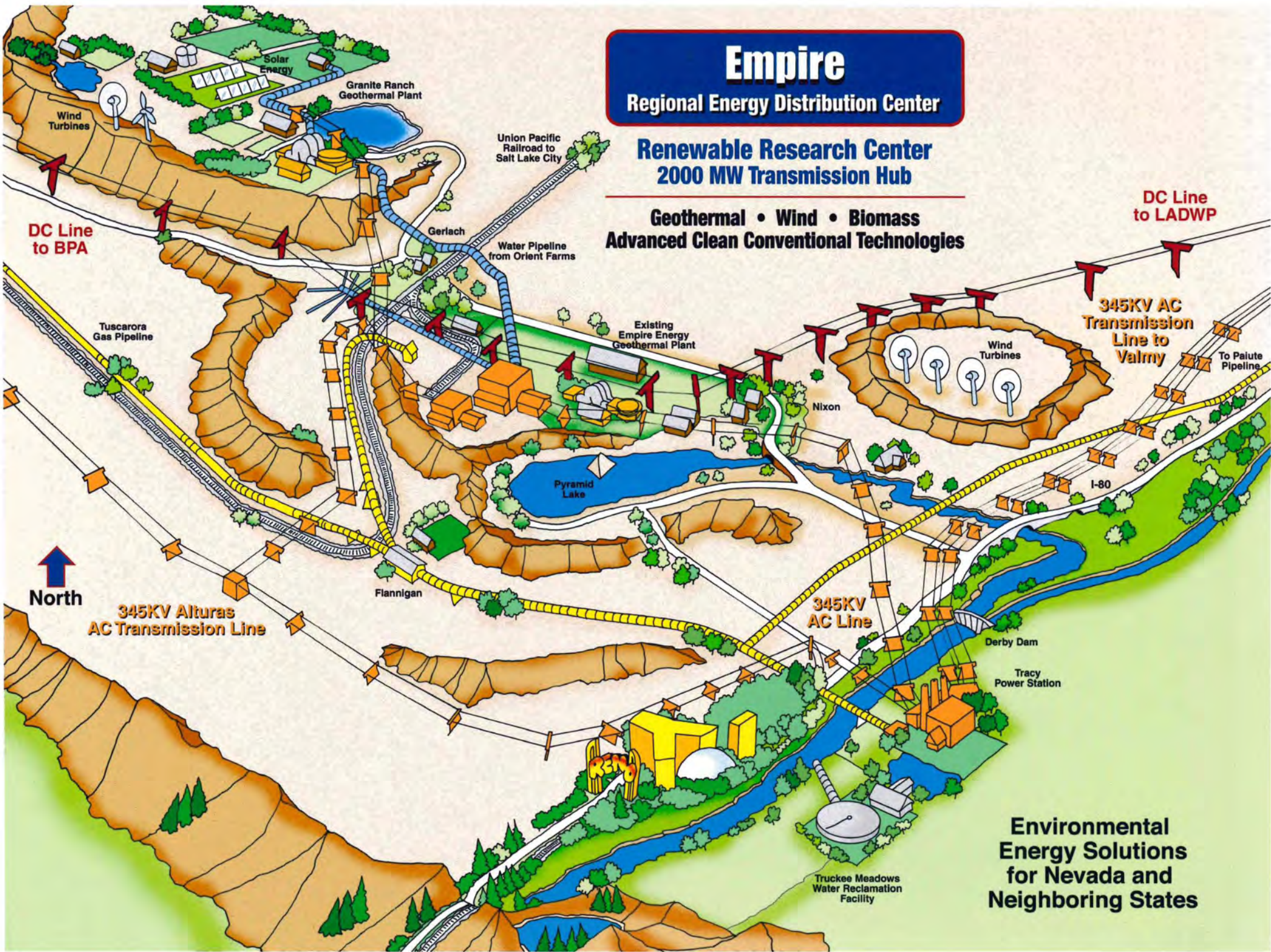


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Environmental Energy Solutions for Nevada and Neighboring States



North

ROAD LOG FOR FIELD TRIP
TO
EMPIRE FOODS, EMPIRE ENERGY,
GERLACH, FLY RANCH GEYSER,
AND ORIENT FARMS

Presented by
High Rock Holding LLC

June 4, 2003

FIELD TRIP TO SAN EMIDIO DESERT, GERLACH, FLY RANCH GEYSER AND ORIENT FARMS
by Dennis T. Trexler, Consultant, and Michael B. Stewart, High Rock Holding LLC

MILEAGE DESCRIPTIONS AND COMMENTS

0 Leave Empire Food's parking lot and proceed north to Gregg St., turn right and proceed to I-80 on ramp at Vista Blvd.

Refer to Figure 1 for trip route.

1.5 I-80 on-ramp: This is the eastern-most part of the Truckee Meadows. The U. S. Corps of Engineers deepened the river channel in this area to lessen flood damage and to lower the watertable. It apparently didn't work as planned as evidenced by the flood of January 1997.

Ahead is the canyon that the Truckee River has cut through the Virginia and the Pah Rah Ranges. The Pah Rah Range is north of the river and the Virginia Range is to the south. In a very general way, this range is a large syncline. At both ends of the canyon, metamorphosed volcanic and sedimentary rocks of the Triassic and/or Jurassic Peavine Sequence are exposed. Progressively younger volcanic rocks are found towards the central portions of the Virginia Range near the freeway. The volcanic rocks range in composition from basalt to rhyolite and their origin varies from intrusive plugs to ash-flow tuffs and extensive lava flows. The age of the volcanic rocks ranges from Oligocene (27 m.y., million years) to Pleistocene (3 m.y.).

The Truckee River existed before warping and faulting uplifted the Virginia Range. As uplifting took place, the river apparently downcut at the same rate, and no deep lake was formed in the Truckee Meadows area where Reno and Sparks are located. The Truckee River has its origin above Lake Tahoe and empties into Pyramid Lake. The river is about 100 miles (160 km) in length.

The Truckee River Canyon has been used since the days of the 49ers as one of the main transportation routes to and from California. The first transcontinental railroad, the Central Pacific (formerly the Southern Pacific and now the Union Pacific Railroad) follows the canyon.

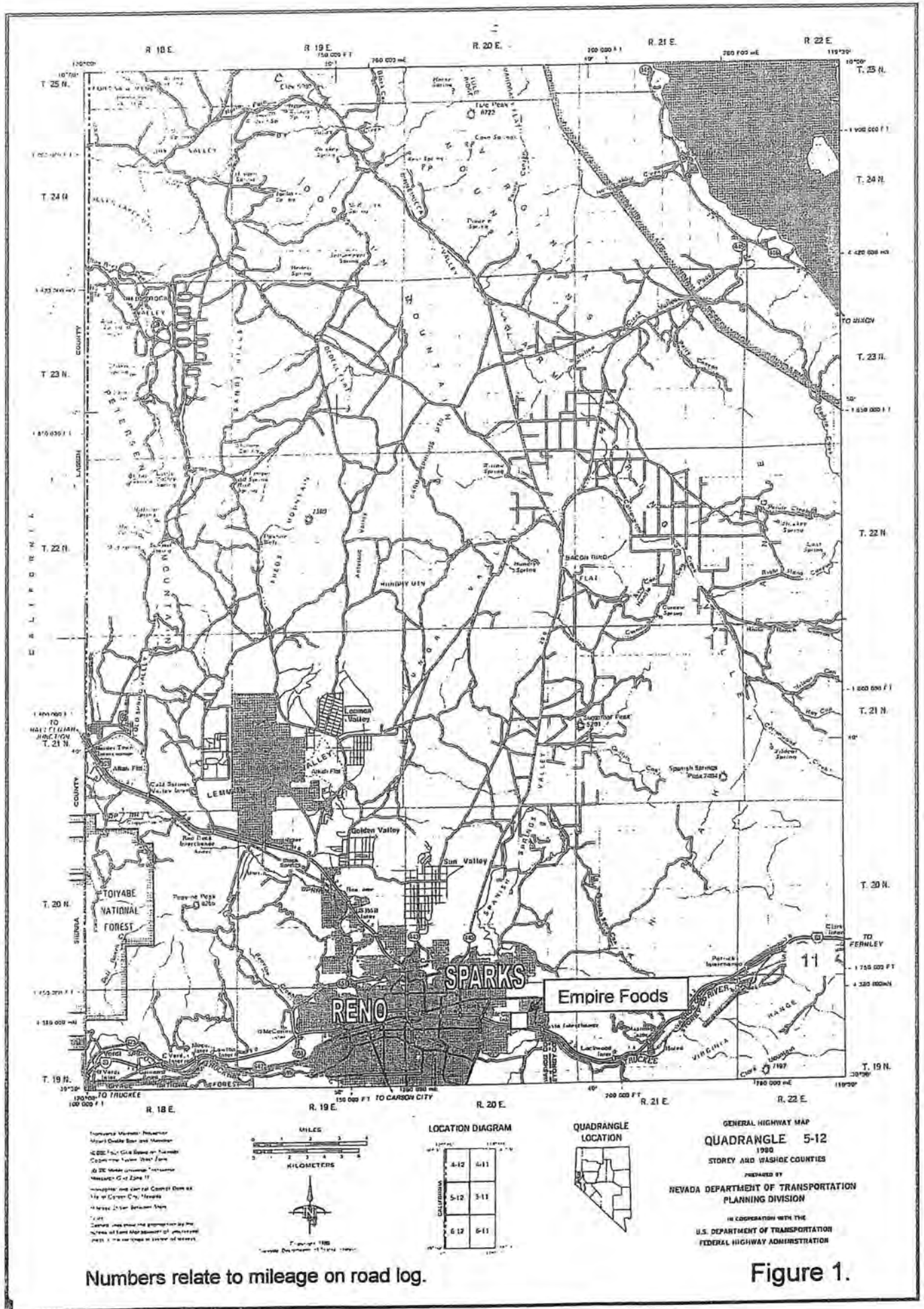
6 Mustang Exit. Progress has come to the area as evidenced by the Chevron Mini Mart recently completed at this location. Pleistocene basalt and andesite flows in this area cover Miocene volcanic and sedimentary rocks.

10.5 On your right across the Truckee River in Storey County is the Tahoe Reno Industrial Park. The large industrial building, nearest the river, is the KalkKan dog and cat food plant.

11 On the south side of the freeway (your right) is Sierra Pacific Power Company's Tracy Power station. The original plant came on-line in 1963 and had an initial capacity of 250 mega watts from conventional gas fired steam turbines. Today, this facility contains eight generating units ranging from 108 to 11 megawatts, totaling 534 megawatts. The larger units are standard natural gas steam turbines and the Pinon Power plant is a coal gasification unit. The smaller, 11-megawatt units are combustion turbines. The large geodesic dome on the west side of the facility is to store coal. The coal gasification plant can operate on natural gas or oil.

12.8 The two high voltage power lines crossing the highway are 345,000 volt each and intertie with the North Valmy coal-fired generating facility near Battle Mountain, Nevada, some 150 miles (245 km) to the northeast. This line is also an intertie with Idaho Power, which is a partner with Sierra Pacific Power in the North Valmy facility.

14.6 On you right is Eagle-Pitcher Industries diatomite plant. The open-pit mine is located about 6 miles (10 km) to the east and will be visible later. Diatomite (diatomaceous earth) is the white, glassy skeletal remains of microscopic organisms that lived in shallow Tertiary age fresh water lakes. When the organism dies the test (shell) falls to the bottom of the lake and under favorable conditions form economic deposits. It is used extensively as an absorbent, filter material, insulation and as an inert filler in many consumer products. The crushing, drying and air-classification sections of the plant produce mostly absorbents and fillers for domestic and foreign consumption.



Numbers relate to mileage on road log.

Figure 1.

Refer to Figure 2 for trip route.

18 Thisbee-Derby Dam. Derby Dam was constructed in 1913 to divert a portion of the Truckee River flow into the Newlands Project, which carries the water to Lahontan Reservoir for storage and subsequent use as irrigation water in the Fallon area. This was the first Bureau of Reclamation project to convert desert into viable agricultural land. It has had its environmental impacts, which we will see later in this trip. In 2002, the dam and overflow structures were completely redone.

19.6 High up at 2:00 are waste dumps at the Celatom mine which supplies the raw diatomite which is processed in the Eagle-Pitcher Plant at Clark station. The white band on the canyon wall to the south is volcanic ash and tuff, not the diatomite bed.

21.6 Painted Rocks. The rocks exposed in the road cuts are Early to Middle Miocene ash-flow tuffs which unconformably overlie Mesozoic rocks. Note the thinly laminated lake sediments partially filling the gullies

25 The remains of a stamp mill can be seen on your left along the base of the low hills. The mill was economically unsuccessful due to inadequate ore reserves in the near-by Olinghouse district and only operated for three months in 1907 and 1908.

25.8 Intersection with I-80 Business-loop, turn left.

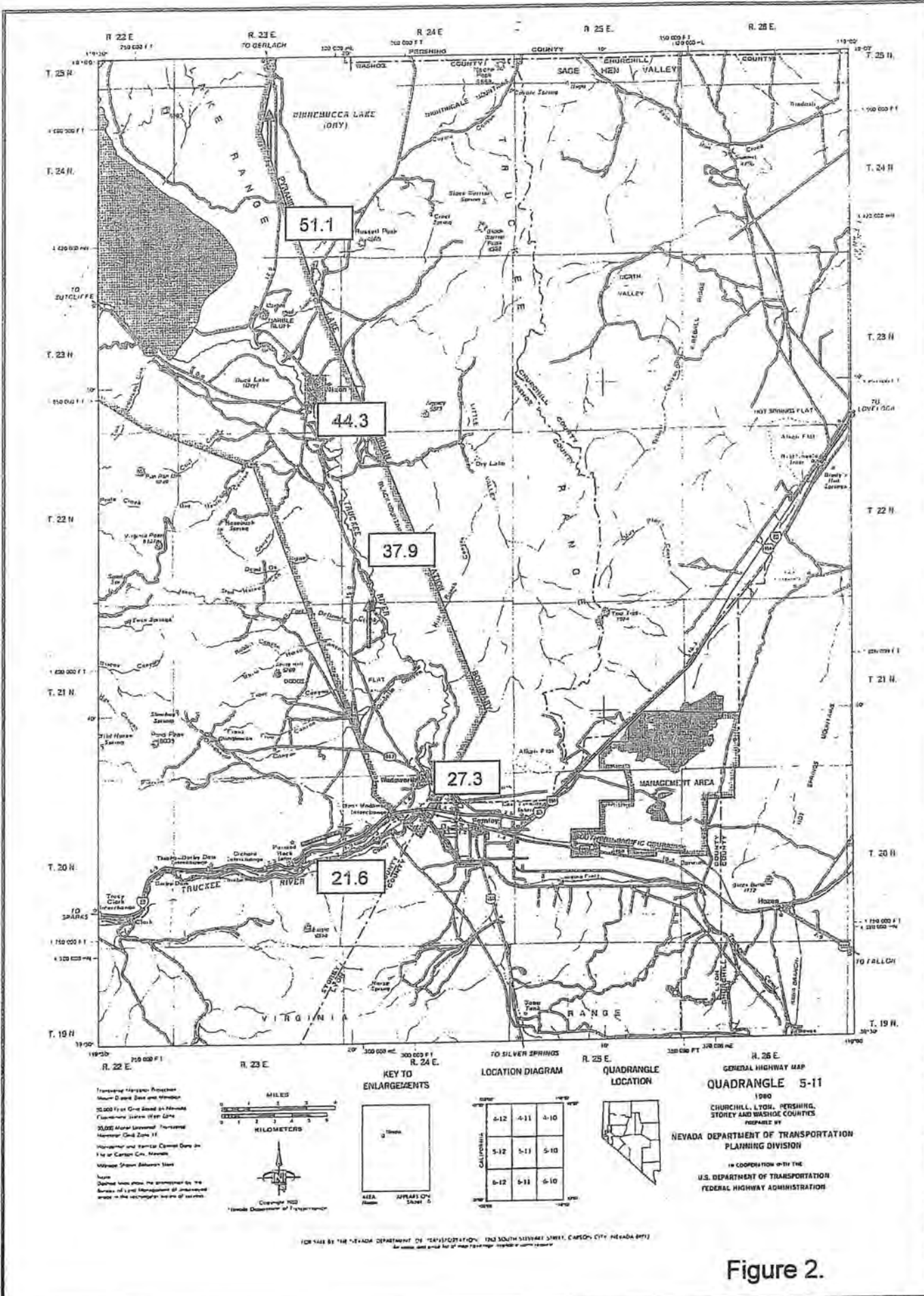
27.3 Intersection with Hwy. 447, turn left.

