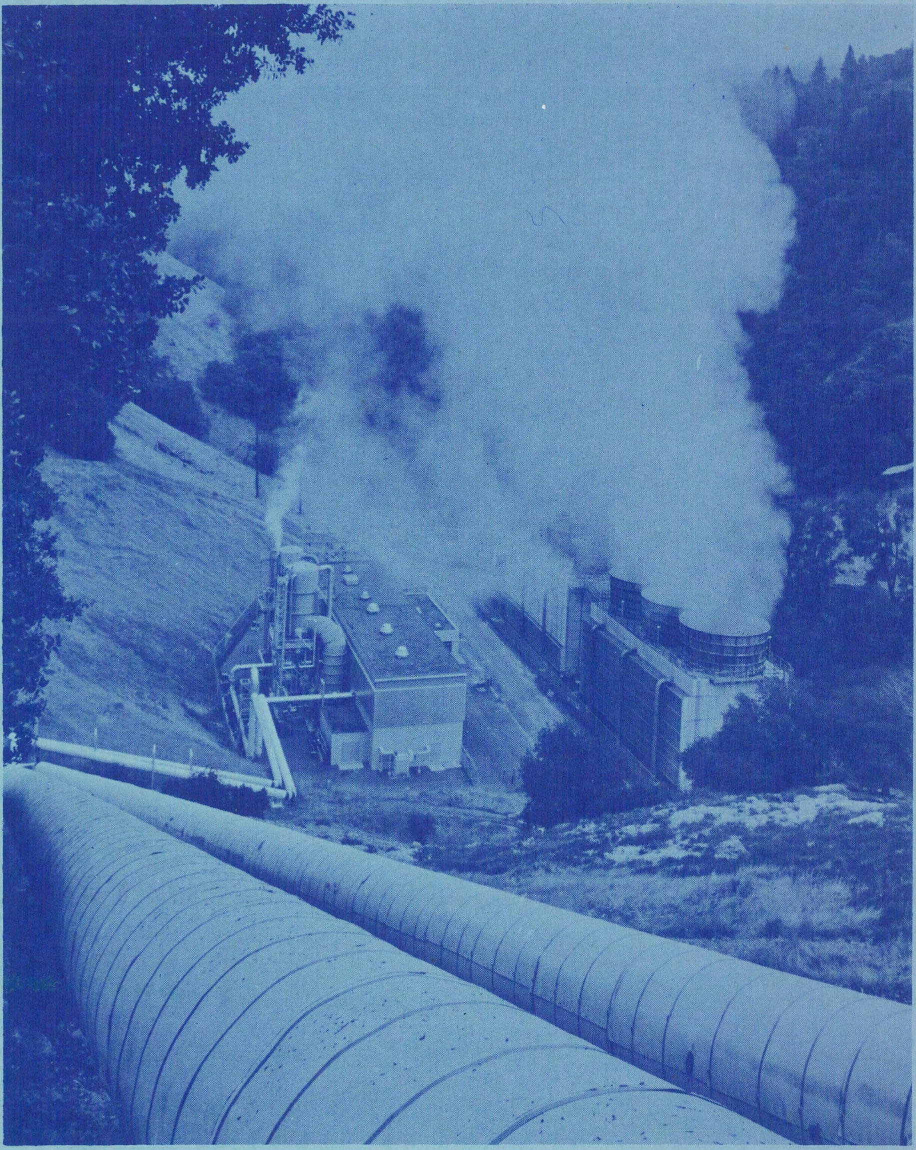
GEOTHERMAL POWER POTENTIAL IN UTAH



Utah Geological and Mineralogical Survey

Special Studies 14

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

103 Civil Engineering Building
University of Utah
Salt Lake City, Utah 84112

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The survey is enjoined to cooperate with all existing agencies to the end that the geological and mineralogical resources of the state may be most advantageously investigated and publicized for the good of the state. The *Utah Code, Annotated, 1953 Replacement Volume 5, Chapter 36, 53-36-2,* describes the Survey's functions.

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The objective is to collect, catalog, and systematically file geologically significant specimens for library reference, comparison, and research, particularly cuttings from all important wells driven in Utah, and from strategic wells in adjacent states, the formations, faunas, and structures of which have a direct bearing on the possibility of finding oil, gas, salines or other economically or geologically significant deposits in this state. For catalogs, facilities, hours, and service fees, contact the office of the Utah Geological and Mineralogical Survey.

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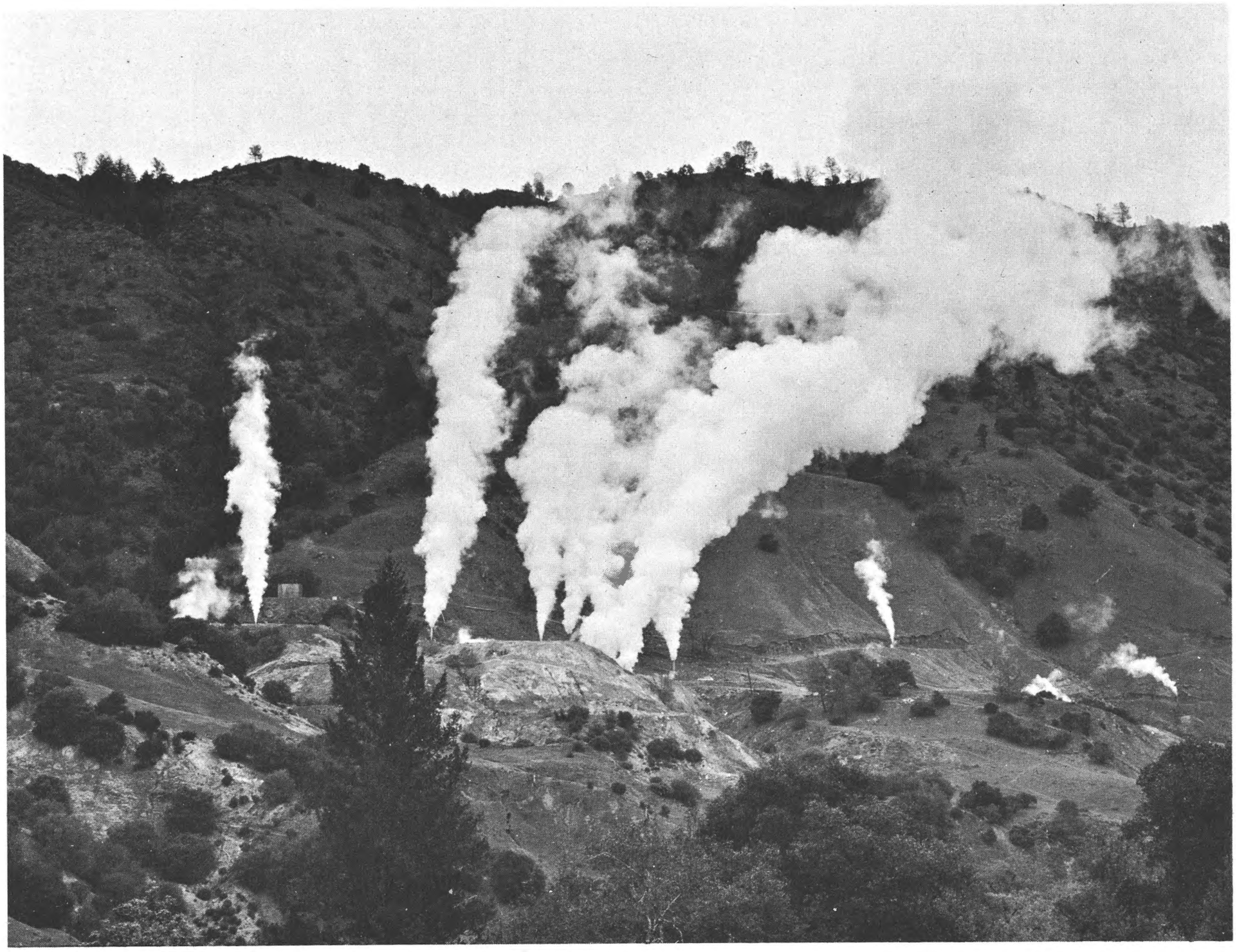
GEOTHERMAL POWER POTENTIAL IN UTAH

by Edgar B. Heylmun



The Geysers, California. General view of steam well area. (Photo courtesy Pacific Gas and Electric Company.)

