ref. 2530]						
1	Alta (Goum) and Halol						Water is slightly saline.
2	Obock, on seashore	69–71	Small				Water is very saline and sulfurous. Used for bathing.
3	Near Tajura (Tadjourah), in valley of Aiboi.	33				Rhyolite	Several springs. Water is potable
4	Ouéah, on Oued Madagala	36					Water is potable.
5	Near Lake Assal:						
	East shore	34.5–35.8				Basalt	About 160 meters below sea level. Ref. 2535.
	South shore	77				do	About 160 meters below sea level. Water is saline. Large deposit of travertine. Ref. 2535.
	5 km from southwest shore.	84					Ref. 2535.
6	Daguiro, on plain of Ounda-Dobi.						
7	Plain of Hanleh:						
	Aguéna			2,355	$NaHCO_3$ (195); Na_2SO_4 (290); NaCl (1,445).	Faulted basalt	Issue at base of cliff.
	Near Ourguéni butte					Basalt	Water is brackish.
	3 other springs	42.5				do	
8	Garbes:						
	3.5 km east-northeast	100				do	Sulfurous and aqueous vapor issuing from fumaroles along a line 400 meters long. Encrustations of gypsum and kalinite.
	2 km south						Large deposit of travertine.

Thermal springs and wells in Eritrea, Ethiopia, French Somaliland, and Somali Republic—Continued

No. on fig. 46	Name or location	Temperature of water (°C)	Flow	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	French Somaliland—Continued						
9	Left bank of Oued Kouri	46.5					
10	Near Dikkil:						
	Doundouma	35				Rhyolite	Water is brackish.
	Many other springs	20–33					
11	Near northeast shore of Lake Abbé.	100 (max)				Basalt	Several springs and fumaroles 80 meters above lake level.
12	Asbahaito. at base of Badikoma piton on east border of Lake Abbé.	100		2,480	$CaCO_3$ (109); $CaSO_4$ (485); NaCl (1,648).		Large deposit of travertine. Also springs issuing at bottom of lake. Sulfurous odor.
13	Calangalata, near south end of Lake Abbé.						
	Somali Republic [Data chiefly from ref. 2542]						
1	Dubar (Dthubar), 13 km south-southeast of Berbera.	40–43				Nubian sandstone	Many springs. Water is unpalatable, tastes strongly of iron. Ref. 2536.
2	Biyo Gora, in gorge 16 km east-southeast of Berbera.	45–54				do	Several small springs within a distance of 2 km.
3	Bihen Gaha, 70 km east of Berbera.	57	Large			do	3 main springs. Water is mineralized but potable.
4	Huguf, 105 km east-southeast of Berbera.	34	Moderately large			do	Issues at base of escarpment.

FRENCH EQUATORIAL AFRICA, FRENCH WEST AFRICA, AND NIGERIA

The northern parts of former French Equatorial Africa (since 1960 the independent nations of the Central African Republic, Chad, and the Congo Republic) and French West Africa (since 1960 the independent nations of Dahomey, Guinea, Ivory Coast, Mauritania, Niger, Senegal, Sudan Republic and Upper Volta) are within the Sahara Desert. The coastal parts of these former territories are better watered, as is also much of Nigeria.

The former French Equatorial Africa has a coastal band of marine Cretaceous and Tertiary sandstone and limestone that extends inland to the higher areas where ancient sedimentary strata overlie granite and metamorphic rocks. In the northwest, these ancient strata are covered largely by the Saharan sand and gravel.

The former French West Africa has a wide zone of uplands composed of granite, gneiss, and crystalline schist. In the west and southward toward the coast, the basement rocks are covered by Paleozoic and older sedimentary strata. A comparatively narrow belt of Quaternary and Recent deposits borders the ocean. The north and northeastern parts are largely covered by desert sand and gravel, although ancient rocks are exposed in the higher areas.

Nigeria has a comparatively wide coastal band of post-Tertiary marine deposits, and there are extensive alluvial areas along the lower courses of the main rivers. The hills and mountains farther inland are composed of ancient sedimentary rocks that rest on the granite and metamorphic rocks exposed in the higher lands.

Extensive areas in Nigeria receive very little rain, and so small an amount of water gets underground that there are very few springs. The geologic conditions also do not seem favorable to the presence of thermal springs, as there are no extensive areas of faulting or of volcanism. There may be a few slightly thermal springs and wells, but no specific ones seem to be recorded.

The location of thermal springs in the former French Equatorial Africa and the former French West Africa are shown on figure 45 and data on them are given in the table below.

Thermal springs in the former French Equatorial Africa and the former French West Africa

No. on fig. 45	Name or location	Temperature of water (° C)	Flow (liters per minute)	Remarks and references
	Former French Equatorial Africa			
1	Yerike, in volcanic crater in Tibesti Mountains of Chad.			Noted for jets of vapor and deposits of sulfur. Refs. 2432, 2557.
	Former French West Africa			
1	Tafadek, 50 km north of Agadès (Agadez) in Niger.	50.4	60	Issues from crystalline schist intruded by granite. Water is slightly sulfurous. Used for bathing. Ref. 2556.
2	Near Nunez River, downstream from Walkerteria in Guinea.			Several springs. Ref. 2554.

MOROCCO

The Grand Atlas Mountains trend east-northeast through the central part of Morocco. The smaller Anti Atlas Mountains are nearly parallel on the south. Beyond them is the northern part of the Sahara Desert. The Atlantic coastal line of French Morocco is remarkably smooth and has very few bays. The low slopes of the coastal area, which are underlain by Tertiary and Cretaceous strata, rise inland to areas of Paleozoic rocks. The highest parts of the Atlas ranges are of ancient schist, slate, and crystalline limestone which are folded and intruded by basalt and diorite. In some areas crystalline rocks are overlain by great thicknesses of limestone, sandstone, and conglomerate chiefly of Silurian and later Paleozoic ages. Paleozoic rocks are exposed in a broad zone along the southern flanks of the Anti Atlas Mountains and extend into the Sahara Desert where dry or marshy saline lake beds (shats, or chats) are present. The coast of former Spanish Morocco extends for about 200 miles along the Mediterranean Sea. It is bordered by the rugged Rif hills, which generally end in sea cliffs, and is interrupted in some places by lowlands at the mouth of stream valleys, especially at the Bay of Alhucemas and the salt marshes of the Mar Chica, south of Melilla. The bordering hills are of marine Tertiary and Cretaceous strata, but Paleozoic rocks are exposed in the highest areas. Jebel Musa, of Tertiary and Cretaceous strata, overlooks the Strait of Gibraltar nearly opposite Jebel Tariq (Gibraltar) on the north side, which is of Jurassic limestone and shale.

Only a few references to thermal springs in Morocco have been found. The locations of the reported springs are shown on figure 45, and the available data concerning them are summarized in the table below.

Thermal springs in Morocco

[Locations of unnumbered springs not identified]

No. on fig. 45	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
1	Guad Bu Azum (Beni Tuzin)						Ref. 2569.
2	Ouezzan (Wezzan) area					Triassic strata	Several springs. Ref. 2563.
3	Aïn Bou Kebrit, on bank of Oued Rdom (Redem).					Contact of Helvetian marl (middle Miocene) and overlying Beni Amar beds.	Ref. 2560.
4	Along Rio Sebu, near Fez:						
	Aïn Kebrit du Tselfat, Mouley Idriss	Hot					Water is sulfurous. Ref. 2560.
	Mouley Yacoub	52	960	31,540	Na (8,747 ppm); K (1,055 ppm); HCO_3; Cl (17,150 ppm).		4 springs. Water is sulfurous pH, 6.2 Refs 2560, 2565, 2571.
	Khaulani, Vaschtata, Abi-Jaqubi (Abu Yacoub)						
5	Aïn Lala Aïa, near Oulmes	40				Granite	Refs. 2564, 2566.
5	Aïn Karouba, near Oulmes						Ref. 2564.
6	Aïn Soukhna, near Ben Rached (Ber Reshid).	Warm				Jurassic strata or crystalline rocks.	Do.
7	Near Figig (Figuig)	35		1,300	Ca, Na, HCO_3, SO_4, Cl		Ref. 2568.
8	Abeino, in Sud de Tiznit	36			Ca, SO_4	Georgian limestone (Middle Cambrian).	Ref. 2562.
	Aïn Haute (Fischquelle)						Ref. 2433.
	Bou Hadschar, on coast	50					Do.

SOUTHERN AFRICA

(Bechuanaland Protectorate, Kenya, Mozambique, Northern and Southern Rhodesia, Nyasaland, Tanganyika, and Uganda)

The northern and central parts of the Bechuanaland Protectorate are within a great plateau region, but they are undulating to hilly and contain many shallow lake basins. Some of the lakes drain to the Zambezi River; others form large brackish marshes without permanent outlets. Most of the southern part of the Protectorate is occupied by the great Kalahari Desert beyond which the drainage is southward toward the Orange River and eastward to the Limpopo River.

Ancient crystalline and metamorphic rocks are exposed over large areas in the east and southeast. Other extensive areas are underlain by marine sedimentary strata of the Karroo system intruded by volcanic dikes and lava flows. These rocks range in age from Permian through Jurassic. There are some fresh-water Tertiary deposits in the desert areas, but most desert lands are covered chiefly by saline marl, sand, and shifting sand dunes.

Kenya borders on the Indian Ocean. The coastal plain is narrow in most places, and only a few miles from the shore the land rises rapidly to plateau regions which occupy nearly all the eastern part of Kenya. Near the central part Mount Kenya, a denuded volcanic mass, rises to an altitude of 17,040 feet and glaciers extend down from its principal peaks. Between the coast and the city of Nairobi, the plateau region is partly interrupted by hills and low mountains. West of Nairobi, the great East-African Rift Valley, or Eastern Rift Valley, cuts deeply below the plateau and extends northward. It contains several small lakes. The brackish Lake Rudolf occupies a considerable part of the Rift Valley farther north. East of Lake Rudolf extensive arid lava plateaus rise to mountains also mainly of lava. Along the north border of Kenya, an escarpment rises to higher lands in Ethiopia. In the northeastern part are arid high plains. On the southwest border Lake Victoria occupies a broad depression considerably below the main plateau areas.

Gneiss and schist form the cores of some of the lesser mountain ranges, and ancient quartzite is exposed in some of the hilly areas. Plateau regions of Kenya are chiefly of ancient crystalline rocks overlain by great flows of lava that is considered to be of post-Jurassic to Recent periods of effusion. The upland plains near the sea coast are of Triassic and Jurassic strata. The coastal plain is underlain largely by raised coral beaches and alluvium. A nearly continuous belt of volcanic rocks extends across the region from the northern to the southern border. Earlier lavas from fissure eruptions along and parallel to the Eastern Rift Valley generally are covered by eruptions from the volcanic mountains, some of which still emit vapors and steam.

Mozambique also borders on the Indian Ocean. The western part of this country rises to a plateau region of granite, gneiss, and schist, which are overlain extensively by beds of the Karroo system and associated basalt layers, especially in the lower part of the Zambezi River basin. Much rhyolite is present in the Lebombo Mountains on the southwest border of the country. Marine Upper Cretaceous rocks are exposed along parts of the coast from Delagoa Bay to Mozambique city. Eocene limestone has been recognized in the south-central portion.

Northern Rhodesia [4] covers a part of the high plateau of central Africa and is mostly within the basin of the Zambezi River. A part is drained by the Congo River through Lakes Mweru, Bangweulu, and Tanganyika.[4] Ancient granites and metamorphic rocks directly underlie a great part of the region, but in the east these rocks are covered by beds of the Karroo system. A wide, thick sheet of basalt belonging to this system is exposed in the gorge of the Zambezi River at and below Victoria Falls. In the northwestern part of this former colony are extensive areas of white sandy beds, probably deposited in a former large lake.

In Southern Rhodesia the highest part of the plateau region forms a northeast-southwest drainage divide between the tributaries of the Zambezi River that flow to the west and north and streams that flow south and east. The east boundary of Southern Rhodesia follows approximately the border of the plateau from which the surface descends through mountainous ridges to lower lands. Most of the region is underlain by ancient metamorphic rocks. Some areas are underlain by rocks of the Karroo system. Extensive faulting has taken place near the southeast border, but there has not been much development of volcanism in geologically Recent time.

Nyasaland (Malawi) is largely a region of high plateau, but is broken by the Eastern Rift Valley from which Lake Nyasa drains to the Zambezi River. The ancient metamorphic rocks of the plateaus are in part overlain by beds of the Karroo system, and in some places they are covered by Quaternary lava. Volcanism is present within the rift valley.

The coastal plain of Tanganyika is generally low and sandy and 10 to 30 miles wide. From the plain the land ascends steeply to plateaus, above which rise several mountain ranges. The highest plateaus are in the southwestern part, but the highest mountains are near the northeast border where Mount Kilimanjaro rises to an altitude of 19,321 feet. It is the highest mountain in Africa and has snowfields and several small glaciers. Lake Victoria, on the north border of the country, lies in a basin below the mean plateau levels; Lake Tanganyika, on the west border, lies at the base of cliffs several thousand feet high that mark the Western Rift Valley. On the southwest border Lake Nyasa occupies the deep depression of the Eastern Rift Valley. Northward along this great depression in the plateau region are several small alkaline or saline lakes, including Natron Lake near the north border of Tanganyika.

Much of the plateau country south of Lake Victoria is underlain by granite, but most of the central plateau region is of metamorphic rocks. In some places, along faults of the rift valleys, there are beds of sandstone and shale that may belong to the Karroo system. The plateaus near the coast are underlain by marine sedimentary strata of Jurassic to early Tertiary ages. The uplands bordering the coastal plain are covered by upper Tertiary and Recent deposits. The plateaus in the region of the volcanic mountains near the northeast border of Tanganyika are chiefly of pre-Tertiary lava, but farther west many volcanic mountains and lava flows of Tertiary and later ages are present along the Eastern Rift Valley, especially near Lake Manyara and Natron Lake.

Uganda is in part a lake region. Lakes of the Western Rift Valley lie along its western border and Lake Victoria is on the south. The Ruwenzori Mountains in the southwest form a high partly snow-covered range, and other high peaks rise along and near the eastern border. Much of the central and southwestern parts of Uganda consists of plateau lands that are arid in the north but are well watered in the south where there are extensive marshy lakes.

Granite, gneiss, and schist are exposed over considerable areas in the region of the gorges of the upper

[4] In 1964 Northern Rhodesia became Zambia; Tanganyika with Zanzibar became Tanzania.

Nile River, but in most plateau areas the basement rocks are covered by sandstone and shale that probably are of Paleozoic age. The lava of the Mfumbiro Mountains, which cross the Western Rift Valley north of Lake Kivu, covers the southwest extremity of Uganda and extends to the flanks of the Ruwenzori Mountains. Basalt of the Karroo system forms the Ripon Falls at the outlet of Lake Victoria. Mount Elgon and other peaks on the eastern border are of volcanic origin, and much volcanic rock overlies granite in the northern part of Uganda. Most of the thermal springs that have been reported are in the lava areas, chiefly along faults in and near the Western Rift Valley.

The available information on thermal springs in Bachuanaland Protectorate, Kenya, Mozambique, Northern and Southern Rhodesia, Nyasaland, Tanganyika, and Uganda are summarized in the table below. The locations of the springs are shown on figure 44.

Thermal springs in Bechuanaland Protectorate, Kenya, Mozambique, Northern and Southern Rhodesia, Nyasaland, Tanganyika, and Uganda

[Location of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 44	Name or location	Temperature of water (°C)	Flow (imperial gallons per hour)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
	Bechuanaland Protectorate						
1	Nungwe, on bank of Chobe (Kwando) River 3 miles above junction with Zambezi River.	Warm		10,800	Ca, Na, SO_4, Cl	Probably basalt (Karroo beds).	2 main springs making stream 3 ft wide. Deposits of common salt (NaCl). Ref. 2576.
	Kenya						
	Nangarok, 6 miles south of Mount Lutoki.	Hot					
	Near small volcano about 30 miles south of Mount Lubur.	Hot				Probably lava	Water is mineralized. Ref. 16.
1	Vicinity of Lake Hannington.	93–95					About 12 springs, of which some are boiling and some are spouting. Refs. 94, 2573, 2574.
2	Vicinity of Lake Naivasha, including steam vents on Mount Longonot, Eburru Mountain, and Orgaria Mountain, and steam vents and springs in Njorowa Gorge.	Hot					Many springs and fumaroles. Steam from some vents is condensed for water supply on farms. Refs. 2578, 2579, 2584, 2589.
3	Near Magad Lakes	Hot			Na, HCO_3		Many springs; small deposits of soda are worked commercially. Ref. 2509.
	Lower Molo River valley	Hot					About 12 springs discharging into river. Refs. 2573, 2574.
	Mozambique						
1	Near base of Sitatonga Range, 1 mile south of Lusitu River.	Warm				Probably Frontier beds (pre-Carboniferous).	Ref. 2583.
2	At south end of Sitatonga Range, 1 mile from Busi River.	Warm				Probably Karroo beds	Do.
3	Shaiva	Warm				Karroo beds	Do.
	Northern Rhodesia, (Zambia)						
	[Data chiefly from ref. 2583. Some of the listed springs near the Zambezi River may have been submerged by water impounded by dam in Kariba Gorge. Dam constructed during 1957–59]						
1	About 40 miles east of Lake Moero (Mweru).	46 (max)					Many springs in two groups 5 miles apart. Ref. 2594.
2	N'Kala geysers					Probably basalt	Spouting springs. Ref. 2577.
3	Lochinvar	Hot			Na, SO_4; much free H_2S		Ref. 2631.
4	Kabwili ooze, 18 miles southwest of junction of Kafue and Zambezi Rivers.	21				Probably Karroo beds	Water is slightly saline.
5	Goa geysers, near Shoma	26–63	14,000	283	SiO_2 (37); $CaCO_3$ (20); NaCl (61); KCl (165); small amount of H_2S.	Granite	Several spouting springs; large deposits of tufa and sinter. Refs. 2577, 2631.
6	Kapesa (Chatenta), 1½ miles west of Zambezi River.	73 (max)				Lava (Upper Karroo beds)	Several springs; flow would fill a 3-in. pipe. Deposits of siliceous sinter. Ref. 2631.
7	Manzaia, 1½ miles west of Zambezi River.	66				Sandstone (Karroo beds)	
8	Nakuyu, on left bank of Zambezi River.	32				do	Water is slightly saline.
9	Chilambwa, near Chezia River and 5 miles from Zambezi River.	90 (max)	Large			Faulted Karroo beds, locally altered.	Several steaming vents for 500 yd; deposits of siliceous sinter and common salt. Ref. 2575.

Thermal springs in Bechuanaland Protectorate, Kenya, Mozambique, Northern and Southern Rhodesia, Nyasaland, Tanganyika, and Uganda—Continued

No. on fig. 44	Name or location	Temperature of water (°C)	Flow (imperial gallons per hour)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
	Northern Rhodesia, (Zambia)—Continued						
10	Chilundu, 1 mile below junction of Zongwe and Zambezi Rivers.	31 (max)				Probably Karoo beds	3 main springs, 100 yd apart. Small deposits of sinter. Refs. 2631, 2634.
11	About 27 miles north of Zambezi River, near road to Monze.	Tepid					Small deposits of tufa. Ref. 2577.
12	About 4 miles north of Zambezi River, near road.	Warm	Small			Folded sandstone	Water is moderately mineralized. Ref. 2577.
13	On left bank of Zambezi River.	Hot	Large			Basalt (Karroo beds)	Water is saline.
	Southern Rhodesia						
	[Data chiefly from refs. 2575, 2583. Some of the listed springs near the Zambezi River may have been submerged by water impounded by dam in Kariba Gorge. Dam constructed in 1957–59]						
1	Mendayatswa ooze, near bank of Zambezi River.	50				Probably faulted Karroo beds.	Black mud; small surface flow.
2	On bank of Charara River	Warm					
3	Sampakaluma, on north side of Matabolo Flats.	Boiling				Middle Karroo beds	Water contains small amount of H_2S. Watering place for cattle. Ref. 2631.
4	Chipiso, 3 miles east of junction of Sundi and Kariba Rivers.	Hot	Large	1,321	Na, SO_4; much free H_2S	Gneiss near down-faulted Karroo beds.	2 main springs: deposit of tufa.
5	About 7 miles east of Zambezi River.	Hot					Used for small production of salt. Ref. 2631.
6	Chipwatata, 3 miles above junction of Masumo and Zambezi Rivers.	Warm				Sandstone (Karroo beds).	
7	Zongola, near Fulunka's Kraal, 2 miles southeast of Zambezi River and 40 miles downstream from mouth of Gwaai River.	52–97	1,800–3,600	622	K (216); Cl (274); SiO_2 (60); free H_2S.	Karroo beds	8 springs, 1 of which spouts continuously to a height of 7 ft. Deposit of calcareous-siliceous sinter. Refs. 2577, 2580, 2631.
8	Chigwadada (Chebira) on right bank of Sebungwe (Lubu) River, 3 miles above its junction with the Zambezi.	49–64.4	Small	667	Ca; Na; HCO_3; SO_4 (89); Cl (320).	Lower Karroo beds	Ref. 2577.
9	Sidenda, on right bank of Zambezi River at mouth of Batoka Gorge.	Very hot				Basalt (upper Karroo beds)	Water is saline.
10	Sigobonya, near junction of Gwaai River with the Zambezi.	Hot				Probablay basalt (upper Karroo beds).	Water is potable.
11	Bidada, 10 miles east of Gwaai River.	Warm				Karroo beds	Water is very saline.
12	Kavira (Shumba) on right bank of Mlibisi River.	46–47.7	250,000	756	Ca; Na; HCO_3; SO_4 (96); Cl (300).	Faulted upper Karroo beds	6 main springs in area of several acres; also other springs, 32°–45°C.
13	Sinisitonka	Hot	Large			Sandy shale (middle Karroo beds).	Some free H_2S.
14	Sibila	Warm				Sandy shale (middle Karroo beds).	Do.
15	Sunga, on Deka River east of Dett, near Wankie.	38	25,000	576	Na, HCO_3	Sandstone (Karroo beds) faulted against Batoka basalt.	3 springs; part of water supply of Wankie, northwest of Dett.
16	Nichenge, 18 miles southwest of Lukosi railway siding.	Warm	Small	6,621	Na, Cl	Faulted basal Karroo beds	3 groups of small springs.
17	Sakabika, 8 miles south of Lukosi railway siding.	Warm	Small			Archean granite	9 springs.
18	Lubimbi, 6 miles east of Shangani drift.	Hot	45,000–91,000	1,290	Na, HCO_3, SO_4, Cl; free H_2S.	Lower Karroo beds	Deposits of Na_2SO_4 and Na_2CO_3.
19	In Gwampa River valley	Hot					Small solfataras. Ref. 2577.
20	Mwengezi (Wengesi), 200 yards from Odzi River.	53	Small	354	Na, HCO_3; some H_2S	Granite, near Sabi fault	Ref. 2631.
21	In Mutambara Native Reserve, 850 yards east of Odzi River.	36–56	3,300	368	Na; HCO_3; SiO_2 (84); free H_2S.	do	2 groups of springs, 400 yds apart. Bathing pool; hotel. Refs. 2631, 2636.
22	On Dunstan farm	Tepid	Small	273	Ca, Na, HCO_3, SO_4	Umkondo beds (Carboniferous).	
23	Chimanimani geyser	Boiling				Probably Frontier beds (pre-Carboniferous).	Spouting spring; water is thrown several ft high.
24	Near head of Rupisi River	62	3,000	389	Na, HCO_3, Cl, SiO_2 (87)	Umkondo beds, faulted against granite.	Water used for bathing. Ref. 2636.
25	Zomba, on bank of Mtilikwe River.	Warm	Small			Granite	Small amount of free H_2S.
26	Chiwichuhagwe, near left bank of Sabi River.	Hot				Contact of granite with intrusive Karroo basalt.	
	Nyasaland (Malawi)						
1	Maronde (Grafin Bose Thermen), for several miles along west side of Songwe River valley.	43–70		359	Ca, Na, SO_4		Many springs. Large deposits of tufa. Ref. 2592.

Thermal springs in Bechuanaland Protectorate, Kenya, Mozambique, Northern and Southern Rhodesia, Nyasaland, Tanganyika, and Uganda—Continued

No. on fig. 44	Name or location	Temperature of water (°C)	Flow (imperial gallons per hour)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
				Tanganyika (Tanzania)			
1	Mtagata Gorge, 35 miles north of Kafuro.	54 (max)		3,700	Na_2CO_3		6 springs; bathing pools, 41°–43° C. Refs. 2590, 2591.
2	In Kibo crater on Mount Kilimanjaro.	Hot				Probably basalt	Solfataras and fumaroles, with deposits of sulfur. Refs. 2585, 2587, 2588.
3	On west shore of Lake Manyara (Manjara-see).	80			Na_2CO_3 (1,500); Na_2SO_4 (110); NaCl (620).		Refs. 2579, 2582, 2586.
	Ibadakule, in Shinyange district.	50–55			Na, HCO_3, SO_4, Cl		Ref. 2581.
				Uganda [Data chiefly from ref. 2596]			
1	Nangarok	Hot					Not noticeably mineralized.
2	30 miles south of Mt. Lubur	Hot					Mineralized.
3	Wolo No. 1, on Abalika River.	Hot					Water is mineralized.
4	Wolo No. 2, on Bujo River	Hot					
5	Aupi, on Bidia River	Hot					
6	Aiwa, on Aiwa River	Hot					
7	Amor pi, in bed of Aswa River.	Very hot					
8	Keyo	Tepid					
9	Keyo Amuro	Tepid					
10	About 30 miles south of Keyo Amuro.	Hot					
11	Mbalo, on Akado River	Warm					Water is mineralized. Common salt produced in dry season.
12	Panyamur	37					Water is mineralized.
13	Kibiro, on east shore of Lake Albert.	Very hot		3,800; 5,300	Na, Cl		2 main springs near salt workings; deposit of sulfur.
14	Buranga, in Bwamba area, 7 miles from Kibuku.	Very hot					Water is sulfurous. Large deposits of tufa. Ref. 2509.
15	Livagimba, in Bwamba area, near Dwimbi River.	Very hot					Water is sulfurous. Used for bathing. Ref. 2509.
16	Small tufa island in Lake Katwe.	Warm		47,560	Na, Cl		
17	Ihumbu (Mtarega), near Kakindu River in Semlike Valley.	38					3 springs. Refs. 2591, 2593.
18	Kitagata	Near boiling		1,500	Ca (110); HCO_3 (50); Cl (70)	Faulted gneiss and pegmatite.	2 small groups of springs. Water used for bathing.
19	Katagata, on Kyangenyi Hill.	Hot					Water is mineralized.
20	Kikagata	Warm					Water is slightly saline; free CO_2. A source of water in dry season.
21	Birara	Hot					
22	Rubabu (Lubaba), 10 miles north-northwest of Nyalusanje.	Hot					Water is mineralized.
23	Minyera, below road bridge	Hot					Do.
24	Ntagata, in Ruakatengi Swamp.	Hot					Do.
25	Ishasha, 5 miles north of Kumba.	Hot					
26	Kizuguta, 3 miles north of Kabale.	Hot					

SOUTH WEST AFRICA AND UNION OF SOUTH AFRICA

The principal reports on thermal springs in southern Africa cover both South West Africa and the Union of South Africa (Transvaal, Natal, Orange Free State, and Cape of Good Hope).

The coastal plain of South West Africa is about 35 miles wide in the south but narrows northward. It is bordered by low mountains. Other mountains in the central and southeastern parts interrupt the interior plateau, which changes from an undulating region eastward to a great plain that merges with the Kalahari Desert. The coastal belt includes some areas of Miocene rocks, but gneiss, schist, and intrusive granite directly underlie most coastal areas as well as the mountains and plateaus of the central region. In the southern plateaus the crystalline and metamorphic rocks are overlain mainly by ancient sedimentary strata, largely of the Karroo system, but in some places they are overlain by the more ancient Cape system of sedimentary rocks of Devonian age.

The Union of South Africa has a low-lying coastal belt which is 50 miles wide at its widest part. In the extreme south, however, mountains come close to the sea and the land rises abruptly in high cliffs. From the coastal plains the country rises through hills to the great interior plateau which constitutes the larger part of the region.

In the northeast, the high veld of the Transvaal occupies the highest part of the plateau which slopes gradually downward to the west and southwest. The borders of the Transvaal are partly encircled by a wide band of ancient crystalline rocks which are overlain in the central part by sedimentary rocks of pre-Carboniferous age and in the south and southeast by sedimentary rocks of the Karroo system (Permian through Jurassic).

The main plateau in Orange Free State consists chiefly of undulating plains. There are numerous hills of ironstone in the southwestern part. Nearly all the State is underlain by Karroo beds, but granite is exposed in a small area in the north.

Much of the coast of Natal is rocky. Cretaceous strata are exposed in some parts. The extreme northeastern part is occupied by wide coastal lowlands, but most of the region rises to an intermediate plateau and thence to the main plateau. Across this highland the Drakensberg Mountains rise considerably higher. They are composed largely of volcanic rocks that constitute the uppermost part of the Karroo system. Mountain spurs of these volcanic rocks also extend into the Crown colonies of Swaziland and Basutoland, which occupy parts of the plateau bordering Natal on the north and south.

From the coastal belt of most of Cape of Good Hope Province, formerly Cape Colony, the surface rises in terracelike bands to the interior plateau. In the basin of the Orange River, which drains a large area, the surface descends northward to the stream, then gradually rises northward and forms the southern extension of the Kalahari Desert. In general, the plateaus and high plains of the province are underlain by nearly horizontal strata of the Karroo system which form a shallow structural basin. In the north and west are rocks older than those of the Cape system (Devonian). In the mountains of the southeastern part, strata of the Cape and lower Karroo systems are sharply folded. The sandstone that caps Table Mountain near Cape Town belongs to the lowest member of the Cape strata, but Cretaceous and younger rocks are present at some places along the coast.

Data on the thermal springs and wells in South West Africa and the Union of South Africa are given in the two tables below. The locations of the springs are shown on figure 47.

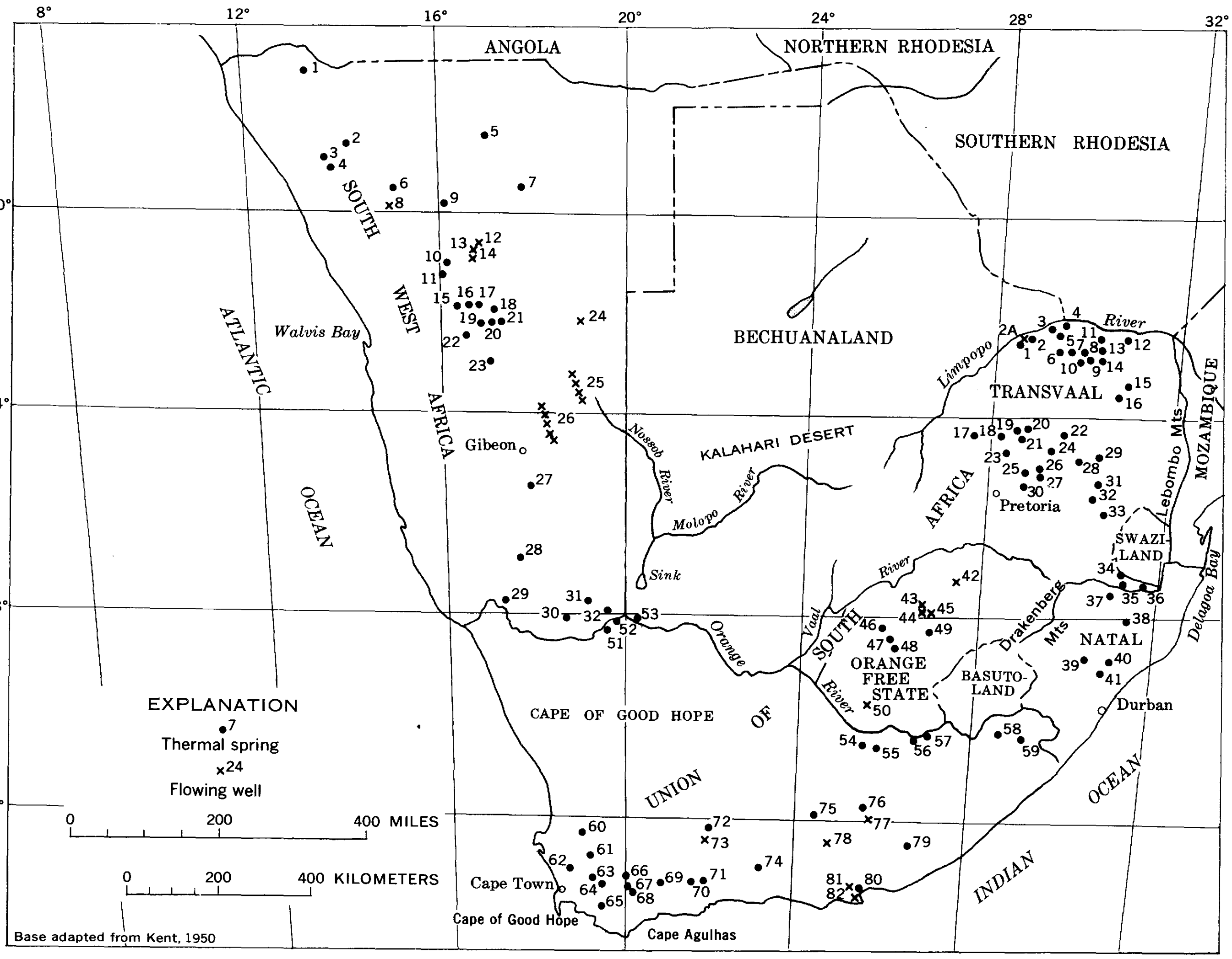

FIGURE 47.—Part of southern Africa showing location of thermal springs and thermal wells in South West Africa and the Union of South Africa.

Thermal springs and wells in South West Africa

[Data chiefly from refs. 2618–2623]

No. on fig. 47	Name or location	Temperature of water (°C.)	Flow (imperial gallons per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Otjangasemo	Hot					
2	Oruwanje	Warm					
3	Numas	Warm					
4	Warmbad	Warm					
5	Namutoni	Warm					
6	Otjitambi	Hot					
7	Rietfontein	27.8	472,000			Otavi limestone Precambrian) overlying Archean schist.	Ref. 2630.
8	Franzfontein	Warm					Well.
9	Outjo (Otjitambi?)	46		1,815			Water is saline.
10	Omburo	76.5					
11	Omapyu	61					
12	Doornkom	35–40	72,000				Well 265 ft deep. Artesian flow augmented by pumping.
13	Peterkin	35	86,000				Well 274 ft deep. Artesian flow augmented by pumping.
14	Ongurukena	Warm					
15	Sneyrivier	28				Dike in Archean granite	
16	Klein Barmen (Otjikango)	61					Refs. 2600, 2604.
17	Gross Barmen	65	159,000	813		Faulted Archean schist	Water contains much K. Free H_2S. Water used for irrigation. Refs. 2600, 2604, 2622.
18	Okatjeru, 22 miles north of Windhoek.	Warm					Issues from breccia-filled fissures. Ref. 2608.
19	Ongeama (Okanjama), 8 miles west of Windhoek.	Warm					Do.
20	Gross Windhoek (Queen Adelaide), including Junkerquelle, Pahlquelle, and Bergquelle.	70–80	88,200	869 (hottest)	Mg, Na, HCO_3, SO_4, SiO_2, (96 ppm).	Archean schist	Formerly 6 springs. Several wells drilled in recent years. Refs. 2433, 2597, 2598, 2604, 2608, 2627, 2632.
21	Klein Windhoek (Glenelg)	45–55		466	Ca, Mg, HCO_3, SO_4, Cl, SiO_2 (23 ppm).	do	Formerly spring. Several wells. Refs. 2597, 2598, 2604, 2608, 2632.
22		46				do	
23	Rehoboth	52					
24	Gobabis	Warm				Ecca sandstone (Permian)	Well. Water at depths ranging from 140–555 ft.
25	Nossob	Warm					Do.
26	Auob River valley (Gibeon area).	32; 34				Ecca sandstone (Permian)	2 pumped wells. Ref. 2607.
27	Ganikobis	40				Dike in Dwyka series (Carboniferous and Permian).	
28	Aikaas	Hot					
29	Aiais	55		2,223			5 springs. Water is saline. Ref. 2430.
30	Warmbad (Nabis, Nesbitt's bath), on banks of Houm River.	37.5				Gneiss intruded by granite	Much gas, chiefly N_2. Ref. 2433.
31	Grundorn	Warm					2 springs forming a stream 6 in. wide and 1½ in. deep. Water used for irrigation. Refs. 2597–2599.
32	Blydeverwacht	Warm	40,000			Amphibolite reef in sheared gneiss.	

Thermal springs and wells in Union of South Africa

[Data chiefly from refs. 2621, 2622, 2627, 2631–2641. Principal chemical constituents are expressed in parts per million]

No. on fig. 47	Name or location	Temperature of water (°C)	Flow (imperial gallons per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Paddysland	26		939	Ca, Mg, Na, HCO_3, Cl	Archean gneiss	
	Tugela:						
2	Spring	42.8	2,650	1,517	Na, SO_4, Cl		
2A	Flowing well	48.9	15,600		Na, SO_4, Cl		65 ft deep.
3	Evangelina	32.5		1,355	Na, SO_4, Cl	Diabase dike in Archean gneiss.	
4	Stindal	Warm					Ref. 2583.
5	Icon	Warm					
6	Vetfontein	29.5				Karroo beds (Permian through Jurassic).	
7	No name	Warm					
8	Sulphur	Warm					
9	Windhoek	Warm					
10	Masequa	Warm					
11	Gordonia	37.7				Faulted Archean gneiss	
12	Klein Chipise	Hot					
13	Chipise	57; 65	100,000	502	Na, HCO_3, Cl	Faulted upper Karroo beds.	
14	Mpefu	42.8; 43.7		Low		Faulted pre-Carboniferous strata.	2 springs.
15	Souting, near west bank of Klein Letaba River.	43.9	30,000	High	$CaCO_3$ (30); $CaSO_4$ (218); NaCl (1,270).	Faulted Archean granite	Water is source of salt supply. Ref. 2610.
16	Letaba, 0.5 mile south of Groot Letaba River:	40.4–42	91,000	966	SiO_2 (71); Ca (30); Na (301); SO_4 (64); Cl (445).	Dolerite dike in granite	3 springs. Water used for bathing and as a source of salt.
	Spring						
	Flowing well	Warm	12,000				
17	Buffelshoek farm, between Thabazimbi and Rooiberg.	30.6	17,000	459	SiO_2 (45); Ca (27); Na (152); HCO_3 (214); SO_4 (35); Cl (139).	Diabase dike in Bushveld granite (Precambrian).	
18	Loubad, 18 miles west-northwest of Nylstroom.	27–34	414,300	188	Ca, HCO_3	do	6 main springs.

Thermal springs and wells in Union of South Africa—Continued

No. on fig. 47	Name or location	Temperature of water (°C)	Flow (imperial gallons per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
19	Welgevonden	44	12,500			Faulted Rooiberg felsite (Precambrian).	
20	Die Oog	39.5	32,000	257	Na, HCO_3, Cl	do	
21	Vischgat	39.5	20,000			Faulted Bushveld granite	
22	Adriaanskop	Warm					
23	Warmbaths	51.9	160,000	408	Na, HCO_3	Faulted Bushveld granite	Government bathhouse.
24	Riffontein	28.3–29	8,000	702	Na (235); HCO_3 (238); Cl (248).	Faulted Rooiberg series.	
25	Kameelpoort	Warm					
26	Goederede	Warm				Bushveld granite	
27	Grovesbad	32.8				do	
28	Buffelsvlei	Hot					Water used for bathing.
29	De Bad	Warm				Pretoria series (Precambrian).	
30	Hartebeestspruit	Warm				do	
31	Badfontein	Warm				do	
32	Machadodorp	27.5–28.5	45,000	214	Na, HCO_3	do	7 springs. Water is sulfurous. Bathing resort. Ref. 2627.
33	Badplaats	50	180,000	409	Na, HCO_3; much free H_2S	Fractured Archean granite	
34	Sulphur, near Ermlo	31	120,000	130		Pongola system (Proterozoic)	Free H_2S.
35	Warm Bad	40; 42.5					2 springs. Gas is 92 percent N_2.
36	Onverwacht	Warm					
37	Natal	44.4	64,800	273	Na, HCO_3	Archean granite	Resort.
38	Black Umfolosi	41				Dwyka tillite (Carboniferous).	2 large springs. Water is slightly saline. Much free H_2S.
39	Entembeni	28				Dolerite sill in Ecca shale (Permian).	
40	In Tugela River gorge, 12 miles north-northeast of Kranskop.	52–53		1,021	Ca (83); Na (231); HCO_3 (31); SO_4 (368); H_2SiO_3 (73).	Faulted Archean gneiss	Several springs. Ref. 2609.
41	Lilani, 20 miles from Greytown.	38–40		Moderately high	Na, HCO_3; free H_2S	do	Do.
42	Tierbank	Warm					Farm well.
43	Wolvepan	28.8	60,000			Ventersdorp series (Precambrian).	Well.
44	Jonkersrust	34	48,000	3,536		Ventersdorp lava	Well 3,500 ft deep. Water is saline.
45	Vermenlenskraal	32.7	48,000			do	Well 2,560 ft deep. Water used for bathing.
46	Baden-Baden (Gannafontein).	24 (max)	480,000			Ecca series (Lermian)	Several springs. Water used for bathing).
47	Florisbad (Rietfontein)	28–30		2,189		do	Water is saline.
48	Vlakkraal	Warm					
49	Winburg	29.5	4,000	High	Na, SO_4, Cl	Beaufort series (Lower Triassic).	Bathing pool.
50	Trompsburg	37.2	24,000	8,463		Norite (Pre-Karroo)	Well 4,700 ft deep. Water is very saline.
51	Warmbad Noord	44.4	15,000			Fractured Archean granodiorite.	
52	Skuitdrif Oos	38				Fractured Archean granite	
53	Riemvastmaak	Hot					
54	Rooiwal	30	56,000	Moderately high	Na, HCO_3	Dolerite dike in Beaufort series (Lower Triassic).	
55	Badsfontein	25.5–30	51,000			do	Water is slightly saline.
56	Aliwal North	36.9	840,600	High	Na, SO_4, Cl; gas, 94 percent N_2.	do	Water is sulfurous. Bathing resort.
57	Badtsfontein	Warm					
58	Kenegha Drift	29.3				Dolerite dike in Beaufort series (Lower Triassic).	
59	Inungi	25		Moderately high		Beaufort series (Lower Triassic).	Free CO_2 and H_2S.
60	Die Bad	42.2; 43.2				Table Mountain sandstone (Devonian).	2 springs. Baths.
61	No name	Warm					
62	Malmesbury	32.9	180,000	1,186	Na, SO_4, Cl; free CO_2, H_2S	Fractured Cape granite (Devonian).	Water is sulfurous. Used for bathing.
63	Goudini (Goudine, Jordaens Bath), near DuToit's Kloof.	40.1		Low		Table Mountain sandstone (Devonian).	Baths. Ref. 2648.
64	Brandvlei (Brand Vley, Brandvalleis).	64.2	2,430,000	95	Na, HCO_3, Cl	Faulted Table Mountain sandstone (Devonian).	Water used for bathing. Refs. 2599, 2601, 2603, 2625, 2628, 2644, 2645.
65	Caledon	35–42	180,000	190		do	Several springs issuing from iron-manganese mound: water contains considerable Fe. Much CO_2. Sanatorium. Refs. 2599, 2603, 2611, 2615, 2625, 2626, 2645.
66	Baden	Hot				do	
67	Montagu	44.6				do	Gas is 88 percent N_2. Sanatorium. Ref. 2645.
68	No name	Warm				do	
69	Warmwaterberg:						
	Spring	45.6	174,000	205	Ca, Na, HCO_3, Cl	do	Water contains considerable Fe. Ref. 2617.
	Flowing well	28	31,000			do	100 ft deep.
70	Gamka Valley	32.3–33.2	65,500	Low		do	Water contains considerable Fe. Used for bathing.
71	Olifants Valley	50–51	144,500	197	Na, HCO_3, Cl		Several springs and wells. Water contains considerable Fe. Used for bathing. Refs. 2432, 2601, 2645, 2650.
72	Stinkfontein	28.7	7,500	806	Na, HCO_3; free H_2S	Lower Beaufort series (Triassic).	
73	Kruidfontein	Warm					Pumped well.

Thermal springs and wells in Union of South Africa—Continued

No. on fig. 47	Name or location	Temperature of water (°C)	Flow (imperial gallons per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
74	Toverwater (Agter de Berg, Warm Bath, Hottentor Holland's Bath, Yser-Baad) south of Zwartebergen.	44.3	216,000	Low		Faulted Table Mountain sandstone (Devonian).	5 springs. Water contains considerable Fe; deposits yellow ochre. Used for bathing. Refs. 2432, 2645, 2647, 2650.
75	Grasrand	26	3,600			Lower Beaufort series (Triassic).	Water is slightly saline.
76	Near Cradock ford of the Fish River.	29–31.3	18,300	181	Na, HCO_3; free H_2S	Dolerite dikes in Lower Beaufort series.	Several springs. Refs. 2615, 2636, 2648, 2649.
77	Tarka Bridge	26–27					Several wells 65–225 ft deep. Free H_2S, CH_4. Water used for bathing
78	Moerlust	Warm					Pumped well.
79	Fort Beaufort	27–29	17,300	520	Na, HCO_3; free H_2S	Lower Beaufort series (Triassic).	Several springs. Ref. 2636.
80	Amanzi (Balmoral)	Warm					Pumped well.
81	Amanzi	Warm					Do.
82	Zwartkops, 4 miles from Port Elizabeth.	53.6	250,000	365	Na, Cl	Cape system (Devonian)	Well 3,620 ft deep. Water is slightly saline. Bokkeveld series(?) entered at depth of 3,400 ft. Refs. 2642, 2643, 2646.

INDIAN OCEAN

MADAGASCAR (MALAGASY REPUBLIC)

Madagascar, or the Malagasy Republic, is nearly 1,000 miles long and 360 miles in greatest width. It is the third largest island in the world, Greenland and New Guinea ranking as first and second. The narrowest part of Mozambique Channel, which separates Madagascar from Africa, is about 260 statute miles wide.

Madagascar is largely mountainous, the main ranges in its eastern part extending nearly throughout its length. Large parts of these mountains are of granite, gneiss, and crystalline schist. There are also many volcanic mountains and lava flows but no active volcanoes. The main ranges are bordered by extensive bands of hills and plains which are underlain in part by marine sedimentary rocks, including a narrow band of Cretaceous strata along part of the east coast. In the western part, a belt of sedimentary rocks 20 to 100 miles wide, as indicated on figure 48, is largely of Cretaceous age; but there are some Triassic strata in the southwest and deposits of Tertiary and Quaternary age near the west border.

There are numerous thermal springs in the island, but information concerning them is scanty. The available data are presented in the table below, and the locations of the springs are shown on figure 48.

Thermal springs in Madagascar (Malagasy Republic)

[Data chiefly from refs. 2653, 2660, and 2666. Principal chemical constituents are expressed in parts per million]

No. on fig. 48	Name or location	Temperature of water (°C)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Sakaramy Camp at Diego-Suarez	29		Basalt	Deposit of tufa.
2	Between Loky and Mananjeby in Andavakoera Valley.	60–62			Many springs.
3	Ambohipiraka	Warm		Faulted basal Triassic limestone.	
4	Ranomafana-sur-Namorana:				
	Montagne	43		do	Water is tasteless. Evolved gas is 97.55 percent nitrogen. Refs. 2656, 2668.
	Cabine	46.9		do	
	Small unnamed springs	30+		do	
5	Mananjily River springs	40			
6	Betsieka (Betsiekabe), 15 km east of Ambohipiraka.	Warm		Faulted basal Triassic limestone.	Several springs. Water is slightly saline and alkaline.
7	Djabala, near Hellville, on Nossi Be Island.	44		Volcanic rock	Water is saline and slightly alkaline. Total dissolved solids, 3,350 ppm. Free CO_2 and H_2S.
8	Betavilo, on Antalaha River	60			Large flow. Water is sulfurous.
9	Maintimbato, north of Maroantsetra	Very hot			Gaseous.
10	Ambato-Boeni (Ambatobe?), on Betsiboka River 100 km south-southeast of Majungo.	Warm		Faulted basal Triassic limestone.	
11	Ankilimahasoa, in Antsalova District	50			Large flow. Water is strongly sulfurous; used for bathing.
12	Ankazobe River springs	36, 60			Two main springs. Deposit of tufa.
13	Raimanandro, about 65 km southwest of Tananarive.	20.6			
14	Betafo, 20 km west of Antsirabe	52–55		Basalt	Large deposit of tufa. Ref. 2669.

Thermal springs in Madagascar (Malagasy Republic)—Continued

No. on fig. 48	Name or location	Temperature of water (°C)	Principal chemical constituents	Associated rocks	Remarks and additional references
15	Antsirabe area	26–51		Lava nearby	10 main springs. Water used for bathing. Refs. 2664, 2665, 2667–2669, 2672, 2674–2676.
16	Mahatsinjo, 12 km north-northwest of Antsirabe.	29	Chiefly bicarbonates Ca, Mg, and Na.	Gneiss; basalt nearby	Large deposit of tufa; pisolites of aragonite. Total dissolved solids, 7.830 g per liter.
17	Antsiravory, 4 km south of Antsirabe	27			Free CO_2.
18	Andranomalaza River spring	65		Granite; basalt nearby	
19	Antsira, west of Makavano	Warm		Diabase dike in sedimentary rock.	Water is sulfurous. Total dissolved solids, 2,048 ppm.
20	Bahavo, on west side of river opposite Ambia.	Warm	Ca (12), Na (365), SO_4 (432), Cl (84), H_2SiO_3 (39).		Total dissolved solids, 1,010 ppm. Evolves H_2S.
21	Near Ambia	Warm			Water is strongly sulfurous. Total dissolved solids, 880 ppm.
22	Kiposa, at Malaimbandy, west of Sakeny River.	40			Water is sulfurous. Total dissolved solids, 480 ppm.
23	Andranomandevy, near Migiko (Migohoko) in Mahabo District.	43–68		Gneiss and Triassic sandstone.	Water is strongly sulfurous. Total dissolved solids, 904 ppm. Free CO_2.
24	Miary, south of Fiherenana River	Warm	Chiefly Ca, HCO_3; low SO_4, Cl, SiO_2.		Total dissolved solids, 948 ppm.
25	Vineta, on southwest flank of Mount Andrambo.	Warm	CaO (185), Cl (14), SiO_2 (146)		
26	On bank of Onilahy River, 2 km from Beza and east of Tongobory.	50			Water is sulfurous. Much gas.
27	Ranomasy, between Tongobory and Betioky.	Warm	CaO (252), SO_3 (105), Cl (1,359).	Lower Cretaceous strata; basalt nearby.	Total dissolved solids, 3,560 ppm.
28	Besakay, 3 km north of Ampanihy	Warm			Water is sulfurous.

MINOR ISLANDS—KERGUELEN, RÉUNION, RODRIGUEZ, AND SAINT PAUL

Kerguelen Island is the largest in a small archipelago about 2,000 statute miles southeast of Madagascar and nearly 2,600 miles from the southern tip of Africa, as shown on figure 49. The main island is of irregular shape and deeply indented by fiords and bays. There are a dozen smaller islands and many islets nearby. The entire group consists almost wholly of volcanic rocks, granite showing only in a small area in the southwest extremity of Kerguelen Island, as indicated on figure 50. According to Aubert de la Rüe (ref. 2677), there are fumaroles near the southwestern shore, mofettes (vents emitting carbon dioxide) at two places, thermal springs at five places, and two other thermal indications.

Réunion Island, formerly known as Bourbon, is an oval-shaped volcanic island about 45 miles long, situated 400 statute miles southeast of Tamatave, Madagascar. In the central part of Réunion, a large eroded crater of andesitic lava is flanked by later basaltic flows. Within the crater are several thermal springs. In the southeastern part of the island there is a smaller volcano with two craters, one of which is solfataric, as shown on figure 51.

According to Moreau and others (refs. 2667, 2668) and Velain (refs. 2690, 2691), there are fumaroles at Le Volcan in the southeastern part of Réunion and thermal springs in four localities in the northwestern part.

Rodriguez Island, about 480 miles north of east from Réunion, is 13 miles long in an east-west direction and 3 to 6 miles wide. (See fig. 49.) The island, which is hilly, was built up by lava flows, mainly of dolerite, and is fringed by coral reefs. Balfour (ref. 2678) noted tepid, brackish springs at several places in the island.

St. Paul Island, about 1,800 statute miles southeast of Réunion, was described by Velain (ref. 2692) as a great volcanic crater, open on the east to the ocean and forming a harbor 1,300 meters across. The main crater is composed largely of trachyte, but on its flanks are two small craters of basalt, one of which is solfataric. Numerous small springs issue near sea level within the main crater, chiefly along its north and west sides, as shown on figure 52.

Other small islands in the Indian Ocean are of volcanic rocks. Amsterdam, or New Amsterdam Island, about 60 miles north of Saint Paul, has an area of about 25 square miles. It is composed almost entirely of lava. There are high cliffs along the coast and a deeply eroded crater that rises to nearly 3,000 feet altitude. All volcanic activity has ceased, and there are no thermal springs or vapor vents. Mauritius Island, 130 miles northeast of Réunion, is about 36 miles long, northeast-southwest. One small area of chloritic schist has been reported, but nearly all the island is of basaltic lava. There are several volcanic craters, but all are greatly

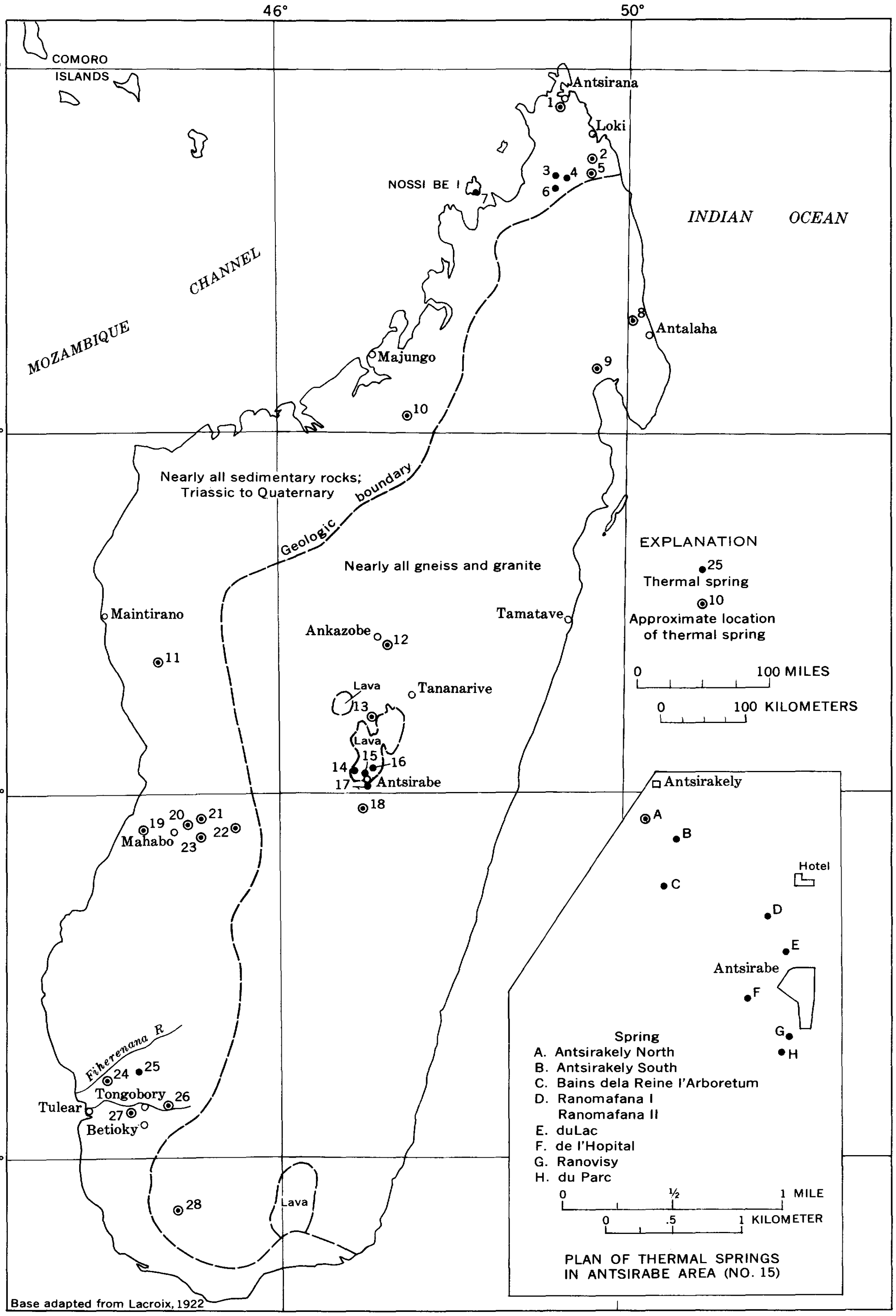

FIGURE 48.—Madagascar (Malagasy Republic) showing location of thermal springs and principal lava areas. Chiefly from refs. 2653 and 2660.

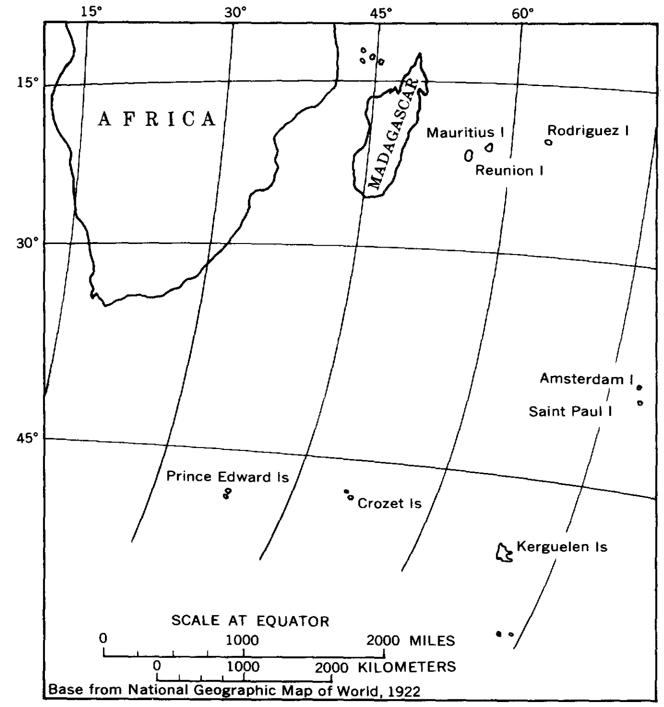

FIGURE 49.—Minor islands in the southern Indian Ocean showing location of thermal springs on Kerguelen, Réunion, Rodriguez, and Saint Paul.

eroded and, according to De Haga Haig,[5] there seems to be no evidence of thermal activity.

ASIA

AFGHANISTAN

The valley of the Oxus River (Amu Dar'ya) forms the northern boundary of Afghanistan. There is much irrigated land in this valley and also along the valley of the Hari Rud River in the northwestern part of the country and along the Helmand River in the southwest. Desert plateaus border the valley of the Helmand, but most of the region is traversed by high mountain ranges that trend, in general, northeastward to the higher Hindu Kush mountains in the northeastern part of the country.

The mountains in the northern part are composed mainly of sedimentary rocks of Carboniferous through Jurassic ages. These rocks were folded and uplifted, and streams have cut many deep gorges into them. In regions below the main mountain ranges Cretaceous strata cover extensive areas in the west and also in the north above the plains of the Oxus River. Miocene formations, including gypsum and salt, are exposed in the main valleys and plains. Fresh-water Pliocene deposits are present in some lower areas. Deposits of loess, called the Chul, cover wide areas, especially along the border of the Oxus River plain. There are great intrusions of granite and basic igneous rocks in the Cretaceous formations, and sheets of lava are interbedded with Lower Cretaceous strata. No Tertiary or later volcanic flows or mountains have been recognized.

[5] De Haga Haig, H., 1895, The physical features and geology of Mauritius: Geol. Soc. London Quart. Jour., v. 51, p. 463–471.

Only a few thermal springs have been reported to be present in the mountain areas of Afghanistan, despite the sedimentary formations having been folded and probably faulted; no thermal springs are known to be present in the areas of volcanic rocks. The locations of the springs in Afghanistan are shown on figure 53, and data on the springs are given in the table below.

Thermal springs in Afghanistan

No. on fig. 53	Name or location	Temperature of water (°F)	Remarks and references
1	Garm-ab	Warm	From General Walker's map of Turkestan. Ref. 2807.
2	Dru (Droo) village, near	Warm	Source of local water supply. Refs. 2775, 2807.
3	Garm-ab	Warm	From General Walker's map of Turkestan. Ref. 2807.
4	Khawak (Sir-Ab), 23 miles from Inderab.	108; 124	Two springs issuing from hillside. Refs. 2694, 2807.
5	Khornushu	Hot	Several springs issuing from narrow rock ledge 14 miles from base of snow-capped mountains. Refs. 2775, 2807.
6	Base of Tehalap Dalan Mountain.		Many sulfurous springs. Ref. 30.
7	Bisut, near valley of Shesh Burjeh.	Warm	Sulfur springs issuing from small mounds of tufa. Refs. 2799, 2807.

ARABIAN PENINSULA

The Arabian Peninsula consists in large part of Saudi Arabia, but includes Aden, Oman, and Yemen in its southern part.

In northwestern Saudi Arabia and along its western border southward to and beyond Mecca are mountains of granite and schist, in part overlain by red sandstone which probably is of Cretaceous and Tertiary ages. In many areas both the crystalline and the sedimentary rocks are covered by thick sheets of lava, and there are many volcanic hills. Farther inland in northern Saudi Arabia is the extensive Red Desert of Nefud, whose great sand dunes probably are derived from the sandstone.

Most of the central part of the region included in Saudi Arabia slopes gradually eastward from the western mountains to irregular plateau lands, which gradually descend to the Persian Gulf. In southern Saudi Arabia the Dahna, or Rub' al Khali, a great sandy desert, extends to the base of mountains that form the highest parts of the Arabian Peninsula. These mountains are in Yemen in the extreme southwest, along the south and southeast coasts in Aden Protectorate, and in Oman.

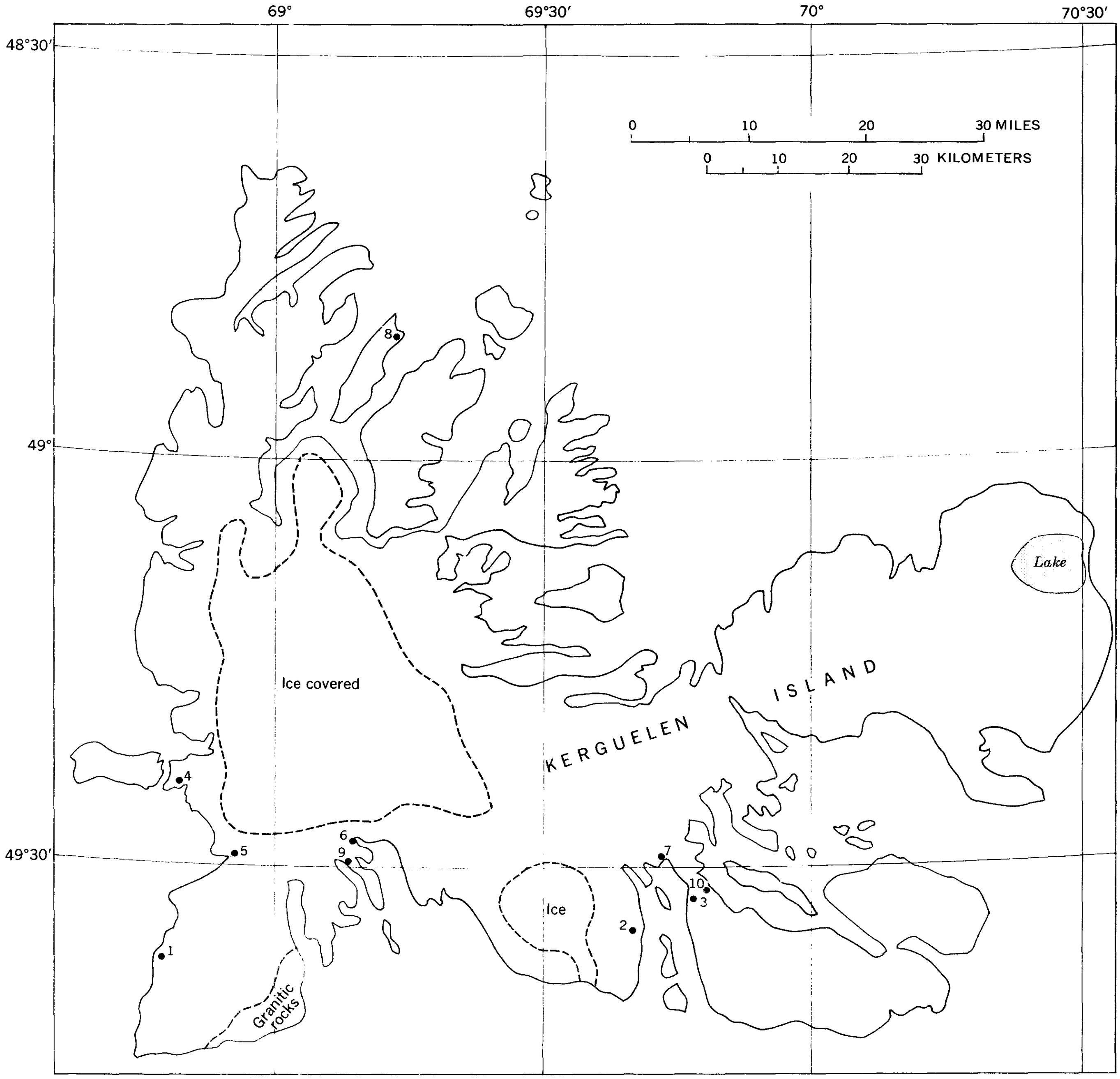

FIGURE 50.—Kerguelen Archipelago, Indian Ocean, showing location of fumaroles, mofettes, and thermal springs. From ref. 2677.

1. Fumaroles on west side of southwest peninsula
2. Mofettes on east side of central southern peninsula
3. Mofettes on west side of southeast peninsula and cold carbon dioxide springs
4. Reported thermal springs, southern part of west coast
5. Reported thermal springs, Bay of Melissas
6. Reported thermal springs, head of Table Bay
7. Reported thermal springs, head of Volage Bay
8. Reported thermal springs on MacCormick Island
9. Hot ground on east side of Chimay or Iceberg Bay
10. Cold sulfur spring at Porte Jeanne d'Arc

In the middle and southern parts of the Arabian Peninsula the ancient granite and schist are exposed in many places, and near Aden are volcanic hills. Ancient red sandstone and scattered areas of limestone that may

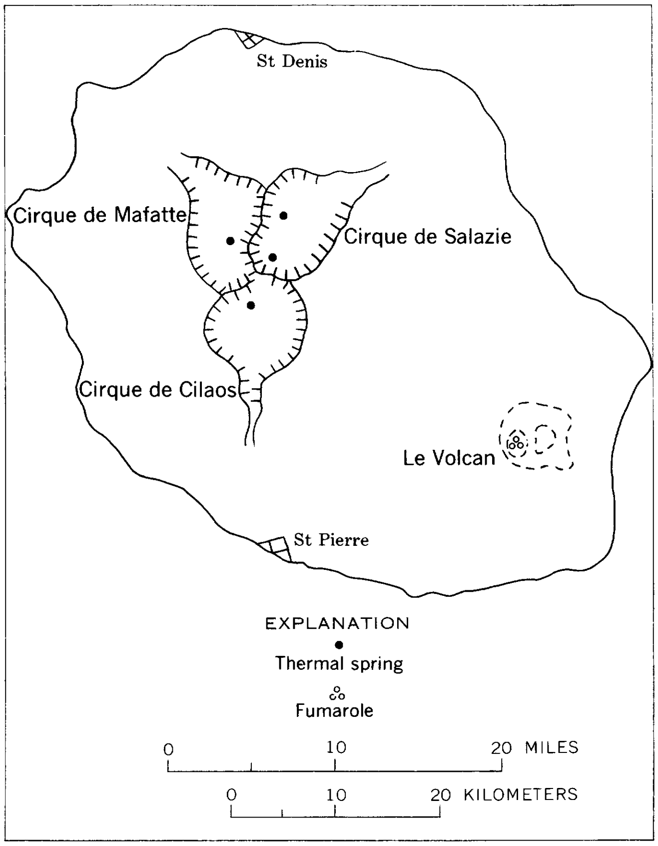

FIGURE 51.—Réunion Island, Indian Ocean, showing location of thermal springs and fumaroles. From refs. 2667 and 2692.

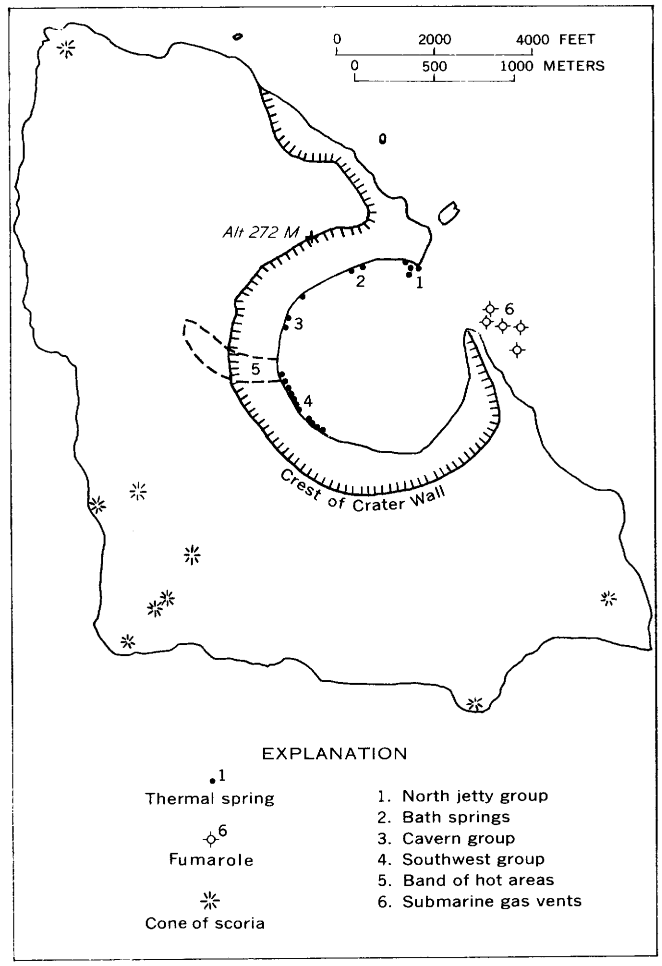

FIGURE 52.—St. Paul Island, Indian Ocean, showing location of thermal springs and fumaroles. From ref. 2692.

be of Cretaceous age cover many parts, but by far the most extensive areas are underlain by marine Tertiary formations.

Although there has been considerable faulting, most of the sedimentary strata are nearly horizontal. The greater part of the Arabian Peninsula is very arid; but in the mountains, where the rainfall is moderately abundant, springs are numerous.

The locations of the thermal springs to which reference has been found are shown on figure 54. The available information on these springs is given in the table on page 170.

CHINA

Mainland China consists of eastern China (including the island of Hainan), Manchuria in the northeast, and Sinkiang and Tibet Provinces in the far west. Formosa Island (Taiwan), off the southeast coast, is traditionally a part of China, but at the time of the writing of this report is a separate political entity. As most of the published reports on thermal springs in China concern one or another of these divisions, the bibliographic references have been grouped accordingly. The description of the topography and geology has been taken chiefly from an article by Philip Lake on the geology of China.[6]

EASTERN CHINA

The great alluvial deltas of the Hwang Ho, or Yellow River, and the Yangtze Kiang (Yang kingdom river) occupy much of the northeastern part of this vast region. The Hwang Ho plains are bordered on the west by folded mountains which are largely gneiss, schist, and crystalline limestone, overlain largely by ancient sandstone, quartzite, and limestone. Farther west, in Shansi and Shensi Provinces, are plateau regions of Carboniferous strata that include a lower limestone

[6] Lake, Philip, 1910, China [section on], Geology, *in* 11th ed., Encyclopaedia Britannica: Cambridge, England, Univ. Press, v. 6, p. 169–170.

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FIGURE 53.—Afghanistan, Baluchistan, and Iran showing location of thermal springs.

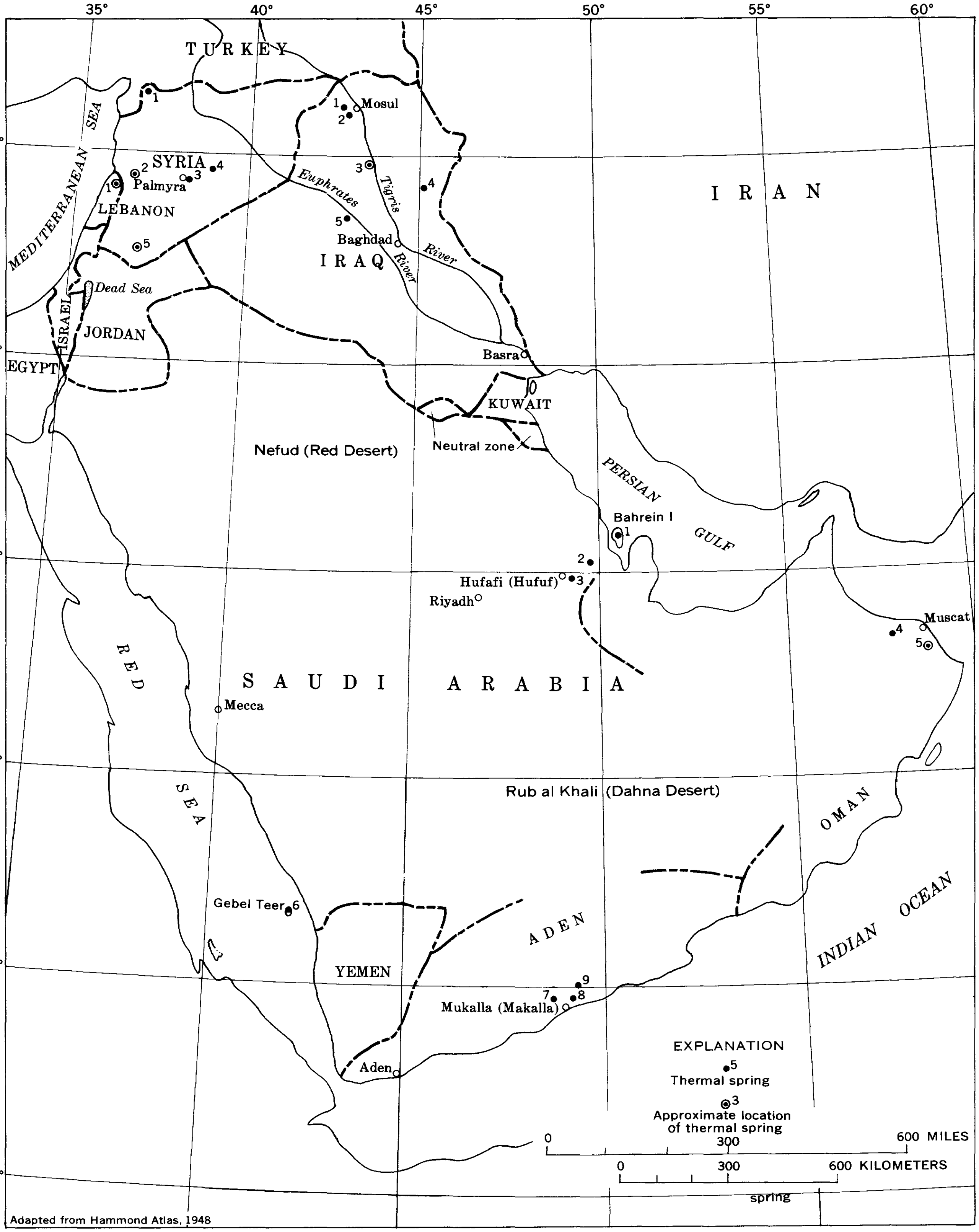

FIGURE 54.—Arabian Peninsula, Iraq, Lebanon, and Syria showing location of thermal springs.

Thermal springs in the Arabian Peninsula

[Location of unnumbered springs not identified]

No. on fig. 54	Name or location	Temperature of water (°C)	Remarks and references
1	Bahrein Island	Warm	Ref. 73.
2	Ain al Harra, near Mubarraz.	Hot	Water rises in pond; tasteless, odorless. Used for bathing. Ref. 2699.
3	Khudud and Haqal, 2½ km east of Hufafi.	Warm	Water rises in 2 sandy pools; transparent green color. Ref. 2699.
4	Nakhl (Tadmor), 80 km west-southwest of Muscat.	39–41	1 main and 20 small springs; flow 200 imperial gpm. Used for water supply of town and for irrigation. Ref. 2698.
5	South of the Bay of Muscat.	44 (max)	Springs issue from red limestone at several places. Used for irrigation. Ref. 2695.
6	On Gebel Teer (Mount Tarr or Dukhan), on Saddle Island.	Warm	Sulfurous water and fumes from 2 volcanic cones. Refs. 43, 2805.
7	About 20 km northwest of Mukalla (Makalla).	37.7–54.4	Many small springs issuing from granite; water chalybeate but potable. Ref. 2700.
8	About 8 km north-northeast of Mukalla.	37–39	Several springs; moderate flow. Free H_2S. Refs. 2696, 2697.
9	Ghail Ba Wazir, 35 km northeast of Mukalla.	Warm	3 large pools, fed by water issuing from massive gypsum (Tertiary?). Source of supply for irrigation. Ref. 2697.
------	Bahr el Sofi	------------	Near oil springs in southeastern Arabia. Ref. 30.
------	Coast of Oman	------------	Many hot carbonated or sulfureted springs. Ref. 30.

series and an upper sandstone series that contains extensive coal beds.

The central and western parts of eastern China, most of which are within the basin of the Yangtze Kiang, include extensive limestone plateaus. In the south and southeast are hills and minor mountain ranges which trend in general about parallel with the coast. In the upper part of the Yangtze Kiang basin the ranges trend in general south-southeast to north-northwest. Triassic red sandstone underlies the greater part of Szechwan Province and is present in synclinal troughs of the older beds in southeast China. Hainan Island is mountainous; it has a conspicuous central range and lower lands along its northern shore. Marine Tertiary deposits are present in some places along the coast of the mainland and the borders of offshore islands.

There are many intrusions of granite and other igneous rocks into the gneiss and schist. Groups of volcanic cones are present in the plateaus of northeastern China, and flows of basalt cover uplands near the Mongolian border. Basalt is also present in the Shantung Peninsula of the northeast coast. In southeastern China, there seems to be no evidence of Tertiary or later volcanism. North of the Yangtze Kiang, thick and extensive deposits of brownish-yellow loess form good agricultural lands.

Structurally, eastern China consists of two main regions that are separated by Tsinling Shan [Tsinling Mountains]. These high lands are greatly folded; but north of them the Paleozoic formations are in general nearly horizontal, and Carboniferous and older limestone and sandstone form an extensive plateau that rises abruptly from the western border of the great river plains of northeastern China. The plateau is deeply cut by streams, and rock strata are considerably faulted but not much folded. South of the Tsinling Shan the Paleozoic strata are folded into ridges that form the hilly region of southern China.

Some of the thermal springs issue near recently extinct volcanoes. Many are along fault zones, especially in the Weiho Valley north of Tsinling Shan, in a region that is bordered by faults of considerable vertical displacement. One group of hot springs is in northern

Thermal springs and wells in eastern China

No. on fig. 55	Name or location	Temperature of water (°C)	Flow (liters per minute)	Remarks and references
1	T'ang Shan, 23 miles northeast of Peiping.	Hot	--------	Baths of the Emperor consisting of two marble bathing pools at Imperial villa built A.D. 1723–35. Other hot springs nearby. Refs. 2708, 2711, 2937.
2	Wun-shih-tun, 23 miles south of Tung-chow.	----------	--------	Baths. Ref. 2710.
3	Near Yi-chou (Yihsien)	----------	--------	Do.
4	Ngai-shan, east of Chefoo.	Hot	--------	5 sulfur springs. Baths. Ref. 2710.
5	Loong-chwen, 20 miles east of Ngai-shan.	----------	--------	Baths. Ref. 2710.
6	Yang Kwei Fe, near Lin Tung.	38	Large	At base of mountain. Bathing pool. Resort since ancient times. Refs. 2707, 2711.
7	Pehpei, 60 miles north-northwest of Chungking.	30	400	In limestone and sandstone gorge. Temple bathing pool. Ref. 2707.
8	Nachuan, 17 miles southeast of Chungking.	Warm	Large	Water issues from limestone. Bathing pool. Ref. 2707.
9	Foochow:			
	Springs	56; 58	--------	Two springs in northeastern suburbs. Hotter water contains Na (130 ppm); SO_4 (153.6 ppm); Cl (92 ppm); SiO_2 (55.5 ppm); F (13.0 ppm). Gas almost wholly N_2. Cooler water chemically similar but contains 8.0 ppm F. Used for bathing. Refs. 2709, 2937.
	Wells	46–68	--------	All about 150 ft deep. Water used for bathing. Ref. 2709.
10	Amoy Island	Warm	Small	Several small springs between high and low tide levels on northeast coast. Principal chemical constituents: $CaCl_2$, NaCl, KCl, K_2SO_4. Ref. 2704.
11	Chung-ling-tow, 35 miles northeast of Canton.	Hot	--------	Used for bathing. Ref. 2703.
12	Yung Mak, 20 miles north-northwest of Macao.	76	--------	Water slightly saline. Used for baths. Refs. 2703, 2937.
13	Chau-Yuen, 20 miles west of Hwang.	Hot	--------	Almost boiling. Ref. 2710.
14	Hainan Island	----------	--------	Several springs. Ref. 30.

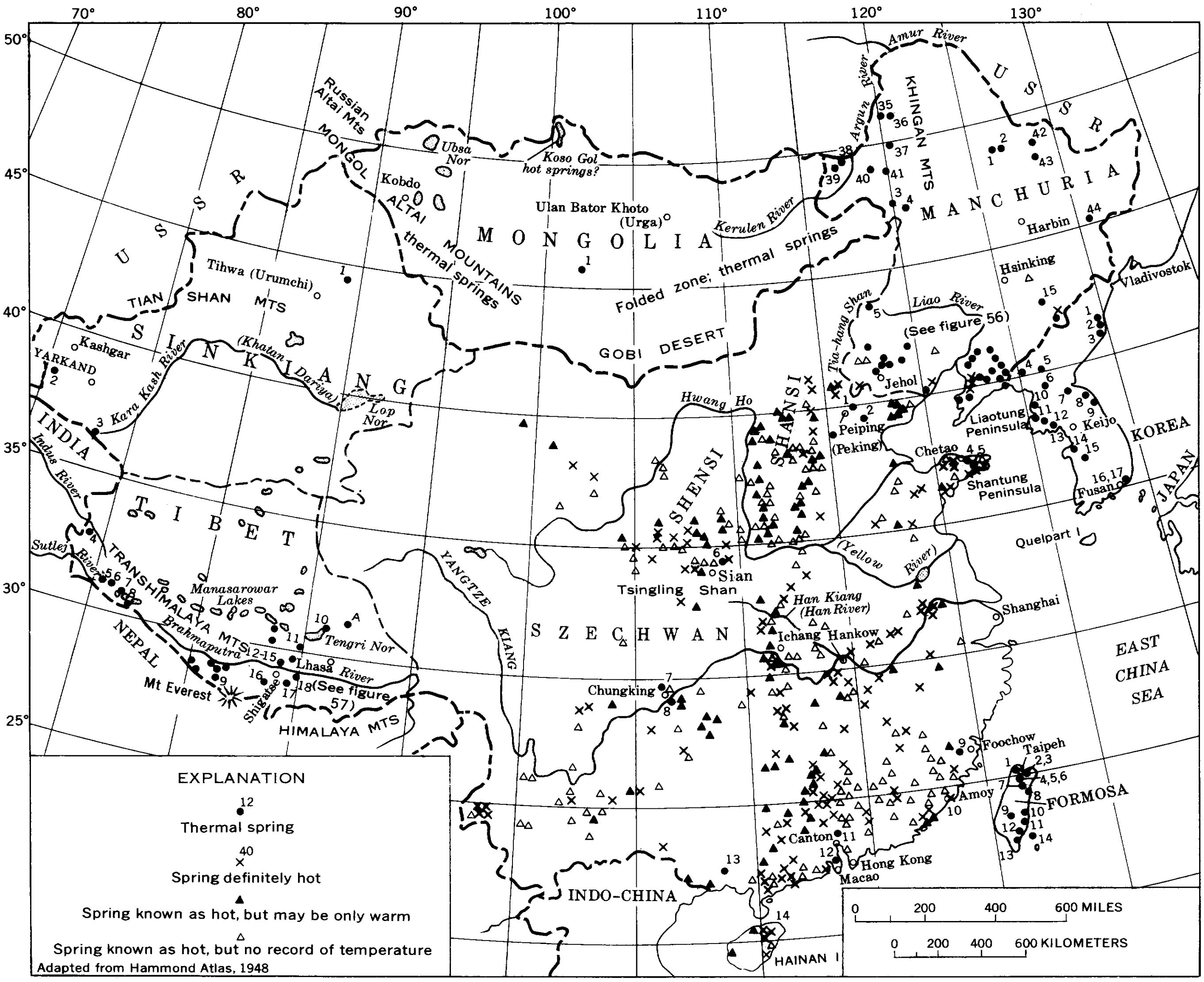

FIGURE 55.—China, Korea, and Mongolia showing location of thermal springs. Eastern China chiefly from refs. 2701 and 2702; Formosa chiefly from refs. 2942 and 2997; Korea chiefly from refs. 3231–3233; Manchuria from refs. 2723 and 2728.

Anhwei Province in easternmost China, and a line of springs near the east border of the Taihang Shan extends southward through the Han River Valley to Ichang on the Yangtze Kiang and farther southwest. Many thermal springs are along definite stratigraphic horizons or on local faults. The locations of known thermal springs in eastern China are shown on figure 55. The table on page 170 lists only those springs on which more than the location has been found in the available literature.

FORMOSA (TAIWAN)

Formosa (Taiwan) Island, about 100 miles from the southeast coast of China, is largely mountainous. The main range extends north-south through the eastern part, and the highest peaks rise to altitudes above 12,000 feet. Along the west side of the island the coastal plain is less than 20 miles wide. On the east side a wide fertile plain extends for many miles, but part of the coast is bordered by high cliffs. The larger mountains are of schist and quartzite. Coal mines near the north end of the island are in strata probably of Tertiary age. Some areas of volcanic rock have been recorded.

The locations of the thermal springs on Formosa Island are shown on figure 55. The available information on those springs is presented in the table below.

Thermal springs on Formosa

No. on fig. 55	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and references
1	Taihoku (Tansu; Ta-yu-kang; Kwang-Tsu-Ling), between Kelung (Kirun) and Tamsui.	77	----------	----------	--------------------	Sulfur springs and steam jets at small sulfur mines. Refs. 2712, 2715, 2717, 2720, 2721, 3341.
2	Hokuto, on west flank of volcano 7 miles from railroad station.	48–95	4, 134 (T., 48°C); 75 (T., 51°C)	300	--------------------	Several springs. Water very acid. Radioactive. Small deposits of lead-barium sulfate (hokutolite). Resort. Refs. 109, 2714, 2716, 2719, 2939, 2942.
3	Sozan (Tsaoshan), 7 miles north-northeast of Taipeh.	62	Large	2, 232	KCl (1,128 ppm); NaCl (396 ppm); $CaCl_2$ (341 ppm); $CaHCO_3$ (201 ppm).	Resort. Ref. 2939.
4	Urai (Wulai), 13 miles south of Taipeh.	80. 3	----------	----------	--------------------	Saline water from Tertiary strata. Ref. 2942.
5	Toi (Tow-wei), 8 miles northeast of Ilan:					
	Artesian well	53	----------	Low	--------------------	Water derived from Quaternary deposits. Ref. 2942.
	Springs	55–79. 3	----------			
6	Ilan, 25 miles southeast Taipeh.	Warm	----------	----------	--------------------	
7	Shokei	57. 5	----------	505	Na_2CO_3, NaCl	Baths. Resort. Refs. 2939, 2997.
8	Suivo (Su-o)	23	----------	215	HCO_3; much free CO_2	Spring issues from clay slate. Ref. 2942.
9	Kwanshirei (Kanserei)	61; 77	17	10, 180 (cooler); 13, 262 (warmer)	Na_2CO_3, NaCl, KCl	2 springs issuing from Tertiary strata. Water is strongly alkaline; much gas. Resort. Refs. 2713, 2939, 2942.
10	Mizuho	Warm	Small	----------	--------------------	Ref. 2997.
11	----------	Warm	Small	----------	--------------------	Do.
12	----------	Warm	Small	----------	--------------------	Do.
13	----------	Warm	Small	----------	--------------------	Do.
14	Kasho Island	Warm(?)	Small(?)	----------	--------------------	Do.