30.5 A locally famous mining settlement known as Olinghouse is located about 5 miles to the west. The town was based on gold mining that began around the turn of the century. Within ten years, the mine played out. Three-quarters the way up slope is evidence of mining activity by Alta Gold, which ceased development several years ago.

31.7 Dodge Flat, on the left, is a deltaic-lake plain deposited by the sediment-rich waters of the ancestral Truckee River where it entered ancient Lake Lahontan. As shown in Figure 3, ancient Lake Lahontan occupied most of the present-day basins in northwest Nevada. It was contemporaneous with the larger and more familiar Bonneville Lake in Utah, and covered approximately 8,400 square miles during its maximum extent.

37.9 Pyramid Lake Massacre Site. On May 7, 1860, several white settlers were massacred by Indians at a site known as Williams Station, which is presently under the waters of Lahontan Reservoir, east of Silver Springs. Therefore, a band of white volunteers gathered in the Carson City-Virginia City area to launch a punitive military mission against the suspected killers. The "militia" headed toward Pyramid Lake, the home of a large band of Northern Paiutes. Unfortunately for the white army, the Paiutes learned of their approach and decided to engage the militia in battle. The conflict began when the white were ambushed on May 12, 1860 by the cunning savages at a site near here. The bewildered white settlers retreated towards Wadsworth suffering a decisive defeat and losing about 40 men, roughly one-half of the contingent. Broken in numbers, but not in spirit, the obsessed white militia regrouped and returned to the scene of their humiliating loss on June 2, 1860. Stronger and, ostensibly smarter, the militia now included regular army troops from California. They fought a running battle with the Paiutes from this location north to Pyramid Lake. The Indian forces, which consisted of several hundred warriors, fought a delaying action, allowing the women, children, and the elderly to escape, thereby depriving the whites of a clear-cut victory.

38.3 Stone stripes can be seen across the canyon on your right. These features are believed to have formed under periglacial conditions by freeze-thaw segregation of coarse clasts into, long narrow rows that descend down-slope and the fines are washed away. Note that the stripes are truncated by the high shoreline of Lake Lahontan.



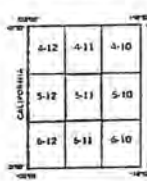
Transverse Magnetic Projection
 Mean Date: Base and Meridian
 50,000 Feet of Contour Interval
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 Vertical Scale: 1:25,000
 Source:
 Derived from photo, the projection by the
 Bureau of Land Management of information
 from the rectangular section of records.



KEY TO ENLARGEMENTS



LOCATION DIAGRAM



QUADRANGLE LOCATION



GENERAL HIGHWAY MAP

QUADRANGLE 5-11

1980

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Figure 2.

Figure 3. Map of northwestern Nevada showing the maximum extent of Lake Lahontan and present day lakes. Field trip route is shown as dashed line.

40.0 Ahead you can see Pyramid Lake. Pyramid Lake is one of two remaining remnants of a huge system of inland lakes known collectively as Lake Lahontan. Most of our journey today will be conducted in the area once occupied by Lake Lahontan, as evidenced by the ancient shorelines visible on the ranges that bound the valleys.

Pyramid Lake itself is 24 miles long, average width is approximately 6.5 miles, and is locally as much as 300 feet deep. As with most desert terminal lakes, Pyramid Lake is brackish (about 4,500 ppm TDS). The chemical composition of the water is sodium-chloride-bicarbonate, not unlike some of the geothermal fluids in the area. The salinity is controlled by the ratio of "fresh water" from the Truckee River input and evaporation, which averages about four feet per year.

The lake level has fluctuated substantially during historic times from natural and manmade causes. It has been estimated that the lake level was at about 3,858 feet when discovered by Fremont in 1844. By the 1860's it reached what appears to be a historic maximum of 3,881 feet. After the completion of the Newlands Irrigation Project in 1915, which diverted about fifty percent of the Truckee River flow to the Fallon area, the level of the lake began a slow decline. The lack of water in the river and lake, and the unrestricted commercial fishing operations during the 1930's and 1940's contributed to the extinction of the native cutthroat trout population. The present fish population was derived from a similar species found in Summit Lake in northern Washoe County. As a result of the diversions, Pyramid Lake reached an historic low level of 3,782 feet in 1967. In 1969, it rose 10 feet because of abnormally high runoff. The lake level has remained fairly constant since the 1970's due to a change in the Truckee River diversion management.

The island is Anaho Island. It is the site of the Anaho Island National Wildlife Refuge. The island supports a wide variety of birds including White Pelicans and Cormorant. The distinctive shoreline about 30 meters above lake level has been dated at 9,600-10,600 BP by two different methods (Benson, 1991 per. comm.).

43.4 Junction with State Route 446. Proceed straight ahead

44.0 Crossing what remains of the Truckee River before it empties into Pyramid Lake. Entering the town of Nixon, named for former Nevada Senator George S. Nixon (1905-1912), who was instrumental in passing legislation, that created the Pyramid Lake Indian Reservation. Nixon is the seat of government for the Pyramid Lake Paiute Tribe. The school and tribal headquarters were built in 1870.

47.3 Turn-off to Marble Bluff Dam. The dam was built in 1977 to facilitate the up-stream spawning migrations of the endangered Cui-ui lake sucker and cutthroat trout. The Truckee River channel below Nixon has undergone dramatic erosion during the past several decades because of the falling baselevel of Pyramid Lake.

47.4 Crossing Mud Lake Slough, the former natural channel for overflow water to Lake Winnemucca.

47.5 Marble Bluff consists of Triassic-Jurassic metamorphosed limestone of the Nightingale Sequence, covered by massive tufa deposits. The Nightingale Sequence comprises several thousand feet of metamorphosed, quartz-rich sandy and argillaceous sediments with subordinate amounts of limestone and dolomite.

Note tufa draping over the outcrop. Tufa is calcium carbonate and has developed several distinctive forms, such as dendritic, thiolitic and lithoid. These formations are predominantly organic in origin, but may be formed by inorganic reactions. The lithoid and dendritic types were formed by algae growing in tufted mats. The various types of tufa have been described in detail by Morrison, 1964. He was able to use tufa formations in the Carson Sink as stratigraphic markers. Cellular and dendritic tufa are by far the most dominant and are especially thick between elevations of 4,115 and 4,355 feet.

49.9 Sand dunes derived from sand produced by the wave action of Pyramid Lake. Many Barchan dunes can be seen on the left. The dunes shift constantly covering the highway. Maintenance to remove the blowing sand from the highway is continual.

51.1 The pass we are going through now separates the Lake Range to the north from the Nightingale Range to the south. We are now entering Winnemucca Lake Valley. This valley was a natural overflow basin for Pyramid Lake. The area received Truckee River inflow when Pyramid Lake attained a level that allowed the river to change course and distribute flow to the east through Mud Lake slough. Historically, Winnemucca Lake was a perennial body of water from sometime before Fremont first visited Pyramid Lake in 1844 to 1939. It received inflow only intermittently after 1911, due to the diversions of Truckee River water through the Truckee Canal, described previously. At its highest historical stage, Winnemucca Lake had a surface area of about 90 square miles and a maximum depth of about 80 feet (Harding, 1965). During its desiccation period, its valuable fishery and waterfowl habitat were lost. This plus the decline of Pyramid Lake appear to have been the only environmental losses caused by the first reclamation project built by the Bureau of Reclamation.

51.6 As we descend into Winnemucca Lake Valley note the massive tufa formations on the right. I predict that before this trip is over you will have grown tired of hearing about tufa mounds, since they are about the only features other than ancient shorelines that exist in the area.

57.6 Ahead we will cross a point bar of ancient Lake Lahontan. Note the shorelines which record the annual recession of the lake.

Refer to figure 4 for field trip route.

58.6 White band on the Lake Range (on left) are lake sediments of Lake Lahontan.

Winnemucca Lake Valley is bounded by the Lake Range on the west and the Nightingale Range on the east. The Lake Range is composed of the Pyramid Sequence, which consists of an extensive sequence of volcanic and sedimentary rocks of Late Miocene age. The sequence is comprised of basalt, basaltic andesite, andesite flows, flow breccias and mudflow breccias. Intercalated with these mafic to intermediate volcanic rocks are sedimentary lenses, generally of diatomite and shale, bedded rhyolitic tuffs and tuff breccias, and dacite welded tuffs.

The Nightingale Range is composed of Tertiary lavas and pyroclastic rocks and younger basalt flows in the southern part. Triassic and Jurassic argillaceous and calcareous sedimentary rocks have been intruded by Cretaceous granodiorite in the north.

65.6 On left are lake gravels cemented with tufa, forming a high bluff.

69.6 Bulbous tufa structures on the right were probably formed by the action of algae similar to stromatolites. They have a radiating vesicular structure internally and a botryoidal surface. These are some of the most unusual tufa deposits that have been recognized in the Lake Lahontan Basin.

71.6 We are now leaving the Pyramid Lake Indian Reservation.

72.6 Graffiti Rock on the left is a tufa structure that has become a canvass for local artists.

73.1 On the left is a reclaimed State highway department gravel pit from which sand and gravel was extracted to resurface the highway 16 years ago.

73.6 The gap in the mountains to the east marks the northern end of the Nightingale Range and the beginning of the Selenite Range. The Selenite Range is composed of metavolcanic rocks of Late Permian age and sedimentary rocks of Triassic and Jurassic age that have been intruded by Cretaceous granodiorite (Johnson, 1977).

74.6 Note springs emerging from the Lake Range on the left. For the next several miles many springs will be evident at about the same elevation.

77.7 Snoopy Rock, another tufa mound that has been painted to resemble the well-known cartoon character.

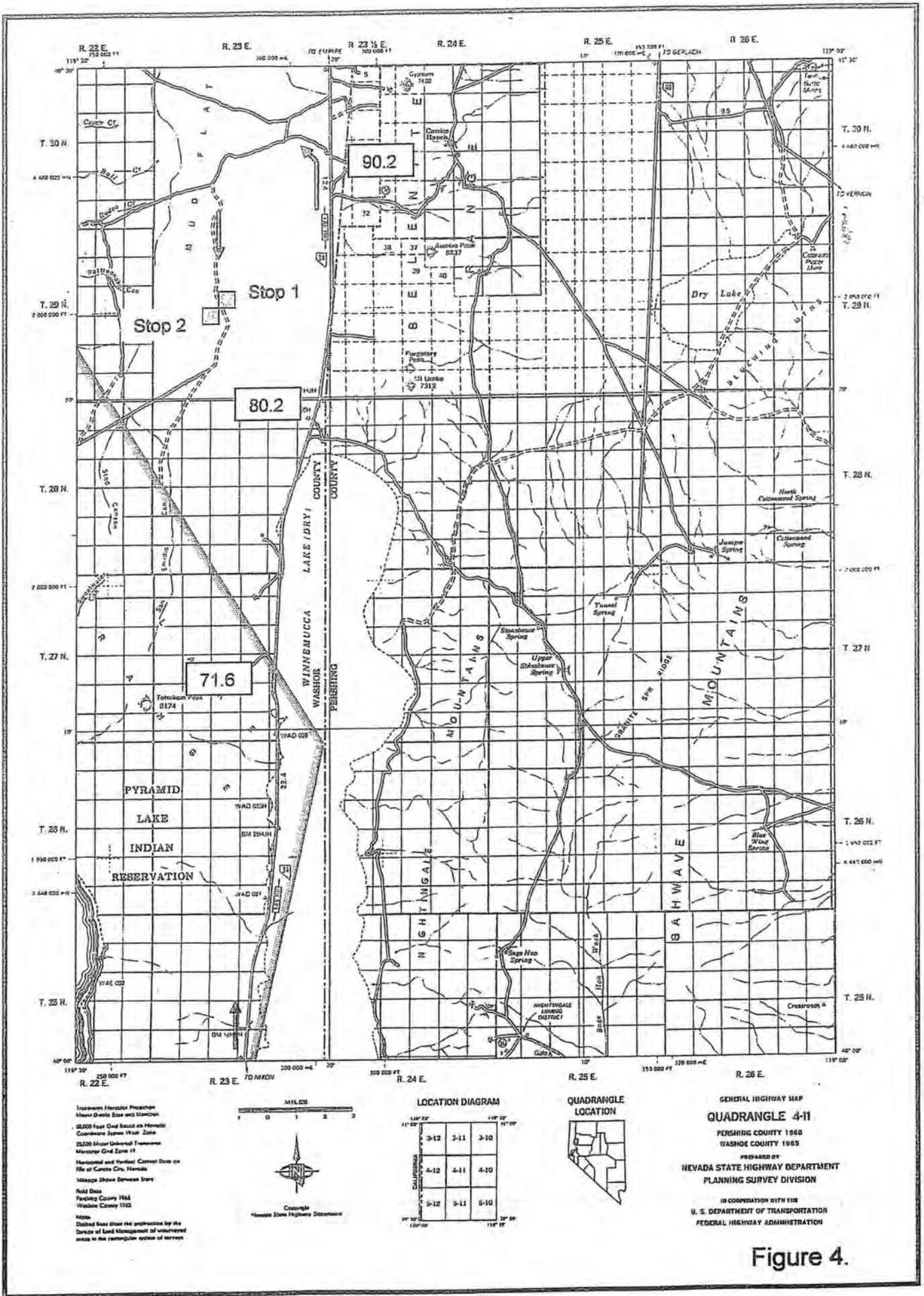


Figure 4.

80.2 Falcon Hill on the left, an archaeological site was excavated in the cave visible at the top of the trail. From a cache, a reed duck decoy and primitive bone, fish hooks were recovered. This provides information on the climatic conditions that prevailed several thousand years ago in this part of Nevada.

