STOREY COUNTY (continued)

The restricted flow strongly suggests that the volcanic and intrusive wall rocks were the source of the heat, rather than the heat being introduced from some more distant source by hot-water flow. Exothermic reactions involving vein materials have been proposed as a possible source of the heat, but the low acidity and relatively unmineralized condition of the water (Appendix 1), and rarity of exothermic reaction products in the vein material suggest that little heat has been generated by this mechanism.

Other areas [249, 250, 251]

Although abundant hot water was encountered in the mine workings on the Comstock Lode, there are no hot springs in the vicinity. In fact, hot springs and evidence of past springs are rare in the entire county.

Waring (1965, Nevada no. 58) lists a warm (73°F) spring in T19N,R23E; probably this is Biddleman Springs, the only springs shown on the Churchill Butte 15′ topographic map. He mentions also a large area of travertine in S2,T17N,R22E (no. 251, pl. 1) and a small terrace and some fissure-filling of travertine in the center of the W/2 S21,T19N,R21E (no. 249, pl. 1).

WASHOE COUNTY

Truckee Meadows area

The Truckee Meadows area (fig. 44) includes the Reno–Sparks urban area between the Carson and Virginia Ranges on the west and east, respectively, and from Peavine Mountain to the north to the Steamboat Hills on the south. In general, the data in Appendix 1 in T17,20N and R19,20N would be generally considered to fall within the Truckee Meadows. This would include also a few warm-water wells in Pleasant Valley, which is technically outside of the Truckee Meadows. This area is just to the south of Steamboat Hot Springs and probably associated with that system. In Appendix 1 most of the water-quality data has been separated into several groups: Lawton Hot Springs, Moana Hot Springs, Steamboat Hot Springs, Pleasant Valley, etc. This separation, in a few cases, has been done somewhat arbitrarily.

Wedekind Mine [274]

In 1903 the Wedekind shaft in the Wedekind Mining District (SW/4 S28,T20N,R20E) encountered hot, acid water at 213 feet. A 150-gallon-per-minute pump was able to hold the water at the 100-foot level. The water was heavily charged with H_2S, and several miners in the bottom of the shaft were overcome by heat and H_2S (Morris, 1903; Overton, 1947, p. 84). No other evidence of thermal ground water is available, as there have been few recent water wells drilled in this area.

Lawton Hot Springs [275]

Hot springs along the Truckee River about 6 miles west of downtown Reno (SW/4 NE/4 S13,T19N,R18E) were named for Sam L. Laughton, who was the proprietor of a spa on the site in the mid-1880's. They were originally called Granite Hot Springs, but the name Lawton was used for a station on a spur of the Southern Pacific Railroad

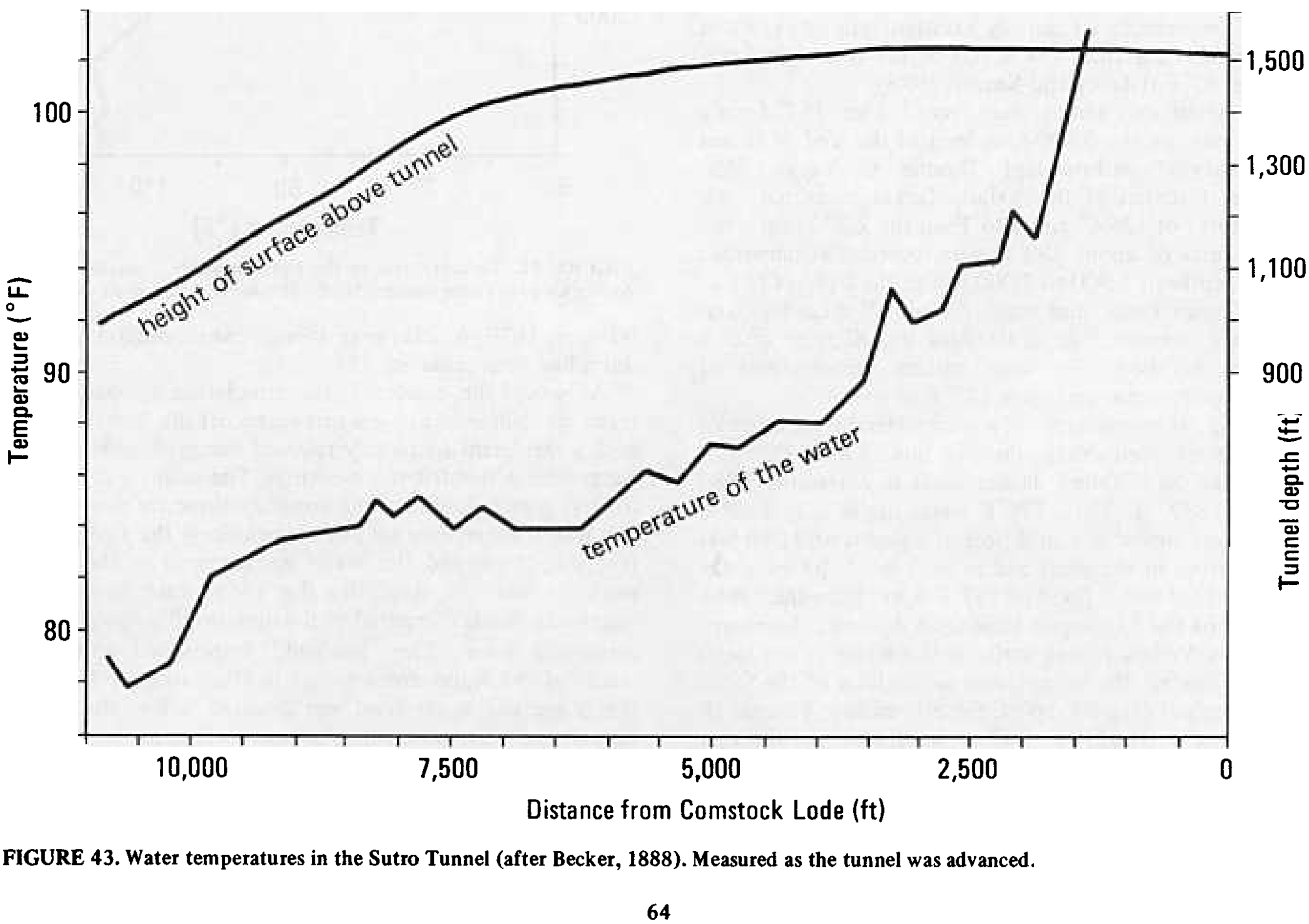


FIGURE 43. Water temperatures in the Sutro Tunnel (after Becker, 1888). Measured as the tunnel was advanced.