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affiliated with
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University of Utah, Salt Lake City, Utah

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ILLUSTRATIONS

Note: although not directly concerning Utah, the photographs in this publication illustrate scenes typical of power development elsewhere.

GEOTHERMAL POWER POTENTIAL IN UTAH

by Edgar B. Heylmun[1]

INTRODUCTION

Current interest in the utilization of the internal heat of the earth, as represented by steam and hot water, for development of electric power and other uses in Utah has prompted this brief survey and synthesis of available information. Since earliest times in Utah hot water has been known to occur in springs and wells; many of these have served as the sites of health resorts. No attempt has yet been made in Utah to drill for high temperature steam that would provide energy for power generation. Areas of high geothermal gradient are confined to the western part of the state where mineral fuel sources for local energy supply have not been found.

Natural steam from wells has been harnessed for the generation of electric power since the late 1930's in Italy, and power plants in that country now have a combined capacity in excess of 300,000 kw. Power plants produce 192,000 kw from steam wells in New Zealand. Other geothermal power developments have been undertaken in Iceland, Mexico, the United States, the Soviet Union, Katanga province of the Congo Republic, and Japan, and active exploration has been conducted in many other countries.

In the United States, the principal areas developed so far are in California and Nevada, with additional areas of interest located in Oregon, New Mexico, and Hawaii. The only active power station in the United States which uses natural steam is located at The Geysers 80 miles north of San Francisco, California (McNitt, 1963). The plant now has a generating capacity of 28,000 kw. A pilot plant has been built near the Salton Sea in southern California, where steam, high temperatures, and highly mineralized brines have been discovered in several deep wells. The activity in this area has extended south into Baja California.

Geothermal power exploration and development have been greatest in areas where neither fuel nor hydroelectric power is readily available. Whereas the operation at The Geysers in California has necessitated a relatively low capital investment (McNitt, 1963), most geothermal developments have required rather high capital investments. The steam operations at Larderello in Italy and at Wairakei in New Zealand have cost nearly twice as much as conventional power plants (Kaufman, 1964). This is offset to some degree by relatively low operating costs. Much of the high capital investment is brought about by the experimental nature of most operations. It appears certain that

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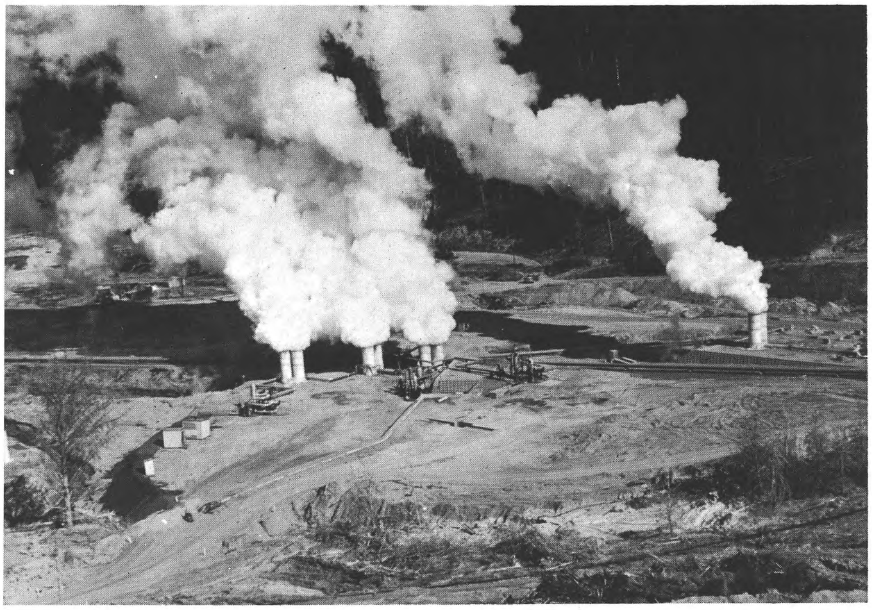

Plate 1A.
New Zealand.
Free flow vents,
Wairakei development area,
North Island.
(Photo courtesy
R. W. Osterstock)

Plate 1B.
The Geysers,
California.
View of expansion loops in steam transmission pipes showing uncapped geyser in background. Steam lines connect wells to the generating plant down the hill to the left.
(Photo courtesy
Pacific Gas and
Electric Company)

large-scale development, accompanied by full-scale installations, would materially decrease the costs. Another expense is incurred by fluid disposal, a problem which has not yet been satisfactorily solved. It is likely, however, that geothermal power will in time be competitive with some conventional power-generating methods.

PREVIOUS WORK

A summary report of the thermal springs of the United States, including 60 springs in Utah, is published in a Water-supply Paper by Stearns and others (1937). A recent Professional Paper by Waring (1965) summarizes the thermal springs of the world, including 57 springs in Utah, and includes a geographically arranged bibliography of 3,733 references. Additional data on thermal springs in parts of Utah are published in Water-supply Papers (Carpenter, 1913; Meinzer, 1911; Richardson, 1907) and Basic-data Reports (Carpenter, 1963; Gates, 1963; Marine and Price, 1963; Mower, 1963; Mower and Feltis, 1964; Sandberg, 1963; Subitzky, 1962) of the Water Resources Division of the U. S. Geological Survey and in a Technical Publication of the State Engineer's Office (Connor and Mitchell, 1958).

The most useful publications of a general nature are perhaps those of the United Nations entitled New Sources of Energy, volumes 1 and 2 (Decius, 1964; Elizondo, 1964; Facca and Tonani, 1964; Studt, 1964; Thompson and others, 1964; White, 1964; and Wilson, 1964). These papers contain considerable information on exploration and development of thermal areas in various parts of the world. Another useful paper is by McNitt (1963), in which geothermal power localities in California are described. The Southern Pacific Railroad publication "Minerals for Industry," volume 1 (1964), briefly describes potential geothermal sites in northern Nevada and northwestern Utah.

The Utah Geological and Mineralogical Survey is indebted to Ted Arnow and James C. Mundorff of the Water Resources Division of the U. S. Geological Survey, who supplied some of the information contained in this report. The Utah Geological and Mineralogical Survey assumes full responsibility, however, for all material included and the interpretations and recommendations expressed.