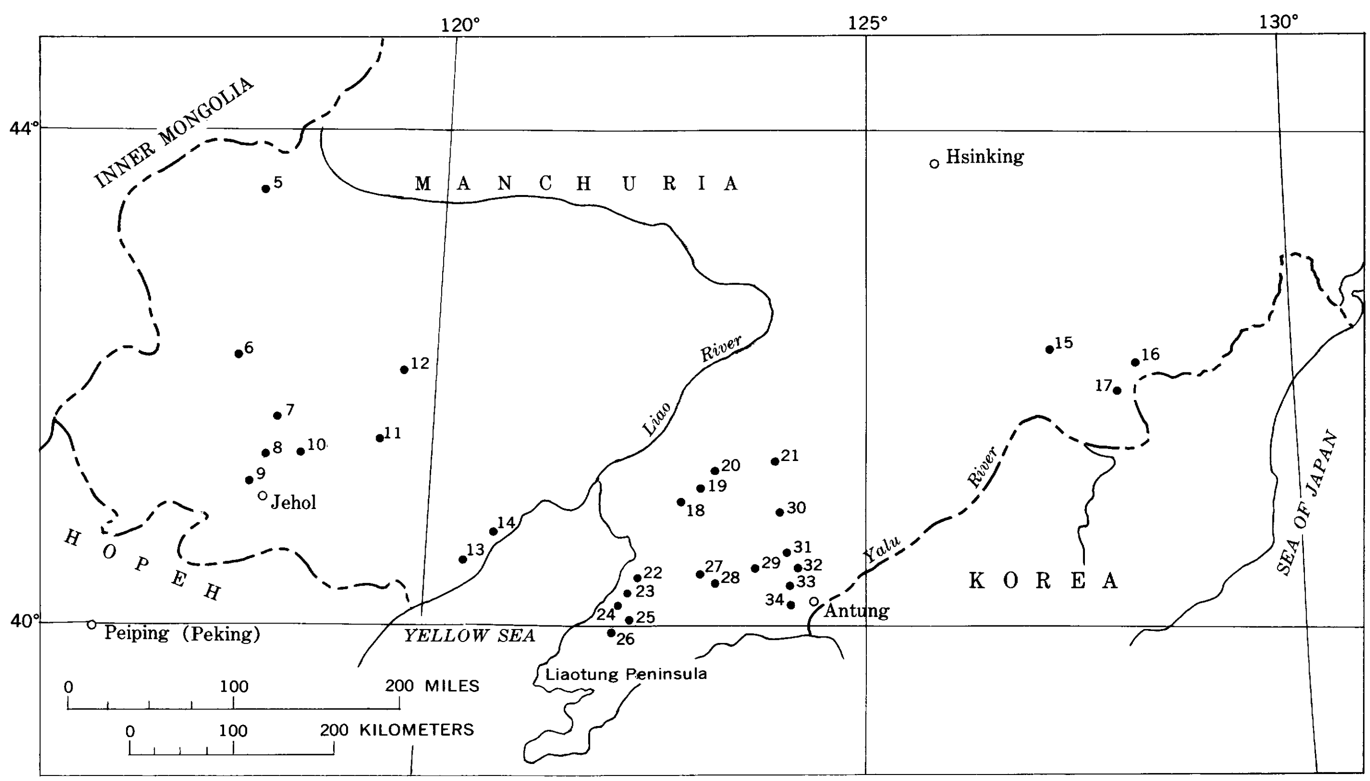

FIGURE 56.—Southern Manchuria showing location of thermal springs. From ref. 2728.

MANCHURIA

In eastern Manchuria mountain ranges consisting largely of crystalline and metamorphic rocks extend northeast-southwest. To the west is the great fertile plain of the Liao Ho, dotted with conical hills, some of which may be of lava. Basalt is exposed in parts of the Liaotung Peninsula. In northwestern Manchuria the Khingan Mountains trend nearly north-south and are composed chiefly of ancient crystalline and metamorphic rocks, overlain by Paleozoic sedimentary strata.

Thermal springs at three places in South Manchuria were mentioned in an official guidebook of the Imperial Japanese Government Railways (ref. 2939), but the best summary of the springs in this region seems to be a report by Monden and others (ref. 2728) which consists of one paper indicating thermal springs at 34 localities and seven other papers describing the principal springs. Their locations are shown on figures 55, and 56, and the available data are included in the table below.

Thermal springs in Manchuria

[Principal chemical constituents are expressed in parts per million]

No. on fig. 55 or 56	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and references
1	Hsiyen and Yeh, 6 km south of Atahushan.	Hot				Ref. 2728.
2	Wutualian-chih, 8 km southwest of Lungchen railway station.					Do.
3	Halun-Arshan, on east side of railway	20–46	7, 125	Low		28 springs issuing from alluvium overlying granite. Water moderately mineralized. Bathing resort for more than 1,000 years. Refs. 2723, 2728.
4	Hsiung-yao-cheng (Great Hingan), 40 km southeast of Halin-Hulun-Arshan.	54	1. 5	1, 063	Na (265); SO_4 (164); Cl (326); SiO_2 (109).	Refs. 2723, 2728, 2731, 2739.
5	Tang shan (Fe-shui-tang), 27 km west of Linghsi.	30–44				3 springs in ravine. Bathing. Ref. 2728.
6	Yinchin, 100 km west of Chihfeng	Hot				Ref. 2728.
7	Mohsing, 45 km north-northwest of Pingchuan.	Hot				Do.
8	Sankoutang	Hot				Do.
9	Northwest, north, and northeast of Jehol.	Warm to hot				Several springs. Refs. 2721, 2724.
10	Maochinpa, 53 km north-northwest of Chengteh.	Hot				Ref. 2728.
11	Je-shui-tang, 15 km north-northeast of Lingyuan:					
	3 main groups of springs	19–25				Baths. Ref. 2728.
	8 wells 5 meters deep	38–44				
12	Jeshuitang, 25 km east-northeast of Kienping.	Hot				Ref. 2728.
13	Tangshang, 15 km north-northwest of Suichung (Fe shiu tang).	Hot				Do.
14	Hsing-cheng, 3 km east of Hingcheng (Hsing-cheng):					
	46 springs in and along stream	20–47				Radioactive. Bathing resort. Refs. 2726, 2728, 2730.
	Several wells	64 (max)				
15	Tanghokoutze, 60 km south of Fushun	Hot				Ref. 2728.
16	Pai Tou Shan (mountain):					
	San Chih Yuan, near Hoshan Lake.					Do.
	Tang Shui Chang, on north side of Hoshan Lake.					Do.
	Pai Wen Chuan, 4 km north of Hoshan Lake.	61				Do.
17	Liuhuang, 8 km southwest of peak of Pai Tou Shan.	Hot				Do.
18	Tangkangtsu, 4 km south-southwest of Anshun railway station:					
	15 sources (wells and springs)	34–64				Sulfureted. Bathing resort and military sanatorium. Refs. 2728–2731, 2939.
	Well 50 meters deep	72	2. 5		Na (113); SO_4 (112); Cl (63); SiO_2 (96); free H_2S.	

Thermal springs in Manchuria—Continued

No. on fig. 55 or 56	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and references
19	Niechiatai, 15 km east of Anshan	Hot				Ref. 2728.
20	Tanghoyin (Tang-ho-yan), 25 km southeast of Liaoyang.	Hot				Ref. 2725.
21	Kouerhtang, 24 km east of Pensihu	Hot				Ref. 2728.
22	Ssulapao, 7 km southeast of Luchiatung.	Hot				Do.
23	Hsiung-yao-cheng, 3 km southeast of town.	60–84. 5			Na (265); SO_4 (164); Cl (326); SiO_2 (109).	5 main springs. Water alkaline, sulfureted. Bathing resort. Refs. 2728, 2731.
24	Lungmentang, 6 km southeast of Sun-chia-ten (Hsu-chia-tung).	Hot				Ref. 2728.
25	Kientze, 25 km northeast of Anpei	Hot				Do.
26	Anpei, 20 km east of Hsiung-yao-cheng.	Hot				Do.
27	Koutang, 16 km northwest of Siuyen (Yuyin).	Hot				Do.
28	Tangchihkou, 9 km from Suiyen	Hot				Do.
29	Miao leng kao, 25 km southwest of Kihwanshan (Chih-kuan-shan).	Hot				Do.
30	Tangchihkou, 28 km northeast of Chaohokou.	Hot				Do.
31	Tangchihtze, 9 km north-northeast of Feng-huang-cheng (Feng-cheng).	Hot				Do.
32	Tungtang, 14 km northeast of Tang-shansheng.	Hot				Do.
33	Wu-ling-pei:					
	6 main springs	42. 5–62. 5	80		Na (58); SO_4 (34); Cl (28); SiO_2 (92).	Resort. Refs. 2728, 2731, 2939.
	2 minor springs; 8 wells (2.6–13 meters deep)	52. 5–63. 1				
34	Tanchihtze, 12 km southwest of Antung.	Hot				Ref. 2728.
35	Darbukan					Ref. 2723.
36	Derbul					Do.
37	Mergel					Do.
38	Lu-pin					Do.
39	Dashiman					Do.
40	Hailar, southwest of town					Do.
41	Mud Lake, southeast of Hailar					Do.
42	Wuiun					Do.
43	Shih-tou-ho					Do.
44	Mu-lin					Do.

SINKIANG AND TIBET

The southern part of Sinkiang Province consists mainly of desert plateaus, but in the northern part several peaks of the Tian Shan reach altitudes above 20,000 feet, where there are many glaciers. Some crestal parts of these mountains consist of greatly folded Paleozoic marine sedimentary rocks; other parts are flanked by marine Mesozoic deposits. Cretaceous beds have been recognized in the western parts of the Tian Shan.

In Sinkiang, Hedin (ref. 2736) noted only one locality of hot springs, about 150 km south-southwest of Kashgar. The water of another spring south of Yarkand was recorded by Shaw (ref. 2742) to be warm and slightly brackish.

Tibet is bordered on the south by the Himalaya Mountains, along whose north base the Brahmaputra River has cut gorges. Farther north another great mountain system, the Trans-Himalaya, has a maximum width of more than 100 miles. Beyond them is the plateau region of northern Tibet, which is dotted by saline and alkaline lakes with no outlets and which extends eastward to escarpments that drop to lands of the upper Yangtze Kiang basin. In the high mountains of southern Tibet are marine Mesozoic strata. On the eastern border of the Tibetan plateau, limestone is exposed; and along the shore of Tengri Nor [Tengri Salt Lake], in the southeastern part of the plateau region, marine Cretaceous strata are present.

The locations of the thermal springs in Sinkiang are shown on figure 55; those in Tibet are shown on figures 55 and 57. The available data on the springs are summarized in the table below.

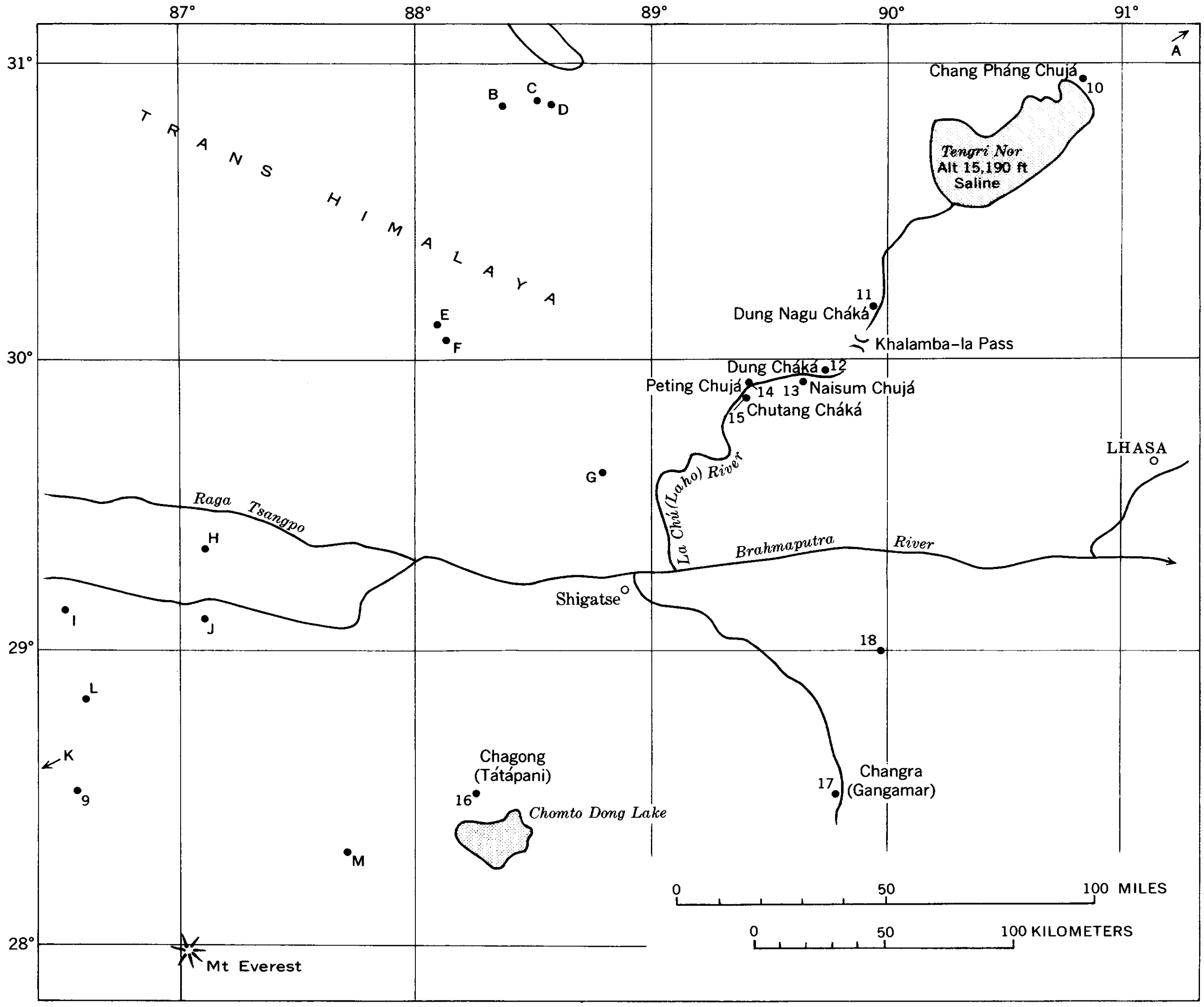

FIGURE 57.—Part of southern Tibet showing location of thermal springs. From refs. 2737, 2739, and 2740.

Thermal springs in Sinkiang and Tibet

No. on fig. 55 or 57	Name or location	Temperature of water (°C)	Remarks and references
	Sinkiang		
1	Urumchi solfatara, near Turfan volcano.	------------	Eruption reported to have occurred in A.D. 1777. Ref. 43.
2	Issyk Bulak, on south side of Mus-tagh-Ata mountain southwest of Kashgar.	51.7–52.8	4 springs. Water sulfurous, leaves iron stains on rocks. Ref. 2736.
3	Near Kara Kash River, between Sanjoo and Sooget Pass.	Warm	Water slightly brackish. Ref. 2742.
	Tibet		
4	Damchok, near town	<37	At altitude of 17,000 ft. Ref. 2807.
5	Kienlung, on left bank of Sutlej River, 1 km north of Kyunglung.	------------	Refs. 2745, 2807.
6	Terthapuri, 19 km above Kienlung:		
	2 springs	Hot	Tufa deposit. Ref. 2745.
	Other springs	90–94	At altitude of 11,000–12,000 ft. Ref. 2745.

Thermal springs in Sinkiang and Tibet—Continued

No. on fig. 55 or 57	Name or location	Temperature of water (°C)	Remarks and references
	Tibet—Continued		
	Manasarowar Lake:		
7	Near northwest shore	Hot	Refs. 2741, 2745.
8	Near southeast shore	Hot	Ref. 2745.
9	Tatapani, on west bank of Sunkusi River.	Hot	3 springs forming small pool. Water sulfurous. Ref. 2807.
10	Chang Pháng Chujá, near north shore of Tengri Nor.	54	Several springs. Refs. 30, 73, 74, 2739, 2740.
11	Dung Nagu Cháká, north of Khalamba-la Pass.	81	Several springs. Refs. 2739, 2740, 2745.
12	Dung Cháká, on south side of Khalamba-la Pass.	54	Several springs at altitude of 15,700 ft. Refs. 2739, 2740, 2745.
13	Naisum Chujá, on both sides of Lahû Chu River.	83 (max)	Many hot springs. Two spout to height of 60 ft. Water freezes into ice pillar. Refs. 2735, 2737, 2739, 2740, 2745.
14	Peting Chujá, in and along Lahû Chu River.	79	12 springs on north bank of river spout to height of 40–50 ft. Also spouting springs in river. Refs. 2739, 2740.

Thermal springs in Sinkiang and Tibet—Continued

No. on fig. 55 or 57	Name or location	Temperature of water (°C)	Remarks and references
	Tibet—Continued		
15	Chutang Chákà:		
	15 springs	74 (max)	Water sulfurous. Used for bathing. Refs. 2735, 2739, 2740.
	One spring	85	
16	Chajong (Tátápani)	Hot	At altitude of 15,000 ft. Water stored in 4 reservoirs 30 ft in circumference and 3 ft deep. Ref. 2740.
17	Changra (Gangamar), 19 km from town.	31	Bathing pools. Refs. 2740, 2807.
18	Trumsa (Thompa), near village	Hot	Water sulfurous. Used for filling bathing pools beside Rong River (Rang Chu) between Shigatse and Lhasa. Ref. 2738.
Letter on fig. 55 or 57			
A	Nakchukha Dzong, 3 km south of town.		Ref. 2745.
B	Chag Pass, 5 km southeast of town.		Ref. 2744.
	Yanga:		
C	5 km east of town		
D	10 km southeast of town		
E	Selindo, 3 km southeast of town		Ref. 2745.
F	Mense Tsuka, 10 km south-southeast of Selindo.		
G	Shigatse, 45 km north-northwest of town.		
H	Raga Tsangpo River, 15 km south of river.		
I	Kuda, 5 km northeast of town		
J	Jenung, 5 km east of town		
K	Kyerong Dz, 4 km south of town		Refs. 2735, 2745.
L	Yoldo, 2 km northeast of town		Ref. 2745.
M	Chundo, 10 km southwest of town.		

INDIA AND ADJACENT AREAS

India and its neighbors—Pakistan, Nepal, Sikkim, Bhutan, Burma, and Ceylon—occupy the vast region southeast of Afghanistan and Iran and south and southwest of central and western China. Much of the northern border of this area is formed by the Himalaya Mountains and the Karakoram Range, which descend southward as east-west trending ranges of hills. The crystalline and metamorphic rocks and the ancient sedimentary strata exposed in the Himalayas and in some of the lower ranges are intensely folded and faulted. The other lower ranges are composed largely of folded marine strata of late Tertiary age. South of the mountainous area is a wide band of plains that extends across the Indian Peninsula from the Bay of Bengal on the east to the Arabian Sea on the west. Drained in large part by the Ganges River, this nearly level region ranges in width from about 90 to 300 miles and is underlain by thick layers of alluvian and wind-deposited material. Most of the southern half of the Indian Peninsula is a plateau that is bordered on the east by the Eastern Ghats and on the west by the Western Ghats. The latter rise steeply from a narrow coastal plain, whereas the former rise less steeply from a wider coastal plain. Granite, gneiss, and other crystalline rocks are exposed throughout the greater part of the plateau region; elsewhere, they are overlain by crystalline schist and sedimentary strata. The Gondwana series of Carboniferous to Jurassic age is composed almost entirely of fresh-water deposits and includes some coal beds. Marine Cretaceous strata form parts of the mountains near the northwest border of the plateau, whereas the prominent hills in the western part of the plateau are composed of basaltic rock, the Deccan Trap of Cretaceous and Eocene age.

Nearly all of Ceylon is underlain by the same series of granitic and metamorphic rocks that is widespread in the southern part of the Indian Peninsula.

Nepal, a small country on the northeast border of India, has a belt of lowland along its southern part. From this belt the land rises northward to the main Himalaya Mountains. It contains some of the highest peaks, including Mount Everest. Sikkim, an even smaller country, borders Nepal on the east and occupies an area in the high mountains within the upper drainage basins of two rivers that flow south to the plain of the Ganges River. Bhutan, farther east, also occupies part of the Himalayan region.

Burma, which lies on the east side of the Bay of Bengal, includes a northwestern mountainous region, a central region of the Irrawaddy River basin with its great delta, and a narrow, hilly strip along the east side of the Bay of Bengal, cut by many streams that flow directly to the Bay. In the eastern part of the country the higher mountains are chiefly of granite, gneiss, and Paleozoic sedimentary rocks, which also underlie alluvium of the river valleys. In some ranges that curve to the northeast, Cretaceous and Eocene strata are flanked by Miocene beds. In the western part are deposits mostly of Tertiary and Quaternary ages. Beneath the alluvium of the Irrawaddy River valley are extensive fresh-water deposits of Pliocene age. Volcanic rocks are not common but are present in some parts of the country. The mud volcanoes in the lower Irrawaddy River valley seem to have no connection with volcanism.

West Pakistan, which lies between India and Afghanistan, includes the former British Baluchistan and most of the lower part of the Indus River drainage basin. In its northwestern part are two southwest-northeast trending mountain ranges, between which lies the great stony Kharan Desert. These mountains are composed predominately of Cretaceous and Tertiary strata that are considerably folded and are intruded by syenite and diorite. Older rocks are exposed in some of the high ridges. The Tertiary and later deposits in the area between the mountains and the Arabian Sea are nearly horizontal. A zone of Recent volcanoes extends westward into southeastern Iran; all those in West Pakistan seem to be extinct. Sulfur has been mined for many centuries at Kuh-i-Sultan, the largest volcano. The lower Indus River drainage basin is a broad plain underlain by thick deposits of alluvium. Compared to the rugged western and northwestern parts of West Pakistan, the Indus River Valley is very fertile and well watered. East Pakistan, on the Bay of Bengal, occupies the lower Ganges-Brahmaputra delta and the Assam highland foothills.

In India and its neighboring countries the relation of the numerous thermal springs to the geologic structure is not clear in all places. The grouping of springs in some areas and the presence of notable bands of springs in other areas suggest faults or close folds that may allow the escape of deep-seated water. Very few springs seem directly related to volcanism.

A report by Oldham (ref. 2807) contains much information on thermal springs in these countries and is the source of most of the data in the seven tables below. No table was prepared for the country of Bhutan because no specific information on the springs reported to be there has been published. The locations of the springs in Baluchistan are shown on figure 53, and those in India, Ceylon, Nepal, Sikkim, Burma, West Pakistan and East Pakistan are shown on figure 58.

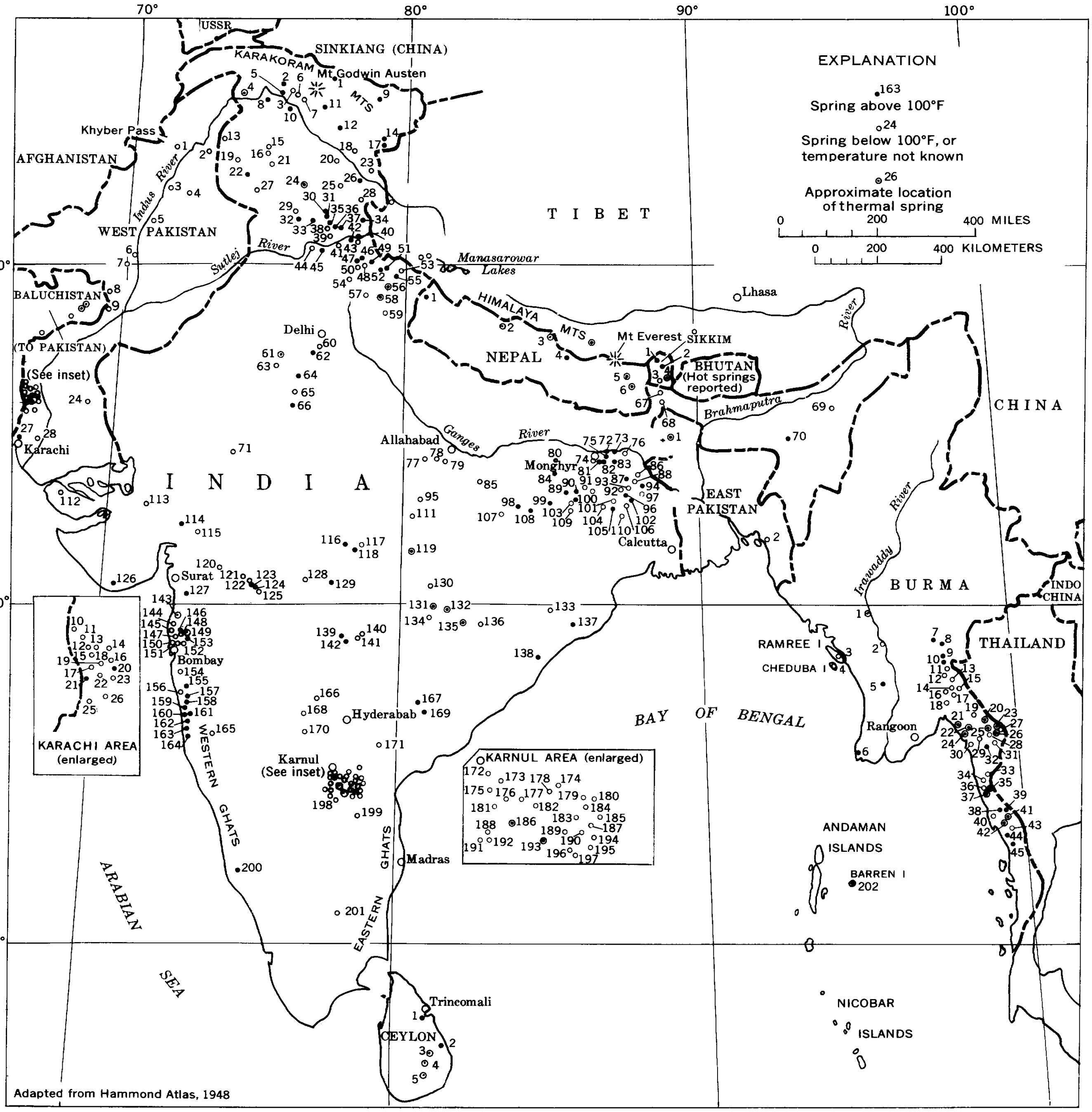

FIGURE 58.—India, Ceylon, Nepal, Sikkim, Burma, East Pakistan, and West Pakistan showing location of thermal springs. Chiefly from refs. 2745, 2807, and 2826.

Thermal springs in Baluchistan

[Chiefly from ref. 2807]

No. on fig. 53	Name or location	Temperature of water (°F)	Remarks and additional references
1	Between Gwader and Ras Kucheri on Mekran coast.	Warm	Many mud volcanoes standing 20–400 ft above plains underlain by Miocene clay and sandstone. Large gas bubbles.
2	Lakha (Lakha Peer), between Janatar and Kichi.	Hot	Large flow of sulfurous water. Ref. 2709.
3	Uch (Ooch)	Warm	Several springs in center of valley bordered by cliffs or dipping sandstone. Water is saline.
4	Doza Khusti (Doza Kooshtee), in Dehrah Valley.	Warm	Issues from limestone.
5	Kissuker (Kissooker)	71 (max)	Several springs issuing near base of Trukkee Range.

Thermal springs and wells in India

[Data chiefly from ref. 2807. Principal chemical constituents are expressed in parts per million]

No. on fig. 58	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
1	Yarkand River, 25 miles below head.	Hot				Several springs issuing from base of cliff at altitude of 14,900 ft. Ref. 2782.
2	Bisil (Behitsil)	160	Large			Water contains much gas, deposits sulfur. Used for bathing. Ref. 2830.
3	Tosha, on right bank of Braldoh River.	Warm				
4	Bulu (Booloo), northeast of town.	Hot				Several springs. Water is saline. Ref. 2775.
5	Chutrum, on right bank of Basha River.	110				Ref. 2779.
6	Hoto, on right bank of Braldoh River.	117; 122; 137	Small			3 springs less than 1 mile apart. Water is sulfurous. Ref. 2779.
7	Chongo (Askali, Askole, Askoley), on Braldoh River.	169				Issues from tufa mound 30 ft high at altitude of 9,700 ft. Water is sulfurous and of emerald hue. Used for bathing. Refs. 2754, 2771, 2779.
8	Duchin (Dashkin, Mush-kin?) on stream bank near plain of Bonj.	154				2 springs. Water is chalybeate; deposits sulfur. Ref. 2816.
9	Kisik Kiul (Kiuk-Kiul, Kisooker), near village.	92–130			NaCl; much free CO_2.	About 50 springs at altitude of 15,500 ft. Water is brackish. Refs. 2782, 2814, 2815, 2828.
10	Sneuron (Tsuh-Tron)	109	Large			Issues from limestone at altitude of 7,700 ft. Used for bathing. Ref. 2830.
11	Khorkun (Kor Chondus), near village.	185				Issues from gneiss(?) at altitude of 9,000 ft. Water deposits sulfur and gypsum; leaves iron stain on rocks. Refs. 2828, 2830.
12	Nubra (Chusan), 1 mile below Panamik.	170.5; 172				2 springs issuing from gneissic debris at altitude of 10,500 ft. Water is sulfurous; leaves calcareous encrustations. Used for bathing. Refs. 2755, 2766, 2801, 2814, 2815, 2827, 2828.
13	Turnawai, 7 miles southeast of Mansurah.	Warm				Issues from nummulitic limestone at altitude of 5,500 ft.
14	Gokra, 8 miles from village	150				Several springs at altitude of 16,500 ft. 1 spring spouts from mound of tufa. Water contains much free CO_2. Temperature of other springs nearby is 90°F. Refs. 2782, 2783.
15	Theed (T'hed) on east shore of Lake Srinagar in Valley of Kashmir.	Hot in winter				

See footnotes at end of table.

Thermal springs and wells in India—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
16	Pampur (Kshir Nag)	70				Issues from contorted limestone. Water contains H_2S. Refs. 2801, 2816, 2830.
17	Kium (Kyam), on south side of Chang-chengmo River.	147				At altitude of 14,000 ft. Ref. 2801.
18	Chigar (Chagrar, Tagar?)	70. 5				At altitude of 15,000 ft. Ref. 2801.
19	Saira (Sohora), on tributary of Mendola River.	Hot				
20	Knarung, in Ladak	Warm				Bad taste. Ref. 2801.
21	Islamabad, in valley of Kashmir	Warm				2 springs. Ref. 2748.
22	Rajawar (Rajapur), 1 day's march east of city.	140				2 springs issuing from marly limestone; water is sulfurous. Ref. 2830.
23	Shushul (Chushul, Chusul)	96				At altitude of 14,400 ft. Refs. 2766, 2801.
24	Tatwani, on bank of Chenab River.	140				Issues from gneiss and slate. Ref. 2816.
25	Kuruchum, on road to Shach	Warm				At altitude of 18,000 ft.
26	Pugha (Puga), on both banks of Rulang-chu stream.	[1] 174				Numerous springs, gently to strongly bubbling, at altitude of 15,270 ft. Water is sulfurous; free H_2S. Refs. 2766, 2827.
27	Aknur (Aknoor), on bank of Chenab River.	Hot				
28	Tsomoriri, at south end of lake.	Warm				Several springs at altitude of 15,670 ft.
29	Lausah, in hills northeast of Nurpur.	72			$CaCO_3$ (20); Na_2CO_3 (2,600); Na_2SO_4 (160); NaCl (740); SiO_2 (40).	Ref. 2794.
30	Bashisht (Bassisht, Beshist, Vashishta Muni, Biseshtamoonh), on left side of Beas (Bias, Byas) River, opposite Monal.	117		700		Several springs (wells?) issuing from mica schist 500 ft above stream level. Water contains much H_2S. Refs. 2765, 2767, 2796, 2801.
31	Sitakund (Sita-Kund. Seeta Koond) at Kelat on right bank of Beas (Bias, Byas) River.	106–110		800		Several springs issuing from mica schist. Main spring is a few feet above river and rises in masonry-walled tank 12 ft in diameter and 3 ft deep. Water is sulfurous and has bitter taste. Refs. 2765, 2767, 2796, 2825.
32	Teva (Futtipani), 10 miles from Dhurmsala.	108			$CaCO_3$ (100); $CaSO_4$ (120); CaCl (546); NaCl (9,233); NaBr (1?).	Possibly 2 springs at this location. Refs. 2795, 2797, 2809, 2816.
33	Tatwani, on tributary of Birmi River.	[1] 120				Several springs issuing from gneiss or schist at altitude of 7,000 ft. Water is bitter and deposits iron.
34	Changrizang (Shalkar, Zungsum), on south bank of Para River a few miles from Shalkar.	116. 5–117. 5				10 small springs at altitude of 11,000 ft. Water leaves saline incrustation; free H_2S. Ref. 2788.
35	Kaluth, several springs on right bank of Parbatti (Parbutty) River, near bridge.	100–108				
	Bishenand, 500 yd from Kaluth springs.					
36	Manikarn (Mannikurn) on right bank of Parbatti (Parbutty) River.	160. 5–202	Large	[2] 320	$CaCO_3$, $CaCl_2$, Na_2SO_4, NaCl.	14 springs issuing from mica schist at altitude of 5,587 ft. Water issues violently and noisily. Ferruginous, siliceous travertine deposited by water. Much vapor and gas. Refs. 2796, 2801.

See footnotes at end of table.

Thermal springs and wells in India—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
37	Khirgunga (Nakthan), 9 miles southeast of Manikarn.	118				Ref. 2816.
38	Dharmaur (Hissaoo Teeruth), in bed at Parbatti (Parbutty) River.	Warm				
39	Babut, near mouth of small tributary of Beas (Bias, Byas) River.	Warm				
40	Puari (Jauri) on left bank of Sutlej River 4 miles northeast of Chini.	125–130				Ref. 2805.
41	Jaori, on left bank of Sutlej River	Hot				5 springs. Water is saline. Ferruginous deposit on stones. Ref. 2776.
42	Natpa (Tatpa, Natssa), on right bank of Sutlej River.	137				
43	Rarang, on right bank of Sutlej River.	Warm				
44	Bhasra (Bhatra, Lohand Khad), at head of tributary of Sutlej River.	Warm				Water is strongly saline and slightly laxative. Refs. 2788, 2816, 2833.
45	Suni (Soonee), on bank of Sutlej River.	[1] 135			NaCl	About 10 springs. Water is saline, alkaline, sulfate; contains much H_2S. Deposits sulfur. Refs. 2776, 2812.
46	Kharsali, on left bank of Jumna River.	72. 1				At altitude of 8,653 ft.
47	Palia (Asarigadh, Wazirgurh) on right bank and in bed of Jumna River.	>100				Several springs. Water is sulfurous. Ref. 2774.
48	Jumnotri, at source of Jumna River.	192.6; 194	Large			Numerous springs at altitude of 9,793 ft. Some iron deposited by water. Refs. 2774, 2784, 2805.
49	Huri (Uri, Ganotri), on left bank of Bhagirathi River.	139. 8				Ref. 2788.
50	Banassa	[1] 160	Low			Numerous springs at altitude of 7,478 ft.
51	Badrinath	129				At altitude of 10,214 ft.
52	Gaurikund (Kedernath)	127				
	Bank of Mandakni River below Gaurikund.	Hot				
53	Bhap-kund, on streambank 1.5 miles from Jhelum.	Hot				
54	Sansaodarah, near Gangnani	73				Issues from limestone. Ref. 2763.
55	Tapoban:					
	0.5 mile from village	99; 109				2 springs. Water clear but deposits ocherous sediment.
	1 mile from village	123; 127				Do.
56	Kulsari, on bank of Pindar River	Warm				
57	Bhaori (Vodri, Gangnani), near Amola (Mala) village.	[1] 94				4 small springs. Refs. 2763, 2816.
58	Agur, on bank of Ramgunda River.	Warm				
59	Naini Tel:					
	In outlet channel of lake	Warm				Water is sulfurous; deposits sulfur.
	Lake bed	Warm				Water is sulfurous.
60	Sunah (Sonub), 35 miles south of Delhi.	108; 125	Variable			2 springs issuing from sandstone. Much free H_2S. Water used for bathing. Refs. 2750, 2805.
61	Kanwery	Warm to hot				Many springs.
62	Pakul (Islamabad, Phrabas Kund), near Pali.	Hot				Referred to as "Pilgrimage Well," but may be a spring. A place of Hindu worship.
63	Ganesar (Gunneshur)	Hot				
64	Talbrick, 14 miles west-southwest of Alwar.	118				
65	Koilesar (Koleshur)	Hot				
66	Mora (Morloh), 60 miles south of Alwar.	120				Ref. 2790.
67	Puklaz (Puglaz Sachu, Puklong Sachoo), on Runjit River.	Warm				Water is malodorous, leaves white deposit. Used for bathing. Ref. 2751.

See footnotes at end of table.

Thermal springs and wells in India—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
68	Menchi (Menchu), on west bank of river.	Warm				Water leaves deposit of iron oxide. Used for bathing. Ref. 2751.
69	Namba, on streambank 12 miles from Golaghat.	Hot	Large			Several springs. Water is slightly sulfurous. Much gas.
70	Kopili, on right bank of stream	122				Water is strongly saline.
71	Gangra (Gangar), 12 miles northwest of Chittore.	80				Issues from sandstone at base of hill.
72	Sitakund (Seeta-koond) 5 miles east of Monghyr and 500–600 yd from Ganges River.	137–140	Large			Issues from quartzite and is enclosed in masonry reservoir. Water slightly sulfurous. Marketed as table water. Refs. 2747, 2757, 2761, 2785, 2819, 2832.
73	Garm-pani, 300 yd northwest of Sitakund spring.	137				Ref. 2832.
	Bainsa Pahar, 0.3 mile southeast of Sitakund spring.	102				Issues from quartzite. Ref. 2832.
74	Singhi Rikh tatal pani	[1] 90. 5	Large			7 springs issuing from quartzite. Ref. 2832.
	Panch-bhur	84. 5				5 springs issuing from quartzite. Ref. 2832.
75	Paharpur (Kishi-kund), 5 miles from village.	[1] 104				Several springs issuing from hornstone (flint). Ref. 2819.
76	Richikund (Rishikund, Rishikoond), 14 miles northwest of Haveli Khargpore.	Warm				Issues from quartz (quartzite?). Water used for bathing. Refs. 2758, 2817, 2819, 2825.
	Bhaduria-bhur	98. 5				Issues from quartzite. Ref. 2832.
77	Gupt Gudaoli, several miles south of Puldeo.	Warm				Issues in a cave. A place of pilgrimage.
78	Manikpur, in jungle near town	Hot				
79	Kandela, 10 miles east-northeast of Manikpur.	Warm				
80	Sitaura (Sittourah), near foot of Rajghir Hills.	110				Ref. 2818.
81	Bharari (Janum Kund), on Anjun River.	145				2 springs issuing from "jaspideous hornstone." Siliceous sinter deposited by water. Ref. 2819.
82	Bhimbandh (Bheembund), 16 miles southwest of Haveli Khargpore.	145–148				Several springs issuing from quartz (quartzite?). Water used for irrigation. Refs. 2758, 2817, 2819, 2825.
83	Karmanburi (Lachni Koond), 8 miles southwest of Haveli Khargore.	144. 5				Issues from quartz (quartzite?). Ref. 2817.
	Rameswar Koond, 5 miles west of Haveli Khargore.	112				Issues from quartz (quartzite?). Water used for bathing. Ref. 2817.
84	Rajghir (Rajgir, Rajgheer), near entrance to gorge and along base of hills.	108				19 wells and several springs. Water is radioactive. Refs. 2762, 2805, 2818, 2820.
85	Hurma, on south side of Sone stream near Gangur village.	Warm				Ref. 2790.
86	Sidpur, at village	Warm				Water is sulfurous. Used for bathing and irrigation. Ref. 2781.
87	Bara, between Dumka and Noni Hat.	145				Ref. 2818.
88	Jerwapani (Jhariya pani).	87–93	Large			Issues from fault between gneiss and coal-bearing strata. Ref. 2832.
89	Katkamsandi (Kutkunsuandy, Katcamsandy), 17 miles northwest of Hazaribagh.	110			Ca, Na, HCO_3, SO_4, Cl.	Several springs issuing from trap rock and granite. Water brackish, used for bathing. Free H_2S. Refs. 2770, 2805, 2813, 2825.
90	Belkapi (Surajkund, Soorujkund, Hararyhaugh), 27 miles northeast of Hazaribagh.	169–190				4 springs; largest is constantly boiling. Large deposits of Na_2SO_4, NaCl. Water is unpotable. Refs. 2785, 2805.

See footnote at end of table.

Thermal springs and wells in India—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
91	Kesodeh, 2 miles southwest of Madurkal.	Hot				Water is sulfurous.
92	Nunbhil, 10 miles west of Koomarabad.	119.5	Small			In saline marsh. Issues from sandstone and trap rock. Ref. 2818.
93	Hatpalia (Hatbullia, Tapat pani?), at village.	102	2			Issues from conglomerate. Water is slightly sulfurous. Refs. 2818, 2832.
94	Lau-lau dah	122	26			Issues from trap rock. Water is slightly sulfurous. Ref. 2832.
	Baramasia (Bhumuk)	93	9			Issues from limestone. Ref. 2832.
95	Bijeragogarh, near town	Warm				
96	Tautlui (Tat-noi), on right bank of Sidh stream.	150	Large			Issues from gneiss. Water is slightly sulfurous. Refs. 2818, 2819, 2832.
97	Su-sum pani	84	Small			Issues from conglomerate. Water is slightly sulfurous. Ref. 2832.
	Bhumka	82	Small			Ref. 2832.
98	Sirguja (Tattapani, Tatapani)	130–196	Large			Several springs issuing from fault. Free H_2S. Refs. 2753, 2808.
99	Jarum, in bed of Tabaka (Tataka) River.	132				Several springs issuing from granitic gneiss. Free H_2S. Ref. 2753.
100	Indra Jurba, 12 miles south of Hazaribagh.	102	Small			Issues from fault between gneiss and coal-bearing strata. Small deposit of sulfur.
101	Nuchibad (Jorya Booree), near village.	Warm				Issues from metamorphic rocks near fault along boundary of coal field. Ref. 2788.
102	Tantipara, on right bank of Buklesur stream.	83–162	[3] 750			6 springs. Free H_2S. Water stored in masonry basins. Used for bathing at temple. Ref. 2788.
	Lakarakoond, 5 miles from Tantipara.	85	Small			Ruined temple nearby. Ref. 2788.
103	Gandwani, on left bank of Sondurah stream.	92				
104	Sheopur, on left bank of Damudar River near Jherria coal field.	Warm				Water is sulfurous. Used for bathing.
105	Tantolya (Tantotyu), near right bank of Damudar River.	190				Water is sulfurous.
106	Ahmedpur, north of Hingla watercourse.	Warm				
107	Ganduari (Ganduani), 4 miles east of Seersa Hill.	Warm				Salt lick. Ref. 2753.
108	Thatha, in Huta coal field near Kokratra (Kokraha) village.	151				Water strongly sulfurous. Ref. 2753.
109	Kowa Gandwani, 1 mile southwest of Kowdeh village.	92				Water forms white deposit. Free H_2S.
110	Susinia, on southwest side of hill	Warm				
111	Deori, near village	82				Issues from contact of two formations.
112	Mhurr	Warm				Issues from fault. Water is saline; evolves gas. Used for bathing.
113	Jalander, near Jhinihuwara	Warm				
114	Lausundra (Lassindra), 18 miles west-northwest of Tui.	[1] 124				6 springs. Water unpalatable. Ref. 2778.
115	Tui (Towa, Tuwa), on Mahai River near Ruttenpur (Ruttenpoor).	82–152				Many small springs. Water is sulfurous and radioactive. Refs. 2778, 2823, 2825.
116	Anhoni Samoni (Amoni, Anhoni Simhoni, Unhonee Sumonee, Kyrie?), north part of Narbada (Nerbudda) coal basin.	120	Small		NaCl	Much hydrocarbon gas. Refs. 2789, 2805, 2812.
117	Budi, 8.5 miles east-northeast of Anhoni Samoni.	Warm				Much hydrocarbon gas.

See footnotes at end of table.

Thermal springs and wells in India—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
118	Anhoni (Unhone, Maljihir?), 17 miles southeast of Anhoni Samoni.	120	Large	Low	Ca, Na, CO_3, SO_4, Cl.	Several springs issuing along rock dike 0.25 mile long. Water is sulfurous; much hydrocarbon gas. Refs. 2805, 2822.
119	Babaiha, in stream bed	Hot				
120	Khair Para, in Sultanpur Dependency.	98				Ref. 2778.
121	Wadla (Unapdeo), 2 miles north of village.	90				
122	Nazardeo (Nijardeo)	100–103				
123	Sunafdeo, near Nazardeo village	85–91				
124	Arawad (Unapdeo), in Chopra Dependency.	139				A place of pilgrimage.
125	Damarni (Dambhorni)	Warm				Ebullition caused by evolved gas. Water stored in reservoir.
126	Tulshi-sham (Donee)	124				Water stored in a series of reservoirs. Ref. 2788.
127	Anaval (Devakl Unei, Ushna-Udaki), 2 miles from village.	115–120				Flows from trap rock. Water used for bathing. Refs. 2805, 2825, 2834.
128	Pili, in river bed	91				Water brackish, slightly laxative.
129	Salbaldi (Salbaldee)	100				Issues from faulted metamorphic rocks. Ref. 2756.
130	Chuikadan, near village	Warm				
131	Bhagatpur, on hill near village	Hot				Water is potable.
132	Mandai Chota, in watercourse	Hot				Do.
133	Atmalik, on north bank of Mahanadi River.	Warm				
134	Dalli, near village	Hot				Water is potable.
135	Mezka	Hot				Issues at base of hill. Water has acid taste; smells of burning charcoal. Used for drinking.
136	Kotgaon, at southeast base of Katpar Hills.	110	Large			
137	Oteri (Ooteer, Jaggarnath), 10 miles west of Khoorda.	112				Ref. 2816.
138	Loagudi, on east side of Girtrabadi Hill.	110				Strongly sulfurous. Free H_2S.
139	Unapdeo (Ounkdeo, Oonup Deo), near temple on right bank of Pem Gunda River.	110	Large			Water used for drinking. Refs. 2756, 2825.
140	Khair (Kair), in East Berar	85–87	Large			Several springs issuing from Precambrian limestone and sandstone. Water used for irrigation. Refs. 2789, 2805.
141	Arjuna (Urjunah), near village	87	Small			Issues from Precambrian sandstone. Ref. 2789.
142	Ganeri, in bed of Pem Gunda River.	101				Issues from faulted Precambrian limestone and shale. Ref. 2756.
143	Periplas, in river bed	Warm				2 springs.
144	Gurgaon, in river bed 800 paces from village.	Warm				
145	Satiwali, 4 miles from Kokner	Warm				4 springs.
146	Kokner (Coaknair, Kobineera)	Warm				Several springs. Ref. 2778.
147	Tuk Muk (Took Mookh)	Hot				
148	Haloli (Hullolee), 50 paces east of Veyturna River.	Hot				Water is sulfurous.
149	Guneshpuri, near Taunsa River	Warm				
	Gandodi, in bed of Taunsa River	Warm				2 springs.
150	Vehloli, near Dysur	Warm				
151	Kulbhone (Kulmun), 50 paces from Taunsa River.	Hot	Small			
152	Nimboli (Nimbowle)	M100				Water is sulfurous.
153	Vijrabhai (Vizrabhaee, Vizerabhoy), in river bed.	[1] 136				Several springs. Ref. 2825.
	Aunklowle					4 springs near temple.
154	Pali (Palee)	<100				Water is sulfurous. Ref 2769.
155	Savi (Sao, Mahr)	109				Ref. 2825.

See footnotes at end of table.

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Thermal springs and wells in India—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
156	Wudaoli (Mandangadh Peta)	130	220	1,730	Ca (49); SO_4 (71); Cl (516); gas, chiefly N_2.	Salts deposited by water. Refs. 2769, 2793.
157	Chisgar	92	4	870	Ca (67); CO_3 (33); SO_4 133); Cl (434).	Water used for bathing.
157	Murda, 3 miles north of Chisgar	Warm				Water used for irrigation. Refs 2769, 2793.
158	Khed	96		1,020	Ca (38); CO_3 (45); SO_4 (104); Cl (454).	Several other warm springs for several miles along valley. Refs. 2769, 2793.
159	Uneri (Unhavare)	155–156	144	1,990	Ca (53); SO_4 (76); Cl (519).	15 springs. Water stored in cisterns for bathing use. Salts deposited by water. Refs. 2769, 2793.
160	Rajwari (Rajwadi):					
	Several springs	[1] 110	25	964	Ca SO_4, Cl	Refs. 2769, 2793.
	Springs near temple	126				Water used for bathing and irrigation. Refs. 2769, 2793.
	Springs 1 mile south	140		920		Water used for irrigation. Refs. 2769, 2793.
	Springs in nearby rice fields	142–147				Refs. 2769, 2793.
161	Arauli (Aravali)	105	10	560	Ca (36); Mg (43); SO_4 (85 ppm); Cl 375 Much H_2S.	Water used for bathing and irrigation. Refs. 2769, 2793.
162	Sangameshwar	105			Gas almost wholly N_2.	Flows from trap rock. Refs. 2769, 2793.
163	Math	157	10	1,120	Ca, SO_4, Cl	Do.
164	Rajapur	105	12	370	Ca, CO_3, SO_4, Cl; free H_2S.	Issues from mouth of stone cow. Refs. 2769, 2778, 2793.
165	Botha (Lin Khal), near village	Warm				Ref. 2778.
166	Beder, on Castle Hill	Warm				
167	Gondala, in bed of Godavari River.	120; 140		2,090	$CaCl_2$, Na_2SO_4, NaCl; free H_2S.	2 springs issuing from faulted granite and trap rock. Refs. 2756, 2805, 2831.
168	Kaulagi, near village	Warm	Large			Several springs. Much gas.
169	Buga (Baugha, Banga, Byora, Byorah, Baidra), 30 miles northwest of Gondala.	110		Low	$CaCO_3$	Issues from sandstone and limestone near contact of Precambrian and Carboniferous rocks. Refs. 2789, 2816, 2831.
170	Ramteeruth, near village	Warm				Issues from faulted strata.
171	Atmacoor, near tank of Siddapur	Warm				
172	Wuddyralla, 1 mile from village	Warm				Issues from quartzite.
173	Chinna Tekur					
174	Gadigerevala (Guddagarval)					2 springs.
175	Bodavanipalli (Bodanpilly)					
176	Wulandikonda (Oolendaconda)					
177	Calwa	89–90				3 springs issuing from fault. Water deposits tufa. Used for irrigation. Ref. 2806.
178	Panem (Paneum)					
179	Vankarum, 7 miles north of Mahanandi pagoda hill.	Warm				
180	Gazulapali					
181	Lanjabanda, 1 mile east of village	85–91		Low	$CaCO_3$	Several springs. Water contains some iron. Ref. 2803.
182	Chamakopalli					
183	Gajjalabonda					
184	Mahanandi	88.7	Large			Source of part of water supply for town of Nandial, 10 miles west of spring. Ref. 2806.
184	Bukkapuram					2 springs.
185	Kadmala Kalva (Kuddamal Calwa).					
186	Narmur					
186	Brahmagundam					
187	Gopavaram					
188	Yembayi					
189	Chagorlmari					2 springs.

See footnotes at end of table.

Thermal springs and wells in India—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
190	Sirwell					
191	Dhone					
192	Malakapuram (Mulkapoor)					
193	Rangapuram					8 springs.
194	Rudravaram (Roodrar)					
195	Alamur					
196	Kotakapali (Cottapilli)					
197	Muttalur					
198	Tinimapuram					
199	Bhuga (Boogga)	88				Several springs issuing from faulted sandstone. Main spring flows from mouth of stone cow. Refs. 2804, 2805.
200	Irade, 6 miles from Pootoor	99–102				
201	Salem	84				Issues from gneiss and slate. Ref. 2805.
202	Barren Island, at landing place	Hot				Issues from basalt. Refs. 2786, 2802.

[1] Maximum.
[2] Main spring.
[3] Hottest.

Thermal springs in Ceylon
[Data chiefly from ref. 2826]

No. on fig. 58	Name or location	Temperature of water (°F)	Remarks and references
1	Kannea (Cannia), 6 miles northwest of Trincomallee.	85–115	7 wells tapping granite; 6 are in stonelined basins. Several unimproved springs nearby. Water is potable. Much gas. Refs. 2764, 2768, 2805, 2807, 2810, 2825, 2826.
2	Patipal Aar, south of Baticaloa	Hot	Several springs. Ref. 2826.
3	Kitool, east of Blintenne	Hot	Refs. 2807, 2826.
4	Badulla, near town	Hot	Several springs. Ref. 2826.
5	Yavi Ooto, near village	Hot	Ref. 2826.

Thermal springs in Nepal
[Data chiefly from ref. 2745]

No. on fig. 58	Name or location	Temperature of water	Remarks and additional references
1	Beside Kali River, 3 km north of Dharchula.	Hot	Ref. 2745.
2	Muktinath	Warm	At altitude of 10,850 ft. Ref. 2805.
3	Sheopuri, on east bank of river 1 mile from village.	Hot	Water is saline, malodorous.
4	Rasua Garhi, about 15 km southwest.	do	Ref. 2745.
5	Hangthuwa, near east side of Tamor River.	do	Water is sulfurous.
6	Nangin, at head of small stream	do	

Thermal springs in Sikkim
[Data chiefly from ref. 2807]

No. on fig. 58	Name or location	Temperature of water (°F)	Principal chemical constituents	Remarks and additional references
1	Mangphu (Mangpuu), 600 ft above Tista River.			Warm vapor issuing from clefts in slate. Refs. 2790, 2791.
2	Momai, 1 mile below Kinchinow glacier.	110–116	Na_2CO_3; Na_2SO_4; NaCl	Issues from granite at altitude of 16,000 ft. Ref. 2785.
3	Phug (Phong Sachoo), on east bank of Runjit River.	Warm		Water is malodorous; leaves white deposit. Ref. 2751.
4	Yeumtong, on Lachong River	112.5	Na_2SO_4; gas, H_2S	Issues from granite at altitude of 11,920 ft. Water is slightly saline. Ref. 2785.

Thermal springs in Burma
[Data chiefly from ref. 2807]

No. on fig. 58	Name or location	Temperature of water (°F)	Remarks and additional references
1	Memboo (Minbu), 0.5 mile from Irrawaddy River.	87	Mud volcanoes. Water is saline. Ref. 2836.
2	Bu-le, on north bank of stream near its mouth.	Warm	
3	Ramree (Ramri) Island	92	Active mud volcanoes. Combustible gas. Refs. 2780, 2792.
4	Cheduba Island		6 large mud volcanoes. Refs. 2780, 2792.
	Amherst Island		3 mud vlcanoes. Refs. 2780, 2792.
	Flat Island		2 mud volcanoes. Refs. 2780, 2792.
	Nearby mainland		Several mud volcanoes. Refs. 2780, 2792.

Thermal springs in Burma—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Remarks and additional references
5	Sandoway River, near source	110 (max)	20 springs; large combined flow. Water is tinted.
6	Cape Negrais, on coast near cape		Mud volcanoes. Ref. 2792.
7	Lepan-bew-Choung	100; 115	2 springs 4 miles apart.
8	Kayeng Choung	110	
9	Choung-na-nay	108	
10	Kayloo Myoung:		
	In Hmoh Valley	157	
	Slopes on east side of Hmoh Valley.		Several springs.
11	Bin-Byai		
12	Mai Pouk		
13	Sair-ao-Khan		
14	Hteepahtoh	Hot	
15	Vadai Choung	Hot	

Thermal springs in Burma—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Remarks and additional references
16	Koon-Pai	Hot	
17	Maitine	Hot	
18	Kyoung Choung	Hot	
19	Gyo, 45 miles north of Moulmein Pagoda.	Warm	
	Allayen (Moulmein)	137	Issues from limestone. Ref. 2805.
20	Poung Yaboo	Warm	Water is saline.
21	Nga Yai Kyoon Juin	Warm	Do.
22	Sienli	Warm	Water is sulfurous; contains iron sulfate.
23	Mai-palai (May-play)	Warm	Water is saline.
24	Kaline Aurig (Eubien)	108	Well. Ref. 2787.
25	Noung-tyne (Noung-ta-bway)	Warm	Water is saline.
26	Thaphun	Warm	Do.
27	Mya-waddi	Warm	Do.
28	Poung (Poung-to-goo)	Warm	Do.
29	Ye-bu	Warm	Do.
30	Damathat, on hill near village	Warm	Water is brackish.
31	Bonet, near village	Warm	
32	Ahtaran (Attayen)	130	3 Wells and several springs. Principal well is in a brick-walled cistern 60 ft in diameter. Water is actively bubbling and gives off much vapor. Much CO_2. Refs. 2773, 2798.
33	Myan Khoung	Warm	Water is saline.
34	Thalan Khoung	Warm	Do.
35	Ingijre	Warm	Do.
36	Nat Gyi Zin, at base of hill	Warm	
37	Henzai, near stream	Warm	
38	Langyen, near head of tributary of Pagayai stream.	144	Water is sulfurous; contains $CaSO_4$.
39	Myitta, on right bank of Tenasserim River northeast of village.	119	Water is chalybeate and very sulfurous. Ref. 2798.
40	Moung Magan, in mangrove swamp.	Warm	Water is saline(?).
41	Paltha Kyoung	Warm	
42	Mandoo, on Bin stream south of Myitta.	Warm	
43	Toung Byouk, at head of east branch of stream.	Warm	
44	Pai, on hillside	198 (max)	Several springs issuing from granite. 1 spring jets to height of 6 ft. Water contains Ca, Na, SiO_2, Cl, H_2SO_4. Ref. 2824.
45	Palouk, on right bank of river	196 (max)	Several springs. Ref. 2798.

Thermal springs and wells in Pakistan

[Data chiefly from ref. 2807]

No. on fig. 58	Name or location	Temperature of water (°F)	Remarks and additional references
	East Pakistan		
1	Rajshahye, between Burgunje and Titalya.	Warm	
2	Sitakund (Seeta Koond), 22 miles north of Chittagong.	Warm to hot	Many springs within one small area and 7 others within distance of 6 miles. Water is saline. Combustible gas.
	West Pakistan		
1	Peshawar, near cantonments	Warm	2 springs issuing from alluvium.
2	Hossein Abdal	Warm	Large flow from nummulitic(?) limestone.
3	Bukh Ravine (Musakhel)	94	Issues from Carboniferous limestone. Free H_2S. Deposits of sulfur. Refs. 2772, 2816.
4	Sodhi, in deep ravine 0.5 mile from village.	75	Large deposit of tufa.
5	Bukkur, east of Indus River and near road to Leia.	Warm	

Thermal springs and wells in Pakistan—Continued

No. on fig. 58	Name or location	Temperature of water (°F)	Remarks and additional references
	West Pakistan—Continued		
6	Tausa, 6 miles west of Indus River.	Warm	
7	Bindar Pir, 6 to 8 miles up the Sodi Pass.	Hot	Water potable.
8	Garm-ab, at foot of Mari Hills	Warm	Water bitter; contains saltpeter and other salts.
9	Garmo, on Shoree watercourse	Hot	
10	Wahi Pandi, 24 miles west of Johi.	Warm	
11	Tandra Rahim Khan (Shahdad-ka-gote), 6 miles north of Peeth.	Warm	Well 70 ft deep; taps conglomerate. Ref. 2829.
12	Gazipur (Gazee-pir, Peeth), on hill called Bhil.	Hot	Water pale green. Much H_2S gas. Large deposit of tufa. Refs. 2752, 2829.
13	Gorandi, 4 miles west of Shah Hassan.	Warm	
14	Sewan, 3 miles south	Hot	Sulfur springs.
15	Phadak (Faduk), 2 miles south of Gorandi.	Warm	
16	Pir Ari, 2 miles south of Jhingarah.	Warm	
17	Nain, 8 miles southwest of Gorandi.	Warm	6 springs.
18	Khai, 8 miles southwest of Jhanghar.	----------	3 springs.
19	Kandhar (Kanda Shah), 10 miles south of Naing.	Warm	
20	Lakhi (Lukkee), 15 miles from Sehwan	102–105	Water is sulfurous. Refs. 2752, 2799.
	Hills below Sehwan (Dharum Hill).	120	Near sulfur mines. Issues from base of limestone cliff.
21	Khosra-ka-wahi, near Hubb River.	120	
22	Garm-ab, on road to Karachi	Warm	Ref. 2799.
23	Rani-jo-kot, 16 miles west of Majanda.	Warm	
24	Deo Chandeswar Mahadeo (Suraj Kund), in Rajputana desert, 80 miles from Suni.	Warm	Referred to as "Fountain of the sun."
25	Tong	Hot	
26	Pokran (Pokran Landee)	Warm	
27	Manga-pir (Muggar-pir, Munga-Peer, Peer Mangul, Maga, Mangear).	99; 119; 127	3 springs 0.5 mile apart. Issue from strata dipping 50°. Possibly the same as "Springs near Karachi" in ref. 2825. Water from main spring supplies alligator pool. Water is sulfurous and leaves black deposit on pebbles. Refs. 2752, 2829.
28	Jein Pir, 16 miles west of Jhirruk	Warm	Ref. 2778.

INDO-CHINA

(Cambodia, Laos, and Viet Nam)

A nearly continuous mountain chain extends southward from China throughout the length of Indo-China and separates the drainage basin of the Song Koi, or Red River, in the northeast from that of the much larger Mekong River, which forms part of the western border of Laos. Each river has a large and fertile delta. Tertiary deposits, including coal beds, are present in the upper basin of the Song Koi, and Triassic strata have been found in the southern part of Indo-China. Most of the mountains are of crystalline schist, which is overlain by limestone in many areas.

The available data on thermal springs in Cambodia, Laos, and Viet Nam are given in the table below. The locations of the springs are shown on figure 59.

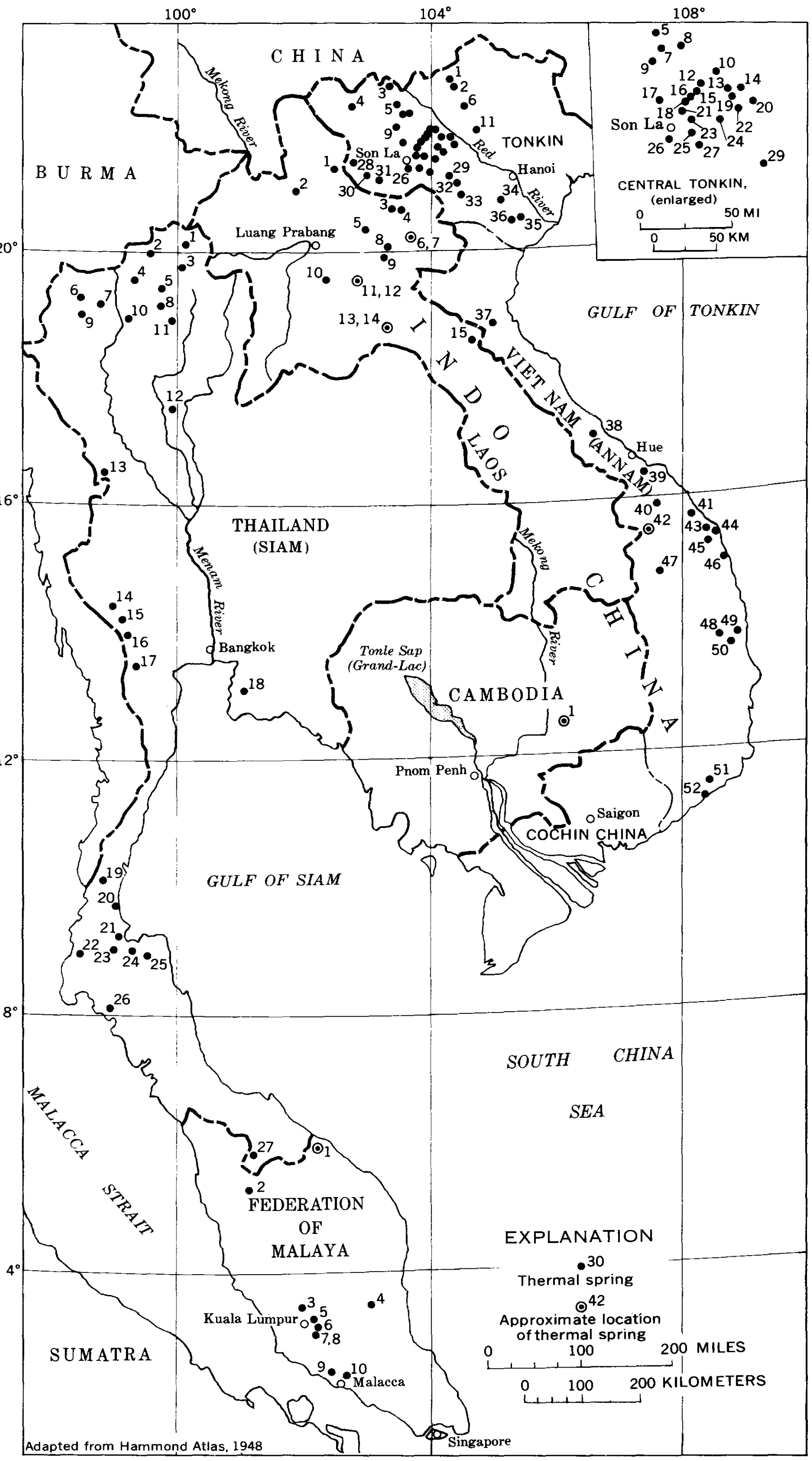

FIGURE 59.—Indo-China, Federation of Malaya, and Thailand showing location of thermal springs. Chiefly from refs. 2837, 2838, and 3249.

Thermal springs in Indo-China (Cambodia, Laos, and Viet Nam)

[Locality Nos. 5, 8, 14, 16, 17, 18, 20, 24, and 33 for Viet Nam are from ref. 2837; the rest are from ref. 2838]

No. on fig. 59	Name or location	Temperature of water (°C)	Flow (liters per hour)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
	Cambodia					
1	Svai Chas, in Kratieh area	Warm			HCO_3	
	Laos					
1	Sop Nao, on bank of Nam Ngao	Warm	Small		SO_4	Issues at base of limestone cliff. Ref. 2840.
2	Muong La, near the Nam Phak	Warm				
3	Houei Doi	Hot	Small		SO_4	Ref. 2840.
4	Muong Yut	Hot			SO_4	Issues from plicated limestone. Ref. 2840.
5	Muong Hiem, on the Nam Khan	89			SO_4	Issues from granite. Ref. 2840.
6	Ban Hom (Muong Khan)	65			SO_4	
7	Ban Thot	Warm			SO_4	
8	Ban Hoc, 10 km northeast of Ban Ban	42			Ca, Mg, SO_4	
9	Ban Ban	42				
10	Pha Tiao (Pha Chao)	Warm				
11	Kha Ta Hoi	Warm		545	SO_4	
12	Do Deng	36		76, 000		
13	Pong Hon	Warm			SO_4	
14	Pong Muong	Warm			SO_4	
15	Na Pe, on bank of Nam Poa	Warm			Ca, SO_4	
	Viet Nam					
1	Hoang Su (Tchou) Phi	36	500		SO_4	
2	Bo Dat (Mo Luot)	60–70	3, 000		SO_4	
3	Ban Mac	36	150	340		
4	Muong Lai, on bank of Noire River	20			SO_4	Water is very alkaline.
5	Ping-phat	30	Small			
6	Vikhe	29	Small			
7	Than Uyen (Than Huyen, Banxa)	28	Small			
8	Minh-luong	Warm	Small			
9	Ban Ki (Ban Khi)	29; 44. 5; 44. 8	40, 000			2 large and 1 small spring.
10	Tu Le (Ban Nuoc Nung)	39	20,000		Ca, Mg, SO_4	
11	Nhan Gia (Nghiem Som)	58. 5	3,000	336		Gas evolved.
12	Ban Sang (Nam San, Ngoc Chen)	48–50	2,000	2,628	$CaSO_4$ (1,356 ppm).	
13	Gia Hoi (Chieng Pan)	37–42. 5	1,000	2,672	Ca, Mg, SO_4	
14	Ban-Tu	35	1,000		Ca, Mg, SO_4	
15	Ban Duot (Ban Det)	50	20,000	3,329	$CaSO_4$	
16	Ban-It	58	3,000			
17	Ban-ma	40				2 springs.
18	Ban-co-vai (Ban-Khua-vai)	30	Small			
19	Pan Phay (Ban-Kai)	36–45	50,000	2,649	Ca, Mg, SO_4; gas, H_2S, CO_2.	
20	Ban-hoc (Cua-nhi)	38	500			
21	Ban It Ong	45	5,000		Ca, Mg, SO_4	
22	Hanh Son (Ban-Ve), at village	30. 5	5,000	667	$CaSO_4$	
23	Muong Pia	53	2,000			
24	Sa-phin	Warm	Small		Ca, Mg, SO_4	
25	Ban Van, on Noire River	46	3,000		Ca, Mg. SO_4	
26	Ban Mong (Ban Muong)	39	15,000			
27	Ban Pe Trong	28. 5	10,000			
28	Na Ten (Pom Lot)	65–80	200	390		Water is acid.
29	Ban Peo	47. 5	40,000		Ca, Mg, SO_4	
30	Na Ha	Warm			SO_4	

Thermal springs in Indo-China (Cambodia, Laos, and Viet Nam)—Continued

No. on fig. 59	Name or location	Temperature of water (°C)	Flow (liters per hour)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
	Viet Nam—Continued					
31	Muong Loi	Warm				
32	Bo Gieng	28	Small			
33	Mo-am	38.5	20,000			
34	Qui Hoa, at village	36	1,000	175		Water contains much organic matter.
35	Phu Nho Quan (Kenh-ga)	52.5	5,000		SO_4	
36	Mai Phuong	Warm				
37	Ha Tan	Warm			SO_4	
38	Huong Hoa	71		587	SO_4	
39	Huong Binh	Warm				
40	Phuoc Binh	Hot			Na, SO_4	
41	Ngoc Nha (Phuoc Loi)	Warm				2 springs, 1 km apart.
42	Deo Hai, near mountain pass	Warm			SO_4	
43	Loc Thanh (Binh Hoa)	56		408	NaCl	
44	Tu Nghia (My Thanh, On Thuy, Pha Thanh).	49		494	NaCl	
45	Cu Va (Phaoc Tho, Thach Nham)	Warm				
46	Mo Duc (Thrach Tru)	52		5,290	NaCl (4,400 ppm).	
47	Dak To	45		307	SO_4	
48	Cay Vung (Cai Vung)	Hot				Mostly vapor.
49	Ha Ba Tuan (Ba Go?)	75				
50	Triem Duc (Ba Su)	90				
51	Tan My (Tong Gong?)	Warm				
52	Vinh Hao, at village	36		2,722	$Ca(HCO_3)_2$, $NaHCO_3$, $KHCO_3$.	Ref. 2843.

IRAN (PERSIA)

Iran is predominantly a mountainous and plateau country. High mountains of the Elburz system rise on the south border of the Caspian Sea, along whose shore is a narrow coastal plain. From near Mount Ararat in northeast Turkey, several nearly parallel ranges trend southeast and form the western part of Iran. There are narrow belts of coastal lowland, but some wide plains at the head of the Persian Gulf. In the northeast and east, high ranges extend eastward to the higher ranges of the Hindu Kush Mountains in neighboring Afghanistan. The interior is chiefly plateau interrupted by a central mountain range, which is highest in the south-central part of the country. This interior region, occupying about one-half the total area of Iran, has no drainage to the sea and forms a desert nearly 800 miles long and 100–200 miles wide. In its northern part are extensive saline marshes and dry salt plains.

Granite, gneiss, and schist are exposed in the Elburz Mountains, but most of the other ranges are composed of marine strata of Devonian to Jurassic ages, which are greatly folded in most areas. Cretaceous formations are exposed throughout much of the plateau and probably underlie many areas that are covered by Quaternary deposits. They are exposed also in the central range within the plateau region. Tertiary strata are present along the bases of many of the mountain ranges, and Pliocene deposits form bands along the sea coasts. There are many areas of recent volcanism in the Elburz Mountains and also in the southeastern part of the country. Some volcanic peaks still emit vapor and gases, especially Demavend volcano about 60 km northeast of Teheran, and Kuh-i-Taftan, near the southeast border of Iran.

Information on the thermal springs in Iran is presented in the table below. The existence of an additional thermal spring, not listed in the table, is suggested by the name—Ab-i-Garm (Hot Water)—of a town in the valley of the Kerkhah River about 170 km south-southeast of Kermanshah. The locations of the known thermal springs, as well as of Ab-i-Garm, are shown on figure 53.

Thermal springs in Iran

No. on fig. 53	Name or location	Temperatue of water (°F)	Flow (gpm)	Total dissolved solids (ppm)	Principal chemical constitutents	Associated rocks	Remarks and references
1	Near Katur (Kotûr)	67		5,990	Na, HCO_3, Cl	Tertiary(?) marl	Much tufa at and near the spring. Water contains iron. Refs. 2846, 2858.
2	Near Derik:						
	2 main springs	96		1,570; 1,800	Ca, Na, HCO_3		Much tufa. Water contains iron. Refs. 2846, 2858.
	Minor springs	90–92					
3	Issi Sû, at base of Zendsht Dagh.	99.5		14,000	Na, HCO_3; much H_2S	Altered limestone	Refs. 2846, 2858.
4	Near Savelan Mountain	95–122	225		Much H_2S	Lava(?)	Several springs. Ref. 2852.
5	Near Chaibagh, in Maragha area.	Tepid					Water contains iron; is unpalatable. Ref. 2847.
5	Babagerger		Large				Deposits tufa. Used for bathing. Ref. 2847.
6	Mount Demavend area:						
	0.5 mile east of Ask (Aska, Usk).	82; 85			$CaCO_3$; much free CO_2	Tertiary lava	2 springs. Much tufa; some pisolitic silica. Water used for drinking and bathing. Refs. 2845, 2848, 2855–2857.
	2 miles northeast of Ask (Aske, Usk).	84	Large		SO_4	do	Water issues from tufa mound. Used for bathing. Refs. 2845, 2855–2857.
	3 miles east of Ask (Aske, Usk).	160				do	
	Ab-i-Garm (Sakh Tessar), 6 miles east of Ask (Aske, Usk).	150			Ca, HCO_3, SO_4	do	Water contains iron. Used for bathing. Ref. 2848, 2856, 2857.
	Near summit of mountain.	200			SO_4	do	Steaming vents; sulfur deposited. Refs. 78, 2845, 2848, 2855.
7	At Daliki	158			Free H_2S		Small deposits of sulfur and bitumen. Ref. 2849.
8	At Shiraz (Chiraz)	Warm					Noted baths. Ref. 2847.
9	Abbad, in Alman mountains, 1 mile above Takkia.	60					Water bubbles strongly with loud noise. (Probably a thermal carbonated spring.) Refs. 2851, 2854.
10	At Dashtab	Warm					Ref. 3294.
11	Qal'ah Asgher	Warm					Do.
12	Garga and Khurkhu, on road between Hormos and Kerman.	Warm					Do.
13	Chasma Abbad, near Dusari	Warm					Used for bathing. Ref. 2854.
14	Bandar Abbas, near base of Kuh-i-Ginao.	113	Large		SO_4	Lava(?)	Orifice 4 ft in diameter. Refs. 2854, 3294.
15	Near Jask (Jashak), close to seashore.	128			SO_4		Several small basins; with tufa deposits. Ref. 2853.
16	Bazman (Basman), near east base of Kuh-i-Baz-man.	98	Large		SO_4	Lava(?)	Water bubbles violently in pool about 12 ft in diameter. Refs. 2850, 2854.
17	Near base of Kuh-i-Taftan	Hot				do	Probably solfataras and fumaroles. Ref. 2854.

IRAQ

Along the northwest border of Iraq are mountains and plateaus, from which the land slopes in general southeast to the valleys of the Euphrates and Tigris Rivers. These streams flow southeastward through the entire length of the country to the head of the Persian Gulf. Southward from hills near the border highlands, the upper courses of these two rivers traverse large areas of flat land underlain by gypsum. Below Hit on the Euphrates and Baghdad on the Tigris, the streams are sluggish, and their water is diverted htrough many irrigation canals to the extensive alluvial lands of Babylonia.

The northeastern part of the country is largely a hilly region of folded Tertiary gypseous and sandy strata that include great anticlines, on which are the Kirkuk oil fields. The Hamad, or Syrian Desert, in western and southwestern Iraq, comprises a great gravelly plain which slopes gently northeast to the Euphrates River. Shallow ground water in the desert is obtained along many wadies (dry washes) and supports many villages and cultivated areas.

Very few thermal springs have been reported. Probably the most noted are springs near the ancient city of Hit on the Euphrates River in the central part of the country. The available information on the springs is given in the table below, and the locations of those springs are shown on figure 54.

Thermal Springs in Iraq

[Data chiefly from ref. 2861. Principal chemical constituents are expressed in parts per million]

No. on fig. 54	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
1	Tall Kaif (Tall Kaif, Tel Kiaf) area:						
	Tlimtha, 4 km from Tall Kaif.	25–28	126	826	Ca (171); CO_3 (105); SO_4 (445).	Limestone (Oligocene?)	Supplies village.
	Barima, 12 km from Tall Kaif.	24	7,200	440			Do.
	Tall Afar, 60 km west of Mosul.	24					Water is of "fair quality."
2	Adaiya, 45 km west of Mosul.	25; 26	120		SO_4; free H_2S	Lower Fars gypsum (Tertiary).	Two springs.
3	Sukhna	Warm					The water is piped 30 km to Mafraq railway station. Ref. 2860.
4	Jaf area:						
	Barlut	32	60			Bakhtiari gravel (Pliocene)	
	Sar Qala	26; 29	150			do	2 springs.
	Fattah Umar	28	60	450	HCO_3 (105); SO_4 (135)	do	
5	Near Hit	31–36.6			Na, Cl	Gypsum and magnesian limestone.	Several springs forming pools in which naptha bubbles up with gas; sulfur deposits. Ref. 2859.

ISRAEL AND JORDAN

The countries of Israel and Jordan (formerly Trans-Jordan), which have been organized since World War II, include the region formerly known as Palestine. Israel occupies a band of varying width along the Mediterranean Sea from Lebanon to the Egyptian border. Jordan occupies a region south of Syria including areas on both sides of the Jordan River and the Dead Sea and extending south and east to the borders of Iran and Iraq. The eastern part of the region consists largely of plateau land cut by deep gorges and wadies; it slopes westward to the great block-faulted valley of the Jordan River and Dead Sea. In several areas gneiss and schist with intruded granite and other crystalline rocks are exposed at the base of the plateau lands. These ancient rocks are overlain by conglomerate and sandstone which may be of Carboniferous age. An overlying formation of similar rocks, probably Lower Cretaceous, is conformably overlain by Upper Cretaceous limestone that covers most of the region. Tertiary lava covers extensive areas northeast of the Sea of Galilee and east of the southern part of the Dead Sea. There are some areas of lava west of the Jordan River. Gently west-dipping Cretaceous strata cover most of the high land west of the Jordan River valley. Toward the Mediterranean Sea are Eocene and later marine deposits. The alluvial coastal plain is less than a mile wide in some places.

Thermal springs issue chiefly along the lower part of limestone bluffs which border the Dead Sea and Jordan River Valley. Information on these springs is presented in the two tables below, and the locations of the springs are shown on figure 60.

Thermal springs in Israel

[Principal chemical constituents are given in parts per million]

No. on fig. 60	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and references
1	El Hamme (Al Hamma), on right bank of Jarmuth (Jarmuk) River:						
	Hammet er-rih	34.1				Basalt	Refs. 2865, 2866, 2868, 2869.
	Hammet ed Dscharef	40.6				do	Do.
	Hammet Selim	48.8		1,212	$CaSO_4$ (194); $CaCl_2$ (244); NaCl (520).	do	Do.
2	Tabigha, 10 km north of Tiberias.	32.2					Ref. 2868.
3	Tiberias, on southwest shore of Lake Tiberias (Sea of Galilee).	58.7–61.9		28,248 (coolest)	$CaCl_2$ (8,526); $MgCl_2$ (1,403); NaCl (16,827); MgBr.	Basalt	3 main springs. Bathing resort; Roman baths of Emmaus. Water is radioactive. Refs. 2865, 2868, 2870, 2871, 2873, 3290.
4	Al Hamma, about 5 km south of Lake Tiberias.	Warm					Ref. 2863.
5	Ain Maleh, near El Maleh	30				Volcanic ash (Lower Cretaceous).	Refs. 2863, 2868, 2872.
6	Hadlitha, about 5 km south of Engeddi (Ain Jidi).	29	18,000				Ref. 2866.
7	Hammam, near west shore of Dead Sea.	36.6	360				Water is sulfurous. Used for bathing. Ref. 2866.

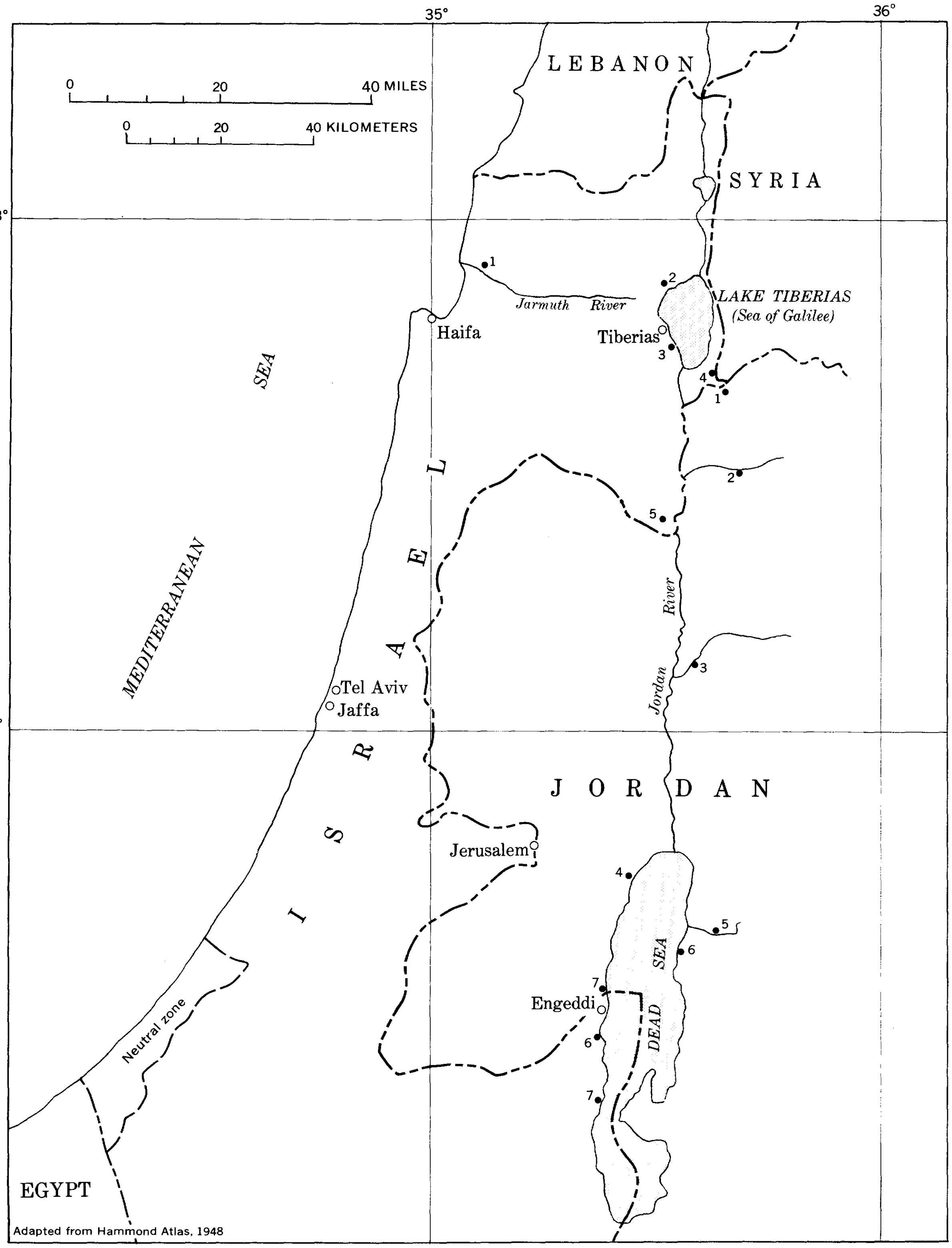

FIGURE 60.—Dead Sea region of Israel and Jordan showing location of thermal springs. Chiefly from refs. 2863, 2866, and 2868.

Thermal springs in Jordan

No. on fig. 60	Name or location	Temperature of water (°C)	Flow (liters per minute)	Associated rocks	Remarks and references
1	Um Keis, south of El Hamme railway station.	45.5			Bathing. Ancient springs of Gadara. Refs. 2867, 2873.
2	Near Wadi Zejd	Warm			Ref. 2863.
3	Sukhne, near Nar ez Zerqa stream	24	15,000		Ref. 2866.
4	Ain Fashkta	Probably warm			Ref. 2863.
5	Zerqa Ma'in, on north side of gorge.	54.4–60	36,000	Base of limestone overlying sandstone; near basalt.	10 main springs. Extensive deposits of tufa. Probably same as Roman baths of Callirrhoe; also the Barras referred to by Josephus. Water is sulfurous. Refs 30, 2866, 2868, 2869, 2872, 2873.
6	Ain al-Zerqa, 5 km south of Zerqa Ma'in.	54 (approx)			Several springs, possibly including those of Wadi Abu Dhableh near ruins of Mirga'ah. Water is sulfurous. Refs. 30, 2869, 2872.
7	About 6 km north of Engeddi (Ain Jidi).	Warm			Ref. 2863.

JAPAN

Although Japan might be considered as one of the groups of Pacific islands, it is virtually an Asiatic country. Its thermal springs are along a great volcanic zone that extends southward from Kamchatka through Chishima, or Kuril, Islands and thence throughout the length of Japan.

Japan comprises the main island of Honshu (Hondo), the island of Hokkaido (Yezo) to the north, the two smaller islands of Shikoku and Kyushu south of Honshu, and many small islands offshore. The country is mountainous and hilly, and has very few extensive areas of lowland. The core of the country is of granite, gneiss, and schist, which form some of the highest mountains and also underlie many lower areas. Other uplands are underlain by Paleozoic and Mesozoic sedimentary rocks. In northern Honshu some large mountain masses of these older sedimentary rocks are surrounded by marine Tertiary strata, which also border the coast in many places.

Volcanic activity began in Tertiary time and has continued to the present. In Hokkaido are two main bands of volcanic rocks. One extends southward from Sakhalin Island, and the other forms the southwestern extension of the volcanic belt of the Kuril Islands. The south-trending band continues through northern Honshu, and there is a narrower band near the west coast. The two bands unite in central Honshu in the volcanic region known as the Japanese Alps. Thence the wider band extends southward, includes the probably extinct volcano of Fujisan (Fujiyama), and continues to the sea. The narrower band parallels the west or northwest coast of southern Honshu and branches southward across Kyushu Island. A total of 165 volcanic mountains have been recognized, of which 63 are classed as active or quiescent (Ishizu, ref. 2942). At least 17 are well-known volcanoes that have been active in historic times.[7]

Many hot springs issue near the active volcanoes and also elsewhere in the lava areas. Some hot springs issue in areas of Tertiary and older sedimentary rocks, probably along lines of faulting. Some are in faulted areas of granite and other ancient crystalline and metamorphic rocks. A few springs that are slightly above boiling temperature and spout intermittently are called geysers, but generally they are not classed as true geysers. Many springs have temperatures between 80° and 100°C. A large number are within the great tectonic depression called the Fossa Magna, which extends north-northwest to south-southeast across Honshu, somewhat west of Tokyo.