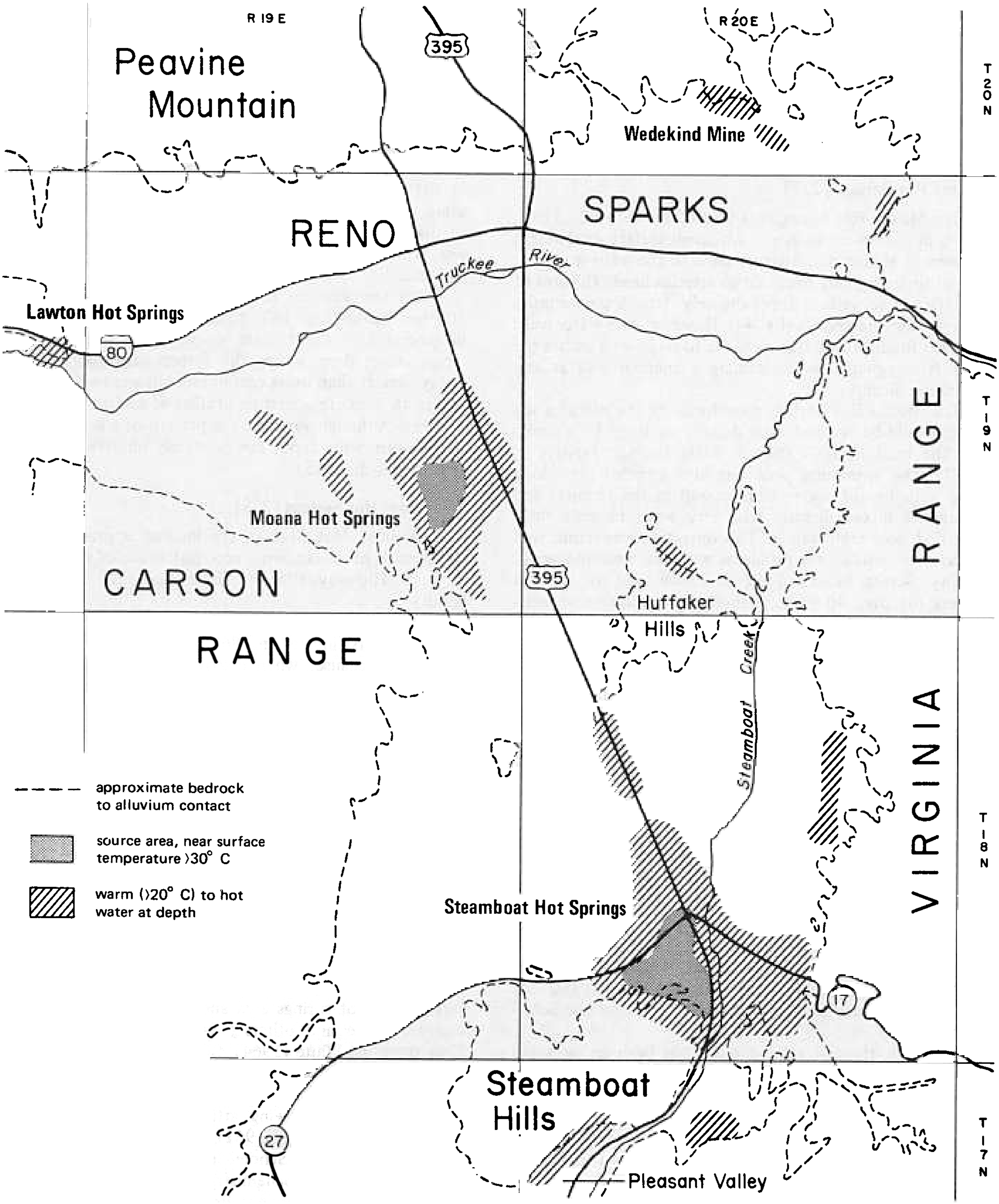


FIGURE 44. Map showing areas of known thermal ground-water occurrence in the Truckee Meadows, Washoe County (modified from Bateman and Scheibach, 1975).

(Carlson, 1974). The springs had a temperature of 120°F, and an artesian well is reportedly 140°F (R. B. Scheibach, written communication, 1975). Lawton Hot Springs lie at the northwestern end of a 12-mile-long zone of thermal ground water which extends from Steamboat Hot Springs to the southeast. The hot water at Lawton Hot Springs is used today in a bathhouse at the River Inn hotel-casino.

Moana Hot Springs [277]

The Moana Hot Springs are located in NE/4 S26,T19N, R19E in southwestern Reno. Although surface discharge is at present almost nonexistent, some of the wells drilled in the surrounding area maintain an artesian head. The area of thermal water wells is approximately 4 to 5 square miles centered on the springs (fig. 44). However, cold water wells are also found within this area, and having a well within the area is no guarantee of striking a thermal well at any particular locality.

The Moana Hot Springs were formerly the site of a spa which could be reached from downtown Reno by a streetcar line built in 1907 (Nevada State Journal, January 2, 1977). The swimming pool was also supplied for a long time with heated water from a well in the vicinity, and water was mixed directly with city water to maintain a specified pool temperature. This operation was terminated because of production problems with the well and water quality. Several homes in the area have used the thermal waters for over 40 years, although the number of wells has increased markedly in the past 10 years as the Reno residential area has expanded. Over 30 homes and three commercial establishments now utilize the geothermal waters for space heating; other uses include the heating of domestic hot water and water for swimming pools. Most of the systems use down-hole heat exchangers, and circulate city water through finned-tube baseboard heaters. Thermostatically controlled pumps are installed in most systems. Bateman and Scheibach (1975) discuss the utilization of the Moana geothermal waters in more detail.

Location of the Moana thermal system is thought to be controlled by north-south-trending faults that parallel the front of the Carson Range to the west (Bateman and Scheibach, 1975; Bonham and Bingler, 1973). Several faults in this area cut glacial outwash deposits of Illinoian age (E. C. Bingler, oral communication, 1977). It has also been noted that there is a striking north-south alignment of those wells with artesian head (past and present) and that the alignment may mark a fault trace (Bateman and Scheibach, 1975).

Although thermal ground water has been encountered in wells over an area of several square miles (fig. 44), the highest temperatures, as well as the area of maximum use for space and domestic hot water heating, is concentrated in an area slightly over 2 square miles (fig. 45). The wells in the Sweetwater Drive–Manzanita Lane area (SE/4 NE/4 S26,T19N,R19E) are usually 100 to 300 feet in depth and many have temperatures of 160° to 185°F. To both the north and west of this area, it has been necessary to drill deeper wells to encounter thermal waters. These hot waters when encountered in drilling are associated with a "blue" clay zone which directly overlies the Tertiary bedrock units here and may be up to 150 feet thick. The hot water is not generally found above this "blue" clay zone (Bateman and Scheibach, 1975). If the water moves upward through faults in the bedrock, this clay zone may act as a relatively impermeable cap, forcing the water to diffuse laterally (and vertically) away from the fault zone. Noticeable increases in water temperature were observed when certain wells were drilled through the contact between the clay and underlying bedrock. The existence of an artesian head only in wells drilled along a certain alignment, presumably a fault, may further support this theory of near-surface operation of the system. Wells drilled into or through the clay at some distance from such an input zone would tend not to display artesian conditions due to the hydraulic head loss involved in moving water laterally through the clays and andesite.

Water temperatures encountered at depths in excess of 100 feet range from 167° to 205°F. Deeper wells do not in general have the highest temperatures, suggesting that temperatures deep within the system may not be appreciably greater than those encountered nearer to the surface. Figure 46 shows temperature profiles of several wells within the area. Although variable, the pattern of a leveling off of temperature with depth can be clearly observed (Bateman and Scheibach, 1975).

Steamboat Hot Springs [278]

Steamboat Hot Springs are located approximately 9 miles south of downtown Reno, just south of the junction of U. S. Highway 395 and State Route 27 (S33,T18N, R20E).

The springs have a long history as a resort and health spa. They were first located in 1860 by Felix Monet. They are so named because, when discovered, escaping steam reportedly produced a noise resembling the puffing of a steamboat. The area had several owners and developments before 1871, when the Virginia and Truckee Railroad was completed to this point and a small town sprang up (Hummel, 1888). A post office was established in 1880 and exists to this day. Some of the resorts have used the names Reno Hot Springs, Mount Rose Hot Springs, or Radium Hot Springs. The deposits of sulfur and cinnabar were first opened up in 1876, and numerous attempts have since been made to mine these deposits (Overton, 1947).

The Steamboat Hot Springs area is the best known and most extensively studied geothermal area in Nevada, and one of the better known thermal areas of the world. The geology and geochemistry have been described in detail by White and others (1964). Other references on the geology of the hot springs area and the surrounding vicinity include: White and others (1946), White (1952, 1953), Thompson and White (1964), Bingler (1975), Bateman and Scheibach (1975), and Tabor and Ellen (1975). The rock alteration has been studied by numerous persons and reported in the following articles: White (1947, 1954), Sigvaldason and White (1962), Schoen and White (1965, 1967), Ehrlich and Schoen (1967). The geochemistry (including isotope geochemistry) and heat flow has been discussed by the following: Brannock and others (1948), White and Brannock (1950a, b), Craig (1953), White and others (1957), White and Craig (1959), White (1957, 1968), and Silberman and White (1975). The mercury, antimony, silver, and gold mineralization has been described in a number of publications, including: Phillips (1871, 1879),

FIGURE 45. Map showing locations of shallow thermal wells in southwest Reno that are used for space heating, domestic hot water, and swimming pools (from unpublished map by R. B. Scheibach, 1974).

Le Conte (1883), Becker (1888, 1889), Lindgren (1905), Jones (1914), Bailey and Phoenix (1944), Gianella and White (1946), White and others (1949), and White (1974).

Geophysical studies are reported in White and others (1964), Hoover, Batzle and Rodriquez (1975), Hoover, O'Donnell, Batzle, and Rodriquez (1975), Long and Brigham (1975b) and Peterson (1975).

Much of the following geologic description is summarized from White (1968), White and others (1964), Thompson and White (1964), and Bateman and Scheibach (1975). Bonham's (1969) summary of White and others (1964) has also been extensively quoted in the following.

The oldest rocks in the Steamboat Springs area are metamorphosed sedimentary rocks which have been intruded by granodiorite (fig. 47). The sedimentary rocks are largely metamorphosed water-lain volcanic tuffs with intercalated beds of sandstone, conglomerate, and limestone. They are probably Triassic in age. Much of the Steamboat Springs area is underlain by granodiorite of probably Cretaceous age. The granodiorite has been hydrothermally altered over most of the area, and near-surface bleaching is prevalent in and adjacent to the thermal areas.