80.7 We are now climbing out of Winnemucca Lake Valley. Note the shorelines, which record the recession of Lake Lahontan in this area.

82.2 We are now passing under the Los Angeles Department of water and Power DC transmission line that carries power from the Dalles, Oregon on the Columbia River to Sylmar, California (near Los Angeles). The substation, on the left, is the connection point between the Empire Energy Power Plant and Sierra Pacific Power Company.

87.2 On the right, a change in vegetation type is readily apparent. This was caused by a fire started by lightning about 25 years ago. The area has subsequently been invaded by cheat grass.

90.2 Turn-off to San Emidio Desert currently the home of Empire Farms, Empire Power Plant, and Empire Foods, and possible future home of the Nevada Energy Park.

See Figure 5 for a detailed map of the area being discussed.

91.7 We are now crossing the northern end of the Lake Range. These low hills consist of Tertiary lake sediments correlative with the Truckee Formation of Upper Miocene age (Bonham, 1969). You should be on the look out for pronghorn antelope while in this valley I have personally seen the elusive beasts on several occasions.

92.7 We are now entering the San Emidio Desert and Empire Farms is visible across the valley. The farm was originally developed in 1964 by Mike Matheson. Mike Stewart purchased the property in 1982. The farm irrigates 1,500 acres and mainly grows alfalfa, but sugar beets, seed garlic and forage crops have also been grown.

The San Emidio Desert is an arm of the more extensive Black Rock Desert to the north. It is bounded on the west by the Fox Range and on the east by the Lake Range. The Fox Range is a fault block, tilted to the east and bounded on the west by high angle faults with several thousand feet of dip-slip displacement. It is composed of several thousand feet of dynamo-thermally metamorphosed sedimentary rocks of presumed Triassic and/or Jurassic age, including slate, phyllite, quartzite, marble, quartz-mica-feldspar schist and skam. The metamorphic rocks were intruded by granodiorite of probable Cretaceous age (Bonham, 1969).

The San Emidio Desert is a designated groundwater basin. That is, water rights cannot be obtained, since consumptive use exceeds annual recharge, as determined by the Department of Water Resources. When the geothermal plant and Wind Mountain Mine began operation they had to lease water rights from Mr. Stewart, who in turn had to take irrigated farmland out of production.

95.7 Ahead on left is Wind Mountain Mine. This mine was operated by Amax, Inc. and began operation in 1989. It was one of the lowest grade mining operations in Nevada with an average tenor of 0.027 ounces of gold per ton of rock. The low rounded hill in the mid-foreground is a reclaimed heap-leach.

97.2 On left is one of the two water supply wells for the mine. The well was drilled to 340 ft. and the static water level is 50 ft. A total of three wells were drilled. The southernmost well had the pump stuck and was abandoned. Prior to plugging, I was able to measure the temperature. The temperature at 120 ft. was 220°F (104.5°C). The Total Dissolved Solids in the water is 4,350 ppm, similar in composition to the geothermal fluids being produced at Empire Foods Dehydration Plant.

98.3 Note prospect pits in the Lake Lahontan sediments. Both cinnabar and sulfur occur in the moderately to highly altered sands and gravels of Pleistocene age and are associated with gypsum, opal, chalcedony, quarts, kaolinite, sericite and other alteration minerals.

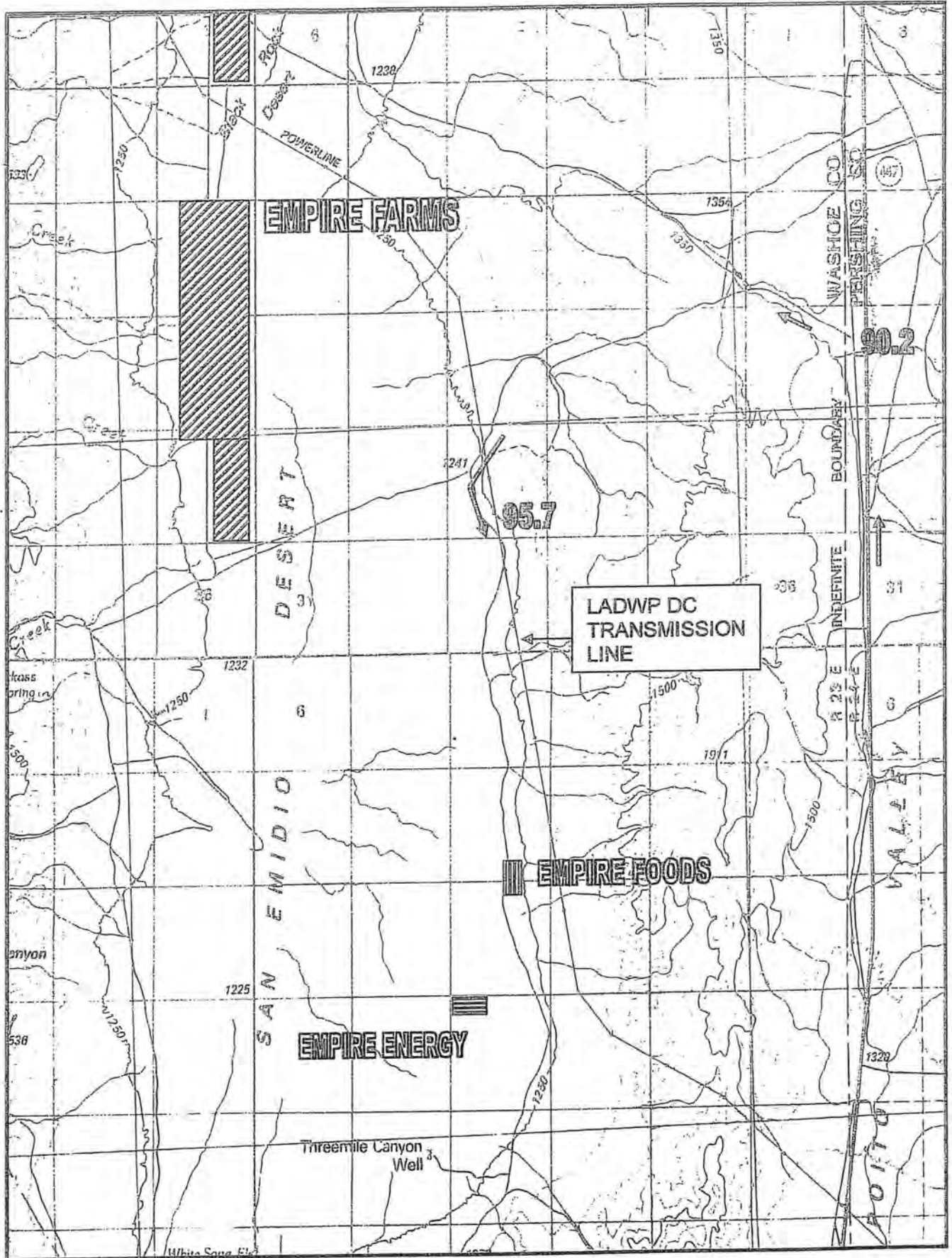


Figure 5.

Chevron Resources Co. began exploration for a geothermal resource in 1973. Geophysical surveys included seismic reflection, seismic/ground noise, resistivity, gravity and temperature gradient surveys.

In 1975, Chevron drilled the Kosmos 1-8 strat test about 3/4 miles to the west, total depth of this hole was 4,012 feet. The maximum recorded temperature was 228°F. The Kosmos 1-9 well was drilled in 1978 to a depth of 5,292 feet and a maximum temperature of 262°F was recorded.

Chevron did not feel that the resource warranted further exploration and the wells were abandoned in 1981. See attached paper by Skip Matlick for a more detailed discussion of exploration activities in the San Emidio Desert.

99.1 Note alteration along the fault to the left. Also note the equipment stored about a mile to the west. This is the drill pad for the Kosmos 1-8 well discussed above. The Kosmos 1-9 well was drilled where the pipe is stored next to the road.

99.3 Entrance to the Kosmos lease. The spray pond on the right cools the geothermal water that has passed through the dehydration plant so it can be released to a constructed wetland.

99.8 Entrance to Empire Foods dehydration plant

99.9 **STOP NO. 1. TOUR DEHYDRATION PLANT.**

Board bus

100.3 Back to the left, east of the geothermal well, is the proposed location of the National Renewable Energy Laboratories, DOE funded, small-scale power plant demonstration site.

101.1 Entrance to Empire Power Plant. This plant was originally designed as a 3.66 MW net geothermal plant. It now produces more than 4 MW to the grid. The original discovery for the production well field was made by Michael B. Stewart in 1986. The geothermal resource is managed by Amor II and the power plant is operated by Empire Energy, LLC.

101.3 **STOP NO. 2. EMPIRE ENERGY GEOTHERMAL POWER PLANT**

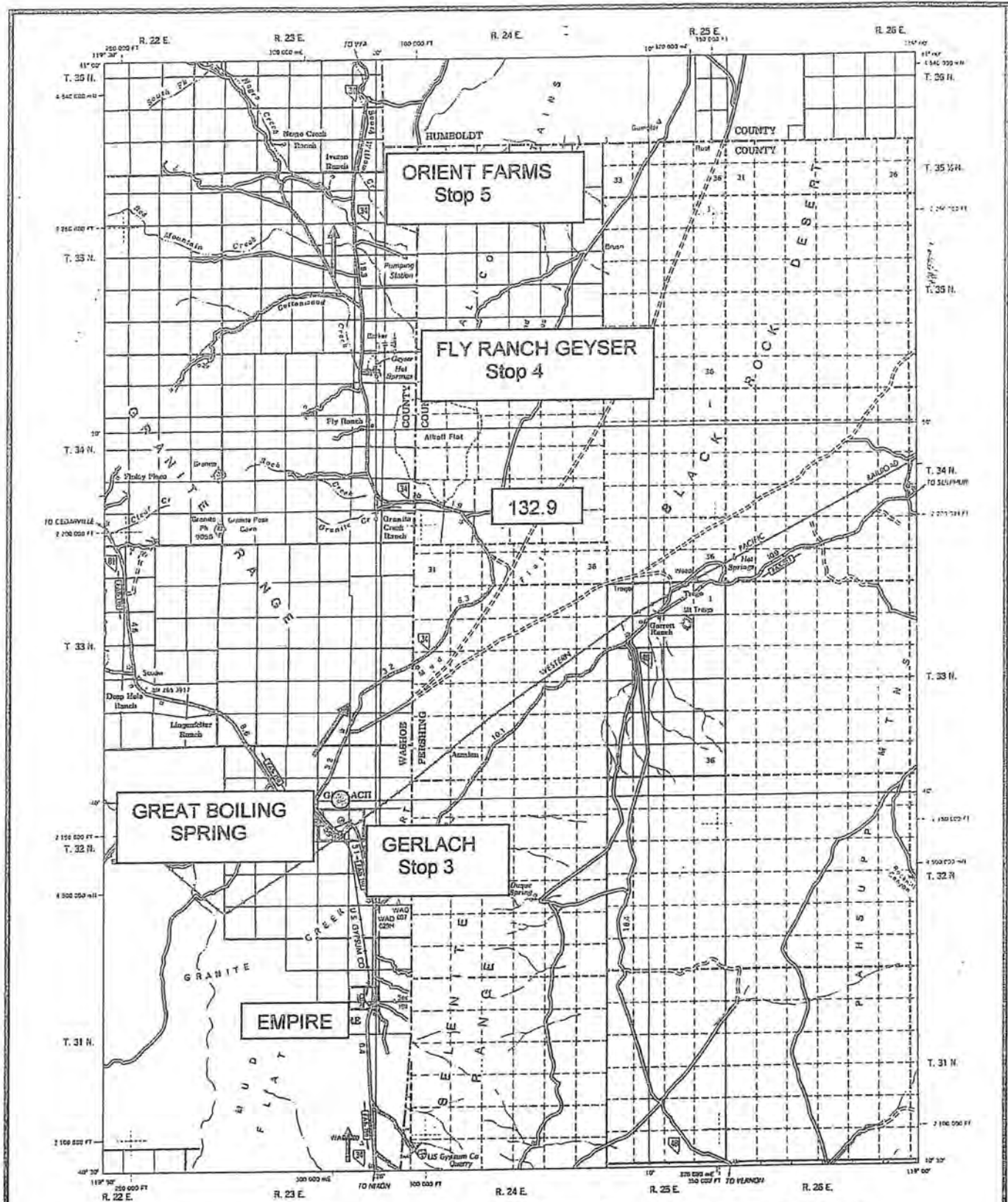
Board bus and return to SR 447

107.3 SR 447 turn left (north). Ahead you can see U. S. Gypsum's mine on the flanks of the Limbo Range. The mine is in Pershing County. The rock gypsum is mined selectively to avoid inclusion of harmful amounts of limestone, anhydrite, or clay. The rock is stockpiled, blended and crushed near the pit and the minus 4-inch material is hauled by truck to the plant at Empire, 6 miles to the north.

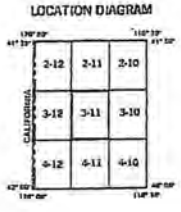
Refer to Figure 6 for trip route.

109.8 On the hills to right you can see the remnants of the cable car system that was originally used to transport the gypsum from the mine to the processing plant.

115.1 Entering Empire, a company town with a population of 350. The principal product from the plant is dry-wall or wallboard. The rock gypsum from the mine is run through a secondary crusher. The crushed material is dried and ground in Raymond mills as raw material for the calcining process. The ground gypsum is heated in 18 ton/day furnaces to a temperature of 1800°F, which produces a dehydrated form of gypsum known as hemihydrate or "plaster of Paris". The product from the kilns is again ground in a ball mill prior to mixing with water and being spread as a slurry between two pieces of heavy paper on a 1/4 mile continuous conveyor belt system. At the end of the conveyor belt the wallboard is cut and stacked for shipment.



1. Increase Horizontal Projection
 2. Horizontal Scale and Meridian
 3. 1929 Four-Corner Based on Nevada
 California Survey 1948 Zone
 4. 1929 Meter Universal Transverse
 Mercator Grid Zone 11
 5. Horizontal and Vertical Control Data on
 File at Carson City, Nevada
 6. Alaska Albers Reference Zone
 7. Road Data
 8. Humboldt County 1952
 9. Pershing County 1952
 10. Washoe County 1953



GENERAL HIGHWAY MAP
QUADRANGLE 3-11
 HUMBOLDT COUNTY 1952
 PERSHING COUNTY 1952
 WASHOE COUNTY 1953
 PREPARED BY
 NEVADA STATE HIGHWAY DEPARTMENT
 PLANNING SURVEY DIVISION

IN COOPERATION WITH THE
 U. S. DEPARTMENT OF TRANSPORTATION
 FEDERAL HIGHWAY ADMINISTRATION

Figure 6.

120.3 On the left is the Smoke Creek Desert, an extension of the much more expansive Black Rock Desert which will be on our right. A land speed record and the sound barrier were broken by the British in October 1997. The lake bed is about 12 miles wide and extends at least 50 miles to the northeast and 30 miles to the east-southeast. It makes quite a race track.