The number of thermal springs in Japan has been variously estimated from about 950 to 5,567 (Kiuto, ref. 2997). The latter figure refers to individual springs and, in some localities, includes numerous wells sunk to augment supplies of hot water. Somewhat more than 200 groups of springs of temperature above 20°C have been developed as bathing resorts. Some of these springs are classed as cold, as the water is below the normal human body temperature (about 37°C), and the water is heated for the baths. Nearly all the thermal springs of consequence probably have been developed, but there may be small remote springs that are known only locally. Hokkaido Island has not been studied in detail and may contain thermal springs that have not yet been recorded.

[7] Lake, Philip, 1911, Japan [section on] Geography, *in* 11th ed., Encyclopaedia Britannica, Cambridge, England, Univ. Press, v. 15, p. 158–159.

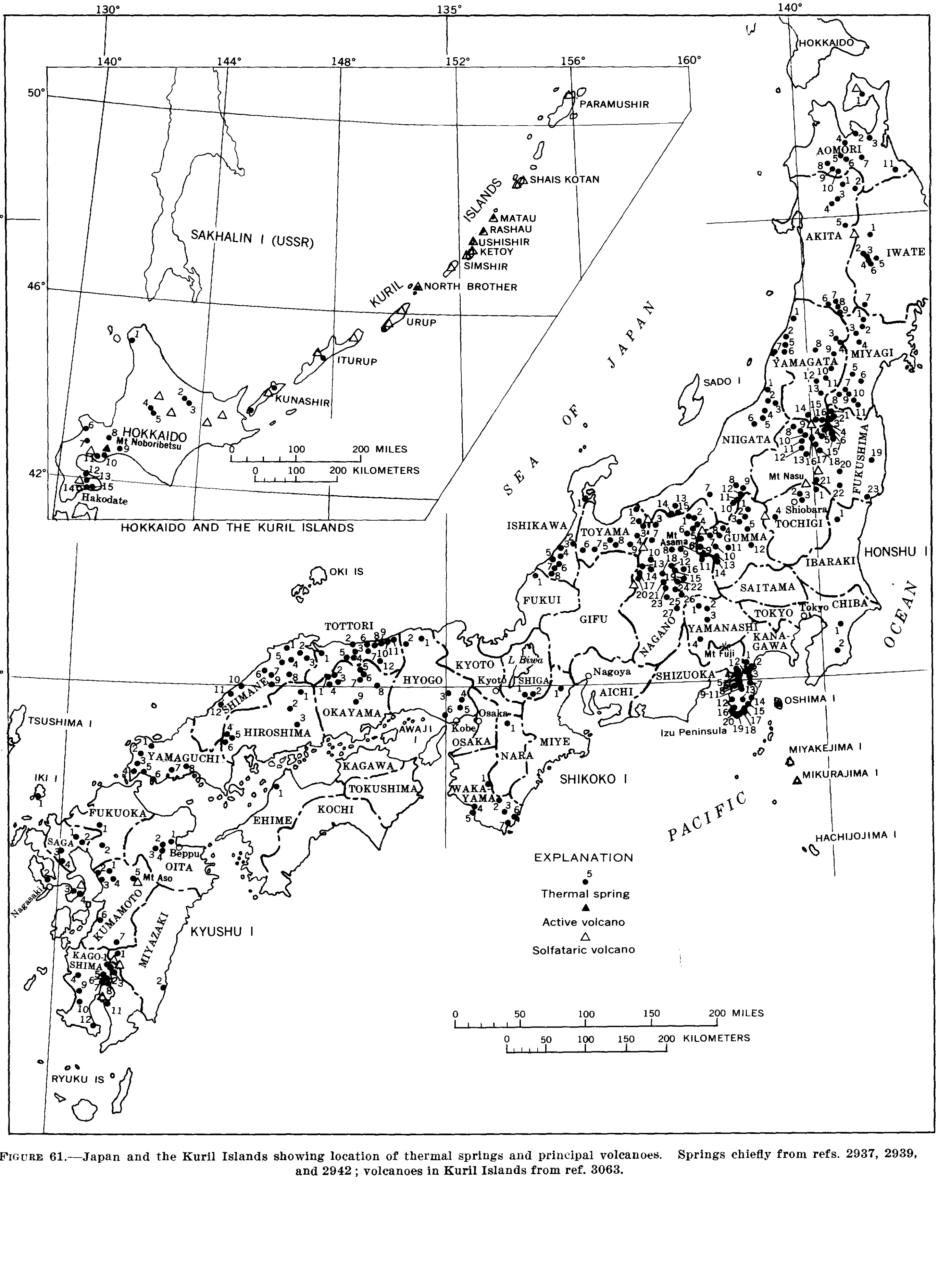

FIGURE 61.—Japan and the Kuril Islands showing location of thermal springs and principal volcanoes. Springs chiefly from refs. 2937, 2939, and 2942; volcanoes in Kuril Islands from ref. 3063.

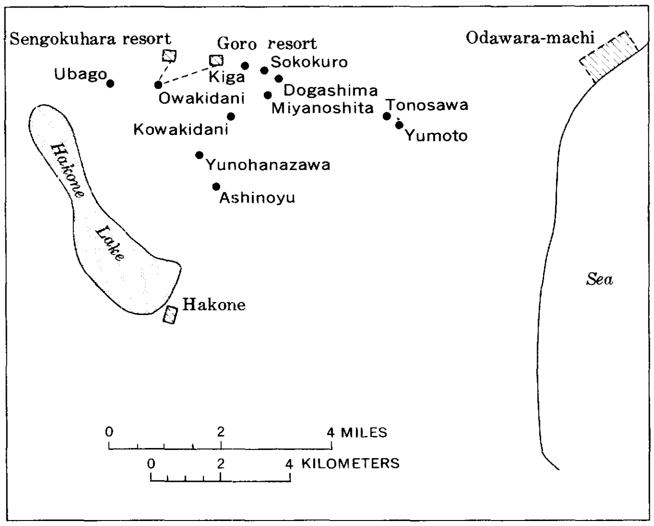

FIGURE 62.—Hakone area, Kanagawa Prefecture, Japan, showing location of thermal springs. From ref. 2939.

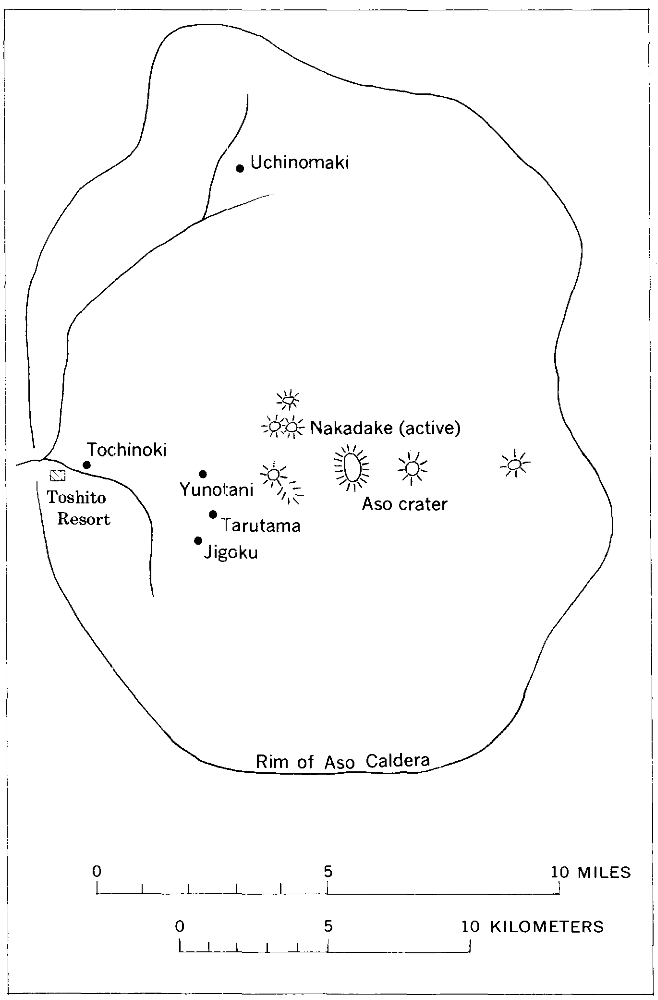

FIGURE 63.—Aso caldera, Kumamoto Prefecture, Japan, showing location of hot springs and craters. From ref. 2935.

A general report on the geology and mineral resources of Japan by the Imperial Geological Survey (ref. 2936) includes a summary of the thermal springs. According to this report, 951 hot springs are of sufficient interest to be listed, because several have temperatures above boiling and many are between 90° and 100°C. Saline springs predominate, but there are also many sulfur and alkaline carbonate springs.

The presence of numerous hot springs associated with volcanoes in the Kuril Islands, which extend northward from Japan to Kamchatka, has been mentioned by several writers, including Fujinami (ref. 2899). No specific information on these springs has been found; but the solfataric character of many of the volcanoes was noted by Milne (ref. 3063), who also recorded hot springs in several islands, including Urup, Iturup, and Kunashir, in the southern part of the chain. It could not be determined whether any information on the volcanoes and springs of the Kuril Islands has been published since this chain of volcanic islands came under Russian administration.

The available data on thermal springs in Japan are summarized in the table below. The locations of nearly all thermal springs and groups are shown on figure 61, and the distribution of springs in six of the more important localities is shown on figures 62–67.

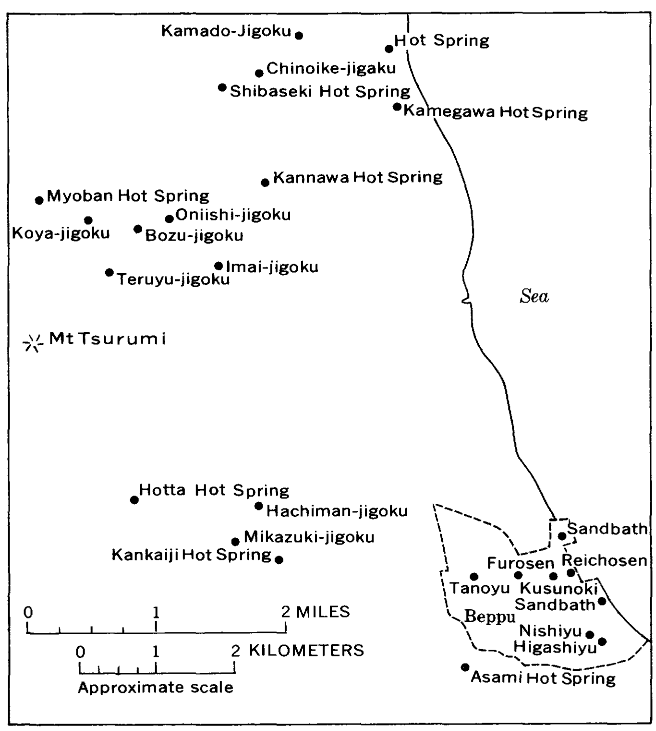

FIGURE 64.—Beppu area, Oita Prefecture, Japan, showing location of thermal springs. From ref. 2939.

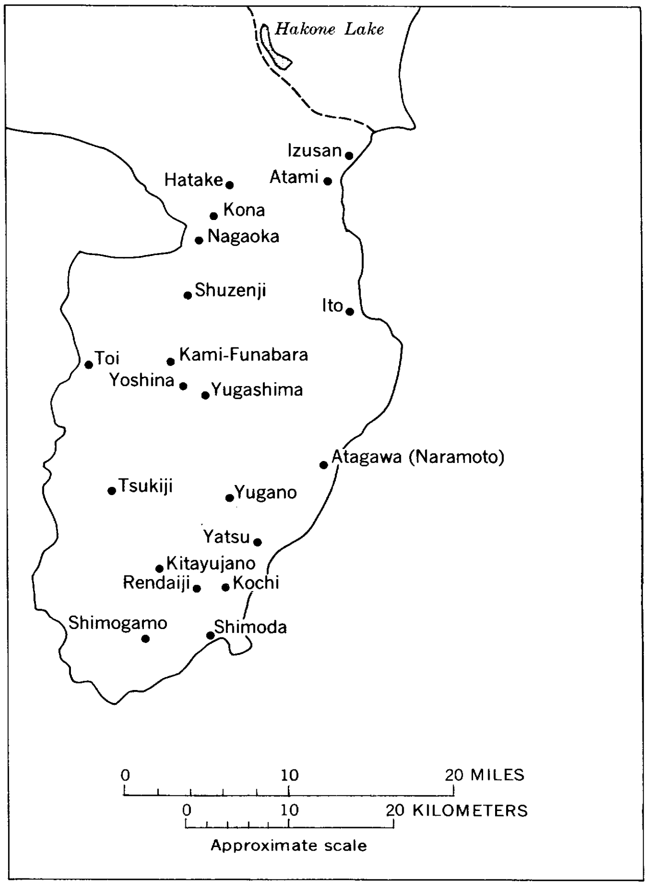

FIGURE 65.—Izu Peninsula, Shizuoka Prefecture, Japan, showing location of thermal springs. From ref. 2939.

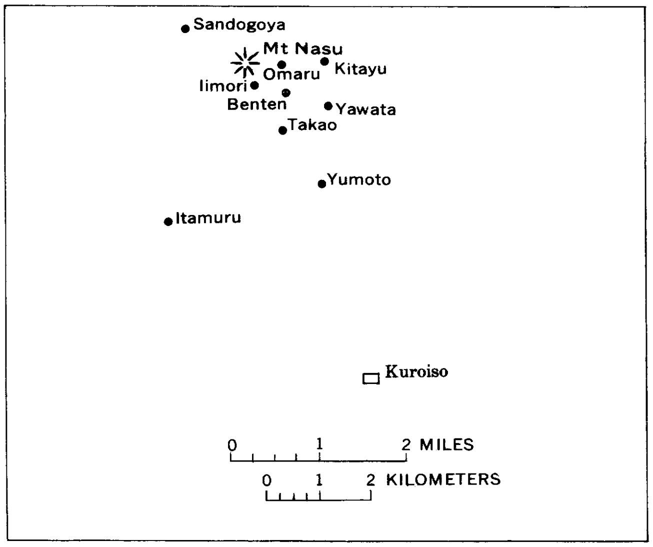

FIGURE 66.—Nasu area, Tochigi Prefecture, Japan, showing location of thermal springs. From ref. 2939.

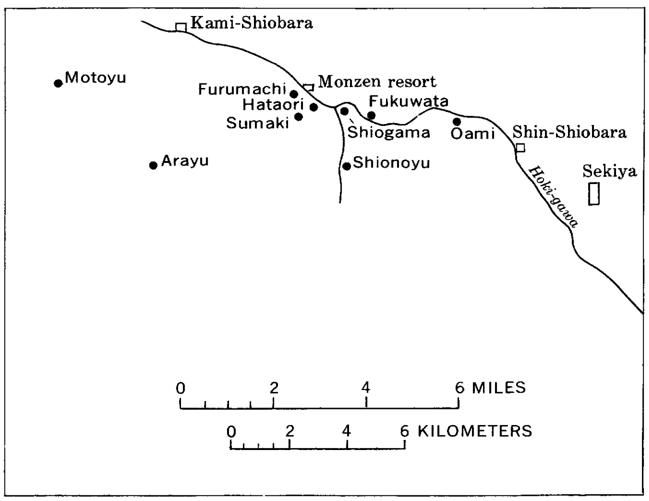

FIGURE 67.—Shiobara area, Tochigi Prefecture, Japan, showing location of thermal springs. From ref. 2939.

Thermal springs and wells in Japan

[Data chiefly from refs. 2937, 2939, 2942 and from Geologic map of Japan, scale 1:3,000,000 (Geol. Survey of Japan, 1953). Locations of unnumbered springs not identified. Principal chemical constituents are given in parts per million]

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Akita Prefecture							
1	Oyuzawa	32–45.5				Saline, sulfide, iron	Quaternary deposits near Tertiary lava.	4 springs.
2	Oyu	46–70.5				Weakly saline	do	Do.
3	Otaki (Odaki)	61; 62	6,012			Sulfur; bitter	do	2 springs.
4	Innai-yunosawa	40.5; 41	24,624			Simple	Tertiary sandstone near Quaternary lava.	2 springs. Sanatorium.
5	Shibukuro (Sibukuro, Shikayu).	80–97		4,717–5,463	SO_4 (938); Cl (2,697); H_2SiO_3 (370); H_2SO_4 (420).	Acid alum vitriol	Quaternary andesite	4 springs. Hokutolite deposited. Refs. 3071–3074, 3119–3123, 3127, 3169.
6	Yunosawa						Quaternary or Tertiary lava.	
7	Yunotai						do	
8	Nazumi						do	
9	Takanoyu						do	
	Tamagawa (Tamakawa).							10 springs along stream. Refs. 3065–3067.
	Aomori Prefecture							
1	Osoreyama	25.5–99		100–14,400	Cl, SO_4	Chalybeate	Miocene strata near lava	15 springs. pH, 1.8–5.8. Refs 2966, 3023.
2	Asamushi (Asamusi).	61.5–79				Sulfate; bitter	Tertiary andesite	8 springs. Ref. 3046.
3	Makado						Pleistocene deposits	
4	Sugayu					Sulfur	Quaternary lava	60 springs.
5	Nuruyu					Saline	do	Resort.
6	Tsutayu						do	
7	Itadome					Saline	do	Resort.
8	Owani	62–77				do	Quaternary liparite	32 springs. Resort.
9	Kuradate	56–78				do	do	6 springs.
10	Ikarigaseki	54–62				Weakly saline	Quaternary volcanic ash	5 springs. Resort.
11	Dake	45–84	4,585			Acid; muriated	Quaternary volcanic detritus.	
	Chiba Prefecture							
1	Mobaro (Mohara, Tagane).						Pleistocene deposits	High concentrations of I, Br, and NO_3 in water. Methane used commercially. Ref. 2988.
2	Otaki						Lower Tertiary strata	Ref. 2988.
	Shigehara							Ref. 3131.
	Ehime Prefecture							
1	Dogo	23–47				Simple	Granite	10 springs. Water is radioactive. Resort. Refs. 2899, 3010, 3011.
	Fukui Prefecture							
1	Awara	53–76	152			Earthy-muriated; saline.	Quaternary alluvium near Tertiary lava.	8 springs; also wells. Resort.
	Fukuoka Prefecture							
1	Musashi	41–46.7				Sulfur	Granite	6 springs. Resort.
2	Funagoya	17.5; 21				Simple; carbonated	Pleistocene deposits overlying crystalline schist.	2 springs. Resort.
	Fukushima Prefecture							
1	Anahara					Saline	Intrusive igneous rock	Resort.
2	Yuno	48–68.5				Simple	Tertiary sandstone	10 springs; also shallow wells. Resort.
3	Iizaka	50–70				Weakly saline	do	11 springs; also shallow wells. Resort. Sanatorium.
4	Shingoshiki	42.2				do	do	Ocher deposited.
5	Goshiki	38.5–44.5				Simple; alkaline		3 springs. Water is radioactive.
6	Shinobu-Takayu	45–49				Acid alum	Quaternary lava	Several springs.
7	Tsuchiyu				HCO_3		do	30 orifices. Artificial geyser. Refs. 3075, 3081, 3106, 3107.
8	Hinaka						Tertiary lava	
9	Atsushio	35–78				Saline; muriated	Quaternary alluvium near Tertiary lava.	Several springs.
10	Kawakami						Tertiary lava	
11	Bandai						Quaternary lava	Ref. 3063.
12	Oshitate						do	
13	Higashiyama	34–61				Saline; bitter	Quaternary andesite	14 springs. Resort.

Thermal springs and wells in Japan—Continued

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Fukushima Prefecture—Continued							
14	Yokomuki						Quaternary andesite	
15	Take (Dake)	39	3,455			Sulfur	Quaternary lava	Several springs. Resort.
16	Numa jiri	63				Acid; hydrogen sulfide.	do	Several springs.
17	Nakanosawa						do	
18	Takaoama						do	
19	Tamayu						Granite	
20	Bobata	14–27				Simple; sulfur	Granite; gneiss	11 springs.
21	Kashi	48.5–51				Simple	Granite	3 springs.
22	Nekonaki	13–22				do	Granite; gneiss	8 springs.
23	Yumoto	49				Saline; sulfur	Tertiary strata near granite	Several springs.
	Gumma Prefecture							
1	Yubiso	81; 88				Simple	Granite	2 springs.
2	Yubara	51.5; 57				do	do	Do.
3	Yujiku	37.2–79	648			Saline; bitter	Tertiary tuff	5 springs.
4	Shima group:							
	Arayu	54–84				Saline	Lower Tertiary sandstone	8 springs. Resort.
	Yamaguchi					do	do	4 springs. Resort.
	Hinatami					do	do	2 springs. Resort.
5	Digami						Quaternary lava	
6	Manza	50.6–81.7				Acid; hydrogen sulfide.	do	Several springs. Ref. 3008.
7	Kusatsu:							
	Main group	43–64.4		12,820 (max)		Acid vitriol, acid alum vitriol.	Quaternary volcanic tuff	27 springs. Used for bathing for more than 1,000 years. Refs. 2894, 2895, 3029, 3036, 3047, 3063.
	Mount Zao group.	41.5–66.3		8,880 (max)				19 springs. Refs. 3029, 3123, 3210.
8	Sawatari	38.9–52.8		Moderate			Quaternary lava	Refs. 2894, 3047.
9	Kajikazawa						Quaternary andesite	
10	Kawarayu	28.9–70.7				Sulfur	do	
11	Ikao (Ikaho)	44.5–47		Low		Sulfate; bitter	do	5 springs. Resort. Refs. 2894, 3132.
12	Akagi-Nashiki	20	195			Earthy; saline	Quaternary volcanic detritus.	
13	Kirizumi						Quaternary andesite	
14	Irinoyu	31.5–37				Saline	do	3 springs.
	Hiroshima Prefecture							
1	Yuki (north)	20.6–23.0		98; 145			Acid intrusive rock (granite?).	3 springs. pH, 7.8–8.2. Ref. 3056.
2	Kômo	20.1		210			do	pH, 7.2.
3	Yano	23.1		217			do	pH, 6.8.
4	Yunoyama	23.6		99			do	pH, 8.2.
5	Yuki (south)	26.4					do	Do.
6	Yoshiwa-mura Yomoto Jinja.	22.5		110			do	pH, 7.8.
	Kanae							Ref. 2972.
	Kutugahara							Do.
	Myogatami							Do.
	Immoyoseki							Do.
	Hokkaido Prefecture							
1	Toyotomi	42		12,190	Na (4,200); HCO_3 (1,690); Cl (6,230); HBO_2 (600).	Saline		Refs. 2988, 3082.
2	Onne	60 (max)				Alkaline; sulfur	Cretaceous strata	8 springs. Resort.
3	Ponyu						do	
4	Giei						Tertiary lava	
5	Kami-furano						do	
6	Usubetsu (Ousubetz).	54–58					do	Large deposit of ferruginous tufa. Refs. 3095, 3143.
7	Aoyama	42–44	2,772			Earthy; saline	Quaternary andesite	3 springs.
8	Jozankei	80–91				Simple; saline	Tertiary liparite	3 springs. Refs. 2940, 3095, 3096, 3199, 3205, 3206.
9	Tsurunyu						Quaternary lava	Ref. 3012.
10	Noboribetsu	48–98	54,000	2,726 (hottest)	Na (560); Cl (1,023); SO_4 (298); HBO_2 (134); H_2SiO_3 (597).	Vitriol; saline; sulfur.	Tertiary andesite	7 springs. Refs. 2899, 2920, 2940, 3133, 3138, 3186, 3198, 3203, 3204.
11	Karurusu	48–60				Simple	do	5 springs.
12	Nigorikawa						Quaternary lava	
13	Shikabe						do	Artificial geyser. Refs. 3009, 3081, 3106, 3107.
14	Yunokawa	40.5–44.4				Earthy; saline	Tertiary liparite	3 springs and many wells. Water high in fluoride. Refs. 2991, 3136.
15	Nezaki	40–66				do	do	20 wells 30–63 meters deep. Ref. 2988.
	Koganeyu							Ref. 3095.
	Futayama							Refs. 2990, 2992, 2293, 3200, 3201.
	Yachigashira							Ref. 2991.
	Yakumo	39.4–59.9		4,720–6,580	Ca, SO_4, Cl			Issue at mine. Ref. 2979.

Thermal springs and wells in Japan—Continued

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Hyogo Prefecture							
1	Kinosaki	47–60.3				Earthy-muriated; saline.	Tertiary sandstone	9 springs. Resort. Refs. 2984, 3058.
2	Yumura	90.5–95	Large			Alkaline; carbonated.	Granite	3 springs.
3	Hirano	27				Earthy-alkaline; saline; carbonated.	Paleozoic strata	Water used for drinking.
4	Takedao	19.5; 23.5				Muriated; sulfur	Quartz porphyry	2 springs.
5	Arima	28.3–53.4	1,000	77,000	Na (20,530); Cl (43,790).	Earthy-muriated	do	7 springs. Analysis is for one spring (Tenmangu-no-yu). Resort. Refs. 2915, 2924, 2925, 2929, 2931, 2933, 2958, 2963, 2988, 3018, 3042, 3059, 3086, 3087, 3092, 3160, 3162.
6	Kobe-Jareyama	21.5				Simple; carbonated	Granite	
	Ibaraki Prefecture							
1	Fukurode	34				Simple	Paleozoic strata near granite.	
	Ishikawa Prefecture							
1	Wakura	82; 93				Earthy-muriated; saline.	Tertiary sandstone	2 springs. Resort. Ref. 3170.
2	Fukaya						do	
3	Yuwaku	41				Sulfate; saline	do	Resort.
4	Tatsunokuchi	25				Saline	do	Several springs. Resort.
5	Katayamazu (Shiotsu).	60–79				do	do	Resort. Refs. 3167, 3170.
6	Awazu (Awadzo)	47–58				Sulfur	Tertiary liparite	Several springs. Resort. Refs. 3044, 3167.
7	Yamashiro	59–71.5				Saline; bitter; sulfur.	Tertiary tuffaceous shale	Resort. Refs. 3044, 3167.
8	Yamanaka		49			Sulfate; bitter; sulfur.	Tertiary volcanic tuff	Resort. Ref. 3044.
	Iwate Prefecture							
1	Tsunagi						Paleozoic strata near granite.	
2	Nishinamari						do	
3	Namari	95				Sulfur	do	
4	Osawa	51 (max)				Simple	Tertiary sandstone near granite.	3 springs.
5	Dai	53–84	270			Simple; bitter	Quaternary deposits overlying Paleozoic strata.	13 springs. Resort.
6	Shidodaira	76	389			Bitter	Tertiary sandstone near granite.	
7	Sugawa						Tertiary sandstone near Quaternary lava.	
	Geke							Ref. 3219.
	Kagoshima Prefecture							
1	Daio						Quaternary lava	
2	Kurinodake						do	
3	Kirishima group:							
	Eno	60–76.7	5,400			Sulfur; sulfide		6 springs. Ref. 2899.
	Iwodani	48.7–60.6	Large			Sulfur; saline		6 springs. Resort. Ref. 2899.
	Myoban	46–68	9,252			Sulfur; saline; alum		6 springs. Ref. 2899.
	Maru					Saline		Resort. Ref. 2899.
	Tono (Gin-no)					do		Do.
	Hisomoe					Milky sulfur		Do.
	Sekihira					Sulfur; alum		Do.
	Yunoko (Yunono).							Many springs and fumaroles in area 100 meters long and 50 meters wide. Resort. Refs. 2808, 2899.
	Hokonage					Simple		Resort. Ref. 2899.
	Ora					do		Do.
4	Soeda (Soita)						Tertiary or Quaternary lava.	
5	Shihobitashi						Quaternary lava and volcanic ash.	
6	Anraku	53.9	9,540			Iron carbonate	do	Resort.
7	Yamanoyu						do	
8	Hinatayama						do	
9	Yunomoto	47				Alum; hydrogen sulfide.	do	7 springs.
10	Isaku						do	
11	Arimura	38.9–45				Iron carbonate	do	Several springs.
12	Ibusuki	42–65				Saline		Do.
	Shimo	87	4,200			Alum	Volcanic ash	Ref. 2942.

Thermal springs and wells in Japan—Continued

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Kanagawa Prefecture [See also fig. 62 for locations of springs in Hakone area]							
1	Hakone area:							
	Ubago (Ubako)	40				Weakly saline; soda	Quaternary andesite	Refs. 2909, 3047, 3129.
	Owakidani	82.2				Saline; sulfur	do	Water piped to 2 resorts. Ref. 2909.
	Kiga	40–46.7				Saline	do	5 springs. Ref. 3129.
	Sokokura	64–76				do	do	4 springs. Ref. 3129.
	Dogashima	46				do	do	Ref. 3129.
	Myanoshita (Miyanoshita)	36–96	1,800			Saline; acid alum	do	8 springs. Resort. Ref. 3129
	Kowakidani	35.6–71				Acid vitriol; sulfur	do	3 springs. Ref. 3129.
	Yunohanazawa:							
	Gongen-yu	40		720–1,410		Acid; hydrogen sulfide.	do	Resort. Refs. 3016, 3019, 3020, 3022, 3023, 3030, 3129.
	Yeomon-yu	74.5		1,718	Ca (103); SO_4 (1,036); H_2SiO_3 (367); Al (120).		do	
	Ashinoyu	45		160–620	NaCl, $CaSO_4$; much free CO_2.	Sulfur	do	3 springs and several solfataras. Refs. 2893, 2908, 3034, 3047, 3129.
	Tonosawa	50				Simple	do	4 springs. Resort. Ref. 3129.
	Yumoto	42–47.3				do	do	5 springs issuing at south base of Yusakayama. Oldest resort in Hakone area. Ref. 3129.
2	Yugawara	34–88.5				Saline	do	12 springs. Resort. Refs 3016, 3019, 3023, 3030, 3181.
------	Monkawa							Ref. 3018.
------	Kadogawa							Refs. 3131, 3132.
	Kumamoto Prefecture [See also fig. 63 for locations of thermal springs and craters in Aso caldera]							
1	Yamaga	41.6				Alkaline; sulfur	Teritary and Quaternary lavas.	Resort.
2	Koama						do	
3	Ryuganji						do	
4	Hirajima						Quaternary andesite	
5	Aso caldera:							
	Uchinomaki		Small				do	Issues from bore hole 75 meters deep. Refs. 2935, 3165.
	Tochinoki (Toshita).	39–45				Sulfate; bitter; saline; iron.	do	5 springs. Water piped 2 km to resort. Refs. 2878, 2935, 2940.
	Yunotani	76 (max)				Alum; iron-alum	do	Artificial geyser and red mud pool. Refs. 2878, 2935, 2956, 3107.
	Tarutama	57–75				Sulfur	do	3 springs. Ref. 2935.
	Hoko-Jigoku	Boiling				Alum	do	2 springs. Refs. 2935, 2954–2956, 2959–2961.
	Kurokawa (Oguni).					Acid; saline; sulfide	do	Ref. 3166.
6	Hinagu	47–48.5				Simple; carbonated	Cretaceous strata	3 springs; also wells (max depth 75 meters). Resort.
7	Hayashi	47				Saline	Mesozoic(?) strata	Several wells about 107 meters deep. Resort.
	Miyagi Prefecture							
1	Kurikoma group:							
	Nuruyu	45				Saline	Quaternary lava	Resort. Ref. 3044.
	Yonokura	42.6				do	do	Ref. 3044.
	Yunohama	45				do	do	Do.
	Komanoyu					Sulfur	do	Do.
	Shin-Komanoyu					do	do	Do.
2	Numayu						do	
3	Onikobe group:							
	Mitaki (Kamitake).	54.4				Saline	do	Resort. Refs. 2881, 2919, 3044, 3081, 3117.
	Arayu					Sulfur	do	2 springs. Resort. Refs. 2881, 2919, 3044, 3081, 3117.
	Todoroki	52.8				Simple	do	Do.
	Miyazawa					Saline; sulfur	do	2 springs, one (formerly?) a geyser. Refs. 3106, 3107.
	Fuki-age	98.8				Saline		Formerly spouted to height of 2–3 meters about once an hr. Refs. 2881, 2919, 2920, 3107.
	Ogama	97.5						The only natural geysers in Japan in 1956. Megama erupts at intervals of 18.5 minutes. Ref. 3107.
	Megama	98.2						
	Sabusawa							

Thermal springs and wells in Japan—Continued

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Miyagi Prefecture—Continued							
4	Tamatsukuri (Yuizumi) group:							
	Kawatabi	43.3–50				Saline; sulfur	Tertiary andesite	3 springs. Ref. 2881.
	Tanaka					Saline; carbonated	do	2 springs. Resort. Ref. 2884.
	Akayu	58 (max)						3 springs. Resort. Ref. 2884.
	Motokurma	65				Saline	Tertiary andesite	2 springs.
	Shinkuruma	47.7–83.5				do	do	5 springs. Resort.
	Naruko (Narugo).	40.5–103				Alkaline sulfate; acid vitriol.	do	Several springs, including artificial geyser. Resort. Refs. 2884, 2998, 3000, 3002, 3081, 3105, 3106, 3108.
	Kararayu							2 springs. Resort.
	Nakayama (Nakayamadaira)					Sulfur		2 springs. Ref. 2880.
5	Sakunami	49.5				Saline	Quaternary lava	Water is radioactive. Ref. 2880.
6	Akiu	51.5		8,120	Ca (970); Na (1,850); SO_4 (314); Cl (4,340); HBO_2 (426).	do	do	Refs. 3082, 3083.
7	Aone	43–52				Simple	Tertiary sandstone near Quaternary lava.	Several springs. Ref. 2883.
8	Gaga	56.6	Large			Saline	Quaternary lava	Resort.
9	Togatta	56 (max)	Large			Saline; carbonated	do	4 springs. Water is radioactive. Resort.
10	Kamasaki	37–48	3,150			Saline	Tertiary andesite	4 springs. Resort.
11	Ohara	53.3; 63.3				Simple	do	2 springs.
	Sakaino							Ref. 3083.
	Sanezawa							Ref. 2988.
	Miyazaki Prefecture							
1	Kuromatsu and Ebino, on northwest flank of Kirishima volcano.	108					Quaternary andesite	Refs. 3008, 3168.
2	Yoshida	42				Saline	Lower Tertiary strata	
	Miye Prefecture							
1	Komono	29				Simple	Granite	
	Nagano Prefecture							
1	Nazawa	41–82	5,148			Sulfur	Quaternary volcanic detritus.	Resort. Ref. 2973.
2	Iijama	20–29	2,160 (hottest)		Cl (19); HCO_3 (35)		Quaternary lava	3 springs. pH, 7.3. Ref. 3142.
3	Ojiya						do	
4	Hirao area:							
	Yudanaka	74–76				Muriated; sulfate; bitter.	do	3 springs.
	Andai	55; 56				Simple	do	2 springs.
	Shibu	45–76				Sulfate; saline; sulfur.	do	15 springs.
	Kamabayashi	55				Saline	do	1 spring and 6 boiling pools (jigoku).
	Hoppo	60				do	do	
5	Kakuma	52–65	1,513			do	do	3 springs. Sulfur sinter.
6	Yamada						do	
7	Kuzu	62–88				Saline	Granite	4 springs.
8	Kami-yamada						Quaternary lava	
9	Tokura						do	
10	Nakabusa	59.5–96				Alkaline	Granite	8 springs.
11	Kose	26.6				Carbonated	Quaternary lava	Resort. Ref. 3064.
12	Tazawa						Granite	
13	Shirahone	48–52				Earthy-alkaline	do	4 springs.
14	Renge	36–47.7				Saline; acid vitriol	Paleozoic strata near granite	Several springs. Resort.
15	Kutsukaki						Granite	
16	Bessho	Hot					do	Do.
17	Hirayu	Hot				Iron carbonate	Paleozoic strata near Quaternary lava.	Resort.
18	Yamabe	28–42				Simple	Tertiary sandstone	4 springs.
19	Reisenji						Quaternary lava	
20	Kamikochi	53.5				Simple	Granite	
21	Asama	36.5–53				do	Tertiary sandstone	3 springs; also wells. Resort. Refs. 3064, 3100–3104, 3155, 3156.
22	Kageyu					do	Quaternary lava	
23	Shimosuwa	47.5–67				do	Alluvium near granite	3 springs. Resort.
24	Shibu (Suwa)	27				Acid; hydrogen	Quaternary andesite	
25	Kamisuwa	67.5–83	130			Simple	Alluvium overlying Quaternary lava.	Do.
26	Taki						Quaternary andesite	
27	Otari	46.1–59				Alkaline	Paleozoic sandstone	
	Yamanouti						Faulted porphyry	8 groups of springs. Ref. 3209.

Thermal springs and wells in Japan—Continued

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Nagasaki Prefecture							
1	Yunomoto, on Iki Island.	43–47				Alum vitriol; earthy-muriated; saline.	Quaternary liparite	Several springs.
2	Michino	24				Vitriol	Tertiary volcanic tuff	
3	Obama	24–94		9,204	$CaCO_3$ (322); Na_2SO_4 (636); NaCl (5,663); $MgCl$ (536); KCl (1,634).	Earthy-muriated; saline.	Quaternary andesite	4 springs. Analysis is for main spring, Fontu-yu. Snow-white sinter. Resort. Refs. 3124, 3144.
4	Unzen area:							
	Aino-mura	38–84		359–1,198		Acid vitriol; hydrogen sulfide.	do	6 springs. Resort. Refs. 2899, 2940, 2978.
	Ko-jigoku	100 (max)				Acid; hydrogen sulfide.	do	Several springs, boiling pools, and fumaroles. Refs. 2899, 3124, 3168.
	Nara Prefecture							
1	Rokuyo	20.5				Vitriol	Alluvium overlying Tertiary strata.	
	Goshiki							Ref. 2913.
	Shionoha							Refs. 2913, 3210.
	Niigata Prefecture							
1	Senami	102	9,000			Saline	Tertiary strata	Oil test 255 meters deep. Resort. Refs. 3013, 3022.
2	Yuzawa	48–52				do	Granite(?)	3 springs.
3	Takanosu						Tertiary lava(?)	
4	Tsukioka						do	
5	Izuyu (Deyu)	31–39.5				Simple, carbonated	Granite	4 springs.
6	Murasugi	13.5–26					do	7 springs. Resort. Ref. 3015
7	Matsunoyama	58.5		36,880		Earthy-muriated; saline.	Lower Tertiary strata	Ref. 3082.
8	Oyu	53–57				Simple	Granite	6 springs. Water is weakly radioactive.
9	Tochiomata	28.5–39	1,800			do	do	6 springs. Water is strongly radioactive.
10	Yuzawa	37–45				Saline	Lower Tertiary sandstone.	6 springs. Resort.
11	Takase	63; 72				do	Quaternary lava	2 springs. Resort.
12	Yakiyama	88		36,800	Ca (2,010); Na (1,540); SO_4 (8,340); Cl (19,990).	Saline; sulfate	do	Ref. 3082.
13	Seki						Quaternary andesite	
14	Tsubame	42–48				Sulfur	do	3 springs.
15	Akakura	55.5–62	7,200			Alkaline; sulfur	do	3 springs. Resort.
	Matunoyama							Water contains beryllium. Ref. 3014.
	Oita Prefecture [See also fig. 64 for locations of thermal springs in the Beppu area]							
1	Beppu area	36–98	144,000	745–3,332	Na, Ca, Cl, CO_2, SiO_2.	Alkaline; saline; sulfur; carbonate.	Tertiary and Quaternary lavas.	Many springs and wells; also fumaroles and solfataras. Resort. Refs. 2899, 2911, 2918, 2940, 2954, 2958, 2962, 2975–2977, 2981, 2986, 3003, 3005, 3006, 3068, 3081, 3087, 3107, 3109–3116, 3146–3154, 3157, 3168, 3169, 3175, 3217.
2	Tsukahara					Milky sulfur	Quaternary andesite	
3	Yufuin		Large			Carbonated	do	Several springs. Refs. 2945, 3218.
4	Dakeshita	50	3,060			Saline	do	Ref. 2942.
	Okayama Prefecture							
1	Yubara	39.4; 49.2	4,500	194; 204			Granite	pH, 8.5; 8.8. Resort. Ref. 3053.
2	Goroku	34.5		131			do	pH, 8.6. Ref. 3053.
3	Taru	37.7		121			do	Do.
4	Maga	39.4	2,700	162			do	Do.
5	Kamisaibara (Josaibara).	31.1		157			do	pH, 8.8. Ref. 3053.
6	Okutsu	39.0; 43.3		128			do	2 springs. pH, 8.6; 8.8. Ref. 3053.
7	Ohtsuri	41.3; 42.6		131; 133			do	Do.
8	Yunogo	25–77	1,296	2,397			Tertiary liparite	5 springs. pH, 8.0. Resort. Ref. 3053.
9	Takebe	28.0					Granite	

Thermal springs and wells in Japan—Continued

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Saga Prefecture							
1	Furuyu						Granite(?)	
2	Kumanokawa						do.	
3	Takeo	49	1,512			Simple	Tertiary andesite	Resort.
4	Ureshino	95	2,592			Alkaline; muriated; carbonated.	do.	Do.
	Shiga Prefecture							
1	Miyano						Granite(?)	
2	Shiono						do.	
	Shimane Prefecture							
1	Gakuto	27				Saline	Tertiary sandstone	2 springs.
2	Tamatsukuri	54-64	Large			do.	do.	3 springs. Water is radioactive. Ref. 3194.
3	Hirose	37; 43					Granite	2 springs. Water is radioactive.
4	Ushio	41.5				Bitter	do.	
5	Yunokawa						do.	
6	Ikeda	17; 24				Carbonated	do.	2 springs. Cooler water is radioactive and is heated for bathing use. Refs. 2957, 2958, 2963, 2968, 2970, 2971, 2987, 3042, 3057, 3221.
7	Koyabara	38.2				Saline; carbonated	do.	Water contains iron. Resort.
8	Yumura	43	3,888			Simple	do.	
9	Shigaku	22.5-46.5	31,100			Saline	do.	3 springs. Large deposits of tufa. Refs. 3054, 3194.
10	Yunotsu	46; 50				Saline; sulfate	Tertiary sandstone near Tertiary lava.	2 springs. Water is radioactive.
11	Arifuku	44.5-49	3,230			Simple	Diorite	3 springs.
12	Fukumitsu	34.5				Saline; carbonated	Tertiary sandstone near lava.	
	Kakinoki							Ref. 3054.
	Koda							Ref. 3054.
	Yugakai							Ref. 3194.
	Saginoyu							Do.
	Sambeyama district							Ref. 3055.
	Shizuoka Prefecture [See also fig. 65 for locations of springs on the Izu (Idu) Peninsula]							
1	Hatake	38-40				Simple	Quaternary andesite	9 springs.
2	Izusan	60				Sulfate; bitter	do.	
3	Atami	77-108		9,235	$CaCl_2$ (2,893); NaCl (5,409); SiO_2 (524).	Earthy-muriated; saline.	do.	8 springs, including formerly active Oyu geyser; also wells. Refs. 74, 2877, 2902, 2914, 2920, 2921, 2940, 3038, 3107, 3141, 3181, 3220.
4	Kona	52 (max)				Simple	Tertiary volcanic tuff	Several springs. Resort.
5	Nagaoka	41-53				do.	do.	11 springs; also wells. Ref. 3181.
6	Shuzenji (Syuzenzi)	55-77	1,400			Saline	Quaternary andesite	17 springs issuing in bed of Katsura River. Resort. Refs. 2940, 3181.
7	Ito group:							
	Matsubara	43.5-50.5				Simple	Quaternary lava	7 springs; also wells. Refs. 2905, 3022, 3025, 3027, 3087.
	Shishido	35.5; 47				Saline	do.	2 springs. Refs. 3022, 3025, 3027, 3087.
	Kusumi	35.5-50	57,800			do.	do.	4 springs. Refs. 3022, 3025 3027, 3087.
8	Toi (Tohi)	36-79				Sulfate; bitter	Tertiary sandstone	16 springs. Refs. 3211, 3214.
9	Kami-Funabara	35-47				Saline; bitter	Quaternary andesite	4 springs.
10	Yoshima	41-50				do.	do.	3 springs; also springs at base of Amagi-san.
11	Yugashima	41-64				Saline; carbonated	do.	11 springs.
12	Tsukiji						do.	
13	Yugano	42; 52				Saline	do.	2 springs. Ref. 3213.
14	Atagawa	42 (max)				Saline; carbonated	do.	Several springs. Resort.
15	Yatsu (Yazu)	46-70				Saline	do.	6 springs. Ref. 2901.
16	Kitayujano						do.	
17	Kochi	42-53				Saline	do.	13 springs.
18	Rendaizi	24-56				do.	Tertiary sandstone near Quaternary lava.	40 springs and wells. Refs. 2900, 2906.
19	Shimoda	22-31				do.	do.	3 springs.
20	Shimogama (Simogama).	63-79				do.	do.	5 springs. Ref. 2900.
	Kawazu							Refs. 3212, 3214.
	Yokogawa							Ref. 3213.
	Simogama							Ref. 2900.
	Simokawazu							Do.
	Sekoyu							Refs. 3212, 3213.

Thermal springs and wells in Japan—Continued

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Tochigi Prefecture [See also figs. 66 and 67 for locations of springs in the Nasu and Shiobara areas]							
1	Nasu area:							
	Sandogoya	52	1,800			Simple	Quaternary lava	
	Iimori	38				Simple; iron	do	
	Omaru (Dai-Maruzuka).	61.5; 71	Large			Simple	do	2 springs. Resort.
	Benten	48; 54				Simple, carbonated	do	Do.
	Kitayu	51–54				Simple	do	5 springs.
	Yawata					Saline	do	
	Takao	34				Sulfur	do	Sinter, with sulfur.
	Yumoto (Nasu-Yumoto).	28–74.5		2,723	Ca, SO_4, Cl	Acid; hydrogen sulfide.	do	4 springs. Resort. Refs. 2925, 2926, 2940, 3047.
2	Itamuro		Large			Simple	do	Resort.
3	Shiobara area:							
	Moto-yu (Furu-Motoyu).				SO_4 (2,029)	Muriated; alkaline	do	Resort. Refs. 2926–2928, 2930 2932, 2934, 2940.
	Arayu					Acid; sulfur	do	4 springs. Resort.
	Furumachi	42–60				Alkaline	do	Do.
	Monzen	50–54				Alkaline; saline	do	3 springs. Resort.
	Sumaki	62.5				Simple	do	Resort.
	Hataori	55–70				Alkaline; muriated	do	5 springs. Resort.
	Shiogama	65				Saline		2 springs. Resort.
	Fukuwata	42–50				do		5 springs. Resort.
	Shionoyu	54–73				do		3 springs. Resort. Ref. 3047.
	Oami	55; 57.5				Saline; bitter		2 springs. Resort.
4	Nikko-yumoto	22–69				Hydrogen sulfide	Quartz porphyry	10 springs. Resort.
	Tottori Prefecture							
1	Kaike	73.5					Quaternary andesite	Water is piped to resort. Ref. 3060.
2	Asozu	46–56				Saline; sulfur	do	4 springs. Ref. 3194.
3	Togo group:							
	Togo	31–50	1,730			Simple		5 springs. Water is piped to resort. Refs. 3194, 3195.
	Matsuzaki (Matuzaki).	32; 36				Saline		2 springs. Refs. 3194, 3195.
4	Misasa	33.5–85	Large	534–1,940	Cl, HCO_3, SO_4	Muriated; sulfur; saline; simple.	Granite	30 springs. Water is very radioactive. Refs. 2887, 2889, 2987, 3033, 3042, 3087, 3139, 3140, 3145, 3173, 3174, 3189–3191, 3193–3195, 3221.
5	Sekigane	40–45				Sulfur	Quaternary andesite	6 springs. Refs. 3060, 3192, 3194.
6	Hamamura	45–49				Saline; bitter	do	4 springs. Ref. 3194.
7	Kachimi	51.5–56				Sulfur; simple	Tertiary sandstone	4 springs. Water is radioactive. Ref. 3194.
8	Yoshioka	42.5–56.5	2,592			do	Tertiary sandstone near Quaternary lava.	5 springs.
9	Yoshikata	24.4–47.5				Saline; bitter	Lower Tertiary sandstone	6 springs. Water is radioactive.
10	Tottori	26; 28.5				do	do	2 springs.
11	Iwai	37–60	4,066			Saline; sulfate; bitter.	do	7 springs.
12	Yudani	32				Alkaline; saline	do	
	Toyama Prefecture							
1	Ogawa	49–60				Alkaline; saline	Tertiary liparite	6 springs.
2	Kuronagi	83; 88.5				Sulfur	Granite	2 springs.
3	Aimoto (Futami)	64.5–95				do	do	3 springs.
4	Kanetsuri	49				Simple	Contact of limestone and granite.	
5	Okubu						Tertiary strata	
6	Johanna						do	
7	Omaki	49				Sulfate; saline	Porphyrite dike	
8	Kasuga						Granite or schist	
9	Tateyama	63	4,464			Hydrogen sulfide	Tertiary andesite	Ref. 3063.
	Wakayama Prefecture							
1	Yumoto (Rejujin)	39.1	9,450			Simple	Mesozoic strata	
2	Yunomine	87.5–92	1,555			Saline; bitter; sulfur.	Tertiary sandstone	3 springs.
3	Yukawa	22–40				Alkaline; sulfur	Lower Tertiary sandstone	5 springs. Ref. 3063.
4	Sedono-Kanayama	42–60				Muriated; alkaline; carbonated.	Cretaceous sandstone	8 springs.
5	Yuzaki						do	Sinter deposit 2.3 percent SrO. Ref. 2886.
6	Katsuura	27–45				Alkaline; sulfur	Tertiary sandstone	3 springs. Water is radioactive.
7	Akashima						Cretaceous or lower Tertiary sandstone.	
------	Shirahama							15 springs. Water is contaminated by sea water. Resort.

Thermal springs and wells in Japan—Continued

No. on fig. 61	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Yamagata Prefecture							
1	Atsumi	45–70				Sulfate; saline	Quatenary volcanic tuff	Resort.
2	Yunohama	43–47.2				Saline	Tertiary sandstone	
3	Semi						Tertiary strata near Tertiary lava.	Ref. 2884.
4	Akakura						do	
5	Yudagawa (Namegawa?).	55				Earthy-muriated; saline.	Tertiary sandstone near Quaternary lava.	
6	Sekine-yunosawa	28				Simple	do	
7	Yuatsumi						do	
8	Hijiori						Tertiary lava	
9	Higashine						Quaternary lava	
10	Tsuyama						do	
11	Mogami-Takaku	30–40	63,000			Acid alum vitriol	Quaternary andesite	Many springs. Resort. Ref. 2892.
12	Kaminoyama	56–62	3,944			Simple; bitter	Quaternary liparite	4 springs. Resort.
13	Akayu	42–58				Earthy-muriated; saline.	Tertiary sandstone near Quaternary lava.	Do.
14	Onogawa	65.5–73.5				do	Tertiary sandstone	5 springs and several wells. Resort.
15	Namerikawa						Tertiary lava	
16	Ubayu						do	
	Bansyoji							Ref. 3131.
	Jagohara							pH, 1.5–1.6. Ref. 3069.
	Yamaguchi Prefecture							
1	Yumoto (Fukagawa).	40.8; 41.5		174			Tertiary liparite	2 springs. pH, 9.0. Ref. 3052.
2	Tawarayama	36.2–42.0		182–195			Cretaceous strata	6 springs. pH, 9.0–9.2. Resort. Ref. 3051.
3	Kawatana	20.5–43.0		1,990–2,149			Granite or diabase	4 springs. pH, 6.8–7.0. Ref. 3125.
4	Yoshimi	30.1		145			do	
5	Yunotôge	20.6; 23.0		156; 182			do	2 springs. pH, 7.4; 8.3.
6	Jiseiji	27.3; 29.5		268; 250			do	2 springs. pH, 8.3; 8.2. Water is radioactive. Ref. 3052.
7	Yuda	40.5; 58.0		463			Quaternary alluvium near granite.	2 springs. pH, 7.1; 7.5.
8	Yuno	28.0; 32.9		670; 157			Granite or crystalline schist	2 springs. pH, 8.4.
	Yamanashi Prefecture							
1	Masutomi (Matsutomi).	20–33				Earthy; saline	Granite	15 springs; also wells. Water is strongly radioactive. Refs. 2907, 2940, 2942, 2957, 2987, 3031, 3032, 3035, 3038, 3040–3042, 3085, 3087, 3119–3123, 3160, 3162, 3170, 3223.
2	Kurobira						Paleozoic strata near granite	
3	Yumura (Kofu)	33.8–42				Saline	Quaternary andesite	4 springs. Refs. 2875, 2876.
4	Shimobe	35–36				Simple	Tertiary shale	3 springs.
	Prefecture Unknown							
	Dai-san, in Futami	95				Sulfur	Granite	Ref. 2942.
	Shin-taki, in Osore-yama.	95	216			Acid alum	Andesite	
	Shirakumo, in Furo-sen.	91	3,060			Iron	Tertiary sandstone	
	Naka, in Hiraochi	90	3,600			Saline	Volcanic ash	
	Spring A, in Kuzu	88				Sulfur(?)	Granite	
	Hokonagi	82	207			Saline; sulfate	Andesite	
	Spring B, in Urai	80				Saline	Tertiary sandstone	
	Orodani	80	4,680			Acid	Volcanic ash	
	Tono, in Shiriuchi	80				Saline		

KOREA (CHOSEN)

Several groups of mountains occupy northern Korea and from them high ranges extend southward along the eastern part of the country. The east coast is mainly steep and rocky. West of the main range is a region of steep hills and narrow valleys. Much of the western coast is low, and there are wide mud flats due partly to the great tidal change, which is as much as 35 feet along the northwest coast. In contrast, there is a change of only 1 to 3 feet along the east coast.

Granite, gneiss, and crystalline schist form the main parts of the main mountain ranges, which have been strongly folded. In the northern part, ancient crystalline and metamorphic rocks are overlain by Paleozoic sandstone, slate, and limestone. In the southeast are Carboniferous strata which contain coal beds. More important coal beds are found in Tertiary deposits in west-central Korea. Recent volcanic rocks are present in some parts of the interior. The south and west coasts are fringed by many small islands, some of which are bare masses of lava. One dormant volcano is on Quelpart Island beyond the south end of the Korean Peninsula.

Information on thermal springs in Korea is given in the table below. Their locations are shown on figure 55.

Thermal springs in Korea

[Data chiefly from refs. 2939, 3222, 3233. Locations of unnumbered springs not identified. Principal chemical constituents in parts per million]

No. on fig. 55	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Shuotsu	36–56.5	18,783	244	$NaHCO_3$ (101); H_2SiO_3 (69)	Granite	23 outlets, including several wells Resort.
2	Lower Shuotsu (Kaneta):						
	Main spring	53	540	268	$NaHCO_3$ (119); H_2SiO_3 (78)	do	Resort.
	Well	60	2,000			do	
3	Heisan	46–55	4,088	270	$NaHCO_3$ (139); Na_2SO_4 (17); NaCl (26); H_2SiO_3 (71).	Granite; gneiss	1 spring, 5 wells. Resort.
4	Sakuchu	Warm					Ref. 2997.
5	Kisen	Warm					Do.
6	Yotoku	Warm					Do.
7	Shakuoji	Tepid		729	CaO (334); Na_2O (117); free CO_2.		Heated for baths.
8	Onseiri (Wenchingli)	40–45	12,062	154	$NaHCO_3$ (60); H_2SiO_3 (62)	Granite; gneiss	4 springs, 2 wells. Developed about A.D. 730. Resort. Refs. 3228, 3236.
9	Tong-nai (Kongosen), at southeast base of Keum-jyong-san (Diamond Mountain).	76		1,009	SiO_2 (122); Na (278); Cl (457).	Granite	Bathing resort since A.D. 1691. Refs. 3230, 3234.
10	Ryuko, 17 miles northwest of Chinnampo.	40.5–55.2	1,800	24,056	Ca (3,340); Mg (224); Na (5,050); K (489); Cl (14,720).	Gneiss overlain by alluvium	6 springs; also several wells. Water is radioactive. Developed in ancient times. Resort.
11	Angaku	47.75	>1,700	969	Na (255); Cl (358)	Granite or gneiss overlain by alluvium.	6 small springs. Water is radioactive. Resort.
12	Shinsen, near railway station.	28–58	9,000	360	Na, HCO_3	do	Springs developed 500 yr ago; 34 wells drilled in recent years. Water is radioactive. Resort.
13	Hakusen	Warm					Used for bathing.
14	On-yo, 0.25 mile northwest of Onsenri railway station.	38–50.3	233	287	Na, HCO_3	Granite	4 springs, 4 wells. Water is radioactive. In use for more than 500 yr. Bathing resort; military sanatorium. Refs. 2937, 2942, 3235.
15	Jujo, 7 miles northwest of Taiden.	34–48.5		191	H_2SiO_3 (63); Na (30); HCO_3 (74); Cl (10).	Granite and porphyry overlain by alluvium.	Spring in use for 500 yr; 10 wells drilled in recent years. Water is radioactive. Resort. Nearby resort developed in 1923 is supplied by 24 wells.
16	Kaiundai, near sea coast, 8 miles northeast of Fusan.	47–52	575	4,454	Ca (669); Na (922); SO_4 (211); Cl (2,510).	Granite and quartz porphyry.	22 wells. Water is radioactive. Resort.
17	Torai, 7 miles northeast of Kaiundai.	50–67	2,435	992–1,077	Na, Cl	Granite overlain by alluvium.	Original spring developed about A.D. 1700. Supply in recent years from 43 flowing wells. Water is radioactive. Resort. Refs. 2942, 3231.
	Bazan						Ref. 3229.
	Suianpo						Ref. 3237.
	Masan-Onsen	80	135				Water is saline. Ref. 2942.

LEBANON AND SYRIA

Lebanon consists of a narrow band of coastal plain along the Mediterranean Sea and highlands that rise eastward to steep mountains which border the southwestern part of Syria. Syria extends from the base of the Taurus Mountains of southeastern Turkey, southward for 300 miles, and inland from the Mediterranean for 100 to 300 miles.

The Lebanon Mountains in northern Lebanon and the adjoining part of Syria are prominent rugged ranges that trend generally north-northeast and are deeply cut by stream gorges. Nearly parallel to these mountains on the east are the Anti-Lebanon Mountains, which are separated from the main mountains by the valley of the Leontes, or Litany, River in southern Lebanon. Both mountain systems are composed largely of Cretaceous limestone, and in many places are worn into sharp ridges. Most of Syria inland beyond the Lebanon Mountains forms a great plateau, interrupted in several places by mountain masses. Some of these masses are of volcanic rocks. In the northeast, beyond the Euphrates River valley, are other mountains, composed of volcanic materials and ancient crystalline rocks. Sedimentary rocks in the mountain areas are considerably folded, but in the plateau regions they lie nearly horizontal. The valley of the Orontes River in northwestern Syria is the major structural feature, and may be a northward extension of the block fault of the Dead Sea and the Jordan River valley.

Numerous springs of large flow, some of which are slightly thermal, are present in the limestone areas, and several springs of higher temperature issue in or near areas of lava. Perhaps the most noted thermal springs are those near Palmyra in Syria. Information on these and other springs in Lebanon and Syria is given in the table below, and the locations of the springs are shown on figure 54.

Thermal springs in Lebanon and Syria

[Locations of unnumbered springs not identified]

No. on fig. 54	Name or location	Temperature of water (°C)	Flow (liters per minute)	Associated rocks	Remarks and references
	Lebanon				
1	Northern part of Lebanon	Warm		Limestone(?)	Ref. 3239.
	Syria				
1	El Hamman (Kurd Dagh)	37	630		3 main and 4 minor springs. Much H_2S. Water used for bathing. Ref. 3241.
2	Hammam Cheikh Issa, in hills of Oronte.	38	90		Water is radioactive. Used for bathing. Refs. 3240, 3241.
3	Palmyra (Palmyre, Tadmor):				
	Two main springs	29	9, 300 (larger spring)	Cretaceous limestone	Issue into subterranean canal and grotto. Water sulfurous but potable. Used for town water supply and irrigation. Refs. 1737, 3238, 3240, 3241.
	Several minor springs	22–23		Eocene limestone	Flow collected by underground galleries. Water used for town water supply and irrigation. Refs. 3238, 3241.
4	Soukhné (Es Sukhne)	28	1, 080	Lower Senonian beds (Upper Cretaceous).	Refs. 3240, 3241.
5	Mount Boueida:				
	Erek			Albien beds (Upper Cretaceous).	Ref. 3241.
	Nédouyat				
	Taïbe				
	El-Kôm				
	Dmair	33			Ref. 3240.
	Ain Kebrit	28	18, 000		Source of commercial sulfur (50 tons per year). Ref. 3251.
	Hammam Aly	28	300		Important bathing place in ancient times.

MALAYA (FEDERATION OF MALAYA)

Malaya occupies the southern and widest part of the Malay Peninsula. A range of granite mountains which forms the narrowest part of the peninsula also extends through the southern part, west of its center. The rocks are deeply weathered over large areas. East of the mountains are hilly regions of slate cut by quartz veins and overlain by limestone. On the flanks of the main range are also hilly areas of sedimentary rocks including Carboniferous limestone, which contains many caves, and Triassic sandstone. Most of the region is densely forested. Along the west coast mangrove swamps and wide muds flats are common.

The comparatively few thermal springs that have been recorded are principally in areas of granitic rocks, presumably along local faults. One of the best known is at Ayer Panas village near Malacca city in the southwestern part of the country. At Sungei Gau, in Pahang, limestone has been replaced by chalcedony, which was deposited by former hot springs. Thermal water probably still issues at this location.

The available information on the springs is given in the table below, and the locations of the springs are shown on figure 59.

MONGOLIA

Mongolia may be divided into three main regions: A high plateau in the northwest, which is bordered on the north by the Russian Altai Mountains and on the south by the Mongol Altai Mountains; the Gobi Desert, which covers most of southern Mongolia south of the Mongolian Altai and extends far eastward; and the higher and fairly well watered Kerulen (Herelen) River drainage basin, which extends northeastward to the drainage basin of the Argun and Amur Rivers in Siberia.

Very little information on thermal springs in Mongolia is available. According to Nekhoroshev (ref. 3382), there are three groups of thermal springs in the Altai Mountains of northwestern Mongolia. One group, near the U.S.S.R. border, is in a tectonic zone that probably is faulted. The other two groups, both in the central part of the Altai Mountains, flow chiefly from granite. The temperature of the water from these springs ranges from 20° to 41°C. All are of similar mineral content, chiefly sodium salts and hydrogen sulfide. Some evolve gas consisting almost wholly of nitrogen. Tolstikhin and Dzens-Litovsky (ref. 3433) report that both thermal and cold springs issue from

Thermal springs in the Federation of Malaya

[Data chiefly from refs. 3242, 3246. Locations of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 59	Name or location	Temperature on water (°F)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Near Pulai, in Kelantan	Hot			Limestone	
2	Sira Kulin, near Grik in Upper Perak.	Hot			Quartz porphyry and triassic strata.	
3	Ulu Yam (Ulu Selangor), in Selangor.	100–102	121	Ca, Na, HCO_3, SO_4, SiO_2 (120); free H_2S.	Contact of mica schist with granite.	Ref. 3244.
4	Sungei Gau, in Pahang	Warm			Limestone and chalcedony.	Probably small flow. Ref. 3246.
5	Ulu Klang, in Selangor	122; 181–183	346	Ca, Na, HCO_3, SO_4, CO_2 (80), SiO_2 (150).		Several springs. Water of 122°F contains much organic matter. Ref. 3245.
6	Dusun Tua, in Selangor	122–130	220	Ca, Na, HCO_3, SO_4, CO_2 (92), SiO_2 (61); free H_2S.	Tourmaline granite.	Ref. 3244.
7	Cheras, 4 miles from Kajang in Selangor.	115			do	Do.
8	Semuniah (Semenyih), 18 miles southeast of Kuala Lumpur in Selangor.	113–122	348	Ca, Na, HCO_3, SO_4, CO_2 (76), SiO_2 (140).		
9	Alor Gajah, in Malacca	95; 104; 133	272 (hottest)	Ca, Na, HCO_3, SO_4, CO_2 (48), SiO_2 (59); free N_2 and CO_2.	Granite	3 springs in padi swamp. Ref. 3244
10	Ayer Panas (Azer-Panas), near Jasin or Chevas in Malacca.	91–134	293 (hottest)	Ca, Na, HCO_3, SO_4, CO_2 (58), SiO_2 (78); free H_2S, N_2, CO_2.		3 main springs; also shallow wells. Deposit of green crystals at water level in each well. Refs. 3243–3245.
	Cherana Puteh, in Malacca	131 (max)	282	Ca, Na, HCO_3, SO_4, CO_2 (45), SiO_2 (59); free N_2, CO_2, H_2S, CH_4.	Granite	Ref. 3242.
	Gombak, in Selangor	122–129	399	Ca, Na, HCO_3, SO_4, SiO_2 (176).	do	Do.
	Setapak, in Selangor	118–122	310	Ca, Na, HCO_3, SO_4, CO_2 (71), SiO_2 (86).	do	Do.

folded rocks in an area of recently extinct volcanoes in eastern Mongolia. They classify the water as "alkaline-earth bicarbonate water emanating carbon dioxide." The only springs whose location is known precisely enough to be shown as No. 1 on figure 55 are those at Arishan, about 270 miles southwest of Urga. Berkey and Morris (ref. 3247) recorded a water temperature of 52°C and stated that the water was used for medicinal bathing.

THAILAND (SIAM)

In northern Thailand parallel north-south ranges of hills rise to steep mountains along the north border of the country. Central Thailand is occupied mainly by the great plain of the Menam River. This lowland is bordered by mountains on the east and west and slopes gently southward to the Gulf of Siam. The eastern part of Thailand is largely a high barren sandy plain, nearly surrounded by hills. Southern Thailand occupies much of the narrow part of the Malay Peninsula. In the mountains on the north border of Thailand are ancient metamorphic and sedimentary rocks. Most of the other high mountains are of granitic and metamorphic rocks and of strata of Paleozoic age. The principal plains are covered almost everywhere by Quaternary deposits, but marine strata of Tertiary age are exposed in some places.

The published information on thermal springs in Thailand is summarized in the table below. The locations of the springs are shown on figure 59.

TURKEY AND CYPRUS

The extreme northwestern part of Turkey is on the European side of the Sea of Marmara (Marmora). The main part of Turkey occupies the peninsula of Asia Minor.

Much of Asia Minor forms a plateau underlain by flat-lying Tertiary marl and limestone. The plateau rises westward to mountains near the Aegean Sea and eastward in Armenia to higher plateaus which are cut by gorges of the Euphrates, Tigris, and other large rivers. The eastern plateau descends steeply to the Black Sea, but breaks down more gradually southward. In its highest parts Archean rocks are exposed. These are overlain on the north by Paleozoic sedimentary

Thermal springs in Thailand

[All data from ref. 3249]

No. on fig. 59	Name or location	Temperature of water (°C)	Associated rocks	Remarks
1	Pong Nam Ron, on border of Mae Chan Valley.	60–100	Porphyritic granite	15–20 springs.
2	Mon Pin, 9 km northwest of Amphur Fang.	91–100	Granite gneiss	More than 50 springs; also steam vents. Small deposits of sulfur. Total dissolved solids 347 ppm.
3	Ban Pong, along highway at km 198	55	Sandstone	
4	Ping Khong, in bed of Mae Ping River	51		
5	Ban Pong, 5 km southwest of Wiang Pa Pao.		Granite	
6	Huay Pong, 36 km south of Mae Hong Son.		Quartzite	2 springs.
7	Muang Paeng; 100 meters from river		Granite wash	
8	Pong Chedi, on west bank of Mae Lao River.			
9	Pa Bong, 12 km south of Mae Hong Son		Limestone	
10	Samerng Amphur		Granite gneiss	Several springs and steam vents. Small deposits of sulfur.
11	Chae Son, 25 km northwest of Chae Hom.		Granite	
12	Mae Sin, in stream near Mae Yom River			
13	Phoe Pha, in small stream		Granite	
14	Hin Dat, in plain of Ban Hin Dat			
15	Kui Yae, on east bank of Khwae Noi	58		
16	Sai Yok, on west bank of Khwae Noi		Limestone	
17	Suan Phung, near Ban Suan Phung		Granite	
18	Bang Phra; 8 km northeast of Si Racha	39–40	Quartzite	Flows about 5 liters per second. Total dissolved solids, 374 ppm; principal chemical constituents: Ca, Mg, Na, Cl, SiO_2. Free CO_2. Water used for bathing.
19	Khao Nivet, 1 km from Ranong	68		3 springs on coastal plain.
20	Phumriang, 1 km from Chai Ya	70		On coastal plain.
21	Ta Chang, along railroad near km 603	70		Several springs on coastal plain.
22	Ta Na, about 10 km north of Kapong	62		
23	Kian Sa, 20 km west of Ta Pi River		Quartzite	
24	Kian Sa, near east bank of Ta Pi River			2 springs.
25	Kop Kaep, 6 km east of Na San station		Granite	
26	Nua Khlong, on east side of highway in Amphur Muang.	48. 5	Tertiary clay	2 springs near tidal creek. Combined flow 3–4 liters per second. Total dissolved solids, 16,800 ppm; principal chemical constituents: Ca (1,020 ppm), Mg (234 ppm), SO (946 ppm), Cl (9,910 ppm).
27	Tanoh Merah, on west side of highway 6 km from Batong.			Several springs.

formations and on the south by formations of later age. Tertiary volcanic rocks have cut through these sedimentary rocks in some places, chiefly where volcanic mountains extend northward from Lake Van. The mountain ranges in the northern part of Asia Minor, near the Black Sea, are largely of Cretaceous limestone with much serpentine. Farther west, rocks of more ancient formations extend to the Sea of Marmara.

The Taurus Mountains, the greatest mountain system in Turkey, extend along the entire southern part of Asia Minor, and also farther eastward. Some of the higher masses southeast of the central part of the peninsula are of Tertiary volcanic rocks. The larger part of the mountainous area consists of ancient sedimentary rocks, but Tertiary strata along the coast rise inland in some areas to considerable altitudes.

The island of Cyprus, whose northern coast is only 45–60 miles from the mainland of Turkey, has two main ranges of mountains, one along the north coast and the other in the southern part. These ranges are considered to be extensions of the Taurus Mountains. The oldest rocks are in the northern range, along whose crest ancient igneous rocks are exposed; but most of the highlands are composed of limestone and marble that are considered to be of Cretaceous age. The mountains are flanked by strata of early Tertiary age. Cretaceous and Tertiary strata also form most of the Troodos Mountains in the southern part of the island. These strata are folded and intruded by diabase, serpentine, and basalt. The plains and some coastal areas are underlain by marine Pliocene and later deposits which unconformably overlie all the older rocks.

There are many mineral springs in Turkey. A large number are thermal and some have been used for bathing since ancient times. Some are in the mountain areas

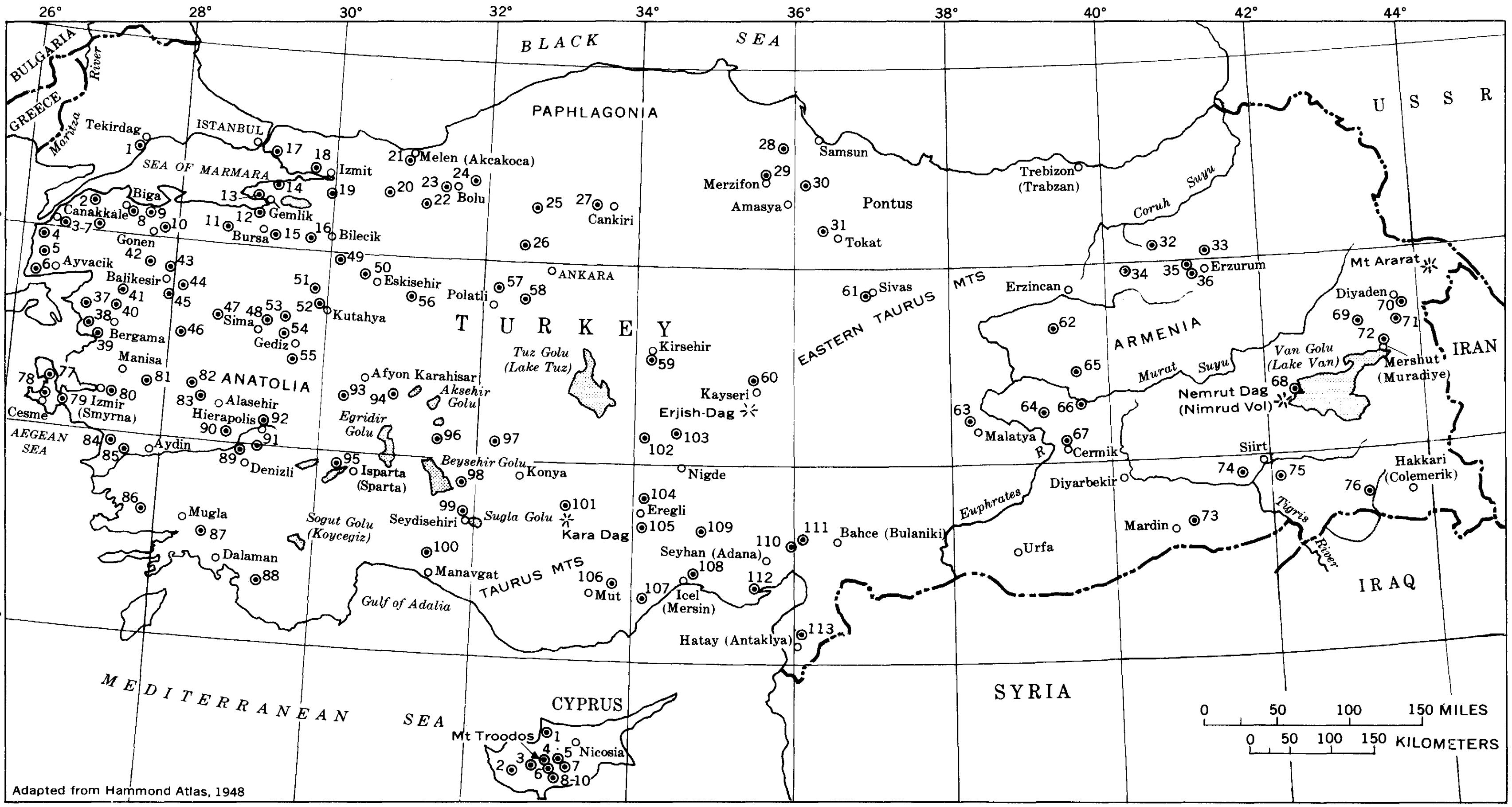

FIGURE 68.—Turkey and Cyprus showing location of thermal springs (positions approximate). Chiefly from refs. 3258–3260.

of folded and faulted rocks; others are in the plateau regions of flat-lying strata. Some well-known springs are in the valleys of the Menderes River and its tributaries near the southwest border of the principal plateau region.

No springs of high temperature in Cyprus have been recorded, but some of the warm saline and sulfur springs that issue at several localities have been developed as bathing resorts.

Information on the principal thermal springs in Turkey and Cyprus is presented in the two tables below. The locations of the springs are shown on figure 68.

Thermal springs in Turkey

[Data chiefly from refs. 3258–3260 and from Geological map of Turkey, scale 1:800,000 (Maden Tetkik ve Arama Enstitüsü, 1942–46). Principal chemical constituents are expressed in parts per million]

No. on fig. 68	Name or location	Temperature of water (°C)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Yarapsin, west of Tekirdag	21–24			Miocene strata	3 springs. Water used locally.
2	Kirkgeçit, northwest of Biga	51.5–52			do	Several springs. Water used for bathing.
3	Ozancik, southeast of Canakkale.	25–65	1,487 (hottest)	Ca (70); Na (295); K (67); HCO_3 (80); SO_4 (721); Cl (104); H_2SiO_3 (83); NH_4 (26).	do	4 groups of springs. Water used for bathing.
4	On plain of ancient Troy	22–34.5			do	3 main groups of springs. Water is brackish to strongly saline. Refs. 3272, 3284, 3290.
5	Northwest of Ayvacik:					
	Akçekeçili	37			Andesite and dacite	Baths. Refs. 3268.
	Kestanbolu	57–73	24,208 (hottest)	Ca (1,389); Na (7,072); Cl (14,250).	do	3 main springs. Water used for bathing.
6	Southwest of Ayvacik:					
	Tuzla	38–64			do	3 main groups of springs. Water used for bathing. Ref. 3262.
	Gayzer suyu	100	63,316	Ca (3,349); Na (19,484); Cl (37,888).	do	Spouts to height of 1–2 meters.
7	East of Çanakkale:					
	Esas	41–81			Volcanic rock	3 springs. Water used for bathing.
	Gicik	38; 77			do	2 springs. Water used for bathing.
	Kum	67–69			do	3 springs. Water used for bathing.
8	Southeast of Biga	Warm			do	Ref. 3284.
9	Köpelike (Kupeli?), north of Gönen.	41; 77	1,806 (hottest)	Ca (48); Na (450); HCO_3 (354); SO_4 (452); Cl (253); NO_3 (25); H_2SiO_3 (161).	Pliocene and Mesozoic strata	2 main springs. Refs. 3258, 3288.
10	Erdek, east of Gönen	23; 26			Volcanic rock	Mineral water used for drinking.
11	Dumbuldek, west of Bursa (Brusa, Broosa).	44			Quaternary deposits overlying volcanic rock.	Water used for bathing.
12	North of Bursa (Brusa, Broosa).	21; 36			Eocene strata	2 springs. Water used for bathing.
13	Armutlu, near Gemlik	50–68			Paleozoic strata	9 springs. Refs. 3282, 3288.
14	Yalova (Jalova), northeast of Gemlik.	48–66.2	1,521 (hottest)	Ca (186); Na (231); K (54); HCO_3 (72); SO_4 (799); Cl (104); H_2SiO_3 (65).	Miocene strata overlying Oligocene sandstone.	5 springs; large flow. Bathing resort. Refs. 3262, 3284, 3288, 3290.
15	East of Bursa (Brusa, Broosa):					
	Çekirge	45.3			Tertiary strata overlying Paleozoic limestone.	Water used for bathing. Ref. 3288.
	Inegol	40.5			do	Do.
	Bademlibance (Bithya?), near Mysian Olympus Mountain.	53.4–84	1,622 (hottest)	Ca (89); Na (220); HCO_3 (580); SO_4 (273); H_2SiO_3 (149); CO_2 (270).	do	Several springs; hottest, Kükürtlü, flows 80 liters per minute from limestone; large deposits of tufa. Refs. 3262, 3279, 3284, 3290.
16	Calti, west of Bilecik	36			Paleozoic limestone	3 springs. Water used for bathing.
17	Kartal, 20 km southeast of Istanbul.	Hot			Devonian strata	Ref. 3250.
18	Tuzla, northwest of Izmit	22			Triassic strata	Water used locally.
19	Southeast of Izmit	21–65			Paleozoic schist	13 main springs in 4 groups. Water is used for bathing. Free H_2S in cooler water.
20	Çatak, between Izmit and Bolu.	32			Eocene(?) strata intruded by andesite.	Water used for bathing.
21	South of Melen:					
	Derdin	30.5			Paleozoic schist	Do.
	Efteni	34; 43			do	2 springs. Water used for bathing.
22	Southwest of Bolu:					
	Kocababas	35.5–37			Upper Cretaceous strata	3 springs. Water used for bathing.
	Sariot	63	1,338	Ca (155); Na (221); HCO_3 (61); SO_4 (783); Cl (18); H_2SiO_3 (64).	do	Water contains 3.8 ppm of I. Used for bathing.
23	West of Bolu:					
	Bolu	44			Upper Cretaceous(?) strata	2 springs. Water is acid; used locally.
	Kinik and Akkaya	21			do	Do.
24	Aktas Uyuz, northeast of Bolu.	22			Tertiary(?) deposits overlying granite.	Water used for bathing.
25	Between Bolu and Çankiri:					
	Acikaplica	31; 34			Andesite and dacite	2 springs. Water used for bathing.
	Kücük	36; 43.5			do	Do.
	Sey (Seyhamam)	43			do	Water used for bathing.
	Kizilcahamam (Kizilca Hamam).	29–50	2,980 (hottest)	Ca (44); Na (630); HCO_3 (1,427); Cl (280); H_2SiO_3 (139); CO_2 (389).	do	Several springs; large flow. Water is radioactive. Bathing resort. Refs. 3256, 3288.
26	Ayas, northwest of Ankara	22–50			Andesite(?)	3 springs. Water used locally.
27	West of Çankiri	Hot			Faulted Cretaceous and Tertiary strata near andesite.	Several springs. Large deposits of tufa. Ref. 3253.
28	North-northeast of Merzifon (Mersivan).	Warm			Cretaceous strata overlying Paleozoic limestone.	Ref. 3284.
29	Byzantine, near Cauvsa (Havza) and 20 km northeast of Merzifon (Mersivan).	51.7 (max)			Andesite and dacite	Water used for bathing. Ref. 3271, 3279.

Thermal springs in Turkey—Continued

No. on fig. 68	Name or location	Temperature of water (°C)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
30	Northeast of Amasya (Amasia)	Warm			Paleozoic and Mesozoic strata intruded by andesite.	Water used for bathing. Ref. 3284.
31	Northwest of Tokat	Warm			Paleozoic schist	Do.
32	Near tributary of Çoruh Suyu (Chorokh River).	Warm			Cretaceous strata	Small springs at 3 places; deposits of tufa. Ref. 3282.
33	Near Arziti, north of Ersurum.	Hot			Andesite, basalt, and tuff	Ref. 3282.
34	Near Lori, 100 km west of Erzurum.	Warm			Cretaceous and Eocene strata overlying Paleozoic slate and limestone.	Several small springs from tufa mounds; much free CO_2. Ref. 3289.
35	At Ulja (Lija, Ilijah, Ilija, Ilidja, Ilica?), northwest of Erzurum.	45			Basalt	1 main spring; large flow. Water is saline and bitter. Refs. 3282, 3288, 3289, 3294.
36	About 15 km west of Erzurum	37–39	3,460	Ca (130); Mg (80); Na (530); HCO_3 (1,790); CO_2 (510); Cl (280); SiO_2 (90); Fe (50).	Probably basalt	4 springs. Water is green and turbid. Evolved hydrocarbon gas is combustible. Ref. 3267.
37	Loutza, northwest of Bergama	80			Andesite and dacite	
38	West of Bergama:					
	Büeller	55; 57			do	2 springs. Water used for bathing.
	Dikili	48–64			do	4 springs. Water used for bathing.
	Bademli	26–70	2,679	Na (645); HCO_3 (1,057); SO_4 (486); Cl (144).	do	3 main springs. Analyses for water having temperature of 64°C and 70°C, respectively. Water used for bathing. Refs. 3259, 3288.
			32,144	Na (11,833); K (358); HCO_3 (405); SO_4 (2,202); Cl (17,013); NO_3 (61); CO_2 (55).		
39	Southwest of Bergama:					
	Pasa	39–43.5			do	3 springs. Water used for bathing.
	Tabaklar	26; 35			do	2 springs. Water used for bathing.
40	Karaagiç Uyuz, north of Bergama.	31			Paleozoic strata or crystalline schist.	Water used for bathing.
41	Southwest of Balikesir:					
	Güre	25–54			Andesite	3 springs. Water used for bathing.
	Derman	57; 59.5	886 (hottest)	Ca (47); Na (162); HCO_3 (62); SO_4 (323); Cl (100); H_2SiO_3 (110); HPO_4 (24).	do	2 springs. Water used for bathing. Ref. 3259.
42	Dag, northwest of Balikesir	58–63			Andesite or Permo-Carboniferous strata.	3 springs. Water used for bathing.
43	Northeast of Balikesir:					
	Ömerköy	29.5–60			Andesite	Do.
	Yildiz Dag	47			dio	Water used for bathing.
44	Southeast of Balikesir:					
	Emendere	32–33			Intrusive andesite or Tertiary volcanic rock.	3 springs. Water used for bathing.
	Hisaralan	59; 98	1,345 (hottest)	Ca (55); Na (274); HCO_3 (573); SO_4 (229); Cl (85); H_2SiO_3 (68).	do	2 springs. Water used for bathing.
45	Asarköy, south of Balikesir	22.5–79			Andesite	7 springs. Free H_2S. Water used for bathing.
46	Ece, northeast of Manisa	23			Cretaceous or Tertiary strata	Mineral water used for drinking.
47	10 km east of Singerli (Sindirgi) and west-northwest of Simav.	Hot			Tertiary volcanic rock	Several springs, one of which spouts. Concretionary deposit. Ref. 3271.
48	North of Simav:					
	Eynal	76–78			Tertiary volcanic rock near granite	4 springs.
	Naşa Çamur	43–52			do	Water is muddy.
49	Inönü, south of Bilecik	25; 27.5			Paleozoic strata	2 springs.
50	Northwest of Eskişehir:					
	Uyuz	29			Tertiary strata near granite	Water used for bathing.
	Eskişehir	38–48			Paleozoic strata near granite	5 springs. Water used for bathing. Ref. 3288.
	Sakarya	25.5–48	2,474 (hottest)	Ca (51); Mg (148); Na (266); HCO_3 (1,437); SO_4 (75); Cl (55); CO_2 (330); H_2SiO_3 (94).	do	3 springs; also shallow wells. Large flow Hottest water contains 1.2 ppm of H_2TiO_3. Refs. 3288, 3290.
51	Gobel, north of Kütahya	31.5–33			Crystalline limestone or basic igneous rock.	Water used locally.
52	Northeast of Kütahya:					
	Kizilsin	24–42.5			do	11 main springs. Water used for bathing.
	Yoncali	32–41			do	12 main springs. Water used for bathing.
53	Southwest of Kütahya:					
	Koyu	51			Paleozoic strata or crystalline limestone.	2 springs. Water used for bathing.
	12 other springs	37.5–49			do	Water used locally.
54	Northwest of Gediz:					
	Muratdagi	34–42			Probably basic igneous rock	4 springs. Water used locally.
	Gediz	44–76	2,933 (hottest)	Ca (114); Na (500); HCO_3 (842); SO_4 (865); Cl (81); CO_2 (300).	do	6 springs. Hottest water contains 17 ppm of HPO_4 and 4.3 ppm of Br. Water used for bathing.
55	South-southeast of Gediz:					
	Aksaz	39			Andesite or basic igneous rock	Water used for bathing.
	Bogazi	22–37			do	3 springs. Water used for bathing.
56	Çardak, southeast of Eskişehir.	34			Tertiary deposits overlying Paleozoic strata.	2 springs. Water used for bathing.
57	North of Polatli:					
	Kürttaciriköyü	26			Tertiary(?) deposits near andesite	
	Sapancaköyü	29			do	
58	East of Polatli:					
	Kokarköyü Baş	27			Eocene or Oligocene strata	2 springs.
	Haymana	34.5; 46			do	2 springs. Water used locally. Ref. 3288.
59	South of Kirsehir	34–50	722 (coolest)	Ca (100); Na (30); HCO_3 (401); SO_4 (22); Cl (39); CO_2 (57).	Probably granitic rock	Several springs having a large flow. Coolest water contains 12 ppm of Br and 0.1 ppm of I. Refs. 3288, 3291.