EXPLORATION METHODS

As noted by McNitt (1963), virtually all of the thermal areas being developed throughout the world are in regions of Tertiary and Quaternary volcanism. The source of heat is related to the processes of volcanism and magmatic intrusion, although much heat is apparently supplied by tectonic stresses. Many thermal areas are in uplifted regions that appear to be underlain by intrusive bodies, or in collapsed regions where there has been extensive volcanism. In areas currently being developed, the fissures which conduct thermal waters are commonly steeply dipping normal faults.

Two types of natural steam are recognized: (a) dry or slightly superheated steam, and (b) saturated wet steam and hot water. The Geysers steam field in California and the steam fields in Italy are of the dry steam type, whereas all other thermal areas drilled to date yield saturated steam and hot water. If possible, it is advantageous to determine by surface measurements whether an area is of the dry or wet steam type, as there is considerable difference in the power-producing potential. Dry steam is preferable for several reasons, although both types of steam can be successfully used. Dry steam is considered by some authorities to be of magmatic origin, whereas wet steam may be recirculated meteoric water which receives its heat primarily from tectonic sources and may possibly be mixed with magmatic fluids and gasses. Wet steam has gained new interest because of the recovery of potentially commercial mineralized solutions with the steam in the Salton Sea area of California. Dry steam areas are characterized by acid-sulfate springs with insignificant chloride content, while springs flowing from wet steam fields usually have a high chloride content. More important, actually, than whether the steam is wet or dry, is whether the spring is "tectonic" or "volcanic." This difference will be discussed later.

Heat flow measurements taken at the surface are among the most common methods of exploration. However, impermeable beds overlying a thermal fluid reservoir can greatly reduce the natural surface heat flow. Thus surface heat flow measurements are useful but not always indicative of the true potential of the underlying reservoir. The Bagnore area in Italy has few surface indications of steam, yet is one of the largest steam fields developed to date. Steam production at some localities occurs eight or more miles from volcanic rocks.

Various geophysical methods, including gravity, magnetic, temperature, radioactivity, and resistivity surveys have been successfully used in prospecting for steam, especially in areas where surface indications of faulting are obscure. Positive gravity and magnetic anomalies have been noted at certain steam fields, possibly indicating buried volcanic or intrusive rocks at depth. Resistivity surveys have been helpful in localizing fault zones as well as indicating geothermally heated areas.

Geochemistry provides one of the best techniques for evaluating the steam potential of a thermal area. Thermal springs should be carefully sampled, not only for the chemical composition of the water itself, but also for the composition of the steam and gasses which evolve. One of the best indicators for magmatic rather than meteoric origin of steam is gas content. The gas content of magmatic steam is normally high, 2 to 3 percent by volume, whereas steam from chloride water is generally of low gas content (Wilson 1964). In cases where it is not easy to distinguish areas of recent volcanic activity from acid hot springs, it is desirable to examine the steam for sulfur dioxide, and the spring water for its polythionate content.

"Volcanic" springs are generally considered to be more favorable than "tectonic" springs for geothermal power development. Heat generated by tectonic stresses rather than from magmatic sources could be expected to contain much less geothermal energy. Wilson (1964) states that true volcanic springs have a calcium to magnesium ratio very close to 4:1, whereas tectonic springs are much more variable, being either higher or lower. Methane gas is characteristic of tectonic springs, whereas the gas of volcanic springs is nearly pure carbon dioxide (CO_2). The deuterium content and the ratios of silica (SiO_2) to solids, bromine to chlorine, potassium to sodium, and lithium to sodium indicate whether or not the waters have received magmatic contributions. For further discussion the reader is referred to White (1957).

Areas where the chemical analyses of thermal waters vary markedly from place to place are not favorable for power development. Uniformity of chemical analyses over a considerable area suggests a sizeable reservoir source. If there are several centers of activity in a given thermal area, the center with the lowest sodium to potassium (Na/K) ratio would be fed most directly from the underground supply (Wilson, 1964).

No reliable methods have been established for calculation of steam reserves at a given field. A great variety of factors must be considered in estimating the reserves. Methods used to calculate the reserves of oil and gas fields are not applicable to steam fields.

LEASING PROCEDURE

Although there is no way that wells can be drilled for steam on federal lands due to conflicts with other interests, a bill is pending[1] before Congress to permit the leasing of federal lands for geothermal power. State and private lands may be drilled for steam by obtaining a well-drilling permit from the State Engineer's Office, and, in the case of state land, filing appropriate lease forms with the State Land Board.

THERMAL AREAS IN UTAH

Broadly speaking, thermal springs in Utah can be grouped into six areas which are roughly parallel or en echelon in nature and trend in general north-south or northeast-southwest directions. (See fig. 1.) The areas or belts of thermal springs have been arbitrarily named as follows:

1. Wasatch area
2. Western desert area
3. Sevier-Sanpete area
4. Panguitch area
5. Hurricane area
6. Snake Valley area

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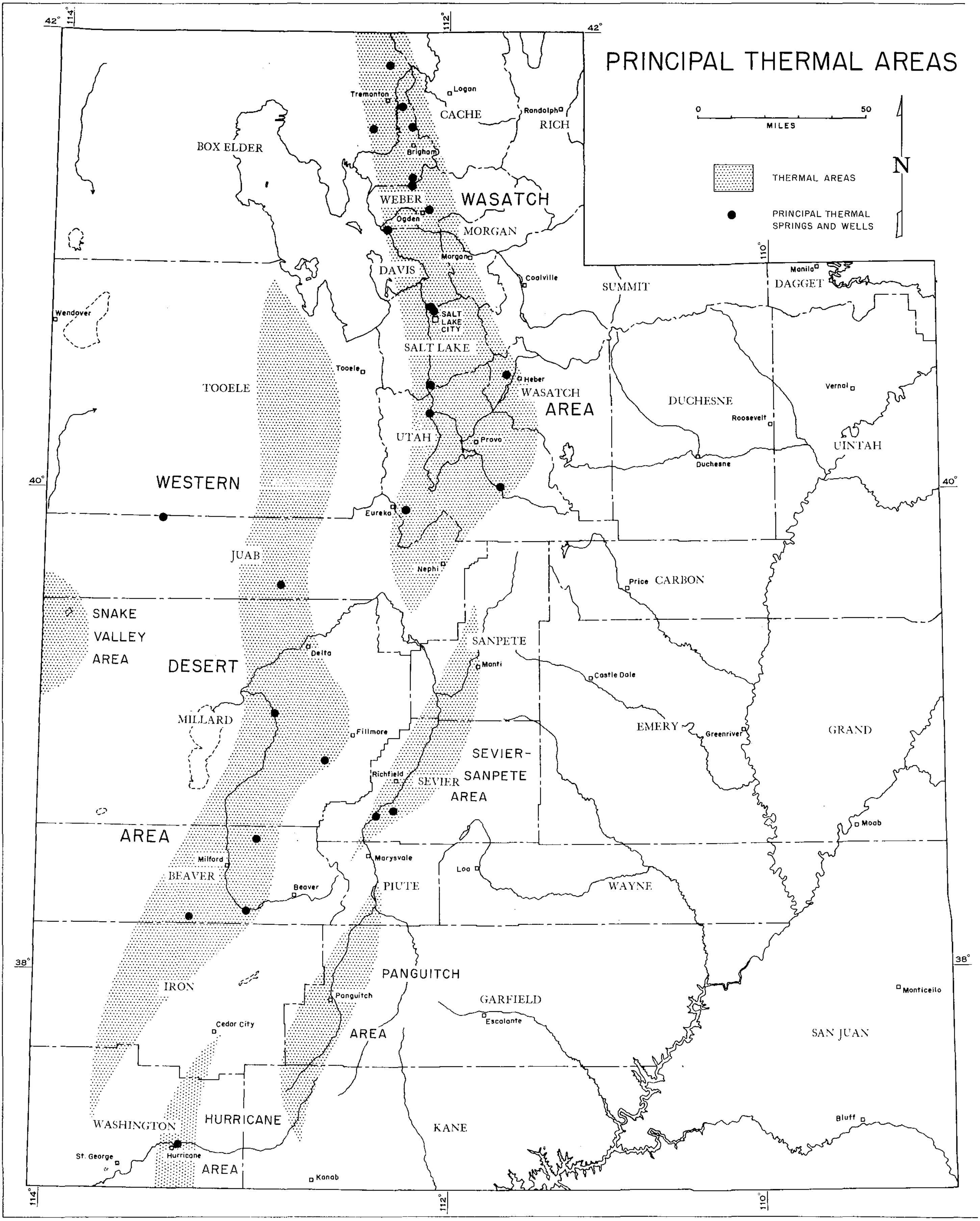
1. At the time of this writing - October, 1965.