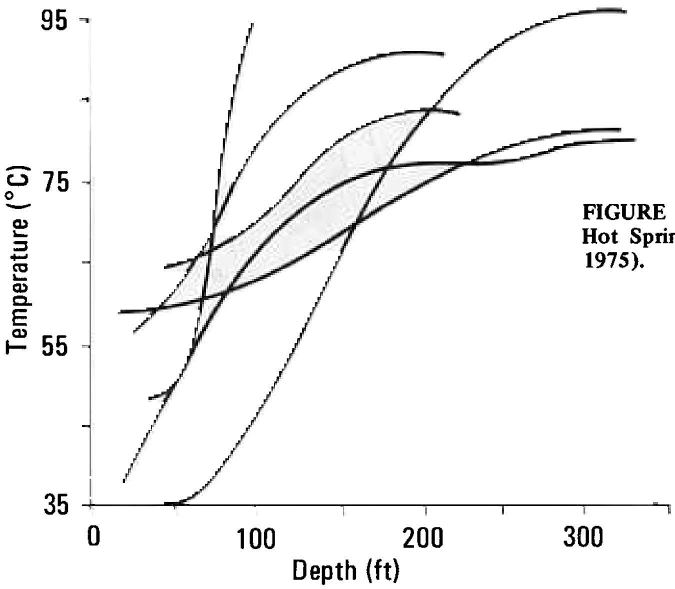


FIGURE 46. Temperature profiles of selected wells in the Moana Hot Springs area, Washoe County (from Bateman and Scheibach, 1975).

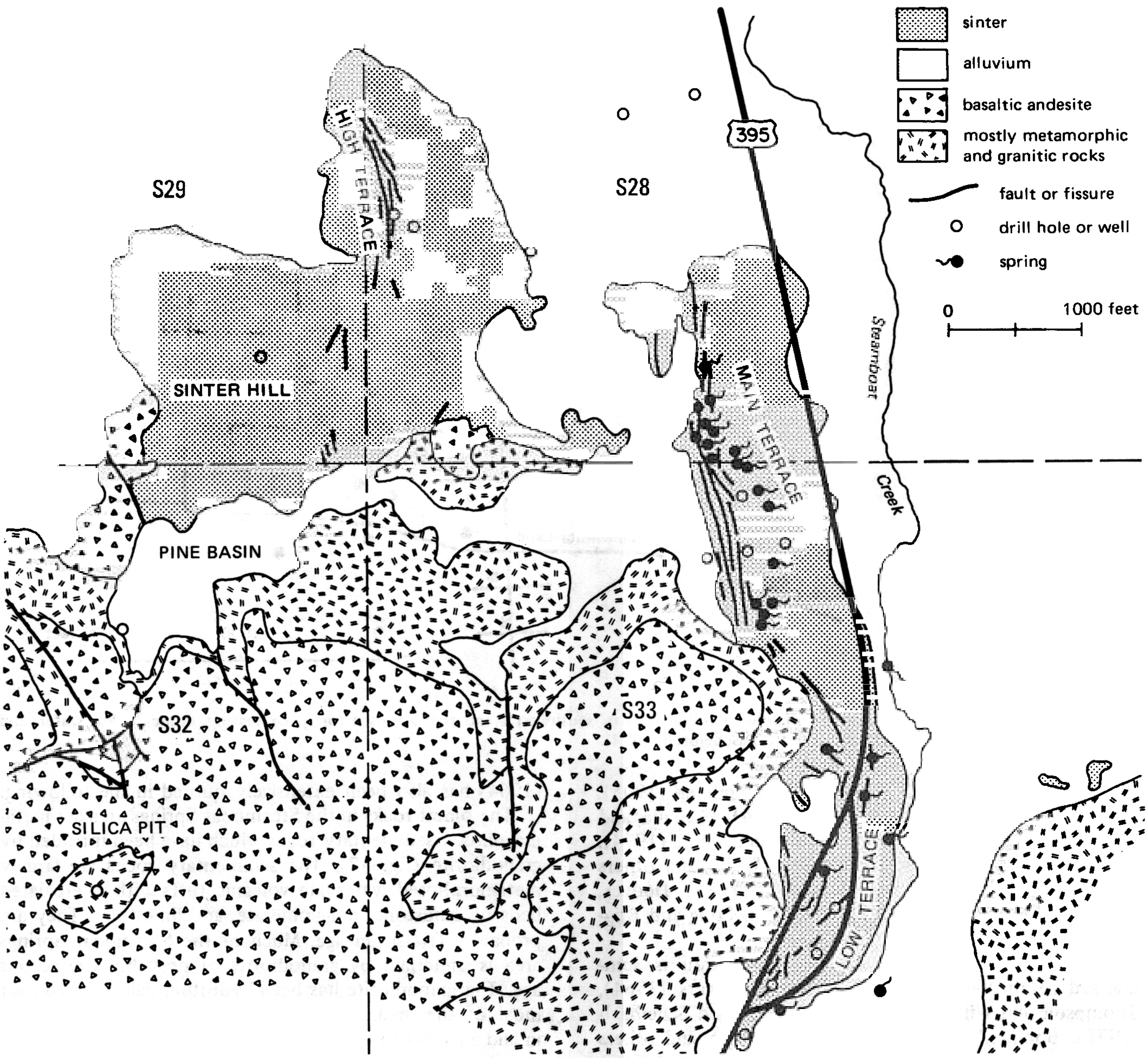


FIGURE 47. Generalized geologic map of Steamboat Springs thermal area, T18N, R20E, Washoe County (modified from White and others, 1964).

WASHOE COUNTY (continued)

Flows of soda trachyte, correlated with the Tertiary Alta Formation, crop out at a few localities in the district and have also been recognized in several of the drill holes located within the thermal area. The soda trachyte overlies granodiorite. Two small erosion remnants of an andesite flow are the only rocks of the Kate Peak Formation that crop out in the district. Rocks of the Kate Peak Formation, however, crop out over extensive areas immediately adjacent to the Steamboat Springs district.

Basaltic andesite flows extend over much of the southern and eastern parts of the Steamboat Springs district. The flows overlie granodiorite and alluvial deposits. These pre-basaltic andesite pediment gravels and alluvium are present over much of the district. They rarely crop out, because they are usually concealed beneath younger rocks, but they

have been encountered in a number of the drill holes. The oldest deposits of hot-spring sinter are also of prebasaltic andesite age. Several areas of this early hot-spring sinter are present in the district.

The Steamboat thermal area lies on a line connecting several rhyolite domes that occur to the southwest and northeast of the thermal area. These rhyolite domes have been named the Steamboat Hills Rhyolite. The emplacement of the large dome that lies southwest of Steamboat Springs was preceded and accompanied by extensive pyroclastic eruptions that mantled much of the adjacent area with a layer of rhyolite pumice. It has been proposed (White and others, 1964) that another rhyolite intrusive may underlie the hot-spring area.

White and others (1964) have differentiated several different types of Quaternary deposits in the Steamboat Springs district, including pre-Lahontan alluvium, post-basaltic andesite sinter, opaline hot-spring sinter, alluvium of Lahontan age, and Recent alluvium and hot-spring deposits. Their detailed mapping of these Quaternary deposits has contributed greatly to an understanding of the history of the Steamboat Springs area.

The hot-springs system formed in the early Pleistocene, prior to the eruption of the basaltic andesite flows in the Steamboat area. The basaltic andesites have been dated at approximately 2.5 m.y., and the rhyolite domes have given K-Ar ages of 1.15 to 1.52 m.y. Also, hydrothermal potassium feldspar which replaces basaltic andesite gave an age of 1 m.y. (Silberman and White, 1975). Thus, the hot-spring system is seen to have been active, possibly intermittently, for over 2.5 m.y. The source of the energy for the thermal convective system is most probably the rhyolitic magma chamber from which the rhyolitic domes were emplaced (Silberman and White, 1975). It has been estimated that about 0.001 km^3 of new magma would have to be provided each year to supply the heat at Steamboat at the present rate of heat loss.

The thermal waters contain small amounts of metals, including mercury, antimony, silver, and gold and have deposited small amounts of stibnite, gold, and silver, and larger amounts of cinnabar in both hot-spring sinter and in the altered wall rocks adjacent to the hot-spring vents.