The mountain range to the north is the Granite Range. This range consists of medium- to coarse-grained granodiorite with plagioclase, microcline, quartz, hornblende and biotite. A sample has been dated by K-Ar techniques at 88.8 ± 2.6 million years. The high peak on the skyline is Granite Peak which has an elevation of 9,056 feet. The minimum vertical displacement of faults bounding the range is 4,200 feet (Bonham, 1969).

121.3 Entering Gerlach, population about 300. This town was originally a Western Pacific Railroad town. The residents were able to purchase property from the railroad in the late 70's. Union Pacific Railroad acquired the Western Pacific holdings several years ago. The town motto is "Gerlach, where the pavement ends and the West begins." Gerlach is the home of Bruno's Country Club where we will have lunch.

STOP NO. 3. LUNCH

Board bus and travel northwest to Fly Ranch Geyser.

121.6 New Gerlach Hot Springs has never opened because of a county ordinance requiring filtration of the water since it is a public pool. Silica dissolved in the geothermal water precipitates out of solution clogs the filter system.

122.3 Great Boiling Springs.

The springs were first described by John C. Fremont in 1844. The spring area is on private land and that is the reason it is fenced. There was too much liability involved in allowing the public to swim in the pools. That is the reason for the New Gerlach Hot Springs complex we just passed. The public land surrounding the private land within the Gerlach Known Geothermal Resource Area (KGRA) is leased by Michael B. Stewart and George Vrain.

The Gerlach geothermal anomaly is the result of upward migration of fluids along a range bounding normal fault which trends north-northeast-south-southwest some distance east of the base of the Granite Range.

Occidental Geothermal drilled three shallow temperature gradient holes in the area in 1981. One hole, located near the center of section 10, was drilled to a depth of 860 feet and tubing was set to 760 feet. The well was artesian and flowed between 200-500 gpm of water near 200°F during drilling. Temperature gradient profiles indicate the maximum temperature of 106°F occurs at 460 feet where the artesian flow conditions were encountered. A bottom hole temperature of 176°F was reported at 750 feet.

Sunedco (Sun Energy Development Co.) drilled a deep test well approximately 1 mile south of the hottest surface anomaly. This well had a total depth of 5,871 feet. Temperature profiles indicated a maximum temperature of 200°F was measured between 2,500 and 3,200 feet. Temperatures decrease below 3,200 to a bottom hole temperature of 170°F at 5,870 feet. The decrease in temperature corresponds to lithologic change from unconsolidated sediments above 3,200 and granite below 3,200 feet.

In 1993 and 1994, San Emidio Resources, Inc. (a Mike Stewart company) in partnership with ESI Energy (Florida Power and Light) drilled 3 strat tests in the area of Great Boiling Springs. Details of this exploration program are provided in companion paper by Skip Matich and Bill Ehni, in your packets.

The highest recorded subsurface temperature for the Great Boiling Springs area was 267°F at a depth of 190 feet.

122.7 On the right is San Emidio Resources production well 18-10. A detailed discussion of the well can be found in the paper by Matlick and Ehni. Originally drilled to 2868 feet the well has been plugged back to 727 feet.

123.5 Ditch Spring on left is a Na-Cl type geothermal fluid similar to Great Boiling Springs and has a TDS of 4,150 ppm.

124.3 Access road to Blackrock Desert playa on the right. Note results of recent erosion on the flanks of the Granite Range for the next mile on the left.

129.3 Entrance to the Burning Man site. Burning Man is an alternative artistic and cultural gathering that takes place during the week preceding Labor Day weekend. About 30,000 people were in attendance last year.

129.9 The road swings away from the Granite Range to go around a basalt flow and vent area. Note tufa deposits on the outcrops and well developed lake terraces on the basalts.

130.7 The range on the horizon, across the Block Rock Desert, is the Jackson Mountains. This is one of the few areas on land where you can see the curvature of the earth.

132.1 The gravel pit on the right is in Permian and Triassic metavolcanic rocks and beach gravels derived from these rocks that have been cemented by tufa.

132.9 Turnoff to Soldiers Meadow; note, bed and breakfast 50 miles.

133.0 We are now entering Hualapai Flat.

133.5 Note the alignment of vegetation on the flanks of the Granite Range.

134.9 Granite Creek Ranch on left is owned by Michael B. Stewart. - A geothermal anomaly was accidentally drilled about one mile south of the ranch house in the early 1900's. Unsubstantiated reports indicated that a water well flowed hot water and steam that was visible for many miles. During the 1960's, Western Geothermal, Inc. drilled an 800-foot deep temperature gradient well in the same area. No temperature data are available from this well. In 1972, a 462 foot temperature gradient well was drilled near the abandoned hot water well by Cordero Exploration (a subsidiary of Sunedco). Down hole temperature measurements indicate a temperature of 221°F at a depth of 196 ft (40 m). A temperature reversal occurred below this depth and indicates that hot water is flowing laterally in a permeable zone. It appears, that a shallow low-temperature resource is accessible at this site and could possibly be used for a moderate-scale greenhouse operation. A deeper high temperature geothermal resource is also a possibility. Chemical geothermometers are not available at this site.

136.6 Calico Mountains across the valley to the east extend 23 miles north- south and are about 6 miles wide. The range is underlain by rocks of Tertiary age, except for one small area on Donnelly Peak, elevation 8533-feet, which is the highest point in the range. Here, both granodiorite of Cretaceous and Tertiary age and metamorphosed fine-grained clastic sedimentary rocks presumably of Triassic or Jurassic age are exposed. The only ore deposits known in the range are found in the Donnelly Mining District where small amounts of gold occur in quartz veins cutting the granodiorite and metamorphic rocks (Wilden, 1964).

138.5 Tertiary volcanic rocks on left.

STOP 4 - FLY RANCH GEYSER (WARD'S HOT SPRINGS)

An area covering nearly 75 acres is the largest wetlands produced by a geothermal resource in northwestern Nevada. The wetlands support many wildlife species such as ducks, fish and raptors. The oldest rocks in the area are Permian and Triassic metavolcanic and metasedimentary rocks intruded by granodiorites of the Granite Range. Younger Tertiary units are represented by tuffaceous sands and air-fall tuffs.

North and north-northeast-trending normal faults transect all lithologic units, and Quaternary fault scarps and tectonic fissures are visible in the floor of Hualapai Flat. Sperandio and Grose (1976) suggest that the localization of the hydrothermal activity at this location is related to deep circulation along a north-trending structure (fault). This structure intersects a major northwest-trending fracture system that terminates the north end of the Granite Range west of Hualapai Flat.

The spring deposits consist of both siliceous sinter and travertine (Sinclair, 1962). To the north the spectacular travertine mound is the "thumb". This feature is the result of calcium carbonate deposition from a well that was drilled in 1916. The "thumb" has been steadily growing and has increased in size over the last decade, Figure 7.

The Fly Ranch Geyser is not a natural phenomena, but the fortuitous results of a leaking geothermal well drilled by Western Geothermal in 1964. The red and green color of the tufa is caused by thermophilic algae. In the Basin and Range, two distinct species of thermophilic algae dominate the hot springs: *Synechococcus lividus*, a dark green mat-forming algae that may exist in waters ranging in temperature from 131 to 158°F (55-70°C), and *Ocellularia terribriiformis*, a red-orange colored mat-forming species may co-exist with *Synechococcus* at the low end of its temperature range. Thermophilic algal mats may be found in hot springs any time of the year; their survival is based directly on water temperature and pH. However, their growth may be limited by several external factors including arthropod and insect herbivores, co-existing thermophilic algae, water chemistry, water depth, flow rate, and influence of man (Flynn and others, 1979). If it were not for the thermophilic algae, the Fly Ranch Geyser would be a drab, unexciting gray color, like the "Thumb" formation to the north.

Board bus and return to County Road 34. Turn right and proceed 6 miles north to Orient Farms.

STOP 4. - ORIENT FARMS

Orient Farms consist of 9,000 acres of which about 4,500 can be irrigated annually. Attendant to the farm are 23,000 acre-feet of certificated water rights. The quality of the water is exceptional. The domestic well at the headquarters house has a total dissolved solids concentration of 262 ppm. This is some of the purist well water found in Nevada.

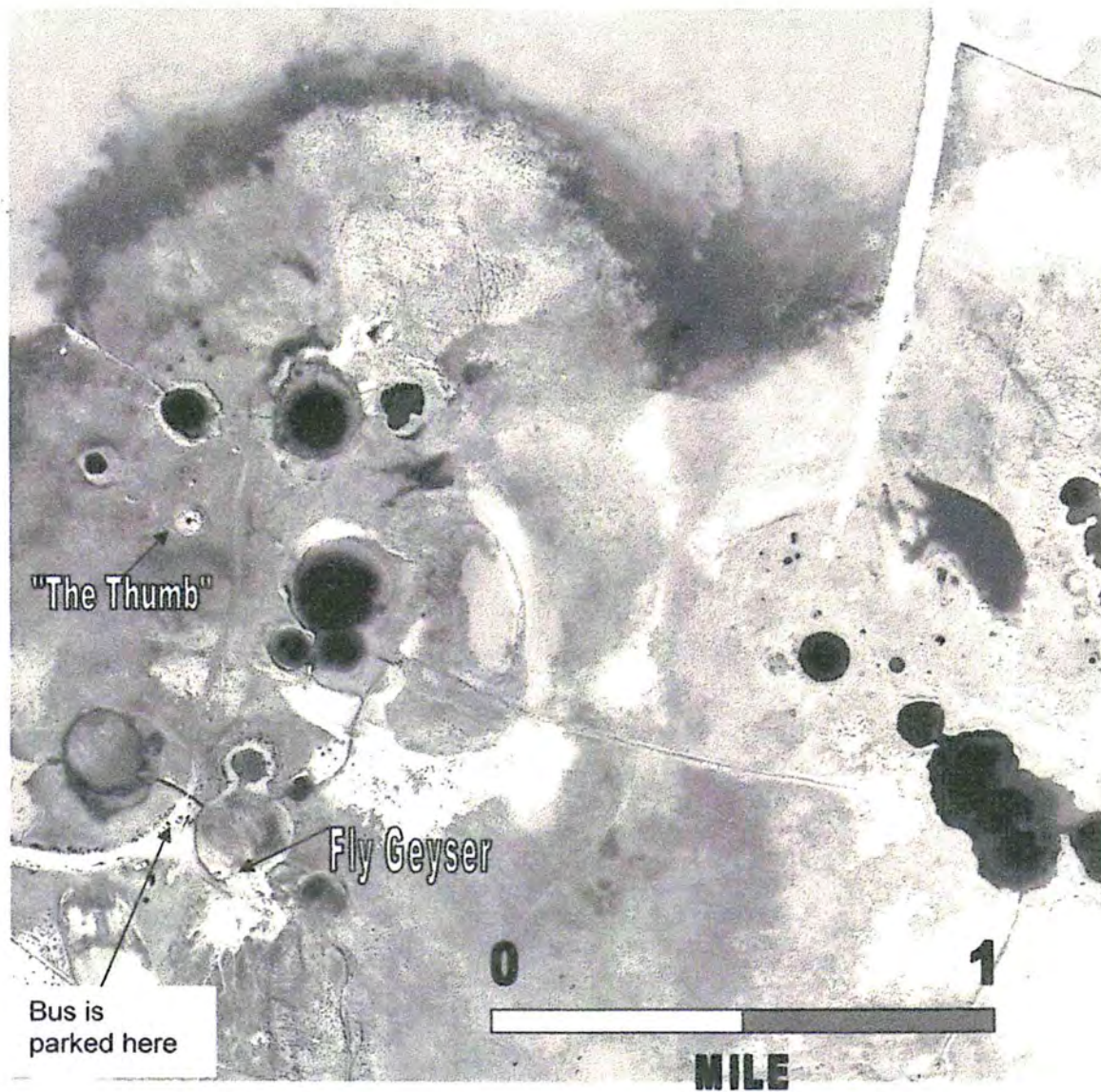


Figure 7.

Aerial photograph of the Fly Ranch Geyser area taken in June 1979. Note numerous explosion craters filled with water. In the past this area was much more active than it is today.

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Field Trip Road Log, Reno to Gerlach

Excerpted from the Guidebook for Field trip 2 (gypsum and clay) for the 39th Forum on the Geology of Industrial Minerals, Sunday May 18, 2003. Field Trip leaders: Keith G. Papke and Larry Garside.

Reno and adjacent Sparks are built in and near Truckee Meadows, a one-time marshy area along the Truckee River. The river and valley were named for an Indian who guided the first emigrant party in 1844. Reno was founded in 1868 when the Central Pacific Railroad (later renamed the Southern Pacific and now owned by the Union Pacific) had been built eastward to this point. It was named for Union General Jesse Lee Reno, killed in the battle at South Mountain, Maryland in September 1862. The population of Reno was 182,818 in 2000. Sparks was founded in 1904 when the railroad division point was moved here. It was named for the then Governor. The 2000 population was 66,420. For the next 25 miles to the Wadsworth exit, the route follows the main emigrant trail, (often termed the Donner trail after the ill-fated party of 1846-47), used by pioneers until the railroad was completed in 1869.

The Sparks Marina is on the left near the edge of Sparks. This was a very deep, sand and gravel pit that supplied aggregate to the area for many years. After it was abandoned in the late 1980s, long-range plans called for it to be converted to a lake and park. While discussions were going on, nature intervened; during the great 1997 New Year's flood, the pit filled with water and thereafter the marina was developed. The upper end of the Truckee River Canyon is ahead. The mountains to the north are the Pah Rah Range and those to the south the Virginia Range. The river cut down through the mountains at about the same rate as they were being uplifted by faulting and folding, so that no deep lake formed in the Truckee Meadows. Mesozoic metavolcanic rocks are exposed along the canyon walls for the next three miles.

Lockwood exit. About 4 miles up the canyon to the south, lightweight aggregate is mined from a pumiceous rhyolite dome dated at about 11 m.y. The rock has a specific gravity of about 2.2 and is used primarily as base and concrete aggregate in the Reno-Sparks area. On the north side of the road, two companies mine bedrock basalt and andesite for aggregate in concrete and other purposes. For the next 10 miles Miocene tuffaceous and diatomaceous sediments and intertonguing dacitic and rhyodacitic flows are the principal rocks exposed. A few bold outcrops near the canyon bottom are basalt that flowed across the valley and probably dammed the Truckee River about 1.5 Ma.

Patrick exit. The ranch to the right was once the home of Patrick A. McCarran, maverick Democratic U.S. Senator from 1933 to 1954. The pit, operated by Granite Construction Co., is the largest sand and gravel producer in the region. A short distance farther along on the north side, beach sand deposited along Lake Lahontan is sold in the Reno area as topsoil and fill. In late Pleistocene time, the valleys of western Nevada were filled by a very irregular, large lake (Lake Lahontan) that had great fluctuations in depth and size as climatic conditions changed in the mountains. At its maximum the lake covered about 8500 square miles and had a depth of about 900 feet at what is now Pyramid Lake. The highest shoreline was at an elevation of 4380 feet. The last high-water period was about 13,000 years ago. Inflow into the lake was from four major rivers -- the Humboldt from northern Nevada and the Truckee, Carson, and Walker from the Sierra Nevada. The last three rivers contributed most of the water, and the fluctuations of the lake level roughly correlate with glacial activity in the Sierras. The lake was named by Clarence King of the USGS during his 1870's Exploration of the Fortieth Parallel to honor Baron de Lahontan, a French army

officer and traveler. Shorelines cut into soft rock units and the flat-lying sediments deposited in the lake will be visible at many places for the rest of the trip. The tufa and the *Chara* calcium carbonate that we will see later were products of the lake.