PRINCIPAL THERMAL AREAS
0 MILES 50
THERMAL AREAS
PRINCIPAL THERMAL SPRINGS AND WELLS
N
42°
114°
112°
110°
40°
38°
BOX ELDER
CACHE
RICH
WEBER
WASATCH
MORGAN
DAVIS
SUMMIT
DAGGET
SALT LAKE
TOOELE
WASATCH
AREA
DUCHESNE
UINTAH
UTAH
WESTERN
JUAB
CARBON
SNAKE
VALLEY
AREA
DESERT
SANPETE
MILLARD
EMERY
GRAND
SEVIER-
SANPETE
AREA
SEVIER
AREA
BEAVER
PIUTE
WAYNE
PANGUITCH
IRON
GARFIELD
AREA
SAN JUAN
WASHINGTON
HURRICANE
AREA
KANE
Tremonton
Logan
Randolph
Brigham
Ogden
Morgan
Coalville
Manila
Wendover
SALT LAKE CITY
Tooele
Heber
Vernal
Roosevelt
Provo
Duchesne
Eureka
Nephi
Price
Delta
Manti
Castle Dale
Fillmore
Greenriver
Richfield
Moab
Marysvale
Milford
Loa
Beaver
Panguitch
Monticello
Escalante
Cedar City
Bluff
St. George
Hurricane
Kanab

Figure 1.

The Wasatch and western desert areas are perhaps the most significant, although geothermal prospects may exist in other areas as well.

The principal thermal areas considered here are coincident with zones of major faulting and crustal collapse near the eastern periphery of the Great Basin. This extensive collapsing occurred during the Late Tertiary and Quaternary, apparently as a result of the evacuation of large amounts of magma from within the crust. The magma was extruded in the form of fiery volcanic outbursts, including lava flows and nuées ardentes. It is presumed that the slow cooling of the volcanic material, both near the surface and at depth, coupled with continued volcanic activity up to recent time, accounts for the heat source supplying the thermal springs in many parts of Utah.

Wasatch Area

The Wasatch area includes the Wasatch Range and flanking valleys to east and west, extending from Idaho south to the Tintic mining district and Nephi. Thermal springs rise from concealed faults at a number of localities, mostly along the west side of the Wasatch Range. Warm and hot springs[1] occur in Ogden, Morgan, Heber, and Round Valleys on the backslope (east side) of the Wasatch Range; of these, Hot Pots at Midway, in Heber Valley, are the most interesting (Wheeler, 1875).

Some of the more important hot springs which occur in the fault zones along the west side of the Wasatch Range are, from north to south, Crystal Springs near Honeyville (north of Brigham City), Utah Hot Springs north of Ogden, and Beck's and Wasatch Springs near Salt Lake City. (See fig. 2.) These springs rise along the Wasatch fault zone, commonly near the apex of spurs or salients projecting westward from the main mountain range. For the most part, waters of springs issuing from fault zones along the west side of the Wasatch Range have relatively high chloride content and are rather remote from Tertiary or Quaternary volcanic rocks. The closest rocks, in many instances, are Paleozoic sedimentary units on the upthrown side of the faults. In all probability, waters rising in thermal springs along the west side of the Wasatch Range and in the adjoining valleys consist largely of recirculated meteoric water. High chloride content of waters in some springs suggests invasion by highly saliniferous waters associated with Great Salt Lake. The heat source for springs along the west side of the Wasatch Range is probably of tectonic origin, and it is doubtful that this source could provide a very great store of geothermal energy.

Waters at the Hot Pots near Midway, in Heber Valley, contain considerably less chloride than those on the west side of the Wasatch Range. (See analysis,

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1. The principal localities of warm and hot springs are described in detail on pages 15 - 19. Chemical analyses of some springs are listed on pages 21 - 25.