The thermal waters at Steamboat are high in Na, Cl, HCO_3, and SiO_2, and have a significant Li content. Also, they are anomalous in As, Sb, Hg, Cs, and B (see Appendix 1). Mercury vapor is commonly detected in the steam from springs and wells. The relative abundance of these highly soluble elements which have a low crustal abundance, coupled with the long life of the geothermal system, creates great problems with maintaining the supply of these elements by rock leaching. White (1974) suggests that the spring waters include a continuing small supply of magmatic water enriched in the previously mentioned constituents. Oxygen isotope data show that there could be no more than 11 percent magmatic water supplied to the hydrothermal system, and it is probably less than 5 percent.

All of the wall rocks in the thermal area have been altered. Near-surface acid bleaching is the most obvious visible effect at the surface, and it has strongly affected the granodiorite and the basaltic rocks. The near-surface acid bleaching extends to depths of 100 feet or more. Below this zone the rocks adjacent to the channelways of migrating thermal waters have been hydrothermally altered. A type of propylitic alteration is prevalent in this zone.

The main terrace at Steamboat Hot Springs is made up of siliceous spring deposits, primarily opaline sinter. It is believed that with time this will change to chalcedonic sinter. A large area of chalcedonic sinter is present in Pine Basin to the southwest of the main terrace and is believed to be the most extensive chalcedonic hot-spring sinter known in the world. It contains disseminated cinnabar. Also, small amounts of siliceous sinter are present about

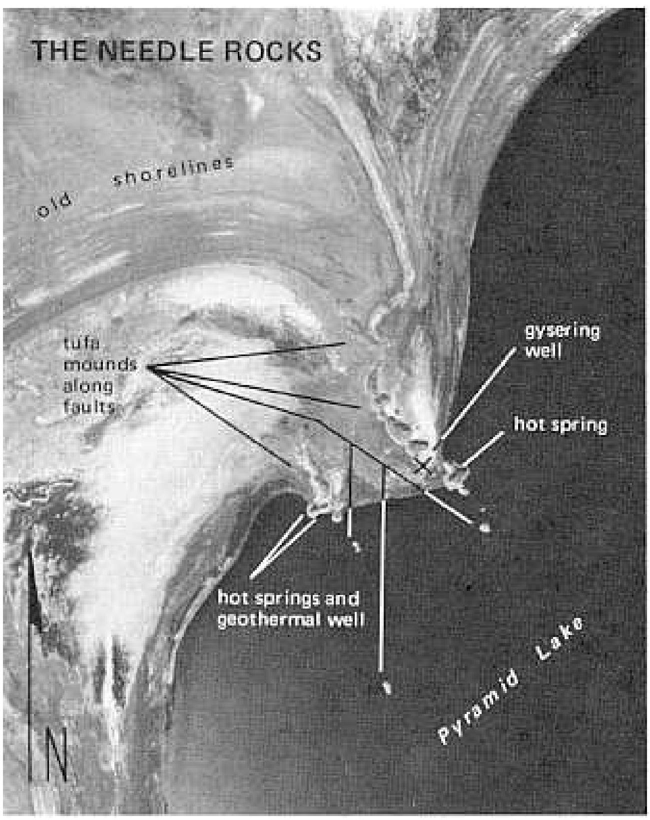
Nevada Thermal Power Co. Steamboat No. 3 geothermal well in Pine Basin at Steamboat Springs, Washoe County.

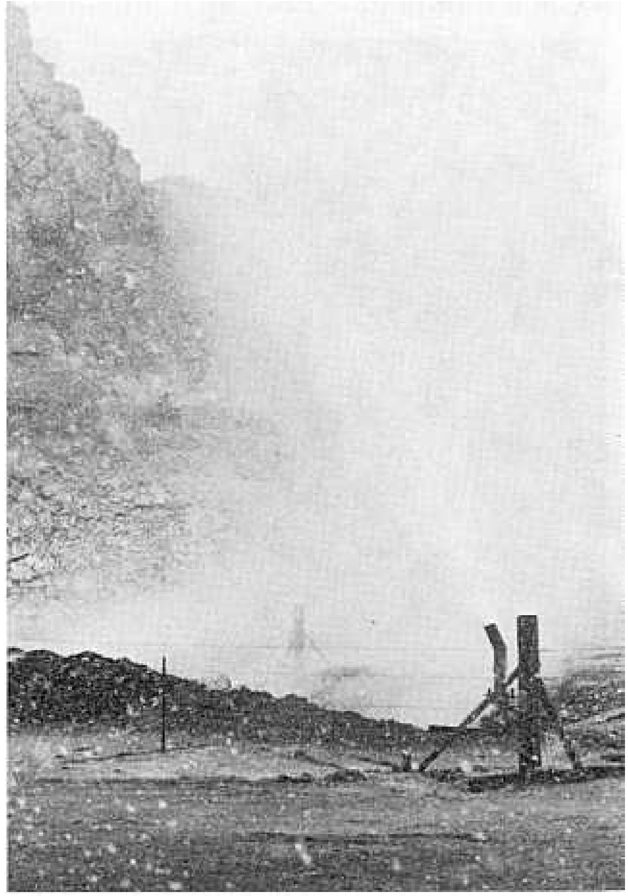
1.5 miles south of Steamboat Hot Springs in C NE/4 S5, T17N,R20E, and a small deposit of spring travertine is located in SW/4 SW/4 SW/4 S5,T17N,R20E on the southeast flank of Steamboat Hills about 100 feet above the floor of Pleasant Valley (Thompson and White, 1964).

The springs at Steamboat are near boiling, and exploration steam wells have reported temperatures as high as 369°F. One well encountered temperatures of up to 280°F at only 160 feet (White, 1968). The hot water is reported to have 5% to 10% steam flashover (Koenig, 1970). Preferred estimated reservoir temperatures from chemical geothermometers are approximately 400°F (Mariner and others, 1974). Six steam wells, ranging in depth from 716 to 1,830 feet were drilled in the late 1950's and early 1960's by Nevada Thermal Power Co. (see Appendix 2). Also, the U. S. Geological Survey drilled eight core holes for a total of 3,316 feet, and, in the past, several other wells have been drilled in the area for spas. Several years ago the hot water from one steam well was used as a flameless source of heat for the manufacture of plastic explosives.

The Needle Rocks [269]

Pyramid Lake is on the Pyramid Indian Reservation, about 30 miles northeast of Reno and lies along the probable trace of the Walker Lane, a major right-lateral strike slip fault zone in western Nevada. The Needle Rocks are at the northeast corner of Pyramid Lake (S12,T26N,R20E and S6,7,T26N,R21E), along north-northeast-trending faults that are presumed to be part of this Walker Lane fault zone (Bonham, 1969). Warm springs are also present at Pyramid Island (S3,T24N,R22E) and on Anaho Island (S16?,T24N,R22E); both localities are also within the Walker Lane fault zone.





Western Geothermal Inc. Needles No. 1 well at Needle Rocks, Washoe County, shortly after drilling in 1965 (photo by Harold F. Bonham, Jr).

Both the Needle Rocks and Pyramid Island are spectacular masses of tufa which were deposited in Pyramid Lake when its level was higher than at present. The collection of tufa into needles, spires, and pyramids is believed to be related to underwater warm springs (Russell, 1885), and divers report that underwater hot springs are present near the Needle Rocks today.

Springs at the Needle Rocks are reported to range from 151°F (Grose and Keller, 1975b) to a maximum of 208°F (Waring, 1965) which is near boiling for that elevation. A number of the springs are shown on the Needle Rocks 7½-minute topographic map. The spring on Anaho Island is reported to be 120°F (Waring, 1965). In the early 1960's Western Geothermal, Inc. drilled 3 geothermal wells at the Needle Rocks. The deepest of these was 5,888 feet, and another was approximately 4,000 feet deep. The maximum recorded temperature was approximately 240°F. From examination of drill cuttings from the deepest well, it is believed that Tertiary basaltic andesites overlie Mesozoic metamorphic rocks at approximately 5,050 feet (H. F. Bonham, written communication, 1964). This well flowed continuously after its completion, but geysered or pulsed, a complete cycle taking about 1 minute. A 35-second eruption, with hot water reaching 30 feet in height above the well, was followed by 32 seconds of diminished activity. During this period the well flowed at a rate of about 100 gallons per minute. A thin film of siliceous sinter (geyserite) collected on the well casing during this time; a slight odor of H_2S was also noted (H. F. Bonham, Jr., written com-

Western Geothermal Inc. Needles No. 1 well at Needle Rocks, Washoe County, in 1971.

munication, 1964). Mariner and others (1974) report that their best estimate of the thermal reservoir temperature is 279°F, using the silica (adiabatic) geothermometer.