Several miles farther, the Tracy power plant of the Sierra Pacific Power Co. is on the right. This plant with a maximum capacity of 246 megawatts is fueled by natural gas with oil standby. Several miles beyond it, the Clark plant of Eagle-Picher Minerals, Inc. is on the right. The diatomite is mined in open pits about 6 miles to the southeast. The material is used as absorbents (cat litter and floor dry) and as various fillers. Eagle-Picher has produced diatomite in this plant since 1945. The fresh-water diatoms consist mostly of *Melosira granulata*, a cylindrical-shaped diatom. The diatomite apparently is about 9.8 million years old.

From here to where we leave Interstate 80, the outcrops are mostly basaltic to rhyodacitic flows and interbedded tuffaceous to diatomaceous sediments of Miocene age. Several miles farther along Derby Dam lies to the right, but it is not visible. This dam diverts water from the Truckee River southeastward to Lahontan Dam on the Carson River. The U.S. Government began the dam and diversion canal in 1903 as part of the Newlands Project, the first Western reclamation project. This system provides irrigation water to the Fallon area about 35 miles east of here. Farther to the east, high on the right canyon wall, dumps of the Eagle-Picher operation are visible. The white outcrops below are a volcanic tuff of different age than the diatomite.

Wadsworth exit. Turn off on State Route 427. Nevada's only cement plant is located several miles east of the turnoff, the Nevada Cement Co. plant of Centex Corp. The plant was built in 1964 and expanded in 1974 to its present capacity of over 500,000 tons. It uses dry processing with two rotary kilns fired by coal from Utah. It supplies much of Nevada and some of east central California. The limestone quarry, 7 miles south of the plant, is in impure lacustrine limestone of Tertiary age. We will visit the Nevada Cement clay mine later today.

In downtown Wadsworth, we turn left onto State Route 447 and into the Pyramid Lake Indian reservation. Wadsworth was once a thriving town until the Southern Pacific moved its operations to Sparks. Just east of Wadsworth the Truckee River makes a sharp northward bend. For the next 15 miles, the route is on Lahontan sediments between the Pah Rah Range on the left and the Truckee River and Black Mountain on the right.

A few miles to the north, the road to the east leads to the Numana Fish Hatchery along the river, where cutthroat trout and cui-ui are raised for release in Pyramid Lake. Shortly thereafter a historical marker commemorates the Pyramid Lake Indian War, fought in this area in May and June of 1860 between Paiutes and white volunteers from Virginia City area (site of the huge silver district, the Comstock Lode) and later by volunteers and regular U.S. Army troops. The sign reads:

THE TWO BATTLES of PYRAMID LAKE

On May 12, 1860, Northern Paiute warriors fighting to retain their way of life, decisively defeated a volunteer army from Virginia City and nearby settlements. The battle and consequent white retreat began with a skillful ambush north of Nixon and continued along the plateau on the opposite side of the Truckee River almost to the present site of Wadsworth.

On June 2, 1860, a strong force of volunteers and regular U. S. Army troops engaged the Indians in battle along the tableland and mountainside. Several hundred braves, attempting

delaying action to allow their women, children & elders to escape, fought with such courage and strategy that the superior Caucasian forces were held back during the day until the Indians withdrew.

Paiute war leader Numaga (Young Winnemucca), described as a superior man of any race, desired only peace for his people.

Farther north the highway parallels and eventually crosses the abandoned railroad grade of the Fernley and Lassen Railway, which connected Fernley (30 miles east of Sparks) to towns in northern California. It was constructed in 1912-14 by the Southern Pacific Railroad, mainly to serve the timber industry. The rails and ties were pulled up in 1971.

At the intersection, State Route 446 goes west for a few miles and then branches to highways going back to Sparks and to the west side of Pyramid Lake. The unusual building to the northwest is the Pyramid Lake Tribal Center. A short distance farther we cross the Truckee River, the major source of water for Pyramid Lake. This river is about 100 miles long, starting at Lake Tahoe in the Sierra Nevada. This is a good example of the interior drainage of the Great Basin portion of the Basin and Range Province.

Nixon. This is the headquarters of the Pyramid Lake Indian Reservation, established in 1874, for the Northern Paiute Indian tribe. The tribal ancestral territory includes much of western Nevada and eastern Oregon. The reservation includes all of Pyramid Lake. When John C. Fremont came down through this country in January of 1844, he found that the local Indians had a reasonably healthy economy based partly on fish. Marble Bluff, several miles north of Nixon, consists of gray marble and dolomite of Mesozoic age. Most of the lower slopes below 4300 feet elevation are covered by tufa that was deposited in Lake Lahontan. Marble Bluff was slated to be the source of limestone for the Fernley cement plant, but discovery of a limestone closer to the plant site and difficulty in leasing from the Indian tribe ended that idea.

Northward from here for some distance, the Lake Range lies to the left, hiding any view of Pyramid Lake. A few miles farther north, Winnemucca Dry Lake comes into view on the right. The dry lake, about 25 miles long and up to 4 miles wide, was once the overflow area of Pyramid Lake. Until 1939 it was a perennial lake with a maximum depth of 80 feet. The lowering of Pyramid Lake and the downcutting of the Truckee River in its delta now prevents any overflow. The spires near the south end are tufa (calcium carbonate) that was precipitated in Lake Lahontan. Some of the rock outcrops in the region that was once Lake Lahontan are covered by tufa.

High water temperature is attributed to the numerous hot springs in the region, but thermal heating in shallow waters probably also was a factor. The tufa was deposited on bedrock, other rocks, vegetation, and bones. The tufas—both towers and coatings—developed under water and often formations can be correlated with various periods of lake stability. The tufas, especially the towers, are complex, commonly containing several types and generations of material. The origin of the thinolite has always been a problem because its shape suggests that it is a pseudomorph. A likely candidate is ikaite ($\text{CaCO}_3 \cdot 6\text{H}_2\text{O}$) which was first identified in the 1960's in a fjord in Greenland where it is associated with tall, subsurface tufa towers. The metastable mineral forms in cold water—a seeming contradiction to the idea that calcium was commonly supplied by thermal springs. Obviously, the last word is not yet in on the origin of tufa.

After traveling some distance to the north, the road to the left leads to the San Emidio Desert and the Empire Farms, a large area irrigated by pumped groundwater. Empire Farms has an onion and garlic dehydrating plant using geothermal steam, with the vegetables coming from all of California and to a certain extent from Nevada. This also is the site of a 4-megawatt geothermal power plant. The Selenite Range forms the high ground to the right of the road.

At the town of Empire, the U. S. Gypsum Co. plant is visible ahead. We turn off to the right, go from Washoe County into Pershing County, and stop at the gypsum mine. U. S. Gypsum has developed a series of pits, collectively called the Selenite Quarry, on a large body of gypsum. The crushed gypsum is hauled 6 miles to the mill. The property was operated from 1922 to 1948 by Pacific Portland Cement Co. and since then by U. S. Gypsum.

Leaving Empire we drive the few miles into Gerlach, crossing an arm of the Black Rock Desert on the way. The main part of the Desert to the northeast has been used for attempts to set world records for racing cars. However, it is best known for the Burning Man Festival held every September. Here perhaps 25,000 people gather and camp for a week in a five-mile square area of BLM-controlled land for what is billed as an "annual celebration of art and self expression in the Nevada desert". Clothes are optional. The psychedelic festival combines camping with a mixture of art and music and is culminated by the burning of a 40-foot high wooden structure. Gerlach's other principal activity is servicing the railroad, originally the Western Pacific built in the first decade of the twentieth century and now owned by the Union Pacific. Bruno runs the largest cafe and bar as well as the motel, and is well known for *Bruno's Famous Ravioli*.

Gerlach hot spring is a short distance northwest of town. According to unpublished USGS data, 3,000 tons of borate were shipped from the hot spring's apron in 1890. This was reported to be ulexite, a hydrous sodium and calcium borate. The lack of any present apron and the low borate content of the water makes this unlikely.

Geologic Descriptions of the San Emidio, Gerlach, Granite Ranch, and Fly Geyser Geothermal Areas – Larry J. Garside, June 2003

San Emidio Desert (Mud Flat, Empire Farms)

An altered zone up to 30.5 m wide and 3 km long is present in Sec. 9 and 16, T29N, R23E along the east side of the San Emidio Desert. Cinnabar, sulfur, gypsum, siliceous sinter, opal, chalcedony, quartz, kaolinite and other alteration minerals occur in sands and gravels of Pleistocene age along the north-south zone. These altered deposits are covered by younger, unaltered alluvial and lacustrine deposits (Bonham, 1969). The alteration and mineralization represent the deposits of hot springs which were probably more active in the past. Both a vegetable dehydration plant (Lund, 1995) and a binary power plant are operational at the Empire (Farms) geothermal area. Following exploration drilling in the early 1980s, the binary power plant produces 4.6 MW of electricity from a 155°C resource; the plant came on-line in 1987. The Empire Energy binary plant shares the geothermal resource with the onion and garlic dehydration plant to the north. The dehydration plant produces about 27 million pounds (~12 million kg) of dried onions and garlic per year. Wells at the dehydration plant produce fluids of 130-152°C (Trexler and others, 1995). The U.S. Department of Energy has provided funds (\$1.6 million over 4 years) to help construct a small-scale geothermal power plant (1 MW net) adjacent to the dehydration facility (<http://www.eren.doe.gov/geothermal>).

Geothermal potential in the San Emidio Desert was little known until the late 1960s, when hot water was encountered in shallow drill holes exploring for sulfur in alluvial material along the east side of the Desert (valley) over 1 km west of the bedrock forming the Lake Range. H.F. Bonham noted mercury for the first time in about 1966 (NBMG mining district files), and described a ≈4.4 km long zone, presumably the surface expression of a fault, having hydrothermal alteration in addition to mercury and sulfur (Bonham, 1969, p. 95-96). Water in shallow drill holes was found to be 53°C at 1 m below the ground surface (Garside and Schilling, 1979), but no surface springs were identified at that time. However, a spring was present in an area to the west of the altered zone, in S½ SSE¼ SW¼ Sec. 9, T29N, R23E (Mariner and others, 1976; Dennis Trexler, written commun., 2003). This spring was used by Empire Farms in the 1970s and photographed from the air by Tom Flynn in 1979; however, it is not shown on topographic maps of the area or described in any geothermal or water resource reports.

Also, a drill hole encountered boiling water at 29.5 m in 1955 in this same general area (Fig. 1), according to T.A. Alberg (written communication, 1975). Chevron Oil Co. drilled a 1,223 m geothermal test to the west of this area (Sec. 8, T29N, R23E) in 1975. No information is available on the temperatures encountered; however, data on gradient wells are available in Sass and others, 1999. Peterson and Dansereau (1975) have reported principal facts for gravity stations in the San Emidio Known Geothermal Resource Area.

The San Emidio Desert is an east-tilted half graben, with major fault displacement on a fault near the east side of the valley. Wells (≈ 500-m deep) for the power plant and dehydration facility produce from Miocene volcanoclastic rocks which overlie Mesozoic metasiltstone and quartzite (Figs. 2, 3). The productive area is at the intersection of NNW- and NNE-striking faults about 1.5 km west of the mountain-front fault (Trexler, 2002).

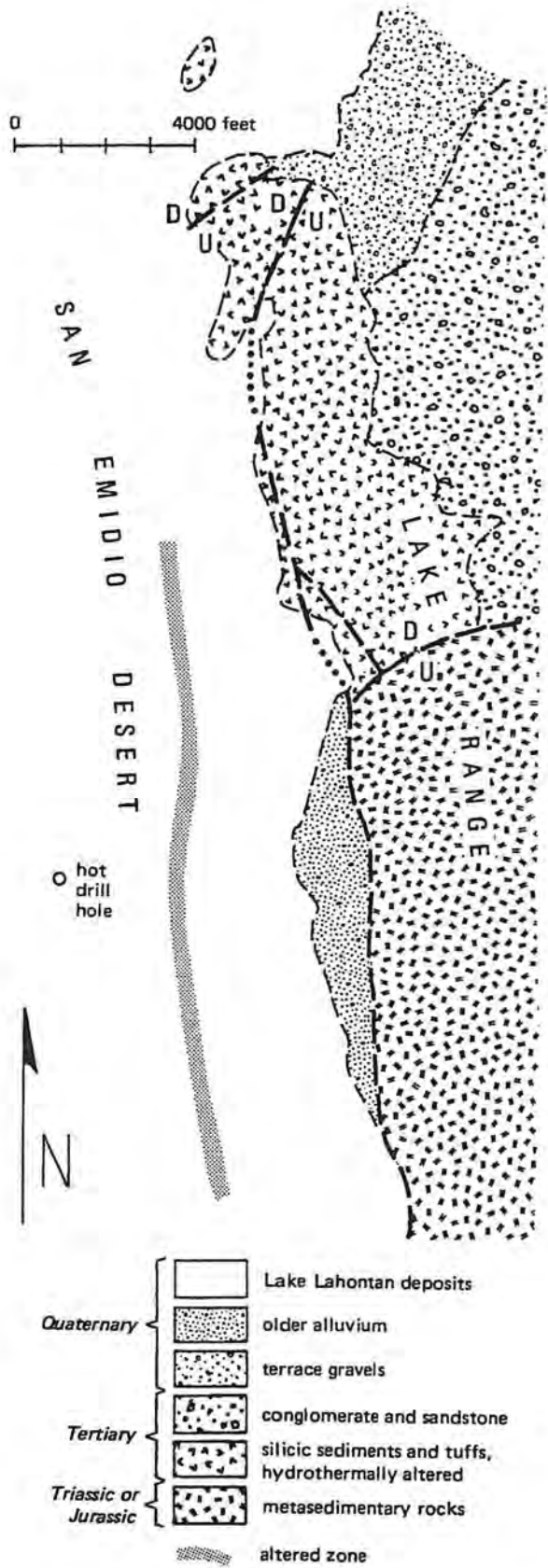
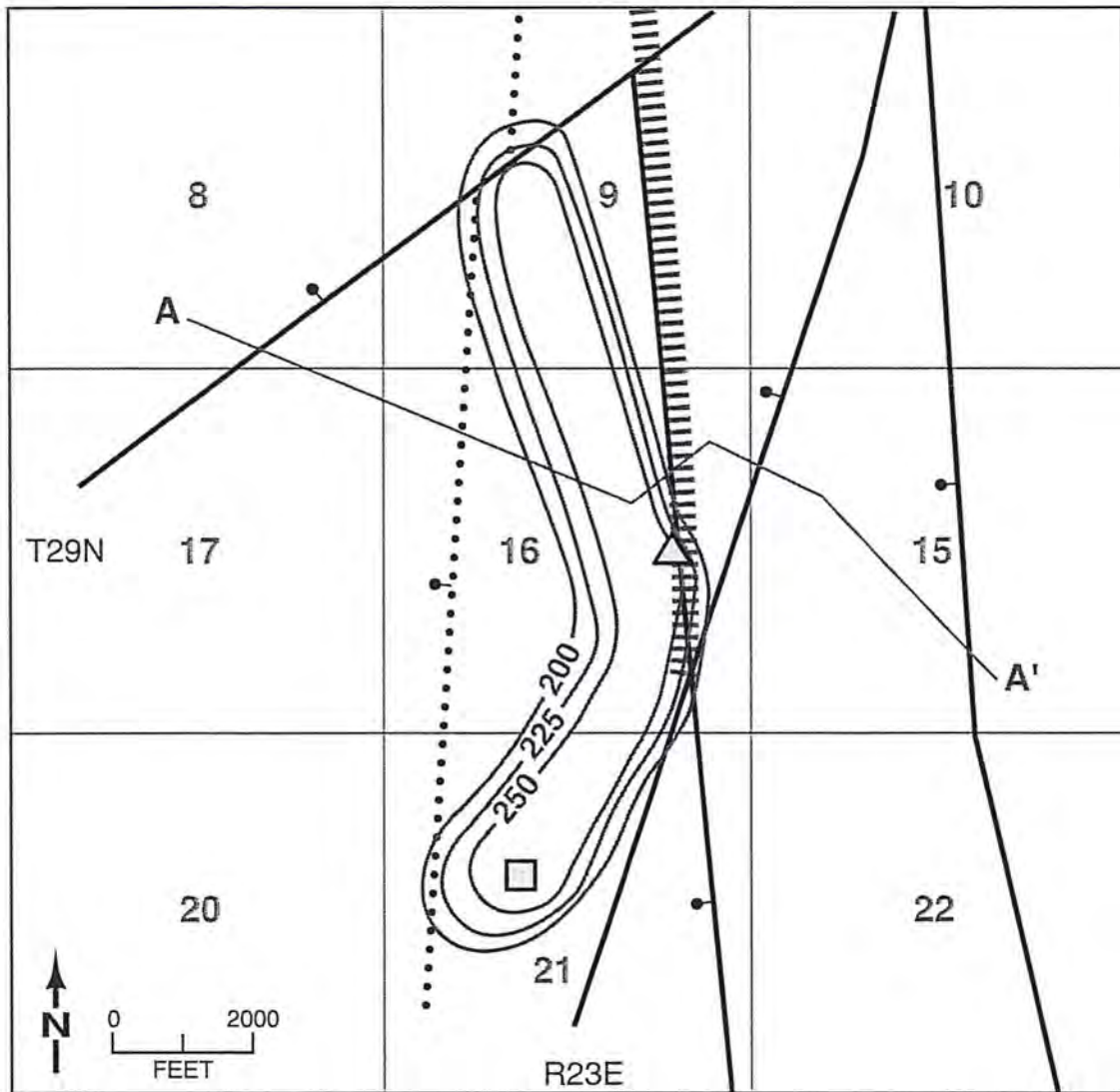