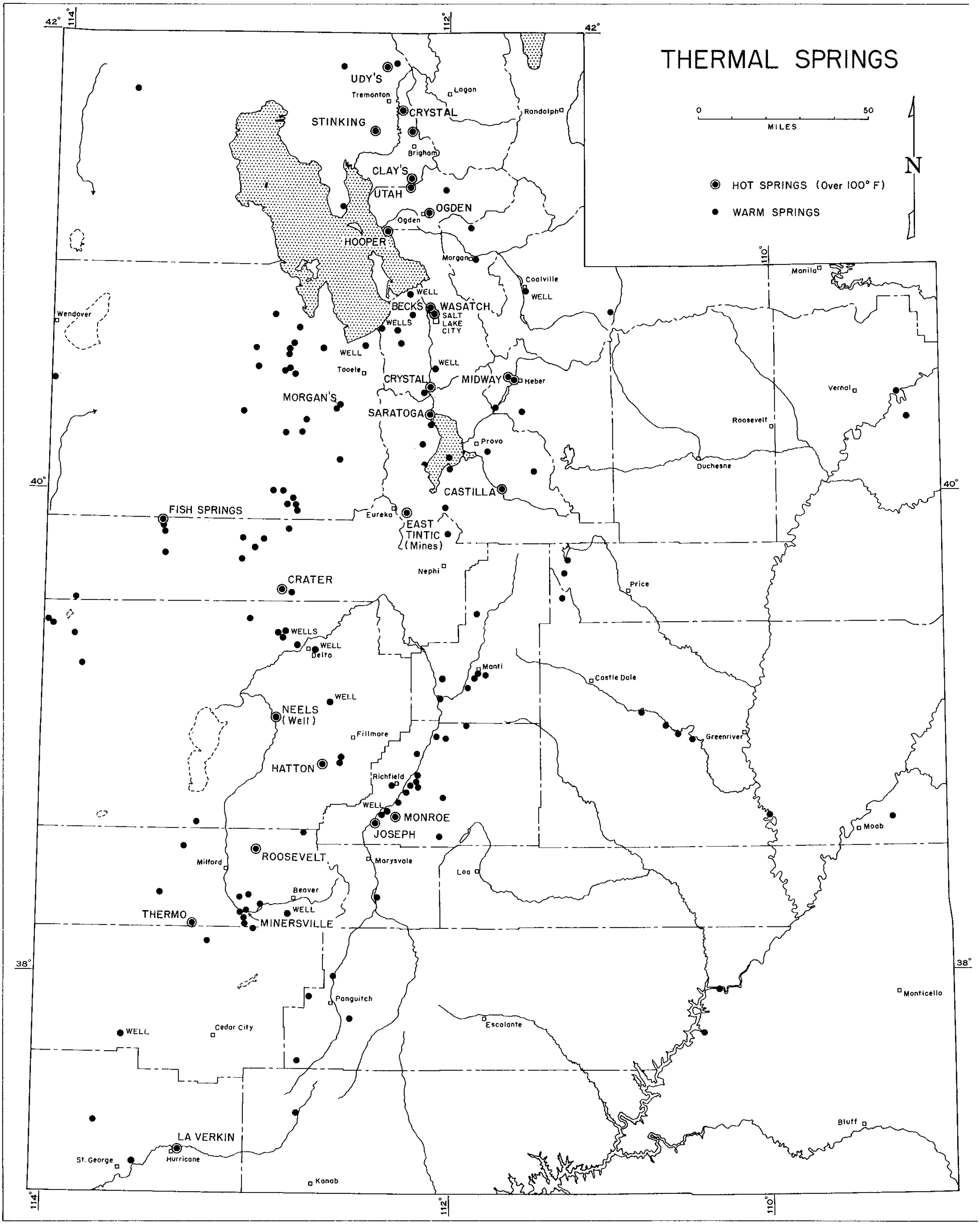
THERMAL SPRINGS
0
50
MILES
N
HOT SPRINGS (Over 100° F)
WARM SPRINGS
42°
114°
112°
110°
40°
38°
UDY'S
Tremonton
Logan
CRYSTAL
STINKING
Randolph
Brigham
CLAY'S
UTAH
OGDEN
Ogden
HOOPER
Morgan
Coalville
WELL
Manila
WELL
BECKS
WASATCH
SALT LAKE CITY
WELLS
Wendover
WELL
Tooele
WELL
CRYSTAL
MIDWAY
Heber
MORGAN'S
Vernal
SARATOGA
Roosevelt
Provo
Duchesne
CASTILLA
FISH SPRINGS
Eureka
EAST TINTIC (Mines)
Nephi
CRATER
Price
WELLS
WELL
Delta
Manti
Castle Dale
WELL
NEELS (Well)
Fillmore
Greenriver
HATTON
Richfield
WELL
MONROE
JOSEPH
Moab
ROOSEVELT
Milford
Marysvale
Loa
Beaver
WELL
THERMO
MINERSVILLE
Panguitch
Monticello
WELL
Cedar City
Escalante
Bluff
LA VERKIN
St. George
Hurricane
Kanab

Figure 2.

p. 22.) If these waters contain steam and gasses of magmatic origin, then the Midway locality would be of prime interest as a source of geothermal power. Hot water encountered in mines at East Tintic is possibly of volcanic origin, so that locality is of interest for the development of steam wells.

Western Desert Area

The western desert area, which extends south from Skull and Tooele Valleys through the Sevier Desert into Milford Valley and the Escalante Desert, includes several centers of Late Tertiary and Quaternary volcanism. Morgan's Springs, Crater (Abraham) Hot Springs, Minersville Springs, and the Thermo Hot Springs are some of the better-known springs. Although isolated, Fish Springs is included in the western desert area for convenience.

Chloride content in the springs is variable through a wide range, and that of the Roosevelt, Minersville, and Thermo Springs is relatively low. Nothing is known of the chemical composition of steam and gasses in the area, but the region may prove to be attractive for geothermal power development. Both "volcanic" and "tectonic" springs appear to be present in this belt. Certain wells have reached thermal waters at depth, particularly in the Sevier Desert and in Milford Valley.

Some springs, such as Crater and Hatton, are in the immediate vicinity of Late Tertiary or Quaternary basalt flows and craters.

Sevier-Sanpete Area

The Sevier-Sanpete area includes portions of Sevier and Sanpete Valleys in central Utah and may be a southern continuation of the Wasatch area. The Sevier and Sanpete Valleys are subsequent to a major north-south rift zone along which movements have occurred until nearly historical times. The Monroe and Joseph Hot Springs, both in the southern part of the region, are the best known. Though Tertiary volcanism has been extensive in the southern part, the probable source of the springs is recirculated meteoric water mixed with magmatic fluids rising along major fault zones.

Panguitch Area

Only a few warm springs are recorded for the Panguitch area. Prospects are not encouraging for steam development in spite of Late Tertiary or Quaternary volcanism.

Hurricane Area

The La Verkin Spring issuing from a fault in Triassic rocks has a temperature of 132° F and a flow of 1,000 gpm (gallons per minute).

Snake Valley Area

Warm springs issue from limestone and alluvium in Snake Valley. Possibilities for steam development appear remote.