Ward's (Fly Ranch, Hualapai Flat) Hot Springs [258]

Ward's or Fly Ranch Hot Springs are located in Hualapai Flat about 15 miles north of Gerlach (mainly in S1,2,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, 1962b). 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.

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 40 to 45 miles 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 Ward's 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 Ward's Hot Springs is favored by this extensional tectonic regime, and the major spring area is located on the upthrown side of a 4-mile long fault scarp that has a maximum relief of 30 feet.

Spring deposits at Ward's Hot Springs consist of both siliceous sinter and calcaerous travertine (Sinclair, 1962b).

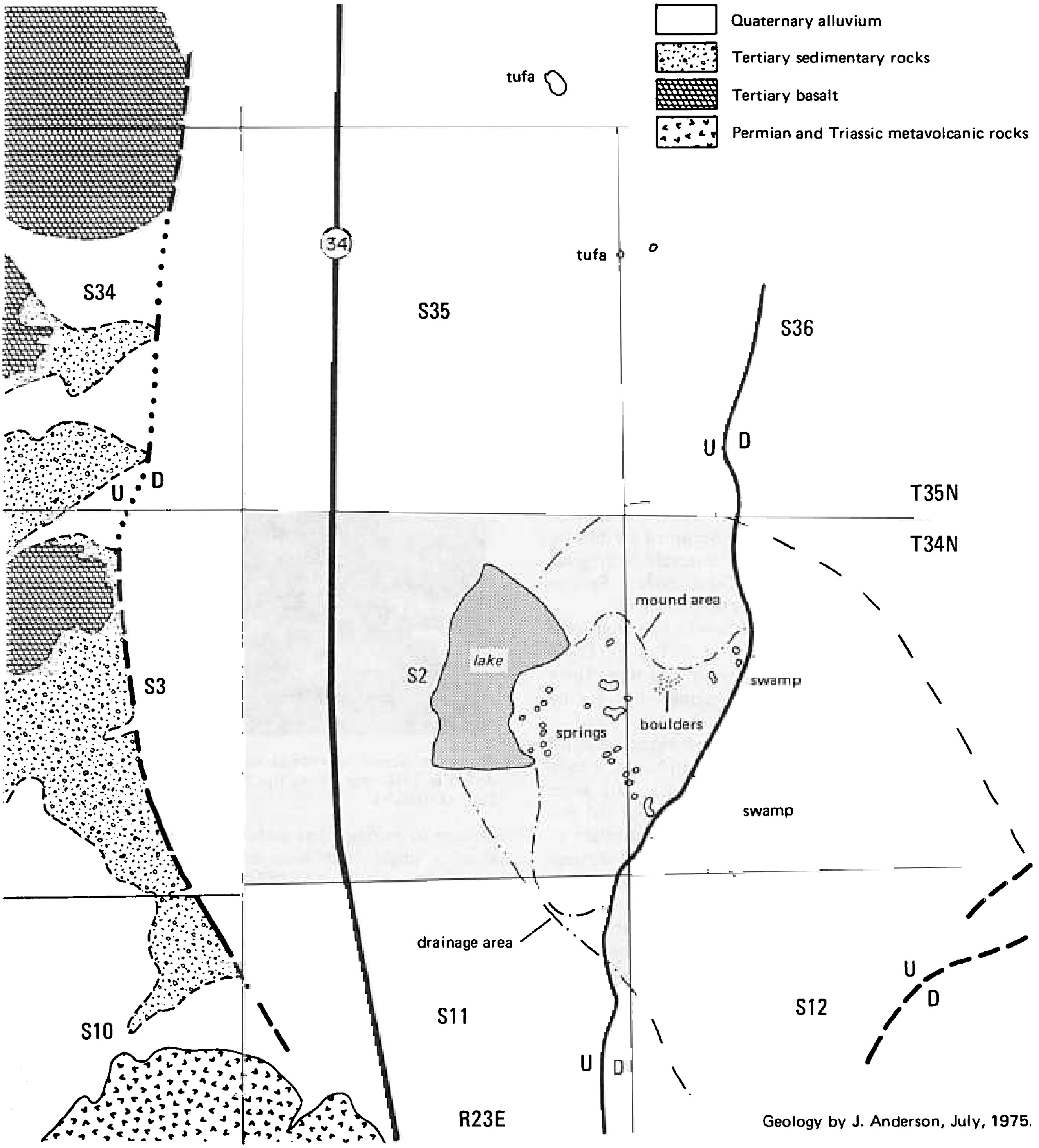


FIGURE 48. Geologic map of the Fly Ranch thermal area, T34 and 35N,R23E, Washoe County (after Grose and Keller, 1975b).

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 15 feet high. Water temperatures in wells and springs of the hot-springs area and vicinity range from near normal to over 220°F (Appendix 1), and Mariner and others (1974) report a 257°F estimated minimum thermal reservoir temperature using the silica geothermometer.

Granite Ranch [259]

A thermal area of unknown extent is present near the south end of Hualapai Flat about 1 mile south of Granite Ranch in S35,T34N,R23E and S2,T33N,R23E. A presently abandoned water well in the area first hit hot water, and in 1965(?) Western Geothermal, Inc. drilled an 800-foot geothermal test in the area (see Appendix 2). Additionally, thermal water was encountered in temperature test holes drilled by Cordero (now 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 150 feet, 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).

Gerlach area [261]

The Gerlach thermal area is at the south end of the Granite Range in the southern Black Rock Desert (fig. 49). It includes two major groups of springs, Great Boiling Springs in S10,15,T32N,R23E about 0.8 mile northwest of Gerlach and Mud Springs in S16,T32N,R23E about 1.1 miles west of Gerlach. These areas have been described together for simplification, but water quality and temperature data in Appendix 1 are subdivided into the separate spring areas.

The springs were first described by Frémont (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. Frémont measured temperatures up to 208°F.

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 have been used extensively for bathing for a number of years and a bathhouse, steamhouse, and warm pools are at the site today (fig. 50). Some pools are too hot for swimming; a 19-year old girl was scalded to death in one of these in 1973, an indication of the danger inherent in geothermal areas. Mud Springs (fig. 51) has 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. 49). 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-trending Basin and Range faults along the east side of the Granite Range (fig. 49). 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

Travertine deposit developed over "Geyser Well," a water well drilled in 1916 near Ward's Hot Springs, Washoe County (photo by Patricia Garside).

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 others, 1975; 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 Ward's 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 μR/hr), according to Wollenberg (1974b). Also, the Great Boiling Spring area is well known for its mud volcanoes and other mud vent activity (Russell, 1885, p. 52; White, 1955b). The mud volcanoes have been reported to erupt clots of mud to heights of at least 100 feet. They are characterized by sporadic and apparently unpredictable intervals of activity separated by very much longer intervals of quiescence (White, 1955b).