Thermal springs in Turkey—Continued

No. on fig. 68	Name or location	Temperature of water (°C)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
60	20 km north of Kayseri (Kaisarie).	Warm			Tertiary volcanic rock or older tuffaceous lava.	Ref. 3284.
61	At Sivas (Siwas)	Warm			Oligocene gypsiferous strata	Ref. 3284.
62	Harcik, south-southwest of Erzincan.	24.5; 25			Mesozoic strata	2 springs. Mineral water used for drinking.
63	Asagiişpendere, north of Malatya.	29			Eocene or Miocene strata	Mineral water used for drinking.
64	Içmeköyü Mushilsuyu, east of Malatya.	21			Paleozoic and Mesozoic strata introduced by granite.	Shallow well. Water is laxative.
65	Kolan, northeast of Malatya	42	3,195	Ca (242); Mg (99); Na (234); K (92); HCO_3 (1,366); SO_4 (186); Cl (171); CO_2 (625); NO_3 (41); Br (88).	do	Water contains 0.4 ppm of I. Used for bathing.
66	Buban Hame, east-northeast of Malatya.	26			Cretaceous(?) strata overlying Paleozoic strata.	Water used locally.
67	Çermik, near the town	48	921	Ca (40); Na (193); HCO_3 (329); CO_3 (42); SO_4 (60); Cl (114); CO_2 (661).	Eocene or Miocene strata overlying Cretaceous strata.	Water contains 4.7 ppm of HPO_4, 13 ppm of Br, and 2.6 ppm of I. Used for bathing.
68	Crater of Nemrut Dag (Nimrod volcano).	Warm	1,144		Pliocene and Quaternary lava	Several small springs. Refs. 3263, 3278, 3282.
69	Tendurek, north of Lake Van.	74	33,900		Andesite and dacite	Refs. 3282, 3286.
70	Near Diyadin (Daoud) village.	Warm			Probably Tertiary and Quaternary lava.	Free H_2S. Ref. 2846.
71	On left bank of Murat Suyu (Murad Chai).	56.6			Pliocene or Quaternary lava	Main spring issues from tufa deposit smaller springs nearby. Free H_2S. Ref. 2846.
72	3 km north of Mershut (Muradiye) village.	74	33,930		do	Large deposit of tufa. Water is strongly saline; tastes of iron. Ref. 3286.
73	Germiab, northeast of Mardin.	40			Eocene strata	Water used locally.
74	Billuris, southwest of Siirt	33.5			Cretaceous and Tertiary strata probably intruded by basalt.	Do.
75	Hista, southeast of Siirt	60			Cretaceous and lower Tertiary strata.	Free H_2S. Water used for bathing.
76	Near right bank of Khabur River, west of Hakkari.	40.5	Low		Mesozoic strata	Ref. 3273.
77	North of Çeşme:					
	Şifne	24–38			Carboniferous strata	5 springs. Ref. 3288.
	Çeşme	28.5–62	19,162	Ca (786); Mg (378); Na (5,721); SO_4 (1,359); Cl (10,450).	do	6 springs. Analysis is for water having temperature of 58° C. Water contains 1.5 ppm of HPO_4, 6 ppm of Br, 0.2 ppm of I. Used for bathing.
78	Malgaca, near Çeşme	21; 22			Andesite or Tertiary volcanic rock	2 springs. Mineral water used for drinking.
79	Near Urla, west of Izmir (Smyrna):					
	Agamemnon	59–63.5			Mesozoic and Tertiary strata; probably intruded by andesite.	3 springs. Water used for bathing.
	Karakoç	59–62			do	3 springs. Ref. 3288.
	Cuma	55–68	18,681 (hottest)	Ca (639); Na (5,713); K (808); HCO_3 (366); Cl (10,488); CO_2 (275).	do	3 springs. Water used for bathing. Ref. 3258.
80	Derekoy, east of Izmir	27–41			Mesozoic and Tertiary strata	4 springs. Water used for bathing.
81	Urganli, southeast of Manisa	43–76			Miocene strata near mica schist	5 springs. Water used for bathing.
82	Northwest of Alaşehir:					
	Kurşunlu	28–91	1,941 (hottest)	Na (364); HCO_3 (992); SO_4 (114); Cl (85); H_2SiO_3 (139); CO_2 (123).	Mica schist	Do.
	Çamur (Sardeş)	51.5			do	Water used for bathing. Ref. 3288.
83	Litza, west of Alaşehir	25–29			do	Water used for bathing.
84	West of Aydin:					
	Çamur	51–63			Crystalline schist and limestone	4 springs.
	Gümüş	40–41			do	6 springs.
	Imamköyü	31–36			do	3 springs.
85	Kemer, west-southwest of Aydin.	33.5			do	3 springs. Water used for bathing.
86	West of Mugla:					
	Bozük	35			Paleozoic strata or gneiss	Water used for bathing.
	Karaada	32			do	Do.
87	Southeast of Mugla:					
	Cavus and Velibey	37–38			Eocene strata overlying Paleozoic shale and limestone.	5 springs. Water used locally.
	Gebeler	35.5–36.5			do	3 springs. Water used for bathing.
	Kokargirme, near Koidjiges (Koycegiz) Lake.	36–38			do	5 springs. Ref. 3284.
	Sultaniye	28–39			do	3 springs. Mineral water used for drinking.
88	Near Lykia, southeast of Dalaman (Koycegiz).	Warm			Upper Cretaceous and lower Eocene strata.	In the Xanthus graben. Ref. 3284.
89	Northwest of Denizli:					
	Ortakçi	25–50			Miocene strata	3 springs. Water used for bathing.
	Kizildere	63–88	4,325 (hottest)	Na (1,245); HCO_3 (1,603); CO_2 (502); SO_4 (557); Cl (138); H_2SiO_3 (126).	do	4 springs. Water used for bathing. Ref. 3259.
	Tekkeköy, near Laodicea	43–97	4,220 (hottest)	a (930); $NHCO_3$ (1,328); SO_4 (1,233); Cl (104); H_2SiO_3 (226); NH_4 (45).	do	5 springs. Large deposits of tufa. Water used for bathing. Ref. 3271.
90	Near Buldan:					
	Çizmeli	33–41.5			Miocene strata overlying gneiss	3 springs.
	Hieropolis (Pamukkale, Pambou-Kalise, Tambouk-Kelessi).	35–54	3,541 (coolest)	Ca (465); Mg (91); HCO_3 (1,045); SO_4 (675); Cl (53); CO_2 (1,144).	do	Several springs; flow about 9,000 imperial gpm. Extensive deposits of tufa. Refs. 1737, 3261, 3262, 3268, 3274, 3276, 3281, 3283, 3285, 3290, 3293.
91	Northeast of Denizli:					
	Gölemez	38–55			Tertiary strata	4 springs. Water used for bathing.
	Karahayit (Karahait)	42–56			do	3 springs. Deposits of tufa. Water used for bathing. Refs. 3262, 3271.
	Kavakbaşi	30			do	Free H_2S. Water used for bathing.

Thermal springs in Turkey—Continued

No. on fig. 68	Name or location	Temperature of water (°C)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
92	Southeast of Alaşehir:					
	Eskihisar	37; 39			Tertiary strata	2 springs. Water used for bathing.
	Sarayeik	23; 51.5			do	Do.
93	Near Sandikli, southwest of Afyon Karahisar:					
	Çeliksu	62; 63			Andesite and trachyte	2 springs. Water used for bathing.
	Erkek Bogulugu	67			do	Water used locally.
	Erkekler Çamurlugu	67–68			do	5 springs. Water used locally.
	Kükürtlü	69	1,814	Ca (175); Na (226); HCO_3 (576); SO_4 (460); Cl (96); CO_2 (176).	do	Water contains 3.4 ppm of HPO_4, 4.4 ppm of Br, and 0.2 ppm of I. Used for bathing. Ref. 3258.
94	Southeast of Afyon Karahisar:					
	Büngüldek	71.5 (max)			Probably Paleozoic strata	Several springs. Water used for bathing.
	Kaya	68			do	Water used for bathing.
	Kizilkilise	46–52			do	3 springs. Water used for bathing.
	Kizik	61.5	5,007	Na (1,643); HCO_3 (762); SO_4 (492); Cl (1,830); CO_2 (132).	do	1 main spring. Water contains 12 ppm of NO_3, 5 ppm of HPO_4, 0.7 ppm of $HASO_4$, 1.2 ppm of H_2TiO_3, 24 ppm of Br, and 0.5 ppm of I. Used for bathing. Ref. 3260.
95	West-northwest of Isparta:					
	Burdurgölü	27			Oligocene and Cretaceous strata	Mineral water used for drinking.
	Kükürtlü	22			do	Free H_2S. Water used for bathing.
96	In Sultan-Daglari, north of Beysehir Gölü.	Warm			Paleozoic strata	Ref. 3284.
97	Ilgin, northwest of Konya	28; 42			Paleozoic and Mesozoic strata	2 springs. Water used locally.
98	East of Beysehir Gölü:					
	Kaşakli	21; 37			Andesite, dacite, and tuff	2 muddy springs. Ref. 3284.
	Kösk	35			do	Water used for bathing.
99	2 km northwest of Seydişehiri (Seidi Sheher).	32; 32.5			Devonian strata	2 springs. Deposits of tufa. Ref. 3271.
100	Near Adalia (Adalar), north of Manavgat.	Warm			Eocene strata overlying Paleozoic strata.	Several springs. Large deposits of tufa. Ref. 3284.
101	Southeast of Konya:					
	Ilicapinari	24			Miocene and Pliocene strata, probably intruded by andesite.	Mineral water used for drinking.
	Eşkimüshilsu, north of Kara Dag (Karadja Dagh).	29			do	Water used locally.
	On slope of Kara Dag (Karadja Dagh).	60			Andesite	Water tastes of iron. Ref. 3252.
102	Near Asaray, northwest of Nigde:					
	Bogazi	25			Tuffaceous lava	2 springs. Water used for bathing.
	Kireçli	53			do	Do.
	Ziga and Kasim (Hassan Kala).	41–52			do	4 springs. Ref. 3294.
103	North-northwest of Nigde:					
	Kocarpinar	27			do	Water is potable; used locally.
	Deliklikaya	27			do	3 springs. Mineral water used for drinking.
	Kiziltepe	20.5–24			do	4 springs. Mineral water used for drinking.
104	North of Eregli:					
	Ciftehan	22–55.5			do	7 springs. Water used for bathing.
	Kekrout, 8 km north of Eregli.	37 (max)			do	10 main springs. Water is saline. Free H_2S. Gypsum and tufa deposited. Ref. 3271.
105	Akhüyük, in Bolkar Mountains south of Eregli.	25.5	24,400		Permo-Carboniferous strata	Flows 30 liters per minute. Water contains considerable Li. Ref. 3275.
106	Hocanti, northeast of Mut	33			Miocene strata	Water used for bathing.
107	Saparka, southwest of Içel (Mersin).	37			do	Do.
108	Mersin (Mersivan), near Tarsus and east-northeast of Içel.	37.5			do	2 springs. Ref. 3284.
109	In south part of Tschakit defile, Tauros Mountains.	Warm			Oligocene(?) strata overlying Cretaceous shale.	Large flow. Ref. 3284.
110	Kokarpinar, northeast of Seyhan.	22			Miocene strata	May be a shallow well.
111	Düzici, west of Bahçe	33			do	Water used for bathing.
112	Erzin Başlamiş, southeast of Seyhan.	22			Upper Cretaceous or Miocene strata.	2 springs. Water used for bathing.
113	Northeast of Hatay (Antakya).	35.5–37			Quaternary(?) deposits overlying Miocene strata.	5 springs. Water used for bathing.

Thermal springs in Cyprus

[Data from refs. 3269, 3277, 3292. Locations of unnumbered springs not identified]

No. on fig. 68	Name or location	Temperature of water (°C)	Principal chemical constituents	Associated rocks	Remarks
1	Myrtos (Myrtou)	20		Micoene strata	2 springs. Water is moderately saline and sulfurous. Free H_2S.
2	Yiolou	Warm		do	3 springs. Water is strongly saline and sulfurous. Used for bathing.
3	Tris Eliaes	Warm		Igneous rocks	3 springs. Water is sulfurous.
4	Kalopanayiotis	20	$CaCO_3$, $MgSO_4$, $MgCl_2$, NaCl; free CO_2, H_2S.	do	4 springs. Water used for bathing.
5	Kakopetria, near village of Galata.	Warm	Mg, Na, SO_4, Cl; free CO_2, H_2S.	do	
6	Pedoulas	Warm		do	Several springs. Water is moderately saline and slightly sulfurous. Resort.
7	Pelendri	25. 5		do	Water is strongly alkaline and moderately saline; no free H_2S.
8	Ayiasmata	23		do	Do.
9	Psammiacon	20. 5		do	Do.
10	Tiochou	19. 7		do	Do.
	Anargyroi	20. 5		Miocene strata	Water is sulfurous. Free H_2S.
	Lethimbon	20. 2		do	Do.
	Mathi	19. 5		do	Do.

UNION OF SOVIET SOCIALIST REPUBLICS

The European part of the U.S.S.R. consists of Russia, which extends from the Black Sea northward to the Arctic Ocean and eastward to the Ural Mountains. The plains, or steppes, in this area are underlain by Quaternary deposits that overlie marine Tertiary and Cretaceous strata. The Urals are composed mainly of Paleozoic sedimentary rocks. In the south, between the Black Sea and the Caspian Sea, the Caucasus Mountains are composed largely of Paleozoic strata overlain by strata of Mesozoic and Tertiary ages. There are also considerable areas underlain by Tertiary volcanic rocks.

The mountain ranges of Kazakhstan and the several smaller States and divisions in the Asiatic part of the Soviet Union east of the Caspian Sea are western extensions of the Tian Shan [Tian Mountains] and the Altai Mountains. The higher parts of these mountains are chiefly of Archean metamorphic and crystalline rocks. The lower parts are of Mesozoic and Tertiary strata. Great areas in the high desert regions are underlain by Quaternary deposits.

The vast central and northern regions which comprise Siberia are largely plains, or steppes, that form the drainage basins of several rivers that flow northward to the Arctic Ocean. Much of this plains region is underlain by marine Paleozoic and Mesozoic strata covered by Quaternary deposits. In the western part of the Lena River basin in central Siberia are large areas of young volcanic rocks.

In the northern part of Russia mineral springs are comparatively common, but very few are definitely thermal. In the Caucasus region, however, there are numerous groups of warm and hot springs.

Most of the springs in this region between the Black and Caspian Seas are of considerable flow, and nearly all have been developed as bathing resorts. Several noted resorts have also been developed at mineral springs that are classed as cold, though the water may be a few degrees above the mean annual temperature of the locality.

Numerous thermal springs issue in the oil fields on the east side of the southern part of the Caspian Sea. The mountainous region far east of the Caspian and

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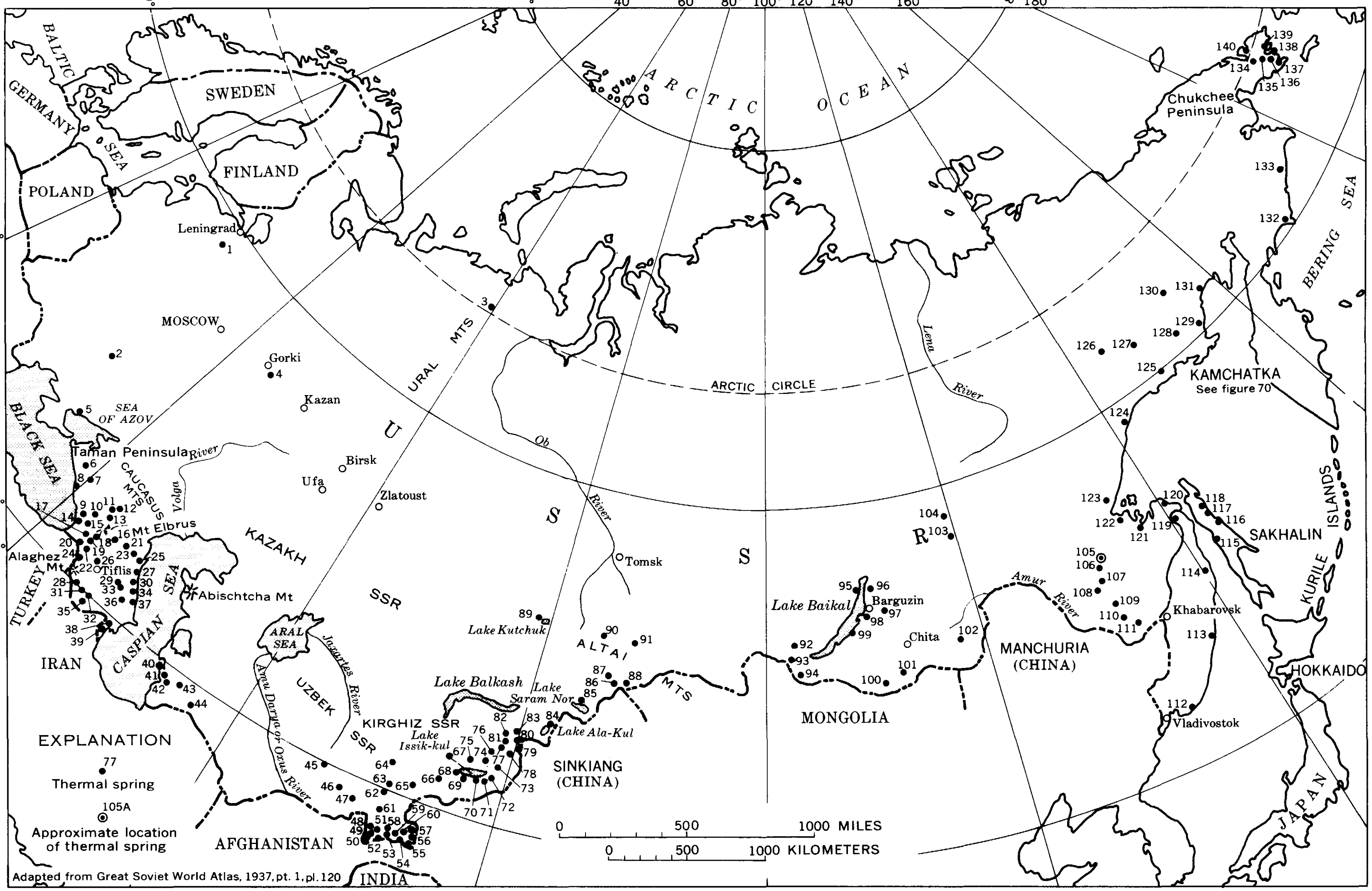

FIGURE 69.—Union of Soviet Socialist Republics showing location of thermal springs. Chiefly from ref. 3377.

south of Lake Balkhash contains many warm and hot springs of various mineral types. Another region where mineral and thermal springs are comparatively common is that surrounding Lake Baikal and extending far eastward in Transbaikalia. In the extreme eastern and northeastern part numerous hot springs are associated with active and recently extinct volcanoes in Kamchatka. The springs of at least seven groups issue in the Chukchee Peninsula, which forms the northeastern extremity of Siberia.

Most of the thermal springs on the Kamchatka Peninsula are in areas of volcanic rocks in the southern part of the peninsula where there are fumaroles on the sides of some volcanic mountains and several groups of mud volcanoes. At Paudzetka are geyserlike springs of intermittent action. Some springs of low mineral content may rise from silicic magmas. Those in volcanic areas of mafic magma are generally saline and contain perceptible amounts of arsenic, antimony, zinc, and other metals. Information on the springs has been compiled by Piip (ref. 3396).

The available information on thermal springs in the Union of Soviet Socialist Republics is summarized in the table below. The locations of the springs, except those on the Kamchatka Peninsula, are shown on figure 69. The locations of those on the Kamchatka Peninsula are shown on figure 70.

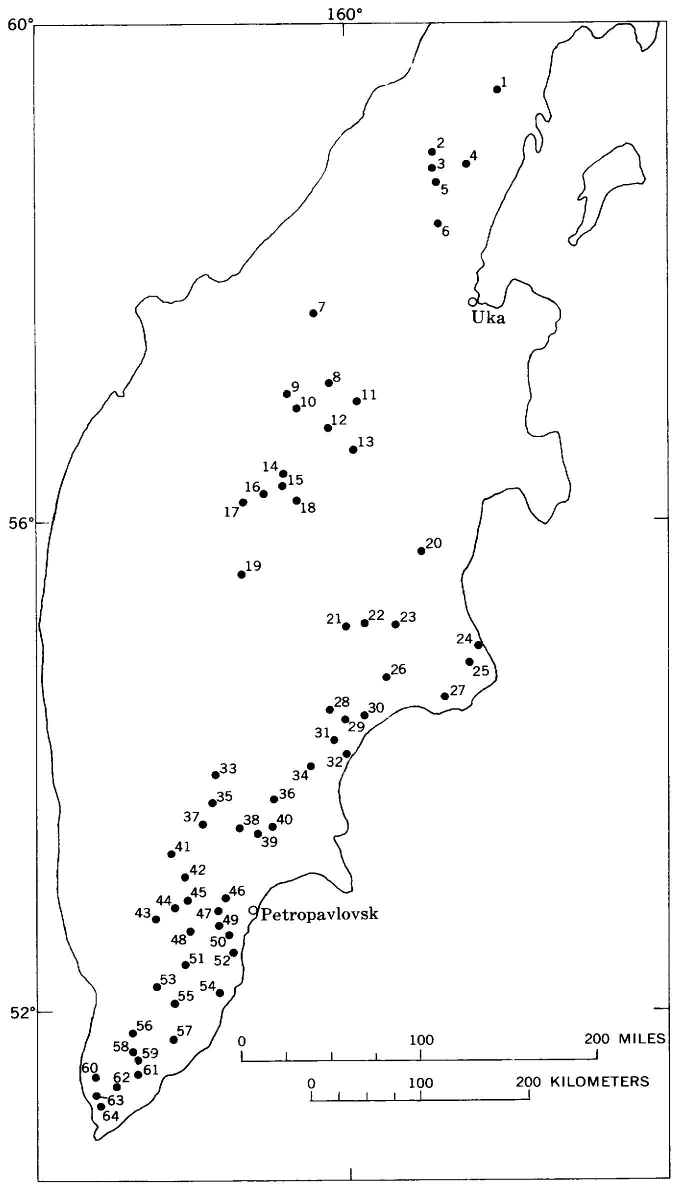

FIGURE 70.—Kamchatka Peninsula showing location of thermal springs. From ref. 3396.

Thermal springs and wells in Union of Soviet Socialist Republics

[Data chiefly from ref. 3377 (Great Soviet World Atlas, 1937, pt. 1, pl. 120). Locations of unnumbered springs not identified. Principal chemical constituents are expressed in parts per million]

No. on fig. 69	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
1	Solzy, on left bank of Shelon River.	17.5		8,300	Ca (825); Mg (261); Na (1,762); K (165); SO (999); Cl (4,283).		Devonian limestone	Springs at river level and well 45 meters deep. Water is radioactive. Ref. 3357.
2	Mirgorod	21.2	3,700	2,800	Ca (32); Mg (18); Na+K (959); HCO_3 (461); SO_4 (188); Cl (1,183).			2 wells 654 meters deep. Water is radioactive; contains 1.6 ppm of Fe. Refs. 3395, 3447.
3	Dyn-Va-Shore	Warm			Na, Cl			
4	Shatki, near Tesha River.	Warm			Ca (572); HCO_3 (229); SO_4 (1,363).			Bathing resort. Ref. 3446.
5	Near Sea of Azov	9–20				Alkaline-saline-sulfate.		Ref. 3307.
6	Psekups (Psecoups), 60 km south of Krasnolar.	28–52.5		1,444	SiO_2 (32); CaO (32); Na_2O (334); SO_3 (96); Cl(330); free CO_2.		Faulted Cretaceous strata	Several springs. Analysis for water of 45°C temperature. Refs. 3344, 3390, 3443.
7	Byelorechensk	Warm				Complex		Resort.
8	Matsesta-Sochi, 3 km from the Black Sea.	21–25	10,600	11,366	Na, Cl; free H_2S		Fault between Cretaceous and Tertiary strata.	Water contains 0.93–3.85 ppm of F. Resort. Refs. 3321, 3332, 3338, 3343, 3358, 3360, 3364, 3366, 3369, 3373, 3409, 3437, 3445, 3449.
9	Tsaishskie	Warm			Na, Cl; free H_2S			Resort.
10	Tkarchelsk (Tkvarcheli?).	Warm				Complex; sulfide		Water is radioactive. Resort Ref. 3395.
11	Zheleznovodsk	14–54	15,000			Alkaline-earth, sodium sulfate, carbonated.		Resort. Refs. 3320, 3321, 3332, 3395, 3422, 3424.
12	Kumogorsk	32.9	3,500	2,118	SiO_2, Na, HCO_3, Cl; free CO_2, H_2S.			Resort. Ref. 3367.
13	Piatigorsk	21–47.5		4,173	SiO_2 (30); Ca; MgO (117); SO_4; Cl; free CO_2.			Several springs and slanting borehole. Water is strongly radioactive. Resort. Refs. 3300, 3317, 3320, 3321, 3332, 3361, 3391, 3392, 3395, 3424, 3437.
14	Menzhi-Teklyati	Warm				Sodic chloride; sulfide.		Resort.
15	No name	Warm				Alkali bicarbonate		
16	Dolinsk (Dolina Tereka?).	Warm				Mixed bicarbonate		
17	Tskhaltubo (Tskhaltubski, Trichalloubo?).	32–35		700	Ca, Mg, SO_3, Cl; free CO_2.			Several springs. Water is radioactive. Resort. Refs. 3332, 3395.
18	No name	35				Complex; sulfide		
19	do	35				Sodic bicarbonate; sulfide.		
20	Abastuman (Abastoumann, Abbas-Tuman), 75 km from Barjome.	41; 45; 48.5	10,800	500	$CaSO_4$ (77); Na_2SO_4 (137); Na_2CO_3 (14); NaCl (234); free CO_2, N_2, H_2S.		Eocene and Oligocene strata intruded by andesite.	3 groups of springs (Zolotouchnii, Zmeinii, and Bogatyrski). Water is radioactive. pH, 9.4. Refs. 3332, 3354, 3363, 3395, 3437.
21	Sernovodsk (Ssiernovodsk, Srnobodsk) and Mikhailovsk.	20–70.3	10,600	4,500	Ca (48); Mg (26); Na (1,317); HCO_3 (1,318); SO_4 (1,288); Cl (484).			3 groups of springs (Mikhailovskaia, Sleptsovsti, Helene). Resort. Refs. 3332, 3406, 3437, 3447.
22	Borzhomi (Borzhon, Borjom).	28.5		5,951	Ca (104); Mg (36); Na+K (1,513); HCO_3 (3,904); Cl (387).			Water contains Fe, Br. Resort. Refs. 3332, 3447.
23	No name	Hot				Complex; sulfide		
24	do	Warm				Mixed bicarbonate		
25	Bragunskie	Hot				Complex; sulfide; CO_2.		Resort.
26	Tiflis (Tbilisi), on both banks of Koura River.	52.5 (max)	20,000		Ca (6–170); Mg (3–44); Na+K (74–154); HCO_3 (34–119); SO_4 (42–308); Cl (53–277).		Volcanic rock	30 springs and wells. Water is highly radioactive. Refs, 3295, 3322, 3332, 3379, 3380, 3395, 3398, 3448.
27	Talginskie	Hot				Mixed chloride; sulfide.		Resort.
28	Dabala	Warm				Alkali bicarbonate		
29	Eli-Su (Eli-Sou, Djili-Sou, Djily-Sou), on bank of Amam-tchai River.	40; 42	3,400	929	Na, K, HCO_3, Cl, H_2SiO_3; free CO_2.		Jurassic strata	2 main and several small springs. Resort. Refs. 3394, 3437.
30	Grozny	88 (max)	Large	Low	Na, Cl; free CO_2, H_2S, CH_4.			Oil-field springs. Water contains I.
31	Arzni	20	30,000	13,752	Ca (464); Mg (380); Na (3,636); K (62); HCO_3 (3,378); SO_4 (708); Cl (5,109).			Several springs and 1 well. Water contains Fe, Br, and I. Refs. 3395, 3447.
32	Isti-Su (Dzhermuk)	52.5–71		6,416	Ca (148); Mg (31); Na (1,710); K (225); HCO_3 (2,658); SO_4 (673); Cl (971); gas, 99.8 percent CO_2.		Tertiary igneous and metamorphic rocks and Quaternary lava.	Water is radioactive; contains much F, B, I. Resort. Refs. 3306, 3334, 3352, 3428, 3447.

Thermal springs and wells in Union of Soviet Socialist Republics—Continued

No. on fig. 69	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
33	Akhynski (Akhy?)	Hot			Na, HCO_3			
34	Rychalskie (Rychal-Su, Rychal-Van).	Warm		4,600	Ca (29); Mg (14); Na (1,266); K (16); HCO_3 (2,715). Cl (484).			Resort. Ref. 3447.
35	Satani-Kamurj, near Nakhichevan.	18–23	30,000			Alkaline-calcic-carbonated.		Refs. 3326, 3362, 3395.
36	Butskie	Warm			Na, HCO_3			
37	Guiik-Salgan	37.7	19,000	4,154	CaO (588); MgO (128); Na_2O (1,290); CO_2 (642); SO_3 (641); Cl (1,438); free H_2S.	Saline		Ref. 3325.
38	Arkevanskie	Hot				Mixed chloride		
39	Dersidskie, 13 km from Lenkoran.	40				Complex, sulfide		Ref. 3374.
40	Chelekenski	Hot				Mixed chloride		Water contains Br, I.
41	Nebut-Dag	Warm				do		Do.
42	Neftedag (Nephtedag), Boiadag, and Monjoukly (Mondjukly).	25–60			Ca, Mg, Na, K, Cl (8,000–18,500).			Many springs, most of which issue from fissures; also mud volcanoes. Water contains I. Refs. 3347–3349, 3355, 3425.
43	Kazandzhikskie	Warm			Na, SO_4, Cl			Resort.
44	Archmanshie	28.5	120,000	1,500	Ca, Na, SO_4; free N_2, H_2S.			Resort. Ref. 3395.
45	Shur	28				Complex, sulfide		
46	Khodzaa-Obi-Garmskie (Khodzhent, Khojend).	Hot				Complex		Ref. 3381.
47	Odi-Garmskie	Hot				do		
48	Garm-Chavma	Hot			Na, HCO_3			Ref. 3431.
49	Barvorskie	Warm						
50	Mulebodzh	Warm						
51	No name	Warm				Complex		
52	Shugin	Hot						
53	Lyangarskie (Issar)	66			Na, HCO_3; gas, 97.9 percent CO_2.			Ref. 3431.
54	No name	Warm						
55	do	Hot				Complex		
56	Kzbil-Rabat	Hot			Gas, 70.5 percent CO_2, 28.2 percent N_2.	Alkali bicarbonate		Ref. 3431.
57	No name	Warm						
58	do	Hot						
59	do	Hot						
60	do	Hot			Na, SO_4			
61	Vanchskie	Hot						
62	Dzhili-Su	22.3–26.1						Ref. 3432.
63	No name	Warm				Alkali sulfate		
64	do	Hot				Complex		
65	Dzhalyalb-Abad (Djalyal).	41	Large	3,000		Complex, sulfide		Resort. Ref. 3395.
66	No name	Warm				Complex		
67	Issyk-Ata (Issyg-Ata).	48	Large	300				12 springs. Resort. Refs. 3395, 3423.
68	Chalkhalbskie	Warm				Mixed bicarbonate		
69	Kerge-Tav	Hot			Na, Cl			
70	Dzhukuchakskie	Warm				Complex		
71	Dzhety-Oguz, in Lake Issuk-Kul area.	43		13,000	SiO_2, SO_4, Cl			6 springs. Resort. Refs. 3395, 3423.
72	Ak-Su (Aksuiski?)	47		Low		Complex		Resort. Refs. 3395, 3423.
73	Chuladbir	Warm				Mixed sulfate		
74	Turgen	Warm				Complex, sulfide		Ref. 3387.
75	Alma-Ata (Alma Arasan?).	40		259	Na_2CO_3 (68); Na_2SO_4 (71); H_2SiO_3 (72).		Granite	Resort. Refs. 3368, 3387, 3399, 3415.
76	Ayak-Kalkanskie	Warm				Complex		
77	Tasmin-Terekskie	Warm						
78	Borokhudzirskie	Warm				Complex		
79	No name	Warm				Complex, sulfide		
80	Kok-Suiske	Warm						
81	Oi-Sazskie	Warm						
82	Kopaleskie	Warm				Complex		Resort.
83	Kopalo-Arasan	Hot				Sulfide		Resort. Refs. 3414, 3423.
84	Near Lake Ala-Kul	43				Complex	Porphyry	2 springs issuing 230 meters above lake level. Ref. 3401.
85	Lake Saram-Nor	Hot	Small					Ref. 3414.
86	Arasan-Kaby	Warm				Sulfide		
87	Rakhmanovskie (Racmanskoi, Rackmanov, Rakhamanovsky).	24–41	5,000		Na, HCO_3		Granite	20 springs. Resort. Refs. 3299, 3332, 3372.
88	Dzhutalinskie	Warm				Complex		
89	Lake Kutchuk	30; 41						2 springs in inlet. Ref. 3393.
90	Byelokourikha (Biélokourikha), at base of Altai Mountains.	20–32			SiO_2 (44); CaO (25); NaCl and KCl (136); SO_3 (44); Cl (16); gas, chiefly N_2.			Springs and wells.
91	Abakan	Hot				Mixed bicarbonate		
92	No name	Hot				Alkali bicarbonate, CO_2.		

Thermal springs and wells in Union of Soviet Socialist Republics—Continued

No. on fig. 69	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
93	No name	Hot			Na, SO_4			
94	do	Hot			Na, SO_4			
95	do	Hot				Complex		
96	Frolikin	Hot			Na, SO_4			Ref. 3429.
97	No name	Hot			Na, SO_4			
98	Kurgulik	Hot			Na, SO_4			Ref. 3429.
99	Goryatchinsk (Barguzin), near Lake Baikal (Baykul).	43–71			Ca, Na, HCO_3, SO_4			Resort. Refs. 3308, 3328–3330, 3384, 3395, 3429, 3436.
100	400 km southeast of Lake Baikal (Baykul).	35				Complex	Granite	Refs. 3310, 3311.
101	No name	Hot				Mixed bicarbonate		Ref. 3311.
102	Yamkum	Warm				Alkali bicarbonate		Resort.
103	Salomat	Hot						
104	Chelenkhe	Hot						
105	Pitatelevsky, on left bank of Selenga River, between Troitskii and Ilinski.	54; 57		1,610	H_2SiO_3 (76); Ca (109); Na (393); HCO_3 (49); SO_4 (762); Cl (180).		Jurassic strata near granite	Springs and 2 shallow wells. Refs. 3310, 3441, 3442, 3444.
106	Byssinskie	Hot				Complex		
107	Unminskie	Warm						
108	Tomskie	Warm						
109	Tyrminskie	Warm			Na, HCO_3			
110	Kulbdurskie (Kuldur).	70				Complex		Resort. Ref. 3331.
111	Tailozhskie	Hot						
112	Slo-Sudzukha	Warm				Alkali bicarbonate		Ref. 3353.
113	Shmakobskie	Hot			Na, HCO_3			Do.
114	No name	Hot				Complex		
115	do	Hot				do		
116	do	Hot				do		
117	Tamai-Dagskie	Hot			Na, Cl			
118	Goromaiskie	Hot						
119	Annenskie	Hot				Complex		Resort.
120	Ulskie	Warm						
121	Kenalskie	Warm						
122	Alskie	Warm						
123	Kurumuryak	Warm						
124	Ulya	Hot						
125	Motykeiskie	Hot						
126	Sytygar-Sylba	Hot				Complex		
127	No name	Hot						
128	Talaya	Hot						
129	No name	Hot						
130	Degdyanskie	Hot						
131	Tabamonskie	Hot						
132	Oliotorskie	Hot						
133	Khatyrskie	Hot						
134	Ogneiskie	Hot						
135	30 km northwest of head of Mechigmensk Bay.	91 (max)	65,000		Na, HCO_3, Cl		Tertiary porphyry and tuff	Several springs. Tufa deposited. Ref. 3385.
136	1.5 km from shore	81 (max)		1,294			Granite prophyry near Tertiary lava.	Several springs. Water is radioactive. Small deposits of pyrite and iron and manganese oxides. Ref. 3337.
137	Unynskie, 14 km west of Chaplino village.	78 (max)	4,300	17,640–18,530			Alluvium	Ref. 3337.
138	Southeastern part of Arakamchechen Island.	15					Slightly bitter-saline	Ref. 3337.
139	Near Ku Kun River, 14 km above its mouth.	58	65,000				Granite and syenite	2 springs. Ref. 3385.
140	35 km south of Neshkin village.	55		35,800	Ca, Na, Cl; free H_2S.		Silurian crystalline schist	2 main springs. Water is radioactive. Small deposit of opaline silica. Ref. 3407.
------	Agoura						Fault between Cretaceous and Tertiary strata.	Issues from fault. Water is sulfurous. Refs. 3343, 3409.
------	Akhtala, in Georgia	23						Saline mud baths. Ref. 3395.
------	Aksuiski, in Semirechen Province.	42.3–44.5						Ref. 3332.
------	Allin, in Baikal area.	72.2						Ref. 3329.
------	Annin, in Amur Province.	45–48						Ref. 3332.
------	Bakhmyr (Springs 1 and 2), in Tadzhik.	36.5						Ref. 3331.
------	Barguzin, in Baikal area.	32						Ref. 3329.
------	Baunto, in Baikal area.	52.3						Do.
------	Birsk, in Bashkir							
------	Chakus, in Baikal area.	68						Do.

Thermal springs and wells in Union of Soviet Socialist Republics—Continued

No. on fig. 69	Name or location	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
	Chakussi, in Baikal area.	43.5		322				Ref. 3330.
	Darasun (Darassun), in central Transbaikalia.				Ca, Mg, SO_4, Cl			Refs. 3298, 3314, 3332.
	Duschak, in Tian Shan region.							Ref. 3297.
	Dzhermuk	65						Resort. Ref. 3306.
	Evlatoriya							Resort. Ref. 3321.
	Garm-Chashma, in Tadzhik.	68						Ref. 3331.
	Geleneznovodsk, in Bechtau region.	41	5,000			Bicarbonate, alkaline, ferruginous.	Tertiary strata	Refs. 3317, 3437.
	Gorelink							Ref. 3387.
	Gusikhim, in Baikal area.	57						Ref. 3329.
	Izberbash, in Dagestan.	Warm		High	Na, Cl			Ref. 3336.
	Kaburabi, on east coast of Sakhalin Island.	Hot						Water is saline and contains methane. Ref. 3350.
	Kalmoukaievski, on Mount Byk in Bechtau region.				Na, SO_4			Ref. 3317.
	Kargin, in Baikal area.	74.6		999	Na_2O (386); SO_3 (352).			Ref. 3329.
	Khazret-Ayub, in Fergan Province.	38.3						Ref. 3332.
	Khnou, in southern Daghestan.	34–47						Ref. 3408.
	Kotelnikowski, in Baikal area.	62.0		359				Ref. 3330.
	Kuchikhyr, in Baikal area.	40.3						Ref. 3329.
	Kulinnye Bolota, in Baikal area.	59.2						Water contains Zn, Fe, Mn. Ref. 3329.
	Kutozorski	32						Ref. 3332.
	Metchouka	46	9,200 (main spring)					Several springs. Supply "the great baths" or "baths of Alexander."
	Mogoi, in Baikal area.	73.6						Ref. 3329.
	Molocovka, near Chita in eastern Siberia.							Ref. 3402.
	Mukungi River valley, on western slope of Burein Mountains in Amur region.	27.5			Ca, Mg, H_2SiO_3; H_2S, NO_3.			Several springs. Ref. 3324.
	Parkent, in Uzbek							Ref. 3388.
	Rubungaruro, on east coast of Sakhalin Island.	Hot						Water is saline and contains methane. Ref. 3350.
	Saki							Resort. Ref. 3321.
	Saratof, on the Volga River.							Ref. 3436.
	Sarepta, on the Volga River.							Water is fetid and sulfurous. Ref. 3436.
	Selo Klintschy, in Perm.							Ref. 3436.
	Semigorsk	16						Ref. 3332.
	Smirnoff	45	370	2,548	CaO (386); Na_2O (743); SO_3 (624); Cl (251).			Ref. 3437.
	Stolypino	22–40						Ref. 3426.
	Talgar, in Tian Shan region.							Several springs. Ref. 3387.
	Tokuz-Bulak, in Tadzhik.	65.1						Ref. 3431.
	Turkin I, in Baikal area.	54.3						Ref. 3329.
	Turkin II (Turka), in Baikal area.	43.7		500				Refs. 3329, 3330.
	Ukhmei, in Baikal area.	46.1						Ref. 3329.
	Urin, in Baikal area.	72.3						Do.
	Yatarobka, in Baikal area.							Ref. 3332.
	Yatkunsk, in Baikal area.							Do.
	Zmeinyi, in Baikal area.	39						Ref. 3329.

Thermal springs and wells in Union of Soviet Socialist Republics—Continued

Kamchatka Peninsula
[Data from ref. 3396]

No. on fig. 70	Name or location of spring	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
1	Tymlyatskie	Hot			Saline; free H_2S.			Several springs; sulfur deposit.
2	Korkavaiamskie	52						Free H_2S.
3	Palanskie	40–92		784	Na, SO_4			Water used for bathing.
4	Drankinskie	Hot						Water is saline. Free H_2S. Water used for bathing.
5	Pankarskie	20						Several small springs.
6	Rusakovskie	Hot						Do.
7	Amaninskie	Hot						
8	Min'chventenskie, at base of volcano.	Hot						
9	Kalgauchskie	Hot						
10	Perevalovye	16	Moderately large					Water is milky. Free H_2S.
11	Elovskie	40						Taste of water is unpleasant.
12	Dvukiurtochnye	Hot						
13	Kireunskie	85–98	33,000	1,471	Na, SO_4, Cl; free H_2S.			Several springs within distance of 1 km.
14	Verkhne-Anaunskie.	80–97						Several large and several small springs.
15	Oksinskie	59						Water used for bathing.
16	Oksichanskie	52–53			$CaSO_4$, NaCl			6 springs.
17	Tigeiueinskie	52–53						Water is saline.
18	Kreruklinskie	Hot		1,080	Na, SO_4, Cl			
19	Kimitinskie, 60 km from Mashur village.	Hot						
20	Bekeshckie	23						Water contains Fe. Free H_2S.
21	Shchapinskie	27–36	Moderately large.	2,016	Na, Mg, CO_3, Cl			3 main springs.
22	Verkhne-Shchapinskie.	Hot	Large					
23	Tymraskie	Hot						Several springs.
24	Nizhne-Chazhminskie.	43–56						Do.
25	Verkhne-Chashminskie.	60–70			Na, SO_4, Cl			
26	Kronotskie	35						
27	Tiushovskie	50–70	Large		Na, SO_4, Cl			Several springs.
28	Taunshitskie	Hot					Lava	
29	Uzonskie	70–94		863–4,884				Many small springs, mud volcanoes, and fumaroles in Uson caldera. Deposits of sulfur.
30	Kikhpinychevskie, on west side of volcano.	Hot						Many springs and fumaroles.
31	Verkhne-Semiachinskie.	Hot						1 main spring and several fumaroles. Free H_2S.
32	Nizhne-Semiachinskie, at south base of volcano.	30–50	70,000	1,610	Ca, Na, HCO_3, SO_4, Cl.			9 springs.
33	Pushchinskie	16–42		5,168				Water is saline. Free H_2S.
34	Berezovskie, near active volcano.	Hot	Moderately large					Several springs.
35	Timonovskie	46	Small					3 springs. Water contains Fe. Free H_2S.
36	Zenzurskie	Hot	Large					
37	Levo-Avachinskie	Warm	Moderately large					
38	Kekhukuiskie	18–33	Moderately large					Several springs. Free H_2S.
39	Nalachevskie	28–75	8,200	4,124	Ca, Na, HCO_3, SO_4, Cl.			23 springs.
40	Kravedcheskie	34–70		7,274	$CaSO_4$, NaCl			5 springs in 2 groups.
41	Malkinskie, near Malka village.	39–83		550	Na, SO_4, Cl			28 springs in 5 groups.
42	Nachikinskie, near Natscheke (Narchiki?) village.	13–81	16,300	446	Na, SO_4, Cl			More than 70 springs in 28 groups.
43	Apachinskie	70–72	Large	596	Na, HCO_3, SO_4, Cl			2 main springs and several small ones. Water used for bathing.
44	Malye Bannye	45–78	2,700	660	Na, HCO_3, SO_4; free H_2S.			Several springs.
45	Boleshie Bannye	30–90	1,250	1,250	Na, SO_4, Cl			3 main springs and several small ones.
46	Nizhe-Paratunskie	23–51		1,530	$CaSO_4$, NaCl			19 springs in 4 groups. Water used for bathing.
47	Sredne-Paratunskie, on streambank.	24–81	Small	1,060	Na_2SO_4			5 springs.
48	Karymchinskie	76 (max)	Small					
49	Verkhne-Paratunskie.	70 (max)		990	Na, SO_4, Cl; free H_2S.			4 groups of springs.
50	Viliuchinskie	Warm	Small					Free H_2S.

Thermal springs and wells in Union of Soviet Socialist Republics—Continued

Kamchatka Peninsula—Continued

No. on fig. 70	Name or location of spring	Temperature of water (°C)	Flow (hectoliters per day)	Total dissolved solids (ppm)	Principal chemical constituents	Distinguishing characteristics	Associated rocks	Remarks and additional references
51	Opal'skie, near Asacha volcano.	74						2 springs.
52	Zhirovye	Hot			HCO_3, $CaSO_4$, NaCl; free H_2S.			
53	Savonskie	73	Moderately large		HCO_3, $CaSO_4$, NaCl; free H_2S.			2 main springs.
54	Asachinskie	Hot						
55	Khadutkinskie	23–100	Large					4 groups of springs. Flow from 1 group is 22 hectoliters per day.
56	Nizhne Golyginskie	60–70	Small	2,782	HCO_3, $CaSO_4$, NaCl; free H_2S.			Several springs.
57	Shtiubelevskie, in volcanic crater.	Hot	Moderately large					Springs form small warm lake; also fumaroles.
58	Sredne Golyginskie	73 (max)			$CaSO_4$, NaCl; free H_2S			
59	Verkhne Golyginskie.	Hot			$CaSO_4$, NaCl: free H_2S.			
60	Ozernovskie (Osernoi, Opalski), in valley near Opalsk volcano.	76–85	4,400	1,300	$CaSO_4$, NaCl; free H_2S.			7 springs, the largest of which boils up to a considerable height and forms a pool which overflows into Lake Osernoi. Tufa deposited on sticks and stones. Another group of springs at a distance of 1 km.
61	Kuril'skie	24–41	Small					Several springs.
62	Pauzhetskie	88–100	Large	3,203				15 Springs, several of which spout. Water is saline. Free H_2S.
63	Along Kataskiya River.	Hot	Small					
64	Along Nuskus River.	50						
	Kluchi	42						
	Zavoiko	81						

PACIFIC REGION

AUSTRALIA

Some of the topographic features of Australia include mountain systems near the coasts—the highest bordering the deepest ocean, the Pacific— and the great comparatively low interior region. Most of the deserts of the southern and western parts of Australia are underlain by Archean granite and other ancient crystalline rocks. These rocks also form uplands in the northern and northeastern parts and cores of the eastern mountain ranges. Marine Paleozoic rocks underlie most of the Northern Territory and form major parts of the eastern and southeastern ranges and most of Tasmania, where there are extensive intrusions of plutonic rocks. The eastern part of Australia is occupied largely by the Great Australian artesian basin. (See fig. 71.)

The artesian basin is underlain by Mesozoic strata, chiefly Lower Cretaceous shale and sandstone. Along the southwest border of the basin, several brackish lakes nearly at sea level extend inland from the south coast. Marine Paleozoic, Mesozoic, and Tertiary strata form bands along the west coast where there are oil-bearing beds in the Tertiary formations. Greater areas of Tertiary rocks extend inland from embayments on the south, southeast, and northeast coasts. Numerous areas of basalt are present in the eastern and southeastern ranges and also in mountains in the northwestern part. Most of these lavas seem to be of late Tertiary and Quaternary ages. In the extreme southeast are some uneroded volcanic cones that are believed to have been active within geologically Recent time.

The island of Tasmania, near the southeast coast of Australia, is composed very largely of marine Carboniferous and Permian strata, but there also are continental Jurassic deposits and intrusions of Mesozoic dolerite and other igneous rocks. Although numerous mineral springs, presumably of normal temperature, have been recorded in Victoria State in the extreme southeast (ref. 3461), and also cold mineral springs in other parts of the country, no mineral or thermal springs seem to be reported in the vast arid western part of Australia.

The locations of the principal thermal springs and zones of springs, and some of the thermal flowing artesian wells, are shown on figure 71; data concerning them are given in the table below.

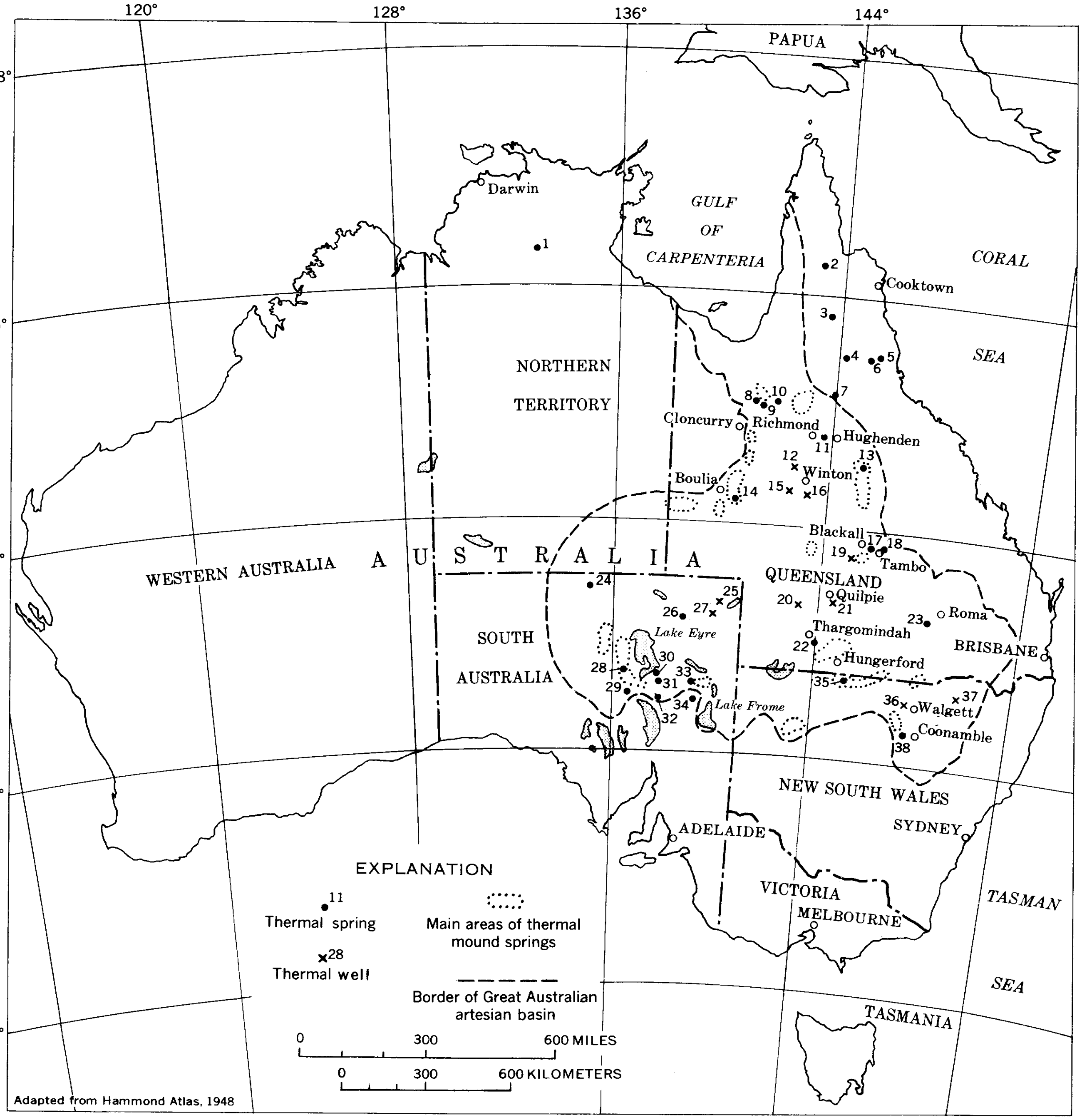

FIGURE 71.—Australia showing location of thermal springs and thermal wells. Chiefly from ref. 3456.

Thermal springs and wells in Australia

[Data chiefly from ref. 3456. Principal chemical constituents are expressed in parts per million]

No. on fig. 71	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	Mataranka	99.5	2,430			Limestone(?)	Water rises in deep pool. Bathing resort. Ref. 3466.
2	Near Musgrave telegraph station.	100.5	Small			Granite	Large deposit of tufa. Free H_2S. Refs. 3451, 3463.
3	Near Mitchell River, 10 miles north of Gamboola station.	Warm	Moderately large		Ca, HCO_3		Several springs issuing from mounds of tufa. Ref. 3467.

Thermal springs and wells in Australia—Continued

No. on fig. 71	Name or location	Temperature of water (°F)	Flow (imperial gpm)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
4	Einasleigh (Talaroo), 0.25 mile from Einasieigh River and 16 miles from Mount Garnet.	145.5	Moderately large	713	NaCl (404); Na_2CO_3 (160); evolved gas 99.7 percent inert (N_2?), 0.3 percent CO_2.	Near lava hill	Issues from tufa mound 15 ft high. Bathing resort. Refs. 3451, 3459, 3463, 3464, 3467.
5	Innot Creek, 8.5 miles east-northeast of Mount Garnet and 28 miles from Herberton.	158; 189	Moderately large	593	NaCl (272); Na_2CO_3 (123); evolved gas 98.2 percent inert (N_2?), 1.8 percent CO_2.	Granite intersected by dikes of felsite.	2 main springs. Bathing resort. Refs. 3451, 3453, 3459, 3460, 3462, 3463.
6	Ambo, in the Innot Creek area.	Warm	Moderately large			Granite(?)	Ref. 3462.
7	Bed of Gilbert River, 10 miles above Gilberton.	94	Small			do	Ref. 3464.
8	South of Mount Brown, near Saxby River.	120	Moderately large		Na, HCO_3; much free CO_2	Cretaceous strata near granite.	2 main springs issuing from large mound of tufa. Deposit of trona (Na_2CO_3). Refs. 3450, 3451, 3455, 3463, 3467.
9	Southeast of Mount Brown, near Fort Bowen.	Warm	Small		Na, HCO_3; much free CO_2	Cretaceous strata	Refs. 3463, 3467.
10	Both sides of lower Flinders River.	100–120	Small		Na, HCO_3; much free CO_2	do	Several springs issuing from large mounds of tufa in area 2 miles in diameter. Intermittent flows of muddy water. Deposits of trona (Na_2CO_3). Refs. 3450, 3458, 3463, 3467.
11	Between Richmond and Hughenden.	Warm	Moderately large		Na, HCO_3; free CO_2	do	Several flowing wells.
12	Kynuna bore, 90 miles northwest of Winton.	198	Large		Na, HCO_3; free CO_2	do	Deep flowing well. Source of water supply for cattle. Ref. 3459.
13	Southeast of Hughenden	Warm	Small		Na, HCO_3; free CO_2	Faulted Cretaceous strata	Many small springs issuing from tufa mounds in a wide area nearly 200 miles long in a north-south direction.
14	Springdale (Springvale) cattle station.	Warm	1,400		Na, HCO_3; free CO_2	Cretaceous strata	Several springs and flowing well. Ref. 3466.
15	Elderslie bore, 50 miles southwest of Winton.	Boiling	350		Na, HCO_3; free CO_2	do	Flowing well 4,523 ft deep. Drilled in 1902. Temperature 212°F at surface; 241°F at depth of 4,225 ft. Source of water supply for cattle. Refs. 3459, 3462.
16	South of Winton	170 (max)	Moderately large	1,400	Na, HCO_3; free CO_2	Faulted Cretaceous strata	Several flowing wells. Small deposits of calcium carbonate.
17	Inniskillen (Enniskillen), on Barcoo River 38 miles east-southeast of Blackall.	Hot	Small		Na, HCO_3	do	Bathing resort. Refs. 3451, 3463.
18	In Tambo area	Warm	Small		Na, HCO_3; much free CO_2	Cretaceous strata	Several flowing wells.
19	Springleigh bore, 50 miles south-southwest of Blackall.	197	20		Na, HCO_3; much free CO_2	do	Flowing well 7,009 ft deep. Drilled during 1913–20. Water mainly from sandy beds at 4,393–4,353 ft; 5,456–5,610 ft; and 6,000–6,280 ft. Originally flowed 50 imperial gpm. Water temperature is 230°F at depth of 5,700 ft. Ref. 3462.
20	Eromanga bore (No. 2)	198	Moderately large		Na, HCO_3	do	Flowing well 4,256 ft deep. Source of water supply for cattle. Ref. 3459.
21	Quilpie	160	Large		Na, HCO_3	do	Source of public water supply. Ref. 3466.
22	South of Thargomindah	Hot	Small			Cretaceous strata near ridge of granite.	Several mud springs. Ref. 3451.
23	Southwest of Roma	Warm-hot	Moderately large		Na, HCO_3	Cretaceous(?) strata	Several deep flowing wells.
24	Dalhousie	100–120	Small			do	More than 30 mound springs in narrow north-south area, 5 miles long. Refs. 3452, 3465.
25	Goyder's Lagoon bore	Hot	Small			do	Flowing well. Water temperature is 208° F at depth of 4,700 ft. Ref 3468.
26	Goyder's Lagoon	Warm	Moderately large			do	2 main and several smaller springs.
27	Mount Gason bore	Hot	Small			do	Flowing well. Water temperature is 204° F at depth of 4,304 ft. Ref. 3468.
28	Strangway	Hot	Large			do	Several springs.
29	Coward	Hot	Large			do	Do.
30	Finis	Hot	Large			do	Do.
31	Hergott	Hot	Large			do	Do.
32	Myrtle	Hot	Large			do	Do.
33	Cat	Hot	Large			do	Do.
34	Paralana, in bed of Hot Spring Creek at east base of Flinders Range.	144	15	1,080	Na (277); SO_4 (148); Cl (322); evolved gas 88.1 percent N_2, 11.9 percent CO_2.	Mesozoic strata faulted against Precambrian rocks.	2 main springs. Water is radioactive. Bathing resort. Refs. 3457, 3465.
35	Southeast of Hungerford	Warm	Small			Cretaceous strata	Many springs issuing from tufa mounds.
36	Rowena bore, near Walgett	78–135	650			do	Flowing well 2,669 ft deep. Water temperature varies. Ref. 3454.
37	Moree bore	110	Moderately large			do	Flowing well 2,793 ft deep. Ref. 3454.
38	Coonamble area	Warm	Moderately large		Na, HCO_3; much free CO_2	do	Numerous flowing wells.

BISMARCK ARCHIPELAGO AND EASTERN NEW GUINEA

The Bismarck Archipelago is an oval group of several islands, 100 to 400 statute miles east of New Guinea, as shown on figure 72.

New Britain, formerly Neu-Pommern, is the largest island and is narrow and crescent shaped. It is mountainous, composed chiefly of volcanic rocks, and includes several active volcanoes. New Ireland, formerly Neu-Mecklenburg, is long and narrow and includes a single mountain range. Granite, porphyry, and basalt are exposed in the southern part of the island, but sandstone, probably of Tertiary age, crops out in the north. The mountains of the other main islands of the archipelago have cores of granite and porphyry partly overlain by sedimentary deposits.

New Guinea, the largest island in the world if Green-

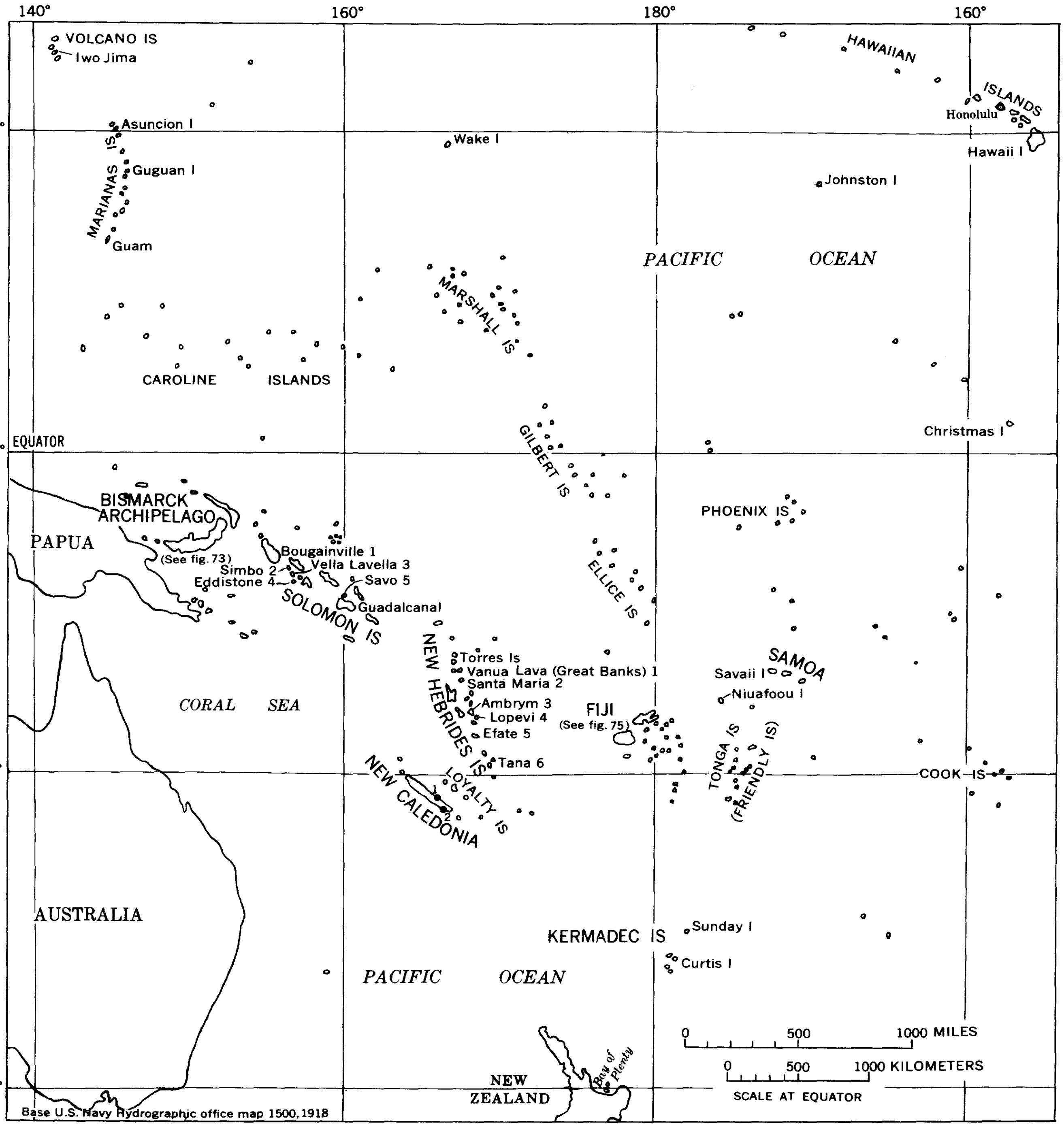

FIGURE 72.—Part of the Pacific region showing location of Volcano Islands, Bismarck Archipelago, Solomon Islands, New Hebrides, New Caledonia, Fiji, Samoa, Tonga Islands, and Kermadec Islands.

land is regarded as a continent, is divided into three main administrative areas. In 1958 the western half formed Netherlands New Guinea; the northern part of the eastern portion, together with the Bismarck Archipelago and other small islands, formed British New Guinea; and the southeastern part, together with nearby small islands, formed the Territory of Papua. Both territories were under Australian administration.

From high limestone cliffs at its southeastern extremity, rugged mountains with perpetual snow on the highest peaks extend west-northwest along the axis of the island. The ranges that have been explored consist chiefly of ancient schist and slate and of intrusive granitic rocks. These rocks are flanked by marine deposits of Jurassic to late Tertiary age. The mountain systems probably extend through most of the western part of the island to its northwestern coast. In some places, raised coral reefs extend inland to altitudes of nearly 2,000 feet. Much volcanic rock is present in the mountains of the southeast peninsula. Mount Victory (Victoria) and Mount Suckling, both in the main range, and Mount Trafalgar near the coast are considered to be solfataric volcanoes, as indicated on figure 73.

The schist and slate of the main ranges reappear in the D'Entrecasteaux and Louisiade groups of small islands off the southeast coast. In the former group there is some Tertiary and later lava. The Louisiade Islands also may be chiefly of lava, but they are covered in large part by coral limestone.

No reference to thermal springs in the western part of New Guinea has been found, but there may be fumaroles and solfataras in the crater of Arfak (Umsini) volcano in that region. The recorded thermal springs in the eastern part are shown on figure 73.

The available information on the thermal springs in the Bismarck Archipelago and eastern New Guinea is summarized in the table below.

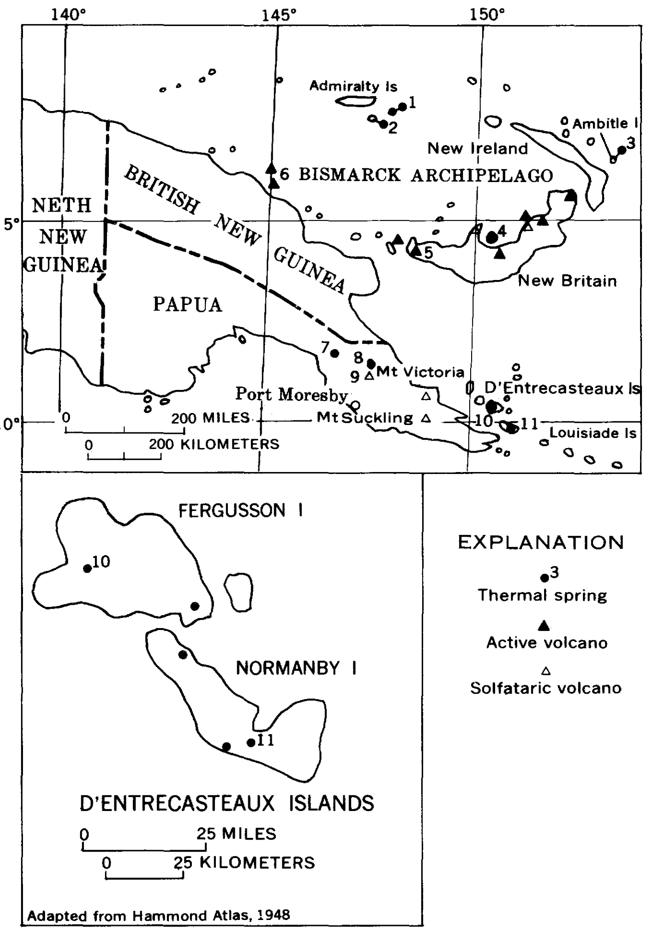

FIGURE 73.—Bismarck Archipelago and eastern New Guinea showing location of thermal springs and volcanoes.

Thermal springs in the Bismarck Archipelago and eastern New Guinea

No. on fig. 73	Name or location	Temperature of water (°C)	Associated rocks	Remarks and references
1	Near southeast coast of Lou Island in Admiralty Group.	Hot	Quaternary or Tertiary lava.	Low-pressure steam vents. Ref. 3470.
2	Baluan Island in Admiralty Group	Hot	do	Many vapor vents in volcanic crater. Ref. 3470.
3	Ambitle Island, off the east coast of New Ireland.	Hot	do	Several springs, one of which spouts to height of 32 ft. Ref. 3476.
4	Near north shore of New Britain Island:			
	Hannam Island, near shore	87–100	do	Several spouting springs, mud volcanoes, and steam fumaroles. Deposits of brown and white sinter. Ref. 3472.
	North Island, near south and northwest shores.	100	do	Several springs, one of which spouts. Water is salty. Deposits of brown sinter. Ref. 3472. (According to ref. 3473, the water from 1 spring in New Britain Group contains 36,312 ppm dissolved solids, chiefly NaCl. Possibly not this spring, but another.)
5	Mount Langila, near west end of New Britain Island.	Hot	do	Large fumaroles emitting steam and SO_2. Ref. 3470.

Thermal springs in the Bismarck Archipelago and eastern New Guinea—Continued

No. on fig. 73	Name or location	Temperature of water (°C)	Associated rocks	Remarks and references
6	Manam (Vulcan) Island, 10 miles off northeast coast of New Guinea.	Hot	Quaternary or Tertiary lava.	2 volcanic craters containing fumaroles emitting much water vapor and CO_2. Ref. 3470.
7	Near Awaru River in Papua, 2 miles upstream from junction with Moni River.	Hot	Trachyte	Several springs. Much free H_2S. Deposits of siliceous sinter and sulfur and incrustations of selenium and cinnabar. Ref. 3479.
8	Near Goropu Mountains in Papua, 40 miles south-southwest of Tufi government station.	Hot	Probably faulted andesite.	Fumaroles and solfataras. Ref. 3469.
9	Mount Victory (Victoria?) in Papua	Hot	Lava	Several steam vents on mountain flank. Ref. 3463.
10	Fergusson Island in D'Entrecausteaux Group.	Hot	do	Acid hot and spouting springs at Iamalele, Deadea, 1 mile south of Debawala, and near Kedidia. Terraces of siliceous sinter and extensive deposits of sulfur. Refs. 3463, 3474, 3480, 3481.
11	Normanby Island	Hot	do	Springs at three places. Ref. 3481.

BORNEO

(North Borneo, Brunei, Sarawak, and Kalimantan)

The island of Borneo lies about 1,000 to 1,500 statute miles northwest of the northwest coast of Australia. It is largely mountainous, and the several groups and chains trend east-west or northeast-southwest. Extensive mangrove swamps occupy much of the coastal area, and wide lowlands form the main river basins. Only reconnaissance surveys have been made of the geology of most of the island, but the general geology and stratigraphy have been summarized by Van Bemmelen (ref. 3516).

In the northwestern part the mountains along the east border of Sarawak are largely of crystalline schist. These mountains are flanked by folded slate, sandstone, and limestone of Carboniferous through Jurassic ages. Triassic schist has been recorded in the western part of Kalimantan, but the principal mountains in this region are believed to be composed chiefly of igneous rocks that are covered largely by nearly horizontal strata of Tertiary age. Tertiary and Quaternary deposits and some strata of Cretaceous age underlie lowlands between the mountain ranges. Cretaceous and Tertiary volcanic rocks also cover extensive areas in the Mueller Mountains near the center of Borneo. Nearly horizontal Tertiary strata that include coal beds are present in the northern part of Kalimantan. Most of this part of the island is underlain by Tertiary strata, which include oil-bearing beds.

Thermal springs have been reported at several places in Borneo, as indicated on figure 74. The small amount of published information concerning them is summarized in the table below.

Thermal springs in Borneo

[Data from ref. 3483. Principal chemical constituents are expressed in parts per million]

No. on fig. 74	Name or location	Temperature of water	Total dissolved solids (p.p.m.)	Principal chemical constituents	Associated rocks	Remarks
1	Near Pinowanter, in Kinoram District	Warm			Paleozoic(?) strata	Water is slightly saline.
2	Near Badang	do	305	SiO_2 (20); Ca (90); Mg (34); Na (31); Cl (21); CO_2 (109).	do	
3	Near upper Lingaa River	do			Probably Quaternary deposits overlying Mesozoic strata.	
4	Near Bajang Mountains in basin of upper Sambas River.	do	228	SiO_2 (67); Ca (34); Na (55); Cl (47); CO_2 (25).	Probably lower Tertiary strata overlying crystalline rocks.	
5	Near Blintang River, a tributary of the Kapuas River.	do				
6	Near Katingan River, a tributary of the Kapuas River.	Warm to hot.			Probably lower Tertiary strata	Several springs. Water is moderately mineralized. Free H_2S.
7	Near Skabat Brook, a tributary of the Katungan (Katingan?) River.	Very hot	Low		Faulted(?) ancient crystalline rocks.	
8	Between Tandjung and Tabalong	Warm			Tertiary(?) strata near intrusive igneous rock.	Water has blue tint. Much free H_2S.
9	Batu bini, in Amandit (Amuntai?) District.	do		Ca, HCO_3	Lower Tertiary limestone	Issues in cave. Water is moderately mineralized.
10	Batu laki, in Amandit (Amuntai?) District.	do		Ca, HCO_3	do	Do.

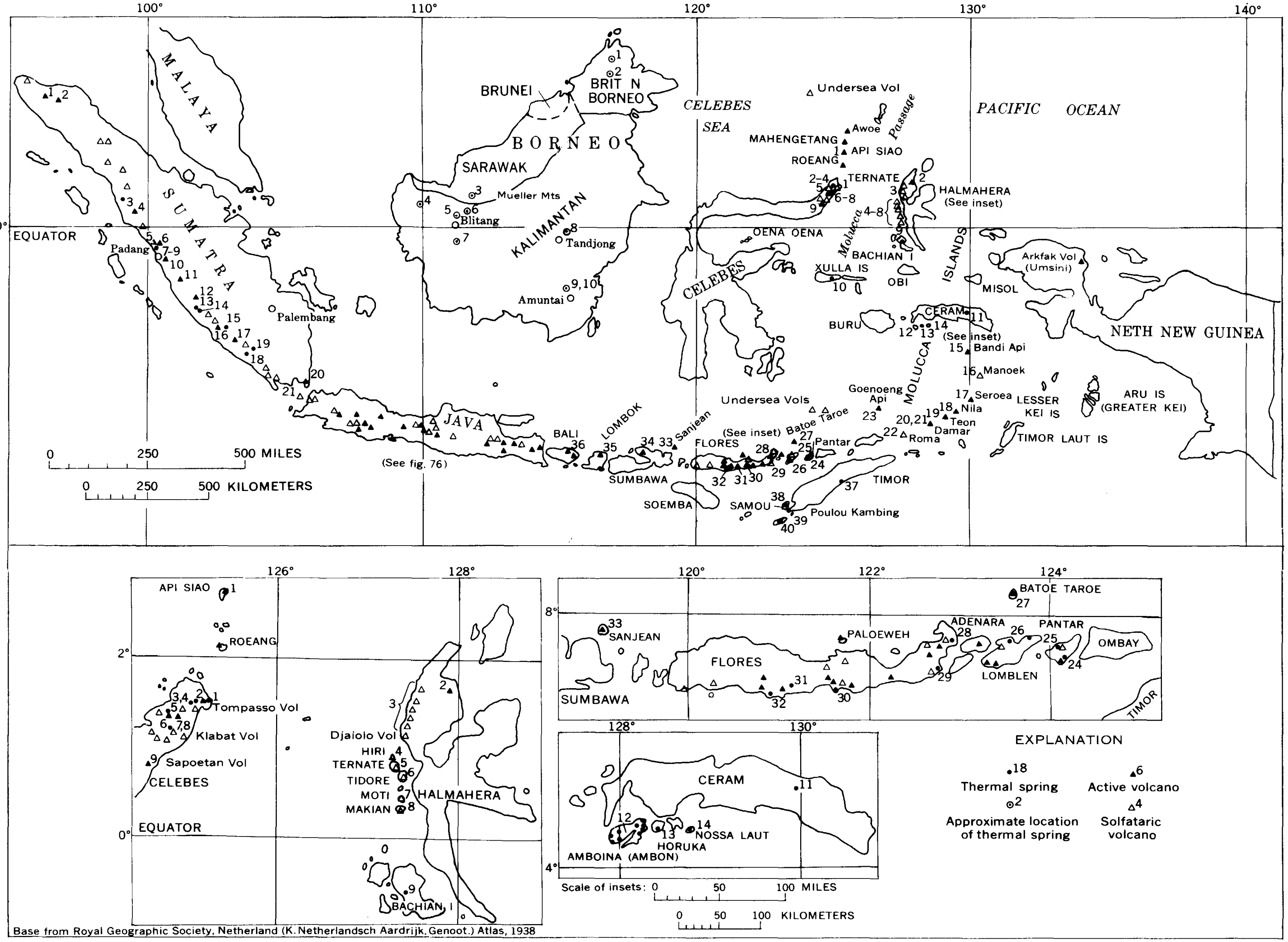

Figure 74.—Part of the East Indies showing location of thermal springs and principal chains of volcanoes in Borneo, Celebes, Molucca Islands, and Sumatra. Springs and volcanoes chiefly from refs. 3532, 3540, and 3725.

CELEBES

The island of Celebes consists of a central mountainous region and four long peninsulas which radiate northeast, east, southeast, and south from it. (See fig. 74.) There is an axial range along each peninsula and the surface is very rugged. Most of the island seems to be of gneiss and other ancient crystalline rocks, which are overlain by conglomerate, limestone, and slate, and in some areas by radiolarian clay. Marine Tertiary deposits border most of the coast. Much intrusive rock cuts the sedimentary formations, and there are volcanic rocks of several periods of effusion. Most of the eastern peninsula is of gabbro. Near the end of the northeastern peninsula are several volcanoes, two or three of which are active and the others solfataric.

Thermal springs are present at several places on or near the principal volcanoes. The available information on them is summarized in the table below.

Thermal springs in Celebes

No. on fig. 74	Name or location	Temperature of water (°C)	Associated rocks	Remarks and references
1	Northeast slope of Tompasso (Tampusu) volcano.	97 (max)	Lava (Quaternary)	About 20 pools of bubbling mud in area of 0.5 sq mi. Much steam. Small deposit of sulfur. Refs. 73, 3484, 3725.
2	1 mile from Langowan and 3 miles southwest of Lake Tondano.	77	Lava	Water rises in large pool from which outflow is considerable. Refs. 3484, 3487, 3488.
3	Panghu, near Lake Tondano	95	do	2 springs spouting to height of 3–4 ft; also pool 40 ft in diameter. Deposit of tufa around pool. Refs. 3486, 3489.
4	1 mile from Panghu	100	Lava, decomposed to red and white clay.	Several pools of boiling mud in area 300 ft in diameter. Vapor is sulfurous. Refs. 3486, 3489.
5	North border of group of volcanoes	Warm		Several springs.
6	Northwest base of Klabat volcano	Warm		Do.
7	Crater on slope of Klabat volcano at north end of Lake Luni.	Hot		Very large solfatara. Ref. 73.
8	Nolok, near Klabat volcano	51		Rises in large pool. Spouts occasionally to height of 50 ft.
9	Slopes of Sapoetan (Soputan) and Mandala Wangi volcanoes.	100		Several steam vents; also steam and sulfurous vapor at sulfur mine. Refs. 16, 3485.

FIJI

The colony of Fiji consists of a group or archipelago of two principal islands and many smaller ones, about 80 of which are inhabited. They are situated about 1,800 to 2,000 statute miles east of Australia, as indicated on figure 72. The larger islands are composed chiefly of plutonic and volcanic rocks, but on Viti Levu, the largest island, the igneous rocks are in some places overlain by massive limestone. Most of the smaller islands are composed of coral.

Many thermal springs are present, chiefly on the two principal islands, as shown on figure 75. Information on the various thermal springs is given in the table below.

Thermal springs in Fiji

[Data chiefly from refs. 3497, 3500. Principal chemical constituents are expressed in parts per million]

No. on fig. 75	Name or location	Temperature of water (°F)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
			Kandavu Island			
1	On southeast coast	144				Ref. 3494.
			Ngau Island			
1	Wakima, near Nawaikama village	Hot	620	$CaCO_3$ (160); Cl (460)	Volcanic rock	Water used for bathing. Refs. 3490, 3496, 3506.

Thermal springs in Fiji—Continued

No. on fig. 75	Name or location	Temperature of water (°F)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
	Ono Island					
1	Near the shore	100				Ref. 3499.
	Rambe Island					
1	Near southwest coast	Warm				
	Vanua Levu Island					
1	Vatuloaloa	140			Probably basic rock	Issues on shore below high-tide level.
2	On south side of Nawavi Range, 4 miles inland.	Warm			do	
3	Nambuonu, 0.5 mile inland	140			do	Issues in swamp.
4	Tambia, 2 miles inland	180			Alluvium	Large deposit of siliceous sinter.
5	Na Kama, 5–6 miles inland	194–204			Volcanic tuff and agglomerate.	Several springs. Small deposits of siliceous sinter.
6	Mbati-ni-kama, near Ngawa River	161			do	Large deposit of siliceous sinter.
7	Nandongo, 4 miles inland	97			Clay	
8	Natuvo, near the shore	131; 136				2 springs issuing in swamp.
9	Ravuka, 9 miles inland	148			Gravel	
10	Vuinasanga, 10 miles inland	131; 134			Alluvium	2 springs.
11	Vandrani, 8 miles inland	100			Gravel	Issues from former streambed.
12	Vunimoli, 8 miles inland	140; 155			Foraminiferous clay	
13	Ndaku-ndaku, on the coast	Warm			Coral reef	
14	Wainunu Valley, from coast to 4 miles inland.	100–130			Alluvium and volcanic tuff	Several springs. Refs. 3498, 3506.
15	Natoarau area, from coast to 4 miles inland.	110–126			Alluvium	Several springs along a valley.
16	Near Nukumbolo, 6 miles inland	157 (max)			Volcanic tuff and agglomerate.	Several springs. Much silico-calcareous sinter.
17	Navakaravi, 1 mile inland	133			Alluvium	
18	Nasavusavu (Savu Savu), near the shore:					
	At rock 50 yd offshore	Hot			Lava(?)	Several springs. Refs. 3496, 3498. 3498. 3505.
	About 200 yd inland	174-212	8, 719	Ca (1,775); Na (1,300); Cl (4,960)	do	3 main springs rising in pool Springs spout occasionally to height of 2–3 ft. Refs. 3496, 3498, 3505, 3507, 3508.
	Nakama, 350 yd inland	Boiling	8, 510	$CaSO_4$ (352); $CaCl_2$, (4, 518); NaCl (3,197).	Volcanic tuff and agglomerate.	Deposit of siliceous sinter. Refs. 3498, 3501, 3505.
19	Vunisawana, 400 yd from beach	Warm			Alluvium	Ref. 3498.
20	Navuni, 0.75 mile inland	112; 113			Volcanic tuff and agglomerate.	2 springs.
21	Ndreke-ni-wai, on coast	130-135			Coral reef	Several springs.
22	Waikatakata, 400 yd inland	148			Basalt	
23	Ndevo, on the coast	Warm			Coral reef	
	Vanua Mbalavu Island					
1	Near Loma Loma village	160			Coral limestone intruded by andesite.	2 springs. Refs. 3492, 3496.
	Viti Levu Island					
1	Tavua, near Nasivi River and 3 miles inland.	150	1, 706	$CaSO_4$ (510); Na_2SO_4 (378); NaCl (520).		Ref. 3490.
2	Near mouth of Mba River on shore of Namaka Islet.	Warm	9, 535	$CaCl_2$ (3,940); NaCl (4,670)		Spring water is contaminated by sea water.
3	Near Sambeto River, 2 miles inland	Warm	2, 609	$CaSO_4$ (1,069); NaCl (4,174)		
4	Waimbasanga Lower, near Wallato River.	150	1, 293	$CaSO_4$ (789); Na_2SO_4 (364); free H_2S.		Ref. 3498.
5	Waimbasanga Higher, 0.25 mile upstream from Waimbasanga Lower.	150	Low		Basalt	Do.
6	Mbusa Lower, 2 miles inland	130	205	Na_2SO_4	Fractured granite	1 spring.
7	Mbusa Higher, 1.5 miles northwest of Mbusa Lower.	150	227	Na_2SO_4	do	Several springs.
8	Naseuvou Southern	106			Andesite	Ref. 3502.
9	Naseuvou Northern, 0.75 mile from Naseuvou Southern.	140			Andesitic agglomerate	Do.

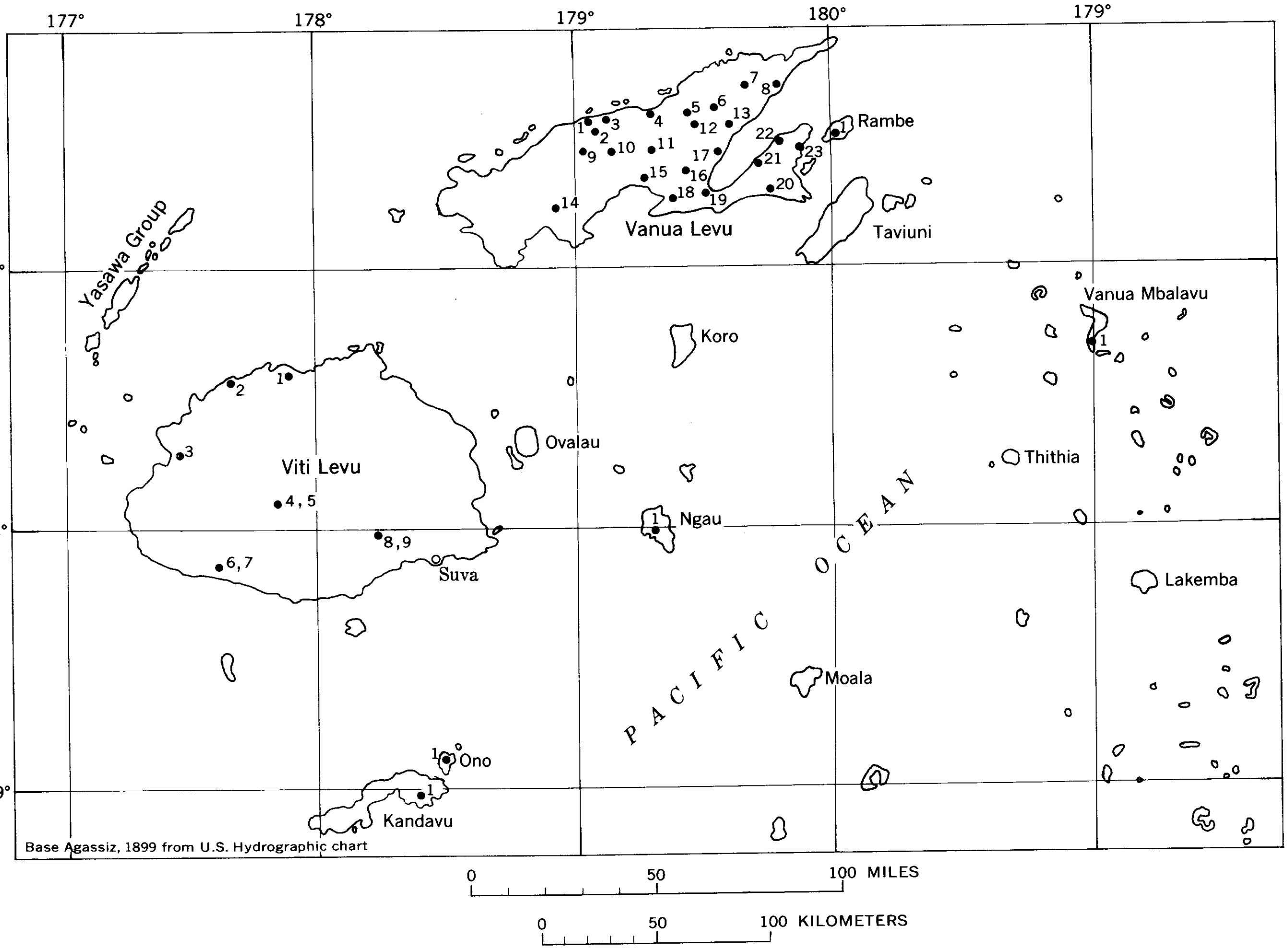

FIGURE 75.—Fiji showing location of thermal springs. From refs. 3497 and 3500.

GALÁPAGOS ISLANDS

The Galápagos Islands form an archipelago of about a dozen small islands and many islets and rocks situated on the equator about 500 to 650 statute miles west of the coast of Ecuador. (See fig. 1.) Albemarle, or Isabela, Island is the largest and westernmost of the principal islands; it is about 70 miles long, north-south, and about 40 miles wide at its maximum. Except for beach sands, it is composed of basaltic lava, scoria, and tuff, and has five main craters, at least three of which have been active within recent years. Narborough, or Fernandina, Island, just west of Albemarle, consists of one large volcano, which has been active at two or more periods since 1925. All the other islands of the group, though volcanic, show few signs of recent activity.

According to Banfield, Behre, and St. Clair (ref. 3509), there are hot springs, hot-water basins, steam vents, and solfataras in the craters of the three volcanoes on Albemarle Island. Fuchs (ref. 43) states that the principal crater on Narborough Island contains several active solfataras.

JAVA

A range of volcanic mountains extends the full length of Java along the axial part of the island. There are also several branch ranges and detached mountains. Much of the land on each side of the main ranges is mountainous to hilly, but wide lowlands extend along the north side of the western part of the island and along the north and south coasts in several other areas. Lowlands also extend nearly across the central part of the island. Schist, possibly of Cretaceous age, is exposed in a few small areas and seems to be the oldest rock in Java, although schist of an earlier geologic age is present in the small islands of the Karimundjawa (Karimon Java) group off the north coast. Nearly all the principal mountains are of lava and other volcanic materials of Tertiary to Recent ages. These rocks underlie large areas surrounding the principal centers of volcanism (on fig. 76).