FIGURE 53. Geologic sketch map of the San Emidio cinnabar prospect, Washoe County (after Bonham, 1969).

FIGURE 1. Geologic sketch map of the San Emidio cinnabar prospect, Washoe County.



- Power plant △ Dehydration plant
- ···· Fault, dotted where concealed, ball on downthrown side
- 250— Temperature (°F) at 3850 feet elevation (subsurface), projected to surface
- ||||| Hydrothermally altered zone of Bonham (1969)
- Approximate line of cross section

Figure 2. Map of the San Emidio geothermal area. From Trexler (2002).

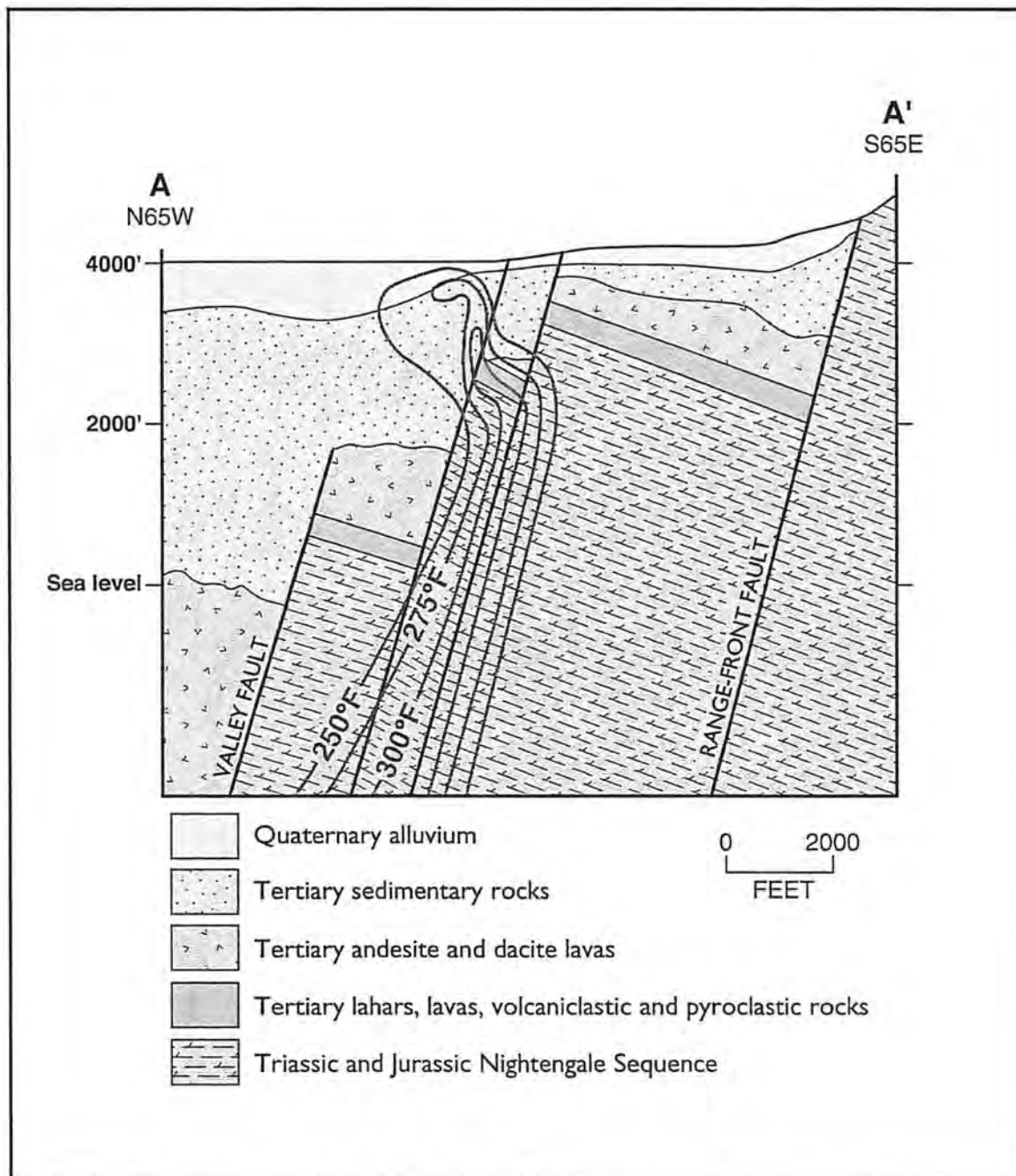


Figure 3. Cross section of the San Emidio geothermal area. From Trexler (2002).

Gerlach area

The Gerlach thermal area is at the south end of the Granite Range in the southern Black Rock Desert (Fig. 4). It includes two major groups of springs, Great Boiling Springs in Sec. 10, 15, T32N, R23E about 1.3 km northwest of Gerlach and Mud Springs in Sec. 16, T32N, R23E about 1.8 km west of Gerlach.

The springs were first described by Fremont (1845) who reported them as "The most extraordinary locality of hot springs we had met during the journey." He mentioned that one large, circular pool was entirely occupied by boiling water, which boiled up at irregular

intervals with great noise. Presumably this was at the Great Boiling Springs area. Fremont measured temperatures up to 97.7°C.

It has been reported that a borax works operated for a short time at Gerlach Hot Springs, but Papke (1976) believes that this information is probably not true. There is not a large amount of boron in the spring water, and no borates can be found at the site.

Great Boiling Springs were used extensively for bathing for many years (Fig. 5). Some pools are too hot for swimming; a 19-year old woman was scalded to death in one of these in 1973, an indication of the danger inherent in geothermal areas. The Gerlach General Improvement District built a bath house using geothermal fluids in 1989. The facility was planned for use by tourists and local residents. The facility has been unable to obtain a permit from the health department because of plugging of water filters by sediment from the well. No bathing facilities are available at the present (2002). Geothermal ground water apparently extends under at least part of the town, as at least two Gerlach homes use geothermal wells for space heating. The water in one well is reported to be 35-36°C (unpubl. data, Nevada Division of Minerals). Mud Springs (Fig. 6) have mainly been used for stock watering and irrigation.

The hot springs issue from unconsolidated lacustrine and alluvial deposits, and hydrothermally altered granodiorite crops out nearby (Fig. 4). Both the unconsolidated deposits and the granodiorite are hydrothermally altered along a fault west of Great Boiling Springs and in places are difficult to distinguish from each other. To the west of the thermal areas, the southern end of the Granite Range consists of relatively uniform medium-crystalline granodiorite which contains several scattered, somewhat elongate inclusions of diorite or gabbro. The thermal water has probably been in contact with granodiorite and related plutonic rocks of the Granite Range throughout most of its path from probable recharge areas high in the range to where it rises into the unconsolidated deposits beneath the springs (Olmsted and others, 1975).

The hot-spring clusters are associated with northeast-striking Basin and Range faults along the east side of the Granite Range (Fig. 4). Fault scarps that are inches to several feet high appear to control the location of the spring clusters. The west side is usually the upthrown side on these faults (Grose and Keller, 1975b), and some offset deposits are as young as Holocene. Some faults in lacustrine and alluvial fan deposits near the hot springs may represent rupture of incompetent materials in response to movement along a single fault zone in the underlying granodiorite (Olmsted and others, 1975). An upfaulted block of altered granodiorite between the Great Boiling Springs and the Granite Range is believed to represent an exposed part of an ancestral Gerlach Hot Spring system. Several geophysical studies (Grose and Keller, 1974a, 1975b; Long and Senterfit, 1977; Christopherson and others, 1977) also provide data that may be useful in structural and geologic interpretations. Sperandio and Grose (1976) suggest that the Gerlach thermal area may be along a deep-seated, north-south fault zone which extends from Winnemucca Lake to High Rock Lake (see section on Wards Hot Springs).

The spring deposits of the Gerlach thermal springs are predominantly siliceous sinter, and the concentration of dissolved solids in the waters is high in comparison with most other hot-spring waters in northern and central Nevada (Mariner and others, 1974). Some spring deposits are reported to be anomalously radioactive (60 to 65 MR/hr), according to Wollenberg (1974). Also, the Great Boiling Spring area is well known for its mud volcanoes and other mud vent activity (Russell, 1885, p. 52; White, 1955). The mud volcanoes have been reported to erupt clots of mud to heights of at least 30.5 m. They are characterized by sporadic and apparently unpredictable intervals of activity separated by very much longer intervals of quiescence (White, 1955b).

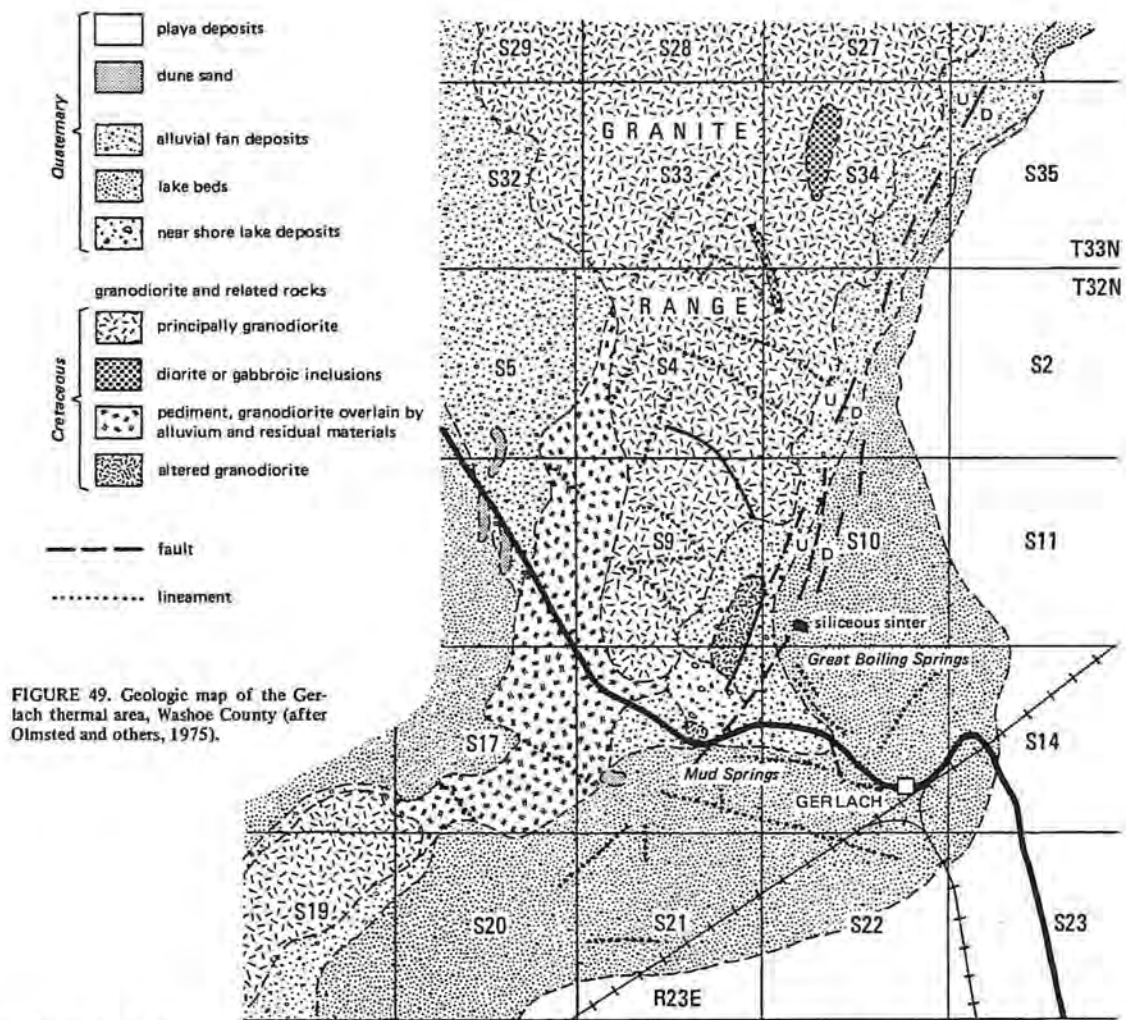
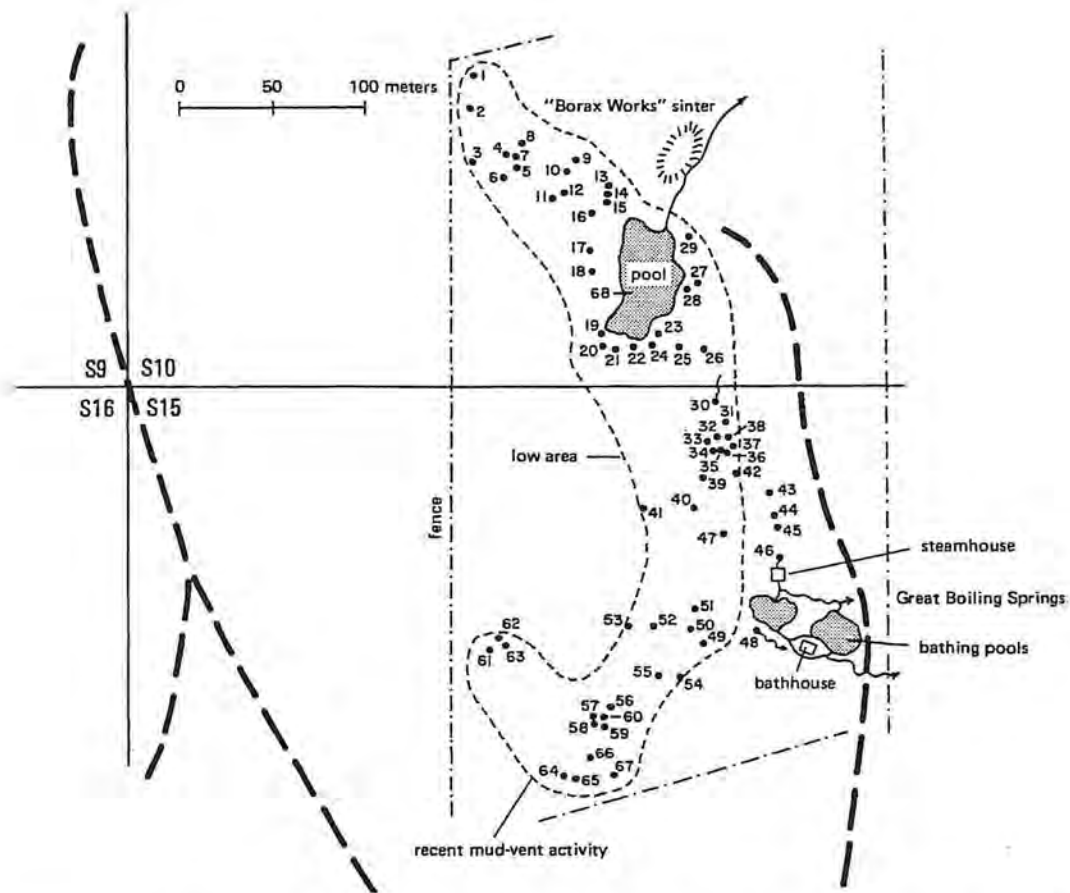