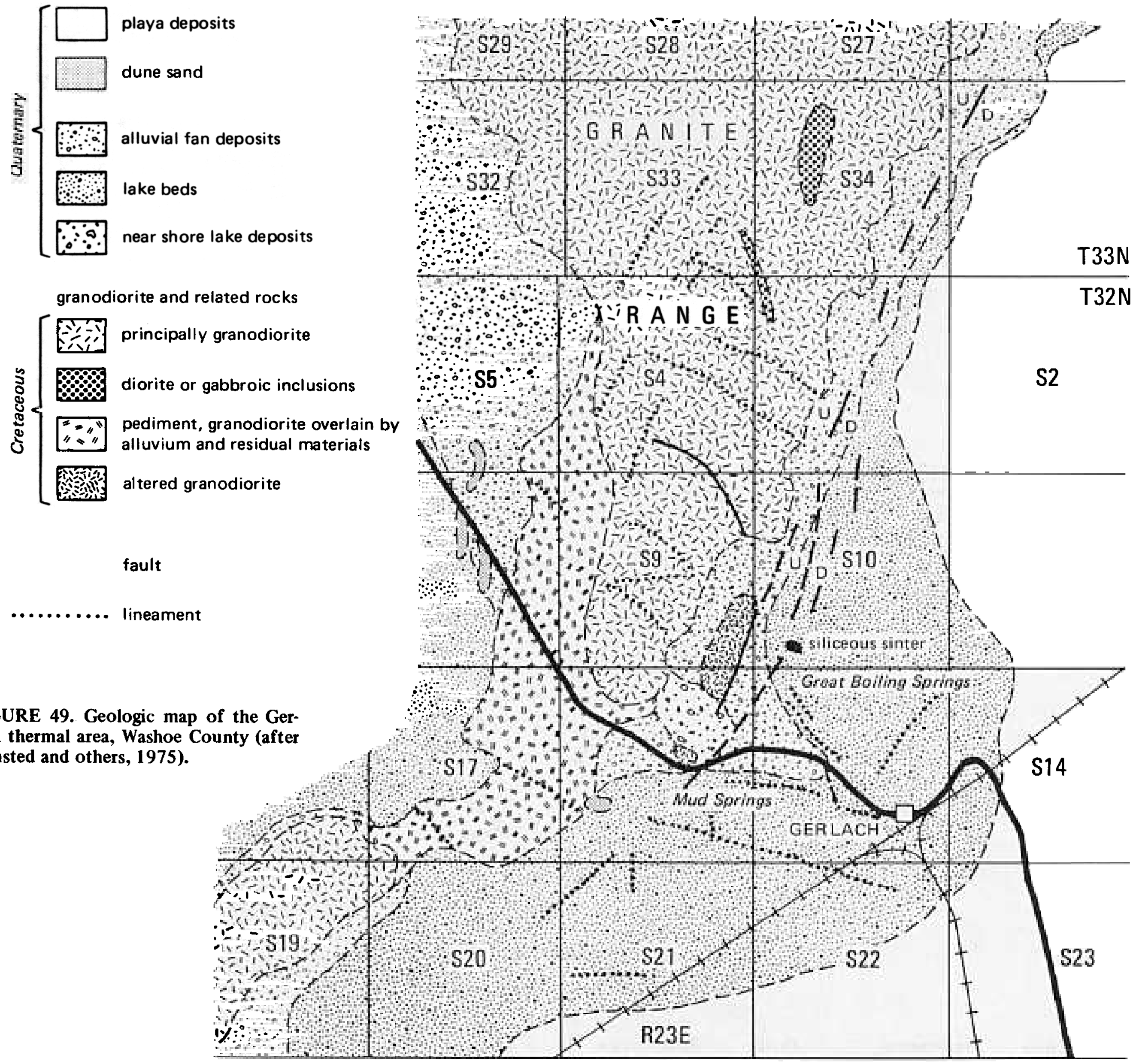
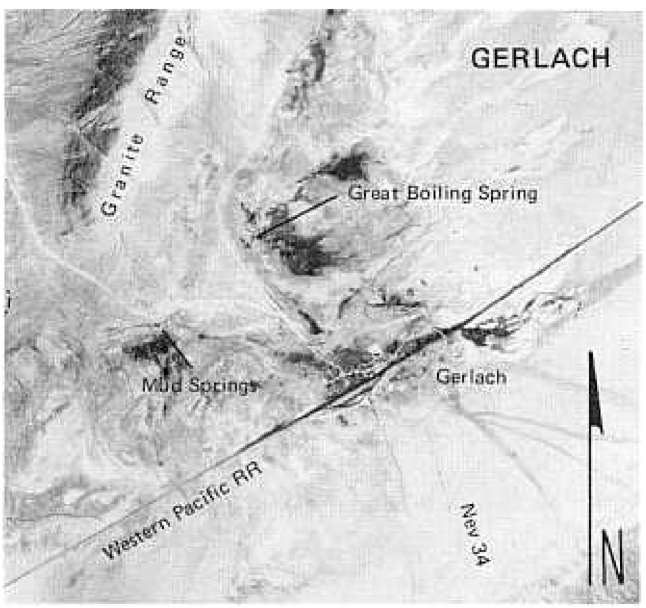


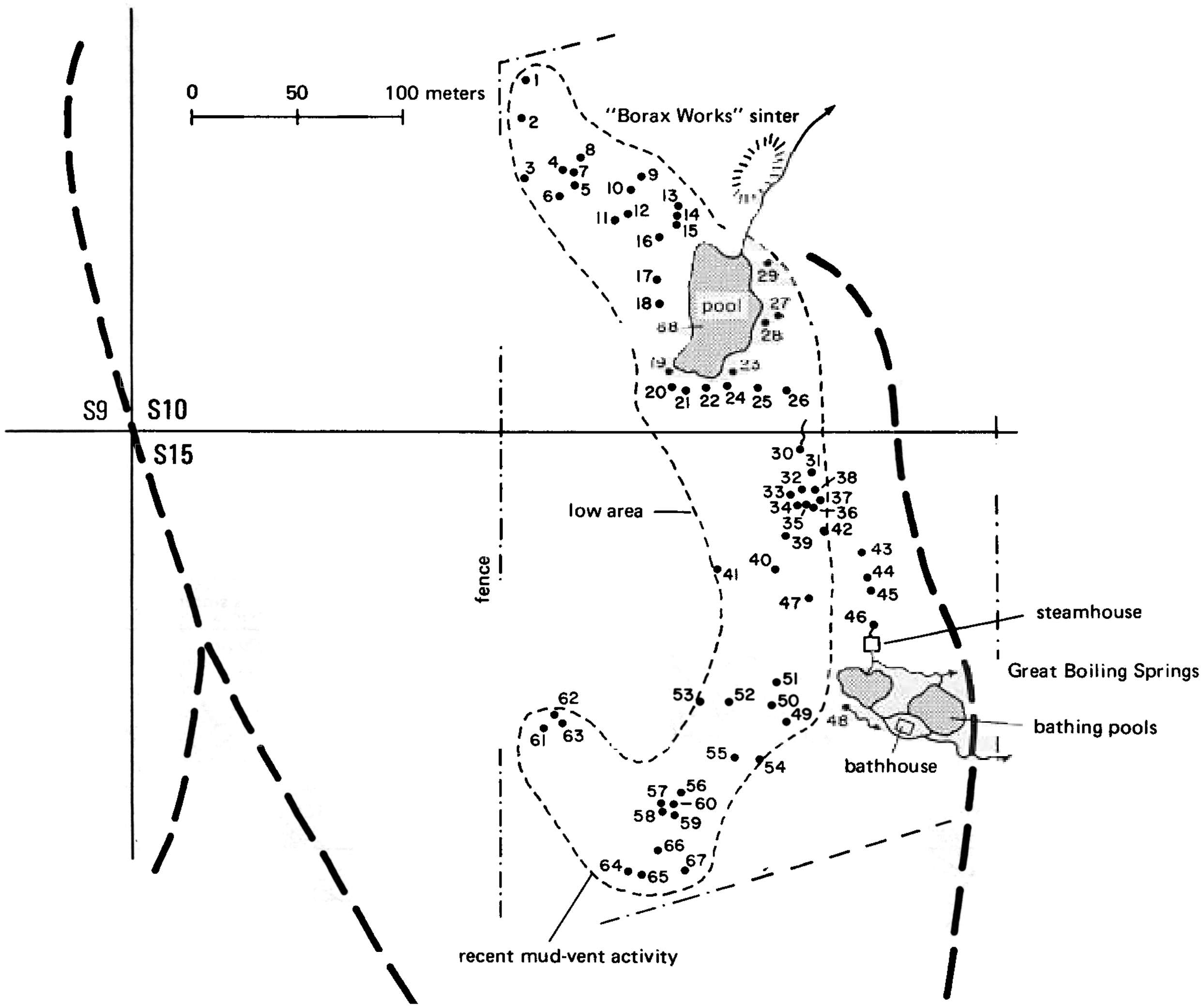
FIGURE 49. Geologic map of the Gerlach thermal area, Washoe County (after Olmsted and others, 1975).

The temperatures measured in springs and pools range up to a maximum of 208°F (Grose and Keller, 1975b) and shallow subsurface measurements are over 248°F or 120°C (fig. 52). In addition to shallow temperature-gradient holes drilled by the U. S. Geological Survey in 1973, Cordero (now Sunoco Energy Development Co.) drilled several gradient holes to depths of 300 to 600 feet in 1972. Mariner and others (1974) have estimated the reservoir temperature at 333°F using the silica-quartz geothermometer and 347°F using the sodium-potassium geothermometer.



