DEPARTMENT OF NATURAL RESOURCES
COLORADO GEOLOGICAL SURVEY
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Geothermal Resources of Colorado

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GEOTHERMAL RESOURCES OF COLORADO

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Colorado's geothermal resources are varied in character and scattered in the western half of the State. In recent years most geothermal exploration has been directed toward high-temperature (>150°C) resources and has tended to ignore the intermediate-temperature (90-150°C) and low-temperature (<90°C) systems. Three high-temperature areas are now being evaluated, at Mount Princeton Hot Springs, Poncha Hot Springs, and Cebolla Hot Springs. Numerous intermediate- and low-temperature resource areas can be exploited for varied significant uses and are expected to supply a large part of the State's energy needs in the years to come.

There are approximately 130 thermal springs and wells in 58 areas of western Colorado. The temperature range is generally from 20°C (68°F) in some areas to a high of 83°C (181°F) at Hortense Hot Spring (Mount Princeton). Discharge rates are less than four L/min (liters per minute) at Trimble Hot Spring and Browns Canyon Warm Spring to more than 8300 L/min at Glenwood Springs. Dissolved mineral matter ranges from 84 mg/L (milligrams per liter) at Eldorado Warm Springs to a high of over 21,000 mg/L at Glenwood Springs.

Accessible resource base: Barrett and Pearl (1978), using various geothermometer techniques, have estimated subsurface temperatures of all the known thermal areas in Colorado. Their calculations indicate reservoir temperatures from a low of 20°C at several sites to over 200°C at Mount Princeton, Waunita, and Poncha Hot Springs. In attempting to define the accessible resource base, Pearl (1979) made basic assumptions on dimensions and calculated the quantity of heat that could be contained in each thermal area. The calculations show there may be as much as 5 x 10^{19} to 13 x 10^{19} Btu (1.37 x 10^{19} joules) of heat energy contained in all the thermal systems of the State. Although no thermal springs or wells have been reported in eastern Colorado, preliminary information from oil and gas wells indicates areas of above normal (>30°C/km) geothermal gradients in northeastern Colorado (unpublished data, Earth Science Laboratory, University of Utah Research Institute).

Geology: Geological conditions in Colorado thermal areas vary from a simple stratigraphic section in the Canon City embayment west of Pueblo to the highly complex structure and lithology of the Ouray and Rico areas. Coe (1978) discusses features of a region favorable for commercial geothermal resources and points out that the San Luis and upper Arkansas Valleys (northern Rio Grande rift) and peripheral areas in south-central and southwest Colorado have these features in varying combinations: 1) young volcanic activity, 2) normal faulting, rifting, and extension, 3) thermal springs and wells, and 4) high heat flow (above 80 mW/m²) and high thermal gradients (above 40°C/km). Keller (1974) analyzes available heat flow, gravity, and seismicity data and suggests that the western slope of the Rocky Mountains and the San Luis and upper Arkansas Valleys are optimum for geothermal systems.

Potential uses: In summarizing some potential uses of geothermal resources in Colorado, Coe (1978) lists: power generation (over 200°C); space and water heating and cooling; refrigeration; biomass processing; feedlot and pen warming; crop drying; agricultural produce processing; manufacturing plywood, veneer, particle board, paper, pulp, and wood-chemicals; milk pasteurization and chilling; mushroom growing; freeze drying; sodium chloride production; nahcolite and dawsonite processing; and wood drying. Coe (1978) also shows that in western Colorado 16,000 homes, plus commercial, industrial, and public buildings, could be supplied with space heating and hot water.

Direct thermal use: Coe (1978) points out that Colorado's thermal resources are predominantly low- and intermediate-temperature, and the greatest exploitation probably will be for direct use, mainly space and water heating. Her study shows that in western Colorado, where the main energy demand is for heating residential and commercial buildings, 17 communities are located in thermal resource areas and 23 communities are within 10 miles of them. Exploitation of geothermal energy for space and water heating could help alleviate negative impact of mineral and other energy development at Craig, Paonia, and localities in Routt and Gunnison Counties. Nearby thermal resources can be used for space heat and hot water in tourist-oriented communities such as Steamboat Springs, Glenwood Springs, Pagosa Springs, Ouray, and Durango. Extensive use of thermal systems for processing agricultural products appears most likely in the San Luis Valley.