Most of the hilly and lower lands of Java are underlain by marine sandstone, marl, and limestone of Miocene and Pliocene age. These deposits have been considerably folded and uplifted. They are overlain along

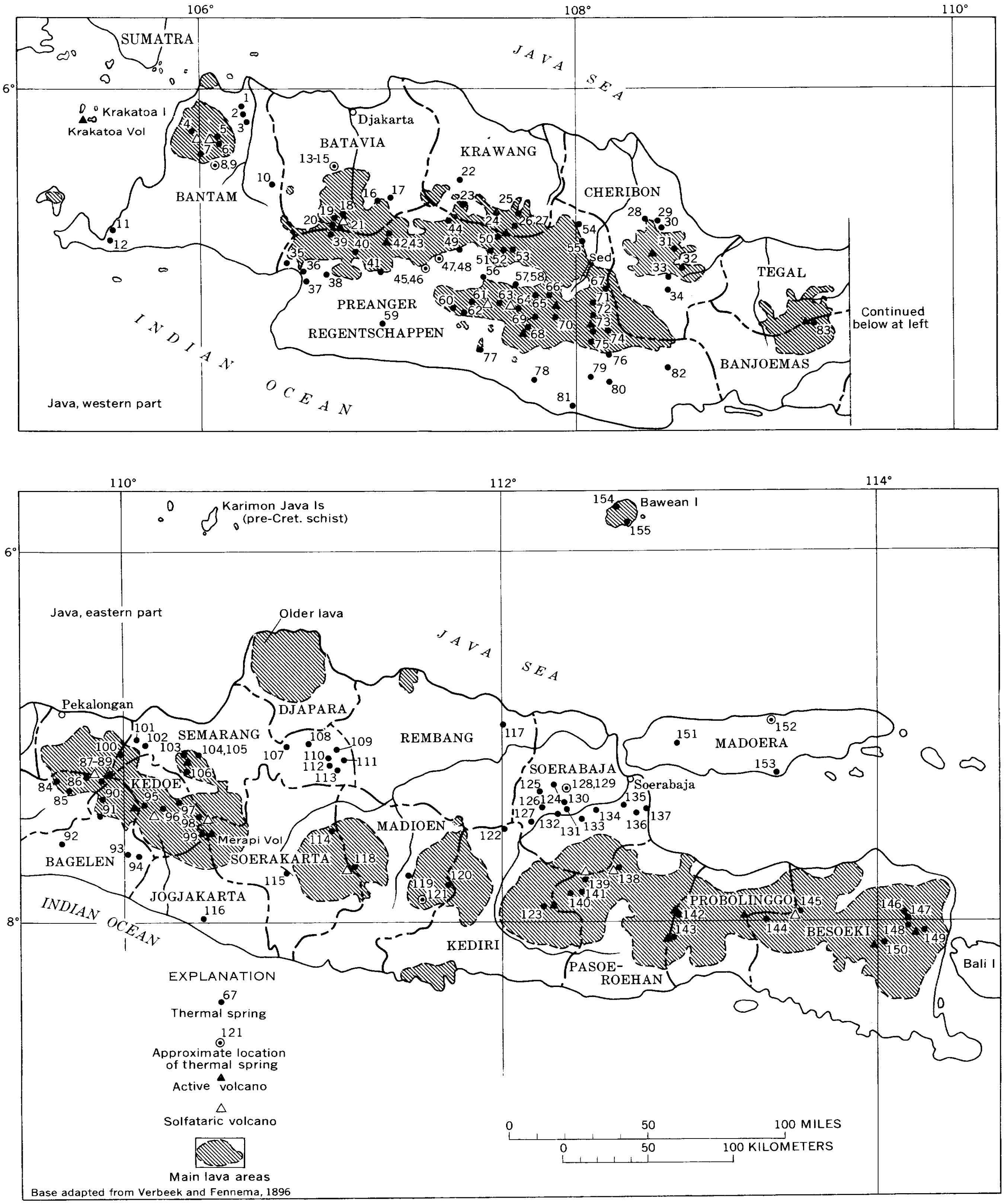

FIGURE 76.—Java and nearby islands showing location of thermal springs, volcanoes, and main lava areas. Springs from refs. 3524 and 3532; volcanoes and lava areas from ref. 3532.

the coasts by Quaternary marine deposits and alluvium. Most of the thermal springs are closely associated with the active or solfataric volcanoes. About 15 springs or groups issue from Tertiary deposits near the borders of areas of lava.

Junghuhn (ref. 3524) described some of the thermal springs. Most of these springs, and others, were noted by Verbeek and Fennema (ref. 3532), who also recorded 121 centers of present or former volcanic activity, of which about 14 are considered to be either active or solfataric volcanoes.

The data on the numerous springs recorded in the two reports are summarized in the table below.

Thermal springs and wells in Java

[Data chiefly from refs. 3524, 3532. Principal chemical constituents are expressed in parts per million]

No. on fig. 76	Name or location	Temperature of water (°F)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	3 km north of Tjiteureup	Warm			Tertiary strata	Considerable gas evolved.
2	Kaboel (Epetan)	Warm			do	Several springs in area 150 ft square. Much sulfurous gas. Ref. 3512.
3	Tiji Pari	Hot			do	
4	Northwest slope of Parakasak volcano.	Warm			Lava	Water is saline and sulfurous. Free CO_2, H_2S.
5	Soemoertoe, on east slope of Karang volcano.	110			do	
6	Legok Prijoek	110–130	9,720	SiO_2 (1,440); $CaCO_3$ (1,360); Na_2CO_3 (2,860); K_2SO_4 (1,190); NaCl (1,730); Al_2O_3 (160); free CO_2.	do	Several springs.
7	South slope of Poelosari Mountain.	Hot			do	Solfataras and boiling springs. Refs. 3516, 3727.
8	Near Wanatake	Warm			Tertiary strata	Water tastes sour.
9	Near Tjitando	Warm			do	
10	Tjipanas	Warm	4,074	NaCl (2,108)	do	
11	In southwest part of Bantam	Warm			do	
12	Tjiobek	Warm			do	Water is sulfurous.
13	Bank of Tji-Sopan stream	97.2			do	Water is saline and bitter. Free CO_2.
14	Kapouran, at Lande Kuripan:					
	Great Spring		15,870		do	Large deposit of tufa. Ref. 3528.
	Hot Spring		27,000			
	Third spring		28,780			
15	Near Tjikopo	Warm			do	
16	Tjimandala	Warm			Andesite	Deposit of iron-stained tufa.
17	Near Kebondanas	Warm	82,215	$CaCl_2$ (14,1300); $MgCl_2$ (3,563); NaCl (62,133).	Tertiary strata	Small flow.
18	North slope and crater of Salak volcano.	Warm			Lava	Several springs on north slope; fumaroles in crater.
19	Kleine Kawah	Warm			do	
20	Groot Kawah	Warm			do	Deposit of jarosite. Ref. 3516.
21	South slope of Salak volcano	Hot			do	Solfataras in two places. Ref. 3516.
22	Near Tjiampel	Warm			Tertiary strata	Water is saline.
23	Batu-kapur Mountain	106.2	1,387	$CaCO_3$ (293); $MgCO_3$ (299); Na_2CO_3 (252); NaCl (367).	Lava	
24	Tjiater (Drangon), on north slope of Tangkhoeban volcano.	108.5–117.5	2,209	$CaCO_3$ (676); $MgCO_3$ (471); Na_2CO_3 (471); NaCl (364); free CO_2.	do	Several springs. Large deposits of jarosite and iron phosphate. Ref. 3516.
25	Valley of Tji Burbus	90.5–106.2			do	Several springs and pools. Water is saline.
26	Northeast slope of Tangkhoeban volcano.	85			do	3 main springs.
27	Bank of Tji Panas stream, east of Tjiater.	108.5			do	Water tastes sour.
28	Near Bongas	130			Tertiary strata	Shallow wells. Deposit of tufa. Ref. 3530.
29	Tjitotok, near north base of Tjerimai volcano.	146		$CaCl_2$ (1,360); NaCl (4,930)	do	Deposits of tufa and sulfur.
30	Tjipanas	Warm			do	Issues near a large deposit of bitumen.
31	Near east base of Tjerimai volcano	105			Lava	Water used for bathing. Refs. 3516, 3525.
32	Tji Tjangelok	112			do	
33	Near Koeningan	99.5			Tertiary strata	Flows 30 liters per minute. Water is saline.
34	Tji Oeja, 2 km north of Tjiniroe	Warm			do	
35	Tjipanas, 2 km north of Tjisolok	Warm			do	Deposit of aragonite.
36	Near Dadap	119.7			Tertiary limestone	Deposit of tufa.
37	10 km southeast of Palaboetan Ratoe.	Warm			Tertiary strata	
38	Near Tji-mandiri stream	Warm			Fractured Tertiary strata	Several springs.
39	35 km west of Gede (Gedah) volcano.	Warm			Lava	
40	20 km southwest of Gede (Gedah) volcano.	Warm			do	
41	Near south base of Gede (Gedah) volcano.	Warm			Fractured Tertiary strata	
42	North-northeast of Gede (Gedah) volcanic crater.	128 (max)			Lava	3 springs.
43	On northeast slope of Gede (Gedah) volcano.	118–120	3,618	$CaCO_3$ (837); Na_2SO_4 (547); $MgCl_2$ (566); NaCl (947).	do	3 springs; also steam vents. Ref. 16.
44	Paloembon, on south slope of Batu Mountain.	108			do	Water strongly saline. Ref. 3522.
45	Near north base of Djampang Mountain.	Warm			Tertiary strata	
46	Bank of Tji Madja stream	101; 150			do	2 springs. Free H_2S.
47	Near base of Linggungmauer	74.7			do	

Thermal springs and wells in Java—Continued

No on fig. 76	Name or location	Temperature of water (°F)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
48	On bank of Tji Tjankar	124.2			Tertiary strata	Water is slightly saline and bitter. Deposit of tufa.
49	15 km northeast of Tji Tjankar	Warm			do	
50	Crater of Tangkaoeban (Tankuban Prahu) volcano.	112			Quaternary lava	Milky water in crater lake; fumaroles on lake border. Refs. 16, 3530.
51	Boerangrang	Warm	1,125	SO_4, Cl	do	
52	Kantjah (Tijpanas), west of Lembang.	Tepid	2,115	NaCl+KCl (640); SO_4 (870); CO_2 (305).	do	Deposits of jarosite and iron oxide Ref. 3516.
53	Bank of Tjipanas stream, 3 km south-southeast of Lembang.	111; 116	1,356 (hottest)	Na, Cl; free CO_2	do	2 main springs.
54	Narimbang, near northeast base Tamponas Mountain.	Warm			Lava overlying Miocene strata.	Water is saline.
55	East of Tjidempet	Warm			do	Several springs. Deposit of tufa containing magnesium carbonate.
56	Northwest of Kopo	Warm			Tertiary strata	
57	On Plateau Pengalengan No. 1	Very hot			do	Large flow of strongly sulfurous water.
58	On Plateau Pengalengan No. 2	120			do	Water is slightly saline.
59	Near base of Brengbeng Mountain	117.5–161.1			do	Several springs. Water is slightly bitter.
60	Telaga Patonggang (Tiji Sopan), on west slope of Patoeha Mountain.	99.5			Lava	Water is astringent and strongly sulfurous.
61	Near north base of Patoeha Mountain.	Warm			do	Large deposit of sulfur.
62	Southwest slope of Tiloe volcano	Hot			do	Several fumaroles.
63	Between Tiloe and Wajang volcanoes.	Warm	1,867	SO_4	Lava overlying Tertiary strata.	Deposits of tufa, ocher, and siliceous sinter.
64	Kawah, on east slope of Wajang volcano.	Warm			do	
65	Northwest slope of Goentoer volcano.	Hot			do	Several solfataras.
66	5 km northwest of Trogong	Warm	1,161	CO_3, SO_4	do	
67	Tjipatjing, near northeast base of Telaga Bodas volcano.	Warm			Lava	Several springs and solfataras. Deposits of tufa and brown opal. Ref. 3516.
68	Kawah Mas, on north slope of Papandajan (Papandayang) volcano.	Hot			do	Spouting springs, hot mud pools, and solfataras. Deposits of sulfur. Refs. 16, 3516.
69	Kawah Manoek (Kawah Manuk), east slope of Kendang Mountain.	128			do	Ref. 3725.
70	Tjipanas, on south slope of Goentoer volcano.	111	2,115	CO_2 (305); SO_4 (870); NaCl+KCl (640).	do	Spring, also solfataras at two places. Ref. 3516.
71	Padjagalan, near southwest base of Sida-keling Mountain.	98			do	
72	Telaga Bodas Lake, on north slope of Galoenggoeng volcano.	Warm			do	Deposits of tufa and opaline silica. Deposits of sulfur at nearby solfataras. Ref. 3525.
73	Southeast slope of Galoenggoeng volcano.	Warm			do	
74	Near Pager-agung	115; 118			do	2 springs. Water is saline. Deposit of ocher.
75	Tjiboekoer, on southeast slope of Galoenggoeng volcano.	Warm			do	Several springs.
76	Tji Woelan (Wulan), 5 km north-northeast of Eureunpala.	81–123			Quartz and hornstone	Several springs. Deposit of tufa.
77	South of Tiloe volcano, near east border of small lava flow.	Warm			Tertiary strata	
78	Bank of Tji-arinem stream	106.2			do	
79	Bebedahan	Warm			do	
80	Near Tji Waline	Warm			Tertiary limestone	
81	Near Tjieras	Warm			Tertiary strata	
82	Easternmost part of Preanger	Warm			do	
83	Slamat volcano	Hot			Lava	Several fumaroles and solfataras.
84	25 km west of Kendeng volcano	Warm			do	
85	3 km south of Tempoaran	Warm			do	
86	West slope of Kendeng volcano	Hot			do	Several springs having small flow. Water contains iodine which is extracted commercially. Also fumaroles and solfataras. Ref. 3516.
87	Telaga Leri (Tologo Lin), on upper slope of Dijeng (Dieng) volcano.	105–178			Quaternary lava	4 main springs supplying lake of milky water. Water is sulfurous. Much steam. Refs. 3513, 3514, 3727.
88	Tjonaro (Chondero) di Moeko, on southwest slope of Dijeng (Dieng) volcano.	Boiling			do	Several springs spouting to maximum height of 5 ft; supply pool 20 ft in diameter. Water is sulfurous. Deposits of sulfur. Refs. 3513, 3514.
89	South of Tjonaro (Chondero) di Moeko:					
	Tologo Warno	Warm			do	Lake 300 yd long. Refs. 3513, 3514.
	In Kawa Kedung (Kawa Kiwung) Valley.	Hot			do	Bubbling pond. Refs. 3513, 3514.
	Pekaraman	Warm			do	
90	Kali Anget:					
	Near Wono Sobo	107.5			Lava	Deposit of ocher.
91	On Seraju Mountain	114.8			Calcareous sandstone (Tertiary).	
92	Krakal, on bank of Look stream 2 km southeast of Alian.	100.4; 103.3	11,861	$CaCl_2$ (6,097); NaCl (5,308)	Tertiary strata	2 main springs.
93	10 km north of Poerworedjo	Warm	19,500	$CaCl_2$ (5,500); NaCl (12,700)	do	
94	Banjoeasin, 10 km northeast of Poerworedjo.	Warm			do	

Thermal springs and wells in Java—Continued

No. on fig. 76	Name or location	Temperature of water (°F)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
95	Soembing volcano	Hot			Lava	Several fumaroles and solfataras.
96	Kalibening, on northeast slope of Gijanti volcano.	Warm			do	
97	Ajer Panas, near base of Andong Mountain, 4 km west of Gerabak.	96			do	Water rises in stone basin at Hindu shrine.
98	Merbaboe volcano	Hot			Quaternary lava	Small fumaroles and solfataras.
99	West slope of Merapi volcano	Hot			do	Several fumaroles. Refs. 3516, 3527, 3529.
100	Pelantoengan (Platungen), on north slope of Prau Mountain.	111	4,990	SiO_2 (147); $Ca(HCO_3)_2$ (595); $Mg(HCO_3)_2$ (499); $NaHCO_3$ (501); NaCl (3,125); Fe_2O_3 (29).	Trachyte	Flows about 30 liters per minute. Military hospital. Ref. 3519.
101	Near north base of Prau Mountain	Warm			Tertiary strata	Water is saline.
102	Near north-northeast base of Prau Mountain.	Warm			do	Do.
103	North-northwest slope of Ungaran volcano.	Hot			Lava	Do.
104	Northeast slope of Ungaran volcano	125			do	Deposit of ocher.
105	Bed of Kali-Ulo stream	Warm			do	2 springs. Terraces of tufa.
106	Oudh Gedong, on south slope of Ungaran volcano.	Tepid			Lava	Water is sulfurous. Free H_2S.
107	Plain of Grobogan, southwest of Poerwodadi.	Warm			Tertiary strata	Water is saline.
108	Southeast of Poerwodadi	Warm			do	Water is highly saline; salt production.
109	Medang Ramsan, north of Koewoe	Warm			do	
110	Djati and Mendikil, west and southwest of Koewoe.	Warm			do	Water is highly saline; salt production.
111	Kesongo, southeast of Koewoe	Warm			do	Do.
112	Tjerewek, Bandar-lor, and Banjar-Kidoel, near Koewoe.	Warm			do	3 small springs. Water is highly saline; salt production.
113	3 km southwest of Grabagan	Warm			do	Water is saline.
114	Lower northern slope of Lawoe Mountain.	Tepid			Lava overlying Tertiary limestone.	
115	Near southwest base of Lawoe Mountain.	93			Tertiary strata	Water used for bathing.
116	Karang Panas, 12 km east of Kali Opak stream.	127; 135			Sand dunes overlying Tertiary strata.	Water is highly sulfurous. Free H_2S.
117	10 km southwest of Toeban	Warm			Tertiary limestone	Water is potable.
118	Koekoesan volcano	Hot			Lava	Several fumaroles and solfataras.
119	Oemboel, near west base of Wilis Mountain.	Tepid	1,800	SiO_2 (119); $CaCO_3$ (357); $MgCO_3$ (375); NaCl (780); free CO_2, H_2S.	Tertiary strata	
120	Southwest slope of Wilis Mountain	Hot			Lava	Solfataras. Ref. 3516.
121	Near southwest base of Wilis Mountain.	146			do	Water is saline.
122	Banjoe Oemboel	Warm	19,518	NaCl (17,060)	Tertiary strata	
123	Keloet volcano	Hot			Lava	Fumaroles and solfataras.
124	Tjitro, at north base of hills	Warm			Tertiary strata	Water is saline.
125	1 km south of Pasinan	Warm			do	Do.
126	Gesinglor, 10 km south of Pasinan	Warm			do	
127	Montroeng, 15 km south-southwest of Gesinglor spring.	Warm			do	
128	Near Desa Molong stream	92	25,280	NaCl (23,025)	do	
129	Paras, on west slope of Hugels Hills	90			do	Large flow of saline water. Free H_2S. Slight amount of petroleum.
130	Moeloedan	Warm			do	
131	Goeng Lantoeng	Warm			do	
132	Near Tjoepak	Warm			do	
133	Padjet	110			Tertiary strata	
134	Kedang-waroe	98.8 (max)			do	7 main and about 20 smaller springs. Water is saline. Contains I (116 ppm). Free H_2S.
135	Genoek	Tepid	26,000	$CaCO_3$ (418); $MgCO_3$ (332); $NaHCO_3$ (900); NaCl (23,920); NaI (12); NaBr (28).	do	Flow 30 liters per minute.
136	Poeloengan, 5 km east of Gedengan.	Warm			do	Several muddy pools of saline water.
137	Koelang-anjar, 3 km from shore	108			do	Issues from tufa mound. Water is strongly saline. Ref. 3522.
138	Welirang volcano	Hot			Lava	Solfataras. Water is sulfurous. Large deposits of sulfur. Ref. 3516.
139	Adjasmoro volcano	Hot			do	Fumaroles and solfataras. Water is sulfurous.
140	Sanggoriti (Singuriti), near northeast base of Kawi volcano.	90.5; 111			do	2 springs, 20 paces apart, supplying large tank beside ruins of altar. Water is saline and ferruginous. Deposit of ocher. Ref. 3514.
141	2 km north of Ngangtang	Warm	10,800–19,400		Lava overlying Tertiary strata.	4 springs. Water is strongly saline.
142	Tengger-Bromo volcano	Hot			Lava	Fumaroles and solfataras.
143	Semeroe volcano	Hot			do	Do.
144	Near east base of Lemongan (Lamongan) volcano.	103.8–108.5	3,300	$CaCO_3$ (205); $MgCO_3$ (788); $MgCl_2$ (346); NaCl (738); CO_2 (1,192); Al_2O_3 (13); Fe_2O_3 (20).	do	Several springs.
145	Argopoero volcano	Hot			do	Fumaroles and solfataras.
146	Djeding, on north slope of Idjén (Idgén) Mountain.	Warm			do	
147	Banjoe Wedang No. 2	Warm			do	
148	Banjoe Wedang No. 1	Warm			do	

Thermal springs and wells in Java—Continued

No. on fig. 76	Name or location	Temperature of water (°F)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
149	Idjén-Merapi volcano	Hot		Al_2O_3 (8,745); Fe_2O_3 (2,395); SO_3 (40,380).	Lava	Fumaroles, solfataras, acid muddy springs, and crater lake. Intermittent overflow from lake diverted to ocean by trenches. Analysis is for water in lake. Refs. 94, 3516, 3520, 3526.
150	Raoeng (Gunung Raung) volcano	Hot			do	Fumaroles and solfataras. Refs. 94, 3526.
151	Lantoeng, Madoera Island	Warm			Tertiary strata	
152	Near Ajer Panas, Madoera Island	93			Tertiary limestone	Issues 20 ft above sea level. Water is sulfurous. Free H_2S. Much gas evolved.
153	Near coast south of Pamekasan, Madoera Island	Warm			Tertiary strata	2 or 3 springs.
154	Near northwest coast of Bawean Island.	80 (max)			Calcareous strata (Tertiary)	
155	Near southeast coast of Bawean Island.	80 (max)			do	Do.

KERMADEC ISLANDS

The Kermadec Islands, nearly 2,000 statute miles east of Australia, form a group of five small islands, which extend north-south for 200 miles, as indicated on figure 72. These islands were described by Smith (ref. 3534), who found them to be composed almost entirely of geologically Recent volcanic materials. They are on a general volcanic line extending from the Bay of Plenty in New Zealand northward to the Tonga Islands and Samoa. Sunday Island, the northernmost and largest of the Kermadec group, is about 20 miles in circumference. It has two craters, the older of which is partly eroded to form Denham Bay, on whose east side Smith found small fumaroles. Farther east the main crater contains a lake which boiled in 1872 when there was an eruption. Smith also noted hot springs below high-tide level on the north shore of Sunday Island. About 90 miles south of Sunday Island, the eastern of the two small Curtis Islands had a crater in which were solfataras, fumaroles, and boiling mud holes; a strong stream of hot water flowed from the crater to a nearby cove in which the salt water was thus warmed.

MOLUCCA ISLANDS

The Molucca Islands generally are considered to consist of the islands that lie between Celebes and New Guinea, those which border the Molucca Passage extending northward, and those to the south which form bands curving westward to Java. (See fig. 74.)

Halmahera (Jilolo), largest of the Moluccas, is about 150 miles east of the northeast end of Celebes and resembles that island in shape, as Halmahera also consists of four peninsulas formed by mountain ranges. Verbeek (ref. 3540) noted that much of the island seems to be of mafic eruptive rocks, probably of Mesozoic age. The eastern and northern parts of the north peninsula are covered by marine Pliocene deposits including raised coral reefs, but most of this peninsula is of Tertiary and later volcanic rocks. One volcanic peak is on the east side of the peninsula, and six others border its west coast. This volcanic line is continued southward by five other volcanic peaks in small islands of the Ternate group. Bachian (Batjan) Island, off the west coast of the south peninsula of Halmahera, is also partly of volcanic rocks.

Most of the other islands of the Moluccas are considered to lie in three concentric arcs, the outer of which includes the Xulla (Sula) Islands, Misol, and the Aru, or Greater Kei, group. These groups and other islands in the arc are chiefly of crystalline schist and limestone overlain by Jurassic, Cretaceous, and Tertiary marine sedimentary rocks. The middle arc includes Buru, Ceram, the Lesser Kei Islands, and the Timor Laut group. These also are composed chiefly of crystalline schist, ancient eruptive rocks, and Mesozoic and Tertiary sedimentary rocks. Ceram has no central range, but steep hills border its north coast. The older rocks of Ceram are largely eruptives and crystalline limestone overlain by marine Tertiary deposits.

The inner concentric arc forms an extension of the volcanic belt through Sumatra and Java, east through Bali, Flores, and Pantar, and northeast through several small volcanic islands to Banda Api Island. Nearly all the islands along this arc are largely or wholly volcanic, or contain active or solfataric volcanoes. Amboina, or Ambon, Island, near the southwest coast of Ceram, is considered by some geologists to be on this inner arc, as its principal mountains are of andesite; but parts of its higher lands are of granite and serpentine, and most of the lower areas are underlain by marine Tertiary beds. Thermal springs seem to be present only in the volcanic islands of the inner arc, as noted in the table below.

Thermal springs on the Molucca Islands

[Data chiefly from ref. 3540]

No. on fig. 74	Name or location	Temperature of water	Associated rocks	Remarks and additional references
1	Craters on Api Siaoe (Siau)	Hot	Recent lava	Fumaroles and solfataras.
2	South base of Mamou volcano on Halmahera.	do	do	Several small springs.
3	Volcanoes near west coast of Halmahera.	do	Recent basalt	Several springs, chiefly near shore at base of Djaiolo volcano. Also solfataras.
4	Crater of volcano on Hiri	do	Recent basalt and andesite.	Vapor vents. Small deposits of sulfur.
5	Crater of volcano on Ternate	do	do	Steam and acid vapor from cracks in lava. Small deposits of sulfur. Ref. 3486.
6	East shore and crater of volcano on Tidore (Tidor).	do	do	Spring on east shore and vapor vents in crater. Small deposits of sulfur. Ref. 3486.
7	Crater of volcano on Moti	do	do	Vapor vents. Small deposits of sulfur.
8	Crater of volcano on Makian	do	do	Do.
9	North base of small volcanic cone on Bachian (Batjan).	Boiling	Lava	Several springs, the largest being Atoe Ri. Refs. 74, 3486, 3513.
10	Beach near mouth of Wai Mantana and in basin of Made River, Xulla (Sula) Islands.	Hot		Several springs.
11	Northeast side of Ceram	do	Tertiary strata overlying fractured Jurassic or Triassic strata.	Several springs. Free H_2S. Refs. 3486, 3536.
12	Amboina (Amboyna, Ambon):			
	West of Telaga Biroe		Quaternary deposits	Water is sulfurous. Deposit of siliceous sinter. Ref. 3539.
	Hitou	Warm		Free H_2S. Ref. 3539.
	Bank of Lila River near Lariki	Hot		Small flow. Free H_2S. Ref. 3539.
	Beach near Toelehoe			3 springs. Water from the largest contains 29,700 ppm of dissolved solids, chiefly NaCl (23,740 ppm). Ref. 3539.
	Near Wai Wasia			Free H_2S. Ref. 3539.
	Mount Wawani and Mount Salhutu.	Hot		Springs and solfataras. Ref. 3535.
13	South coast of Horuka (Oma)	Warm		Small flow. Water is ferruginous. Used for bathing.
14	Nossa (Nusa) Laut	About 70°F	Lava	Several springs.
15	Volcano on Banda Api	Hot	Recent lava	Jets of hot steam from many fissures. Fumaroles and solfataras.
16	Southeast flank of volcano on Manoek (Manouk).	do	do	Sulfurous vapor. Deposit of sulfur.
17	Near summit of volcano on Seroea (Seroe).	do	do	Solfataras.
18	East slope of volcano on Nila	do	do	Fumaroles and solfataras.
19	Near summit of volcano on Teon	do	do	Do.
20	Northern volcanic cone on Damar (Dammer, Daam).	do	Lava	Solfataras. Deposits of sulfur.
21	East coast of Damar (Dammer, Daam):			
	Woeloer	do	do	Free H_2S. Deposit of siliceous sinter. Water used for cooking.
	Keli	do	do	Do.
22	South flank of volcano on Roma	do	do	Moderately large flow. Pebbles of alunite (probably formed by decomposition of lava).
23	West slope of volcano on Gunung (Goenoeng) Api (Gunongapi).	do	Recent lava	Fumaroles and solfataras. Deposits of sulfur. Ref. 3486.
24	Near summit of Api volcano on Pantar	do	do	Fumaroles and solfataras.
25	Northern slope of Iljasi volcano on Pantar.	do	do	Several small springs.
26	Near base of Kedang volcano on north coast of Lomblen.	Warm	do	Small springs in two places.
27	Near summit of small volcano on Batoe Taroe (Komba).	Hot	do	Fumaroles and solfataras.

Thermal springs on the Molucca Islands—Continued

No. on fig. 74	Name or location	Temperature of water	Associated rocks	Remarks and additional references
28	Slope of volcano near east end of Flores.	Hot	Recent lava	Solfataras.
29	do			
30	Slope of volcano near south coast of Flores.	do	do	Small flow. Ref. 3725.
31	do			
32	do			
33	Near summit of volcano on Sanjean	do	do	Fumaroles and solfataras.
34	Near summit of Tambora volcano on Sumbawa.	do	do	Do.
35	Near summit of volcano on Lombok	do	do	Do.
36	Slopes of 2 volcanoes in northeastern part of Bali.	do	do	Do.
37	Slope of Mount Atlas near southeast coast of Timor.	Warm		Mud springs. Also mud volcanoes, some ejecting fragments of fossiliferous rock.
38	East coast of Samou	do		Many mud volcanoes. Refs. 3537, 3541.
39	Poulou Kambing, between Timor and Samou.	do		Mud volcanoes ejecting fragments of fossiliferous limestone and sandstone.
40	Rote (Roti)	do		3 groups of mud volcanoes, several of which have large mounds. Fragments of schist and sedimentary rocks of Permian to Quaternary age are ejected.

NEW CALEDONIA

Thermal springs at two localities in New Caledonia, as indicated on figure 72, were described by Avias (ref. 3542). The springs at the northern locality issue in three groups, at temperature of about 40°C, from sedimentary strata, probably of Liassic age, overlying peridotite or serpentine, and probably faulted. The water is lightly sulfureted and has been developed with bath establishment. Other warm springs, not developed, issue from peridotite or serpentine near the south end of the island, at two places near the shore.

NEW HEBRIDES

The New Hebrides form a chain of half a dozen principal islands and numerous smaller ones about 300 to 500 statute miles east to northeast of New Caledonia, as shown on figure 72. This group or chain includes the Torres Islands in the north and extends south-southeast from them for about 800 miles. The small Torres group is low and bordered by coral reefs, but nearly all the other islands are of considerable height and are composed chiefly of basalt and Recent eruptive materials. They include several active craters and numerous sulfur deposits.

Information concerning thermal springs on several of the islands is given in the table below.

Thermal spring on the New Hebrides

[Data chiefly from refs. 3543–3545]

No. on fig. 72	Name or location	Temperature of water (°C)	Remarks and additional references
1	Volcano on Vanua Lava (Great Banks).		Vapor vents on north side of main crater, boiling sulfur springs in pool in minor crater on east slope of main mountain, and solfataras in two places. Deposits of sulfur.
2	Volcano on Santa Maria		Solfataras and fumaroles.
3	Ambrym:		
	Bat-in and on northwest coast.	37–41	Several springs.
	Crater of volcano		Solfataras and fumaroles.
4	Volcano on Lopevi		Fumaroles.
5	Efate:		
	Shore of Meli Bay	Hot	
	Swamp near coast, 0.25 mile north of Quoin Hill.	54	
6	Yasowa volcano on Tana (Tanna).	Boiling	Numerous springs near crater; also fumaroles.

NEW ZEALAND

The northern part of North Island in New Zealand forms the Auckland Peninsula, in which the hilly areas are of Paleozoic and Mesozoic rocks and the lower lands are of Tertiary volcanic rocks and marine Tertiary sedimentary deposits. (See fig. 77.) The main mountain ranges are in the eastern part of North Island parallel with the coast. They are formed chiefly of Paleozoic and early Mesozoic rocks and partly of gneiss

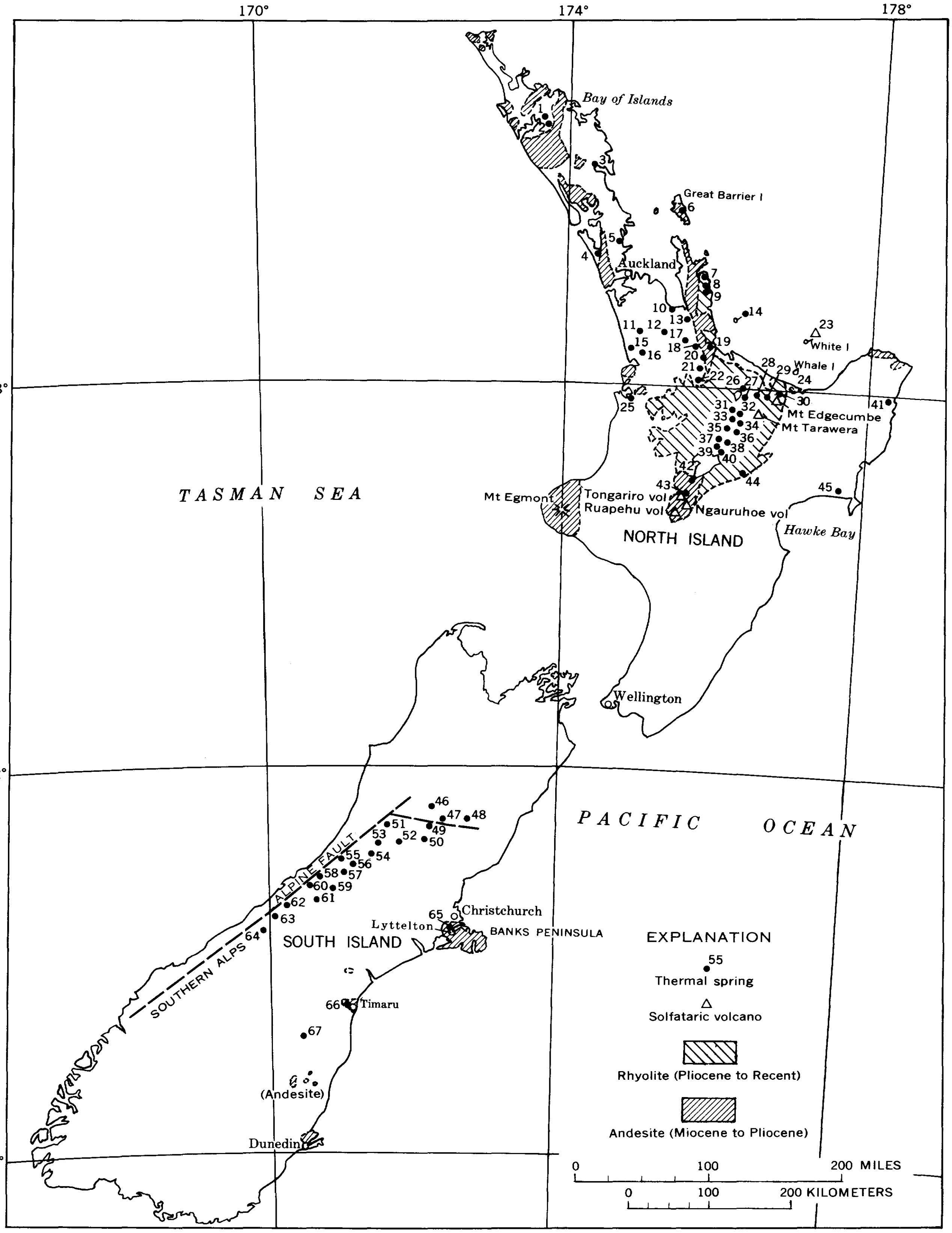

FIGURE 77.—New Zealand showing location of geysers, thermal springs, and main lava areas. Springs from refs. 3565 and 3596. Lava areas from ref. 3653.

and schist. These mountains are bordered by marine Cretaceous and Tertiary strata, especially in the southeastern part of the island. The southwestern projection and the greater part of the central and northern portions form hilly areas and plateaus that are underlain by volcanic rocks, largely pumice and tuff. A range of volcanic mountains and volcanoes, three or four of which are still active or in the solfataric stage, extend through the north-central part of North Island.

The mountains in the northeastern part of South Island, also those in the southern part, seem to be a southward extension of the eastern mountain chain of North Island. In both parts of South Island the mountains are bordered on the east by a broad band of Paleozoic, Triassic, and Jurassic marine strata and on the west by a band of schist. The Southern Alps, a range in the west-central part of South Island, have a core of schist. The principal peaks of the Southern Alps are snowcapped, and there are many glaciers. The western coast, in the vicinity of the Southern Alps, is deeply indented by fiords. East of the Southern Alps is a wide band of marine strata of Tertiary age. The Banks Peninsula and a smaller peninsula near Dunedin, both extending out from the east coast of South Island, consist of Tertiary basalt and andesite. These and a few other small areas of volcanic rocks are the only evidences of volcanism in South Island.

The famous geysers and hot springs of New Zealand are concentrated chiefly in a band within the main volcanic areas of North Island, as indicated on figure 77. Two of the most noted areas of thermal activity are shown in detail on figures 78 and 79.

Outside the main belt of geysers and thermal springs, numerous springs issue chiefly in groups farther northwest, near the borders of lava areas and apparently along fault fractures. In South Island several moderately thermal springs are in the eastern and central ranges, and others have been noted in the western mountains.

Information on the principal groups of springs and geysers is given in the table below.

Thermal springs and wells in New Zealand

[Data chiefly from refs. 3583, 3596, 3614. Principal chemical constituents in parts per million]

No. on fig. 77	Name or location	Temperature of water (°C)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
1	3 miles southwest of Kaikohe	[1] 43			Dacite	Several small springs and gas vents. Free H_2S. Ref. 3592.
2	Ngawha (Ohaewai)	21–45	5,442	Na (689); HCO_3 (470); SO_4 (332); Cl (929); NH_4 (129); H_2SiO_3 (154); HBO_2 (2,739).	Lake beds near Quaternary lava.	3 groups of springs (shore of Tuwhakino Pond, pools at Waitetera Pond, and along Tuwhakino stream). Analytical data for water having temperature of 43°C. Nearby cinnabar deposits formerly mined. Refs. 3551, 3576, 3594, 3612.
3	Kamo	[1] 25.5	[2] 2,025	SiO_2 (105); Ca (216); Na (206); HCO_3 (1,180); Cl (224); much free CO_2.	Basalt overlying Tertiary sandstone and limestone.	2 springs issuing from low mounds of sinter on sanatorium grounds. Flow varies, maximum 30 imperial gpm. Water used for bathing. Ref. 3575.
	Puhipuhi				do	Several small springs. Nearby cinnabar deposits mined. Refs. 3567, 3575, 3612, 3646.
4	Helensville, on shore of Kaipara Harbor.	46–65.5	[2] 1,992	$Ca(HCO_3)_2$ (56); $CaCl_2$ (137); NaCl (1,510); $Na_2B_4O_7$ (82).	Faulted Quaternary and Tertiary strata.	Several flowing wells. Springs in same locality stopped flowing when wells were drilled. Bathing resort. Ref. 3638.
5	Waiwere, on sea coast	40	3,140	$Ca(HCO_3)_2$ (153); $NaHCO_3$ (1,252); NaCl (1,669).	Faulted Miocene sandstone	Several springs and drilled wells. Bathing resort. Ref. 3626.
6	Great Barrier Island	61; 85.5		Ca, Na, Cl	Andesite(?)	2 groups of springs. Water is saline and sulfurous. Refs. 3626, 3676.
7	Taputapu, in stream bed near shore.	49			do	
8	Near Wigmore stream, 0.25 mile from shore.	Hot			Rhyolite	
9	Orua, on beach	Warm	3,710	$Ca(HCO_3)_2$ (322); $CaCl_2$ (309); NaC. (2,871); KCl (103).	Tertiary andesite and Quaternary rhyolite.	Small flow issuing between tide limits. Not contaminated by sea water.
10	Miranda, on west border of Hauraki Plain.	Warm			Faulted Tertiary strata	Water is brackish. Ref. 3651.
11	Te Maire, 5 miles west of Lake Whangape (Wangape).	65–93	[2] 665	$NaHCO_3$ (370); Na_2SO_4 (73); NaCl (351); free H_2S.	Tertiary strata	2 springs, each flowing 140 imperial gpm. Temperature of water varies with the season. Small deposits of sulfur and siliceous sinter. Refs. 3577, 3611, 3625, 3626, 3651.
12	Motukanae, in Lake Waikare	[1] 35			Faulted Tertiary strata	Several springs rising in a small lake. Much free H_2S. Refs. 3591, 3651.
13	Puriri	16.6	7,673	Na (309); HCO_3 (620); Cl (28)	Tertiary strata near andesite	Small flow. Water temperature probably much higher at source of water.
14	Near north and west shores of Mayor Island.	Warm			Andesite	Several small springs.
15	Near tributary of Waikorea stream.	54	400	$NaHCO_3$ (46); NaCl (205); free CO_2, H_2S.	Tertiary strata, probably faulted.	Flow 0.5 imperial gpm.
16	Banks of Waingaro stream	54			do	Several springs; combined flow is 75 imperial gpm. Ref. 3611.
17	Banks of Waitoa River	[1] 76.6	1,051	SiO_2 (65); Na (185); HCO_3 (540); Cl (39).	do	Many small springs. Analytical data for water having temperature of 40.5°C. Ref. 3613.
18	Te Aroha, at west base of Te Aroha Mountain.	30–85	[2] 8,150	Na (3,162); HCO_3 (6,660); CO_3 (1,920); SO_4 (388); Cl (581); HBO_2 (535).	Faulted Tertiary strata	Several springs and drilled wells. Bathing resort. Refs. 3608, 3613, 3634, 3642, 3655, 3678.
19	Katikati, near Tauranga Harbor.	34; 36	221	$Ca(HCO_3)_2$ (49); $NaHCO_3$ (38); NaCl (21); Al_2O_3 (16).	Pleistocene deposits and rhyolite breccia.	2 groups of springs 5 miles apart. Analytical data for water from main spring. Refs. 3613, 3651.

See footnotes at end of table.

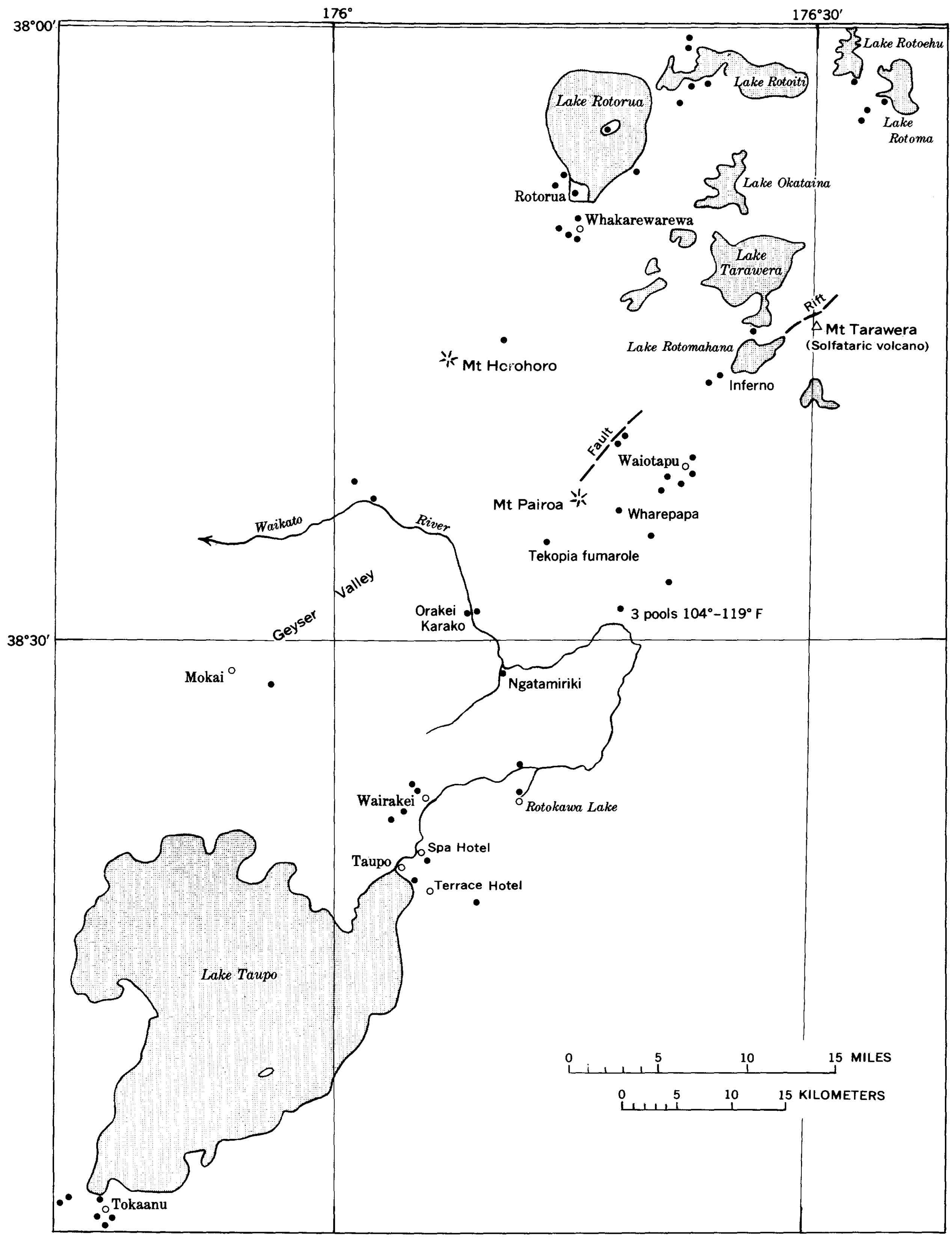

FIGURE 78.—Rotorua-Taupo area, New Zealand, showing location of thermal spring groups. From ref. 3583.

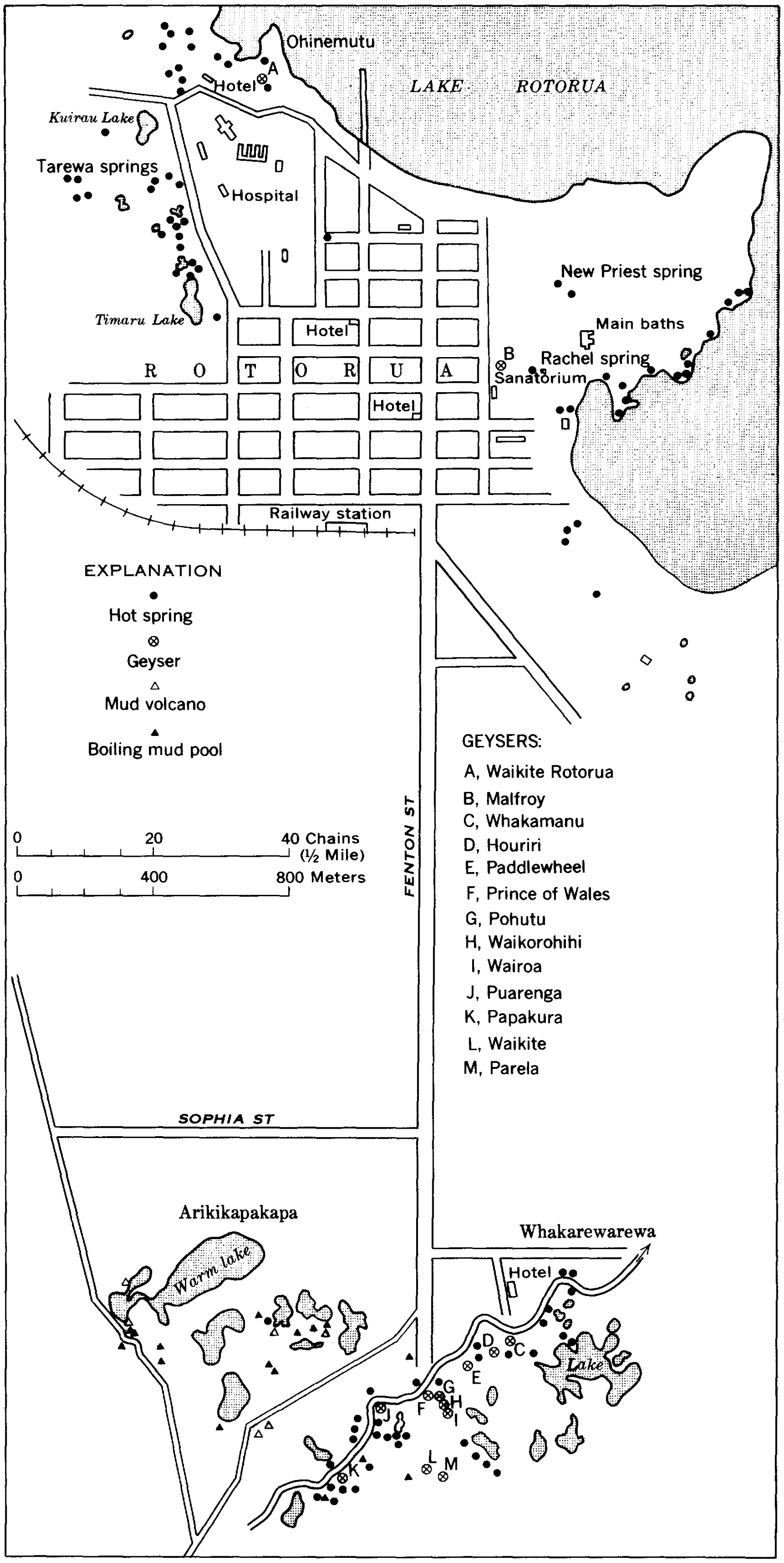

FIGURE 79.—Rotorua and Whakarewarewa districts, New Zealand, showing main springs and geysers. From ref. 3583.

Thermal springs and wells in New Zealand—Continued

No. on fig. 77	Name or location	Temperature of water (°C)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
20	Okauia, on banks of small stream.	40–41	[2] 664	SiO_2 (127); Na (179); HCO_3 (600); Cl (25).	Tertiary strata, probably faulted.	Several springs; largest flows 20 imperial gpm. Ref. 3613.
21	Matamata, on banks of small stream.	41–43			----do	Several springs. Ref. 3651.
22	Okoroire, on banks of Waihou River.	[1] 45			Volcanic tuff	Largest spring (temperature 36.6°C) flows 750 imperial gpm.
23	White Island				Andesite	Many springs of hot acid water; also steam jets, mud geysers, and many acid fumaroles. Water from 1 spring contains 10 percent mixed hydrochloric and sulfuric acids. Fumarole gases include HCl and SO_2. Large deposit of sulfur. Refs. 20, 3554, 3559, 3569, 3572, 3581, 3594, 3601, 3603, 3611, 3632, 3633, 3655, 3662, 3364, 3666.
24	West part of Whale Island	[1] 98			----do	1 small spring; also several sulfurous fumaroles. Deposit of siliceous sinter. Refs. 3594, 3635.
25	Beach west of Kawhia	Hot			Faulted Tertiary strata	Several springs between tide limits. Water is strongly saline; probably mixed with sea water.
26	Taheke, at head of two ravines	42–100	1,241	SiO_2 (322); Al (46); Ca; Na; SO_4.	Rhyolite (Pliocene to Recent).	Several springs and small fumaroles. Analytical data for water having temperature of 50°C. Bathing resort.
27	Tikitere, near Lake Rotoiti	54–90	962	SiO_2 (110); Na (27); SO_4 (691); NH_4 (55).	----do	Several groups of springs and boiling mud pots in area 1.5 by 2 miles. Analytical data for water from Devil's Bath (temperature 54°C). Water from one spring contains 16,340 ppm of SO_4. Deposit of sulfur. Refs. 3642, 3655, 3668.
28	Waitangi, between Rotoma and Rotoehu Lakes. [3]	49	1,117	SiO_2 (182); Na (304); HCO_3 (278); SO_4 (49); Cl (365).	----do	Flows 500 imperial gpm. Also several smaller springs; water temperature 40–50°C. Ref. 3668.
29	Near Tarawera River	50–82			Faulted rhyolite (Pliocene to Recent).	Several groups of springs issuing along line 5 miles long. Water from springs near river is alkaline, that from springs on higher ground is acidic. Ref. 3668.
30	Awakeri, near north base of Mount Edgecumbe.	58	888	Na (155); SO_4 (253); Cl (112); H_2SiO_3 (437).	----do	2 small springs. Analytical data for water from Pukaahu spring. Ref. 3635.
31	Whakarewarewa, near south end of Lake Rotorua. [4]	50–100	1,309	SiO_2 (319); Na (256); HCO_3 (317); SO_4 (55); Cl (337).	----do	Several geysers, including Pehuta, Waikiti, and Wairoa, and many other springs; also many wells and mud pots. Analytical data for water from Waikiti geyser. Water from Rachel spring (flow, 70 imperial gpm, temperature 85°–93°C) is alkaline; water from many springs near lake shore is acid. Water from wells is used for heating and other domestic purposes, but it corrodes pipes and plumbing fixtures. Bathing resort. Deposit of siliceous sinter. Refs. 20, 3547, 3550, 3554, 3555, 3557, 3558, 3560, 3561, 3570, 3579, 3582, 3585, 3586, 3600, 3601, 3610, 3621, 3623, 3634, 3639, 3642, 3643, 3647, 3648, 3655, 3660, 3668, 3675, 3677.
32	Near Lake Rotomahana [3]	50–100	3,240	SiO_2 (741); Na (737); SO_4 (297); Cl (1,250).	----do	Many hot springs, hot pools, and steam vents. Combined flow, exceeding 1,000 imperial gpm, maintains Lake Rotomahana in crater of Tarawera volcano. Eruption occurred on June 10, 1886, when opening fissure intersected former Lake Rotomahara. Famous Pink and White Terraces and the geysers which formed them were destroyed by eruption. Violent hydrothermal activity continued for several months after eruption. Waimangu geyser appeared in 1900 and erupted intermittently until 1908, sometimes throwing column of mud and water to height of 1,200 ft. In 1929, gas at site of geyser was 92 percent CO_2 and 8 percent N_2. Refs. 3546, 3549, 3570, 3573, 3585, 3611, 3621, 3624, 3627, 3642–3645, 3650, 3652, 3655–3657, 3663, 3665–3668, 3673.
33	Paeroa area: [3]					
	Northern group	67–91	[2] 753	SiO_2 (115); Na (169); HCO_3 (288); Cl (103).	----do	Several springs along a fault. Water from each is of chloride type.
	Southern group	60–100			----do	Several mud pots and fumaroles along same fault as Northern group. Te Kopia fumarole is large steam vent. Water from each is of acid sulfate type.
34	Waiotapu Valley [3]	41–100	4,156	SiO_2 (448); Na (1,215); SO_4 (119); Cl (1,990).	Rhyolite tuff and breccia	Several springs. Analytical data for water of Champagne Pool (temperature 73°C). Refs. 3587, 3611, 3642.
35	Orakei Korako, on banks of Waikato River. [3]	60–100	1,606	SiO_2 (428); Na (366); HCO_3 (289); SO_4 (97); Cl (358).	Faulted rhyolite (Pliocene to Recent).	Several springs and fumaroles. One spring, the Terrace geyser, boils continuously, throwing water to height of 12 ft. Analysis is for water in Blue Pool. Refs. 3582, 3621, 3640, 3642, 3655, 3672.
36	Ohaki, near Waikato River	60–100	3,309	SiO_2 (305); Na (926); HCO_3 (769); Cl (1,049); B_2O_3 (94).	----do	Several alkaline springs in area 0.25 mile square. Analytical data for water from boiling pool. Small deposits of siliceous sinter.

See footnotes at end of table.

Thermal springs and wells in New Zealand—Continued

No. on fig. 77	Name or location	Temperature of water (°C)	Total dissolved solids (ppm)	Principal chemical constituents	Associated rocks	Remarks and additional references
37	Wairakei, 6 miles north of Lake Taupo.[3]	60–100	3,856	SiO_2 (304); Na (1,244); Cl (2,003).	Rhyolite (Pliocene to Recent), probably faulted.	Many geysers, one called "Lightning," and boiling springs for nearly 0.5 mile along a stream and along fault near Mokai. Deposits of siliceous sinter. Bathing resort. Refs. 3552, 3582, 3585, 3586, 3598, 3599, 3623, 3668, 3669, 3670, 3675.
38	Rotokawa (Rotokaua), near north shore of small lake.[3]	60–100	2,816	SiO_2 (398); Na (555); SO_4 (962); Cl (729); much gas.	do	Several springs in area of 1 square mile. Analytical data for boiling spring. Deposit of sulfur. Bathing resort. Refs. 3592, 3611, 3675.
39	Waiora, near head of valley	60–100	1,746	SiO_2 (318); Na (428); SO_4 (189); Cl (718).	do	Several springs and fumaroles. Karapiti fumarole is large steam vent. Analytical data for boiling spring. Refs. 3582, 3621, 3642, 3661, 3675.
40	Taupo, beside Waikato River[3]	35–100	2,329	SiO_2 (176); Na (820); Cl (1,256)	do	Many springs. Analytical data for Crow's Nest geyser. Deposits of siliceous sinter. Bathing resort. Refs. 3552, 3582, 3623, 3641, 3643, 3655.
41	Te Puia	[1] 65.5	[2] 14,000	SiO_2 (53); $Ca(HCO_3)_2$ (104); $CaCl_2$ (2,194); NaCl (11,522).	Faulted shale and limestone (Upper Cretaceous).	Several springs. Bathing resort. Refs. 3636, 3654.
42	South end of Lake Taupo:[3]					
	Near and at Tokaanu	60–100	6,623	Na (2,182); Cl (3,410); B_2O_3 (318).	Tertiary andesite	Geyser, several other springs, and test wells. Analytical data for geyser. Bathing resort. Refs. 3559, 3566, 3593, 3594, 3621, 3642.
	Waihi, 2 miles west of Tokaanu.	Hot	High	Na, SO_4	Faulted Tertiary andesite	Several springs and fumaroles in an area of steaming ground. Ref. 3584.
43	Ketetahi, on north flank of Tongariro volcano.	60–100	2,805	Ca (80); Na (60); SO_4 (1,548); NH (276); H_2SiO_3 (373); HBO_2 (612).	Andesite	Hot springs, boiling pools, and fumaroles in area about 800 ft square. Analytical data for water having temperature of 70°C. Refs. 3570, 3584, 3611, 3621.
44	Tarawera, on east margin of volcanic plateau.	Hot		Na, Cl	Andesite near fault	Several small springs. Water contains considerable I. Refs. 3586, 3643, 3666.
45	Morere (Nuhaka), in stream valley.	49			Shale and sandstone (Cretaceous), probably faulted.	Water is strongly saline. Gas is 84 percent CH_4, 16 percent N_2. Refs. 3573, 3616.
46	Maruia, on gravel plain of Maruia River.	[1] 60	598	SiO_2 (51); Na (165); HCO_3 (139); SO_4 (51); Cl (152); free H_2S.	Faulted graywacke (Triassic).	Several springs having combined flow of 10 imperial gpm. Refs. 3609, 3611, 3651.
47	Near Lewis River	Warm			do	Ref. 3565.
48	Hanmer, near south base of Kaikoura Mountains.	40–55	[2] 1,185	Na (379); HCO_3 (196); SO_4 (19); Cl (483); HBO_2 (200); gas 96.5 percent CH_4.	do	8 main springs and 1 well 300 ft deep. Combined flow, 50 imperial gpm. Analytical data for water from well. Bathing resort. Refs. 3573, 3589, 3590, 3604, 3611, 3626, 3642.
49	Huruni River (Hot Spring Creek).	Warm			do	Ref. 3565.
50	Bank of Huruni River, near Lake Sumner.	34	265	Na, Cl	Triassic strata, probably faulted.	Large flow. Ref. 3627.
51	Upper Haupiri River Valley	Hot			do	Several springs. Ref. 3651.
52	Near Otehaka River	Warm			do	Small flow. Ref. 3565.
53	Near Otira River	30.5	180	Na, Cl	do	Do.
54	Frazer, on east bank of Taipo River.	82	330	SiO_2 (91); Na; K; SO_4; Cl; dissolved H_2S (34).	Triassic(?) strata	Small deposits of sulfur and siliceous sinter. Ref. 3651.
55	Cedar Flat, near Toaroha River.	71	440	SiO_2 (104); Na; K; Cl; SO_4 (295); dissolved H_2S (27).		Large flow. Strong odor of H_2S. Refs. 3565, 3649.
56	Near Kokatahi River	[1] 71		Na, Cl	Mesozoic or Paleozoic strata	Several springs for several miles along the river valley. Small deposits of sulfur and siliceous sinter. Ref. 3651.
57	Mungo River Valley, near mouth of Brunswick Creek.	65			do	3 springs having combined flow of 3 imperial gpm. Refs. 3565, 3649.
58	Near Wanganui River ferry	Warm			do	Several small springs. Free H_2S. Refs. 3565, 3649.
59	Banks of Wanganui River	38	640	Ca, Na, SO_4, Cl; free H_2S	do	2 main springs having combined flow of 100 imperial gpm. Free H_2S. Small deposit of silica. Ref. 3649.
60	Along Hot Spring Creek near junction with Wanganui River.	38	340–600	Ca, Na, SO_4, Cl	do	Several small springs; temperature and flow vary with the season. Ref. 3649.
61	Bed of Wataroa River	65			do	Large flow. Free H_2S. Refs. 3565, 3659.
62	Near upper Waiho River:					
	Hans spring	Warm	800		do	Also other small springs.
	Drilled well	Warm	1,560	Na, HCO_3, Cl	do	
63	Along upper Fox River	Warm	1,130	Na, HCO_3, Cl	do	Several springs. Analytical data for spring having largest flow.
64	Along upper Copeland River:					
	Several small springs	Warm			do	Small flow.
	Welcome Flat	Hot	2,033	SiO_2 (52); Ca (47); Na (237); HCO_3 (566); Cl (81).	do	Large flow.
65	Banks Peninsula, from Heathcote Valley (3 miles north of Lyttelton) to 10 miles southwest of Lyttelton.	21–28	450	Ca $(HCO_3)_2$ (87); $NaHCO_3$ (73); NaCl (260).	Upper Tertiary volcanic rock.	Small springs at Lyttelton tunnel, Cass Bay, Rapaki, Motukahara, and in Heathcote Valley. Refs. 3565, 3629.
66	Timaru	21			Pleistocene(?) lava	Shallow well. Used for domestic purposes and irrigation. Ref. 3565.
67	50 miles southwest of Timaru	51–68				Water is sulfurous. Used for bathing. Ref. 3570.

[1] Maximum. [2] Hottest. [3] See also fig. 78. [4] See also figs. 78, 79.

PHILIPPINE REPUBLIC

The Philippine Republic includes 11 main islands, which form about 92 percent of the total area of the group; 20 others of about 100 to 700 square miles each; and more than 3,000 smaller islands, most of them less than 1 square mile in area. Nearly all the larger islands are mountainous, and the principal ranges trend north-south to northeast-southwest.

Part of the Eastern Cordillera of Luzon Island is of crystalline rocks and schist flanked by intensely folded Tertiary sedimentary strata. The Central Cordillera in the northern part of Luzon forms a belt of granite and diorite with some andesite and dacite. Farther west is a range of pre-Tertiary volcanic flows and intrusive rocks flanked by folded sedimentary strata. The Cagayan Valley is a region of folded Tertiary sandstone and shale, and Miocene coral limestone is present in some places at an altitude of as much as 4,000 feet. Basalt and andesite of Tertiary to Recent age cover large areas, especially in southern Luzon.

Schist is exposed in the northern part of Mindoro Island, but the principal mountain is of andesite. The long, narrow island of Palawan, farther southwest, has a core chiefly of schist with some plutonic and extrusive rocks. Several prominent peaks are probably volcanic.

In the central part of the Philippine group, Masbate Island consists of pre-Tertiary sedimentary strata, with diorite intrusives and later mafic volcanic rocks, and extensive areas of marine Miocene deposits. Samar is underlain largely by Tertiary sedimentary strata. Leyte also is composed chiefly of Tertiary strata, but it has a central volcanic range. Panay has a main range that is chiefly andesitic, with some pre-Tertiary sills of diorite; but most of the island is covered by marine Tertiary beds. The axial range of Negros is largely of sedimentary and metamorphic rocks, but there are some volcanic areas in the north and the extreme south. On Cebú and Bohol, pre-Tertiary schist is overlain by folded marine Tertiary strata.

Mindanao Island has ranges and plateaus of andesite and basalt, and several volcanic cones. The southwestern part of the island is largely of marine Tertiary strata covered in places by lava flows.

About 20 volcanoes in the Philippines are classed as solfataric, and nearly 30 other volcanic cones seem to be extinct (ref. 3689). The volcanoes of northern Luzon, and of Babuyan Claro and other small islands off the north coast, are in nearly straight alinement. Other volcanoes are in southern Luzon, Negros, Mindanao, the small island of Camiguin off the north coast of Mindanao, Basilian (extinct), and Jolo in the far southwest.

Most of the thermal springs in the Philippines issue from lava on or near volcanic cones, some of which are still solfataric; but a few springs issue from granite or other types of rock, probably along faults.

Little detailed information on the thermal springs seems to be available. Their locations are shown on figure 80, and published information is summarized in the table below.

Thermal springs in the Philippine Republic

[Data chiefly from refs. 3689, 3698, 3703, 3714. Principal chemical constituents are expressed in parts per million]

No. on fig. 80	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
1	Babuyan Claro Island					Steam vents and steam explosions near two volcanic craters. Refs. 3700, 3709.
2	Didicas Island					Solfataric volcano in main part of island. Probably some fumaroles. Refs. 3687, 3708.
3	Camiguin de Babuyanes					Hot springs and solfataras on west flank of volcano. Deposits of sulfur. Refs. 83, 3689, 3699, 3708.
4	Mount Cagua					Fumaroles on flank of volcano. Refs. 3699, 3708.
5	Danglas (Ilocos Sur)	Hot		2,114		Several springs. Ref. 3701.
6	Pideng, near Villa Vieja	39				
7	Tiagan	Hot				Several springs.
8	Cabab, near Lepanto	56.2				
9	Quentiang, near Amamasan	56.2				
10	Dilong, near Madileg	66				
11A	15 km north of Lubuagan:					
	Crater of Ambalatungan volcano	Hot				Many springs and hot gas jets. Deposits of sulfur. Ref. 3688.
	Craters of Bumbag volcano	Hot				Many springs and hot gas jets. Ref. 3688.
	Crater of Podakan volcano	Hot				Strong jet of steam. Ref. 3688.
11	Balotoc, or Mainit (Mayinit), 10 km east of Lubuagan.	Boiling	Large	2,113	SiO_2 (195); CaO (128); Na_2O (457); CO_3 (208); SO_4 (295); Cl (750).	Salt workings. Refs. 3696, 3702.
12	Cervantes, on Rio Abra	56		1,700		Issues from andesite. Refs. 3702, 3717.
13	Comillas	50			HCO_3 (70); SO_4 (200); Cl (360)	Do.
14	Bugias	45–60	200	10,800	HCO_3 (708); SO_4 (270); Cl (5,000)	4 springs. Analytical data for spring having temperature of 60° C and flowing 40 liters per minute. Water from other springs is less highly mineralized. Ref. 3702.

Thermal springs in the Philippine Republic—Continued

No. on fig. 80	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
15	Asin, near Daklan	65	Small		HCO_3 (378); SO_4 (78); Cl (4,700)	Water strongly saline; highly radioactive. Ref. 3702.
16	Salvadora	70 (max)				Several springs.
17	Badukbuk	70			Fe (450); SO_4 (3,000); Cl (420)	Solfatara. Temperature and analytical data are for condensed vapor. Water is highly radioactive. Ref. 3702.
18	Daklan	60.5				
19	Asin sitio (Tukukan?)	52	Small			Water is very saline.
20	Orioung	Hot				
21	Balongabong, on west bank of Bued River.	50				
22	Klondike, 25 km northwest of Lubang	55 (max)	Large	1,520	SiO_2 (41); Ca (134); Na (388); SO_4 (349); Cl (588).	Refs. 3702, 3717.
23	Meabe, near Rio Sili	86				
24	Itogon	40–60			HCO_3 (410); SO_4 (350); Cl (650)	Several springs issuing from andesite. Analytical data for hottest water. Refs. 3702, 3717.
25	Salinas, 25 km southwest of Bayambang.	31.3				Water very saline. Salt workings. Ref. 3696.
26	Napundut, Balingao	45				
27	Sapang Mainit	43				
28	Canan, near O'Donell	55–58				Several springs.
29	Balong Anito	38		4,200		
30	Dinalupihan	Warm		1,900		
31	Tibio	Warm		680; 2,200		2 springs.
32	San Jose Mainit	48				
33	Cardona	Hot				
34	Lubo	40–51				Several springs.
35	Galas	35				
36	Bumbungan	31				Water used for bathing.
37	Apasan	39				
38	Pansol:					
	No. 1	43–47	Large	850	SiO_2 (135); Ca (39); HCO_3 (256); SO_4 (37); Cl (250).	Refs. 3680, 3717.
	No. 2	44.5				
39	Los Baños: At base of Mount Maquiling	70	20	1,440	SiO_2 (220); Ca (40); HCO_3 (270); SO_4 (30); Cl (500).	Water is radioactive. Refs. 3680, 3689, 3690, 3705, 3708, 3717.
	Aguas Santas	38				Water is radioactive. Resort. Ref. 3690.
40	Binobusan	37.5				
41	Crater of Taal volcano in Bombon Lake.	Boiling			Na (2,584); SO_4 (2,732); Cl (6,024).	Lake, 1 km in diameter. Site of Yellow and Green Lakes before eruption in 1911. Refs. 20, 3685, 3689, 3693, 3705, 3708, 3712.
42	Anos, near San Pablo	40				Also several other springs nearby. Water is radioactive. Ref. 3717.
43	Mount Banajao					Solfataric volcano. Probably some fumaroles.
44	San Emilio	48–60		1,800		
45	Lanot, on west shore of San Miguel Bay.	Warm				Water is ferruginous. Much free CO_2. Resort. Ref. 3684.
46	Manito (Maniti)	Hot				Several springs. Ref. 3684.
47	Punta Mainit	41–56		505		Do.
48	Lalo	37				
49	Jigabo	40–100				Several springs.
50	North of Mayon volcano:					
	Tiui, in bed of Naga stream	52		129		Free H_2S. Water used for bathing. Refs. 3684, 3689, 3701.
	Naglagbong	100				Maintains pool 20 meters in diameter. Free H_2S. Deposit of siliceous sinter. Refs. 3684, 3689.
51	Tancalao, near east base of Mayon volcano.	Hot				Also solfataras. Refs. 3689, 3708.
52	Irosin, or Monbon, 5 km north-northwest of Irosin.	Warm				Free CO_2.
53	Bujan, or Bulusan, near east base of Bulusan volcano.	44.5			HCO_3, Cl	Water is ferruginous. Also solfataras. Ref 3708.
54	Puerta (Punta?) Galera, northwest of Calapan.	Hot		5,878	Na, HCO_3, SO_4	Several hot springs. Resort. Ref. 3701.
55	East border of Lake Naujaun (Naujan)	Hot				Several springs and solfataras. Ref. 3712.
56	Near Gasang, on southwest coast of Marinduque Island.	Hot		1,178	Ca, Na, HCO_3	
57	Villa Hermosa, on west coast of Samar Island.	Hot		450; 750		2 springs.
58	Billirán Island:					
	East side of Guinón volcano	42				Several springs near sulfur mines. Refs. 3679, 3689.
	Cajúcao, on west side of Guinón volcano.					Solfataras and fumaroles. Deposit of sulfur. Refs. 3679, 3683, 3689.
59	North end of Leyte Island	Hot	Small			Water is sulfurous. Ref. 3683.
59	Mount Ogris	Hot	Small			Do.
60	Mount Himalacagan (Manacagan), near Burauen.	37.5				Flows of several springs combine to make stream 12 ft wide. Deposits of sulfur and siliceous sinter. Also Kasiboi (Casiboy) solfatara. Refs. 3683, 3689.
61	Mount Danán, near Kasiboi (Casaboy) volcano.	63 (max)				Several springs. Also To-od and Pangujaan solfataras and several fumaroles.
61	East slope of Mount Cabalian	Hot				Ref 3683.
62	Palawan Island:					
	Alivancia volcano					Solfataras and fumaroles.
	Talasquin volcano					Do.
63	Near Apdo, on Panay Island	48.9		10,500		Water is strongly saline.
64	Palimpinon	Hot		6,025		Several springs. Water is saline.
65	Mambucal, on northwest slope of Canlaon, or Malaspina, volcano.	39		460		Water used for bathing.
65	Mambajao, on southwest slope of Canlaon, or Malaspina, volcano.	Hot				
66	Guiguingan	Warm		595	$Ca(HCO_3)_2$; NaCl	Several springs.

Thermal springs in the Philippine Republic—Continued

No. on fig. 80	Name or location	Temperature of water (°C)	Flow (liters per minute)	Total dissolved solids (ppm)	Principal chemical constituents	Remarks and additional references
67	Near Isabella	Warm	Small			Water is sulfurous.
68	Dumaguete, in gorge of Okio River	Hot		4,600		
	Near Bacong					Small solfatara.
69	Canlaon volcano, or Mount Silay					Fumaroles and solfataras. Deposits of sulfur. Ref. 3689.
70	Tabogon	Hot				Several springs. Water is sulfurous.
71	Aguas Calientes	Warm				Several springs on shore between high and low tides.
72	Candaguit	36.5				
73	Naga Mainit	34.5 (max)				2 main springs.
74	Tagbag, or Bolocboloc	33				
75	Guadalupe	34.2				1 main and several small springs.
76	Moulboal	Warm	2,000			Several springs.
77	Alegria, near Casipitan	47.5–63.5				Do.
78	Oslob Mainit	35; 35.8				2 main springs.
79	Tanon Mainit	36.2				
80	Southwest base of Catarman volcano on Camiguin Island.	63 (max)		5,720		Several springs near shore. Water is strongly saline. Refs. 3686, 3708–3710.
81	Near north border of Lake Mainit	Warm	1,700			Refs. 3691, 3706, 3712.
82	Balian, near coast 8 km north of mouth of Sibugeuy River.	Warm				Several springs. Ref. 3691.
83	Near coast 16 km south of mouth of Sibuguey River.	Warm				Do.
84	Ragang, or Macaturin, volcano					Sofataras and probably fumaroles. Ref. 3708.
85	Cotabato	38				
86	Apo volcano:					
	East side 300 meter below summit					Several large solfataras. Refs. 3689, 3708.
	Southeast slope	Hot				Jetting springs and fumaroles. Water is sulfurous. Ref. 3689.
87	Near extinct volcano on Basilan Island	Hot				Several springs.
88	Near Candasubig on Jolo Island	34 (max)				Several springs issuing from volcanic rock. Also solfataras.
89	Balut Island:					
	Northwest coast	Hot				2 springs. Ref. 3715.
	Crater of Sanguil volcano					Steam vents? Ref. 3715.

SAMOA

The main islands of the Samoan group lie about 500 to 700 statute miles northeast of the eastern part of the Fiji group, as indicated on figure 72. The islands are composed almost entirely of volcanic materials, although they are partly surrounded by coral reefs. The main islands are recognized to be on a great fracture zone. Hot springs do not seem to be specifically mentioned in the literature concerning the islands, but according to Jensen (ref. 3718), large fumaroles emitting steam and acid vapors have accompanied volcanic eruptions on Savaii Island, the largest of the group. It seems probable that at some periods between the eruptions, hot springs, solfataras, and other manifestations of thermal activity may be present.

SOLOMON ISLANDS

The Solomon Islands form a double chain of about a dozen main islands and many smaller ones, which extend from 100 to 600 statute miles southeastward from the Bismarck Archipelago, as shown on figure 72. Bougainville, near the northwest end of the group, is the largest island. Its highest mountain rises above 10,000 feet altitude. All the large and some of the smaller islands of the Solomons seem to be of volcanic rock coated with uplifted coral reefs along the coast. Other small islands seem to be entirely of coral limestone, but this rock probably overlies volcanic rock.

Data on hot springs and other thermal activity on several of the islands are given in the following table.

Thermal springs in the Solomon Islands

[Data from refs. 3719, 3720]

No. on fig. 72	Name or location	Temperature of water (°C)	Remarks
1	Mount Bogana, on Bougainville Island.		Probably solfataras and fumaroles.
2	Simbo (Zimboa?) Island:		
	Crater of volcano	70–98	Several springs.
	Side of crater	70–92	Fumaroles exhaling H_2S and SO_3. Heat used for cooking.
	Border of lagoon in south part of island.	78	Several springs and fumaroles.
	Near east coast	Hot	Issue below low-tide level.
3	Vella Lavella Island		Fumaroles. Deposits of sulfur.
4	Narovo (Eddistone) Island		Solfataras and many fumaroles.
5	Savo Island, near northwest end of Guadalcanal Island.	Hot	Several springs near shore and on beach.

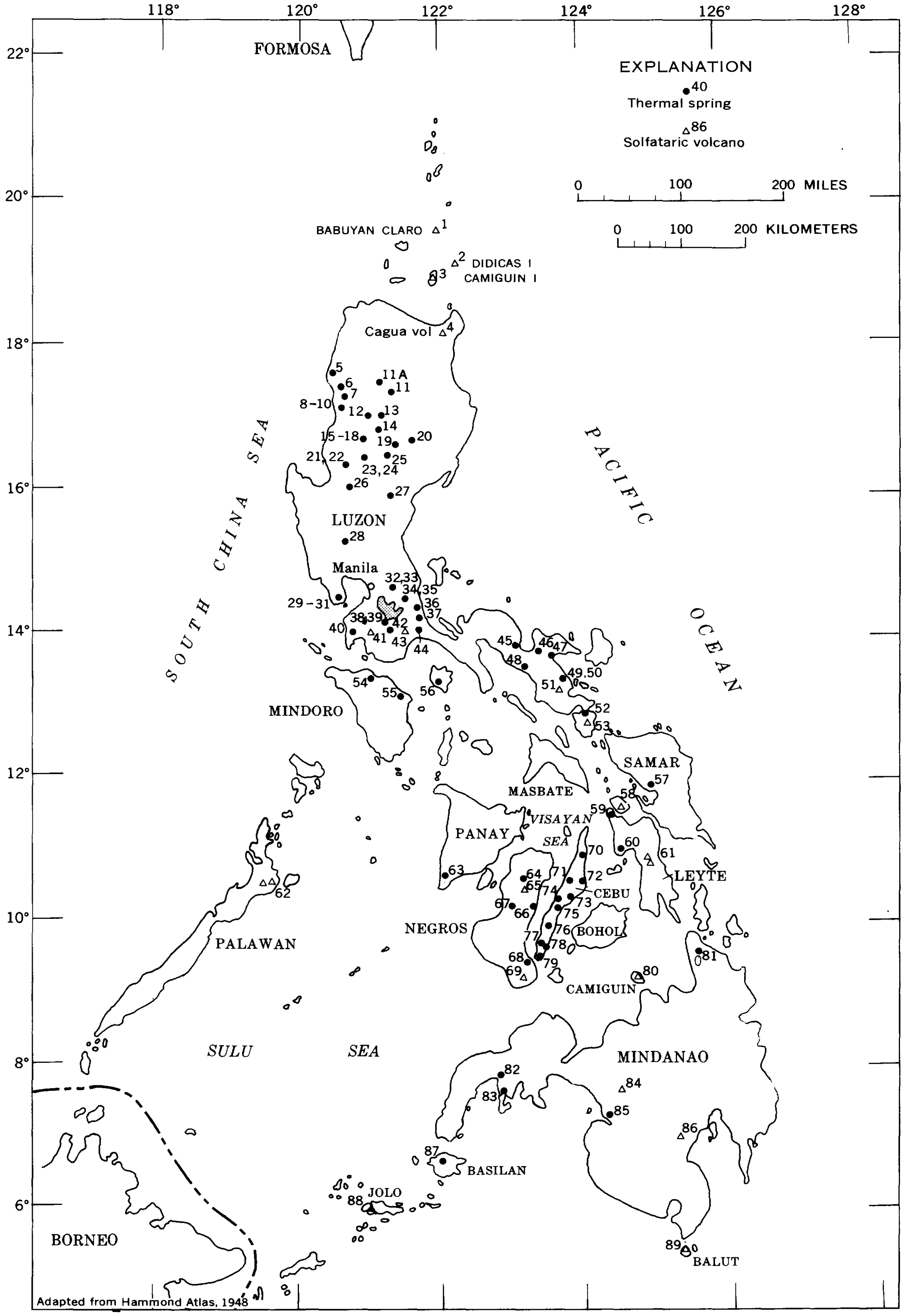

FIGURE 80.—Philippine Republic showing location of thermal springs and principal volcanoes (all solfataric). Springs chiefly from ref. 3698; volcanoes from ref. 3689.

SUMATRA

A chain of high mountains that rise steeply from the southwest coast extends throughout the length of Sumatra. Their northeastern slopes descend more gradually to broad alluvial plains that border the coast on the north. Ancient gneiss, schist, quartzite, and granite intrusives form the cores of the main ranges. In the northwest these rocks are overlain by Upper Cretaceous slate and limestone; in the southeast they are overlain by steeply dipping beds of Triassic clay and sandstone and some Cretaceous sedimentary rocks. Eocene beds that have commercial coal seams are present in the central part of the island. Marine Tertiary beds cover most of the lower lands, and there are oil-bearing deposits near the east coast. In this region are also Pliocene deposits, largely covered by alluvium.

Bands of eruptive andesite extend along the lower slopes of the mountains near the southwest coast, and along the crests of the ranges are numerous volcanic cones, some of which contain lakes. About 11 mountains are considered to be active volcanoes, which occasionally throw out ash and scoria. Several others are in the solfataric stage. Although there seems to be little information available on thermal activity at and near the main volcanoes, the recorded thermal springs seem to be associated with volcanoes. Their location is shown on figure 74, and data concerning them are presented in the table below.

Thermal springs in Sumatra

[Locations of unnumbered springs not identified. All, or nearly all, springs issue from lava]

No. on fig. 74	Name or location	Temperature of water (°F)	Remarks and references
1	Bateekeubeue volcano	Hot	Fumaroles and solfataras.
2	Boer-in-Telong volcano	Hot	Do.
3	Base of Goenoeng Rate (Rati), near Natal.	Warm	1 main spring. Free H_2S.
4	Sorik-merapi volcano	Hot	Fumaroles and solfataras. Ref 83.
5	Tandikat volcano	Hot	Do.
6	Goenoeng Merapi (Gunungberapi) volcano.	Hot	Do.
7	Near Bukit-sipinang, between Goenoeng Merapi and the sea.	Hot	
8	Priangan, near Goenoeng Merapi.	Hot	Several springs called Panchuran Tujuh. Water used for bathing. Ref. 3723.
9	Flank of Maninyu volcano between Goenoeng Merapi and the sea.	102.5	Low mineral content.
10	Talang volcano	Hot	Fumaroles and solfataras.
11	Goenoeng Kerintji volcano	Hot	Do.
12	Goenoeng Soembing volcano	Hot	Do.
13	Near Tanjong village, northeast of Opu.	120–170	Several springs in marsh area 55 meters in diameter. Water is bitter, astringent. Much free H_2S. Ref. 3723.
14	Near Opu (Yepu) River	100	Several springs, combined flow fairly large. Ref. 3723.
15	Kaba volcano	Hot	Fumaroles and solfataras.
16	East base of Kaba volcano	170	Several springs. Much vapor.
17	Dempo volcano	Hot	Fumaroles and solfataras.
18	Lake Ranau, in ancient crater on north slope of Siminung Mountain.	127	
19	Margin of Pilomasin Basin, northeast of Siminung Mountain.	Hot	Several springs along a line. Much evolved CO_2, H_2S. Ref. 3728.
20	Goenoeng Radjabasa volcano	Hot	Fumaroles and solfataras.
21	Near Krakatoa volcano	Hot	Intermittent steam vents in small islands. Refs. 3721, 3726.
------	Near small river Ayer Grau (Abu).	Hot	Springs bubbling up at several places. Ref. 3723.
------	Near Padang-baru, 1 km south of Bondjol.	Warm	Ref. 3524.

TONGA ISLANDS

The Tonga Islands (Friendly Islands) consist of a north-south-trending chain of many small islands about 200 to 600 miles south of the Samoan group, as indicated on figure 72. Most of these islands are low and of coral formation, but in the northern half of the chain are several high islands of volcanic origin. Some of the islands are of submarine volcanic tuff penetrated by dikes of andesite and diabase. Several of the islands have active volcanoes, and a zone of volcanic activity is recognized as passing along the west side of the northern part of the chain.

Niuafoou Island [Good Hope Island on some early maps] is the northernmost in the chain. It was described by Jaggar (ref. 3729) as being a volcanic crater about 3 miles in diameter, with a central lake of fresh water whose surface was 70 feet above sea level. The crater erupted lava in 1853, and had a great steam-blast eruption in 1886. There were eruptions also in 1912 and 1929. Jaggar does not specifically mention hot springs, but at Niuafoou and other active volcanoes in the Tonga Islands there may be hot springs and fumaroles. [The crater of Niuafoou erupted again in 1946, after which it was reported that all native residents moved to other islands.]

VOLCANO ISLANDS

The Volcano Islands form a group of four small islands about 4,000 statute miles west of Honolulu, as shown on figure 72.

Iwo Jima (Iō-sima, or Sulphur Island) is the largest in the group. It is 5.2 miles long and is formed of two volcanic mountains connected by an isthmus of lowland. It was well known during World War II as a Japanese stronghold. The geology and petrography of the island were studied by Tsuya (ref. 3731), and the geology and water resources were described by Swenson (ref. 3730). The northern highland is almost entirely of volcanic tuff. Mount Suribachi at the south end is of andesite overlain by cinders and scoria. The intervening lowland is of loose volcanic ash and cinders.

There are many fumaroles on Iwo Jima. According to Swenson (ref. 3730), they are especially numerous in the crater of Suribachi, on the west beach, and in a belt extending northeasterly across the center of Moto Mountain. Swenson also reports that military-supply wells drilled to sea level in the central lowland yielded warm to hot water.[8]

[8] A volcano on Guguan Island, farther south, was reported to emit vapor from many openings (Fuchs, ref. 43).

ANTARCTIC REGION
(Balleny Islands, Ross Island, and South Shetland Islands)

The Balleny Islands, about 1,500 statute miles south of New Zealand, are a volcanic group. (See figs. 1, 81.) According to Fuchs (ref. 43), the volcano on Bukle Island was emitting vapor from many openings when the islands were discovered in 1839.

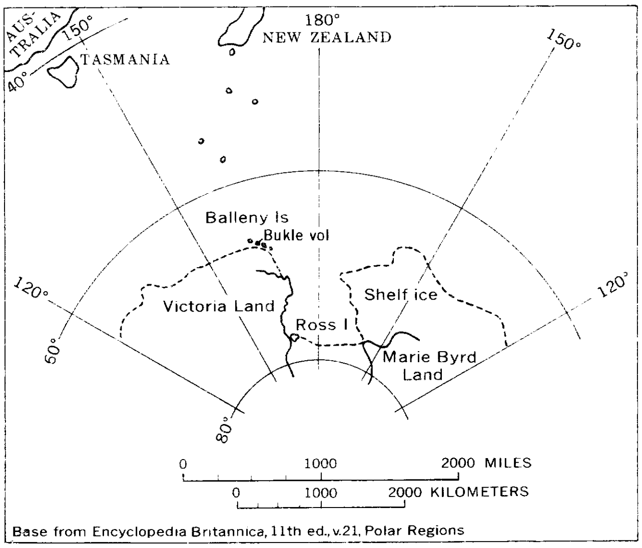

FIGURE 81.—Part of the South Polar region showing location of Balleny Islands and Ross Island.

Ross Island, in the Ross Sea about 2,200 miles south of New Zealand, is volcanic. (See figs. 81, 82.) Sir Ernest Shackleton (ref. 3733) states that Ross Island is formed of four large volcanic cones, those of Mounts Bird, Erebus, Terra Nova, and Terror. The last three seem to be on an west-east fault, and probably another fault passes through Mount Bird and Mount Erebus. The latter stands as a sentinel at the base of the Great Ice Barrier. From the side of its main crater rises an active cone, generally giving off steam and other vapors. Ice mounds are formed by the freezing of vapor from many fumaroles. The greatest steam eruptions come from a locality between the cones of Mount Bird and Mount Erebus.

The South Shetland Islands, about 500 miles south-southeast of Cape Horn, are volcanic. (See fig. 1.) Fuchs (ref. 43) states that a volcano on Deception Island often emits steam and other vapors from many openings.

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The first group of references in the following bibliography consists of 119 titles arranged alphabetically by author. Most of these contain information on the physical and chemical conditions under which thermal springs may occur and (or) on thermal activity in general.