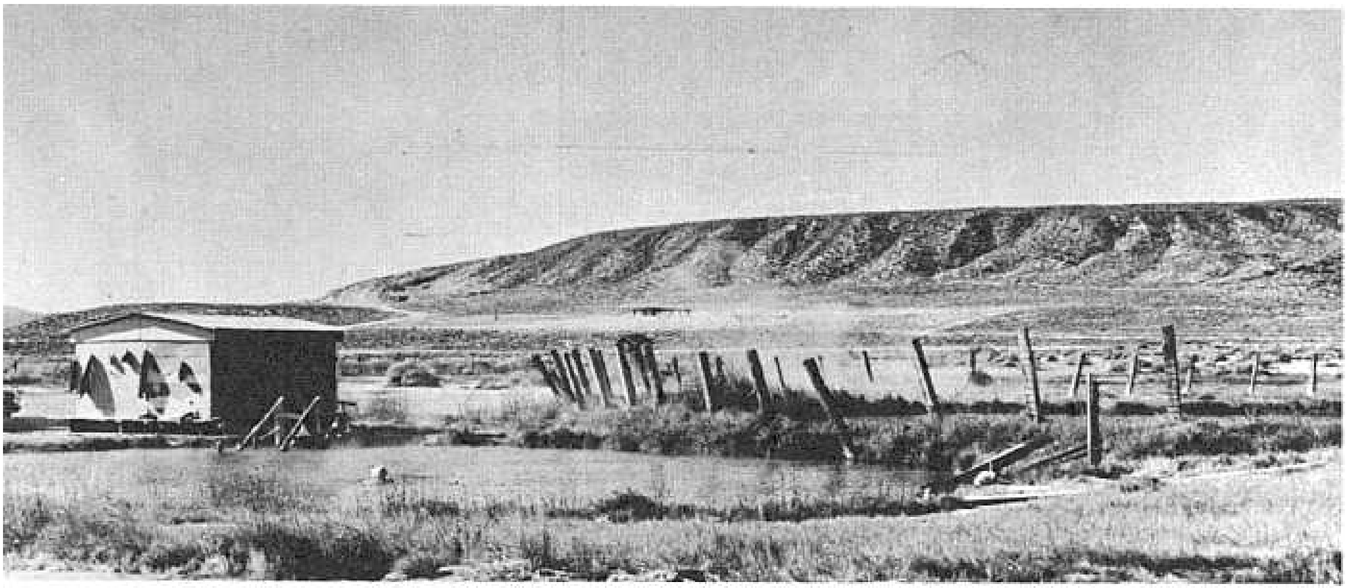
San Emidio Desert (Mud Flat) [265]

An altered zone up to 100 feet wide and two miles long is present in S9 and 16,T29N,R23E (unsurveyed) 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

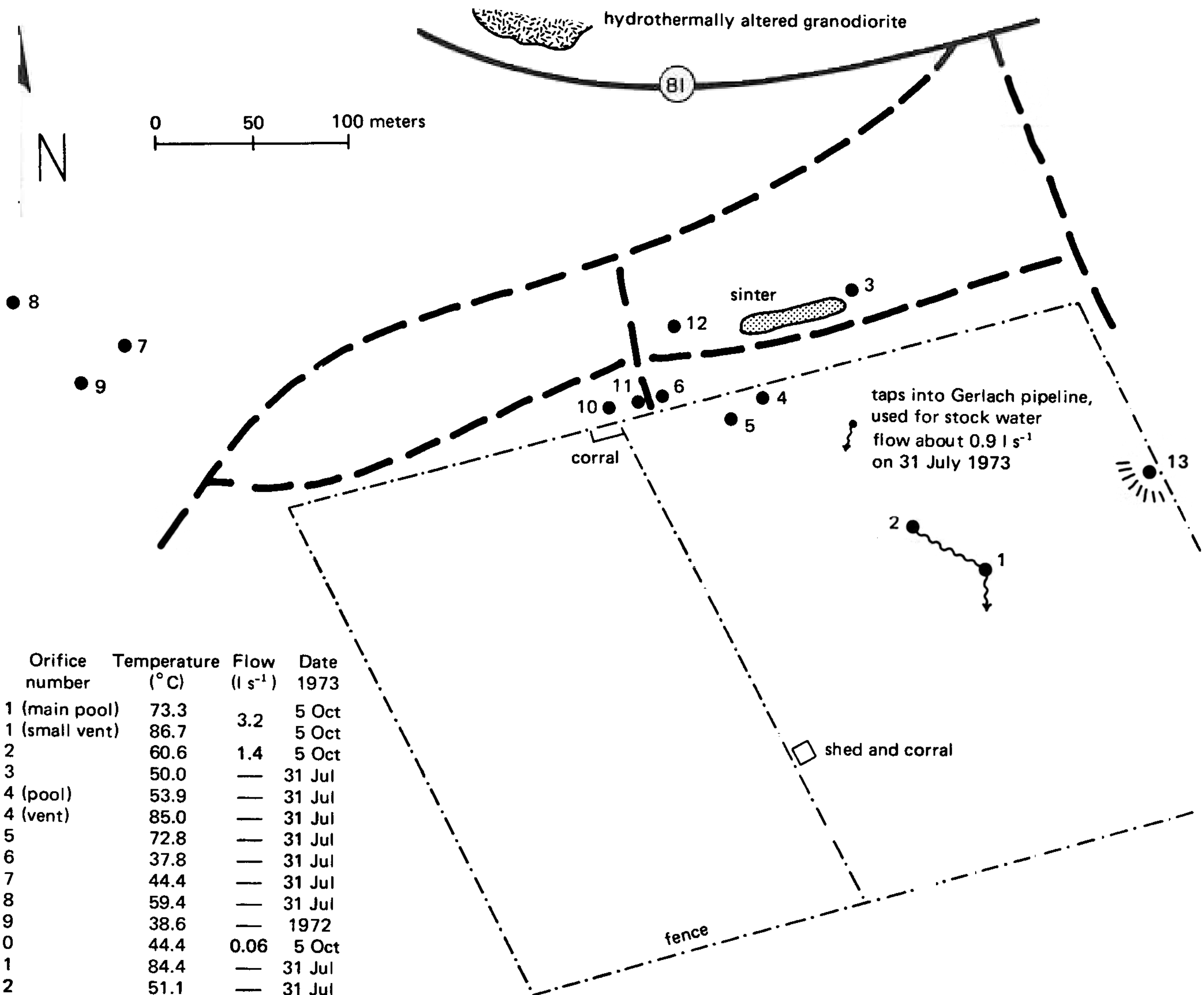


Orifice number	Temperature (° C)	Orifice number	Temperature (° C)	Orifice number	Temperature (° C)	Orifice number	Temperature (° C)
1	60.6	18	50.6	35	27.2	52	44.4
2	40.0	19	96.1 (boiling)	36	50.6	53	34.4
3	49.4	20	48.3	37	48.9	54	70.0
4	42.2	21	59.4	38	64.4	55	77.8
5	50.0	22	40.6	39	52.2	56	58.9
6	33.3	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).



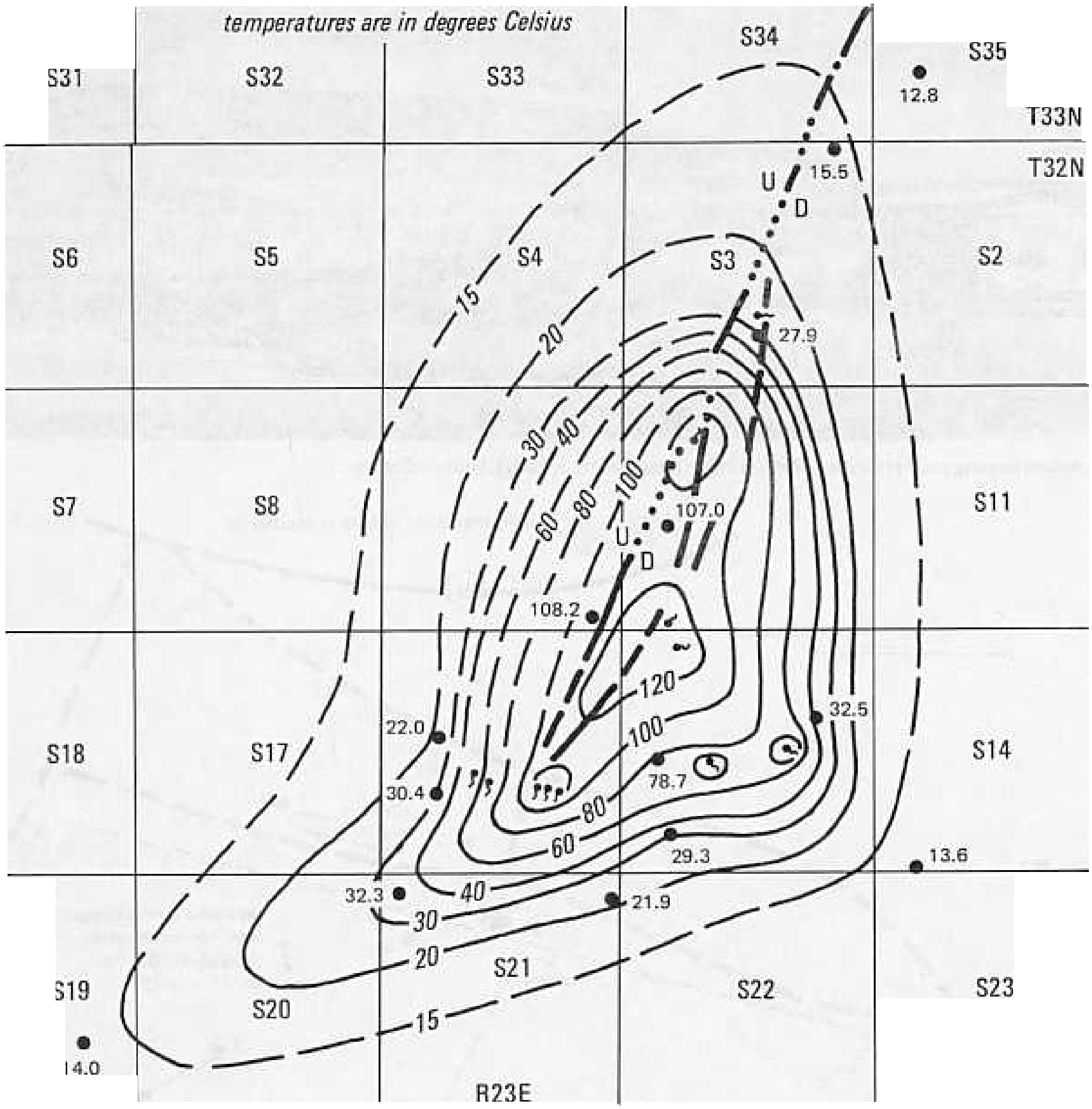
Bathhouse and swimming pool at Gerlach Hot Springs (Great Boiling Springs), Washoe County.