Power generation: Large energy companies have acquired geothermal leases on over 116,000 acres of Federal and State lands, and additional private lands, in Colorado. Mount Princeton, Poncha, and Cebolla Hot Springs are currently being evaluated for commercial power generation, and resources appear to be adequate in magnitude and temperature (over 200°C). The Valley View-Mineral Hot Springs area of northern San Luis Valley has attracted considerable exploration.

REFERENCES

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Coe, B.A., 1978: Geothermal energy development in Colorado: processes, promises and problems. *Colorado Geological Survey Information Series* 9, 48 pp.

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U.S. Geological Survey and Colorado Geological Survey, 1977: Energy resources map of Colorado. *U.S. Geological Survey Miscellaneous Investigations Map* I-1039.

Low-Temperature Geothermal Waters

Area of significant lateral extent favorable for discovery and development of local sources of low-temperature (<90°C) water. Areas are defined on the basis of thermal springs, wells, and geohydrologic settings generally favorable for recovery of thermal water. *Existing knowledge does not in general permit the inference that thermal water may be found everywhere within the depicted areas, nor do the boundaries represent certain knowledge of the areal extent of the geothermal systems.*

Areas are modified from those defined by E.A. Sammel, Duncan Foley and R.H. Pearl. See Sammel, E.A., Occurrence of low-temperature geothermal waters in the United States, in Muffler, L.J.P., ed., 1979, Assessment of geothermal resources of the United States—1978: U.S. Geological Survey Circular 790

Thermal Springs and Wells

Thermal springs
- Surface temperature ≤50°C
- Surface temperature >50°C

Thermal wells
- Surface temperature ≤50°C
- Surface temperature >50°C

Temperature, ° Celsius / Total Dissolved Solids milligrams/liter — Flow, liters/minute — Depth, meters

*81 Heat flow in milliwatts/meter²
See Sass, J.H., and Lachenbruch, A.H., Heat flow and conduction-dominated thermal regimes, in Muffler, L.J.P., ed., 1979, Assessment of geothermal resources of the United States—1978: U.S. Geological Survey Circular 790.

METRIC CONVERSION FACTORS
1 liter = .2642 gallon
1 meters = 3.281 feet
1 milligram/ liter = 1 part per million
°Celsius= 5/9 (°Fahrenheit – 32)
°Fahrenheit= 9/5 °Celsius + 32

- Known Geothermal Resources Area (KGRA) as designated by the U.S. Department of the Interior. Name in red lettering
- U.S. Department of Energy Reservation
- Indian Reservation
- Military Reservation
- National Forest, National Grassland
- National Park, National Monument, National Wilderness Area, National Wildlife Refuge, or State Park

Private land may exist within federal boundaries

Scale 1:500,000
1 centimeter equals 5 kilometers
1 inch equals approximately 8 miles
0 5 10 20 30 50 Kilometers
0 5 10 20 30 40 Miles

Contour Interval 500 feet
Datum is mean sea level
1927 North American datum
Lambert conformal conic projection based on standard parallels 33° and 45°
Base map data compiled in 1968

POPULATION KEY
DENVER ..... more than 100,000
BOULDER ..... 50,000 to 100,000
Grand Junction ..... 10,000 to 50,000
Del Norte ..... 1,000 to 10,000
Central City ..... 0 to 1,000
Population indicated by size of letters

- State capital
- County seat
- City, town, village, or locality
- Scheduled service airport
- Built-up area shown for towns over 10,000 population
- Interstate Highway
- U.S. Highway
- State Highway
- Other Principal Road

Geothermal data compiled under the direction of Richard H. Pearl of the Colorado Geological Survey. For additional information concerning the geothermal resources of Colorado, see Pearl, R.H., 1979: Colorado's hydrothermal resource base—an assessment. *Colorado Geological Survey Resource Series* 6

Map available free of charge from: Colorado Geological Survey, Department of Natural Resources, 1313 Sherman Street, Room 715, Denver, Colorado 80203

Map produced by David M. Clark and Ronald H. Smith, NCSDCNOAA, Boulder, Colorado, in cooperation with the Earth Science Laboratory/University of Utah Research Institute, Salt Lake City, Utah

Digital thermal well and spring data available from GEOTHERM Project, United States Geological Survey, 345 Middlefield Road, MS84, Menlo Park, California 94025

Base map supplied by the United States Geological Survey

Geothermal data compiled by the
Colorado Geological Survey

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