FIGURE 49. Geologic map of the Gerlach thermal area, Washoe County (after Olmsted and others, 1975).

FIGURE 4. Geologic map of the Gerlach thermal area, Washoe County (after Olmsted and others, 1975).

The temperatures measured in springs and pools range up to a maximum of 97.7°C (Grose and Keller, 1975b) and shallow subsurface measurements are over 120°C (Fig. 7). In addition to shallow temperature-gradient holes drilled by the U. S. Geological Survey in 1973, Cordero (later Sunoco Energy Development Co.) drilled several gradient holes to depths of 91.4 to 183 m in 1972. Mariner and others (1974) have estimated the reservoir temperature at 167°C using the silica-quartz geothermometer and 175°C using the sodium-potassium geothermometer.



Orifice number	Temperature (°C)	Orifice number	Temperature (°C)	Orifice number	Temperature (°C)	Orifice number	Temperature (°C)
1	60.6	18	50.6	35	27.2	52	44.4
2	40.0	19	96.1 (boiling)	36	50.6	53	34.4
3	49.4	20	48.3	37	48.9	54	70.0
4	42.2	21	59.4	38	64.4	55	77.8
5	50.0	22	40.6	39	52.2	56	58.9
6	33.3	23	48.3	40	35.6	57	86.7
7	36.7	24	33.3	41	58.9	58	47.8
8	43.3	25	48.3	42	28.9	59	43.3
9	72.2	26	61.7	43	43.3	60	55.6
10	50.5	27	33.3	44	56.7	61	66.1
11	31.7	28	42.8	45	59.4	62	73.3
12	33.9	29	47.8	46	86.7	63	67.8
13	70.0	30	63.3	47	51.1	64	57.7
14	36.7	31	74.4	48	92.2	65	57.7
15	35.6	32	29.4	49	51.1	66	61.1
16	36.7	33	48.9	50	61.1	67	32.2
17	57.8	34	53.3	51	60.0	68	58.3

FIGURE 50. Sketch map of Great Boiling Springs, S10 and S15, T32N, R23E (after Olmsted and others, 1975).

FIGURE 5. Sketch map of Great Boiling Springs, Sec. 10 and S15, T32N, R23E (after Olmsted and others, 1975).

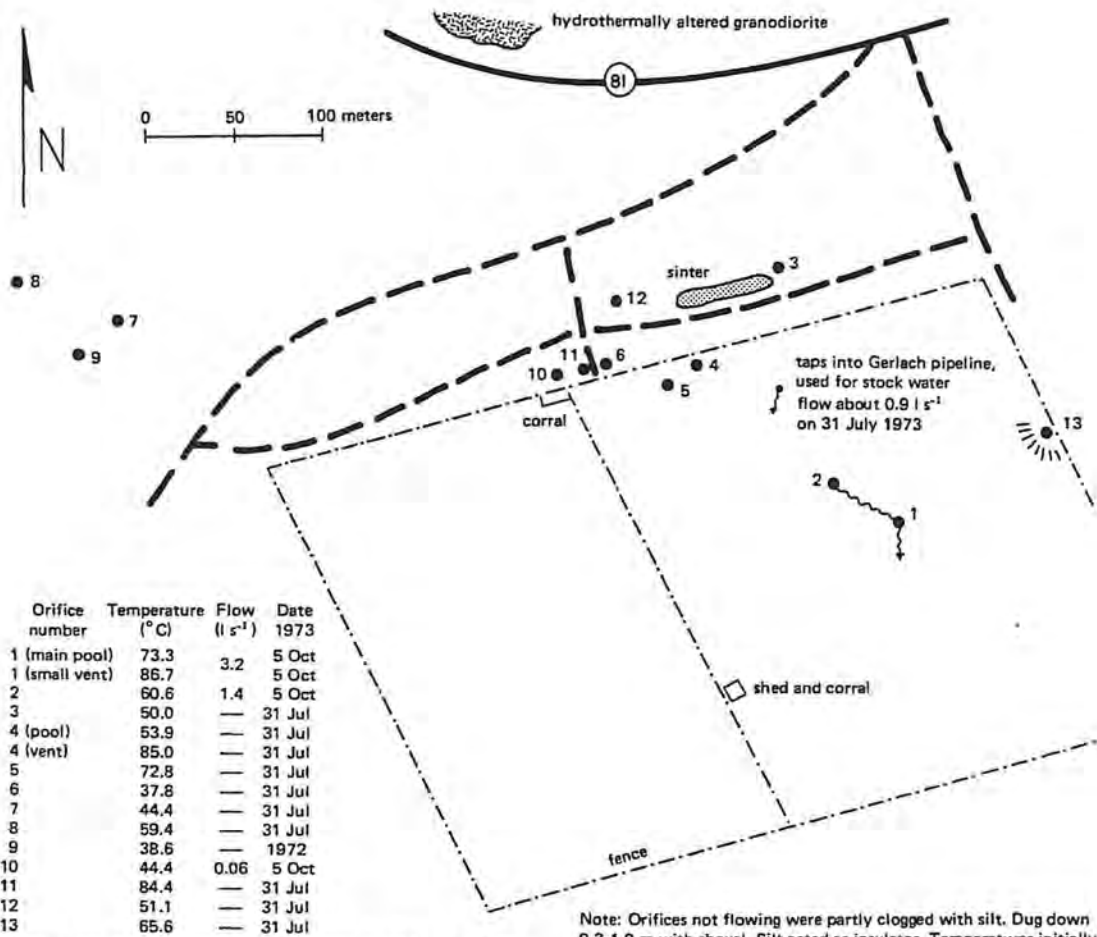


FIGURE 51. Sketch map of Mud Springs in S16,T32N,R23E, Washoe County (after Olmsted and others, 1975).

Note: Orifices not flowing were partly clogged with silt. Dug down 0.3-1.0 m with shovel. Silt acted as insulator. Temperatures initially measured at orifices 3 (75.5°C), 7 (48.3°C), and 8 (67.2°C) were significantly hotter than temperatures measured after digging.

FIGURE 6. Sketch map of Mud Springs in Sec. 16, T32N, R23E, Washoe County (after Olmsted and others, 1975).

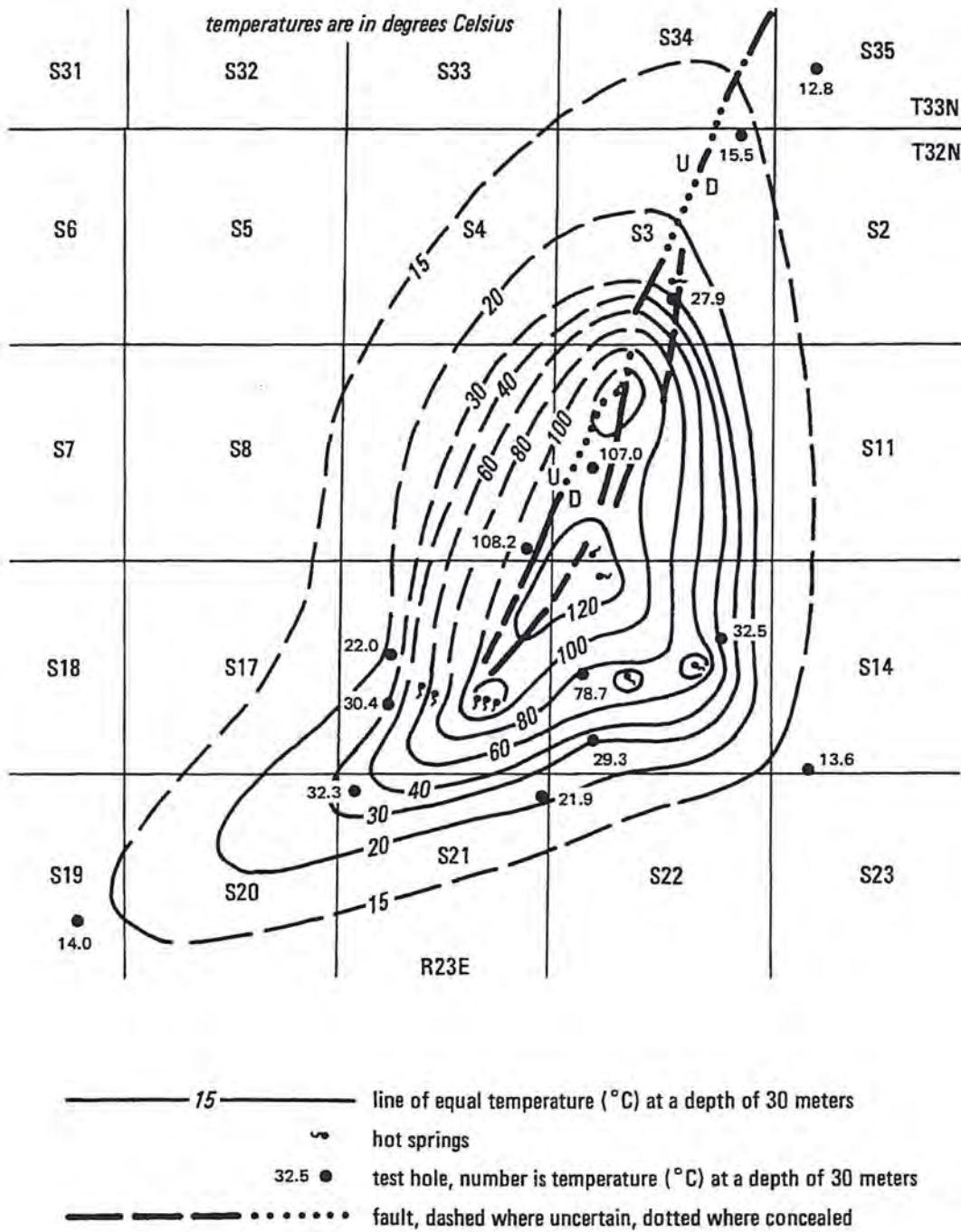


FIGURE 52. Map of the Gerlach thermal area, Washoe County, showing temperature at a depth of 30 meters, October, 1973 (from Olmsted and others, 1975).

FIGURE 7. Map of the Gerlach thermal area, Washoe County, showing temperature at a depth of 30 m, October, 1973 (from Olmsted and others, 1975).

Granite Ranch

A thermal area of unknown extent is present near the south end of Hualapai Flat about 1.5 km south of Granite Ranch in Sec. 35, T34N, R23E and Sec. 2, T33N, R23E. A presently

abandoned water well in the area first hit hot water, and in 1965(?) Western Geothermal, Inc. drilled a 244 m geothermal test in the area. Additionally, thermal water was encountered in temperature test holes drilled by Cordero (later Sunoco Energy Development Co.) and the U. S. Geological Survey. The temperature profile in the Cordero test hole indicates a reversal in thermal gradient below a depth of 46 m , which suggests a lateral flow of thermal water through an aquifer at that depth. The thermal water presumably moves into the aquifer from much greater depth along a concealed conduit, probably a fault (Olmsted and others, 1975, p. 128).

Wards (Fly Ranch, Hualapai Flat) Hot Springs [258]

Wards or Fly Ranch Hot Springs are located in Hualapai Flat about 24 km north of Gerlach (mainly in Sec. 1, 2, T35N, R23E). The springs are the largest in northwestern Nevada, discharging into 30 to 40 pools over an area of 75 acres. The surface flow is used for irrigation (Sinclair, 1962). A number of warm-water wells are also present in the area (Harrill, 1969).

The oldest rocks in the Hualapai Flat area are Permian and Triassic metavolcanic and metasedimentary rocks (Fig. 48) that have been tentatively correlated by Bonham (1969) with the Happy Creek volcanic series in Humboldt County. Cretaceous granodiorite intrudes the sequence to the south in the Granite Range. In the vicinity of Hualapai Flat, the Tertiary is represented by a sedimentary unit of tuffaceous sands and air-fall tuffs; this is overlain by a finely crystalline, black basalt. Elsewhere in the vicinity andesitic to rhyolitic flows and tuffs also underlie the basalt. Grose and Keller (1975b) also describe a number of different Quaternary units.



Figure 8. Travertine deposit developed over "Geyser Well," a water well drilled in 1916 near Wards Hot Springs. Photo ca. 1978.