Orifice number	Temperature (°C)	Flow ($l\ s^{-1}$)	Date 1973
1 (main pool)	73.3	3.2	5 Oct
1 (small vent)	86.7		5 Oct
2	60.6	1.4	5 Oct
3	50.0	—	31 Jul
4 (pool)	53.9	—	31 Jul
4 (vent)	85.0	—	31 Jul
5	72.8	—	31 Jul
6	37.8	—	31 Jul
7	44.4	—	31 Jul
8	59.4	—	31 Jul
9	38.6	—	1972
10	44.4	0.06	5 Oct
11	84.4	—	31 Jul
12	51.1	—	31 Jul
13	65.6	—	31 Jul

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



15 ——— line of equal temperature (°C) at a depth of 30 meters

hot springs

32.5 ● test hole, number is temperature (°C) at a depth of 30 meters

fault, dashed where uncertain, dotted where concealed

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).

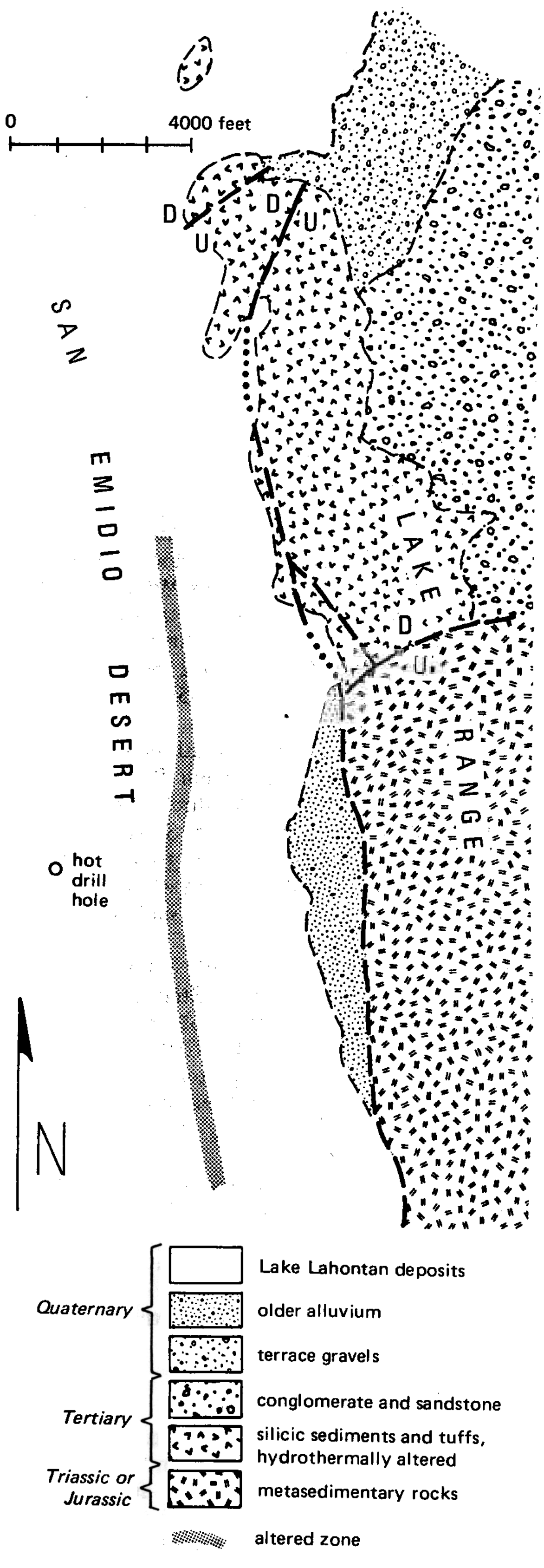


FIGURE 53. Geologic sketch map of the San Emidio cinnabar prospect, Washoe County (after Bonham, 1969).

and lacustrine deposits (Bonham, 1969). The alteration and mineralization represent the deposits of hot springs which were probably more active in the past. The zone is near the high-water level of Lake Lahontan, to which the mineralization may be related in some way (Papke, 1969).

The zone is still thermally active, and the ground is often warm 2 to 3 feet below the surface. Water standing in shallow bore holes is up to 128°F 3 feet below the ground surface, and a flowing spring or old well in S9 is approximately 86°F. Also, a drill hole encountered boiling water at 87 feet in 1955 in this same section (fig. 53), according to T. A. Alberg (written communication, 1975). Chevron Oil Co. drilled a 4,013-foot geothermal test to the west of this area (S8,T29N,R23E) in 1975. No information is available on the temperatures encountered. Peterson and Dansereau (1975) have reported principal facts for gravity stations in the San Emidio Known Geothermal Resource Area.

Bowers Mansion (Franktown) Hot Spring [280]

Bowers Mansion is a recreational park located to the west of Washoe Lake and developed around a mansion built in 1864 by Sandy Bowers, a prosperous miner on the Comstock Lode. The restored two-story sandstone structure is operated by the Washoe County Department of Parks and Recreation. Two swimming pools are open to the public during the summer season.

The hot spring has been utilized for the swimming pools in the past, but is now used for irrigation (Peterson, 1976). In 1962 an attempt to drill a cold-water well encountered 117°F water at 207 feet, and this well now supplies the thermal water for an olympic-size pool and a 15- by 25-foot pool for younger children. The pool waters are reduced to 76° to 78°F by addition of 54°F water from Riter Springs, about 5,500 feet northwest of the mansion.

The hot spring issues from the granodiorite-alluvium contact, which is an obvious fault scarp along the east side of the Carson Range. The hot water well probably intersects this same normal fault at depth. The geology of the area has been mapped by Tabor and Ellen (1975).

WHITE PINE COUNTY

Monte Neva (Melvin, Goodrich) Hot Springs [288]

The Monte Neva (Melvin, Goodrich) Hot Springs in SW/4 S24, NW/4 S25,T21N,R63E on the west edge of Steptoe Valley, are by far the hottest in White Pine County. Although a temperature of 193°F was reported by Stearns and others (1937, no. 98) other observers reported the temperature as 174°F in 1917 (Clark and others, 1920, p. 47), again in 1966 (Mifflin, 1968), and in 1974 (Hose and Taylor, 1974).

There is one main spring plus several smaller ones, all issuing from alluvium. The main spring flowed 625 gpm in 1917 (Clark and others, 1920, p. 47). A 20- to 40-foot-high mound of travertine, covering about 12 acres, has been built up. Mineral water is presently being deposited, and considerable CO_2 (?) gas is escaping from the springs.

Magma Power Co. drilled a 402-foot well at the springs in 1965. Hot water but no steam was encountered; the maximum temperature reported, was 190°F (Koenig, 1971). Audiomagnetotelluric data for the geothermal area is reported in Long and Batzle (1976a).