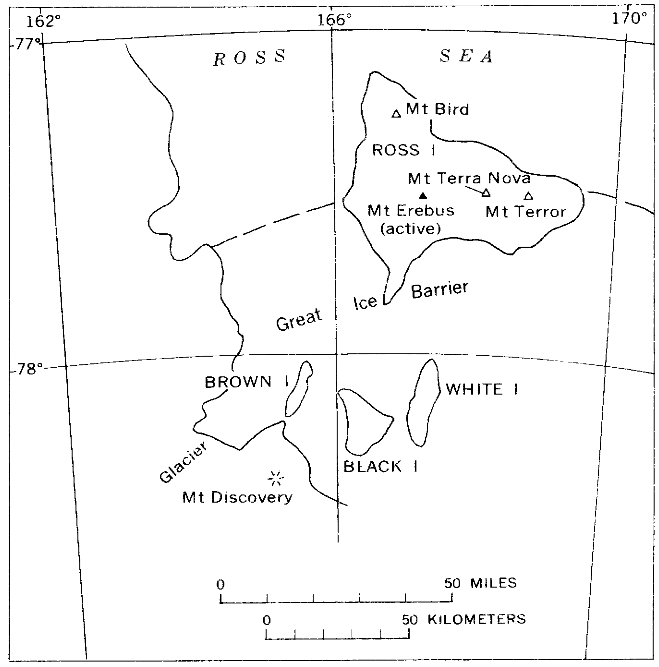

FIGURE 82.—Ross Island area, Antarctica, showing location of volcanic mountains. From ref. 3733.

Also included in the first group are a few references that contain information on several specific springs or volcanic areas which are so widely separated geographically that placement of the references under a geographic heading was not feasible. References 26–28, 30, 43, 73, and 105 fall in this latter category. The other 3,614 references in this bibliography are grouped according to the geographic areas or countries to which they pertain. As in the first group, the references under the geographic headings are arranged alphabetically by author.

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Describes some of the fumaroles.

163. 1918b, The eruption of Katmai: Nature [London], v. 101, no. 2547, p. 497–499, 4 figs.
Mentions fumaroles in the Valley of Ten Thousand Smokes.

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177. **Underwood, John Jasper,** 1913, Alaska; an empire in the making: New York, Dodd, Mead, & Co., 440 p., 55 illus.
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182. **Zies, Emanuel George,** 1924, Hot springs of the Valley of Ten Thousand Smokes: Jour. Geology, v. 32, no. 4, p. 303–310, 1 fig.

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185. **Boving, Adam Giede,** 1914, Notes on the larva of hydroscapha and some other aquatic larvae from Arizona: Entomol. Soc. Washington Proc., v. 16, no. 4, p. 169–174, 2 pls., 2 figs.
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186. **Bryan, Kirk,** 1925, The Papago country, Arizona, a geographic, geologic, and hydrologic reconnaissance with a guide to desert watering places: U.S. Geol. Survey Water-Supply Paper 499, 436 p., 27 pls., 41 figs.
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187. **Buehrer, Theophil Frederic,** 1927, The radioactivity of the thermal waters of Castle Hot Springs, Arizona: Am. Jour. Sci., 5th ser., v. 13, p. 445–449.

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192. **Ross, Clyde Polhemus,** 1923, The lower Gila region, Arizona, a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U.S. Geol. Water-Supply Paper 498, 237 p., 23 pls., 16 figs.
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See also references 138, 144, 328, and 667.

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197. **Bryan, Kirk,** 1922, The hot water supply of the Hot Springs, Arkansas: Jour. Geology, v. 30, no. 6, p. 425–449, 5 figs.

198. 1924, The Hot Springs of Arkansas: Jour. Geology, v. 32, no. 6, p. 449–459, 2 figs., 1 table.

199. **Cron, Frederick W.,** 1939, Mineral water at Hot Springs, Ark.: Mil. Engineer, v. 31, no. 176, p. 133–137; Chem. Abs., v. 33, no. 11, col. 4355.

200. **Cutter, Charles,** 1891, Cutter's guide to the Hot Springs of Arkansas: 28th ed., St. Louis, Mo., Slauson Printing Co., 63 p., 24 illus.; 1st ed., 1876 (?).

201. **Haywood, John Kerfoot,** and **Weed, Walter Harvey,** 1902, The hot springs of Arkansas: U.S. 57th Cong., 1st sess., S. Doc. 282, 94 p., 10 pls., 2 figs.

202. 1912, Analyses of the waters of the Hot Springs of Arkansas, and geological sketch of Hot Springs, Arkansas: Washington, Govt. Printing Office, U.S. Dept Interior, 56 p., 2 figs.

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205. **Purdue, Albert Homer,** 1910, The collecting area of the waters of the hot springs, Hot Springs, Arkansas: Jour. Geology, v. 18, no. 3, p. 279–285, 3 figs.

206. **Purdue, A. H.,** and **Miser, H. D.,** 1923, Description of Hot Springs district (Arkansas): U.S. Geol. Survey Geol. Atlas, Folio 215, 12 p., 3 maps.

207. **Schlundt, Herman,** 1935, The radioactivity of the spring waters on the Hot Springs Reservation, Hot Springs, Ark.: Am. Jour. Sci., 5th ser., v. 30, no. 175, p. 45–50, 3 tables.

208. **U.S. Dept. Interior, National Park Service,** 1950, Circular of general information regarding Hot Springs National Park, Arkansas, 16 p., 7 views, maps.

209. **Weed, Walter Harvey,** 1905, Notes on certain hot springs of the southern United States: U.S. Geol. Survey Water-Supply Paper 145, p. 185–206, 3 figs.

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210. **Wood-Seys, Roland Alexander,** 1903, Hot Springs, Arkansas; an impressionist sketch: Chicago, Rock Island and Pacific Railroad Co., 48 p., 19 illus.

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212. **Allen, Eugene Thomas,** and **Day, Arthur Louis,** 1927, Steam wells and other thermal activity at "The Geysers," California: Carnegie Inst. Washington Pub. 378, 106 p., 34 figs., map.

213. **Anderson, Charles Alfred,** 1935, Alteration of the lavas surrounding the hot springs in Lassen Volcanic National Park: Am. Mineralogist, v. 20, p. 240–252.

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217. **Angel, Myron,** 1890, San Luis Obispo County: California State Mining Bur. 10th Ann. Rept., p. 567–585, 2 pls.

Mentions Pecho hot sulfur springs and Sycamore springs.

218. **Antisell, Thomas,** 1856, Geological report on routes in California and New Mexico, *in* U.S. War Dept., Reports of explorations and surveys * * * for a railroad from the Mississippi River to the Pacific Ocean: 33d Cong., 2d sess., S. Doc. 78, v. 7, pt. 2, 204 p., 14 pls., 2 maps.

Contains information on a hot spring near Warner's Ranch in California and on Agua Caliente springs 5 miles from the Mimbres River in New Mexico.

219. **Arnold, Ralph,** 1907, Geology and oil resources of the Summerland district, Santa Barbara County, Calif.: U.S. Geol. Survey Bull. 321, 93 p., 17 pls., 3 figs.

Mentions the hot springs in Hot Spring Canyon 4 miles northeast of Santa Barbara. The geology of the vicinity of Mentecito hot springs is shown on a map .

220. **Auchincloss, Henry B.,** 1864, The Devil's Cañon [at The Geysers] in California: Continental Monthly, v. 6, no. 3, p. 280–289.

Describes the Witches' Caldron and other hot springs in Devil's Cañon. Also quotes descriptions of geysers in Iceland and hot springs in Central America and on White Island, New Zealand.

221. **Bailey, Edgar Herbert,** 1946, Quicksilver deposits of the western Mayacmas district, Sonoma County, Calif.: California Jour. Mines and Geology, v. 42, no. 3, p. 199–230, 3 figs., 2 tables.

Describes "The Geysers."

222. **Blake, William Phipps,** 1857, Geological report on routes in California, *in* U.S. War Dept., Reports of explorations and surveys * * * for a railroad from the Mississippi River to the Pacific Ocean: 33d Cong., 2d sess., H. Doc. 91, v. 5, pt. 2, 370 p., 14 secs., 14 views, 87 wood engravings, 5 maps.

Contains information on thermal springs on the flanks of the San Bernardino Mountains, between the San Bernardino Mountains and El Cajon Pass, 10 miles south of San Gorgonio Pass, in Warner's Valley; also on mud volcanoes near Salton Sea and in the northern part of Baja California.

223. 1872, Algae at the Geysers, California: California Acad. Sci. Proc., Oct. 7, 1871, Mtg., v. 4, pt. 4, p. 193–194.

Describes algae growing in the warm water of springs at "The Geysers" in Sonoma County. Mentions the abundance of algae in the water of Calistoga spring and in the water of thermal springs in Nevada.

224. **Boddam-Whetham, John Whetham,** 1874, Western wanderings; a record of travel in the evening land: London, R. Bentley & Son, 364 p., 12 illus.

Describes a visit to "The Geysers" in Sonoma County.

225. **Bradley, Walter Wadsworth,** 1918, Quicksilver resources of California: California Mining Bur. Bull. 78, 389 p., 42 pls., 77 figs.

Mentions the thermal springs at Sulphur Bank.

226. 1922, Radioactivity in thermal gases at The Geysers, Sonoma County, Calif.: California Mining Bur. Rept., v. 18, no. 10, p. 545–550, 4 figs.

227. 1946, Observations at "The Geysers," Sonoma County, Calif.: California Jour. Mines and Geology, v. 42, no. 3, p. 295–298, 2 pls.

228. **Brewer, William Henry,** 1866a, On the presence of living species in hot and saline waters in California: Am. Jour. Sci. and Arts, 2d ser., v. 41, no. 123, p. 391–394.

Describes plant and animal life in water of "The Geysers." Also mentions algae in water of the Little Geysers and of springs in Owens Valley, both in California, and of Steamboat Springs in Nevada.

229. 1866b, Note on the organisms of the Geysers of California: Am. Jour. Sci. and Arts, 2d ser., v. 41, no. 126, p. 429.

230. 1868, Notice of plants found growing in hot springs in California: California Acad. Nat. Sci. Proc., v. 3. p. 120–121.

Describes algal life in water of "The Geysers," of the Little Geysers, and of hot springs and around steam jets near Lassen Peak.

231. **Brown, John Stafford,** 1922, Fault features of Salton Basin, California: Jour. Geology, v. 30, no. 3, p. 217–226, 1 pl., map.

Mentions Palm springs and Agua Caliente springs.

232. **Brown, John Stafford,** 1923, The Salton Sea region, California, a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U.S. Geol. Survey Water-Supply Paper 497, 292 p., 19 pls., 18 figs.

Contains data on Palm springs, Fish springs, Jacumba springs, and Agua Caliente springs.

233. **Chamberlin, Blair,** 1952, Plutonian power plant ["The Geysers," Calif.]: Nature Mag., v. 45, no. 1, p. 13–16, 50, 4 views.

234. **Clarke, Frank Wigglesworth,** 1890, Report of work done in the division of chemistry and physics, mainly during the fiscal year 1887–88: U.S. Geol. Survey Bull. 60, 174 p., 9 figs.

Includes a chemical analysis of water from Matilija hot springs.

235. **Crawford, John Jones,** 1894, Report of State Mineralogist: California Mining Bur. 12th Rept. (2d Bienn.), 541 p., pls., figs.

Contains short descriptions of several thermal springs and chemical analyses of the water from 14 thermal springs.

236. 1896, Report of State Mineralogist: California Mining Bur. 13th Rept. (3d Bienn.), 726 p., pls., figs.

Contains information on 15 thermal springs and chemical analyses of the water from 5 springs at Highland Springs.

237. **Day, Arthur Louis,** 1924, Hot springs and fumaroles of "The Geysers" region, California: Jour. Geology, v. 32, no. 6, p. 459–560.

238. **Day, Arthur Louis, and Allen, Eugene Thomas,** 1924, The sources of the heat and the source of the water in the hot springs of the Lassen National Park: Jour. Geology, v. 32, no. 3, p. 178–190.

239. 1925, The volcanic activity and hot springs of Lassen Peak: Carnegie Inst. Washington Pub. 360, 190 p., 13 illus., 81 figs.

240. **Diller, Joseph Silas,** 1916, The volcanic history of Lassen Peak: Science, new ser., v. 43, no. 1117, p. 727–733, 2 figs.; repr., 1918, U.S. Dept. Interior, Natl. Park Service Pamph., 14 p.

Mentions the fumaroles and solfataras at Bumpass Hell, the Devil's Kitchen, and Tartarus (Boiling) Lake.

241. **Dun, H. H.,** 1923, Geysers harnessed to furnish power: Pop. Mechanics Mag., v. 39, no. 5, p. 705–706, 2 illus.

States that one of the steam vents at "The Geysers" has been connected to a steam engine yielding 150 horsepower.

242. **Edwards, Arthur Mead,** 1868, On the occurrence of living forms in the hot waters of California: Am. Jour. Sci. and Arts, 2d ser., v. 45, no. 134, p. 239–241.

States that diatoms were found in a sample of water from "The Geysers."

243. **Ellis, Arthur Jackson, and Lee, Charles Hamilton,** 1919, Geology and ground waters of the western part of San Diego County, Calif.: U.S. Geol. Survey Water-Supply Paper 446, 321 p., 47 pls., 18 figs.

Describes the hot springs on Warner's ranch.

244. **Everhart, Donald Lough,** 1946a, Quicksilver deposits at the Sulphur Bank mine, Lake County, Calif.: California Jour. Mines and Geology, v. 42, no. 2, p. 125–153, 8 figs., 2 tables.

Mentions the hot springs and fumaroles along faults in the vicinity of the mine.

245. **Everhart, Donald Lough,** 1946b, New geologic data at Sulphur Bank, Lake County, Calif. [abs.]: Geol. Soc. America Bull., v. 57, no. 12, pt. 2, p. 1251.
Mentions the hot springs and fumaroles in the vicinity of the mine.

246. **Fairbanks, Harold Wellman,** 1894, Some remarkable hot springs and associated mineral deposits in Colusa County, Calif.: Science. v. 23, no. 578, p. 120–121.

247. 1896, Stratigraphy at Slate's Springs with some further notes on the relation of the Golden Gate series to the Knoxville [Calif.]: Am. Geologist, v. 18, no. 6, p. 350–356.

248. **Fraser, Horace John; Wilson, Harry David Bruce;** and **Hendry, N. W.,** 1942, Hot springs deposits of the Coso Mountains: California Jour. Mines and Geology, v. 38, nos. 3–4, p. 223–242, 3 pls., 17 figs.

249. **Gist, Evalyn Slack,** 1952, Where the earth burps [Calif.]: Nature Mag., v. 45, no. 5, p. 245–247, 5 views.
Mentions mud pots, steam vents, and thermal wells on the east side of Salton Sea.

250. **Goldstone, L. P.,** 1890, Fresno County: California Mining Bur. 10th Ann. Rept., p. 183–204, 1 pl.
Describes the Fresno hot springs.

251. **Hamilton, Fletcher,** 1919, Mono County: California Mining Bur. 15th Rept., 1915–16, maps, illus.
Mentions hot springs at the travertine deposit 1 mile southeast of Bridgeport in Mono County.

252. **Hanks, Henry Garber,** 1886, Mineral springs in California: California Mining Bur. 6th Ann. Rept., pt. 1, p. 58–76.
Includes short descriptions of 31 thermal-spring localities, 28 of which have been developed as resorts.

253. **Ireland, William, Jr.,** 1888, Lake County: California Mining Bur. 8th Ann Rept., p. 324–329.
Briefly describes Anderson, Harbin, Highland, Howard Mills (Castle), Siegler, and Soda Bay springs. Contains 5 chemical analyses of water from Highland springs.

254. **Ives, Ronald Lorenz,** 1951, Mud volcanoes of the Salton depression: Rocks and Minerals, v. 26, nos. 5–6, p. 227–235, 5 figs.

255. **James, George Wharton,** 1911, The wonders of the Colorado Desert (Southern California): Boston, Mass., Little, Brown & Co., 547 p., 32 illus., 3 diagrams, 4 maps.
Contains information on Palm spring, Warner's ranch hot spring, and mud volcanoes at the south end of Salton Sea, all in California; also mud volcanoes near Volcano Lake in Baja California.

256. **Kellicott, D. S.,** 1897, An odonate nymph from a thermal spring: Cincinnati Soc. Nat. History Jour., v. 19, no. 2, p. 63–65.
Describes dragonfly nymphs in water of Amedee(?) springs.

257. **Kelly, V. C.,** and **Soske, Joshua Lawrence,** 1936, Origin of the Salton volcanic domes, Salton Sea, California: Jour. Geology, v. 44, no. 4, p. 496–509, 9 figs.
Suggests that the mud volcanoes near the south end of Salton Sea are on a buried extension of the San Andreas fault. Mentions that carbon dioxide from buried fumaroles northeast of the mud volcanoes is used for the manufacture of dry ice.

258. **Killinger, Paul E.,** 1947, Notes of Lassen Volcanic National Park: Rocks and Minerals, v. 22, no. 10, p. 912–913, 1 fig.
Describes fumaroles, boiling pools, and mud volcanoes in Bumpass Hell, also fumaroles near the top of Lassen Peak.

259. **LeConte, John Lawrence,** 1855, Account of some volcanic springs in the desert of the Colorado, in southern California: Am. Jour. Sci. and Arts, 2d ser., v. 19, p. 1–6.
Describes the mud volcanoes near the south end of Salton Sea.

260. **LeConte, Joseph,** and **Rising, W. B.,** 1882, The phenomena of metalliferous vein-formation now in progress at Sulphur Bank, California: Am. Jour. Sci., 3d ser., v. 24, no. 139, p. 23–33.
Mentions hot springs and solfataras near Clear Lake, also hot springs in the Sulphur Bank mine.

261. **Loew, Oscar,** 1876, Report on the geological and mineralogical character of southeastern California and adjacent regions, *in* Wheeler, George M., U.S. Geog. and Geol. Surveys W. 100th Mer., Ann. Rept. Chief of Engineers, app. JJ: p. 173–188, 5 figs.
Mentions a hot spring near Montan's ranch and thermal springs in Death and Panamint Valleys, in the Coso Range, and near the Blind Spring mining district, all in California. Also mentions thermal springs between Carson City and Virginia City in Nevada.

262. 1876b, Report on the alkaline lakes, thermal springs, mineral springs, and brackish waters of southern California and adjacent country, *in* Wheeler, George M., U.S. Geog. and Geol. Surveys W. 100th Mer., Ann. Rept. Chief of Engineers, app. JJ: p. 188–199.
Includes information on 11 thermal springs.

263. **McGregor, Alexander,** 1890, Mendocino County: California Mining Bur. 10th Ann. Rept., p. 311–314.
Describes Vichy and Orr's hot springs.

264. **McLeod, Edith Rutenic,** 1951a, Mud gusher: Nat. History, v. 60, no. 8, p. 379–381, 6 illus.
Describes an eruption, in 1951, of mud and hot water in Surprise Valley.

265. 1951b. Hot spring erupts in farmer's meadow: Mineralogist, v. 19, no. 10, p. 431–433.
Contains information similar to that in reference 264.

266. **McNutt, William Fletcher,** 1888, Notes on the mineral and thermal springs of California: Internat. Med. Cong. 9th, San Francisco 1887, Trans., v. 5, p. 117–125.
Contains short descriptions of 20 thermal springs and mentions 15 others. Also contains chemical analyses of 6 thermal springs.

267. **Manning, J. F.,** 1870, The Geysers of California: Lippincott's Mag., v. 6, p. 633–639.
Mentions Calistoga sulfur springs and springs at "The Geysers."

268. **Mendenhall, Walter Curran,** 1905, The hydrology of San Bernardino Valley, California: U.S. Geol. Survey Water-Supply Paper 142, 124 p., 12 pls., 16 figs.
Mentions Arrowhead, Eden, Relief, Ritchie, and Harlem hot springs, also the Urbita thermal well.

269. 1909a, Some desert watering places in southeastern California and southwestern Nevada: U.S. Geol. Survey Water-Supply Paper 224, 98 p., 4 pls.
Contains short descriptions of Agua Caliente spring in San Diego County, Figtree John's springs in Riverside County, Fish springs in Imperial County, Hot springs in Inyo County, and Paradise springs in San Bernardino County, all in California. Also mentions Manse springs

269. **Mendenhall, Walter Curran**—Continued
in Nye County, Nev., and Las Vegas springs in Lincoln County, Nev.

270. 1909b, Ground waters of the Indio region, California, with a sketch of the Colorado Desert: U.S. Geol. Survey Water-Supply Paper 225, 56 p., 12 pls., 5 figs.
Describes mud volcanoes near the south end of Salton Sea. Also mentions mud volcanoes near Volcano Lake in Baja California.

271. **Noble, Levi F., Mansfield, George Rogers,** and others, 1922, Nitrate deposits in the Amargosa region, southeastern California: U.S. Geol. Survey Bull. 724, 99 p., 35 pls., 7 figs.
Mentions Saratoga springs.

272. **Nomland, Jorgen O., and Schenck, Hubert Gregory,** 1932, Cretaceous beds at Slate's hot springs, California: California Univ., Dept. Geol. Sci. Bull., v. 21, no. 4, p. 37–49, 4 figs.

273. **Phillips, J. Arthur,** 1868, Notes on the chemical geology of the goldfields of California: London, Edinburgh, and Dublin Philos. Mag. and Jour. Sci., 4th ser., v. 36, no. 244, p. 321–336.
Mentions Sulphur springs 10 miles northeast of Borax Lake.

274. 1871, On the connexion of certain phenomena with the origin of mineral veins: London, Edinburgh, and Dublin Philos. Mag. and Jour. Sci., 4th ser., v. 42, no. 282, p. 401–413, 1 pl.
Describes Sulphur Bank in California as a solfatara. Also contains information on springs at Steamboat Springs, Nev.

275. 1877, The alkaline and boracic lakes of California: Pop. Sci. Review [London], new ser., v. 1, no. 2, p. 153–164.
Describes hydrothermal activity in several localities in California. Also states that boronatrocalcite is deposited by a hot spring in northwestern Nevada.

276. 1879, A contribution to the history of mineral veins: Geol. Soc. London Quart. Jour., v. 35, p. 390–396.
Describes hydrothermal activity at Sulphur Bank, Calif., and at Steamboat Springs, Nev.

277. **Posepny, Franz,** 1902, The Genesis of ore deposits: 2d ed., New York, Am. Inst. Mining Engineers, 806 p.; repr. in part *from* Am. Inst. Mining Engineers Trans., v. 23, p. 197–368, 1893.
Describes the mineral deposits associated with thermal springs at Sulphur Bank.

278. **Price, Thomas,** 1888, The California geysers: Tech. Soc. Pacific Coast Trans., v. 5, no. 2, p. 46–48.

279. **Rogers, Lloyd A.,** ed., 1951, Hot springs blow top; Lake City awakened by roaring eruption: [Alturas, Calif.] Alturas Plaindealer, v. 56, no. 9, Mar. 8, p. 1, 12.

280. **Ross, Clyde Polhemus, and Yates, Robert G.,** 1943, The Coso quicksilver district, Inyo County, Calif.: U.S. Geol. Survey Bull. 936–Q, p. 395–416, 4 pls.; 1942, abs., Washington Acad. Sci. Jour., v. 32, no. 9, p. 280.
Mentions the hot springs in the Coso Range.

281. **Russell, Israel Cook,** 1884, A geological reconnaissance in southern Oregon: U.S. Geol. Survey 4th Ann. Rept., 1882–83, p. 431–464, 3 pls., 10 figs.
Mentions the hot springs in Surprise Valley in northeastern California.

282. 1889, Quaternary history of Mono Valley, California: U.S. Geol. Survey 8th Ann. Rept., 1886–87, pt. 1, p. 261–394, 29 pls., 12 figs.
Contains information on Casa de Diablo hot springs, a spring on the northeast shore of Mono Lake, and springs on Paoha Island in Mono Lake.

283. **Russell, Richard Joel,** 1928, Basin range structure and stratigraphy of the Warner Range, northeastern California: California Univ., Dept. Geol. Sci. Bull., v. 17, no. 11, p. 387–496, 32 figs., map.
Mentions the thermal springs in Surprise Valley.

284. **Sanders, F. C. S.,** 1916, California as a health resort: San Francisco, Calif., Bolte & Braden Co., 300 p., 80 illus.
Contains descriptions of 28 thermal-spring resorts. Includes chemical analyses of the water from the springs in 8 of the localities.

285. **Shepherd, Forest,** 1851, Observations of the Pluton geysers [The Geysers] of California: Am. Jour. Sci. and Arts, 2d ser., v. 12, p. 153–158.

286. **Simoons, Frederick J.,** 1954, Nineteenth century mines and mineral spring resorts of Lake County, Calif.: California Jour. Mines and Geology, v. 50, no. 2, p. 295–319, 12 figs.
Mentions the resort developed at Harbin warm springs.

287. **South, Marshall,** 1947, Healing waters of Agua Caliente [San Diego County, Calif.]: Desert Mag., v. 10, no. 9, p. 4–8, 4 illus. El Centro, Calif.

288. **Switzer, George S.,** 1951, "The Geysers," Sonoma County, Calif.: Rocks and Minerals, v. 26, nos. 9–10, p. 504–509, 2 illus.

289. **Thompson, David Grosh,** 1921, Routes to desert watering places in the Mohave Desert region, California: U.S. Geol. Survey Water-Supply Paper 490–B, p. 1–4, 87–269, 16 pls., 3 figs.
Includes mention of Newberry, Paradise, Saratoga, and Yeoman thermal springs.

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Contains data on Paradise, Newberry, and Saratoga springs, also two springs near the railway station at Soda.

291. **Tucker, W. Burling, and Sampson, R. J.,** 1945, Mineral resources of Riverside County: California Jour. Mines and Geology, v. 41, no. 3, p. 121–182.
Includes descriptions of and chemical analyses for 10 thermal springs.

292. **Turner, Henry Ward,** 1891, Mohawk Lake beds: Philos. Soc. Washington Bull., v. 11, p. 385–409.
Mentions McLear Sulphur springs.

293. **Van Winkle, Walton, and Eaton, Frederick M.,** 1910, The quality of the surface waters of California: U.S. Geol. Survey Water-Supply Paper 237, 142 p., 1 pl.
Includes chemical analyses of water from springs in the Sulphur Bank mine.

294. **Veatch, John A.,** 1857, Notes of a visit to the "mud volcanoes" in the Colorado Desert in the month of July, 1857: California Acad. Nat. Sci. Proc., v. 1, p. 104–108; 2d ed., 1873, p. 116–121; 1858, Am. Jour. Sci. 2d ser., v. 26, p. 288–295.

295. **Vonsen, Magnus,** 1941, Preliminary report on minerals of geysers of Sonoma County, California: Mineralogist, v. 9, no. 7, p. 245–248.

296. 1946, Minerals at "The Geysers," Sonoma County, California: California Jour. Mines and Geology, v. 42, no. 3, p. 287–293, 1 pl.

297. **Waring, Gerald Ashley,** 1915, Springs of California: U.S. Geol. Survey Water-Supply Paper 338, 410 p., 13 pls., 4 figs.

Contains detailed information on 163 thermal-spring and 9 thermal-well localities.

298. **Waring, Gerald Ashley,** 1919, Ground water in the San Jacinto and Temecula basins, California: U.S. Geol. Survey Water-Supply Paper 429, 113 p., 14 pls., 15 figs.
Contains data on eight thermal springs.

299. **Watts, William Lord,** 1893, Marin County: California Mining Bur. 11th Rept., 1892 (1st Bienn.), p. 249–254.
Mentions hot sulfur springs on the shore west of Rocky Point.

300. **Weight, Harold O.,** 1948, Nature's freaks on Salton shore: Desert Mag., v. 11, no. 6, p. 5–8, 7 illus.
Describes the mud pots and mud volcanoes near the south end of Salton Sea.

301. **White, Donald Edward,** 1940, Antimony deposits of the Wildrose Canyon area, Inyo County, Calif.: U.S. Geol. Survey Bull. 922–K, p. 307–325, 2 pls., 2 figs.
Describes five hot-spring deposits.

302. 1954, Notes on certain thermal springs in California: Unpublished field notes.
Includes information on thermal springs or vapor vents in 16 places.

303. 1955a, Sulphur Bank, California, a hot-spring quicksilver deposit [abs.]: Geol. Soc. America Bull., v. 66, no. 12, pt. 2, p. 1669.

304. 1955b, Violent mud-volcano eruption of Lake City hot springs, northeastern California: Geol. Soc. America Bull., v. 66, no. 9, p. 1109–1130, 4 pls., 3 figs.
In addition to describing the mud-volcano eruption, mention is made of mud volcanoes in the Lassen Peak and Coso hot-springs areas in California, near Gerlach hot springs in Nevada, in Yellowstone National Park in Wyoming, at Volcano Lake in Baja California, and in the hot-spring districts of Iceland and New Zealand.

305. **Whiting, H. A.,** 1888, Mono County: California Mining Bur. 8th Ann. Rept., p. 352–401, 2 pls.
Contains information on the thermal springs on Paoha Island in Mono Lake, the Casa Diablo hot springs, and the thermal springs at Benton. Also mentions deposits of travertine 1 mile southeast of Bridgeport.

306. **Whitney, Josiah Dwight,** 1865, Geological survey of California; Geology, v. 1, Report of progress and synopsis of the field work from 1860 to 1864: 498 p., 10 pls., 81 figs.
Contains information on several thermal-spring localities in California.

307. **Williams, Howel,** 1932, Geology of the Lassen Volcanic National Park, Calif.: California Univ., Dept. Geol. Sci. Bull., v. 21, no. 8, p. 195–385, 64 figs., map.
Discusses the hydrothermal activity in the park area.

308. **Wilson, Harry David Bruce,** and **Hendry, N. W.,** 1940, Geology and quicksilver deposits of Coso hot springs area [abs.]: Geol. Soc. America Bull., v. 51, no. 12, pt. 2, p. 1965.

309. **Wood, Horatio Charles, Jr.,** 1867 [Remarks made by Dr. Wood]: Acad. Nat. Sci. Philadelphia Proc., Oct., 15, 1867, Mtg., p. 125.
Mentions that algae have been found in water of thermal springs in Mono County, Calif.

310. 1868, Notes on some algae from a California hot spring: Am. Jour. Sci. and Arts, 2d ser., v. 46, p. 31–34.

311. **Yates, Robert G.,** and **Hilpert, Lowell Sinclair,** 1946, Quicksilver deposits of Eastern Mayacmas district, Lake and Napa Counties, Calif.: California Jour. Mines and Geology, v. 42, no. 3, p. 231–286, 8 figs.
Mentions deposits related to hydrothermal activity at the Aetna Mine and Anderson springs areas.

See also references 19, 20, 62, 75, 108, 109, 125, 126, 128, 130, 137, 144, 399, 400, 401, 409, 413, 418, 426, 441, 442, 526, 660, 667, 746, and 784.

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312. **Bastin, Edson Sunderland,** 1923, Silver enrichment in the San Juan Mountains, Colo.: U.S. Geol. Survey Bull. 735–D, p. 65–129, figs. 14–32.
Contains a chemical analysis of the water from the Ouray hot springs.

313. **Campbell, Marius Robinson,** 1923, The Twentymile Park district of the Yampa coal field, Routt County, Colo.: U.S. Geol. Survey Bull. 748, 82 p., 13 pls., 11 figs.
Mentions the Steamboat springs.

314. **Comstock, Theodore Bryant,** 1889, Hot-spring formations in Red Mountain district, Colorado; a reply to the criticisms of Mr. Emmons: Am. Inst. Mining Engineers Trans., v. 17, p. 261–264.
Reiterates the author's conclusion that the mounds or ridges of ore-bearing siliceous sinter are the chimneys of extinct geysers. Denies that he had expressed the idea that the ore itself was the result of geyser action.

315. **Cox, Doak Carey,** 1945, General features of Colorado fluorspar deposits: Colorado Sci. Soc. Proc., v. 14, no. 6, p. 263–285, 7 figs.
Discusses the occurrence of fluoride in the deposits of the hot springs at Wagon Wheel Gap and of the Poncha hot springs southwest of Salida.

316. **Cross, Whitman; Howe, Ernest;** and **Irving, John Duer,** 1907, Description of the Ouray quadrangle, Colorado: U.S. Geol. Survey Geol. Atlas, Folio 153, 20 p., 1 sheet of illus., 4 figs., 3 maps.
Contains a chemical analysis of the water from the Ouray hot springs. Mentions the hot springs near Ridgway.

317. **Denison, Charles,** 1880, Rocky Mountain health resorts; an analytical study of high altitudes in relation to the arrest of chronic pulmonary disease: Boston, Mass., Houghton, Osgood & Co., 192 p., map; 2d ed., 1881, Boston, Mass., Houghton, Mifflin & Co., 192 p., map.
Includes information on 10 thermal springs in Colorado. Also mentions Ojos Calientes and Las Vegas springs in New Mexico.

318. **Emmons, William Harvey,** and **Larsen, Esper Signius, Jr.,** 1913, The hot springs and the mineral deposits of Wagon Wheel Gap, Colo.: Econ. Geology, v. 8, no. 3, p. 235–246, 3 figs., 1 table.

319. **Endlich, Frederick Miller,** 1877, Geological report on the southeastern district [Colorado] *in* Hayden, Ferdinand V., U.S. Geol. and Geog. Survey Terr. 9th Ann. Rept., 1875, p. 103–235, 25 pls.
Contains information on the chemical quality of the water and on the deposits of three springs near Hot Springs Creek 1 mile upstream from its mouth. Also includes diagrams of Pagosa Springs.

320. **Frazer, Persifor, Jr.,** 1873, Mines and minerals of Colorado, *in* Hayden, Ferdinand V., U.S. Geol. and Geog. Survey Terr. 3d Ann. Rept., 1869: p. 201–228.
Describes a group of springs in Homan's Park between Sawatch and Homan's Creek. Mentions Ojos Calientes in New Mexico.

321. **George, Russell D.,** 1927, Geology and natural resources of Colorado: Univ. Colorado Semicentennial Pubs., v. 1, 228 p., 25 pls.

Discusses natural mineral waters and their chemical classification.

322. **George, Russell D.; Curtis, Harry Alfred; Lester, Oliver Clarence; Crook, James King; Yeo, J. B.;** and others, 1920, Mineral waters of Colorado: Colorado Geol. Survey Bull. 11, 474 p., 2 pls., 40 figs.

Contains information, including chemical-quality and radioactivity data on thermal springs in 36 localities. Also contains information, for purposes of comparison, on several European thermal springs.

323. **Hancock, Eugene Thomas,** 1925, Geology and coal resources of the Axial and Monument Butte quadrangles, Moffat County, Colo.: U.S. Geol. Survey Bull. 757, 134 p., 19 pls., 6 figs.

Page 77: Water of Juniper Hot Springs probably comes from Dakota sandstone.

324. **Hayden, Ferdinand Vandiveer,** 1876, Colorado and parts of adjacent territories: U.S. Geol. and Geog. Survey Terr. 8th Ann. Rept., 1874, 515 p., maps.

Mentions warm springs on Rock Creek in the Elk Range.

325. **Lakes, Arthur,** 1905a, Geology of the hot springs of Colorado and speculations as to their origin and heat: Colorado Sci. Soc. Proc., v. 8, p. 31–38.

326. 1905b, The hot and mineral springs of Routt County and Middle Park, Colo.: Mining Reporter, v. 52, no. 18, p. 438–439.

327. 1906, Mineral and hot springs in Colorado: Mining World, v. 24, p. 359–360.

328. **Loew, Oscar,** 1875, Report upon mineralogical, agricultural, and chemical conditions observed in portions of Colorado, New Mexico, and Arizona, *in* Wheeler, George M., U.S. Geog. and Geol. Surveys W. 100th Mer. Rept., v. 3, Geology: p. 569–661, quarto.

Contains information on Cañon City, Parnassus, Wagon Wheel Gap, and Pagosa Springs in Colorado; also on Rio San Francisco (Clifton) springs in Arizona, and Ojos Calientes, San Ysidro, Abiquiu, Las Vegas, and Rio Pajarito springs in New Mexico.

329. **Packard, Alpheus Spring, Jr.,** 1882, Larvae of a fly in a hot spring in [Gunnison County] Colorado: Am. Naturalist, v. 16, p. 599–600.

330. **Peale, Albert Charles,** 1877, Geological report on the Grand River district, *in* Hayden, Ferdinand V., U.S. Geol. and Geog. Survey Terr., 9th Ann. Rept., 1875: p. 31–101, pls. 1–8.

Mentions two groups of warm springs in the White Earth River valley, also the Uncompahgre warm springs.

331. **Russell, Robert Thayer,** 1948, Fluorine hot springs of Poncha Springs, Colo. [abs.]: Geol. Soc. America Bull., v. 59, no. 12, pt. 2, p. 1400.

332. **Siebenthal, Claude Ellsworth,** 1910, Geology and water resources of the San Luis Valley, Colo.: U.S. Geol. Survey Water-Supply Paper 240, 128 p., 13 pls., 15 figs.

Contains information on Dexter warm springs, Chamberlain hot springs, Valley View hot springs, and hot springs near Capulin.

333. **Spurr, Josiah Edward,** and **Garrey, George H.,** 1906, The Idaho Springs mining district, Colo.: U.S. Geol. Survey Bull. 285–A, p. 35–40.

334. **Spurr, Josiah E.; Garrey, George H.;** and **Ball, Sydney Hobart,** 1908, Economic geology of the Georgetown quadrangle, Colo.: U.S. Geol. Survey Prof. Paper 63, 422 p., 87 pls., 155 figs.

335. **Stevenson, John James,** 1875, Report on the geology of a portion of Colorado explored and surveyed in 1873, *in* Wheeler, George M., U.S. Geog. and Geol. Surveys W. 100th Mer. Rept., v. 3, Geology, pt. 4: p. 303–501, 9 figs.

Contains data on thermal springs in several localities in Colorado.

336. **Washburne, H. D.,** 1872 [Data on hot springs], *in* Statistics of mines and mining in the States and Territories west of the Rocky Mountains, for the year 1870: Washington, Govt. Printing Office, p. 213–216.

See also references 109, 128, 137–140, 144, 459, 513, 526, 641, and 666.

FLORIDA

337. **Ferguson, George Ernest; Lingham, C. W.; Love, Samuel Kenneth;** and **Vernon, Robert Orion,** 1947, Springs of Florida: Florida Geol. Survey Bull. 31, 196 p., front., 37 figs., 4 tables, map.

Describes Warm Salt spring 8 miles northwest of Murdock. Also states that the Panasoffkee River is formed in part by the flow of Warm Spring.

338. **Parker, Garald Gordon,** and **Cooke, Charles Wythe,** 1944, Late Cenozoic geology of southern Florida, with a discussion of the ground water: Florida Geol. Survey Bull. 27, 119 p., 26 pls., 4 figs.

Contains a chemical analysis of water from Warm Salt (Big Salt) spring.

GEORGIA

339. **Duggan, J. R.,** 1881, The mineral springs of Georgia: Macon, Ga., J. W. Burke & Co., 56 p.

340. **Hall, B. M.,** and **Hall, M. R.,** 1907, Water resources of Georgia: U.S. Geol. Survey Water-Supply Paper 197, 342 p., 1 pl.

Includes data on the discharge of the springs at Warm Springs.

341. **Hewett, Donnel Foster,** and **Crickmay, Geoffrey William,** 1937, The Warm Springs of Georgia, their geologic relations and origin; summary report: U.S. Geol. Survey Water-Supply Paper 819, 40 p., 8 pls., 1 fig.

342. **McCallie, Samuel Washington,** 1904, Notes on wells, springs, and water resources, Georgia: U.S. Geol. Survey Water-Supply Paper 102, p. 207–237.

Includes information on the springs at Warm Springs.

343. 1908, A preliminary report on the underground waters of Georgia: Georgia Geol. Survey Bull. 15, 370 p., 29 pls., 5 figs.

Contains chemical analyses of water from the springs at Warm Springs.

344. 1913, A preliminary report on mineral springs of Georgia: Georgia Geol. Survey Bull. 20, 190 p., 24 pls., map.

Contains data on Warm, Thundering, and Lifsey springs.

See also references 137 and 543.

HAWAII

345. **Ballard, Stanley S.,** and **Payne, John H.,** 1940, A chemical study of Kilauea solfataric gases, 1938–1940: U.S. Dept. Interior, Natl. Park Service Volcano Letter 469, p. 1–3, 3 figs.

346. **Boddam-Whetham, John Whetham,** 1876, Pearls of the Pacific: London, Hurst & Blackett, 362 p., 8 illus.
Mentions that steam is condensed for sulfur baths at Solfatara on the Kilauea volcano.

347. **Dana, James Dwight,** 1849, Report on geology; United States Exploring Expedition during the years 1838–1842, under the command of Charles Wilkes, U.S.N.: Philadelphia, Pa., C. Sherman, v. 10, Geology, 756 p., 21 pls., 109 figs., 4 maps.
Mentions a hot spring in a small crater between Kilauea volcano and Kapoho Point, a warm cavern on the shore at Kailua, and warm springs at Kawaihae, all on the Island of Hawaii. Also describes hot springs along the shore of Savu Savu Bay on Vanua Levu Island (Fiji), hydrothermal activity in several localities in New Zealand, and Los Baños on Luzon Island in the Philippines.

348. 1890, Characteristics of volcanoes, with contributions of facts and principles from the Hawaiian Islands: New York, Dodd, Mead & Co., 399 p., 16 pls., 55 figs.
Mentions the water vapors associated with volcanic activity on the Island of Hawaii.

349. **Fagerlund, Gunnar O.,** 1944, Output changes in Kilauea steam vents: U.S. Dept. Interior, Natl. Park Service Volcano Letter 485, p. 1–2, 2 figs.

350. **Finch, Ruy Herbert,** and **Macdonald, Gordon A.,** 1950, Thermal water on Kilauea Volcano: U.S. Dept. Interior, Natl. Park Service Volcano Letter 507, p. 1.

351. **Gordon-Cumming, Constance Frederica,** 1883, Fire fountains: The kingdom of Hawaii, its volcanoes, and the history of its missions: Edinburgh, W. Blackwood & Sons, 2 v.; v. 1, 297 p., front., 3 illus., map; v. 2, 279 p., front., 3 illus., map.
Describes use of hot vapors for sulfur steam baths near crater of Kilauea volcano.

352. **Macdonald, Gordon A.,** 1955, Hawaiian Islands, pt. 3 *of* Catalogue of active volcanoes of the world including solfatara fields: Naples, Italy, Internat. Volcanol. Assoc., 37 p., 6 figs., map.
Contains data on Haleakala, Hualalai, Mauna Loa, and Kilauea volcanoes and associated hydrothermal activity.

353. **Macdonald, J. W.,** 1899, The great volcano of Kilauea.
Contains data on the vapor vents.

354. **Olson, Gunder Einer,** 1941, The story of the Volcano House: 4th ed., Hilo, Hawaii, Hilo Tribune Herald, 91 p., 31 illus., maps.
Describes the use of steam for sulfur vapor baths.

355. **Palmer, Harold Schjöth,** 1950, Steam vents on Kilauea volcano, Hawaii: Personal commun. to G. A. Waring.

356. **Stearns, Harold Thornton,** and **Clark, William Otterbein,** 1930, Geology and water resources of the Kau district, Hawaii (including parts of Kilauea and Mauna Loa volcanoes), with a chapter on ground water in the Hawaiian Islands, by Oscar E. Meinzer: U.S. Geol. Survey Water-Supply Paper 616, 194 p., 33 pls., 9 figs.
Mentions warm water in a crack near Waiwelawela Point, 12 miles southeast of Pahala.

357. **Stearns, Harold Thornton,** and **Macdonald, Gordon A.,** 1942, Geology and ground-water resources of the island of Maui, Hawaii: Hawaii Div. Hydrography Bull. 7, 344 p., 44 pls., 46 figs.
Mentions warm-water well at the mouth of Ukumehame Canyon.

358. 1946, Geology and ground-water resources of the island of Hawaii: Hawaii Div. Hydrography Bull. 9, 363 p., 54 pls., 60 figs.
Mentions that steam issues from cracks in and near the craters of Kilauea and Mauna Loa, also that a crack at Waiwelawela Point contains warm water.

359. 1947, Geology and ground-water resources of the island of Molokai, Hawaii: Hawaii Div. Hydrography Bull. 11, 113 p., 15 pls., 18 figs.
Describes a warm-water well on the northwest slope of West Molokai.

See also references 22, 660, and 1077.

IDAHO

360. **Frémont, John Charles,** 1845, Report of the exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and northern California in the years 1843–44: U.S. 28th Cong., 2d sess., H. Doc. 166, 583 p., 9 pls., 9 other illus.
Describes Bear River Soda (Beer) springs and White Arrow hot springs and mentions Hot Spring Gate, all in Idaho. Also mentions hot springs and a basin of saline water near Mary's Lake in Nevada, hot springs near Las Vegas camp ground in Nevada, and several hot springs in California.

361. **Gairdner, M.,** 1835, Letter from Dr. M. Gairdner, Fort Vancouver: Edinburgh New Philos. Jour., v. 20, p. 206–207.
States that springs are numerous between the Columbia River and the Rocky Mountains. Mentions the existence of six hot springs not previously described.

362. 1836, Thermal spring in the Columbia Territory: Edinburgh New Philos. Jour., v. 21, p. 371–372.
Contains a chemical analysis of water from a thermal spring on the Bear River.

363. **Lindgren, Waldemar,** 1898, Description of the Boise quadrangle, Idaho: U.S. Geol. Survey Geol. Atlas, Folio 45, 7 p., 4 maps.
Mentions the Boise hot springs, a tepid spring on Cottonwood Creek, and a hot spring on Squaw Creek.

364. **Lindgren, Waldemar,** and **Drake, Noah Fields,** 1904, Description of the Silver City quadrangle, Idaho: U.S. Geol. Survey Geol. Atlas, Folio 104, 6 p., 3 maps.
Mentions a warm spring near Walters Butte and a hot spring near Enterprise. States that wells near Enterprise and Guffey yield warm water.

365. **Meinzer, Oscar Edward,** 1924, Ground water in Pahsimeroi Valley, Idaho: Idaho Bur. Mines and Geology Pamph. 9, 36 sheets, 3 pls., 5 figs. [mimeo.].
Mentions two slightly thermal springs in Pahsimeroi Valley; also a warm spring in Little Lost River Valley.

366. **Peale, Albert Charles,** 1879, Report on the geology of the Green River district, *in* Hayden, Ferdinand V., U.S. Geol. and Geog. Survey Terr. 11th Ann. Rept., 1877: p. 511–646, 30 pls.
Describes Bear River Soda (Beer) springs and mentions a slightly thermal spring in the canyon of Blackfoot River.

367. **Piper, Arthur Maine,** 1923, Geology and water resources of the Goose Creek basin, Cassia County, Idaho: Idaho Bur. Mines and Geology Bull. 6, 78 p., 6 pls.
Contains information on eight thermal springs.

368. [1924?], Geology and water resources of the Bruneau River basin, Owyhee County, Idaho: Idaho Bur. Mines and Geology Pamph. 11, 56 p., 2 pls., 12 tables [mimeo.].
Describes nine thermal springs.

369. **Rhodenbaugh, Edward F.,** 1953, Is Boise [Idaho] sitting on a volcano?: Earth Sci. Digest, v. 7, no. 2, p. 7–11, 27, 3 figs.
States that two wells near Boise yield water having a temperature of 178°F.

370. **Russell, Israel Cook,** 1902, Geology and water resources of the Snake River Plains of Idaho: U.S. Geol. Survey Bull. 199, 192 p., 25 pls., 6 figs.
Mentions 10 thermal-spring localities.

371. 1903, Preliminary report on artesian basins in southwestern Idaho and southeastern Oregon: U.S. Geol. Survey Water-Supply Paper 78, 53 p., 2 pls., 3 figs.
Describes eight hydrothermal localities in Idaho and four in Oregon, all in the Lewis artesian basin. Also describes hydrothermal localities in the Otis, Harney, and Whitehorse artesian basins, all in Oregon.

372. **St. John, Orestes,** 1879, Report of the geological field work of the Teton Division, *in* Hayden, Ferdinand V., U.S. Geol. and Geog. Survey Terr. 11th Ann. Rept., 1877: p. 323–508, 40 pls.
Mentions thermal springs on the west side of the Snake River valley between The Narrows and McCoy Creek.

373. **Schultz, Alfred Reginald,** 1918, A geologic reconnaissance for phosphate and coal in southeastern Idaho and western Wyoming: U.S. Geol. Survey Bull. 680, 84 p., 2 pls., 8 figs.
Mentions the warm springs at Heise and two other thermal-spring localities in Idaho. Also mentions a thermal spring in western Wyoming.

374. **Tillman, Samuel E.,** 1878, Executive and descriptive report *in* U.S. Geog. and Geol. Surveys West of 100th Mer., G. M. Wheeler, Ann. Rept. Chief of Engineers, 1878, app. NN: p. 107–112.
Mentions several thermal-spring localities in southeastern Idaho.

375. **Umpleby, Joseph Bertram,** 1915, Ore deposits in the Sawtooth quadrangle, Blaine and Custer Counties, Idaho: U.S. Geol. Survey Bull. 580–K, p. 221–249, 2 pls., 1 fig.
Mentions Pierson, Wasewick, and Russian John springs.

376. **Umpleby, Joseph Bertram; Westgate, Louis Gardner;** and **Ross, Clyde Polhemus,** 1930, Geology and ore deposits of the Wood River region, Idaho, with a description of the Minnie Moore and nearby mines, by Donnel F. Hewett: U.S. Geol. Survey Bull. 814, 250 p., 33 pls., 20 figs.
Contains chemical analyses of the water from Clarendon, Guyer, and Hailey hot springs. Also mentions a thermal spring near the west edge of the area.

377. **Waring, Gerald Ashley,** 1936, Two thermal springs in Idaho and Oregon [abs.]: Geol. Soc. America Proc. 1935, p. 115–116.
Contains information on Indian spring in Idaho and on a spring in the Owyhee River canyon in Oregon.

See also references 113, 124, 126, 133, 137, 138, 144, 148, 150, 383, 413, 433, 482, 505, 525, 526, 625, 666, and 667.

MASSACHUSETTS

378. **Fitch, William Edward,** 1927, Mineral waters of the United States and American spas: Philadelphia, Pa., and New York, Lea & Febiger, 799, p., 37 figs.
Describes Sand spring near Williamstown.

See also references 135, 137, and 144.

MONTANA

379. **Calvert, William R.,** 1909, Geology of the Lewistown coal field, Montana: U.S. Geol. Survey Bull. 390, 83 p., 5 pls., 1 fig.
Describes the warm springs near Lewistown.

380. **Clarke, Frank Wigglesworth,** and others, 1886, Report of work done in the division of chemistry and physics, mainly during the fiscal year 1884–85: U.S. Geol. Survey Bull. 27, 80 p.
Includes chemical analyses of water from Matthews spring near Bozeman and of White Sulphur springs.

381. **De Lacy, Walter W.,** 1876, A trip up the south Snake River in 1863: Helena, Mont., Contributions to the Historical Society of Montana, v. 1.
Mentions thermal springs.

382. **Lewis, Meriwether,** and **Clark, William,** 1814, History of the expedition of Captains Lewis and Clark 1804–5–6, with introduction and index by James K. Hosmer: Chicago, Ill., A. C. McClurg & Co., 2 v.; v. 1, 500 p., front., 3 maps; v. 2, 583 p., front., 3 maps; 2d ed., 1903, Cambridge, Mass., Univ. Press.
Describes Traveller's Rest (Medicine Rock) springs and springs in Hot Spring Valley near the Wisdom River.

383. **Lindgren, Waldemar,** 1904, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: U.S. Geol. Survey Prof. Paper 27, 123 p., 15 pls., 8 figs.
Mentions several thermal-spring localities.

384. **Lorenz, H. W.,** and **McMurtrey, R. G.,** 1956, Geology and occurrence of ground water in the Townsend Valley, Mont.: U.S. Geol. Survey Water-Supply Paper 1360–C, p. 171–290, 2 pls., 12 figs.
Contains information on Big, Plunket (Mockel), Bedford, and Kimpton springs.

385. **Meinzer, Oscar Edward,** 1917, Artesian water for irrigation in Little Bitterroot Valley, Mont.: U.S. Geol. Survey Water-Supply Paper 400–B, p. 9–37, 4 pls., 4 figs.
Contains information on Camas hot springs; mentions a warm spring 1 mile west of the Camas hot springs.

386. **Mullan, John, Jr.,** 1855, Report of a reconnaissance from the Bitter Root Valley to Fort Hall, thence to the head of Hell Gate River, thence to the Bitter Root Valley: U.S. War Dept., Reports of explorations and surveys * * * for a railroad from the Mississippi River to the Pacific Ocean: U.S. 33d Cong., 2d sess., S. Doc. 78, v. 1, pt. 1, Reports from the field, p. 322–349.
Mentions the numerous thermal springs near Big Hole prairie and the Anaconda(?) hot springs near Deer Lodge Creek.

387. **Pardee, Joseph Thomas,** 1925, Geology and ground-water resources of Townsend Valley, Mont.: U.S. Geol. Survey Water-Supply Paper 539, 61 p., 2 pls., 7 figs.
Contains information on Big, Mockel (Plunket), Bedford, and Kimpton springs.

388. **Peale, Albert Charles,** 1872, Report on minerals, rocks, thermal springs, etc., *in* Hayden, Ferdinand V., U.S.

Geol. Survey of Montana and portions of adjacent Territories: 5th Ann. Prog. Rept., p. 165–204.
Describes Hapgood springs near Virginia City; also contains data on the principal geysers and hot springs in Yellowstone National Park.

389. 1896, Description of the Three Forks quadrangle, Mont.: U.S. Geol. Survey Geol. Atlas, Folio 24, 6 p., 4 maps.
Mentions the hot springs on the West Gallatin River, the warm springs east of Red Bluff, Hapgood springs on the South Branch of Willow Creek, and a small spring in the lower canyon of the Jefferson River.

390. **Sobotka, Harry, and Reiner, Miriam,** 1941, Chemical composition of a lithia spring near McLeod, Mont.: Am. Jour. Sci., v. 239, no. 5, p. 383–385.
Describes Anderson's springs 8 miles south of McLeod.

391. **Stout, Tom,** 1921, Montana; its story and biography: Chicago and New York, Am. Hist. Soc., 3 v.
Lists 19 principal hot-spring resorts in Montana, among them those at Hunter's, Chico, Corwin, and Camas hot springs.

392. **Weed, Walter Harvey,** 1899, Description of the Little Belt Mountains quadrangle, Mont.: U.S. Geol. Survey Geol. Atlas, Folio 56, 10 p.
Contains information on White Sulphur springs.

393. 1900, Mineral vein formation at Boulder Hot Springs, Mont.: U.S. Geol. Survey 21st Ann. Rept., pt. 2, p. 227–255, 3 pls., 8 figs.

394. 1904, Gypsum deposits in Montana: U.S. Geol. Survey Bull. 223, p. 74–75.
Contains information on Hunter's hot springs.

395. 1905, Economic value of hot springs and hot-spring deposits: U.S. Geol. Survey Bull. 260, p. 598–604.
Contains information on the mineral deposits of Sun River, Boulder, Anaconda, and Hunter's hot springs.

396. **Weed, Walter Harvey, and Pirsson, Louis Valentine,** 1896, Geology of the Castle Mountain mining district, Montana: U.S. Geol. Survey Bull. 139, 164 p., 17 pls., 11 figs.
Describes White Sulphur hot springs.

397. 1898, Geology and mineral resources of the Judith Mountains of Montana: U.S. Geol. Survey 18th Ann. Rept., pt. 3, p. 437–616, 18 pls., 23 figs.
Mentions Warm Spring Creek near Maiden.

See also references 109, 128, 133, 137, 138, 141, 144, 148, 409, 652, 667, and 679.

NEVADA

398. **Bain, Harry Foster,** 1906, A Nevada zinc deposit: U.S. Geol. Survey Bull. 285, p. 166–169.
Mentions Indian spring and warm spring at White's ranch.

399. **Ball, Sydney Hobart,** 1907, A geological reconnaissance in southwestern Nevada and eastern California: U.S. Geol. Survey Bull. 308, 218 p., 3 pls., 17 figs.
Contains information on Alkali spring 11 miles northwest of Goldfield. Mentions Hicks, Staininger ranch, and Grapevine springs, also springs in Ash Meadows.

400. **Becker, George Ferdinand,** 1888, Geology of the quicksilver deposits of the Pacific slope: U.S. Geol. Survey Mon. 13, 486 p., 7 pls., 20 figs.
Describes Steamboat springs.

401. 1889, Summary of the geology of the quicksilver deposits of the Pacific slope: U.S. Geol. Survey 8th Ann. Rept., pt. 2, p. 961–985, 2 pls.
Mentions Steamboat springs in Nevada and the hot springs at Sulphur Bank and Oathill mines in California.

402. **Beckwith, Edward Griffin,** 1855, Report of explorations for a route for the Pacific railroad, on the line of the forty-first parallel of North Latitude: U.S. War Dept., Reports of explorations and surveys * * * for a railroad from the Mississippi River to the Pacific Ocean: U.S. 33d Cong., 2d sess., S. Doc. 78, v. 2, 114 p. [Geol. Report, by James Schiel, p. 96–114, 4 pls.]
Contains data on a group of hot springs near the east base of the Humboldt Mountains.

403. **Blake, William Phipps,** 1873, Diatoms in a hot spring in [Pueblo Valley, Humboldt County] Nevada: California Acad. Sci. Mtg. Aug. 21, 1871, Proc., v. 4, pt. 4, p. 183.

404. **Brannock, Walter Wallace; Fix, Philip Forsyth; Gianella, Vincent Paul; and White, Donald Edward,** 1948, Preliminary geochemical results at Steamboat springs, Nevada: Am. Geophys. Union Trans., v. 29, no. 2, p. 211–226, 12 figs., 6 tables.

405. **Browne, John Ross,** 1867, A report upon the mineral resources of the States and Territories west of the Rocky Mountains: U.S. 39th Cong., 2d sess., Ex. Doc. 29, 321 p.
Comments on the numerous thermal springs in Nevada.

406. 1868, Resources of the Pacific slope. A statistical and descriptive summary of the mines and minerals, climate, topography, agriculture, commerce, manufactures, and miscellaneous productions of the States and Territories west of the Rocky Mountains, with a sketch of the settlement and exploration of Lower California: New York, D. Appleton Co., 674 and 200 p. (2 parts, paged separately); 1869 ed., 678 and 200 p.
States that there are many thermal springs in Nevada and describes several. Also contains chemical analyses of the water from six springs in Nevada and from Fish springs in Utah.

407. **Carpenter, Everett,** 1915, Ground water in southeastern Nevada: U.S. Geol. Survey Water-Supply Paper 365, 86 p., 5 pls., 3 figs.
Contains data on 10 thermal springs.

408. **Clark, William Otterbein, and Riddell, C. W.,** 1920, Exploratory drilling for water and use of ground water for irrigation in Steptoe Valley, Nevada, with an introduction by O. E. Meinzer; U.S. Geol. Survey Water-Supply Paper 467, 70 p., 6 pls., 6 figs.
Describes Ely warm spring, McGill warm springs, Melvin hot springs, Cherry Creek hot springs, Collar and Elbow spring, Murry springs, Borchert John spring, and a large group of thermal springs 10 miles northwest of McGill.

409. **Clarke, Frank Wigglesworth, and Chatard, Thomas Marean,** 1884, A report of work done in the Washington laboratory during the fiscal year 1883–84: U.S. Geol. Survey Bull. 9, 40 p.
Includes chemical analyses of water from hot springs on Ward's ranch and at Hot Spring railway station, both in Nevada; from a warm spring near Mono Lake and a boiling spring near Honey Lake, both in California; from hot springs 8 miles north of Ogden, Utah; from Livingston, Emigrant Gulch, and Helena hot springs, all in Montana; and from six thermal springs at Hot Springs, Va.

410. **Darlington, Philip Jackson, Jr.,** 1928, New *Coleoptera* from western hot springs: Psyche, v. 35, no. 1, p. 1–6.

Contains technical descriptions of three new species of *Coleoptera*, one from a spring 37 miles south of Battle Mountain, one from Beowawe hot springs, and from a spring near Opal Mine, all in Nevada.

411. **Dole, Richard Bryant,** 1913, Exploration of salines in Silver Peak Marsh, Nev.: U.S. Geol. Survey Bull. 530, p. 330–345, 3 figs.

States that there are hot springs at the edge of the Marsh.

412. **Dreyer, Robert Marx,** 1940, Goldbanks mining district, Pershing County, Nev.: Nevada Univ. Bull., v. 34, no. 1 (Geology and Mining Ser. 33), 38 p., 13 figs.

States that the cinnabar in the Goldbanks mining district was deposited by circulating hot waters. Mentions hot springs a few miles north of the mine.

413. **Engelmann, Henry,** 1876, Report on the geology of the country between Fort Leavenworth, Kansas Territory, and the Sierra Nevada near Carson Valley, *in* Simpson, James Hervey, Report of explorations across the Great Basin of the Territory of Utah * * * in 1859: Washington, Govt. Printing Office, U.S. Engineer Dept., p. 243–336.

Mentions Steamboat and Hot Sulphur springs and hot springs near bend of the Walker River, all in Nevada; Bear River Soda (Beer) springs in Idaho; boiling springs near Mud Lake and near Honey Lake in California; and thermal springs in four localities in Utah.

414. **Evans, Albert S.,** 1869, In Whirlwind Valley: Overland Monthly [San Francisco, Calif.], v. 2, no. 2, p. 111–115.

Describes the Beowawe geysers.

415. **Fall, Henry Clinton,** 1928, A new coelambus from a thermal spring in [Ruby Valley] Nevada: Psyche, v. 35, no. 1, p. 64–65.

416. **Gianella, Vincent Paul,** 1939, Mineral deposition at Steamboat springs, Nevada [abs.]: Econ. Geology, v. 34, no. 4, p. 471–472.

417. **Gianella, Vincent Paul,** and **White, Donald Edward,** 1946, Minerals of Steamboat springs, Nevada [abs.]: Geol. Soc. America Bull., v. 57, no. 12, pt. 2, p. 1196; 1947, Am. Mineralogist, v. 32, nos. 3–4, p. 200–201.

418. **Hague, Arnold,** and **Emmons, Samuel Franklin,** 1877, Geologic reports: U.S. Geol. Explor. 40th Parallel (King), v. 2, 890 p., front., 25 pls.

Mentions several thermal-spring localities in Nevada; also warm springs at mouth of Ogden Canyon and north of Salt Lake City in Utah; and a large hot spring near Eagle Lake in Antelope Valley, Calif.

419. **Hill, James Madison,** 1915, Some mining districts in northeastern California and northwestern Nevada: U.S. Geol. Survey Bull. 594, 200 p., 19 pls., 4 figs.

Mentions the hot mineral springs at Sodaville in Mineral County, Nev. Also shows location of Hinds hot springs on a map of the south end of the Pine Nut Range in Douglas County, Nev.

420. **Jones, J. Claude,** 1914, Occurrence of stibnite and metastibnite at Steamboat Springs, Nevada [abs.]: Geol. Soc. America Bull., v. 25, no. 1, p. 126.

421. **Kearney, W. M.,** 1913, Biennial report of State Engineer of Nevada, for 1911–1912: 294 p., 8 views, 1 graph.

Includes measurements of the discharge of Warm Creek in Elko County and Preston springs, Lund spring, and springs at the head of Warm Creek, all in White Pine County.

422. **Kerr, Paul Francis,** 1940, Tungsten-bearing manganese deposit at Golconda, Nev.: Geol. Soc. America Bull., v. 51, no. 9, p. 1359–1389, 5 pls., 6 figs.; abs., Geol. Soc. America Bull., v. 51, no. 12, pt. 2, p. 2026.

States that the rock overlying the ore deposit is of hot-spring origin.

423. 1946, Tungsten mineralization in the United States: Geol. Soc. America Mem. 15, 241 p., 23 pls., 34 figs.

States that tungsten-bearing manganese deposit near Golconda, Nev., was formed by hot springs. Also mentions hot springs near Sodaville, Nev.

424. **King, Clarence,** 1878, Systematic geology: U.S. Geol. Explor. 40th Parallel (King), v. 1, 803 p., 26 pls., 12 maps.

Contains information on the mineral deposits of Steamboat springs and of hot springs in Ruby, Reese River, and Grass Valleys, in the Humboldt Range, and at Geiger Grade, all in Nevada. Mentions the hot springs at Salt Lake City and north of Ogden, both in Utah.

425. **Knopf, Adolph,** 1917, Tin ore in northern Lander County, Nev.: U.S. Geol. Survey Bull. 640–G, p. 125–138, 1 fig.

Mentions a warm spring 20 miles north of Battle Mountain (town).

426. **LeConte, Joseph,** 1883, On mineral vein formation now in progress at Steamboat Springs [Nev.] compared with the same at Sulphur Bank [Calif.]: Am. Jour. Sci., 3d ser., v. 25, p. 424–428, 2 figs.

427. **Lindgren, Waldemar,** 1905, The occurrence of stibnite at Steamboat Springs, Nevada: Am. Inst. Mining Engineers Bull. 2, p. 275–278; Trans., v. 36, p. 27–31.

Describes the Steamboat springs and gives a chemical analysis of the water.

428. 1911, The Tertiary gravels of the Sierra Nevada of California: U.S. Geol. Survey Prof. Paper 73, 226 p., 28 pls., 16 figs.

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429. **Loeltz, O. J.,** and **Eakin, T. E.,** 1953, Geology and water resources of Smith Valley, Lyon and Douglas Counties, Nev.: U.S. Geol. Survey Water-Supply Paper 1228, 89 p., 3 pls., 6 figs., 8 tables.

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430. **Marshall, Ruth,** 1928, A new species of water mite from thermal springs: Psyche, v. 35, no. 2, p. 92–96, 1 pl.

Describes a mite from a warm spring 15 miles north of Deeth and from Minden hot springs, both in Nevada.

431. **Maxey, George Burke,** and **Eakin, T. E.,** 1950, Ground water in White River Valley, White Pine, Nye, and Lincoln Counties, Nev.: Nevada, Office State Engineer, Water Resources Bull. 8, 59 p., 2 pls., 5 figs., 10 tables.

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432. **Meinzer, Oscar Edward,** 1917, Geology and water resources of Big Smoky, Clayton, and Alkali Spring Valleys, Nevada: U.S. Geol. Survey Water-Supply Paper 423, 167 p., 15 pls., 11 figs.

Describes Spencer, Darrough, McLeod's ranch, Charnock, and Gendron springs. Contains chemical analyses of the water of Spencer, Alkali, Charnock, and Darrough springs.

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436. **Overton, Theodore D.,** 1947, Mineral resources of Douglas, Ormsby, and Washoe Counties: Nevada Univ. Bull., v. 41, no. 9 (Geology and Mining Ser. 46), 91 p., 5 pls., 14 figs.
Describes Steamboat springs and mentions Gerlach hot springs.

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Mentions the hot springs near Golconda and suggests a hot-spring origin for the manganese ore.

438. **Ransome, Frederick Leslie,** 1909a, Notes on some mining districts in Humboldt County, Nev.: U.S. Geol. Survey Bull. 414, 75 p., 1 pl., 7 figs.
Mentions the Sou hot springs.

439. 1909b, The geology and ore deposits of Goldfield, Nev.: U.S. Geol. Survey Prof. Paper 66, 258 p., 35 pls., 34 figs.
Contains data on the Alkali springs.

440. **Reeds, Chester Albert,** 1927, Desert landscapes of northwestern Nevada: Nat. History, v. 27, no. 5, p. 448–461, 22 figs.
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441. **Russell, Israel Cook,** 1885, Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada: U.S. Geol. Survey Mon. 11, 288 p., 46 pls., 36 figs.
Mentions the numerous hot springs in the Lahontan basin and briefly describes the principal ones. Contains chemical analyses of the water from a spring at Hot Spring railway station and from hot springs north of Granite Mountain, both in Nevada; also, analyses of a spring near Honey Lake in California.

442. **St. John, Orestes,** 1883, Report on the geology of the Wind River district, *in* Hayden, Ferdinand V., U.S. Geol. and Geog. Survey Terr. 12th Ann. Rept., 1878, pt. 1: p. 173–269, 49 pls.
Mentions warm springs and tufa deposits 1 mile downstream from the mouth of Warm Spring Creek and 0.5 mile from the Wind River, also warm springs at the mouth of Jakes Creek Canyon, in Nevada. Includes views of Sou hot springs and of hot-spring deposits in Osobb Valley, both in Nevada, and of hot-spring deposits in Provo Valley, Utah.

443. **Spurr, Josiah Edward,** 1903, Descriptive geology of Nevada south of the 40th parallel and adjacent portions of California: U.S. Geol. Survey Bull. 208, 229 p., 8 pls., 25 figs.
Mentions Indian springs and hot springs in White River valley and on Hot Creek ranch.

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Describes the Devil's Punchbowl in Monitor Valley 45 miles northeast of Tonopah and mentions a hot spring and a nearby tepid spring 25 miles southwest of Tonopah.

445. **Spurr, Josiah Edward,** 1906, Ore deposits of the Silver Peak quadrangle, Nevada: U.S. Geol. Survey Prof. Paper 55, 174 p., 24 pls., 40 figs.
Mentions hot springs at Silver Peak and on the east side of Clayton Valley.

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Mentions Mound Spring, hot springs east of Fish Creek, and hot springs in Buffalo Valley. Also contains chemical analyses of water from the springs at Hot Springs ranch, a spring 1 mile north of those springs, and a spring in Buffalo Valley.

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See also references 20, 102, 108, 109, 125, 126, 128, 130, 137, 138, 140, 141, 144, 269, 274, 276, 304, 395, 520, 562, and 667.

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Contains information on the sulfur springs near Mount Pelado, Soda Dam springs, Jemez hot springs, and Indian, San Ysidro, and Phillips springs, also on two thermal wells.

458. **Clarke, Frank Wigglesworth,** 1893, Report on work done in the division of chemistry during the fiscal years 1891–92 and 1892–93: U.S. Geol. Survey Bull. 113, 115 p.
Contains a chemical analysis of water from Ojo Caliente spring in Taos County, N. Mex.

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Mentions hot springs 5 miles northwest of Las Vegas, N. Mex., also warm sulfur springs on the right bank of the Grand River just upstream from the head of its canyon in Colorado.

460. **Jones, Fayette Alexander,** 1904, New Mexico mines and minerals: Santa Fe., N. Mex., New Mexican Printing Co., 349 p., 50 figs.
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463. **Lindgren, Waldemar,** 1910, The hot springs at Ojo Caliente, Taos County, N. Mex., and their deposits: Econ. Geology, v. 5, p. 22–27.

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484. **Phillips, Kenneth N.,** 1936, A chemical study of the fumaroles of Mount Hood: Mazama, v. 18, no. 12, p. 44–46, 2 figs., Portland, Oreg.

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Contains data on several thermal springs and wells.

487. **Russell, Israel Cook,** 1905, Preliminary report on the geology and water resources of central Oregon: U.S. Geol. Survey Bull. 252, 138 p., 24 pls., 4 figs.
Mentions several thermal-spring localities.

488. **Stearns, Harold Thornton,** 1929, Geology and water resources of the upper McKenzie Valley, Oreg.: U.S. Geol. Survey Water-Supply Paper 597–D, p. 171–188, 3 pls., 2 figs.
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See also references 109, 113, 133, 137, 141, 144, 150, 371, 377, 386, and 2092.

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Contains data on 49 deep wells and states that the geothermal gradient is about 1°F for each 40- to 50-foot increase in depth.

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See also references 73, 138, and 144.

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Contains information on several thermal-spring localities in Utah, Wyoming, and Idaho.

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507. **Callaghan, Eugene,** and **Thomas, Harold Edgar,** 1939, Manganese in a thermal spring in west-central Utah: Econ. Geology, v. 34, no. 8, p. 905–920, 6 figs., 3 tables.
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508. **Carpenter, Everett,** 1913, Ground water in Boxelder and Tooele Counties, Utah: U.S. Geol. Survey Water-Supply Paper 333, 87 p., 2 pls., 9 figs.
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511. 1893, The Wasatch Mountains: Internat. Geol. Cong., 5th, Washington 1891, Compte rendu, p. 381–391, 2 figs.; Geol. Guide Book, Rocky Mountain Excursion, p. 253–487.
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See also references 20, 109, 124, 125, 128, 133, 137, 138, 144, 317, 406–409, 413, 418, 424, 433, 442, 666, 686.

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CENTRAL AMERICA

(Costa Rica, El Salvador, Guatemala, Nicaragua, and Panama)

773. **Belcher, Edward,** 1843, Narrative of a voyage round the world, performed in her Majesty's ship *Sulphur* during the years 1836–1842, including details of the naval operations in China from Dec. 1840 to Nov. 1841: London, H. Colburn, 2 v.; v. 1, 387 p., front., 7 engravings, 11 vignettes, maps; v. 2, 475 p., front., 10 engravings, 9 vignettes.

Mentions hot vapors rising from the craters of Volcan de Viejo near Lake Managua; also mentions a thermal saline spring on the shore of a bay on the easternmost island of the Admiralty Group.

774. **Biolley, Pablo,** 1889, Costa Rica and her future: Washington, Judd & Detweiler, 96 p.; translated from the French by Cecil Charles, 1890, Costa-Rica und seine zukunft: Berlin, Thormann u. Goetsch, 90 p.

Mentions fumaroles and hot springs on the north slope of Irazu volcano and boiling springs on the slopes of Poas Volcano.

775. **Boddam-Whetham, John Whetham,** 1877, Across Central America: London, Hurst & Blackett, 353 p., 2 illus.

Mentions the hot springs near Lake Amatitlan, the Almolonga hot spring near Quezaltenango, and hot sulfur springs near the village of La Canoa.

776. **Castro, Esteban,** 1878, Estadística de la jurisdicción municipal de San Vicente: San Salvador [Govt. pub.].

Describes Ausol El Obrajuelo near San Vicente, La Joya, and three other springs about 10 miles southeast of San Vicente.

777. **Deger, Erwin Conradin,** 1937, Die geochemische Stellung und balneologische Bedeutung einiger Thermalquellen Mittelamerikas: Chemie Erde, v. 11, no. 2, p. 249–255, 2 figs.

778. **Dollfus, Auguste, and Mont-Serrat [Montserrat], Eugene de,** 1868, Voyage geologique dans les républiques de Guatemala et de Salvador. Mission Scientifique au Mexique et dans L'Amérique Centrale: Paris, Imprimerie impériale, 539 p., 18 pls.

Contains information on fumaroles, mud volcanoes, and thermal springs.

779. **Dóndoli B., César,** 1941, Nota geológica; Ojo de Agua y sus alrededores: Costa Rica Dept. Nac. Agr. Bol. Téc. 36, Ser. Geol. 3, 10 p., 3 figs.

780. **Dunlop, Robert Glasgow,** 1847, Travels in Central America, being a journal of nearly three years' residence in the country; together with a sketch of the history of the Republic and an account of its climate, productions, commerce, etc.: London, Longman, Brown, Green, & Longmans, 358 p. map.

Mentions the boiling springs on the shore of Lake Amatitlan and thermal wells in the town of Amatitlan, also several areas of mud volcanoes and fumaroles.

781. **Dunn, Henry,** 1828, Guatemala, or the united provinces of Central America, in 1827–8; being sketches and memorandums made during a twelve months' residence in that republic: New York, G. & C. Carvill, 318 p.; 1829 ed., London.

Mentions a hot sulfur spring about 3 miles from San José, Guatemala.

782. **Frantzius, A. von,** 1862, Die warmen Mineralquellen in Costarica: Preussiche Medizinal-Zeitung, new ser., v. 5, no. 14–16, 16 p.

783. 1873, Die warmen Mineralquellen in Costarica: Neues Jahrb, Mineralogie, Geologie u. Paläontologie, no. 5, p. 496–510.

784. **Fröbel, Julius,** 1859, Seven years' travel in Central America, Northern Mexico, and the far West of the United States: London, R. Bentley, 587 p., 8 illus.

Describes a hot spring near Tipitapa village and mud volcanoes of San Jacinto and Tisate, all in Nicaragua; also Ojo Caliente in northern Mexico and Warner's ranch springs in California.

785. **Grebe, Willi Herbert,** 1955, La minería en El Salvador [Centro América]: El Salvador Servicio Geol. Nac. Anales Bol., no. 1, 62 p., 3 pls., 12 figs.

Mentions fumaroles on the flanks of Tecapa and Cuyanausul volcanoes; also mentions solfataras.

786. 1956, Las fumaroles y fuentes termales en las montañas volcánicas de mayor edad de El Salvador: El Salvador Servicio Geol. Nac. Anales Bol., no. 2, p. 34–43, 2 pls., 7 figs.

787. 1957a, Dampfquellen in El Salvasor und ihre wirtschaftliche Bedeutung: Umschau, 1957, no. 6, p. 176–179, 4 figs, 1 map.

788. 1957b, Fumarolen and Thermalquellen in den älteren vulkanischen Gebirgen von El Salvador: Petermanns Geog. Mitt., v. 101, p. 31–35, map, 3 tables.

789. **Guzmán, D. J.,** 1883, Apuntamientos sobre la topografía física de la República de El Salvador: San Salvador.

Mentions several thermal springs.

790. **Hale, J.,** 1826, Six months' residence and travels in Central America, through the free states of Nicaragua and particularly Costa Rica: New York, 32 p.; 1827, abs., Geog. Soc. France Bull., v. 8, no. 53, p. 99–111.

Mentions a hot spring 1 mile south of Cartago and another near San José, both in Costa Rica.

791. **Hustedt, Friedrich,** 1953, Algunas observaciones sobre la vida de microorganismos en los arroyos termales de los ausoles de El Salvador: El Salvador Univ. Inst. Tropical Inv. Cient. Comun., v. 2, nos. 3–4, p. 103–108.

792. **International Bureau of American Republics,** 1892, Nicaragua: Bull. 51, 183 p.

Mentions hot springs.

793. 1892, El Salvador: Bull. 58, 169 p.

Mentions geysers and hot springs.

794. **Lardé, Jorge,** 1924, Geología general de Centro América y especial de El Salvador: San Salvador.

Mentions several warm springs in El Salvador.

795. **Lötschert, Wilhelm,** 1956, Temperatur- und pH-Studien in salvadorenischen Solfataren und Thermen: Deutchen Bot. Gesell. Ber., v. 69, p. 21–31, 4 figs., 3 tables.

796. **McBirney, Alexander R.,** 1955, Aspecto químico de la actividad de fumarolas en Nicaragua y El Salvador: El Salvador Univ. Inst. Tropical Inv. Cient. Comun., v. 4, nos. 3–4, p. 95–100, 5 tables.

797. 1956, An appraisal of the fumarolic activity near Ahuachapán, El Salvador: El Salvador Servicio Geol. Nac. Anales Bol., no. 2, p. 19–32 [English], 3 graphs, 3 maps; 1958, abs., Annot. Bibliography Econ. Geology, 1956, v. 29. no. 2, p. 307.

798. **Meyer-Abich, Helmut,** 1953, Los ausoles de El Salvador, con un sumario geológico-tectónico de la zona volcanica

occidental: El Salvador Univ. Inst. Tropical Inv. Cient. Comun., v. 2, nos. 3–4, p. 55–102, 8 pls., 8 figs., 3 tables, map.

799. **Meyer-Abich, Helmut,** 1956, Los volcanes activos de Guatemala y El Salvador (América Central): El Salvador Servicio Geol. Nac. Anales Bol., no. 3, 102 p., 26 pls., 20 figs.
Mentions fumaroles, solfataras, and thermal springs in several localities.

800. **Meyer-Abich, Helmut,** and **McBirney, Alexander R.,** 1958, Active volcanoes of Guatemala and El Salvador, *in* Central America, pt. 6 *of* Catalogue of active volcanoes of the world including solfatara fields: Naples, Italy, Internat. Volcanol. Assoc., p. 38–146, 29 figs.
Contains information on hydrothermal activity in Guatemala, El Salvador, Nicaragua, and Costa Rica.

801. **Montgomery, George Washington,** 1839, Narrative of a journey to Guatemala in Central America in 1838: New York, Wiley & Putnam, 195 p.
Describes boiling ponds near Ahuachapán and hot springs near the town of Salama.

802. **Penta, Francesco,** 1953, Sulle possibilitá offerte dal territorio della repubblica di El Salvador nell'America Centrale nel campo delle "forze endogene": Annali Geofisica, v. 6, no. 3, p. 309–314.

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804. **Pittier, Henri François,** 1910, Costa Rica—Vulcan's smithy: Natl. Geog. Mag., v. 21, no. 6, p. 494–525, 30 views, 2 maps.
Mentions solfataras and hot springs on the slopes of Irazú and Poás volcanoes.

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Mentions fumaroles, mud volcanoes, and hot springs in several localities.

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Describes the hot springs associated with individual volcanoes in Guatemala, El Salvador, Nicaragua, and Costa Rica.

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811. 1932, Ueber einige Mineral- und Thermalquellen von Costa Rica: Eclogae geol. Helvetiae, v. 25, no. 1, p. 139–162.

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Mentions vapor vents at the Hornillos de Miravalles, a hot spring near Salitral, and fumaroles and solfataras near Guachipilin.

814. 1892, Ueber Vulkane Centralamerikas: K. Gesell. Wiss. Göttingen abh. 38, 251 p., 14 pls.
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Mentions hot springs in Panama and Colombia.

816. **Segura Paguaga, Alfonso,** and **Arguedas, Jorge Leon,** 1940, El valle de Cartago y Coris: Costa Rica Dept. Agriculture Rev., v. 5, nos. 9–12, p. 438–449, 7 figs.
Mentions hot springs.

817. **Sonnenstern, Maximilian von,** 1858, Carta topographica de la República de El Salvador, con una descripción de cada uno de los Departamentos del Estado de El Salvador; repr., 1950, Mus. Nac. "David J. Guzman" Annales, v. 1, no. 3, p. 37–67.
Describes several areas of hydrothermal activity.

818. **Squier, Ephraim George,** 1852, Nicaragua; its people, scenery, monuments, and the proposed interoceanic canal: New York, D. Appleton & Co., 2 v.; v. 1, 424 p., 13 pls., 35 engravings, 2 figs.; v. 2, 452 p., 12 pls., 25 engravings, 7 figs.
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819. 1855, Notes on Central America, particularly the States of Honduras and San Salvador; their geography, topography, climate, population, resources, production, etc., and the proposed Honduras interoceanic railway: New York, Harper & Bros., 397 p., 11 illus., 3 topog. sections, 3 charts, maps.
Mentions hydrothermal activity in the vicinities of Ahuachapán and San Vicente and Tecapa volcanoes.

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Mentions vapor vents on the slopes of San Vicente and Tecapa volcanoes and hot springs near Ahuachapán.

821. **Stephens, John Lloyd,** 1858, Incidents of travel in Central America, Chiapas, and Yucatan: 12th ed., New York, Harper & Bros., 2 v.; v. 1, 424 p., 32 illus., map; v. 2, 474 p., 46 illus.; 1st ed., 1841.
Describes hydrothermal activity in El Salvador and Guatemala.

822. **Villafranca, Richard,** 1895, Costa Rica—the gem of American republics; the land, its resources, and its people: New York, Sacket & Wilhelms Litho. Co., 139 p.
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823. **Williams, Howel,** 1953, Geology of southern El Salvador, Central America [abs.]: Geol. Soc. America Bull., v. 64, no. 12, p. 1517.

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824. **Aenlle, Joaquín Fabion,** 1866, Apuntos para el estudio de las aguas minero-medicinales de la Isla de Cuba: 2d ed., Royal Univ. Habana Fac. Pharmacy, 108 p.

825. **Beato y Dolz, José,** 1882, Informe sobre las aguas minero-medicinales de la isla de Cuba: Acad. Cienc. [Habana] Anales, v. 18, no. 210, p. 325–336.

826. **Blanquet, Lucienne,** and **Morette André,** 1957a, Sur la composition des eaux et des gaz spontanés de quelques sources thermominérales de Haiti: Acad. sci. [Paris] Comptes rendus, v. 245 p. 1556–1559.

827. 1957b [Composition of water from some thermo-mineral sources in Haiti]: Annales pharm. françaises, v. 15, p. 611–616.

828. **Broderman, Jorge,** 1942, Investigación geológica de las aguas minero-medicinales de la Provincia de la Habana: Soc. Cubana Ingenieros Rev., v. 37, no. 4, p. 195–219.

829. **Brown, John Stafford,** 1924a, The hot springs of the Republic of Haiti: Jour. Geology, v. 32, no. 5, p. 384–399, 3 figs., 3 tables.

830. 1942b, Water Resources, *in* Woodring, Wendell Phillips; Brown, John Stafford; and Burbank, Wilbur Swett, Geology of the Republic of Haiti: Haiti Dept. Public Works, 631 p. [French ed., 710 p.]; Baltimore, Md., Lord Baltimore Press (both eds.).

Describes four groups of thermal springs.

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832. **Cosculluela y Barreras, Juan A.,** 1945, Aspectos fundamentales relacionados con la hidrología mineral de Cuba: Habana Acad. Cienc. Med., Fís. y Nat. Anales, v. 83, no. 5, p. 228–254. Discurso de Contestación, by José I. Corral, p. 255–278.

Includes data on thermal springs in nine localities. Summarizes earlier publications on springs in Cuba.

833. **De la Beche, H. T.,** 1829, Remarks on the geology of Jamaica: Geol. Soc. London Trans., ser. 2, v. 2, p. 143–194.

Describes St. Thomas Bath mineral spring.

834. **Fernández y Benítez, José A.,** 1907, Estudio químico, micrográfico y bacteriológico de las aguas minero-medicinales de San Diego, en la provincia de Pinar del Río; Santa Rita, Santa María del Rosario, y Madrugada, en la provincia de la Habana; con algunos datos sobre las aguas de San Vicente (Viñales), Fuente de Obispo (Guanabacoa), San Miguel de Guamacaro (Matanzas) y Delicias de San Antonio (Santiago de Cuba): Habana Acad. Cienc. Med., Fís. y Nat. Anales, v. 44, p. 64–72, 181–196, 297–336, 369–397, 451–475, 18 figs.

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835. **Hazard, Samuel,** 1871, Cuba with pen and pencil: Hartford, Conn., Hartford Publishing Co., 584 p., front., 17 illus., vignettes; Spanish ed., 1928, *in Colección* de libros Cubanos: Habana Cultural S. A. Chicago, Ill., Pitkin & Parker.

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836. **Hill, Robert Thomas,** 1899, Cuba and Porto Rico; with the other islands of the West Indies; their topography, climate, flora, products, industries, cities, people, political conditions, etc.: 2d ed., New York, Century Co., 447 p., front., 86 illus., map.

Mentions San Antonio de los Baños in Cuba; warm springs at Coamo, Quintana, Ponce, and elsewhere in Puerto Rico; St. Thomas and Milk River Baths in Jamaica; sulfur baths in Nevis Island; and thermal springs and soufrières in Guadeloupe, Dominica, and St. Lucia.

837. **Hodge, Edwin Thomas,** 1920, The geology of the Coamo-Guayama district, Porto Rico: New York Acad. Sci. Survey of Porto Rico and the Virgin Islands, v. 1, p. 111–228, 50 figs., map.

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838. **Martin, R. Montgomery,** 1837, The British colonies, their history, extent, condition, and resources: 2d ed., London, J. Cochran & Co. (6 v. in 3); v. 4, Book 1, West India Islands, 188 p., 5 pls., maps.

Contains information on thermal activity in Jamaica, St Lucia, St. Vincent, Grenada, Trinidad, Dominica, Nevis, and St. Christopher (St. Kitts).

839. **Phillippo, James Cecil,** 1883, Mineral springs of Jamaica, *in* Sinclair, A. C., and Fyfe, Laurence R., Handb. of Jamaica for 1883: London, Jamaica, Govt. Printing Establishment, p. 461–471.

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Describes hydrothermal activity on St. Vincent and Martinique Islands; also mentions the Grande Soufrière and Boiling Lake in Dominica.

848. **Anonymous,** 1952, Use of power from volcanic energy being explored in West Indies by UN expert: Chem. and Eng. News, v. 30, no. 10, p. 1012.
Refers to the possibility of utilizing volcanic energy to produce electricity on St. Lucia as has been done at Lardarello, Italy.

849. **Breen, Henry Hegart,** 1844, St. Lucia—Historical, statistical, and descriptive: London, Longman, Brown, Green, & Longmans, 423 p., map.
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Describes a small lake of boiling water in the volcanic crater in St. Vincent and the fumaroles in Martinique.

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Describes the disastrous eruptions, in 1902, of boiling water and boiling mud in Martinique.

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Mentions that a stream flowing down the mountainside turns to boiling water when it comes in contact with hot sulfurous exhalations.