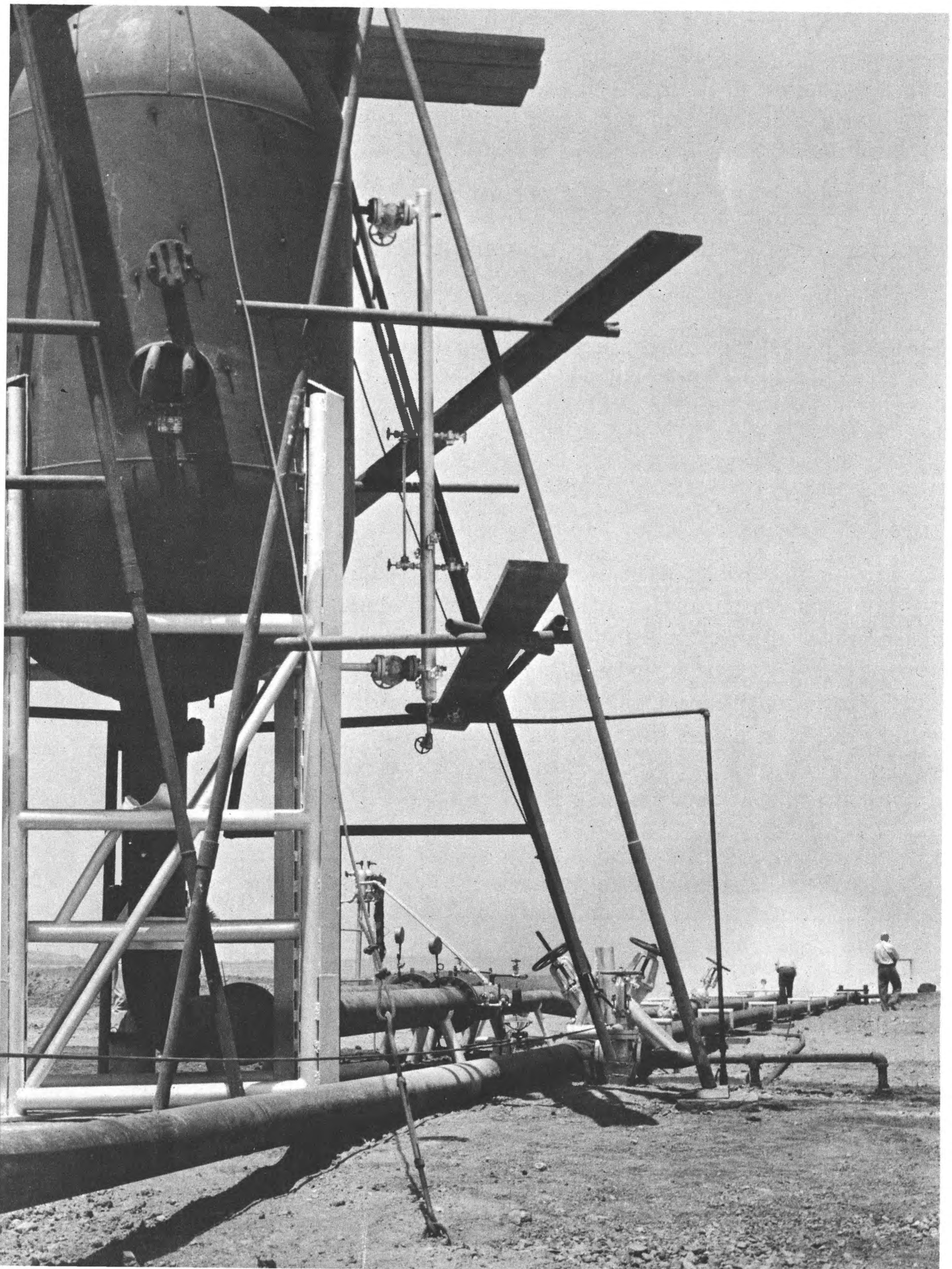

Figure 3. Testing Imperial Irrigation District no. 1 geothermal well drilled by O'Neill Geothermal, Inc. in sec. 23, T. 11 S., R. 13 E., SBBM, Imperial County, California. Large tank is water steam separator. (Photo courtesy Imperial Irrigation District)

PRINCIPAL WARM AND HOT SPRINGS

Localities of hot springs, i. e., springs with waters in excess of 100° F, along with a few warm springs, will be briefly described. Clusters of warm springs, none reported to have temperatures above 100° F, will not be discussed, although it is recognized that geothermal prospects could exist in these areas. Groups of warm springs occur in many parts of Utah. (See fig. 2.) The following springs are located with reference to the Salt Lake Base and Meridian.

Wasatch Area

Beck's Hot Springs, sec. 14, T. 1 N., R. 1 W., Salt Lake County. Springs issue from Warm Springs fault, which is part of the Wasatch fault system. Paleozoic rocks crop out immediately to the east. A nearby associated spring is known as "Hobo Hot Spring." Maximum temperature observed, 132° F. Probable source of heat: tectonic.

Castilla Hot Springs, sec. 18, T. 9 S., R. 4 E., Utah County. Springs issue from Permian rocks in Spanish Fork Canyon. Volcanic rocks crop out 3 miles to the east. Maximum temperature observed, 145° F. Probable source of heat: tectonic.

Crystal Hot Springs (Honeyville), sec. 29, T. 11 N., R. 2 W., Box Elder County. About 30 springs issue from Wasatch fault zone at base of Wellsville Mountain, a tilted fault block of Paleozoic rocks. The nearest volcanic flows are nearly 30 miles to the east. Maximum observed temperature, 132° F. Probable source of heat: tectonic.

Crystal Hot Springs (Point of the Mountain), secs. 11 - 12, T. 4 S., R. 1 W., Salt Lake County. Up to 60 gpm issue from concealed faults along north flank of the Traverse Range, a small east-west range of Late Paleozoic and volcanic rocks. Most temperatures observed have been less than 100° F, but one observer recorded 137° F. Probable source of heat: tectonic.

Hooper Hot Springs, sec. 27, T. 5 N., R. 3 W., Davis County. About 30 gpm issue from tufa deposits on valley sediments near shores of Great Salt Lake. Nearest volcanic rocks are over 30 miles from this locality. Maximum observed temperature, 140° F. Probable source of heat: tectonic.

Midway Hot Pots, secs. 26, 27, 34, and 35, T. 3 S., R. 4 E., Wasatch County. Large groups of springs issue from tufa beds and mounds in Heber Valley. Included are Schneitter's and Luke's Hot Pots. Faulted Triassic and Paleozoic rocks are nearby, and volcanic rocks crop out 4 miles to the northeast. Maximum temperature observed, 116° F. Probable source of heat: volcanic or tectonic.

Ogden Hot Springs, sec. 23, T. 6 N., R. 1 W., Weber County. Springs rise along Wasatch fault zone at base of the Wasatch Range. Rocks in range consist of lower Paleozoic and Precambrian sedimentary formations. No volcanic flow rocks are exposed within 40 miles. Maximum temperature observed, 137° F. Probable source of heat: tectonic.

Saratoga Hot Springs, sec. 25, T. 5 S., R. 1 W., Utah County. Over 200 gpm issue from concealed faults under valley sediments on the northwest shore of Utah Lake. Paleozoic sedimentary rocks are exposed 1 mile to the west, while volcanic rocks crop out 4 miles to the north. Most springs are less than 100° F, but one observation of 118° F has been made. Probable source of heat: tectonic.

Stinking Springs, sec. 30, T. 10 N., R. 3 W., Box Elder County. Springs issue from concealed fault zone at base of Little Mountain, a hill composed of Paleozoic (Mississippian) sedimentary rocks. The area has high radioactivity. Maximum temperature observed, 124° F. Probable source of heat: tectonic.

Udy's Hot Springs, sec. 14, T. 13 N., R. 3 W., Box Elder County. Approximately 3,500 gpm discharge from probable concealed faulting under Malad Valley. Late Tertiary tuff beds crop out 2 miles to the northeast. Maximum temperature observed, 110° F. Probable source of heat: tectonic.

Utah Hot Springs, sec. 14, T. 7 N., R. 2 W., Weber and Box Elder Counties. Over 100 gpm issue from Wasatch fault zone at base of lower Paleozoic (Cambrian) quartzite hill. No volcanic rocks are exposed within 40 miles of this locality. Clay's Hot Springs adjoin to the north, also along the fault zone. Maximum temperature observed, 142° F. Probable source of heat: tectonic.

Wasatch Hot Springs, sec. 25, T. 1 N., R. 1 W., Salt Lake County. About 1,000 gpm issue from Warm Springs fault zone, part of the Wasatch fault system, within the Salt Lake City limits. Paleozoic and Tertiary rocks crop out immediately to the east. Small patches of volcanic ejecta can be found less than 1 mile to the east. Maximum temperature observed, 112° F. Probable source of heat: tectonic.

Western Desert Area

Crater (Abraham) Hot Springs, secs. 10, 14, and 15, T. 14 S., R. 8 W., Juab County. Approximately 1,200 gpm issue from base of Fumerole Butte, a basaltic mesa in the Sevier Desert. Steam and gasses escape from fissures and fumeroles on the mesa. Maximum temperature observed, 189° F. Probable source of heat: volcanic.

Fish Springs, secs. 4, 5, 15, 23, 24, 25, and 26, T. 11 S., R. 14 W., Juab County. A group of large springs along the faulted east and north flanks of the Fish Springs Range, an uplifted block of lower Paleozoic rocks. Included in this group of springs are Big Springs and Wilson Hot Springs. Most springs have temperatures under 100° F, but a reading of 140° F was obtained at the Wilson Hot Springs (Little Yellowstone) at the north end of the Fish Springs Range. The nearest volcanic rocks are 12 miles to the southwest. Probable source of heat: tectonic.