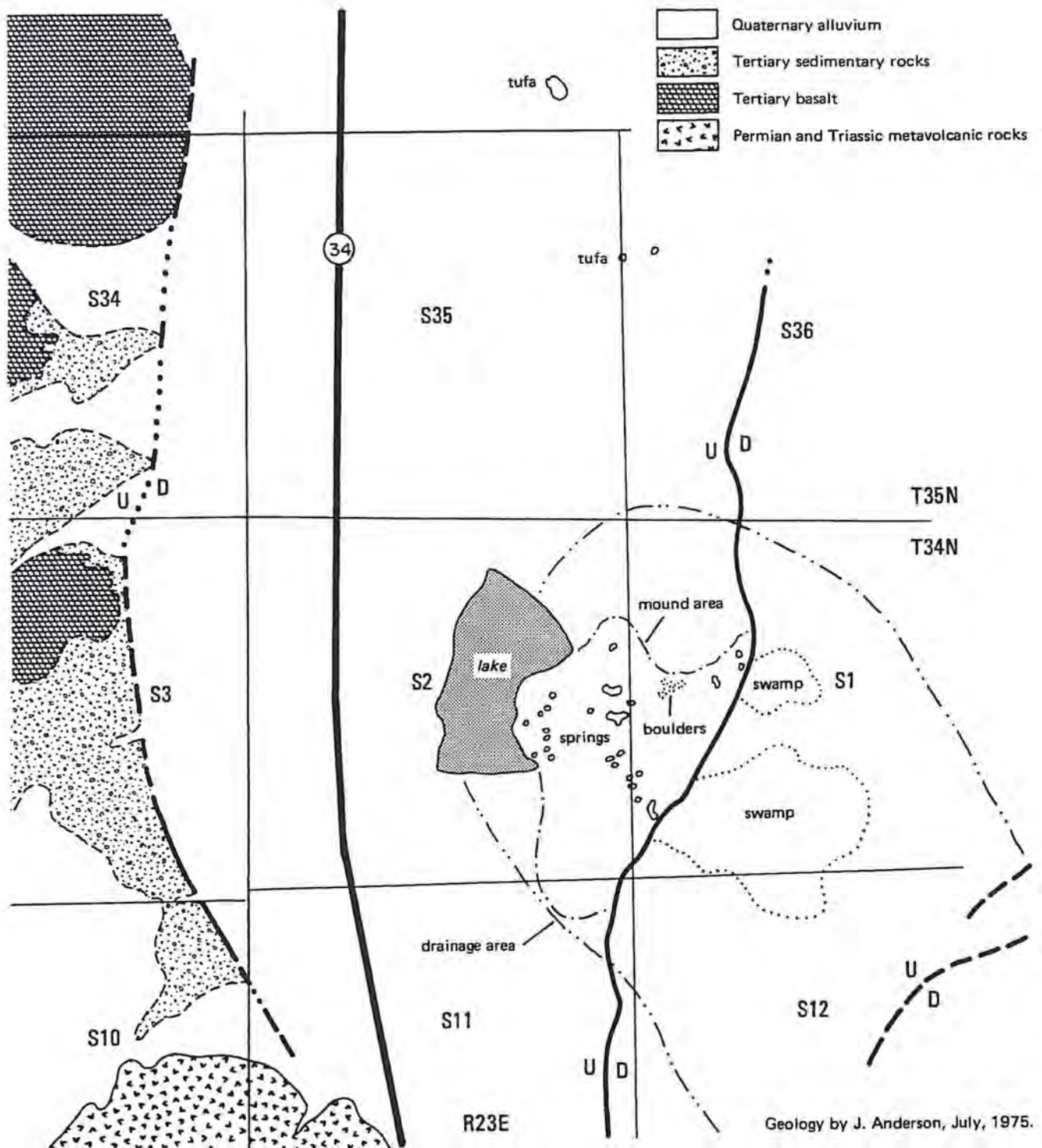


FIGURE 48. Geologic map of the Fly Ranch thermal area, T34 and 35N, R23E, Washoe County (after Grose and Keller, 1975b).

FIGURE 8. Geologic map of the Fly Ranch thermal area, T34 and 35N, R23E, Washoe County (after Grose and Keller, 1975b).

North and north-northeast-trending normal faults cut all of the lithologic units, and Late Quaternary fault scarps and tectonic cracks transect the floor of Hualapai Flat, which is a small structural-topographic basin (Sperandio and Grose, 1976). Many of the normal faults occur along the western side of Hualapai Flat and have their eastern sides downthrown.

Displacements appear to be dip slip, amounting to tens to hundreds of feet on any one fault, but totaling several thousand feet between the Tertiary volcanic rocks and Cretaceous granodiorite along the southwest margin of Hualapai Flat (Grose and Keller, 1975b).

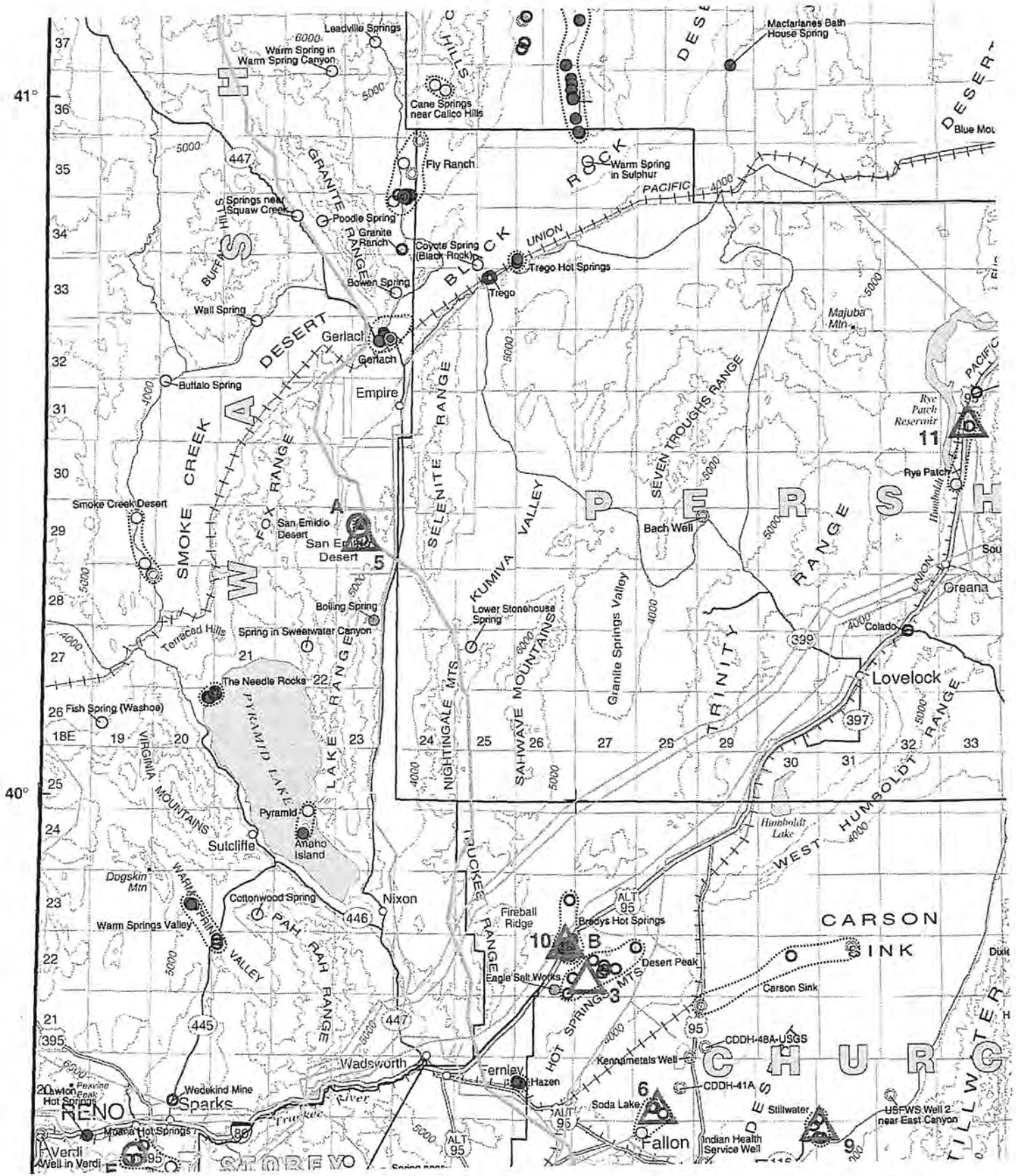
The faults at Hualapai Flat are believed to be part of a regional and probably deep-seated fault zone that may extend 64 to 72 km from Winnemucca Lake north along the west side of the Selenite Range, through Gerlach Hot Springs, along the east side of the Granite Range, along the west side of Hualapai Flat, and northward to High Rock Lake. Sperandio and Grose (1976) suggest that the localization of the thermal anomaly at Wards Hot Springs is probably due to deep hydrocirculation along deep-seated fractures where the north-south fault zone intersects a major northwest-trending fracture system that terminates the north end of the Granite Range west of Hualapai Flat. Quaternary alluvial units in Hualapai Flat record rifting, normal faulting, and subsidence in Late Quaternary (Grose and Keller, 1975a). These features indicate extension of the area, generally along a northwest-southeast axis. The development of the thermal system at Wards Hot Springs is favored by this extensional tectonic regime, and the major spring area is located on the upthrown side of a 4.4 km long fault scarp that has a maximum relief of 10 m.

Spring deposits at Wards Hot Springs consist of both siliceous sinter and calcareous travertine (Sinclair, 1962b). A shallow well (the "Geyser Well") was drilled in the hot spring area in 1916 and has been discharging steam and boiling water since that time. The water is highly mineralized and precipitation of the chemical constituents at the surface has created a tower of travertine 5 m high (ca. 1978). Water temperatures in wells and springs of the hot springs area and vicinity range from near normal to over 104.4°C, and Mariner and others (1974) report a 125°C estimated minimum thermal reservoir temperature using the silica geothermometer. In 1979 a 1589 m large-diameter geothermal well (the Sunoco Energy Development Co. Holland Livestock Ranch No. 1-2-FR in NE¼ NE¼ Sec. 2, T34N, R23E) was drilled near the spring area.

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Map of northwestern Nevada geothermal areas. From Shevenell and Garside, 2003 (NBMG Map 141)



**Dehydrated
Onion & Garlic**



empire foods

Garlic



Garlic Powder

Weight	300 lb. Drum, 60 lb. Box, 50 lb. Bag	
Particle Size	Screen	Maximum %
	US #45	2% Max. on
	US #80	25% Max. on
	US #100	50% Max. on
Hot Water Insolubles	Premium < 12.5% Standard < 20%	



Garlic Granulated

Weight	300 lb. Drum, 60 lb. Box, 50 lb. Bag	
Particle Size	Screen	Maximum %
	US #30	Trace on
	US #35	5% Max. on
	US #100	6% Max. thru
Bulk Index Range	120 - 140	



Garlic Ground

Weight	300 lb. Drum, 60 lb. Box, 50 lb. Bag	
Particle Size	Screen	Maximum %
	US #16	Trace on
	US #20	20% Max. on
	US #50	3% Max. thru
	US #80	1% Max. thru
Bulk Index Range	120 - 145	



Garlic Minced

Weight	300 lb. Drum, 60 lb. Box, 50 lb. Bag	
Particle Size	Screen	Maximum %
	US #6	Trace on
	US #8	2% Max. on
	US #20	3% Max. thru
	US #35	1% Max. thru
Bulk Index Range	120 - 140	

Onion



Onion Powder

Weight	250 lb. Drum, 50 lb. Box, 60 lb. Bag	
Particle Size	Screen	Maximum %
	US #45	2% Max. on
	US #80	25% Max. on
	US #100	50% Max. on
Hot Water Insolubles	Premium	< 20%
	Standard	< 30%



Onion Granulated

Weight	250 lb. Drum, 50 lb. Box, 60 lb. Bag	
Particle Size	Screen	Maximum %
	US #30	Trace on
	US #35	5% Max. on
	US #100	6% Max. thru
Bulk Index Range	140 - 170	



Onion Ground

Weight	250 lb. Drum, 50 lb. Box, 60 lb. Bag	
Particle Size	Screen	Maximum %
	US #16	Trace on
	US #20	20% Max. on
	US #50	3% Max. thru
	US #80	1% Max. thru
Bulk Index Range	150 - 175	



Onion Minced

Weight	200 lb. Drum, 40 lb. Box, 50 lb. Bag	
Particle Size	Screen	Maximum %
	US #4	Trace on
	US #6	2% Max. on
	US #20	3% Max. thru
	US #35	1% Max. thru
Bulk Index Range	180 - 210	



Onion Small Chopped

Weight	175 lb. Drum, 30 lb. Box, 40 lb. Bag
Particle Size	Screen Maximum %
	Tyler #3 Trace on
	US #4 2% Max. on
	US #8 70% Max. thru
	US #12 10% Max. thru
Bulk Index Range	205 - 245



Onion Chopped

Weight	150 lb. Drum, 30 lb. Box, 40 lb. Bag
Particle Size	Screen Maximum %
	Tyler #3 Trace on
	US #4 2% Max. on
	US #8 60% Max. thru
	US #12 10% Max. thru
Bulk Index Range	215 - 300



Onion Large Chopped

Weight	125 lb. Drum, 30 lb. Box, 30 lb. Bag
Particle Size	Screen Maximum %
	Tyler #.371 Trace on
	Tyler #3 5% Max. on
	US #8 30% Max. thru
	US #12 10% Max. thru
Bulk Index Range	300 Minimum

Options

Products are available in the following microbiological categories:

Regular

Standard Plate Count - ≤1,000,000/g maximum
 Yeast - ≤1,000/g maximum
 Mold - ≤1,000/g maximum
 Coliforms - ≤1,000/g maximum
 E. coli - Negative
 Salmonella - Negative

Lo Bac

Standard Plate Count - ≤300,000/g maximum
 Yeast - ≤500/g maximum
 Mold - ≤500/g maximum
 Coliforms - ≤500/g maximum
 E. coli - Negative
 Salmonella - Negative

Extra Lo Bac

Standard Plate Count - ≤100,000/g maximum
 Yeast - ≤100/g maximum
 Mold - ≤100/g maximum
 Coliforms - ≤100/g maximum
 E. coli - Negative
 Salmonella - Negative

Custom Packaging

Custom Blending

Toll Milling

Kosher Certified



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The Empire Foods Promise

Quality products provided with outstanding service. This is our priority. From seed, to field, to processing plant, to you our customer, Empire Foods is committed to producing the finest in dehydrated onion and garlic.

Empire Foods utilizes leading edge manufacturing practices, combined with careful development of seed varieties and cultivation in high desert fields. This enables us to naturally produce lo and extra lo bacteria finished products. We include a variety of piece sizes on our dehydrated product list and several packaging options. Let us know if your requirements specify a size not listed. Custom milling, blending and packaging are services we are happy to provide.

As part of the Empire Group, which also includes Empire Farms, Empire Energy, and Empire Research, we are a fully vertically integrated producer/supplier. As our customer, you benefit by purchasing from the company that grew the seed, harvested the field, dehydrated the raw material, and is dedicated to satisfying your needs.

If you would like to talk further about our products, please give us a call today at **888-590-8248** or **702-331-1576**. Or visit our web site at:

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