863. **Ober, Frederick Albion,** 1880, Camps in the Caribees—The adventures of a naturalist in the Lesser Antilles: New York, C. T. Dillingham, 366 p., 34 illus.
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865. **Perret, Frank Alvord,** 1935, The eruption of Mt. Pelée 1929–1932: Carnegie Inst. Washington Pub. 458, 126 p., front., 72 figs., diagram, chart.
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867. **Robson, G. R., and Willmore, P. L.,** 1955, Some heat measurements in West Indian soufrières: Bull. volcanol., ser. 2, v. 17, p. 13–39, 6 figs., 3 tables.
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869. **Sapper, Karl Theodor,** 1903a, Ein Besuch der Insel Grenada: Centralbl. Mineralogie, Geologie u. Paläontologie, 1903, Abt. A, p. 182–186, map.
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ALGERIA AND TUNISIA

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See also reference 43.

BELGIAN CONGO (REPUBLIC OF THE CONGO) AND RUANDA-URUNDI (REPUBLIC OF RWANDA AND KINGDOM OF BURUNDI)

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Lists, by name or location, the thermal springs in the Congo and neighboring regions of Ruanda-Urundi and Uganda.

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See also reference 2393.

EGYPT, LIBYA, AND SUDAN

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2511. **Bagnold, R. A.,** 1931, Journeys in the Libyan Desert, 1929 and 1930: Royal Geog. Soc. [London] Jour., v. 78, p. 13–39, 524–535, 6 pls., map.
Describes Ain Dalla.

2512. **Barron, T.,** 1907, The topography and geology of the Peninsula of Sinai (western portion): Egypt Survey Dept., 241 p., 10 pls., 5 figs.
Describes hot springs at the foot of an escarpment facing El Tor, the group of springs near the northwest-facing Gebel Hammam Faraûn, and the springs of Ayun Musa.

2513. **Desio, Ardito,** 1943, L'Esplorazione mineraria della Libia: Collezione sci. e doc. Africa italianá, v. 10, Ist. studi politica internaz., 333 p., 24 pls., 39 figs., map.
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2514. **Dunn, Stanley C.,** 1911, Notes on the mineral deposits of the Anglo-Egyptian Sudan: Geol. Survey Anglo-Egyptian Sudan Bull. 1, 70 p., maps.
Mentions hot mineral springs at Akasha.

2515. **Fourtau, R.,** and **Georgiadès, N.,** 1905, Sur la source de Hammam Moussa près de Tor (Sinai): Acad. sci [Paris] Comptes rendus, v. 140, p. 166–167.

2516. **Gastinel, Pacha,** 1861, Waters of Ain el Sira: Inst. Égypte Bull.

2517. 1881, Étude topographique, chimique, et médicale des eaux minérales d'Hélouan-les-Bains (Moyenne Égypte): Inst. Égypte Bull., ser. 2, no. 2, p. 70–99.

2518. **Grabham, G. W.,** 1931, Report of the geological survey of the Anglo-Egyptian Sudan for the year 1930: Khartoum, Sudan Republic, 10 p.
Describes hot spring at Akasha.

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Mentions tufa deposits near mouth of deep gorge upstream from Derna.

2520. **Holroyd, Arthur T.,** 1839, Notes on a journey to Kardofán in 1836–37: Royal Geog. Soc. [London] Jour., v. 9, p. 163–191, map.
Describes a group of springs 4 miles south of Okmeh village.

2521. **Hume, William Fraser,** 1925, Geology of Egypt: Cairo, Government Press, 2 v.; v. 1, The surface features of

Egypt, their determining causes and relation to geological structure, 408 p., 122 pls.
Includes descriptions of the principal springs in Egypt.

2522. **Hume, William Fraser; Madgwick, T. G.; Moon, F. W.;** and **Sadek, H.,** 1920, Preliminary general report of the occurrence of petroleum in Western Sinai: Survey of Egypt Petroleum Resources Bull. 2, 15 p., 5 pls., 2 maps.
Contains information on the Hammam Faraûn hot springs.

2523. **May, William Page,** 1904, Helwân and the Egyptian Desert; with articles by Prof. A. H. Sayce and Prof. G. Schweinfurth: 2d ed., London, G. Allen, 102 p., 32 illus., map.

2524. **Michaéloff, S.,** 1939, Chemical-biological study of hot sulfurous water from the source "Hammam Faraun" (Sinai): Inst. Égypte Bull., v. 21, p. 25–29; 1940, Chem. Abs., v. 34, col. 3851.

2525. **Narkirier, S.,** 1928 [Sulfur waters of Helouan-les-Bains, their composition and therapeutic value]: Egyptian Med. Assoc. Jour., v. 11, p. 57–72, 114–128 [French]; Chem. Abs., v. 22, p. 4175.

2526. **Sadek, H.,** 1926, Geography and geology of the district between Gebel Atâqa and El-Galâla El-Baharîya: Survey of Egypt Paper 40, 120 p., 13 figs.
Describes sulfur springs near north base of Khashm El-Galâla.

2527. **Warrington, G. H.,** 1844, Extract from "A short account of Tripoli in the west": Royal Geog. Soc. [London] Jour., v. 14, p. 104–107.
Mentions a warm spring at Duga.

2528. **Wilkinson, John Gardner,** 1843, Modern Egypt and Thebes; being a description of Egypt, including the information required for travellers in that country: London, John Murray, 2 v.; v. 1, 476. p., illus., map; v. 2, 591 p., illus.
Describes the springs in Little, Kharga, Dakhla, and Farafra Oases.

See also references 30, 79, 2433, 2544, 2805, and 2873.

ERITREA, ETHIOPIA (ABYSSINIA), FRENCH SOMALILAND, AND SOMALI REPUBLIC

2529. **d'Abbadie, Antoine Thomson,** 1848, Lèttre a M. Dausay (Voyage en Abyssinie): Soc. géographie [Paris] Bull., v. 9, p. 97–118.
Contains mention of thermal springs.

2530. **Aubert de la Rüe, Edgar,** 1939, Le volcanisme en Cote Française des Somalis: Bull. volcanol. ser. 2, v. 5, p. 71–108, 12 pls., 11 figs., rev., Nature [London], v. 145, no. 3682, p. 828–829, 1940.
Mentions several thermal-spring localities, also two groups of fumaroles.

2531. **Barker, William C.,** 1842, Extract report on the probable position of Harrar, with some information relative to the various tribes in the vicinity: Royal Geog. Soc. [London] Jour., v. 12, p. 238–244.
Mentions the hot springs at Sirke (Sirge).

2532. **Beke, Charles Tilstone,** 1842, Communications respecting the geography of southern Abyssinia: Royal Geog. Soc. [London] Jour., v. 12, p. 84–102, map.
Describes the hot springs of St. Abbo and of the Holy Virgin.

2533. **Beke, Charles Tilstone,** 1844, Abyssinia—being a continuation of routes in that country: Royal Geog. Soc. [London] Jour., v. 14, p. 1–76, map.
Describes the warm springs on the east bank of the I'sser River near Dúbbi.

2534. **Blanford, William Thomas,** 1870, Observations on the geology and zoology of Abyssinia: London, Macmillan & Co., 487 p., front., 12 pls., map, 9 vignettes.
Describes several thermal-spring localities.

2535. **Cana, Frank R.,** 1911, Somaliland, *in* Encyclopaedia Britannica; 11th ed., New York, Encyclopaedia Britannica, Inc., v. 25, p. 378–384.
Mentions a warm spring-fed stream that flows into Bahr-Assal.

2536. **Cruttenden, Charles J.,** 1849, Memoir on the western or Edoor tribes, inhabiting the Somali coast of N-E Africa * * *: Royal Geog. Soc. [London] Jour., v. 19, p. 49–76.
Describes the hot springs northwest of Dubar.

2537. **Galinier,** and **Ferret,** 1844, Rapport sur les travaux exécutés en Abyssinie: Bibliography Univ., v. 55, 1845, p. 308–320; v. 56, p. 83–93; 1884, summ., Acad. sci. [Paris] Comptes rendus, v. 19, p. 870–886.
Mentions several thermal springs.

2538. **Gwynn, C. W.,** 1911, A journey in southern Abyssinia: Royal Geog. Soc. [London] Jour., v. 38, no. 2, p. 113–139, 8 illus., map.
Describes hot springs near Lake Stephanie.

2539. **Harris, William Cornwallis,** 1844, The highlands of AEthiopia, described during eighteen months' residence of a British embassy at the Christian court of Shoa: 2d ed.: London, Longman, Brown, Green & Longmans, 3 v.; v. 1, 419 p., front., vignette, map; v. 2, 425 p., front., vignette; v. 3, 423 p., front., vignette.
Describes hot-water wells near Arto hill and a group of springs in a bend of the Casam River.

2540. **Isenberg, Karl William,** and **Krapf, John Ludwig,** 1843, Journals of the Rev. Messrs. Isenberg and Krapf, missionaries of the Church Missionary Society, detailing their proceedings in the kingdom of Shoa and journeys in other parts of Abyssinia in the years 1839, 1840, 1841, and 1842: London, Seeley, Burnside, & Seeley, 529 p., maps.
Mentions hot-water wells in the Finfini area.

2541. **Johnston, Charles,** 1844, Travels in southern Abyssinia, through the country of Adal to the kingdom of Shoa: London, J. Madden & Co. 2 v., v. 1, 492 p., front., map; v. 2, 447 p., front.
Describes a group of boiling springs at Ta'hou.

2542. **Macfadyen, William Archibald,** 1933, The geology of British Somaliland; pt. 1 *of* Geology and Paleontology of British Somaliland: London, 87 p., 4 pls.
Contains information on four thermal-spring localities.

2543. 1952, Water supply and geology of parts of British Somaliland: Govt. Somaliland Protectorate, 184 p., 1953, Chem. Abs., v. 47, col. 8293.

2544. **Parkyns, Mansfield,** 1856, Life in Abyssinia—Being notes collected during three years' residence and travel in that country: New York, D. Appleton & Co., 2 v. (in one); v. 1, 350 p., 8 illus.; v. 2, 355 p., 5 illus.
Describes Ayun Musa in Egypt and hot springs at Ailat in Ethiopia.

2545. **Penta, Francesco,** 1939, L'attività svolta dal Centro Studi delle risorse naturali dell'Italia meridionale: Soc. naturalisti Napoli Boll. 50, p. 75–125.
Includes brief description of the hot springs of Galla and Sidano in Ethiopia.

2546. **Plowden, Walter Chichele,** 1868, Travels in Abyssinia and the Galla country, with an account of a mission to Ras Ali in 1848: London, Longmans, Green, & Co., 485 p., maps. (From the manuscript of the late Walter Chichele Plowden, edited by his brother Trevor Chichele Plowden.)
Contains information on several thermal-spring localities.

2547. **Rochet d'Héricourt, C. F. X.,** 1841a, Considerations géographiques et commerciales sur le golfe Arabique, le pays d'Adel et le royaume de Choa (Abyssine-méridionale) [extr.]: Soc. géographie [Paris] Bull., ser. 2, v. 15, p. 269–293.
States that there are 24 hot springs in the kingdom of Choa.

2548. 1841b, Observations faites durant un voyage dans le pays d'Adel et le royaume de Choa: Acad. sci. [Paris] Comptes rendus, v. 12, p. 732–735.
Contains the same information as reference 2547.

2549. 1850, Mémoire sur l'état constant de soulèvement du golfe Arabique et de l'Abyssinie, et sur les résultats scientifiques de son voyage [extr.]: Acad. sci. [Paris] Comptes rendus, v. 30, p. 24–28.
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2550. **Toffoli, Cesco,** 1937a, Le acque dell'Eritrea: Annali chimica appl., v. 27, p. 30–32, 2 figs.
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2551. 1937b, Le acque termali della regione di Ailet (Eritrea): Annali chimica appl., v. 27, p. 165–174.

2552. 1937c, L'acqua termale di Ali-Hasa (Eritrea): Annali chimica appl., v. 27, p. 175–178.

2553. **Usoni, Luigi,** 1952, Risorse minerarie dell'Africa orientale; Eritrea-Etiopia-Somalia: Rome, Ministerio Africa Italiana, Ispettorato Gen. Mineralogia, 547 p., illus.; 1954, abs., Bibiliography and Index of Geology Exclusive of North America, v. 18, 1953, p. 427.
Includes a section on mineral springs.

See also references 30, 43, and 2432.

FRENCH EQUATORIAL AFRICA, FRENCH WEST AFRICA, AND NIGERIA

2554. **Belcher, Edward,** 1832, Extracts from observations on various points of the west coast of Africa, surveyed by his Majesty's ship *Aetna* in 1830–32: Royal Geog. Soc. [London] Jour., v. 2, p. 278–304.
Mentions hot springs on the Nunez River downstream from Walkeria.

2555. **Combier, M.,** 1935, Carte géologique de Dakar [French West Africa]: Com. Études Afrique Occidentale, ser. B, Bull. 1, p. 1–39.

2556. **Lambert, Roger,** 1938, Contributions à la connaissance hydrologique de la Colonie du Niger [French West Africa]; Govt. Gén. Afrique Occidentale Française, Service Mines Bull. 1, p. 29–46, 6 pls.
Describes Tafadek, a thermal spring about 50 km north of Agadez.

2557. **Nachtigal, Gustav Hermann,** 1876, Journey to Lake Chad and neighboring regions: Royal Geog. Soc. [London] Jour., v. 46, p. 396–411, map.
Mentions a hot spring (Yerike?) on the east slope of a crater at the summit of Tarso.

2558. **Raeburn, C.,** 1928, The Nigerian Sudan; some notes on water supply and cognate subjects: Nigeria Geol. Survey Bull.

2559. **Raeburn, C., and Jones, B.,** 1934, The Chad basin; geology and water supply: Nigeria Geol. Survey Bull. 15.

See also reference 2432.

MOROCCO

2560. **Abrard, R.,** 1921, La Source sulfureuse Aïn bou Kebrit (Maroc): Soc. géol. France Compte rendu, 1921, p. 158–159.

2561. **Anonymous,** 1926, Recherches géologiques dans la méséta Marocaine: Soc. sci. nat. Maroc Bull. 14, p. 1–154.
Mentions a group of warm springs along the west flank of the Cherrat anticline.

2562. **Bondon, J.,** and **Frey, R.,** 1935, Les sources thermales d'Abeino (Sud de Tiznit), Maroc Méridional: Com. études eaux souterraines [Rabat], v. 2, no. 4, p. 34–35, 1 pl.; abs., 1936, Rev. géologie, v. 16, p. 523, 1936.

2563. **Bourcart, Jacques, and Urbain, P.,** 1933, Sur la présence de sources minérales au voisinage d'affleurements aberrants du Trias, en particulier dans le R'arb marocain: Soc. géol. France Compte rendu, ser. 5, v. 3, p. 14.

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2565. **Graudé, Charles,** and **Rodier, J.,** 1955, Contribution à l'étude des eaux thermominérales de Moulay Yacoub (composition, vieillissement et radioactivité): Soc. sci. nat. Maroc Compte rendu, no. 4, p. 78–81.

2566. **Liouville, Jacques,** 1923, La mission des eaux minérales du Docteur Jean Bertrand (Recensement des richesses hydrothermominérales du l'empire Cherifien): Soc. sci. nat. Maroc Bull., v. 3, nos. 5–6, p. 92–101.
Contains information on Lada Aïa spring.

2567. **Marin, A.,** 1930 [Geographic description of the Spanish Protectorate zone in Morocco]: Soc. geog. nac. Bol. 70. Madrid.

2568. **Nègre, L.,** 1913, Bactéries thermophiles des eaux de Figuig: Soc. biologie [Paris] Comptes rendus, v. 74, p. 867–869.

2569. **Ruiz Albeniz, Victor,** 1930, Colonization española en Marruecos: Madrid, 259 p.
Mentions thermal spring in Guad Bu Azum.

2570. **Russo, Philibert Augustin François,** 1927, Recherches géologiques sur le territoire de hauts plateaux (Maroc Oriental): Annales univ. Lyon, new. ser., 1, Sci. médecine, pt. 46, 198 p., 1 pl., 51 figs., map.

2571. 1934, La science au Maroc: Coup d'oeil d'ensemble sur l'hydrogéologie du Maroc.
Mentions hot spring at Moulay Yacoub near Fez, Ain Souknhna near Ben Rached, and mineral springs near Oulmes.

2572. **Russo, Philibert Augustin François,** 1936, Hydrogéologie Chiker (Région de Taza Maroc septentrional): Cong. internat. mines, 7th, Paris 1935, v. 2, p. 779–782.
See also references 20 and 2433.

SOUTHERN AFRICA

(Bechuanaland Protectorate, Kenya, Mozambique, Northern and Southern Rhodesia, Nyasaland, Tanganyika, and Uganda)

2573. **Akeley, Mary L. Jobe,** 1929, Carl Akeley's Africa: New York, Blue Ribbon Books; Cornwall, N.Y., Cornwall Press, 321 p., front., 1 pl.
Mentions hot springs along lower Molo River and boiling springs near the south end of Lake Hannington.
2574. 1949, Rumble of a distant drum, a true story of the African hinterland: New York, Dodd, Mead & Co., 364 p., 20 figs.
Mentions the same thermal spring as reference 2573.
2575. **Bond, Geoffrey W.,** 1953, The origin of thermal and mineral waters in the middle Zambezi Valley and adjoining territory: Geol. Soc. South Africa Trans., v. 56, p. 131–148, 4 figs., 5 tables.
2576. **Bradshaw, Benjamin F.,** 1881, Notes on the Chobe River, South Central Africa: Royal Geog. Soc. [London] Proc., new ser., v. 3, p. 208–213, map.
Describes a hot saline spring on the bank of Chobe (Kwando) River in Bechuanaland.
2577. **Ferguson, David,** 1903, The geysers or hot springs of the Zambesi and Kafue valleys: Rhodesia Sci. Assoc. Proc., v. 3 [1902], p. 9–20.
2578. **Gregory, John Walter,** 1896, The great Rift Valley; being a narrative of a journey to Mount Kenya and Lake Baringo * * *: London, J. Murray, 422 p., front., 20 pls., 23 figs., 2 maps.
Mentions a steam vent on the north wall of the crater on Mount Longonot, 10 miles south of Lake Naivasha.
2579. 1921, The rift valleys and geology of East Africa: An account of the origin and history of the rift valleys of East Africa and their relation to the contemporary earth movements which transformed the geography of the world: London, Seeley, Service, & Co., Ltd., 479 p., 20 pls., maps, 44 figs.
Mentions steam vents in several localities, also a hot spring in Njorowa Gorge and another at Lake Manyara.
2580. **Hahn, Daniel Paul,** 1911, A geyser in South Africa: South African Jour. Sci., v. 7, p. 240–241, 1 pl.
Describes the Zongola geyser in Southern Rhodesia.
2581. **Handley, J. R. F.,** 1954, The hot springs at Ibadakule, Shinyange district: Tanganyika Geol. Survey Recs., v. 1, p. 38; 1955, abs., Bibliography and Index of Geology Exclusive of North America, v. 19, 1954, p. 189.
2582. **Lenk, Hans,** 1894, Ueber Gesteine aus Deutsch-Ostafrika, *in* Baumann, Oscar, Durch Massailand zur Nilquelle. Reisen und Forschungen der Massai-Expedition des deutschen Antisklaverei-Komite in den Jahren 1891–1893: Berlin, Otto Elsner, 386 p., 27 pls., 140 illus., map.
Includes information on a hot spring on the west side of Lake Manyara in Tanganyika.
2583. **Maufe, H. B.,** 1933, A preliminary report on the mineral springs of Southern Rhodesia: Southern Rhodesia Geol. Survey Bull. 23, 78 p., 2 pls.; 1935, Chem. Abs., v. 29, col. 5205.
2584. **Mugge, O.,** 1886, Ueber einige Gesteine des Massai-Landes: Neues Jahrib. Mineralogie, Geologie u. Paläontolgie, Beilage-Band. 4, p. 576.–609.
Contains a chemical analysis of the water from a hot spring near Lake Naivasha in Kenya.
2585. **Richards, J. J.,** 1945, Kilimanjaro; crater fumaroles of Kibo and seismic activity during 1942–1945: Nature [London], v. 156, no. 3960, p. 352–354, 3 figs.
Describes fumaroles in the Kibo crater on Mount Kilimanjaro in Tanganyika.
2586. **Schmidle, W.,** 1902, Beiträge zur Algenflora Afrikas: Engler's Bot. Jahrb., v. 30, no. 2, p. 58–68, 14 figs.
Describes algae growing in warm spring near Lake Manyara in Tanganyika.
2587. **Spink, P. C.,** 1944, Weather and volcanic activity of Kilimanjaro: Royal Geog. Soc. [London] Jour., v. 103, no. 5, p. 226–229, 2 pls., 1 fig.
Describes fumaroles in the Kibo crater on Mount Kilimanjaro in Tanganyika.
2588. 1945a, Further notes on the Kibo inner crater and glaciers of Kilimanjaro and Mount Kenya: Royal Geog. Soc. [London] Jour., v. 106, nos. 5–6, p. 210–216, 8 pls., 2 figs.
2589. 1945b, Thermal activity in the eastern Rift Valley: Royal Geog. Soc. [London] Jour., v. 105, nos. 5–6, p. 197–207, 5 pls., map.
Describes fumaroles, steam vents, boiling pools, and hot springs in the vicinity of Lake Naivasha in Kenya.
2590. **Stanley, Henry Morton,** 1878, Through the Dark Continent, or the Sources of the Nile: New York, Harper & Bros., 2 v.; v. 1, 522 p., front., 57 illus., map; v. 2, 566 p., front., 90 illus., map.
Describes Mtagata hot springs in Tanganyika, also hot springs near Kwaniwa's village in the Congo.
2591. 1890, In Darkest Africa: New York, C. Scribner's Sons, 2 v.; v. 1, 547 p., front., 73 illus., map; v. 2, 540 p., front., 72 illus., maps.
Describes three hot springs at Mtarega in Uganda and mentions the Mtagata hot springs and other hot springs near Iwanda and Luajimba.
2592. **Teale, E. O., and Oates, F.,** 1934, The limestone caves and hot springs of the Songwe River (Mbeya) area with notes on the associated guano deposits: East Africa and Uganda Nat. History Soc. Jour., v. 12, no. 4., p. 130–137.
Describes the Maronde springs (Grafin Bose Thermen) in Northern Rhodesia.
2593. **Tucker, Alfred Robert,** 1908, Eighteen years in Uganda and East Africa: London, E. Arnold, 2 v.; v. 1, 359 p. front., 29 illus., map; v. 2, 388, p., front., 30 illus.
Contains a description of the boiling springs in the Semliki River valley between Lakes Edward and Albert.
2594. **Wallace, L. A.,** 1899, The Nyasa-Tanganyika plateau: Royal Geog. Soc. [London] Jour., v. 13, no. 6, p. 595–621, map.
Describes a group of hot springs 40 miles east of Lake Mweru in Northern Rhodesia.
2595. **Wayland, E. J.,** 1921, Hot springs, *in* Uganda Geol. Dept. Ann. Rept., 1920, p. 72–75.
2596. 1935, Notes on thermal and mineral springs in Uganda: Uganda Geol. Survey Bull. 2, p. 44–55, map.
See also references 16, 94, 2508, 2509, 2634, and 2636.

SOUTH WEST AFRICA AND UNION OF SOUTH AFRICA

2597. **Alexander, James Edward,** 1838a, Report of an expedition of discovery through the countries of the Great Namáquas, Boschmans, and the Hill Dámaras, in South Africa: Royal Geog. Soc. [London] Jour., v. 8, p. 1–28, map.

Contains information on Nisbett's Bath, Glenelg Bath, and Queen Adelaide's Bath.

2598. 1838b, An expedition of discovery into the interior of Africa, through the hitherto undescribed countries of the Great Namáquas, Boschmans, and Hill Dámaras: London, H. Colburn, 2 v.; v. 1, 320 p., front., 5 illus.; v. 2, 306 p., front., 7 illus.

Describes the same springs as reference 2597.

2599. **Backhouse, James,** 1844, A narrative of a visit to the Mauritius and South Africa: London, Hamilton, Adams & Co., 648 p., front., 43 illus., maps.

Refers to several hot-spring localities.

2600. **Baines, Thomas,** 1864, Explorations in South-west Africa, being an account of a journey in the years 1861 and 1862 from Walvisch Bay, on the western coast, to Lake Ngami and the Victoria Falls: London, Longman, Green, Longman, Roberts, & Green, 535 p., front., 32 illus.

Describes Gross Barmen hot springs and nearby tepid springs.

2601. **Barrow, John,** 1806, Travels into the interior of southern Africa, in which are described the character and the condition of the Dutch colonists of the Cape of Good Hope, and of the several tribes of natives beyond its limits; the natural history of such subjects as occurred in the animal, mineral and vegetable kingdoms; and the geography of the southern extremity of Africa: 2d ed., London, T. Cadell & W. Davies, 2 v.; v. 1, 419 p., 8 pls.; v. 2, 372 p., map.

Describes visits to several thermal-spring localities.

2602. **Bond, Geoffrey W.,** 1946, A geochemical survey of the underground water supplies of the Union of South Africa: Geol. Survey South Africa Mem. 41, 216 p.

Contains data on some of the deep thermal wells.

2603. **Burchell, William John,** 1822-24, Travels in the interior of southern Africa: London, Longman, Hurst, Rees, Orme, & Brown, 2 v.; 1822, v. 1, 586 p., 10 pls., 50 vignettes, map.; 1824, v. 2, 648 p., 10 pls., 46 vignettes 1953, repr., with some additional material and an introduction by I. Schafera: London, Batchworth Press, 2 v.

Describes visits to several thermal-spring localities.

2604. **Chapman, James,** 1868, Travels in the interior of South Africa, comprising fifteen years' hunting and trading; with journeys across the continent from Natal to Walvisch Bay, and visits to Lake Ngami and the Victoria Falls: London, Bell & Doldy, 2 v.; v. 1, 454 p., front., 10 illus., map.; v. 2, 480 p., front., 15 illus., map.

Describes Gross Barmen, Klein Barmen, and Eikham's hot springs.

2605. **Cock, Gilbert,** 1929, The composition of some water supplies in South West Africa: South West Africa Sci. Soc. Jour., v. 2, p. 63–70.

2606. **Finn, N.,** 1941, Crenotherapy in South Africa: South African Med. Jour., v. 15, p. 229–234.

Contains data on some of the thermal springs

2607. **Frommurze, H. F.,** 1932, Flowing boreholes in the Rehoboth, Gibeon, and Gobabis districts, South-West Africa: Geol. Soc. South Africa Trans., v. 34, p. 129–149, pl., 6 figs.

2608. **Gevers, Traugott Wilhelm,** 1932, The hot springs of Windhoek, South West Africa: Geol. Soc. South Africa Trans., v. 35, p. 1–28, 3 pls., 3 figs., 4 tables; abs., Geol. Soc. South Africa Proc., p. 38–42; 1933, abs., Annot. Bibliography Econ. Geology, 1932, v. 5, p. 160.

2609. 1943, The hot springs in the Tugela River near Kranskop, Natal: Geol. Soc. South Africa Trans., v. 45, p. 65–74.

2610. 1948 [Notes on Souting spring], *in* Kent, Leslie E., Diatomaceous deposits in the Union of South Africa with special reference to Kieselguhr: Union South Africa Dept. Mines, Geol. Survey Mem. 42, pt. 1, p. 71–73.

Describes Caledon spring in the Cape Colony.

2611. **Hahn, Daniel Paul,** 1906, A South African mineral spring: British Assoc. Adv. Sci. Rept., 1905, p. 366–367.

2612. 1911, A geyser in South Africa: South African Assoc. Adv. Sci. Jour., v. 7, no. 6, 240–241, 1 pl.

Describes geyser near the Zambezi River.

2613. **Hall, Arthur L.,** 1938, Analyses of rocks, minerals, ores, coal, soils, and waters from southern Africa: Union South Africa Dept. Mines, Geol. Survey Mem. 32, 876 p.

2614. **Houghton, S. H.,** and **Frommurze, H. F.,** 1936, The geology of the Warmbad District, South West Africa: South West Africa Dept. Mines Mem. 2, 64 p., 2 figs., 3 maps.

2615. **Itier, Jules,** 1844, Notice sur la constitution géologique du Cap de Bonne-Espérance: Acad. sci [Paris] Comptes rendus, v. 19, p. 960–970.

Contains information on a sulphur spring 8 km from Cradock in Somerset, on two saline springs near Caledon, and on springs at Roodeberg and Coyman's-Kloof.

2616. **Jameson, Robert; Wilson, James;** and **Murray, Hugh,** 1831, Narrative of discovery and adventure in Africa, from the earliest ages to the present time, with illustrations of the geology, mineralogy, and zoology: New York, J. and I. Harper, 359 p.; 1850 ed., by Hugh Murray.

2617. **Jeppe, Frederick,** 1877, Notes on some of the physical and geological features of the Transvaal, to accompany his new map of the Transvaal and surrounding Territories: Royal Geog. Soc. [London] Jour., v. 47, p. 217–250, map.

Mentions several thermal-spring localities.

2618. **Kent, Leslie E.,** 1942, The Letaba hot spring: Royal Soc. South Africa Trans., v. 29, pt. 2, p. 35–47, 1 pl.

2619. 1946, The warm springs at Loubad, near Nylstroom, Transvaal: Royal Soc. South Africa Trans., v. 31, pt. 2, p. 151–168, 3 figs.

2620. 1948, Diatomaceous deposits in the Union of South Africa with special reference to kieselguhr: Union of South Africa Dept. Mines, Geol. Survey Mem. 42, pt. 1, Geology and economic aspects, by L. E. Kent, 184 p.; pt. 2, The diatom flora, by the late A. W. Rogers, p. 185–242, 14 pls., 16 figs.

Includes data on Souting hot spring and springs on Riffontein 16 in the Groblersdal district and on Kolwanie 293 in the Ermelo district.

2621. 1949, The thermal waters of the Union of South Africa and South West Africa: Geol. Soc. South Africa Trans., v. 52, p. 231–264, 3 figs., tables.

Contains data on 74 thermal springs and 9 thermal wells in South Africa and on 24 thermal springs and several thermal wells in South West Africa.

2622. 1951, The thermal water of the Union of South Africa and South West Africa: Internat. Union Geodesy Geophysics; Assoc. Sci. Hydrology, Oslo 1948, Trans., v. 3,

pt. 1, The Union of South Africa, p. 203–223, map, 3 tables; pt. 2, South West Africa, p. 224–228, map, table.
Contains the same information as reference 2621 and, in addition, data on two thermal wells in the Union of South Africa and on 1 spring and 2 thermal wells in South West Africa not included in reference 2621.

2623. **Kent, Leslie E.,** 1952, The medicinal springs of South Africa: South African Railways Publicity and Travel Dept. Pamph., 22 p., map, tables.
Discusses the source and distribution of thermal springs; includes chemical analyses of water from 27 springs.

2624. **Kent, Leslie E.,** and **Russell, H. D.,** 1949, The warm spring on Buffelshoek, near Thabazimbi, Transvaal: Royal Soc. South Africa Trans., v. 32, pt. 2, p. 161–175, 4 figs.

2625. **Lichtenstein, Hinrich,** 1811–12, Reisen im südlichen Afrika: in den Jahren 1803, 1804, 1805, und 1806: Berlin, C. Salfeld, 2 v.; repr., 1928–30 of translation from the original German, by Anne Plumptre: Cape Town, Van Riebeeck Soc., 2 v.; v. 1, 470 p., front., 4 pls., 1928; v. 2, 498 p., front., 3 pls.
Describes a hot spring in the Brandvlei and hot springs at the south end of Swarteberg.

2626. **Methuen, Henry H.,** 1846, Life in the wilderness; or wanderings in South Africa: London, R. Bentley, 318 p., front., 2 pls., 14 figs.
Describes the warm springs at Caledon.

2627. **Muller, J. F.,** ca. 1948, Report on underground water conditions and research, Union of South Africa: Union géodésie et géophysique internat.; Assoc. internat. hydrologie sci., Washington 1939, Compte rendu. v. 2, Rept. Inv. 6, 4 p.
Describes 11 thermal-spring localities in the Union of South Africa and 2 in South West Africa.

2628. **Murray, Hugh,** and **Jameson, James Wilson,** 1850, Narrative of discovery and adventure in Africa from the earliest ages to the present time; with illustrations of the geology, mineralogy, and zoology: 5th ed., Edinburgh and London, T. Nelson, 472 p., map; 1830, 1st ed.; 1853 ed., London, T. Nelson, 482 p., illus., maps.
Describes six thermal-spring localities in the Union of South Africa.

2629. **Paterson, William,** 1790, A narrative of four journeys into the country of the Hottentots and Caffraria, in the years 1777, 1778, and 1779: 2d ed., London, J. Johnson, 175 p., 19 pls., map.
Describes a warm spring in the vicinity of Swarteberg and another in Channa Land.

2630. **Rindl, M. M.,** 1915, Medicinal springs of South Africa; the mineral spring on the farm Rietfontein, Dist. Brandfort, Orange Free State: South African Jour. Sci., v. 12, p. 579–588.

2631. 1916, The medicinal springs of South Africa: South African Jour. Sci., v. 13, p. 528–552, map.
Lists and describes 40 thermal-spring localities. Includes chemical analyses of the water from several of the springs.

2632. 1918, The medicinal springs of South Africa; Supplement I: South African Jour. Sci., v. 15, p. 217–225.
Describes Gross Barmen hot springs at Gross Windhoek and Klein Windhoek in South West Africa, also Winburg springs in the Union of South Africa.

2633. **Rindl, M. M.,** 1925, The medicinal springs of South Africa: Official Yearbook, South Africa, v. 8, p. 41–46.

2634. 1928, The medicinal springs of South Africa; Supplement II: South African Jour. Sci., v. 25, p. 116–126.
Contains chemical analyses of water from thermal springs in South West Africa and Union of South Africa. Mentions Chilundu springs in Northern Rhodesia.

2635. 1930, International standard measurements in hydrology, and a provisional register of mineral waters of South Africa, based on these standards: South African Jour. Sci., v. 27, p. 213–226.
Includes descriptions of seven thermal springs and chemical analyses of the water from each.

2636. 1931a, The medicinal springs of South Africa; Supplement III: South African Jour. Sci., v. 28, p. 119–123.
Contains information on Fort Beaufort and Cradock springs in Union of South Africa and on springs near head of Rupisi River and in the Mutambara Native Reserve in Southern Rhodesia.

2637. 1931b, International standard measurements in hydrology and a provisional register of medicinal waters of South Africa based on these standards. Second communication: South African Jour. Sci., v. 28, p. 124–130.
Includes information on springs at Caledon, Floris Bad (Rietfontein), Warmbaths, Winburg, and Baden Baden (Gannafontein).

2638. 1932, The medicinal springs of South Africa; Supplement IV: South African Jour. Sci., v. 29, p. 278–280.
Contains data on the Ezulwini springs, the Kursaal (Oldenburg) spring, and the Warmbaths.

2639. 1934, The medicinal springs of South Africa; Supplement V: South African Jour. Sci., v. 31, p. 173–176.
Describes the Sipofaneni and Gansbaai springs; also contains chemical analyses of water from Gansbaai, Malmesbury, and Pahlquelle springs.

2640. 1936, The medicinal springs of South Africa: South African Med. Jour., v. 10, p. 695–698.
Summarizes the principal thermal springs.

2641. 1937, The medicinal springs of South Africa; Supplement VI: South African Jour. Sci., v. 33, p. 254–257.
Contains a chemical analysis of water from Badplaats spring, also radioactivity determinations of water from Gansbaai spring and Warmbaths, all in the Union of South Africa.

2642. **Rogers, A. W.,** 1909, The Zwartkops borehole: Geol. Comm. Cape of Good Hope Rept., p. 110–116.

2643. **Rose, John George,** 1910, A new Cape thermal chalybeate spring: South African Jour. Sci., v. 7, p. 202–203.
Describes a thermal well at Zwartkops near Port Elizabeth; includes a chemical analysis of the water.

2644. **Scherzer, Karl Ritter von,** 1861–63. Narrative of the circumnavigation of the globe by the Austrian frigate Novara, undertaken by order of the Imperial Government in the years 1857, 1858, & 1859: London, Saunders, Otley, & Co., 3 v.; v. 1, 485 p., 52 illus.; v. 2, 627 p., 8 illus.; v. 3, 544 p., 6 illus.
Includes descriptions of hot springs of Brandvlei in the Union of South Africa, hot springs in St. Paul's Island in the Indian Ocean, and the chain of boiling springs, solfataras, and fumaroles in New Zealand.

2645. **Schwartz, Ernest H. L.,** 1904, Hot springs [South Africa]: Geol. Mag., dec. 5, v. 1, no. 6, p. 252–260, 1 fig.

2646. **Smith, George William,** 1913, Some notes concerning a deep bore at Zwartkops near Port Elizabeth and the resulting thermal chalybeate spring: South African Jour Sci., v. 9, p. 119–127, 1 pl.

2647. **Sparrman, Andrew (Anders),** 1789, A voyage to the Cape of Good Hope, towards the Antarctic Polar Circle, and round the world, but chiefly into the country of the Hottentots and Caffres, from the year 1772 to 1776: Perth, R. Morison & Son, 2 v. (in one); v. 1, 254 p., front., 3 pls.; v. 2, 261 p., 6 pls.; translated into English from the Swedish original, by George Forster.

Describes Warm Bath at the foot of Swarteberg in the Union of South Africa.

2648. **Steedman, Andrew,** 1835, Wanderings and adventures in the interior of southern Africa: London, Longman & Co., 2 v.; v. 1, 330 p., front., vignette, 4 illus., map; v. 2, 358 p., front., vignette, 6 illus.

Describes springs near Cradock ford of the Fish River, Goudine springs near Du Toits Kloof, and the springs in Brandvlei and near the source of Fisher's River, all in the Union of South Africa.

2649. **Thompson, George,** 1827, Travels and adventures in southern Africa, comprising a view of the present state of the Cape Colony: 2d ed., London, H. Colburn, 2 v.; v. 1, 450 p., front., 12 illus., 10 vignettes; v. 2, 493 p., front., 8 illus., 7 vignettes, map.

Describes the springs near Cradock ford of the Fish River in the Union of South Africa.

2650. **Thunberg, Karl Peter,** 1795, An account of the Cape of Good Hope and some parts of the interior of southern Africa: London, Longman, Hurst, Rees, & Orme, 4 v.; extr., *in* Pinkerton, John, A general collection of the best and most interesting voyages and travels in all parts of the world; many of which are now first translated into English. v. 16, 1814, p. 1–147, 1 pl.

Describes the spring at the foot of Swarteberg and mentions spring in Olyfants Valley, both in the Union of South Africa.

2651. **Townsend, R. W.,** 1844, On the minerals of Cork: British Assoc. Adv. Sci. Rept., 1843, Notices and abs., p. 38.

Describes manganese in spring deposits near the Cape of Good Hope.

See references 21, 34, 2433, and 2583.

INDIAN OCEAN

MADAGASCAR

2652. **Anonymous,** 1927, Les eaux minérales à Madagascar: Madagascar et Dépendances Bull. écon., 1927, no. 1, p. 1–36.

2653. **Besairie, Henri,** and **Hourcq, Victor,** 1936, Eaux thermominerales de Madagascar récemment étudiés: Cong. internat. mines, metallurgie et geologie appl., 7th, Paris 1935, v. 2, Géologie appl. p. 839–840.

2654. **Besairie, Henri,** and **Pavlonsky, Rotislav,** 1951, Étude géologique des feuilles Manéra (563) et Manombo (562): Madagascar, Bur. géol. Travaux, no. 17, 22 p. (processed), illus.; 1953 abs., Annot. Bibliography Econ. Geology, 1952, v. 24, no. 1, p. 15.

Includes information on springs.

2655. **Bocquillon-Limousin, M. H.,** 1859, Analyses d'eaux minérales de Madagascar: Soc. hydrologie et climatologie méd. Paris Annales, v. 6, p. 320–326.

2656. **Ellis, William,** 1858, Three visits to Madagascar during the years 1853, 1854, 1856, including a journey to the capital; with notices of the natural history of the country and of the present civilization of the people: London, J. Murray, 476 p., front., 24 illus., map.

Describes a spring 0.5 mile from Ranomafana village.

2657. **Ferraud, V.,** 1898, Étude sur les eaux d'Antsirabe; Notes, Reconnaissances et Explorations, 1897–1900, pt. 24: Tananarive, p. 1647–1652.

2658. **Herault, P.,** 1899, Les eaux minérales à Madagascar: Rev. Madagascar.

2659. **Kermorgant, A.,** 1901, Eaux thermales et minérales des colonies françaises: Archives hygiène et medecine coloniales, v. 4, p. 236–244.

2660. **Lacroix, Antoine François Alfred,** 1922, Minéralogie de Madagascar: Paris, Augustin Challamel, ed., Librairie maritime et coloniale, 3 v.; v. 1, Geology; descriptive mineralogy, 624 p., 27 pls., 504 figs., map; v. 2, Applied mineralogy; lithology, 694 p., 29 pls., 11 figs.; v. 3, Lithology; Appendix; Geographic index, 431 p., 8 pls., 25 figs., map.

Contains information on 20 springs, several of which are thermal.

2661. 1932, Madagascar et Dépendences, *in* La géologie et les mines de la France d'outre-mer: p. 295–348.

Mentions hydrothermal activity in Madagascar and St. Paul Island.

2662. **Lautel, Robert,** 1949, Étude géologique des feuilles Ambatomainty et Andranomavokely: Madagascar, Bur. géol. Travaux, no. 2, 25 p. [processed], maps; 1952, abs., Bibliography and Index of Geology Exclusive of North America, v. 16, 1951, p. 181; 1953, abs., Annot. Bibliography Econ. Geology, 1952, v. 24, no. 1, p. 17.

Includes data on hot springs.

2663. **Lemoine, Paul,** 1906, Étude géologique dans le nord de Madagascar: Paris, A. Hermann, 520 p., maps, pls.

Contains chemical analyses and other data on the thermal springs.

2664. **Lenoble, André,** and **Robillard, Reginald de,** 1946, Le bassin thermo-minéral d'Antsirabe: Acad. Malgache [Tananarive] Bull., new ser., v. 27, p. 54–71, 5 pls.

Describes thermal springs and wells in the Antsirabe area.

2665. **Monnier, Dr.,** 1924, La station thermale et climatique d'Antsirabe: Madagascar et Dépendances, Bull. écon., 1924, 3 et 4 trimestres, p. 32–53, 5 figs.; repr. from Bull. Soc. hydrologie et climatologie France.

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2666. **Moureu, Charles,** 1924, Rapport sur les études de quelques sources thermales de Madagascar: Madagascar et Dependances Bull. écon., 1924, 3 et 4 trimestres, p. 21–31.

2667. **Moureu, Charles; Lepape, A.;** and **Moureu, H.,** 1924, Radioactivité de quelques sources thermales de Madagascar (bassin d'Antsirabe) et de la Réunion: Acad. sci. [Paris] Comptes rendus, v. 179, p. 123–129.

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2669. **Mullens, Joseph,** 1875, Twelve months in Madagascar: 2d ed., London, J. Nisbet & Co., front., 10 illus., map.

Mentions hot springs near Betafo and Sirabe.

2670. **Perrier de la Bathie, H.,** 1910, Notes sur la vallée permotriasique et le contact des terrains métamorphiques et

des terrains sédimentaires dans l'Ouest de Madagascar: Colonie Madagascar et Dépendances, Bull. écon., v. 10, no. 2, p. 199–235, figs., map.
Mentions some of the thermal springs in western Madagascar.

2671. **Perrier de la Bathie, H.,** 1915, Études et recherches pour la captation des eaux thermales d'Antsirabe: Colonie Madagascar et Dépendances, Bull écon., v. 15, no. 1, p. 93–103.

2672. 1923a, Nouvelles recherches pour la captation des eaux thermales d'Antsirabe: Madagascar et Dépendances, Bull. écon., v. 20, no. 1, 255–261. Tananarive.

2673. 1923b, Liste des sources thermales ou minérales de Madagascar. Madagascar et Dépendances, Bull. écon., v. 20, no. 1, p. 277–282.

2674. **Réland,** 1905, Les eaux thermales et minérales d'Antsirabe: Colonie Madagascar, Bull. écon., v. 5.

2675. **Salvat,** 1916, Recherches sur la radioactivité des eaux thermales d'Antsirabe: Rapport presenté au comité consultatif hygiène et salubrité de Madagascar, 1916.

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MINOR ISLANDS—KERGUELEN, REUNION, RODRIGUEZ, AND SAINT PAUL

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Briefly describes fumaroles, mofettes, and thermal springs.

2678. **Balfour, Isaac Bayley,** 1879, The physical features of Rodriguez: Royal Soc. [London] Philos. Trans., v. 168, p. 289–292.
Mentions warm springs.

2679. **Bostock, John,** 1838, Notice of the analysis of a mineral water from the Island of St. Paul, in lat. 38°45′ S., and long. 77°53′ E.: Geol. Soc. London Trans., ser. 2, v. 5, p. 261–262; Geol. Soc. London Proc., v. 2, p. 112–113.

2680. **Eaton, A. E.,** 1879, The physical features of Kerguelen Island, *in* An account of the petrological, botanical, and zoological collections made in Kerguelen's Island and Rodriguez during the Transit of Venus Expedition in the years 1874–75: Royal Soc. [London] Philos. Trans., v. 168, 579 p., 55 pls., p. 1–4.
Mentions hot springs.

2681. **Encyclopaedia Britannica,** 1911, Kerguelen Island, Kerguelen Island, Kerguelen's Land, or Desolation Island: 11th ed., New York, Encyclopaedia Britannica, v. 15, p. 754–755.
Mentions hot springs.

2682. **Lacroix, Antoine François Alfred,** 1936, Le volcan actif de l'île de la Réunion et ses produits: Paris, Gauttier-Villars, 297 p., 68 pls., map.
Briefly describes the fumaroles and their deposits in the volcanic crater.

2683. **Maillard, L.,** 1853, Note sur l'île de la Réunion: Soc. géol. France Bull., ser. 2, v. 10, p. 499–504, 1 pl.
Mentions vapor vents in the volcanic crater.

2684. **Moseley, Henry Nottidge,** 1885, Notes of a naturalist on the *Challenger*, *in* Tizard, Thomas Henry, Report on the scientific results of the voyage of H.M.S. *Challenger* during the years 1873–1876: Edinburgh, Neill & Co., v. 1, 509 p., illus.
Mentions hot springs on Kerguelen Island and describes hot springs and gas vents on Camiguin Island in the Philippines.

2685. **Rabat, Charles,** 1915, Résultats hydrographiques et géographiques de l'expédition Rallier du Baty à Kerguelen: Géographie, v. 30, p. 294–296.
Mentions fumaroles.

2686. **Rallier du Baty, R.,** 1922, Le voyage de la "Curieuse": Géographie, v. 37, p. 1–26, 6 figs.
Briefly describes vapor vents and hot springs on Kerguelen Island.

2687. **Velain, Charles,** 1875a. Observations efectuées à l'île Saint-Paul: Acad. sci. [Paris] Comptes rendus, v. 80, p. 998–1003.
States that there are numerous thermal springs on St. Paul Island, but no thermal springs or vapor vents on Amsterdam Island, 42 miles northwest of St. Paul Island.

2688. 1875b, Analyse des dégagements gazeux de l'île Saint-Paul: Acad. sci. [Paris] Comptes rendus, v. 81, p. 332–335.
Mentions thermal springs and gas and vapor vents.

2689. 1875c, Les îles Saint-Paul et Amsterdam: Rev. sci., ser. 2, v. 5, no. 6, p. 121–129, 4 figs.
Describes the numerous thermal springs on St. Paul Island.

2690. 1876a, Les Îles Saint-Paul et Amsterdam—L'île de la Réunion: Assoc. française, av. sci. Compte rendu, 4th sess., Nantes 1875, p. 581–600, pls.
Mentions the vapor vents in the crater on Réunion Island and the thermal springs and gas vents on St. Paul Island.

2691. 1876b, Une excursion au volcan de la Réunion: Nature [Paris], no. 160, p. 50–54, 4 figs.; English translation, Nature [London], v. 14, no. 355, p. 333–336, 1876 .
Describes the vapor vents in the crater on Réunion Island.

2692. 1878, Déscription géologique de la presqu'île d'Aden, de l'île de la Réunion, des îles Saint-Paul et Amsterdam: Paris, Typographie A. Hennuyer, 360 p., front., 27 pls., 46 figs.
Describes the thermal springs and fumaroles on Réunion and St. Paul Islands.

2693. **Zbyszewski, Georges,** 1933, Nouvelles reconnaissances aux îles Kerguelen: Rev. géographie, phys. et géologie dynamique, v. 6, pt., 3, p. 263–265.

See also references 1077, 1086, 2644, 2661, 2667, and 2668.

ASIA

AFGHANISTAN

2694. **Wood, John,** 1841, A personal narrative of a journey to the source of the River Oxus, by the route of the Indus, Kabul, and Badakhshan, performed under the sanction of the Supreme Government of India in the years 1836, 1837, and 1838: London, J. Murray, 424 p., map; Wood, Alexander ed., 1872, A personal narrative of a journey to the source of the River Oxus, by Captain John Wood, with an essay on the geography of the valley of the Oxus, by Colonel Henry Yule: London, J. Murray, 280 p., front., map.
Mentions thermal springs near Issar (U.S.S.R.) and at Sir-Ab [Khawak].

See also references 30, 2775, 2799, 2807, and 2853.

ARABIAN PENINSULA

2695. **Fraser, James,** 1824, Notes made in the course of a voyage from Bombay to Bushire in the Persian Gulf; transmitted with a series of illustrative specimens: Geol. Soc. London Trans., ser. 2, v. 1, p. 409–412.
Mentions warm springs issuing south of the Cove of Muscat.

2696. **Hibbert, W.,** 1838, Remarks upon the Maculla hot spring in Arabia, together with some notes regarding the Red Sea islands: London and Edinburgh New Philos. Jour., v. 24, no. 47, p. 30–35.

2697. **Little, O. H.,** 1925, The geography and geology of Makalla (South Arabia): Survey of Egypt, Geol. Survey, 250 p., front. 35 pls., 5 figs.
Mentions thermal sulfur spring north of Makalla city and thermal wells near Ghail Ba Wazir.

2698. **Miles, S. B.,** 1901, Across the Green Mountains of Oman: Royal Geog. Soc. [London] Jour., v. 18, no. 5, p. 465–498, map.
States that thermal springs are source of supply for town of Nakhl (Palmyra or Tadmor) and for irrigation of gardens and groves of date palms.

2699. **Philby, Harry St. John Bridger,** 1922, The heart of Arabia; A record of travel and exploration: London, Constable & Co., Ltd. 2 v.; v. 1, 386 p., front., 39 illus.; v. 2, 354 p., 8 illus., map.
Describes Ain al Harra near Mubarraz and Khudud and Haqal springs east of Hufuf.

2700. **Wrede, Adolphe Baron,** 1844, Account of an excursion to Hadramaut: Royal Geog. Soc. [London] Jour., v. 14, p. 107–112.
Mentions thermal springs northwest of Makalla.

See also references 30, 43, 73, and 2805.

CHINA

GENERAL REFERENCES AND EASTERN PART OF CHINA

2701. **Chang, H. T.,** 1926, On the distribution of thermal springs in China: Pan-Pacific [Pacific] Science Cong., 3d, Tokyo, Proc., v. 1, p. 812–813, map.
States that 512 springs are known, the water from 177 being definitely hot and from most of the others reportedly hot. Map shows distribution of springs.

2702. 1935, On the distribution of thermal springs in China: Geog. Soc. China Jour., v. 2, no. 3, p. 13–22, map. [Chinese, English summary, p. 3.]
Contains the same information as reference 2701.

2703. **Gray, John Henry,** 1878, China. A history of the laws, manners, and customs of the people: London, Macmillan & Co., 2 v.; v. 1, 397 p., 53 illus.; v. 2, 374 p., 84 illus.
Mentions hot springs at Yung-Mak, Chung-ling-tow, and Foochow Foo.

2704. **Hayasaka, Ichiro,** 1955, Brief description of the geology of hot springs in Amoy Island: Tokyo. Printed Japanese manuscript belonging to the Compilation Comm. Geology and Mineral Resources of the Far East; English translation for the Engineer Intelligence Div., U.S. Army forces, Far East, 9 p. [typescript]; incl. map showing location of Amoy Island.

2705. **Hoeppli, R., and Chu, H. J.,** 1932, Free-living nematodes from hot springs in China and Formosa: Hong Kong Naturalist,, Supp. 1, p. 15–28.

2706. **Hsieh, C. Y.,** and **Chang, K.,** 1928, Geology of Tang Shan and its vicinity, Nanking: Geol. Soc. China Bull. 7, p. 157–174, 4 pls., figs.

2707. **Thorp, James,** 1945, Unpublished notes: Earlham College, Richmond, Ind.
Mentions warm springs of Yang Kwei Fe near Lintung, at Pehpei, and at Nanchuan.

2708. **Timkovskii, Egor Fedorovich (Timkowski, George),** 1827, Travels of the Russian mission through Mongolia to China, and residence in Peking, in the years 1820–1821, with corrections and notes by Julius von Klaproth: London, Longman, Reed, Orme, Brown, & Greene, 2 v.; v. 1, 468 p., front., map; v. 2, 496 p., front; translated from Russian by H. E. Lloyd.
Mentions warm springs 23 miles northeast of Peking.

2709. **Wang, Tiao-hsin,** and **Lin, Yuan-Tsun,** 1940, The analysis and study of hot-spring water in Foochow: Am. Jour. Sci., v. 238, no. 11, p. 799–804, 1 pl., 2 figs., table.

2710. **Williamson, Rev. A.,** 1868, Notes on the productions, chiefly mineral, of Shan-Tung: Royal Asiatic Soc. Jour., North-China Br., new ser., no. 4, 1867, p. 64–73.
Mentions thermal springs at Ngai-shan, at Loong-chwen, at Wun-shih-tun, near Yi-chou, and at Chau-Yuen.

2711. **Willis, Bailey,** 1949, Friendly China: Stanford, Calif., Stanford Univ. Press, 312 p., 39 illus.
Describes hot springs of T'ang Shan and Lin Tung.

See also references 30 and 2937.

FORMOSA (TAIWAN)

2712. **Collingwood, Cuthbert,** 1867, The sulphur-springs of northern Formosa: Geol. Soc. London Quart. Jour., v. 23, 382–384; "On the sulphur springs of northern Formosa": London, Edinburgh, and Dublin Philos. Mag. and Jour. Sci., ser. 4, v. 34, p. 401, 1867.

2713. **Han, Kwan,** 1944, Chemical investigation of the hot springs of Formosa. I, The hot spring of Kansirei: Chem. Soc. Japan Jour., v. 65, p. 342–345, 2 figs., 4 tables [Japanese]; 1947, Chem. Abs., v. 41, col. 3557.

2714. **Hayakawa, Masataro,** and **Nakano, Tomonori,** 1912, Die radioaktiven Bestandteile des Quellsedimentes der Thermen von Hokuto, Taiwan: Zeitschr. anorg. u. allg. Chemie, v. 78, p. 183–190, 3 figs., 7 tables.

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2735. **Harrer, Heinrich,** 1954, Seven years in Tibet; translated by Richard Graves: New York, E. P. Dutton & Co., p. 19–314, map.
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2736. **Hedin, Sven Anders,** 1899, Through Asia: New York and London, Harper & Bros., 2 v.; v. 1, p. 1–663, front., 135 illus., map; v. 2, p. 664–1278, front., 124 illus., map.
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2737. **Markham, C. R.,** 1875, Travels in Great Tibet, and trade between Tibet and Bengal: Royal Geog. Soc. [London] Jour., v. 45, p. 299–315, 1 pl.
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2738. **McGovern, William Montgomery,** 1924, To Lhasa in disguise: a secret expedition through the mysterious Tibet: New York and London, Century Co., 462 p., 76 illus.
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2746. **Waddell, Lawrence Austine,** and **Holdich, Thomas Hungerford,** 1911, Tibet, *in* Encyclopaedia Britannica: 11th ed., New York, Encyclopaedia Britannica, v. 26, p. 916–918.
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2748. **Adams, Andrew Leith,** 1867, Wanderings of a naturalist in India, the western Himalayas, and Cashmere: Edinburgh, Edmonston & Douglas. 333 p., front.
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2752. **Baker, W. E.,** and **Maclagan,** 1848, Temperature of the hot springs at Peer Mangul, or Maga, or Mangear: Asiatic Soc. Bengal Jour., v. 17, pt. 2, p. 230–232.

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2783. **Henderson,** ca. 1860, Lahore to Yarkand.
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2802. **Mouat, F. J.,** 1862, Narrative of an expedition to the Andaman Islands in 1857: Royal Geog. Soc. [London] Jour., v. 32, p. 109–126, 2 figs; Royal Geog. Soc. [London] Proc., v. 6, p. 41–43, 1862.
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2811. **Piddington, H.,** 1831, Analytical examination of a mineral water from the Athan hills, Tenasserim Province: Gleanings in Sci., v. 3, no. 1, p. 24–26, Calcutta.

2812. **Prinsep, J.,** 1831a, Examination of the water of several hot springs on the Arracan coast: Gleanings in Sci., v. 3, no. 1, p. 16–18, Calcutta.

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2814. **Schlagintweit, Adolphe,** 1857, Report on the progress of the magnetic survey, and of the researches connected with it, from November 1855 to April 1856: Asiatic Soc. Bengal Jour., v. 26, no. 2, p. 97–132.
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2815. **Schlagintweit, Adolphe, Schlagintweit, Hermann,** and **Schlagintweit, Robert,** 1857, Journey across the Kuen-Luen from Ladak to Khotan: Royal Geog. Soc. London Proc., v. 1, p. 273–277.
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2821. **Smoult,** 1843, Guide to Darjeeling.
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2822. **Spilsbury, George C.,** 1827, On two hot springs in the valley of the Nerbudda: Med. Phys. Soc. Calcutta Trans., v. 3, p. 450–451.

2823. **Steichen, A.,** 1916, The variation of the radioactivity of the hot springs of Tuwa: London, Edinburgh, and Dublin Philos. Mag. and Jour. Sci., ser. 6, v. 31, no. 181, p. 401–403.

2824. **Stevenson, J. F.,** 1864, Account of a visit to the hot springs of Pai in the Tavoy district: Asiatic Soc. Bengal Jour., v. 32, 1863, no. 4, p. 383–386.

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2826. **Tennent, James Emerson,** 1860, Ceylon; an account of the island, physical, historical, and topographical: 5th ed., London, Longman, Green, Longman & Roberts, 2 v.; v. 1, 643 p., 31 engravings, 7 illus., 6 maps; v. 2, 669 p, 60 engravings, 10 illus., 3 maps.
Mentions five thermal-water localities.

2827. **Thomson, Thomas,** 1852, Western Himalaya and Tibet; a narrative of a journey through the mountains of northern India during the years 1847–48: London, Reeve & Co., 501 p., front., map.
Describes thermal springs of Nubra and Pugha.

2828. **Vicary, N.,** 1846, Geological report on a portion of the Baloochistan Hills: Geol. Soc. London Quart. Jour., v. 2, p. 260–267, 1 fig.
Mentions thermal springs near Ooch, at Kissooker, and at Doza Khooshtee.

2829. 1847, Notes on the geological structure of parts of Sinde: Geol. Soc. London Quart. Jour., v. 3, p. 334–349, 5 figs.
Mentions springs in Munga-Peer basin and near Peeth in the Hala Mountains; also warm-water wells near Shahdad-ka-gote.

2830. **Vigne, Godfrey Thomas,** 1842, Travels in Kashmir, Ladak, Iskardo, the countries adjoining the mountain-course of the Indus, and the Himalaya north of the Panjab: London, H. Colburn, v. 1, 406 p., front., 3 illus., maps.
Describes Pampur spring and thermal springs at Behitsil, Tsuh-Tron, and near Rajapur, Duchin, and Kor Chondus.

2831. **Voysey, H. W.**, 1833, Second report on the geology of Hyderabad: Asiatic Soc. Bengal Jour., v. 2, no. 18, p. 392–405.
Includes information on Gondala and Bangah hot springs.

2832. **Waddel, L. A.**, 1890, On some new and little known hot springs in South Bihar: Asiatic Soc. Bengal Jour., v. 59, pt. 2, no. 3, p. 224–235.
Describes 15 thermal springs.

2833. **Wade, C. M.**, 1837, Note on the hot spring of Lohand Khad: Asiatic Soc. Bengal Jour., v. 6, p. 153–154.

2834. **White**, 1833, Description of a jatra, or fair, which takes place annually at the hot wells about fifty miles in a southeasterly direction from Surat: Royal Asiatic Soc. Great Britain and Ireland [London], v. 3, 1831–33, p. 372–378.

2835. **Younghusband, Francis Edward**, 1904, To the heart of a continent: London, J. Murray, 332 p., front., 8 pls., map.
Mentions hot springs at Ak-Chak-tash and in the Ashkuman, Yarkun, and Lutku valleys.

2836. **Yule, Henry**, 1858, A narrative of the mission sent by the Governor-General of India to the Court of Ava in 1855, with notices of the country, government, and people: London, Smith, Elder & Co., 391 p., front., 29 pls., 49 figs.
Describes a visit to the mud volcanoes near Memboo village in Burma.

See also reference 2745.

INDO-CHINA

(Cambodia, Laos, and Viet Nam)

2837. **Autret, M.**, 1941, Les sources thermales et minérales du Tonkin: Indochine Bull. écon., v. 44, pt. 2, p. 93–140, 2 maps, 14 tables.
Contains short descriptions of 28 thermal springs; also gives chemical analyses of water from 26 of the springs.

2838. **Blondel, F.**, 1928, Notes sur les sources thermales et minérales d'Indochine; I. Premier Inventaire des sources d'Indochine: Indochine Service Géol. Bull. v. 17, pt. 3, 23 p. map.
Includes information on 77 springs, 59 of which are thermal.

2839. **Bredillet, M., Fontaine, H.,** and **Richard, C.**, 1958 [Review of hot springs and mineral springs in southern Viet-Nam]: Annales pharm. françaises, v. 16, p. 246–251 [French]; 1959, Chem. Abs., v. 53, col. 3551.

2840. **Dussault, Léon**, 1925, Études géologiques dans la Chaine Annamatique Septentrionale: Indochine Service Géol. Bull., v. 14, pt. 4, 45 p., 4 pls., 9 figs., maps.
Mentions warm sulfur springs at five locations.

2841. **Fontaine, H.**, 1957 [Hot springs of southern Viet-Nam]: Archives géol. Viet-Nam, no. 4, p. 35–123 [French]; 1959, Chem. Abs., v. 53, col. 1598.

2842. **Guichard, Franck,** and **Nguyên-Kim-Kính**, 1939, Étude préliminaire d'une eau de source thermale sulfureuse: [French Indo-China], Conseil Recherches Sci. Indochine Compte rendu. 1938–39, p. 97–100; 1943, abs., Bibliography and Index of Geology Exclusive of North America, v. 9, 1941–1942, p. 112.

2843. **Lambert**, 1910, Indochine Bull. Econ. Sept.–Oct.
Contains data on Vinh Hao hot springs in Annam.

2844. **Madrolle, C.**, ca. 1920; Indochine du Nord; and Indochine de Sud: [Guidebooks].
Lists data on 22 thermal and 11 nonthermal mineral springs.

IRAN (PERSIA)

2845. **Bell, Charles M.**, 1840, Geological notes on part of Mazunderan: Geol. Soc. London Trans., ser. 2, v. 5, p. 577–581, 1 fig.
Describes thermal springs in the vicinity of Usk.

2846. **Loftus, William Kennett**, 1855, On the geology of portions of the Turko-Persian frontier, and of the districts adjoining: Geol. Soc. London Quart. Jour., v. 11, p. 247–344, 23 figs., map; 1854, abs., Geol. Soc. London Quart. Jour., v. 10, p. 464–469.
Mentions thermal springs in several localities.

2847. **Morier, James Justinian Jacques**, 1818, Second voyage en Perse, en Arménie, et dans l'Asie Mineure, fait de 1810 à 1816: Paris, Gide fils, 2 v.; v. 1, 464 p., front., 1 illus., v. 2, 482 p., front., 1 illus.
Mentions springs at Chiraz and describes several springs in vicinity of Maragha.

2848. **Murray, C. A.**, 1859, On some mineral springs near Tehran, Persia: Geol. Soc. London Quart. Jour., v. 15, p. 198–199.

2849. **Pilgram, G. E.**, 1908, Geology of the Persian Gulf and the adjoining portions of Persia and Arabia: Geol. Survey India Mem., v. 34, pt. 4, 177 p.
Mentions thermal spring at Daliki.

2850. **Pottinger, Henry**, 1816, Travels in Baloochistan and Sinde; accompanied by a geographical and historical account of those countries: London, Longman, Hurst, Rees, Orme, & Brown, 423 p., front., map.

2851. **St. John, Oliver Beauchamp Coventry**, 1876, Narrative of a journey through Baluchistan and southern Persia, 1872, *in* Persian Boundary Commission, Eastern Persia. An account of the journeys of the Persian Boundary Commission, 1870–71–72: London, Macmillan & Co., 2 v.; v. 1, The geography, with narratives, by Majors St. John, Lovett, and Euan Smith, and an introduction by Sir Frederic John Goldsmid, 443 p., front., maps; v. 2, Zoology and geology, by W. T. Blanford, 516 p., illus.
Describes a spring in the high mountains south of Mashîsh.

2852. **Sjögren, H.**, ca. 1920, Beiträge zur Geologie * * * Nördlichen Persien: Pamph., 31 p.
Refers to springs near Savelan Mountain.

2853. **Stiffe, A. W.**, 1874, On the mud-craters and geological structure of the Mekran coast: Geol. Soc. London Quart. Jour., v. 30, p. 50–54, 3 figs.
Describes hot springs near Jashak and Karâchi, also the mud craters between Guadur and Ras Kucheri.

2854. **Sykes, Percy Molesworth**, 1902, Ten thousand miles in Persia, or eight years in Iran: London, J. Murray, 481 p., front., 68 illus., map.
Describes a solfatara, a hot well, and several thermal springs.

2855. **Thomson, R. F.,** and **Kerr, Lord Schomberg H.**, 1859, Journey through the mountainous districts north of the Elburz, and ascent of the Demavend, in Persia: Royal Geog. Soc. [London] Proc., v. 3, no. 1, p. 2–17.
Describes the thermal springs in the vicinity of Mount Demavend.

2856. **Tietze, Emil Ernst August,** 1874, Geologische Untersuchungen in Persien (Reise nach dem Demavendberge und der Provinz Mazenderan): Geol. Reichsanst. Wien Verh., p. 360–363.
Contains data on the thermal springs of Demavend Mountain.

2857. 1875, Ueber Quellen und Quellenbildungen am Demavend und dessen Umgebung: Geol. Reichsanst. Wien Jahrb., v. 25, no. 2, p. 129–140, map.

2858. **Witt, Henry M.,** 1856, Chemical examination of certain lakes and springs on the Turko-Persian frontier near Mount Ararat: London, Edinburgh, and Dublin Philos. Mag. and Jour. Sci., 4th ser., v. 11, p. 257–262.
Contains chemical analyses of four thermal springs.

See also references 78 and 3294.

IRAQ

2859. **Ainsworth, William Francis,** 1888, A personal narrative of the Euphrates Expedition: London, K. Paul, Trench & Co., 2 v.
Describes the thermal saline springs near Hit.

2860. **Iraq Petroleum Company, Ltd.,** 1934, The construction of the Iraq-Mediterranean pipe-line; a tribute to the men who built it. An account of the construction in the years 1932 to 1934 of the pipe-line * * * from near Kirkuk, Iraq, to the Mediterranean ports of Haifa (Palestine) and Tripoli (Lebanon): London, St. Clements Press, Ltd., 125 p., front., illus., map.
Mentions that water from Sukhna springs is piped to Mafraq depot crossing.

2861. **Macfadyen, W. A.,** 1938, Water supplies in Iraq: Iraq Geol. Dept. Pub. 1, 206 p., 19 pls.
Includes data on many springs, wells, and collecting galleries, a few of which yield thermal water.

ISRAEL AND JORDAN

2862. **Blake, George Stanfield,** 1928, Geology and water resources of Palestine: Jerusalem, 51 p., map.

2863. **Blake, G. S.,** and **Goldschmidt, M. J.,** 1947, Geology and water resources of Palestine; app., Rainfall in Palestine and Trans-Jordan, by R. Feige and E. Rosenau: Jerusalem, Palestine Dept. Land Settlement and Water Commissioner, 413 p., 31 pls., maps.
Contains information on many important springs, five of which are thermal.

2864. **Carson, Rachel Louise,** 1951, The sea around us: New York, Oxford Univ. Press, 230 p.
States that the Dead Sea is supplied by hot springs.

2865. **Friedmann, A.,** 1913, Analysen der Thermalwasser einiger berühmter Quellen Palästinas: Chemiker-Zeitung, v. 37, no. 146, p. 1493–1494.

2866. **Ionides, M. G.,** and **Blake, G. S.,** 1939, Report on the water resources of Transjordan and their development, by M. G. Ionides, incorporating a report on geology, soils and minerals, and hydrogeological correlations, by G. S. Blake: London, Govt. Transjordan, 372 p., 98 pls., 108 figs., 42 tables.
Includes data on Hadlitha, El Hamme, Zerqa Ma'in, Sukhne, and Hammam springs.

2867. **Lawrence, Thomas Edward,** 1935, Seven pillars of wisdom: London and Toronto, J. Cape, 672 p., front., 53 illus., maps; abbreviated ed., Revolt in the Desert: New York, George H. Doran Co., 355 p., front., 15 pls., 1927.
Refers to the hot springs of Gadara.

2868. **Luke, Harry Charles Joseph,** and **Keith-Roach, Edward,** eds., 1934, The handbook of Palestine and Trans-Jordan: 3d ed., London, Macmillan & Co., Ltd., front., map.
Describes Ain Maleh, Al-Hamma, Zerqa Ma'in, Ain al-Zerqa, and hot springs near Lake Tiberias.

2869. **Merrill, Selah,** 1881, East of the Jordan—A record of travel and observation in the countries of Moab, Gilead, and Bashan during the years 1875–1877: New York, C. Scribner's Sons, 549 p., 69 illus., map.
Describes thermal springs at three places.

2870. **Rosenblatt, David B.,** 1951, Radioactivity of the hot springs of Tiberias: Science, v. 114, no. 2950, p. 46.

2871. **Rosenblatt, David B.,** and **Lindeman, H.,** 1952, The radioactivity of the hot springs at Tiberias: Science, v. 116, no. 3025, p. 689–690.

2872. **Tristam, Henry Baker,** 1873, The land of Moab—Travels and discoveries on the east side of the Dead Sea and the Jordan: New York, Harper & Bros., 416 p., front., 41 figs., map.
Includes descriptions of springs at Callirrhoe and near Zara.

2873. **Wilson, C. W.,** 1873, Recent surveys in Sinai and Palestine: Royal Geog. Soc. [London] Jour., v. 43, p. 206–240, map.
Mentions hot springs at foot of Jebel Hammán Far'ún, near Lake Tiberias, near Umm Keis (Gadara), and in Zerqa Ma'in (Callirrhoe).

See also references 30 and 3290.

JAPAN

2874. **Aihara, Yonosin,** 1934, On the distribution of thermal springs in Kyushu: Kwagaku (Science), v. 4, p. 97–98. [Japanese.]

2875. **Akiyama, Teishiro,** and **Yamamoto, Yoshimasa,** 1952, On the geochemical studies of hot springs in Kofu city (no. 1): Jour. Geography [Tokyo], v. 61, no. 4, p. 152–153, illus. [Japanese, English summary]; 1954, abs., Bibliography and Index of Geology Exclusive of North America, v. 18, 1953, p. 4; 1955, abs., Annot. Bibliography Econ. Geology, 1954, v. 26, no. 1, p. 95.
"Determines the distribution of temperature and pH values of the hot springs of Kofu, Japan, and correlates the variations with the structure of the region."

2876. 1953, Geochemical studies of hot springs in Kofu city (no. 2): Jour. Geography [Tokyo], v. 62, no. 3, p. 118–125, illus. [Japanese, English summary]; 1954, Chem. Abs., v. 48, col. 11690; 1955, abs., Bibliography and Index of Geology Exclusive of North America, 1954, v. 19, p. 6.

2877. **Alcock, Rutherford,** 1861, Narrative of a journey in the interior of Japan, ascent of Fujiyama, and visit to the hot sulphur-baths of Atami, in 1860: Royal Geog. Soc. [London] Jour., v. 31, p. 321–356, map.

2878. **Anderson, Robert van Vleck,** 1907, The great Japanese volcano Aso: Pop. Sci. Monthly, v. 71, no. 1, p. 29–49, 10 figs.
Mentions hot spring at Tochinoki and steam vents in crater of volcano. Includes view of hot springs of Yunotani.

2879. **Anonymous,** 1940, Abstracts of papers on scientific hydrology published in Japan during the years 1927–1938 (excluding those given in previous volumes): Japanese Jour. Astronomy and Geophysics Trans. and Abs., v. 17, no. 2, p. 20–51.

Contains about 60 papers on thermal springs. Most of these papers are included in this bibliography.

2880. **Arii, Kimio, and Nagasawa, Sin,** 1947, Geochemical study on mineral springs in the northeastern districts of Japan; II, Sakunami group; III, Nakayamadaira spring group: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 68, p. 13–15 [Japanese]; 1949, Chem. Abs., v. 43, col. 7611.

Analyses were made, and other data obtained, on nine hot springs of the Sakunami group, Miyagi Prefecture, and also for the Nakayamadaira spring group.

2881. 1953, Geochemical studies on mineral springs in the Tohoku district; XIII, Kawatabi group; XIV, Onikobe spring group: Tohoku Univ., F. Ishikawa Anniversary Volume, Sci. Repts., v. 37, no. 1, p. 106–116, illus. [Japanese]: 1954, Chem. Abs., v. 48, col. 8990; 1955, abs., Bibliography and Index of Geology Exclusive of North America, v. 19, 1954, p. 17.

2882. 1956, Geochemical studies on mineral springs in the Tohoku Districts; XV, Narugo spring group: Tohoku Univ. Sci. Repts., 1st ser., v. 39, p. 246–249 [Japanese]; 1958, Chem. Abs., v. 52, col. 11322.

2883. **Arii, Kimio, Nagasawa, Sin, and Seto, Kimio,** 1948, Geochemical studies on mineral springs in the northeastern district of Japan; IV, Aone spring groups, Kamakurazawa spring, and Ashidate spa: Chem. Soc. Japan Jour,. Pure Chemistry Sec., v. 69, p. 125–127 [Japanese]; 1950, Chem. Abs., v. 44, col. 9268.

2884. 1949, Geochemical studies on mineral springs in the northeastern districts of Japan; VI, Semi spring group; VII, Tendo spring group; VIII, Akayu-Tenaka spring group; IX, Kurumayu spring group; X, Narugo-Yumoto group: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 70, p. 43–45, 99–101, 155–160 [Japanese]; 1951, Chem. Abs., v. 45, col. 4379.

2885. **Arii, Kimio, and Seto, Kimio,** 1948, Geochemical studies on mineral springs in the northeastern district of Japan; V, Radon content of mineral springs in Miyagi Prefecture: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 69, p. 127–129 [Japanese]; 1950, Chem. Abs., v. 44, col. 9268.

2886. **Asari, Tamuja,** 1949, The geochemical distribution of strontium; V, Strontium contents of the sinter deposits of hot springs: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 70, p. 430–431 [Japanese]; 1951, Chem. Abs., v. 45, col. 2832.

2887. **Ashizawa, Takashi,** 1950–52, Chemical studies on the Misasa hot springs: Okayama Univ. Balneol. Lab. Repts.; 1950, v. 3, p. 21–34; 1951, v. 4, p. 1–10; 1952, v. 6, p. 4–14 [Japanese]; 1953, Chem. Abs., v. 47, cols. 10774–10776.

2888. 1951, Vitriol springs. VI, Colorimetric determination of antimony, determination of free mineral acid, and detection of sulfides of the second group: Okayama Univ. Balneol. Lab. Repts., v. 5, p. 51–54 [Japanese, English summary]; 1952, Chem. Abs., v. 46, col. 8296.

Contains data on the mineral content of water from the Yanahara hot springs.

2889. **Ashizawa, Takashi,** 1952, Chemical studies on Misasa hot spring. XVIII, A pyrite-polysulfide theory of sulfur springs: Okayama Univ. Balneol. Lab. Repts., v. 7, p. 15–19 [Japanese]; 1956, Chem. Abs., v. 50, col. 3680.

2890. **Ata, Saneo,** 1931, Some hot springs of southern Kyushu: Jour. Geog. [Tokyo], v. 43, p. 504–512. [Japanese.]

2891. **Chamberlain, Basil Hall,** 1891, Things Japanese; being notes on various subjects connected with Japan, for the use of travellers and others: 2d ed., London, J. Murray, 503 p., map.

Mentions some of the most noted thermal springs and the use of their waters.

2892. **Chitani, Y.,** 1924, On the Mogami hot spring in the Prefecture of Yamagata: Imp. Geol. Survey Japan Rept., v. 91, p. 1–2. [Japanese.]

2893. **Cochius, H.,** 1873, Die Solfatara von Aschinoyu: Deutsche Gesell. Natur. u. Volkerkunde Ostasiens Mitt., pt. 3, p. 2–5.

2894. **Descharmes, Augustin Marie Léon,** 1874, Itinerary of a journey from Yedo to Kusatsu, with notes upon the waters of Kusatsu: Asiatic Soc. Japan [Tokyo] Trans., v. 2, p. 23–49; repr., 1907, new. ser., v. 2, p. 22–48. [English.]

2895. **Divers, Edward,** 1889, Note on the amounts of sulphuretted hydrogen in the hot springs of Kusatsu: Asiatic Soc. Japan [Tokyo] Trans., v. 6, pt. 2, p. 346–347; repr. of original edition of 1878.

2896. **Emoto, Y.,** 1933a, Die Mikroorganism der Thermen: (Eine historische Übersicht über die Erforschung der Thermalmikroorganismen): Bot. Mag. [Tokyo], v. 47, p. 268–295.

2897. 1933b, Verbreitung der schwefeloxydierenden Bakterien in den Thermen Japans: Bot. Mag. [Tokyo], v. 48, no. 538, p. 6–29.

2898. **Foster, Helen Laura, and Mason, Arnold Caverly,** 1955, The 1950 and 1951 eruptions of Mihara Yama, O Shima volcano, Japan: Geol. Soc. America Bull., v. 66, no. 6, p. 731–762, 5 pls., 14 figs.

Describes fumaroles in the inner crater.

2899. **Fujinami, Kiochi,** 1936, Hot springs in Japan: Tokyo, Japanese Government Railways, Board of Tourist Industry, Tourist Library, v. 10, 87 p., front., 66 illus., map.

States that about 85 percent of the 946 springs in Japan are classified as thermal. Mentions several individual springs and groups of springs.

2900. **Fukutomi, Takaharu,** 1936a, Physical and chemical properties of the Simogamo, Rendaizi, and Simokawazu thermal springs in southern Idu [Izu] Peninsula, I: Tokyo Imp. Univ. Earthquake Research Inst. Bull., v. 14, p. 259–270, 7 figs. [English, Japanese summary.]

2901. 1936b, On the hot springs of Yazu, Sikuoka Prefecture: Disin (Earthquake), v. 8, p. 457–468. [Japanese, English summary.]

2902. 1937, On the hot springs of Atami, Izu Peninsula: Tokyo Imp. Univ. Earthquake Research Inst. Bull., v. 15, p. 113–133, 13 figs., 2 tables. [English, Japanese summary.]

2903. 1952, On the Baba hot springs in Niseko volcanic region Hokkaido: Hokkaido Univ. Geophys. Bull., v. 2, p. 23–30 [Japanese]; 1956, abs., Pacific Sci. Cong., 8th, Proc. v. 2, p. 45.

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2905. **Fukutomi, Takaharu, and Huzii, Ziro,** 1937, On the thermal springs of Ito, Izu Peninsula: Tokyo Imp. Univ. Earthquake Research Inst. Bull., v. 15, pt. 2, p. 506–535, 18 figs., 1 pl., 2 tables. [Japanese, English summary.]

2906. **Fukutomi, Takaharu, and Nakada, Musakazu,** 1935, On the Rendaizi thermal spring in southern Idu Peninsula: Tokyo Imp. Univ. Earthquake Research Inst. Bull., v. 13, pt. 3, p. 616–628, 17 figs., 1 table. [English, Japanese summary.]

2907. **Fushimi, Hiroshi,** and **Akiyama, Tesihiro,** 1955, Geochemical study of hot springs and test borings in Masutomi district: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 76, p. 620–624, 4 figs., 2 tables [Japanese]; 1956, Chem. Abs., v. 50, col. 11569.

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2909. 1881b, Analyses of ten Japanese mineral waters: Asiatic Soc. Japan [Tokyo] Trans., v. 9, pt. 1, p. 94–105.

2910. **Gokan, Bunnosuke,** 1939, The European and American influence on the mineralogy and geology of Japan in the modern age: Tokyo Sci. Mus. Bull. 1, p. 53–104 [Japanese, English summary]; 1940, abs., Bibliography and Index of Geology Exclusive of North America, v. 7, 1939, p. 106.

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2911. **Habu, Katakusu,** 1938, On the effect of the sea seiches upon the flow of some thermal springs in Beppu: Nippon Gakuzyutu-Kyokai (Jour. Assoc. Adv. Sci. Japan), v. 13. [Japanese, English abstract.]

2912. **Hamada, Hidenori,** 1929, Re-determination of the radioactivity of hot springs in the San-in district and neighborhood: Tohoku Imp. Univ. Sci. Repts., 1st ser., v. 18, p. 317–321. [Japanese.]

2913. **Haraguchi, Kuman,** and others, 1950, Report on the hot spring researches at Goshiki spa and Shionoha spa, Kawakamimura, Yoshin o-gun, Nara Prefecture: Japan Geol. Survey Bull., v. 1, no. 4, p. 37–40, illus. [Japanese, English summary]; 1958, abs., Bibliography and Index of Geology Exclusive of North America, v. 21, 1956, p. 238; 1958, abs., Annot. Bibliography Econ. Geology 1956, v. 29, no. 2, p. 306.

2914. **Hartel, Fr. F.,** 1935, Die Heilbader Japans: Balneologie; Berlin, v. 2, p. 302–317; abs., Wasser u. Abwasser, v. 33, no. 11, p. 321.

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2915. **Hatsuta, Jinichiro,** 1935, Gush-quantity of the Arima thermal springs, Hyogoken: Kyoto, Tikyu (Globe), v. 24, no. 6, p. 428–436. [Japanese.]

2916. **Hatuta, Yorimi, and Suzuki, Masatatu,** 1936, On the geyser at the *"Itazi Hatiman-Digoku"*: Tikyu-Buturi (Geophysics), v. 1, p. 94–103. [Japanese, English abstract.]

2917. **Hayasaka, Ichiro,** 1941, Observations on the thermal springs of Urai, Taihoku Prefecture: Taiwan Tigaku Kizi, v. 12, no. 4, p. 68–75, illus. [Japanese.]

2918. **Homma (Honma), Fujio,** 1926, Guidebook for the geological excursion to Beppu, the hot-spring city: Pan-Pacific [Pacific] Sci. Cong., 3d Tokyo, Guidebook, Excursion E–1, 5, 16 p., 3 views, maps. [English.]

2919. **Honda, K., and Sone, T.,** 1915, On the geyser at Onikobe, Miyagi Prefecture, *in* Ishizu, Risaku, The mineral springs of Japan: pt. 1, p. 73–77, 3 figs. [English.]

2920. **Honda, K., and Terada, Torahiko,** 1906a, On the geyser in Atami: Earthquake Inv. Comm. Pub. in Foreign Languages 22, Sec. B, art. 4, p. 51–73, 7 figs., 12 pls., map. [English.]

2921. 1906b, On the geyser in Atami, Japan: Phys. Rev., v. 22, no. 5, p. 300–311, 8 figs; repr. *in* Ishizu, Risaku, The mineral springs of Japan: pt. 1, p. 47–52, 1915. [English.]

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2923. **Iimori, Satoyasu, and Hata, Shin,** 1937, Radon content of some mineral springs in Japan: Inst. Phys. Chem. Research [Tokyo] Bull., v. 16, p. 1471–1478 [Japanese]; 1938, Chem. Abs., v. 32, col. 7622.

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2926. 1954a, Chemical studies on the hot springs of Nasu [Tochigi Prefecture]. I–III: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 75, p. 362–371, 3 figs., 17 tables [Japanese]; Chem. Abs., v. 48, col. 11685.

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3243. **Cameron, John,** 1865, Our tropical possessions in Malayan India—being a descriptive account of Singapore, Penang, Province Wellesley, and Malacca; their peoples, products, commerce, and government: London, Smith, Elder & Co., 408 p., front., 6 pls.
Describes the hot springs of Ayer Panas.

3244. **Jones, W. R.,** 1914, On the supposed case of tin in *statu nascenti* in the Malay Peninsula: Geol. Mag., dec. 6, v. 1, p. 537–541.
Mentions several hot springs.

3245. **Meunier, Stanislas,** 1890, Examen chimique d'eaux minérales provenant de Malaisie; minerai d'étain de formation actuelle: Acad. sci. [Paris] Comptes rendus, v. 110, p. 1083–1085.

3246. **Scrivenor, John Brooke,** 1931, The geology of Malaya: London, Macmillan & Co., Ltd., 217 p., 33 figs., map.
Describes the deposits of several thermal springs.

See also reference 1467.

MONGOLIA

3247. **Berkey, Charles P.,** and **Morris, Frederick K.,** 1927, Natural history of central Asia; v. 2, Geology of Mongolia: New York, G. Putnam's Sons, 475 p., 44 pls., 161 illus.
Includes a description of a hot spring at the northeast base of Sain Noin (mountain) in the Arishan area.

3248. **Ossendowski, Ferdinand,** 1922, Beasts, men, and gods: New York, E. P. Dutton & Co., 325 p., map.
Describes Lake Kogosol and states that it may be fed by hot springs on its floor.

See also references 3382 and 3433.

THAILAND (SIAM)

3249. **Sresthaputra, Vija,** 1951, Hot springs: U.S. Geol. Survey Bull. 984, p. 171–175, 2 figs., 4 tables [1952].
Contains a list of 27 thermal-spring localities. Describes springs near Amphur Fang and 8 km northeast of Si Racha.

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3250. **Abich, Otto Wilhelm Hermann von,** 1877, Das thrialetische Thermalquellensystem in Karthalinien vom geologischen Standpunkte betrachtet: Deutsche geol. Gesell. Zeitschr., v. 29, p. 820–829.

3251. **Ainsworth, William Francis,** 1842, Travels and research in Asia Minor, Mesopotamia, Chaldea, and Armenia: London, J. W. Parker, 2 v., front., illus.
Contains data on thermal springs.

3252. **Baker, James,** 1877, Turkey in Europe: 3d ed., London and New York, Cassel, Petter, & Galpin, 650 p., map; revised ed., 1879, entitled "Turkey": New York, Cassel, Petter, & Galpin, 495 p.
States that Turkey is rich in thermal springs. Specifically mentions spring at Lija (Ilijah) near Burgas and another spring near Eski Zaghra. Also mentions thermal springs in the vicinity of Therma in Greece.

3253. **Blumenthal, Maurice M.,** 1941, Géologie des montagnes de la transversale d'Eskipazar et leurs sources minérales (vilâyet de Cankiri): Maden Tetkîk ve Arame, Ankara, Turkey, sene 6, no. 3/24, 4/25, p. 320–352, 550–593, 8 pls., 1 fig. [Turkish and French]; 1943, abs., Bibliography and Index of Geology Exclusive of North America, v. 9, 1941–42, p. 29–30.

3254. 1950, Beiträge zur Geologie des Landschaften am mittleren und unteren Yeşil Irmak (Tokat, Amasya, Havza, Erbaa, Niksar); Maden Tetkik ve Arama Enstitüsü Yayinlarindan, Jeol. Harta Mater., ser. D, no. 4, 153 p., illus. [German, Turkish summary]; 1951, abs., Bibliography and Index of Geology Exclusive of North America, v. 15, 1950, p. 28.
Includes information on mineral and thermal springs of the region.

3255. **Broughton, John Cam Hobhouse** (First Baron), 1858, Travels in Albania and other provinces of Turkey in 1809 and 1810: London, J. Murray, new ed., revised and corrected, 2 v.; v. 1, 544 p., 10 illus; v. 2, 528 p., 3 illus., maps.
Mentions warm spring near Bunarbashi (Bali Dagh) village, which is close to the site of ancient Troy.

3256. **Caglar (Kaglar), Kerim Ömer,** 1939 [Investigation of the medicinal springs and waters of Kizilcahamam]: Yuksek Ziraat Enstitüsü Calismalarindan (Arb. Yuksek Ziraat Enstitüsü Ankara) no. 93, p. 1–20 [Turkish]; abs., Chem. Zentralbl. 1940 [pt.] I, 3506.