Hatton (Black Rock) Hot Springs, sec. 35, T. 22 S., R. 6 W., Millard County. Large spring issues from tuffaceous beds in a recent lava flow. This volcanic area is described by Gilbert (1890). Maximum observed temperature, 100° F. Probable source of heat: volcanic.

Minersville (Dotson's or Radium) Warm Springs, sec. 7, T. 30 S., R. 9 W., Beaver County. Approximately 57 gpm issue from complex fault zone along west side of Mineral Mountains. Triassic sedimentary rocks and volcanic rocks are exposed in the immediate vicinity. Maximum temperature observed, 97° F. Several other warm springs are in the general area. Probable source of heat: volcanic or tectonic.

Morgan's Warm Springs, sec. 9, T. 5 S., R. 5 W., Tooele County. About 2.5 cfs[1/] flow from springs near base of low hill of late Paleozoic sedimentary rocks at north end of Rush Valley. Faulting is probably concealed under valley alluvium. Russell's Warm Springs are approximately one-half mile to the southwest. Maximum temperature observed, 96° F. Probable source of heat: tectonic.

Roosevelt (McKean's) Hot Springs, sec. 34, T. 26 S., R. 9 W., Beaver County. Small springs issue from fault zone on west side of Mineral Mountains. Granitic and metamorphic rocks crop out immediately to the east. Volcanic flows are found 6 miles from the springs. The largest of the springs, flowing about 10 gpm, is reported to be boiling. The presence of boiling water and live steam enhances the geothermal prospects. Maximum recorded temperature, 185° F. Probable source of heat: volcanic or tectonic.

Thermo Hot Springs, secs. 21 and 28, T. 30 S., R. 12 W., Beaver County. Large group of springs issuing from tufa deposits in desert valley. Volcanic rocks crop out one mile to the east. Located 15 miles west of a cluster of warm springs in the Minersville area. Maximum temperature observed, 185° F. Probable source of heat: volcanic or tectonic.

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1. Cubic feet per second.

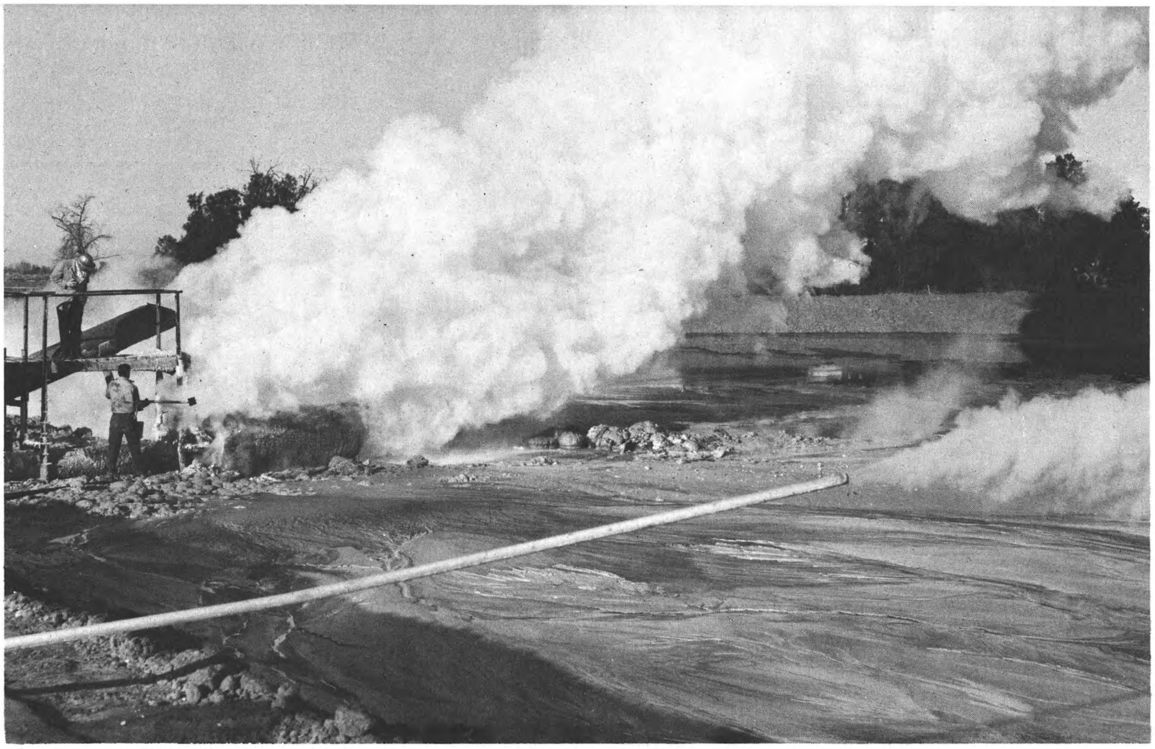

Plate 2A. River Ranch Well, Salton Sea area, California.
(Photo courtesy Earth Energy Inc.)

Plate 2B. River Ranch Well, Salton Sea area, California, being tested upon completion of the well. (Photo courtesy Earth Energy, Inc.)

Sevier-Sanpete Area

Joseph Hot Springs, sec. 23, T. 25 S., R. 3 W., Sevier County. Approximately 30 gpm issue through tufa beds at base of lava ridge. Region is complexly faulted. Maximum observed temperature, 146° F. Probable source of heat: volcanic or tectonic.

Monroe Hot Springs, secs. 10, 11, and 15, T. 25 S., R. 3 W., Sevier County. Over 100 gpm issue from several springs, including Cooper Hot Springs in fault zone at base of volcanic mountains. Maximum temperature observed, 168° F. Probable source of heat: volcanic or tectonic.

Hurricane Area

La Verkin (Dixie) Hot Springs, sections 25 and 26, T. 41 S., R. 13 W., Washington County. Over 1,000 gpm issue from Permian rocks along the Hurricane fault in the Virgin River Canyon. Recent basalt flows and cinder cones are in the vicinity. Maximum observed temperature, 132° F. Probable source of heat: tectonic or volcanic.

WELLS

Many oil, gas, and water wells have penetrated warm or hot water at depth. A water well drilled in 1906 at Neels, Utah (T. 20 S., R. 8 W., Millard County), penetrated hot water and live steam to a depth of 1,998 feet. Steam reportedly escaped freely from the hole. A high pressure gas zone was struck at a depth of 1,802 feet (Lee, 1908).