3257. **Caglar (Kaglar), Kerim Ömer,** 1946 [Analyses of Turkish hot springs]: Maden Tetkik ve Arama Enstitüsü Mecmuasi (Ankara), v. 11, no. 36, p. 307–319 [Turkish]; 1948, Chem. Abs., v. 42, col. 6965.

3258. 1947, Türkiye maden sulari ve kaplicalari [Turkish mineral waters and thermal springs, Maden Tetkik ve Arama Enstitüsü yayinlarindan: Mineral studies and research institute publications], ser. B, no. 11, pt. 1, p. 1–94. [Turkish, French summary.]
Contains chemical analyses of water from Kükürtlü (near Brusa), Kupeli, Gonen, and Cuma springs.

3259. 1948, Türkiye maden sulari ve kaplicalari [Turkish mineral waters and thermal springs]: Maden Tetkik ve Arama Enstitüsü yayinlarindan [Mineral studies and research institute publications], ser. B, no. 11, pt. 2, p. 95–318. [Turkish.]
Contains chemical analyses of water and other data on 174 hot springs. Includes analytical data for springs at Bademli, Derman, Kizildere, Yalova, and Kizilcahammam.

3260. 1950, Türkiye maden sulari ve kaplicalari [Turkish mineral waters and thermal springs] Maden Tetkik ve Arama Enstitüsü yayinlarindan [Mineral studies and research institute publications], ser. B, no. 11, pt. 3, p. 319–638. [Turkish.]
Contains chemical analyses and other data on many thermal springs including those at Gediz, Sakarya, Kizik, and Kolan.

3261. **Chikachev, Petr Aleksandrovich (Tchihatschef, Pierre de),** 1866, Asie Mineure; description physique de cette contrée (8 v., and atlas, 1860–69): Gotha, Germany, v. 1, Physical geography, 1866; 20 pls., atlas; Reisen in Kleinasien und Armenien, 1847–1863: Petermanns Mitt. Ergänzungsband 4, v. 20; 68 p., map, 1867.
Describes Hieropolis and its thermal springs.

3262. 1887, Klein-Asien, von P. de Tchihatschef, Das Wissen der Gegenwart, Deutsche Universal-Bibliothek für Gebildete; Leipzig, Germany, G. Freytag, 188 p., 19 figs., map.
Mentions Bithya springs near Brusa, Yalova springs, Elidja Valley springs, and springs near Tuzla, at the ancient city of Hierapolis, and near Karahait.

3263. **Clayton, E.,** 1887, The mountains of Kurdistan: Alpine Jour. [London], v. 13, no. 97, p. 293–330, 1 pl.
States that there are numerous hot springs in the crater of Nimroud Dagh.

3264. **Davis, (Rev.) Edwin John,** 1874, Anatolica; or The journal of a visit to some of the ancient ruined cities of Caria, Phrygia, Lycia, and Pisidia: London, Grant & Co., 374 p., fronts., illus., pls.

3265. 1879, Life in Asiatic Turkey. A journal of travel in Cilicia (Pedias and Trachoea), Isauria, and parts of Lycaonia and Cappadocia: London, Edward Stanford, 536 p., front., illus., pls., 2 maps, 2 plans.

3266. **DeKay, James Ellsworth,** 1833, Sketches of Turkey in 1831 and 1832, by an American: New York, J. and J. Harper, 527 p., illus.
Describes thermal springs near Smyrna.

3267. **Dirisu, Nüzhet Sakir,** 1947 [The thermal springs of Erzurum]: Fac. méd. Ankara Bull., v. 1, p. 44–46 [Turkish]; 1948, Chem. Abs., v. 42, col. 998.

3268. **Fellows, Charles,** 1852, Travels and researches in Asia Minor, more particularly in the province of Lycia: London, J. Murray, 510 p., illus., map.
Describes the extensive deposits of tufa near the ancient city of Hierapolis.

3269. **Francis, W.,** 1930, Mineral springs of Cyprus, *in* Ronald Storrs and B. J. O'Brien, eds., Handbook of Cyprus, 368 p., map.
Describes six thermal-spring localities.

3270. **Geary, Grattan,** 1878, Through Asiatic Turkey—Narrative of a journey from Bombay to the Bosphorus: London, S. Low, Marston, Searle and Rivington, 2 v., fronts., pls., map.
Mentions thermal springs.

3271. **Hamilton, William J.,** 1842, Researches: Asia Minor, Pontius, and Armenia; with some account of their antiquities and geology: London, J. Murray, 2 v.; v. 1, 544 p., 6 pls.; v. 2, 508 p., 6 pls., map.
Describes the Byzantine Baths of Cauvsa and the extensive deposit of tufa near the ancient city of Hierapolis. Also contains information on hot springs in several other localities.

3272. **Homer,** ca. 850 B.C., Iliad; 1934, Translated into English by Augustus Taber Murray, with title, Homer, The Iliad: New York, G. P. Putnam's Sons; London, W. Heinemann, 2 v.; 1. 1, 479 p.; v. 2, 643 p.
Mentions warm spring that feeds "eddying Scamander," near the site of ancient Troy (v. 2, p. 465).

3273. **Hubbard, Oliver P.,** 1847, Notices of Koordistan * * * derived chiefly from the letters of Rev. A. H. Wright: Am. Jour. Sci., ser., 2, v. 3, p. 347–354.
Mentions hot sulphur spring west of Julamerk.

3274. **Humann, Carl; Cichorius, Conrad; Judeich, Walther;** and **Winter, Franz,** 1898, Altertümer von Hierapolis: K. Deutsche, Archaeol. Inst. Jahrb., Ergänzungsheft 4.

3275. **Kleinsorge, H.,** 1939, La source thermale lithinifère de Akhüyük, Province de Konya, district d'Eregli: Bull. trimestriel Inst. Recherches Minières, no. 4, p. 105–109, 2 figs.; Ankara Ref. in Rev. géologie et sci. connexes, v. 20, pt. 3, p. 116, 1940.

3276. **Larsen, Sven,** 1950, The petrified waterfalls of Hierapolis; a 14,000-year-old wonder of Anatolia: Illus. London News, v. 127, no. 3314, p. 698, 5 illus.

3277. **Luke, Harry Charles,** and **Jardine, D. J.,** 1920, Handbook of Cyprus: London, E. Stanford, 300 p.; 1913 ed.
Describes six mineral-spring localities, and five other spring localities.

3278. **Lynch, F. H. B.,** 1901, Armenia: Travels and studies: London, Longmans, 2 v.; v. 1, The Russian provinces, 470 p., 52 pls., 56 illus., 7 maps; v. 2, The Turkish provinces, 512 p., 45 pls., 41 illus., 9 maps.
Describes a small warm lake in Nimrud Crater.

3279. **MacFarlane, Charles,** 1850, Turkey and its destiny—The results of journeys made in 1847 and 1848 to examine into the state of that country: London, J. Murray, 2 v.; v. 1, 543 p.; v. 2, 681 p.
Describes hot springs near Brusa and at base of a ridge of Ak Daghler.

3280. **Marek, Kurt W. (C. W. Ceram,** pseud.), 1949, Götter, Gräber, und Gelehrter: Hamburg and Stuttgart, Germany; 1951, translated into English by E. B. Garside, with title, Gods, Graves, and Scholars: New York, Knopf, 426 p., 32 pls., many figs.
Mentions the springs near Bunarbashi (Bali Dagh) village, which is close to the site of ancient Troy.

3281. **Martel, E. A.,** 1919, Hierapolis (Asie Mineure): Nature [Paris], v. 47, no. 2378, p. 262–266, 5 figs.

3282. **Oswald, Felix,** 1906, A treatise on the geology of Armenia: Iona, England, F. Oswald, 516 p., 19 pls., 12 maps.

Contains maps showing the hot springs at Ilija, near Arzit, and at Tendurek; also the warm lake in Nimrud Crater, and deposits of travertine along the Chorokh River.

3283. **Phene, J. S.,** 1879, On the deposit of carbonate of lime at Hierapolis in Anatolia, and the efflorescence of the limestone at Les Baux, in Provence: British Assoc. Adv. Sci. 49th Mtg., 1879, Rept.

3284. **Phillippson, Alfred,** 1918, Kleinasien, *in* C. Winters, Handb. regionalen Geologie, v. 22, no. 5, pt. 2, 183 p., 3 pls., 4 figs.

States that there are 70 thermal-spring localities in Asia Minor. Names and describes the locations of several.

3285. **Reclus, Jean Jacques Elisée,** 1884, L'Asie Antérieure, *in* Nouvelle Géographie Universelle; la terre et les hommes: Paris, Hachette et Cie., v. 9, 950 p., 85 views and wood engravings, 160 maps.

Describes the deposits of travertine near the site of ancient Hierapolis.

3286. **Richardson, Thomas,** and **Browell, E. J. J.,** 1857, On the analysis of waters from the Turko-Persian frontier: Geol. Soc. London Quart. Jour., v. 13, p. 184–187.

Includes a chemical anlysis of water from a hot spring near Mershut village, north of Lake Van.

3287. **Salomon-Calvi, Wilhelm,** 1940 [Have the European mineral springs counterparts in Turkey?]: Turkey, Zeitschr. hyg. u. exptl. Biol., v. 2, no. 2, p. 63–101 [German]; 1946, Chem. Abs. v. 40, col. 6717.

Contains chemical analyses of 59 mineral springs in Turkey.

3288. 1941, Kann man in der Türkei Heilbäder nach Art der Warm Springs von Georgia (U.S.A.) einrichten?: Maden Tetkik ve Arama, Enstitüsü Mecmuasi, Ankara, sene 6, no. 3/24, p. 356–360. [Turkish and German.]

Describes 12 thermal springs in Turkey suitable for development of bathing resorts.

3289. **Smith, Eli,** and **Dwight, H. G. O.,** 1834, Missionary researches in Armenia, including a journey through Asia Minor and into Georgia and Persia, with a visit to the Nestorian and Chaldean Christians of Oormiah and Salmas: London, G. Wightman, 472 p., map.

Describes springs near Lori village and at Ilija village.

3290. **Smith, John Lawrence,** 1873, Mineralogy and chemistry—Original researches: Louisville, Ky., J. P. Morton Co., 401 p.

Describes the thermal springs in the vicinity of Brusa, in the Yalova Valley on the south side of the Gulf of Nicomedia, near the ancient city of Hierapolis, near Eski-Shehr, near the ancient city of Troy, on Mitylene Island, and on the west shore of Lake Tiberias.

3291. **Stchepinsky, V.,** 1942, Géologie et ressources minérales de la région de Kirsehir-Bogazhijan cayi: Maden Tetkik ve Arama, Ankara, sene 7, no. 3/28, p. 489–502, map [Turkish and French]; 1943, Chem. Abs., v. 37, col. 5341: 1946, abs., Bibliography and Index of Geology Exclusive of North America, v. 10, 1943–1944, p. 122.

Describes several thermal springs.

3292. **Tamari, M.,** 1943, Sulphur springs of Cyprus: Nature [London], v. 152, no. 3853, p. 277–278.

3293. **Wilson, Charles William,** and **Hogarth, David George,** 1910, Hierapolis *in* Encyclopaedia Britannica: 11th ed., New York, Encylopaedia Britannica, v. 13, p. 452.

Describes the extensive travertine terraces.

3294. **Yule, Henry,** 1903, The book of Ser Marco Polo, the Venetian, concerning the kingdoms and marvels of the east; translated and edited with notes * * *: London, J. Murray, 2 v.; v. 1, 462 p., illus.; v. 2, 662 p., illus.

States that "Greater Hermenia" possesses "the best baths from natural springs that are anywhere to be found." Mentions hot springs at Ilija and at Hassan Kala'a. Also states that there are many natural hot baths in the area now known as Iran and mentions several by name.

See also references 7, 30, 43, 78, 79, 1737, 2024, and 2846.

UNION OF SOVIET SOCIALIST REPUBLICS

3295. **Abich, H.,** 1870 Mineral springs of Tiflis]: Tiflis. [Russian.]

3296. **Abramof, Major-General,** 1871, The principality of Karategin: Royal Geog. Soc. [London] Jour., v. 41, p. 338–342; translated from the Russian and communicated by R. Mitchell.

Mentions the hot springs in the Surkhaŭ Valley.

3297. **Aleksandrov, V. V.,** 1933, The Dushak thermal springs: [Russia], Central Geol. Inst. U.S.S.R. Materialy, Regional geology no. 2, p. 1–19, figs. [Russian, English summary.]

3298. **Arsenev, A. A.,** and **Nechaeva, E. A.,** 1951, Geologo-petrograficheskii ocherk raiona kurorta Darasun: Akad. Nauk SSSR., Inst. Geol. Nauk Trudy, v. 128, Geol. Ser. 49, p. 120–194, illus.; 1955, abs., Bibliography and Index of Geology Exclusive of North America, v. 19, 1954, p. 19.

Describes the geology and petrology of the Darasun mineral springs area.

3299. **Atkinson, Thomas Witlam,** 1858, Oriental and western Siberia, a narrative of seven years' explorations and adventures in Siberia, Mongolia, the Kirghis Steppes, Chinese Tartary, and part of Central Asia: New York, Harper & Bros., 17–533 p., 52 illus., map.

3300. **Balneologicheskii institut * * * Pyatigorsk,** 1927 [Mineral waters of the Caucasus]: Leningrad, 80 p. [Russian.]

3301. **Basharina, L. A.,** 1956, Fumaroles of Sheveluch volcano [northern Kamchatka] during Sept.–Dec., 1953: Akad. Nauk SSSR, Lab. Vulkanologii, Vulkanol. Sta. Byull. 24, p. 21–27, 1 fig., 9 tables.

3302. **Bentkhen, P. P.,** 1937, Mineral springs of Toulovskaya and Starikova Rivers, Little Khingan Range: Acad. Sci. U.S.S.R., Far Eastern Br., Bull. 25, p. 75–83, 6 figs. [Russian, English summary.]

3303. **Barthenson, Léon,** 1897, Ressources balnéaires de la Russie: Internat. Cong. hydrologie, climatologie, et géologie, 4th, Clermont-Ferrand [France], 1896, Compte rendu, p. 119–130.

3304. **Bickel, Adolf,** 1933, Der "warme Berg," ein geologisches und balneologisches Unikum auf der Erde: Zeitscher. Gesell. physikal. Therapie, v. 45, no. 2, p. 78–84, 2 figs.; 1935, abs., Bibliography and Index of Geology Exclusive of North America, v. 2, 1934, p. 20.

"Describes the geology of 'Warm Hill,' and explains origin of the springs, Ural Region, Russia."

3305. **Billings, Joseph,** 1802, An account of a geographical and astronomical expedition to the northern parts of Russia * * * in the years 1785–1794; narrated from the original papers by Martin Sauer, Secretary to the expedition: London, T. Cadell, 332 p., app., 58 p., 14 pls.
Describes several hot-spring localities.

3306. **Bozoyan, O. A.,** 1956 [The gas contents of the mineral waters at the Dzhermuk health resort]: Voprosy-Geologii i Gidrogeologii Armyanskoi SSR, p. 156–171 [Russian]; 1958, Chem. Abs., v. 52, col. 1519.

3307. **Brudin, I. D.,** 1935, Goryuchie gazy i mineralnye vody yuzhnoi Ukrainy: Priroda [Nature], no. 3, p. 64–67, map.

3308. **Cochrane, John Dundas,** 1824, Narrative of a pedestrian journey through Russia and Siberian Tartary, from the frontiers of China to the frozen sea and Kamchatka: 2d ed., London, printed for C. Knight, 2 v.; v. 1, 428 p., front., 2 illus., map; v. 2, 344 p., front., 2 illus., map.
Mentions hot sulfur springs near Lake Baikal.

3309. **Collins, Perry McDonough,** 1860, A voyage down the Amoor; with a land journey through Siberia, and incidental notices of Manchooria, Kamchatka, and Japan: New York, D. Appleton & Co., 390 p., front., 3 illus.; ed., 1864, Overland explorations in Siberia, northern Asia, and the Great Amoor River country.
Mentions thermal springs in the vicinity of Lake Baikal and also 50 miles west of Petropaulosky in Kamchatka.

3310. **Denguin, Yury,** 1931, Some mineral springs of the south part of the central Transbaikalian region: East-Siberian Br. Geol. and Prosp. Survey, Geology and mineral resources East Siberia Recs. no. 4, p. 57–73, 10 figs. [Russian, English summary.]

3311. 1932, Mineral springs of central Transbaikalia (upper parts of Chikoi, Onon, and Ingoda Rivers): [Russia], Glavnoe geologo-razvedochnoe upravlenie Trudy (United Geol. and Prosp. Service U.S.S.R. Trans.), no. 184, 43 p., 7 pls., 11 figs., 21 tables. [Russian, English summary.]

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3314. **Dombrowskaja, N. S.,** and **Juschkewitsch, F. F.,** 1927, Chemische Zusammensetzung der Darassun Mineralwasser: Univ. Extreme-Orient Mem., 4, 19 p.; 1931, abs., Chem. Zentralbl., 1931, Referate 2, p. 980.

3315. **Drechev, S. M.,** 1954 [Hot waters in the valley of the River Manych]: Gidrokhim. Materialy, v. 22, p. 57–59 [Russian]; 1955, Chem. Abs., v. 49, col. 15126.

3316. **Dru, Léon,** 1883, Rapport sur les eaux minérales du Caucase (Mission de 1882): 115 p., 55 pls.

3317. 1884, Note sur la géologie et l'hydrologie de la région du Bechtaou (Russie-Caucase): Soc. géol. France Bull., ser. 3, v. 12; 1883–84, p. 474–515, 4 pls., 2 figs., 3 tables.
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3318. **Durov, S. A.,** 1955 [The genesis of the water of a sulfate-bicarbonate hot spring (near Kislovodsk)]: Novocherkasskogo Politekh. Inst. imeni Sergo Ordzhonikidze, v. 26, p. 252–264 [Russian]; 1957, Chem. Abs., v. 51, col. 13269.

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3320. **Dzens-Litovsky, A. I.,** 1940, The mineral sources of the Caucasian group of mineral waters: Priroda [Nature], no. 6, p. 70–83, 6 figs., 3 tables. [Russian, English title.]

3321. **Dzens-Litovsky, A. I.,** and **Tolstikhin, N. I.,** 1937, Mineral springs and muds of the Soviet Union: Priroda [Nature], no. 10, p. 104–124, 12 figs., 2 tables. [Russian.]

3322. **Eristavi, D. I.,** and **Kituashvili, N. A.,** 1955, The physicochemical investigation of hot spring waters of Tbilisi [Tiflis]: Gruzinskogo Politekh. Inst. Trudy, no. 5, p. 56–67 [Russian]; 1959, Chem. Abs., v. 53, col. 5553.

3323. **Erman, Georg Adolph,** 1848, Travels in Siberia, including excursions northwards, down the Obi, to the Polar Circle, and southwards, to the Chinese frontier: London, Longman, Brown, Green, & Longman, 2 v.; v. 1, 495 p., map; v. 2, 536 p.; translated from the German by William Desborough Cooley.

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3425. **Smolko, G. I.,** 1932, The iodic springs in the western part of the Turkmenian S.S.R. (in Boiadag, Mondjukly, and Nephtedag): [Russia], Glavnoe geologo razvedochnoe upravlenie Trudy (United Geol. and Prosp. Service U.S.S.R. Trans.), no. 175, 72 p., 4 figs., 8 tables. [Russian, English summary.]

3426. **Sokolov, D. V.,** and **Stopnevich, A. D.,** 1917, Sources minérales de Stolypino: Geol. Komitet, Materialy (Comité géol., Matériaux géologie gén. et appl. no. 19, 28 p., 2 pls. [Russian, French title.]

3427. **Starik, I. E.,** 1943, Radiological study of Caucasian region mineral waters: Acad. Sci. U.R.S.S., Cl. Sci. chim., Bull. 1943, p. 435–442 [Russian, English summary]; 1945, Chem. Abs., v. 39, col. 1592.

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3429. **Tkachuk, V. G.,** 1958, Types of thermal springs in the Sayan-Baikal Mountain region: Acad. Sci. U.S.S.R., Geol. Sci. Sec., Proc. (Akad. Nauk SSSR Doklady); English translation, v. 118, nos. 1–6, p. 181–184, 3 figs.

3430. **Tolmachev, P. I.,** 1932 [Tian-Shan gaseous springs]: Acad. Sci. U.R.S.S. Bull. 1932, p. 51–64 [Russian]; 1933, Chem. Abs., v. 27, p. 3762.

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3432. **Tolstikhin, N. I.,** 1938 [Mineral water provinces of the U.S.S.R.]: Sovetskaya geologiya, v. 8, no. 3, p. 240–243, 1 fig. [Russian]; 1936, Chem. Abs., v. 33, col. 4355.

3433. **Tolstikhin, N. I.,** and **Dzens-Litovsky, A. I.,** 1937, Mineral waters of northern Asia in connection with its geologic structure and tectonics: Internat. Geol. Cong., 17th, Moscow, Pamph., "Additional abstracts of papers." [English.]

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3435. **Tolstikhin, O. N.,** 1958 [The hot springs of the Kamchatka peninsula, and the problems of their utilization]: Sovetskaya Geologiya 1958, no. 2, p. 109–133 [Russian]; Chem. Abs., v. 52, col. 11323.

3436. **Tooke, William,** 1799, View of the Russian Empire during the reign of Catherine the second and to the close of the present century: London, T. N. Longman & O. Rees, 3 v.; v. 1, 564 p., map; v. 2, 612 p.; v. 3, 694 p.
Mentions several thermal springs in widely scattered parts of Russia.

3437. **Tsébricoff, P. de,** 1928, Quelques observations concernant les eaux minérales du Caucase: Rev. universelle mines, 7th ser., v. 20, no. 2, p. 66–82.

3438. **Ustinova, T. I.,** 1946, Geizery na Kamchatke: Vsesoyuz. Geog. Obshchestvo Izv., v. 78, no. 4, p. 393–402; 1957, abs., Bibliography and Index of Geology Exclusive of North America, v. 20, 1955, p. 557.

3439. **Ustinova, T. I.,** 1949 [The geysers of Kamchatka]: Akad. Nauk SSSR, Lab. Gidrogeol. Problem imeni F. P. Savaranskogo Trudy, v. 2, p. 144–157, map [Russian]; 1953, Chem. Abs., v. 47, col. 7702.

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3442. **Vasilievsky, M. M., Bogoiavlensky, L. N., and Kobzeva, A. S.,** 1926, Les sources thermales de Biélokourikha dans l'Altaï: Geol. Komitet, Materialy (Comité géol., Matériaux géologie gén. et appl.) no. 46, 54 p., 7 figs., 12 tables. [Russian, French summaries.]

Consists of the following papers: Vasilievsky, M. M., The thermal springs of Biélokourikha: Bogoiaviensky, L. N., The causes of radioactivity of the thermal springs of Biélokourikha; Kobzeva, A. S., Chemical study of the thermal springs of Biélokourikha.

3443. **Vasilievsky, M. M., and Ivtchenko, P.,** 1927, Aperçu géologique des sources minérales du Psécoups: [Russia], Glavnoe Geologo-Razvedochnoe upravlenie Isv. (Comité géol. Bulls.), v. 46, no 3, p. 269–279, 3 figs. [Russian, French summary.]

3444. **Vasilievsky, M. M., and Naletov, P. I.,** 1931, Geological outlines of Pitatelevsky spring of the Selenga River, Buriat-Mongolian A.S.S.R.: East-Siberian Br. Geol. and Prosp. Survey, Geology and Mineral Resources East Siberia Recs., no. 4, p. 47–56, map. [Russian, English summary.]

3445. **Veselovskii, N. V.,** 1941 [Radioactivity of mineral waters of the resort Sochi-Matsesta, determined on the location in the fall of 1938]: Gidrokhim. Materialy, v. 12, p. 43–46 [Russian, German summary]; 1943, Chem. Abs., v. 37, col. 4008.

3446. **Vinogradov, I. V.,** 1939 [The Shatki (Gor'kiĭ region) balneary resort and the Shatki sapropelic mud]: Voprosy Kurortologii 1939, no. 2, p. 53–56 [Russian]; 1939, Khim. Referat. Zhur., no. 11, p. 29; 1940, Chem. Abs., v. 34, col. 7493.

3447. **Yanovskiy, P. L.,** compiler, 1957, Mineral waters of the USSR: 2d ed., Moscow, Food Industries, 120 p., 53 illus. [Russian.]

3448. **Zavaritsky, A. N.,** 1936, K voprosu o genezice Tiflisskikh term: Acad. Sci. U.R.S.S. (Akad. Nauk), Inst. Géol. Travaux, v. 5, p. 79–94; 1937, abs., Bibliography and Index of Geology Exclusive of North America, v. 4, 1936, p. 317.

3449. **Zeverev, K. S., Levchenko, V. M., and Miller, E. I.,** 1947 Determination of gold in Matsesta waters]: Gidrokhim. Materialy, v. 13, p. 258–260 [Russian]; 1951, Chem. Abs., v. 45, col. 8170.

See also references 43, 167, 1293, 1737, 2694, 2807.

PACIFIC REGION

AUSTRALIA

3450. **Anonymous,** 1892, Notes on thermal springs in New South Wales [Queensland]: Nature [London], v. 46, no. 1185, p. 256.

3451. **Anonymous,** 1951, Thermal springs in Queensland: Internat. Union Geodesy and Geophysics Assoc. Sci. Hydrology, Gen. Assem., Oslo 1949, Trans., v. 3, p. 198–200.

3452. **Brown, H. Y. Lyell,** 1888, The Mesozoic plains of South Australia: Australian Assoc. Adv. Sci. Proc., v. 1, p. 241–245.

States that warm springs emerge near the contact of the Cretaceous strata with bedrock.

3453. **Bruck, Ludwig,** 1891, The mineral springs of Australia: Australian Med. Gazette, Jan., p. 97–106.

3454. **Burge, C. O.,** 1907, The artesian water supply of Australia: Eng. Rec., v. 56, no. 20, p. 551–552.

Includes information on several deep flowing wells.

3455. **Daintree, R.,** 1872, Notes on the geology of the Colony of Queensland: Geol. Soc. London Quart. Jour., v. 28, p. 271–317, 3 pls., 19 figs., map.

Describes deposit of trona at a hot spring near Gibson's cattle station on the Saxby River.

3456. **David, Tannatt William Edgeworth,** 1950, The geology of the Commonwealth of Australia, edited and much supplemented by W. R. Browne: London, E. Arnold & Co., 3 v.; v. 1, Hist. geology, 747 p.; v. 2, Physiography, Econ. geology, 618 p.; v. 3, atlas.

Describes several artesian basins, particularly the Great Australian Artesian Basin. Mentions several thermal-spring localities and states that the boring of wells to tap the artesian reservoirs has reduced or stopped the flow from several springs.

3457. **Grant, Kerr,** 1938, The radioactivity and composition of the water and gases of the Paralana hot spring: Royal Soc. South Australia Trans., v. 62, pt. 2, p. 357–365, 1pl., 2 figs.

3458. **Gregory, John Walter,** 1906, The dead heart of Australia—A journey around Lake Eyre in the summer of 1901–1902, with some account of the Lake Eyre basin and the flowing wells of Central Australia: London, J. Murray, 384 p., 32 illus.

Contains information on the mound springs of Queensland and the springs along the lower Flinders River; discusses the temperature gradient in artesian wells.

3459. 1911, The flowing wells of central Australia: Royal Geog. Soc. [London] Jour., v. 38, no. 1, p. 34–59; no. 2, p. 157–181, 16 figs.

Mentions the geysers and hot springs in the Eastern Highlands of Australia, the hot springs at Herberton, the geysers along the Einasleigh River, and the high temperature of the water in deep bore holes.

3460. **Henderson, J. Baillie,** 1909, Tables of artesian borings, perennial springs, and water analyses: Queensland, Water Supply Dept. Rept., 1908, p. 41–52.

Includes data on the Herberton thermal spring, which probably is a bored well.

3461. **Herman, H.,** 1914, Economic geology and mineral resources of Victoria: Victoria Geol. Survey Bull. 34, 36 p.

States that 85 mineral springs are known in Victoria but gives no information on water temperatures.

3462. **Irrigation and Water Supply Commission of Australia,** 1954, Springleigh Bore: Official commun. to G. A. Waring.

Contains detailed information on the Springleigh bore. Also includes information on a deep well at Elderslie and mentions hot springs at Ambo and Innot Spa. Discusses the thermal gradient in various places in Australia.

3463. **Jack, Robert Logan, and Etheridge, Robert, Jr.,** 1892, The geology and paleontology of Queensland and New Guinea: Queensland, Minister Mines and Public Instruction Pub. 92, 768 p., 68 pls., map.

Describes the mound springs of South Australia, the mud springs along the lower Flinders River, two springs near Mount Brown, the Einasleigh, Innot Creek, and Inniskillen hot springs, and hot mud springs near Thargomindah, all in Queensland. Also describes hydrothermal activity on Fergusson and Dobu (Goulvain) Islands in the D'Entrecasteaux Group and mentions that steam issues from the sides of Mount Victory on the northeast coast of New Guinea.

3464. **Marks, Edward Oswald,** 1911, The Oaks and eastern portion of the Etheridge goldfields: Queensland Geol. Survey Pub. 234, 30 p., 4 pls., 3 figs., 2 maps.

Mentions the Einasleigh hot springs, also warm springs in the Gilbert River 10–12 miles upstream from Gilberton.

3465. **Mawson, Douglas,** 1927, The Paralana hot spring: Royal Soc. South Australia Trans. and Proc., v. 51, p. 391–397.

3466. **Miles, Beryl,** 1954, The stars my blanket: London, J. Murray, 235 p., front., 16 pls., map.

Describes a spring at the Mataranka tourist resort 224 miles southeast of Darwin; also mentions an artesian well near the Springvale cattle station and the artesian wells at Quilpie, about 100 miles north-northeast of Thargomindah cattle station.

3467. **Palmer, E.,** 1885, Hot springs and mud eruptions on the Lower Flinders River: Royal Soc. Queensland Proc., 1884, v. 1, pt. 1, p. 19–23.

Describes the hydrothermal activity along the lower Flinders River. Also describes springs near Mount Brown and mentions springs about 10 miles north of Gamboola Station on the Mitchell River and a spring on the Einasleigh River about 30 miles from Georgetown.

3468. **Ward, L. Keith,** 1950, Underground water in Australia. 3, Australian artesian basins; The Great Australian Basin: Chem. Eng. Mining Rev., v. 43, no. 3, p. 97–107, 7 figs.

BISMARCK ARCHIPELAGO AND EASTERN NEW GUINEA

3469. **Baker, George,** 1946, Preliminary note on volcanic eruptions in the Goropu Mountains, southeastern Papua, during the period December, 1943 to August, 1944: Jour. Geology, v. 54, no. 1, p. 19–31, 5 figs.

Mentions steam and sulfurous vapors related to volcanic activity in the Goropu Mountains and on the D'Entrecasteaux Islands.

3470. **Best, J. G.,** 1956, Investigations of recent volcanic activity in the Territory of New Guinea: Pacific Sci. Cong., 8th, Quezon City, Philippines, 1953, Proc., v. 2, p. 180–204, 12 pls.

Describes fumaroles on Mount Langila on New Britain Island, on Lou and Baluan Islands in the Admiralty Group, and on Manam (Vulcan) Island 10 miles from the northeast coast of New Guinea.

3471. **Fisher, N. H.,** 1957, Melanesia, pt. 5 *of* Catalogue of active volcanoes of the world including solfatara fields: Naples, Italy, Internat. Volcanolog. Assoc., 105 p., 41 figs., map.

Contains information on volcanoes and associated solfataras in the Admiralty Group, the coastal islands of New Guinea, New Britain, Papua, the D'Entrecasteaux Islands, small islands east of New Ireland, Solomon Islands, Santa Cruz Islands, New Hebrides Islands, Matthew Island, and Hunter Island.

3472. **Lehmann, E.,** 1908, Petrographische Untersuchungen an Eruptivgesteinen von der Insel Neupommern; unter besonderer Berücksichtigung der eutektischen Verhältnisse pyroxenandesitischer Magmen: Tschermak's mineralog. petrog. Mitt., v. 27, p. 181–243, 6 figs., 1 table.

Describes hot springs near the shore of Hannam and North Islands in the Bismarck Archipelago.

3473. **Liversidge, A.,** 1880, Water from a hot spring, New Britain: Chem. News, v. 42, p. 324; Royal Soc. New South Wales Proc., v. 14, p. 145, 1881.

3474. 1890, Note upon the hot spring waters of Fergusson Island, D'Entrecasteaux Group: British New Guinea, Ann. Rept., 1888–89.

3475. **Noakes, L. C.,** 1942, Geological reports on New Britain: New Guinea, Geol. Bull. 3.

Contains mention of thermal springs.

3476. **Sapper, Karl,** 1910a, Wissenschaftliche Ergebnisse einer amtlichen Forschungsreise nach dem Bismarck-Archipel im Jahre 1908. I, Beiträge zur Landeskunde von Neu-Mecklenburg und seinen Nachbarinseln: Deutsche Schutzgebiete Mitt. Ergänzungsheft 3, p. 1–130.

Mentions spouting hot springs on Ambitle Island off the coast of New Ireland.

3477. 1910b, Beiträge zur Kenntnis Neupommerns und des Kaiser-Wilhelm-Landes: Petermanns Geog. Mitt., v. 56, p. 189–193, 255–256, 2 maps.

Describes fumaroles, solfataras, and boiling mud springs on New Britain Island.

3478. 1910c, Neu-Mecklenburg: Deutscher Geographentag, 17th, Lübeck, 1–6 Juni, 1909, Verh., p. 141–168.

Mentions hot springs at Lihir (Lir) near Luisehafen, and at Feni (Anir) on the Hibernian Islands. Among those at Feni is Geyser Balamussón.

3479. **Stanley, Evan R.,** 1919, Australia, Territory of Papua annual report, for 1917–1918: 99 p., maps.

Describes hot springs 65 miles west-northwest of the Goropu Mountains.

3480. 1920, Report on the geology of Fergusson Island (Moratau): Minister for Home and Territories, Terr. Papua, Bull. 6, 27 p., 13 figs., map.

Mentions several thermal-spring localities.

3481. 1924, The geology of Papua. (To accompany the geological map of the Territory of Papua): Papua Geol. Survey, 56 p., 50 figs.

Describes hydrothermal activity at two locations on Fergusson Island and at three on Normanby Island.

See also references 83, 562, 564, 773, and 3463.

BORNEO

(North Borneo, Brunei, Sarawak, and Kalimantan)

3482. **Everett, Alfred Hart,** 1878, Volcanic phenomena in Borneo: Nature [London], v. 17, p. 200–201.

Cites the existence of thermal springs in Borneo as proof of former volcanic activity on the island.

3483. **Posewitz, Tirador (Theodor),** 1889, Borneo * * * Verbreitung der nutzbaren Mineralien: Berlin; 1892, translated into English by Frederick H. Hatch, with title, Borneo—its geology and mineral resources: London, E. Stanford, 495 p., 18 figs., 4 maps.

Describes several thermal-spring localities in North, South, and West Borneo and in Sarawak.

CELEBES

3484. **Bickmore, Albert Smith,** 1868, Travels in the East Indian Archipelago: New York, D. Appleton & Co., 553 p., 36 illus., map.
Describes a hot spring near Langowan village and an area of mud pools at the northeast end of Celebes. Also mentions a hot sulfur spring on Damar Island and a warm spring on the flank of Maninyu volcanic crater in Sumatra.

3485. **Fairchild, David Grandison,** 1943, Garden islands of the great East: New York, C. Scribner's Sons, 239 p., front., 124 views.
States that several of the volcanoes on Celebes are in the solfataric stage: also that steam and sulfur fumes issue at a sulfur mine on the upper slope of Sapoetan.

3486. **Guillemard, Francis Henry Hill,** 1894, Australasia, v. 2, Malaysia and the Pacific archipelagoes: London, Edward Stanford, 694 p.; 2d ed., 1908, revised by A. H. Keane, 574 p., front., 47 illus., 16 maps; London, Edward Stanford, Stanford's compendium of geography and travel, new issue.
States that there are numerous hot springs, mud volcanoes, solfataras, and gas vents on Celebes. Also mentions boiling springs on Batjan Island in the Moluccas, the smoking volcano on Ternate Island, hot springs on Tidore Island, hot springs on Ceram Island, and the active volcano of Goenoeng Api (Gunongapi) Island in the Banda Group.

3487. **Hickson, Sydney John,** 1889, A naturalist in North Celebes: London, J. Murray, 392 p., front., 35 figs., maps.
Mentions hot-water springs near Langowan village in Celebes.

3488. **Van Spreeuwenberg, M. A. F.** 1848, A glance at Minhassa [Minahassa]: Jour. Indian Archipelago and Eastern Asia, v. 2, p. 825–845.
Mentions the hot springs in northeastern Celebes.

3489. **Wallace, Alfred Russel,** 1869, The Malay archipelago; the land of the orangutan, and the bird of paradise—A narrative of travel, with studies of man and nature: London, Macmillan & Co., 2 v.; v. 1, 478 p., 27 illus., 5 maps; v. 2, 524 p., front., 23 illus., 4 maps.
Describes hydrothermal activity near Panghu in Celebes.

See also references 16, 73, 74, 3516, 3532, and 3725.

FIJI

3490. **Agassiz, Alexander Emanuel,** 1899, The islands and coral reefs of Fiji: Harvard College Mus. Comp. Zoology Bull., v. 33, 167 p., 120 pls., 44 figs.
States that Ngau Island, the Great Astrolabe Reef, Vanua Mbalavu, and Rambe Islands are either partly or wholly composed of volcanic rocks. Hot springs on these islands are related closely to these rocks.

3491. 1903, The coral reefs of the tropical Pacific: Harvard Coll. Mus. Comp. Zoology Mem., v. 28, 410 p., 238 pls.
Describes the geology of the Tonga Islands, several of which contain hot springs.

3492. **Andrews, Ernest Clayton,** 1900, Notes on the limestones and general geology of the Fiji Islands, with special reference to the Lau Group, based upon surveys made for Alexander Agassiz: Harvard Coll. Mus. Comp. Zoology Bull., v. 38 (Geol. ser., v. 5, no. 1), 50 p., 40 pls.
Describes two hot springs near the shore of Vanua Mbalavu.

3493. **Brock, Reginald Walter,** 1924, Sketch of the geology of Viti Levu, Great Fiji: Royal Soc. Canada Proc. and Trans., 3d ser., v. 18, sec. 4, p. 63–83, 2 figs.
Mentions hot springs at Tavua and in the Namosi district.

3494. **Buchner, Max,** 1878, Reise durch den stillen Ozean.
Mentions hot springs on the coast of Kandavu Island.

3495. **Foye, Wilbur Garland,** 1918, Geological observations in Fiji: Am. Acad. Arts and Sci. Proc., v. 54, no. 1, p. 1–145, front., 40 figs.
Mentions hot springs near Lambasa and in the southern part of Fiji.

3496. **Gordon-Cumming, Constance Frederica,** 1881, At home in Fiji: Edinburgh, W. Blackwood & Sons; new ed., 1882, New York, A. C. Armstrong, 365 p., front., 3 illus.
Describes thermal springs on Ngau Island, along the shore of Savu Savu Bay on Vanua Levu Island, and near Loma Loma on Vanua Mbalavu Island. Also describes a visit to the geyser region of New Zealand.

3497. **Guppy, Henry Brougham,** 1903, Observations of a naturalist in the Pacific between 1896 and 1899; v. 1, Vanua Levu, Fiji, a description of its leading physical and geological characters: London, Macmillan & Co., Ltd.; New York, Macmillan Co., 392 p., 5 pls., 20 figs.
Contains data on 23 thermal-spring localities on Vanua Levu Island, including the well known springs of Savu Savu, Wainanu, Nukumbolo, Mbati-ni-Kama, and Na Kama.

3498. **Horne, John,** 1881, A year in Fiji, or an inquiry into the botanical, agricultural, and economical resources of the colony: London, E. Stanford, 297 p., 1 pl.
Describes visits to several thermal-spring localities in Fiji.

3499. **Kleinschmidt, T.,** 1879, Reisen auf den Viti-Inseln: Jour. Mus. Godeffroy [Hamburg], no. 14.
Contains a description of a visit to the warm springs near Nambualu village on Ono Island.

3500. **Ladd, Harry Stephen,** 1934, Geology of Vitilevu, Fiji: Bernice P. Bishop Mus. Bull. 119, 263 p., 44 pls., 11 figs., 7 tables.
Contains information on several thermal springs.

3501. **Liversidge, A.,** 1880, Water from a hot spring, Fiji Islands: Chem. News [London], v. 42, p. 324–325; Royal Soc. New South Wales Jour. and Proc., v. 14, p. 147–148, 1881.

3502. **MacDonald, John Denis,** 1857, Proceedings of the expedition for the exploration of the Rewa River and its tributaries, in Na Viti Levu, Fiji Islands: Royal Geog. Soc. [London] Jour., v. 27, p. 232–268, map.
Mentions two warm springs near Na Seivau village.

3503. **Thiele, H. H.,** 1891, Rewa River, Fiji: Scottish Geog. Mag., v. 7, no. 8, p. 434–441, 1 pl., map.
Cites hot springs in the Wai-Dina as evidence of volcanic activity on Viti Levu.

3504. **Usher, Leonard G.,** ed., 1943, Fiji—Handbook of the Colony: Suva, Fiji, A. Barker, 96 p., 16 pls., map.
Cites thermal springs as evidence of volcanic activity on Vanua Levu.

3505. **Wilkes, Charles,** 1845, Narrative of the United States Exploring Expedition during the years 1838–1842: Philadelphia, Pa., Lee & Blanchard, 5 v. and atlas; v. 3, 438 p., 11 pls., 50 woodcuts, 10 vignettes.
Describes hot springs along the shore of Savu Savu Bay on Vanua Levu Island.

3506. **Williams, Thomas, and Calvert, James,** 1870, Fiji and the Fijians, edited by George Stringer Rowe: 3d ed., London, Hodder & Stoughton, 592 p., front., 41 illus., map.
Cites the presence of thermal springs on Vanua Levu and Ngau Islands as proof of the volcanic orgin of the Fiji Islands.

3507. **Wright, C. Harold,** 1922, The hot springs of Nasavusavu: Fiji Dept. Agriculture, Agr. Circ., v. 3, no. 1, p. 5–7. Suva, Fiji.

3508. 1926, The hot springs at Nasavusavu: Analyst [London], v. 51, p. 235–237.

See also references 20, 73, 74, and 347.

GALAPAGOS ISLANDS

3509. **Banfield, A. F.; Behre, Charles H., Jr.; and St. Clair, David,** 1956, Geology of Isabela (Albemarle) Island, Archipiélago de Colón (Galápagos): Geol. Soc. America Bull., v. 67, no. 2, p. 215–234, 4 pls., 4 figs., 2 tables.
Describes hydrothermal activity in the craters and on the slopes of Volcan Alcedo, Volcan Grande, and Volcan Wolf.

3510. **Beebe, Charles William,** 1926, The Arcturus adventure; an account of the New York Zoological Society's first oceanographic expedition: New York and London, G. P. Putnam's Sons, 439 p., 8 pls., 69 figs.
Describes an eruption of Volcan Wolf in 1925 and states that several fumaroles were produced.

3511. **Chubb, Lawrence John,** 1933, Geology of Galápagos, Cocos, and Easter Islands: B. P. Bishop Mus. Bull. 110, 68 p., 9 figs.
States that vapors were discharged and fumaroles formed during eruption in northern part of Albemarle Island in 1926.

See also reference 43.

JAVA

3512. **Abel, Clarke,** 1818, Narrative of a journey in the interior of China, and of a voyage to and from that country, in the years 1816 and 1817: London, Longman, Hurst, Rees, Orme, & Brown, 420 p., quarto, front., 6 pls., map.
Describes mineral springs at Epetan in Java and Los Baños on Luzon Island in the Philippines.

3513. **Adams, William Henry Davenport,** 1880, The Eastern Archipelago—A description of the scenery, animal and vegetable life, people, and physical wonders of the islands in the eastern seas: London and New York, T. Nelson & Sons, 576 p., front., 54 illus., map.
Mentions several thermal-spring localities in Java, also hot springs and geysers on Batjan Island in the Moluccas.

3514. **d'Almeida, William Barrington,** 1864, Life in Java; with sketches of the Javanese: London, Hurst & Blackett, 2 v.; v. 1, 319 p., front.; v. 2, 303 p., front.
Mentions several hydrothermal localities.

3515. **Bemmelen, Reinout Willem van,** 1934, Geologische Kaart van Java, 1:100,000 Schaal; Toelichting bij Dienst Mijnb. Ned-Ind: The Hague, Govt. Printer, p. 1–95, pls., figs.
Shows the locations of several thermal springs.

3516. 1949, The geology of Indonesia: The Hague, Govt. Printing Office, 2 v. and portfolio; v. 1A, General geology of Indonesia and adjacent archipelagoes, 732 p., 378 figs., 124 tables; v. 1B, Portfolio, 41 pls., figs., table; v. 2, Economic geology of Indonesia, 265 p., 52 figs., 56 tables.
Discusses the mineral deposits associated with hydrothermal activity in several places in Java.

3517. **Flückiger, F. A.,** 1862, Ueber den Salzäurebach Sungi Paït in Ost-Java: Naturf. Gesell. Bern Mitt., p. 17–20.
Describes a saline sulfate brook fed in part by thermal springs.

3518. **Forbes, Henry Ogg,** 1885, A naturalist's wanderings in the Eastern Archipelago; A narrative of travel and exploration from 1878 to 1883: New York, Harper & Bros., 536 p., front., 78 illus., 32 figs., 6 maps.
Mentions thermal springs at Tjipanas village, along the south border of Ranau Lake, and at the east base of Kaba volcano.

3519. **Fresenius, C. Remigius,** 1843, Chemische Untersuchung zweier Mineralwasser der Insel Java: Annalen Chemie u. Pharmacie (Liebig), v. 45, p. 308–318; Belique Jour. Pharmacie, v. 4, p. 63–66, 1843.
Describes the warm springs of Platungen.

3520. **Hartmann, M.,** 1933, Bijdrage tot de kennis van gassen, sublimatie-en inkrustatieprodukten en thermale wateren in de Merapi-Ladoe's: Vulkanol. en seismol. Mededeel. 12, Dienst van den Mijnbouw in Nederlandsch Indie, p. 117–131, 1 fig.; 1935, abs., Rev. géologi, v. 15, p. 242.

3521. **Horsfield, Thomas,** 1816, On the mineralogy of Java. Essay I: Batavia, Genoot. Verh., v. 8, p. 141–173.
Describes a thermal lake in the crater of Tankuban-Prahu volcano, hot-water wells at the base of the Panawangan hills in Cheribon, and warm mud pools between the districts of Grobogan on the west and Blora and Jipang on the east.

3522. **Jukes, Joseph Beete,** 1847, Narrative of the surveying voyage of H.M.S. Fly, commanded by Captain F. P. Blackwood, R.N., in Torres Strait, New Guinea, and other islands of the Eastern Archipelago, during the years 1842–1846; together with an excursion into the interior of the eastern part of Java: London, T. & W. Boone, 2 v.; v. 1, 423 p., front., 24 illus; v. 2, 362 p., front., 11 illus.
Describes hot springs in a small valley about 2 miles from Batu in Java.

3523. **Junghuhn, Franz Wilhelm,** 1845, Reise durch die Insel Java [Journey through Java]: Annalen Nat. History, v. 16, p. 329–332, 462–466; v. 17, p. 46–48, 469–476.

3524. 1852–54, Java, seine Gestalt, Pflanzendecke, und innere Bauart: Leipzig, Germany, Arnold, 3 v., atlas; 1852, v. 1, Die Gestalt und Bekleidung des Landes, 483 p., illus.; 1854, v. 2, Die Vulkane und vulkanischen Erscheinungen. 964 p., illus.; 1854, v. 3, Die neptunischen Gebirge, 314 p., illus.
Includes a description of Platungen springs; also contains information on several other thermal springs and fumaroles.

3525. **Junghuhn, Friedrich,** 1845, Topographische und naturwissenschaftliche Reisen durch Java, with introduction by C. G. Nees von Esenbeck: Magdeburg, Germany, K. Leopold-Carol Akad. Naturf., 520 p., 38 pls., 2 maps.
Contains chemical analyses of water from three thermal springs and from thermal lake Telaga-bodas.

3526. **Kemmerling, Georg Laure Louis,** 1919, Het Idgen-Hoogland. De Geologie en Geomorphologie van den Idgen: Batavia, G. Kolff & Co., Koninkl. Natuur. Ver., 169 p., 58 pls., 24 figs., 3 maps.

Describes fumaroles, solfataras, and mofettes of the Kawah-Idgen and Goenoeng Raoeng areas in eastern Java, also several thermal springs and their deposits of travertine. Contains chemical analyses of water from thermal springs and the crater lake in the Idgen-Merapi volcanic area.

3527. **Maier, P. J.,** 1850–51 [Analyses of mineral waters of Java]: Naturk. Tijdschr. Nederland. Indië.

3528. **Meunier, Stanislas,** 1886, Examen d'eaux minérales de Java: Acad. sci. [Paris] Comptes rendus, v. 103, p. 1205–1207.

Contains information on three mineral springs near Kapouran.

3529. **Neumann van Padang, Maur,** 1933, De Uitbarsting van den Merapi (Midden Java) in de Jaren 1930–31: Vulkanol. en seismol. Mededeel., Dienst. van den Mijnbouw in Nederlandsch Indie, no. 12, 135 p., 7 pls., figs.; appendix and English summary by M. Hartmann.

Contains map showing the location of hot springs near Merapi volcano.

3530. **Raffles, Thomas Stamford,** 1817, The history of Java: London, Black, Parbury, & Allen, 2 v.; v. 1, 479 p., front., 24 pls., map; 2d ed., 2 v., 1830, London, J. Murray.

Quotes the information given in reference 3521 on thermal water.

3531. **Stevens, Horace J.,** 1904–05 [Copper in Java]: Chicago, M. A. Donohue & Co., Copper Handb., 1904, v. 4, 1903, p. 156; 1905, v. 5, 1904, p. 156.

States that iodide of copper is obtained by evaporating water from springs in the Kendeng district.

3532. **Verbeek, Rogier Diederik Marius, and Fennema, Reinder,** 1896, Geologische Beschrijving van Java en Madoera: Amsterdam, J. G. Stemler Co., 2 v.; atlas; v. 1, p. 1–503, 11 pls., 17 views; v. 2, p. 504–1135, 8 views; French ed., 1896, 2 v., 1183 p., atlas; 1898, summary, Petermanns Geog. Mitt., v. 44, p. 24–33, 1 pl.

Contains data on thermal springs in nine localities in east Java.

See also references 16, 20, 83, 94, 109, 3725, and 3727.

KERMADEC ISLANDS

3533. **Smith, Stephenson Percy,** 1887, The Kermadec Islands, their capabilities and extent: Wellington, New Zealand, G. Didsbury, 29 p.

Mentions steam vents on the banks of Green Lake, and steam vents and a small warm spring at Denham Bay, both on Sunday Island.

3534. 1888, Geological notes on the Kermadec Group: New Zealand Inst. Trans. and Proc., 1887, v. 20, p. 333–344.

Contains information, similar to that in reference 3533, on hydrothermal activity on Sunday Island. Also mentions solfataras, fumaroles, boiling mud ponds, and a hot spring on the eastern of the two Curtis Islands 90 miles south of Sunday Island.

MOLUCCA ISLANDS

3535. **Encyclopedia Britannica,** 1910, Amboyna (Dutch Ambon): 11th ed., New York, Encyclopaedia Britannica, v. 1, p. 797.

Mentions the hot springs and solfataras on Wawani and Salhutu mountains.

3536. **Emmons, William Harvey,** 1931, Geology of petroleum: 2d ed., New York and London, McGraw-Hill Book Co., 736 p., 435 figs.

Mentions the hot sulfur springs and mud volcanoes on the northeast side of Ceram.

3537. **Ten Kate, Herman F. C.,** 1894 [Mud volcanoes in Samau Island]: Tidjschr. Koninkl. Nederland. Aard. Gen., p. 350–358.

3538. **United States Navy Department,** 1935, Sailing directions for Celebes: Washington, HO 163, 628 p.

Mentions the hot springs on the beach near the mouth of Wai Mantana and in the basin of River Made, both localities in the Sula (Xulla) Islands.

3539. **Verbeek, Rogier Diedrik Marius,** 1905, Description géologique de l'Isle d'Ambon. French edition translated from Mijnw. in Nederlandsch Oost-Indië Jaarb.: v. 35, pt. sci., 323 p., figs., maps.

Contains information on several thermal springs.

3540. 1908, Rapport sur les Moluques. French edition translated from Mijnw. in Nederlandsch Oost-Indië Jaarb.: v. 37, pt. sci., 844 p., 10 pls., atlas.

Mentions hydrothermal activity on the islands of Batjan, Tidore, Ternate, Halmahera, Roti, Samau, Timor, Pantar, Roma, Gunongapi, Damar, Nila, Seroe, and Manouk.

3541. **Wichmann, Arthur,** 1892 [Mud volcanoes on Samau Island]: Tijdschr. Koninkl. Nederland. Aard. Gen., p. 223–226.

See also references 74, 596, 1086, 3485, 3486, 3513, 3524, and 3725.

NEW CALEDONIA

3542. **Avias, Jacques,** 1953, Note sur les sources thermales de Nouvelle Calédonie: Pacific Sci. Cong., 7th, New Zealand 1949, Proc., v. 2, Geology, p. 482–484, 4 figs.

NEW HEBRIDES

3543. **Atkin, Joseph,** 1868a, On volcanoes in the New Hebrides and Banks's Islands: Geol. Soc. London Quart. Jour., v. 24, p. 305–307.

Mentions hot sulfur springs and vapor vents on Vanua Lava (Great Banks Island); also vapor vents on other islands in the New Hebrides.

3544. 1868b, On volcanoes in the New Hebrides and Banks Islands (communication): London, Edinburgh, and Dublin Philos. Mag. and Jour. Sci., ser. 4, v. 36, p. 72–73.

Mentions the hot sulfur springs on Vanua Lava (Great Banks Island).

3545. **Mawson, D.,** 1905, The geology of the New Hebrides: Linnean Soc. New South Wales Proc., v. 30, pt. 3, p. 400–485, 16 pls., 5 figs.

Contains information on hot springs on Vanua Lava (Great Banks Island), Tanna, Ambrym, and Efate.

See also reference 43.

NEW ZEALAND

3546. **Abbay, R.,** 1878, On the building-up of the white sinter terraces of Rotomahana: Geol. Soc. London Quart. Jour., v. 34, p. 170–178, 6 figs.

3547. **Aitken, J. B.,** 1914, Medicinal and other springs of New Zealand: Pharm. Jour. [London], v. 92, p. 710–712; Chem. Abs., v. 8, p. 2665.

3548. **Anonymous,** 1949, Seventh Pacific Science Congress, second report; geology, volcanology, and geophysics: New Zealand Sci. Rev., v. 7, no. 3, p. 29–32, 2 figs.; 1950, abs., Bibliography and Index of Geology Exclusive of North America, v. 14, 1949, p. 294.

3549. **Bell, James Mackintosh,** 1906, The great Tarawera volcanic rift, New Zealand: Royal Geog. Soc. [London] Jour., v. 27, no. 4, p. 369–382, 7 views, 2 maps.
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States that the siliceous sinter at Whakarewarewa contains gold and silver.

3551. **Bell, James Mackintosh,** and **Clarke, E. de C.,** 1909, The geology of the Whangaroa Subdivision, Hokianga Division: New Zealand Dept. Mines, Geol. Survey Bull. 8 (new ser.), 115 p., 17 pls., 8 maps.
Contains information on hot springs and hot pools.

3552. **Boord, Hilda,** 1904, On the Hot Lakes district, New Zealand: Victoria Inst., Journal of the Transactions, v. 36, p. 129–147, 1 pl., London.
Mentions 10 geysers and also other indications of hydrothermal activity.

3553. **Bruce, J. A.,** and **Shorland, F. B.,** 1932–33, Utilization of natural heat resources in thermal regions: New Zealand Jour. Agriculture, v. 45, p. 272–278, 1932; v. 47, p. 29–32, 1933.

3554. **Bruce, J. Arthur,** 1942, Nature's heat resources; their post-war utilization in thermal regions: Dunedin, N.Z., John McIndoe, 40 p., 9 illus.
Discusses the possibilities of utilizing natural heat in the thermal areas of New Zealand. Describes the use of natural steam in Iceland for heating and at Larderello in Italy for the production of power.

3555. **Bucke, E. W.,** 1887, Geysers of the Rotorua District, North Island of New Zealand: Geol. Mag. [London], new ser., dec. 3, v. 4, no. 1, p. 39–40; 1887, British Assoc. Adv. Sci. Rept., 1886, p. 644.

3556. **Bunbury, C.,** 1879, The geysers of New Zealand: Frazer's Mag. [London], p. 761; Living Age [London], p. 812.

3557. **Cadell, Henry M.,** 1897, A visit to Mount Tarawera: Scottish Geog. Mag., v. 13, p. 246–259, 7 views, maps.
Describes hydrothermal activity near Lake Rotorua and the geyser area near Whakarewarewa village.

3558. 1899, A visit to the New Zealand volcanic zone: Edinburgh Geol. Soc. Trans., v. 7, p. 183–200, 6 pls., 3 figs.
Mentions the geysers near Whakarewarewa village.

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Mentions the many hot springs, mud volcanoes, and fumaroles near Lake Taupo and the hot springs near Lake Rotorua. Also mentions the terraces at Lake Rotomahana which were destroyed by the eruption of Tarawera volcano.

3561. **Chamberlain, G.,** 1944, Fluorine in New Zealand waters. Part I, North Island waters: New Zealand Jour. Sci. and Technology, v. 26, Sec. B, no. 2, p. 90–94.

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Contains chemical analyses of three samples of geyserite from New Zealand.

3563. **Cleaver, A. S.,** 1895, Through the Hot Lake district of New Zealand: Belfast Nat. History and Philos. Soc. Rept. and Proc., 1894–95, p. 34–42.
Mentions the geysers and hot springs.

3564. **Collie, W.,** 1880, **Remarks** on volcanoes and geysers of New Zealand: New Zealand Inst. Trans. and Proc., 1879, v. 12, p. 418–420.

3565. **Collins, B. W.,** 1953, Thermal waters of Banks Peninsula, Canterbury, New Zealand: Pacific Sci. Cong., 7th, New Zealand 1949, Proc., v. 2, Geology, p. 469–481, 2 figs., 1 table.

3566. **Corbett, J. G.,** 1870, An account of a remarkable phenomenon observed at a hot spring near Lake Taupo: New Zealand Inst. Trans. and Proc., 1869, v. 2, p. 414.

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Contains a chemical analysis of water from a hot lake on White Island.

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3575. **Ferrar, H. T.,** and others, 1925, The geology of the Whangarei—Bay of Islands Subdivision, Kaipura Division: New Zealand Dept. Mines, Geol. Survey Br., Bull. 27 (new ser.), 134 p., front., 5 pls., 3 figs., 2 sheets geol. sections, 11 maps.
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3578. 1870, Account of a visit to a hot spring called "Te Puia" near Wangape Lake, central Waikato, Auckland, in August 1868: New Zealand Inst. Trans. and Proc., 1869, v. 2, p. 169–173.

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3580. **Grange, Leslie I.,** 1927a, Rotorua district: New Zealand Dept. Sci. and Indus. Research, Geol. Survey Br., 21st Ann. Rept. (new ser.), p. 14–15.
Contains information on five groups of hot springs, five fumaroles, and the Pohutu geyser.

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States that the eruption was hydrothermal, no lava being extruded. Mentions the hot springs and their deposits, which were destroyed by the eruption.

3628. **Keam, R. F.,** 1955, Volcanic wonderland, the scenery and spectacle of the New Zealand thermal region: Auckland, N.Z., G. B. Scott, Publishers, 49 p., 125 views.

3629. **Laing, R. M.,** 1884, A few notes on thermal springs at Lyttelton: New Zealand Inst. Trans. and Proc., 1883, v. 16, p. 447–448.

3630. **Liversidge, A., Skey, W., and Gray, G.,** 1898, On the composition and properties of the mineral waters of Australiasia: Australiasian Assoc. Adv. Sci. Rept., 7th Mtg., p. 87–108, Sydney.
Contains chemical analyses of the water from several springs in the Rotorua, Taupo, and Te Aroha areas in New Zealand.

3631. **Maclaren, J. Malcolm,** 1906, The source of the waters of geysers: Geol. Mag. [London], new ser., dec. 5, v. 3, p. 511–514.
States that the water of geysers in New Zealand is believed to be of meteroic, rather than of magmatic, origin.

3632. **Maclaurin, James Scott,** 1906, Colonial Laboratory, 39th report: New Zealand Mines Dept.
Contains a chemical analysis of the water in the crater lake on White Island.

3633. 1912, Occurrence of pentathionic acid in natural waters: Chem. Soc. London Proc., v. 27, p. 10–12.
Contains information on the chemical quality of the water in the crater lake on White Island.

3634. **Maclaurin, James Scott,** and **Wright, C. M.,** 1911, Radioactivity of the thermal waters of Rotorua-Taupo and Te Aroha: Dominion Lab., 44th Ann. Rept., p. 63–70.

3635. **Macpherson, Eric Ogilvy,** 1944, Notes on the geology of Whakatane district and Whale Island: New Zealand Jour. Sci. and Technology, v. 26, Sec. B, no. 2, p. 66–76, 5 figs.
Contains information on several thermal springs and wells.

3636. 1945, Te Puia hot springs: New Zealand Jour. Sci. and Technology, v. 26, Sec. B. no. 5, p. 244–254, 4 figs.

3637. **Mair, Gilbert,** 1877, Notes on the influence of atmospheric changes on the hot springs and geysers in the Rotorua district: New Zealand Inst. Trans. and Proc., 1876, v. 9, p. 27–29, 623.

3638. **Mair, Robert,** 1872, Notes on a thermal spring near Helensville, Kaipara: New Zealand Inst. Trans. and Proc., 1871, v. 4, p. 396.

3639. **Malfroy, Camille,** 1892, On geyser-action at Rotorua: New Zealand Inst. Trans. and Proc., 1891, v. 24, p. 579–590, 3 pls.

3640. 1894, Report on the geyser at Orakei Korako: New Zealand Dept. Lands and Surveys Ann. Rept., C–1, p. 68–69.

3641. **Mallet, J. William,** 1853, Results of analyses of siliceous deposits from the hot springs of Taupo, New Zealand: Dublin Geol. Soc. Jour., v. 5, p. 263–264; Erdmann prakt. Chemie Jour., v. 59, p. 158–159, 1853.

3642. **Marshall, Patrick,** 1912, Geology of New Zealand: Wellington, N.Z., J. Mackay, Govt. Printer, 218 p., front., 112 figs., map.
Mentions fumaroles, mud pots, geysers, and hot springs in several localities.

3643. **Martin, Josiah,** 1879, The geysers, hot springs, and terraces of New Zealand: Pop. Sci. Rev. [London], v. 18 (new ser., v. 3), p. 366–384, 1 pl., 2 figs.

3644. 1887a, The terraces of Rotomahana, N.Z.: Geol. Soc. London Quart. Jour., v. 43, p. 165–177, 1 fig.; Geol. Mag. [London], new ser., dec. 3, v. 4, p. 135–136, 1887.

3645. 1887b, A descriptive account of the White Terrace at Rotomahana [abs.]: New Zealand Inst. Trans. and Proc., 1886, v. 19, p. 605–606.

3646. **Modriniak, N.,** 1944, Geophysical investigation of the Puhipuhi mercury deposit: New Zealand Jour. Sci. and Technology, v. 26, Sec. B, no. 2, p. 61–65, map.
States that there is a close connection between the loss of magnetic properties and thermal activity.

3647. 1945, Thermal resources of Rotorua: New Zealand Jour. Sci. and Technology, v. 26, Sec. B, no. 5, p. 277–289, map.

3648. 1948, Geophysical investigation of Rotorua: New Zealand Jour. Sci. and Technology, v. 30, Sec. B, no. 1, p. 1–19, 5 figs.
Describes the use of thermal water for heating.

3649. **Morgan, Percy Gates,** 1908, The geology of the Mikonui Subdivision, North Westland: New Zealand Geol. Survey Bull. 6 (new ser.), 175 p., 29 pls., 12 maps, 2 diagrams, 2 geol. sections.
Mentions thermal springs in several localities.

3650. 1917, Eruption of Frying-pan Flat, near Waimangu, Rotorua district: New Zealand Geol. Survey 11th Ann. Rept., C–2B, p. 11–12.

3651. 1927, Minerals and mineral substances of New Zealand: New Zealand Dept. Sci. and Indus. Research, Geol. Survey Br. Bull. 32, new ser., 110 p., maps.
Contains information on the thermal springs.

3652. **Mundy, D. L.,** and **Hochstetter, Ferdinand von,** 1875, Rotomahana, and the boiling springs of New Zealand: London, Samson, Low.

3653. **Ongley, Montague,** Director, 1948, The outline of the geology of New Zealand, by officers of the Geological Survey: Wellington, N.Z., Harry H. Tooms, 47 p., map.
Map shows the location of some of the volcanoes and the geology of the thermal-spring regions.

3654. **Ongley, Montague,** and **Macpherson, Eric Ogilvy,** 1928, The geology of the Waiapu Subdivision, Raukumara Division: New Zealand Dept. Sci. and Indus. Research, Geol. Survey Br. Bull. 30, new ser., 79 p., 6 pls., maps.
Mentions the hot springs at Te Puia.

3655. **Park, James,** 1910, The geology of New Zealand; an introduction to the historical, structural, and economic geology: Christchurch and London, Whitcombe & Tombs, Ltd., 488 p., front., 17 pls., 145 figs., 6 maps.
Describes hydrothermal activity in several localities. Contains data on 35 thermal springs.

3656. 1911, Tarawera eruption and after: Royal Geog. Soc. [London] Jour., v. 37, no. 1, p. 42–49, 4 pls., map.
Describes the effect of the eruption on hydrothermal activity.

3657. **Pond, James Alexander,** and **Smith, Stephenson Percy,** 1887, Observations on the eruption of Mount Tarawera, Bay of Plenty, New Zealand, 10th June, 1886: New Zealand Inst. Trans. and Proc., 1886, v. 19, p. 342–371.
Mentions hot springs in the volcanic district.

3658. **Poynton, J. W.,** 1904, Notes on an insect found in some hot springs at Taupo: New Zealand Inst. Trans. and Proc., 1903, v. 36, p. 170–172.

3659. **Ralph, W. H.,** 1874, Communication regarding a hot spring in the bed of Wataroa River Westland: New Zealand Inst. Trans. and Proc., 1873, v. 6, p. 380.

3660. **Reaney, R. H.,** 1899, Thermal springs, Rotorua: New Zealand Dept. Lands and Surveys Ann. Rept., C–1, p. 125.

3661. **Rogers, M. N.,** 1927, The radioactivity of the Karapiti blowhole: New Zealand Inst. Trans. and Proc., v. 57, p. 892.
States that the blowhole emits much steam and other gases at a high velocity. Contains information on the radon content of the gases.

3662. **Rolston, Edward, and Edwin, R. A.,** 1869, On the crater of White Island [abs.]: New Zealand Inst. Trans. and Proc., 1868, v. 1, p. 463–465, 1 pl.
Mentions the steam jet and mud geyser near the shore of the crater lake.

3663. **Savage, Joseph,** 1889, The Pink and White Terraces of New Zealand: Kansas Acad. Sci. Trans., 1887–88, v. 11, p. 26–30.

3664. **Sewell, William,** 1874, Notes on a visit to White Island, in the course of a trip made in H.M.S. "Basilisk" [abs.]: New Zealand Inst. Trans. and Proc., 1873, v. 6, p. 386–387.
Mentions hydrothermal activity in the crater on White Island.

3665. **Shaw, G. C.,** 1954, The angry mountains; New Zealand's volcanic belt: Pacific Discovery, v. 7, no. 4, p. 13–18, 9 views.
Mentions the warm lake in the crater of Ruapehu volcano and hydrothermal activity in the volcanic belt of the North Island.

3666. **Skey, William,** 1878, On certain of the mineral waters of New Zealand: New Zealand Inst. Trans. and Proc., 1877, v. 10, p. 423–448.

3667. **Smith, Stephenson Percy,** 1886, The eruption of Tarawera; a report to the surveyor general: Wellington, N.Z., Govt. Printer, 84 p., 21 pls., maps.

3668. **Springall, Percy W.,** 1888, A trip through the Hot Lake district, New Zealand: Royal Geog. Soc. Australasia Proc. and Trans., v. 3, pt. 1, p. 53–63.
Contains information on hot springs in several localities.

3669. **Steiner, A.**, 1953, Hydrothermal rock alteration at Wairakei, New Zealand: Econ. Geology, v. 48, no. 1, p. 1–13, 4 figs.

3670. **Studt, F. E.**, 1957, Wairakei hydrothermal system and the influence of ground water: New Zealand Jour. Sci. and Technology, Sec. B, v. 38, no. 6, p. 595–622, illus.; 1958, abs., Bibliography and Index of Geology Exclusive of North America, v. 22, 1957, p. 521.

3671. **Tucker**, 1895, Description of the Hot Springs District, *in* Pictorial New Zealand: London, 301 p.

3672. **Wallace, Alfred Russel**, 1879, Australasia; based on Hellwald's "Die Erde und ihre Völker"; edited and extended by A. R. Wallace, with ethnological appendix by A. H. Keane: London, Edward Stanford, 672 p., front., 54 illus., 29 maps.

Briefly describes the hot springs and geysers of New Zealand.

3673. **Warbrick, Alfred**, 1934, Adventures in Geyserland; life in New Zealand's thermal regions, including the story of the Tarawera eruption and the destruction of the famous terraces of Rotomahana: Dunedin and Wellington, N.Z., A. H. and A. W. Reed.

3674. **Wilson, Stuart H.**, 1953, The chemical investigation of the hot springs of the New Zealand thermal region: Pacific Sci. Cong., 7th, New Zealand 1949, Proc., v. 2, Geology, p. 449, 6 figs.

3675. 1955, Chemical investigations, *in* Grange, L. I., compiler, Geothermal steam for power in New Zealand: New Zealand Dept. Sci. and Indus. Research Bull. 117, chap. 4, p. 27–42, figs., tables.

Contains information on the chemical character of the thermal waters and their evolved gases in several areas.

3676. **Winkelmann, C. P.**, 1887, Notes on the hot springs Nos. 1 and 2, Great Barrier Island, with sketches showing temperature of the waters: New Zealand Inst. Trans. and Proc., 1886, v. 19, p. 388–392, 1 pl.

3677. **Wohlmann, H. S.**, 1907, The mineral waters and health resorts of New Zealand. Part I, Rotorua: Wellington, N.Z., New Zealand Tourist and Health Resort Dept., 48 p.

3678. **Wright, Alfred**, 1887, Te Aroha, New Zealand; a guide for invalids and visitors to the thermal springs and baths: Te Aroha, Hot Springs Domain Board, 34 p., front., map.

See references 20, 21, 73, 106, 108, 109, 347, 649, 672, 687, 700, 2092, 2248, 2644, and 3496.

PHILIPPINE REPUBLIC

3679. **Abella y Casariego, Enrique**, 1884a, La isla de Bilirán (Filipinas) y sus azufrales: Spain, Comisión Mapa Geol. Espãna Bol., v. 11, pt. 2, p. 359–373, map; Madrid, Ministerio de Ultramar, Tello, 1885.

3680. 1884b, El Monte Maquiling (Filipinas) y sus actuales emanaciones volcánicas: Spain, Comisión Mapa Geol. Espãna Bol., v. 11, pt. 2, p. 374–391; 1937, translated into English by José B. Blando, *in* Philippine Agriculturist (Univ. Philippines Pub., ser. A), v. 26, no. 2, p. 199–221.

Contains information on six thermal-spring localities.

3681. 1884c, Emanaciones volcánicas subordinadas al Malinao (Filipinas): Spain, Comisión Mapa Geol. España Bol., v. 11, pt. 2, p. 395–404, 3 pls.; Madrid, Ministerio de Ultramar, Tello, 1885.

3682. **Abella y Casariego, Enrique, and Vera y Gomez, José de**, 1893, Estudio descriptivo de algunos manantiales minerales de Filipinas: Manila, 150 p.

Includes chemical analyses of water from several thermal springs, descriptions of some of the springs, and a list of reported springs.

3683. **Adams, George I.**, 1909, Geological reconnaissance of the Island of Leyte—with notes and observations on the adjacent smaller islands and southwestern Samar: Philippine Jour. Sci., v. 4, Sec. A, no. 5, p. 339–358, map.

Contains information on several solfataras, mud pots, and thermal springs.

3684. **Adams, George I., and Pratt, Wallace Everette**, 1911, Geologic reconnaissance of southeastern Luzon: Philippine Jour. Sci., v. 6, Sec. A, no. 6, p. 449–481, 6 pls., 4 figs.

Mentions Tiui hot springs, Naglagbong springs, Lanot mineral spring, and hot springs on the beach near Maniti.

3685. **Alcaraz, Arturo**, 1956, Taal Volcano: Pacific Sci. Cong., 8th, Quezon City, Philippines, 1953, Proc., v. 2, p. 34.

Mentions lake in volcanic crater and steam vents on southwest shore of the lake.

3686. **Alcaraz, Arturo; Abad, Leopoldo F.; and Quema, José C.**, 1952, Hibok-Hibok volcano, Philippine Islands, and its activity since 1948; Volcano Letter 516, p. 1–6; no. 517, p. 1–4, 7 figs.

Mentions that a hot spring issues near sea level on the north side of the volcano; also mentions that eruption of volcano (1948) began with steam blasts.

3687. **Alcaraz, Arturo; Abad, Leopoldo F.; and Tupas, M. H.**, 1953, The Didicas submarine volcano [abs.]: Pacific Sci. Cong., 8th, Quezon City, Philippines, 1953, Abstract of Papers, p. 4.

Mentions that steam was given off during the eruption of Didicas volcano in 1952.

3688. **Alvir, A. D.**, 1956, A cluster of little known Philippine volcanoes: Pacific Sci. Cong., 8th, Quezon City, Philippines, 1953, Proc., v. 2, p. 205–206.

Mentions hot springs and steam vents in the craters of Ambalatungan, Bumbag, and Podakan volcanoes.

3689. **Becker, George Ferdinand**, 1901, Report on the geology of the Philippine Islands: U.S. Geol. Survey 21st Ann. Rept., pt. 3, p. 487–614, 3 pls., 2 figs.

Describes the principal volcanoes, both active and extinct; includes information on the fumaroles, solfataras, hot springs, and crater lakes.

3690. **Bowring, John**, 1859, A visit to the Philippine Islands: London, Smith, Elder, & Co., 438 p., front., 14 illus.

States that three are many mineral and thermal springs in the La Laguna district of Luzon; also states that there are boiling springs at pueblo of Mainit.

3691. **Brown, Glen Francis**, 1943, Thermal sbrings in Mindanao: Unpublished notes.

3692. **Centeno y Garcia, José**, 1876, Memoria geológico-minera de las Islas Filipinas: Spain, Comisión Mapa Geol. España Bol., v. 3, p. 181–234, map; Madrid, Ministerio de Ultramar, Tello 8, 64 p., map.

Contains descriptions of thermal springs and analyses.

3693. 1885a, El Volcán de Taal: Spain, Comisión Mapa Geol. España Bol., v. 12, pt. 2, p. 169–208; Madrid, Ministerio de Ultramar, Tello, 1885, 53 p., 4 pls.

3694. **Centeno y Garcia, José,** 1885b, Noticia acerca de los manantiales termo-minerales de Bambang y de las salinas de Monte Blanco: Spain, Comisión Mapa Geol. España Bol., v. 12, p. 223–236, map; Madrid, Ministerio de Ultramar, Tello, 1885, 14 p., map.

3695. **Centeno y Garcia, José,** and others, 1889, Memoria decriptiva de los manantiales minero-medicinales de la Isla de Luzon: Spain, Comisión Mapa Geol. España Bol., v. 16, p. 177–295; Madrid, Ministero de Ultramar, Tello, 1890, 117 p.

3696. **Cox, Alvin Joseph,** and **Dar Juan, T.,** 1915, Salt industry and resources of the Philippine Islands; Philippine Jour. Sci., v. 10, Sec. A, no. 6, p. 375–401, 17 pls., 5 figs.

Contains information on Mayinit hot spring and Salina springs, both in Luzon.

3697. **Cox, Alvin Joseph; Heise, George William;** and **Gana, V. Q.,** 1914, Water supplies in the Philippine Islands: Philippine Jour. Sci., v. 9, Sec. A, no. 4, p. 273–410, 5 pls., 8 tables.

Includes information on nine thermal springs.

3698. **Feliciano, J. M.,** 1928, A study of thermal springs in the Philippines: Pan-Pacific [Pacific] Sci. Cong., 3d, Tokyo 1926, Proc., v. 1, p. 804–811, map.

Contains information on 54 thermal springs.

3699. **Ferguson, Henry Gardiner,** 1908, Contributions to the physiography of the Philippine Islands. II, Batanes Islands: Philippine Jour. Sci., v. 3, Sec. A, no. 1, p. 1–25, 9 pls., 4 figs., 3 maps.

3700. **Goodman, Maurice,** 1907, Sulphur in the Philippines: Far Eastern Rev., v. 4, p. 120–121.

Mentions sulfur deposits near some of the solfataras.

3701. **Heise, George William,** 1915, Water supplies in the Philippine Islands, II: Philippine Jour. Sci., v. 10, Sec. A, no. 2, p. 135–169, 8 tables.

Includes chemical analyses of water from the hot springs at Ilocos Sur, a hot spring near Punta Galera, and a hot spring at Tiui.

3702. 1917, The radioactivity of the waters of the mountainous region of northern Luzon: Philippine Jour. Sci., v. 12, Sec. A, no. 6, p. 293–307, 1 pl., 2 figs., map, 2 tables.

Contains information on 11 thermal springs and 1 solfatara.

3703. **Heise, George William,** and **Behrman, Abraham S.,** 1918, Philippine water supplies: Philippine Dept. Agriculture and Nat. Resources, Bur. Sci. Pub. 11, 218 p., 19 pls., 4 figs., 16 tables.

Describes 20 mineral springs, some of which are thermal.

3704. **Jagor, Fedor,** 1873, Reisen in den Philippinen: Berlin, 381 p., map; Spanish ed., 1875, Madrid; English ed., with some omissions, Travels in the Philippines: London, Chapman & Hall, 370 p., 1875.

Mentions several thermal springs.

3705. **Marche, Alfred de la,** 1843, Déscription des sources thermales nommées Los Baños et du volcan de Taal, dans les environs de Manille: Soc. géographie [Paris] Bull., ser. 2, v. 19, p. 79–83.

3706. **Montano, Joseph,** 1885, Voyage aux Philippines, *in* Rapport a M. le Ministre de l'Instruction publique sur une mission aux îles Philippines et en Malaisie (1879–1881): Paris, Hachette et Cie., p. 271–479.

Mentions hot springs in the mountains near Lake Mainit in Mindanao Island.

3707. **Neumann van Padang, Maur,** 1953, Philippine Island and Cochin, China, pt. 2 *of* Catalogue of active volcanoes of the world including solfatara fields: Naples, Italy, Internat. Volcanolog. Assoc., 49 p., 16 figs., map.

Contains information on volcanoes or solfataras at 31 localities in the Philippines and 2 in Cochin China (southern Viet Nam). Mentions thermal springs in some of the localities.

3708. **Pelaez, Vinicio R.,** 1953a, The behaviour and characteristics of volcanoes in the solfataric and fumarolic stage of activity: Pacific Sci. Cong., 7th, New Zealand 1949. Proc., v. 2, Geology, p. 364–368.

Mentions several localities in the Philippines where there are fumaroles, solfataras, and thermal and mineral springs.

3709. 1953b, The volcanic activity of Catarman and Hibok-Hibok, Camiguin Island, Mindanao, of September, 1948 [abs.]: Pacific Sci. Cong., 8th, Quezon City, Philippines, 1953, Abstract of Papers, p. 4–5.

Mentions steam as one of the products of eruption.

3710. 1956, The volcanic activity of Catarman and Hibok-Hibok, Camiguin Island, Mindanao, of September 1948: Pacific Sci. Cong., 8th, Quezon City, Philippines, 1953, Proc., v. 2, p. 89–112, 5 figs., 2 tables.

States that solfataras and fumaroles are present on Mount Catarman; also states that release of water vapor characterized eruptions of Camiguin and Hibok-Hibok craters.

3711. **Pratt, Wallace Everette,** 1911, The eruption of Taal volcano, January 30, 1911: Philippine Jour. Sci., v. 6, Sec. A, no. 2., p. 63–86, 14 pls., 3 figs., map.

Mentions that two streams of hot water fed the new lake that formed in the crater of Taal volcano after the eruption.

3712. 1916, Philippine lakes: Philippine Jour. Sci., v. 11, Sec. A, no. 5, p. 223–239, 1 pl., 2 figs.

Describes the hot lake in the crater of Taal volcano in Luzon, also Lake Mainit in Mindanao and Lake Naujan in Mindoro. Both the latter are considered to be crater lakes and have thermal springs near their shore.

3713. **Rosario, Mariano V. del,** 1938 [Crenotherapy with reference to the Philippines]: Rev. filipina medecina y farmacia, v. 29, p. 51–78 [Spanish]; Chem, Abs., v. 32, col. 4257.

Describes some of the more important mineral springs.

3714. **Smith, Warren DuPre,** 1925, Geology and mineral resources of the Philippine Islands: Philippine Dept. Agriculture and Nat. Resources, Bur. Sci. Pub. 19, 559 p., 39 pls., 23 figs., 41 tables.

Mentions several thermal areas containing solfataras, fumaroles, steam vents, and hot springs. Contains brief descriptions of several thermal springs.

3715. **U.S. Department of Commerce, Coast and Geodetic Survey,** 1940, U.S. Coast Pilot, Philippine Islands, Part 2, Palawan, Mindanao and Sulu: 3d ed., Washington, 542 p.

Mentions two hot springs near the shore of Balut Island.

3716. **Worcester, Dean C.,** 1912, Taal volcano and its recent destructive eruption: Natl. Geog. Mag., v. 23, no. 4, p. 313–367, 41 views, maps.

Mentions that great columns of steam accompanied the eruption in 1911.

3717. **Wright, J. R., and Heise, George William,** 1917, The radioactivity of Philippine waters: Philippine Jour. Sci., v. 12, Sec. A, no. 3, p. 145–165, 1 pl., 2 figs., 2 tables.
Contains information on the radioactivity of the water from six thermal springs and on the chemical quality of the water from four others.

See also references 20–22, 73, 83, 347, 1086, 2684, and 3512.

SAMOA

3718. **Jensen, H. I.,** 1907, The geology of Samoa and the eruptions in Savaii: Linnean Soc. New South Wales Proc., 1906–07, v. 31, p. 641–672, 11 pls., 6 figs.
Mentions that immense steam clouds rose from the main crater and that vapors issued from a vent near the crater during the eruptions of 1905 and 1906.

SOLOMON ISLANDS

3719. **Guppy, Henry Brougham,** 1887a, The Solomon Islands, their geology, general features, and suitability for colonization: London, S. Sonnenschein, Lowery & Co., 152 p.
Mentions hydrothermal activity on Simbo (Zimboa?) and Savo Islands.

3720. 1887b, The Solomon Islands and their natives: London, S. Sonnenschein, Lowrey & Co., 384 p., 9 illus.
Mentions fumaroles and solfataras on Eddystone Island, fumaroles on Vella-la-vella Island, and fumaroles and steam vents on Simbo (Zimboa?).

SUMATRA

3721. **Dammerman, Karel William,** 1948, The fauna of Krakatau, 1883–1933: Verh. der Konink. Nederlandisch Akad. van Wissen., Afd. Natuurkunde: Amsterdam, Noord-Hollandsche Uitj.–Mij., Tweede Sectie, pt. 44, 594 p., front., 11 pls., 46 figs.
States that crater of Anak Krakatau Island contains a lake, probably of hot water. Contains a photograph showing steam vents on Anak Krakatau.

3722. **Kemmerling, Georg Laure Louis,** 1920, Vulkanen en Vulkanische Verschijnselen in de Residentiën Sumatra's Westkust (noordelijk deel) en Tapanoeli door den tijdelijken geoloog bij s'Lands Mijndiensten: Vulkanol. Mededeel. Mijnw. Nederlandsch Oost-Indie, no. 1, p. 1–93, 27 pls., atlas.

3723. **Marsden, William,** 1811, The history of Sumatra, containing an account of the government, laws, customs, and manners of the native inhabitants, with a description of the natural productions, and a relation of the ancient political state of that island: 3d ed, London, Longman, Hurst, Reese, Orme, & Brown, 479 p., and index, 8 p., map.
Mentions hot springs northeast of Ipu, a warm spring on the bank of the Ipu River, hot springs close to Ayer Grau stream, and hot mineral springs at Priangan near Goenoeng Merapi volcano.

3724. **Netherlands East Indian Volcanological Survey,** 1927–49: Bull. 1–98; nearly all numbers contain maps, diagrams, and photo views.
Includes a few chemical analyses of thermal waters and many comments on changes in the temperature and outlet points of hot springs, solfataras, and fumaroles.

3725. **Neumann van Padang, Maur,** 1951, Indonesia, pt. 1 *of* Catalogue of the active volcanoes of the world including solfatara fields: Naples, Italy, Internat. Volcanol. Assoc., 271 p., 110 figs., map.
Contains data on 30 localities of volcanoes or solfataras in Sumatra, 28 in the Lesser Sunda Islands, 13 in Celebes, 1 in New Guinea, and 21 in minor islands. Includes information on thermal springs and wells in Sumatra, Java, Flores, and Celebes.

3726. **Stehn, Ch. E.,** ca. 1929, Krakatau: Pacific Sci. Cong., 4th, Java 1929, Rept., Pt. 1, The geology and volcanism of the Krakatau group: p. 1–55, 20 pls.
Describes hydrothermal activity associated with eruptions of Krakatau in 1927–29.

3727. **Verbeek, Rogier Diederik Marius,** 1886, Krakatau: Batavia, Java, Imprimerie Etat, 567 p., 43 figs., 25 chromolithographs.
States that the hot springs of Poeloesari volcano boiled more vigorously and that the great hot springs of Dieng spouted with increased energy after the great eruption of Krakatau. Both springs are in Java.

3728. **Westerveld, J.,** 1952, Quaternary volcanism on Sumatra: Geol. Soc. America Bull., v. 63, no. 6, p. 561–594, 5 pls., 3 figs., 11 tables.
Mentions that fumaroles, solfataras, and hot springs are the only active signs of volcanism on Sumatra.

See also references 84, 3470, 3519, and 3525.

TONGA ISLANDS

3729. **Jaggar, Thomas Augustus,** 1935, Living on a volcano: Natl. Geog. Mag., v. 68, p. 91–106, 18 illus., map.
Mentions a steam eruption in 1946.

VOLCANO ISLANDS

3730. **Swenson, Frank Albert,** 1948, Geology and ground-water resources of Iwo Jima: Geol. Soc. America Bull., v. 59, no. 10, p. 995–1008, 2 pls., 2 figs., 3 tables.
States that fumaroles are numerous and that the temperature of the water in wells ranges from 105°F to 160°F. Includes a chemical analysis of the water from a well.

3731. **Tsuya, Hiromichi,** 1936, Geology and petrography of Io-sima (Sulphur Island), Volcano Islands Group: Tokyo Imp. Univ. Earthquake Research Inst. Bull. 14, pt. 3, p. 453–480, 3 pls., 10 figs. [English.]
States that there are more than 20 solfataras on the island (Iwo Jima).

ANTARCTIC REGION

(Balleny Islands, Ross Island, and South Shetland Islands)

3732. **Encyclopedia Britannica,** 1911, South Shetland Islands: Encyclopaedia Britannica: 11th ed., New York, Encyclopaedia Britannica, v. 25, p. 516.
States that voyagers in 1828 and 1842 reported that steam issued from numerous vents on Deception Island.

3733. **Shackleton, Ernest Henry,** 1909, The heart of the Antarctic: Philadelphia, Pa., J. B. Lippincott Co., 2 v.; v. 1, 372 p., front., 131 pls.; v. 2, 419 p., front., 139 pls., 38 illus,. 3 maps.
Describes Mount Erebus and other volcanic cones, remarking on the huge column of steam rising from the crater of Mount Erebus, on the ice mounds formed from the vapor escaping from fumaroles in the crater, and on the steam eruptions at a low point between Mount Erebus and Mount Bird.

See also reference 43.