Other wells drilled for water in Utah that reached thermal fluids include the following:

Location	Total Depth (feet)	Temperature (°F)
T. 1 N., R. 2 W., sec. 25	?	84
T. 2 N., R. 2 W., sec. 35	?	80
T. 1 S., R. 2 W., sec. 19	333	83
T. 1 S., R. 3 W., sec. 17	502	85
T. 2 S., R. 4 W., sec. 9	687	86
T. 3 S., R. 1 E., sec. 18	1,150	82
T. 4 S., R. 1 W., sec. 2	825	83
T. 5 S., R. 1 W., sec. 25	147	95
T. 16 S., R. 8 W., sec. 12	954	80
T. 16 S., R. 8 W., sec. 21	996	84
T. 16 S., R. 8 W., sec. 26	1,076	85
T. 17 S., R. 6 W., sec. 17	840	82

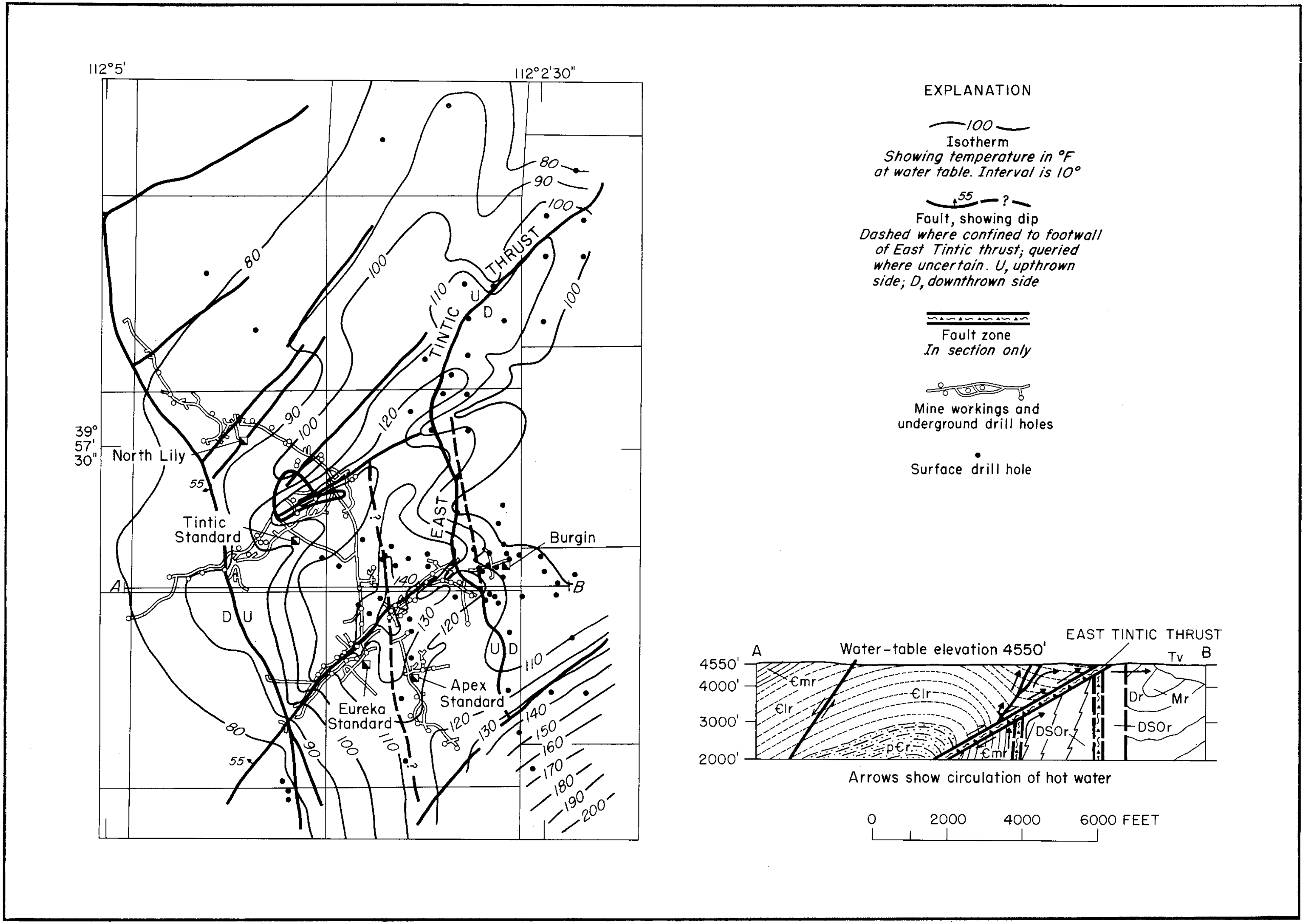

Figure 4. Isothermal map of the East Tintic mining district, by Dr. T. S. Lovering. (Courtesy Mining Engineering, copyrighted by A.I.M.E.)

Location	Total Depth (feet)	Temperature (^oF)
T. 17 S., R. 7 W., sec. 4	865	80
T. 12 S., R. 5 W., sec. 31	375	85
T. 30 S., R. 9 W., sec. 7	?	92
T. 36 S., R. 15 W., sec. 7	250	87

Wells drilled for oil and gas in section 16, T. 2 N., R. 5 E., Summit County, near Coalville, and in the area of the Virgin oil field, T. 41 S., R. 12 W., Washington County, encountered warm sulfur water at depth. A number of other wells probably penetrated zones containing thermal fluids, but records are often incomplete, and many are difficult to interpret.

MINES

The temperature of water found in mines in the East Tintic mining district, T. 10 S., R. 2 W., Utah and Juab Counties, is as high as 163° F, with an average of 104° F (Lovering, 1965). The general elevation of the water table under the district is 4,550 feet, that is, about 1,500 feet below the ground. The water-table surface slopes eastward roughly 50 feet per mile, and may emerge at thermal springs on the west and south ends of Utah Lake. Information from mines and drill holes indicates that there is a steady rise in temperatures southeast from the main part of the mining district, and temperatures up to 200° F are postulated by Lovering. (See fig. 4.)

Temperatures found in other mining districts are not available, but in all probability, most other areas have normal temperatures in line with the standard thermal gradient.

CHEMICAL ANALYSES

Partial chemical analyses are available from certain thermal springs and wells most of which are described in detail above (p. 15). The available analyses are as follows:

Wasatch Area

Crystal Hot Springs (Honeyville)
Box Elder County

	ppm[1]
Bicarbonate	454
Calcium	901
Chloride	27,081
Magnesium	218
Sulfate	497
Total solids	45,541

1. Parts per million.

Crystal Hot Springs (Point of the Mountain)
Salt Lake County

	ppm
Bicarbonate	285
Calcium	106
Chloride	598
Magnesium	25
Silica	60
Sodium and potassium	304
Sulfate	97
Total solids	1,665

Midway Hot Pots
Wasatch County
Sample taken from Luke's Hot Pots

	ppm
Bicarbonate	0
Calcium	329
Chloride	122
Fluoride	1
Magnesium	74
Nitrate	0
Silica	26
Sodium and potassium	154
Sulfate	705
Total solids	2,003

Ogden Hot Springs
Weber County

	ppm
Bicarbonate	220
Calcium	340
Chloride	5,120
Magnesium	10
Silica	45
Sulfate	95
Total solids	9,720

Stinking Springs
Box Elder County

	ppm
Bicarbonate	393
Calcium	878
Chloride	18,460
Magnesium	379
Sulfate	20
Total solids	30,440

Utah Hot Springs
Weber County

	ppm
Bicarbonate	215
Calcium	1,020
Chloride	12,980
Magnesium	40
Silica	15
Sulfate	185
Total solids	22,370

Wasatch Hot Springs
Salt Lake County

	ppm
Bicarbonate	87
Calcium	490
Chloride	3,612
Magnesium	108
Silica	26
Sodium and potassium	2,106
Sulfate	1,036
Total solids	8,432

Well (sec. 9, T. 2 S., R. 4 W.)[1]
Tooele County

	ppm
Calcium	112
Chloride	1,520
Magnesium	44
Silica	30
Sodium and potassium	894
Sulfate	66
Total solids	2,780

Western Desert Area

Crater (Abraham) Hot Springs
Juab County

	ppm
Bicarbonate	142
Calcium	352
Chloride	1,480
Potassium	54
Silica	75

1. Between Wasatch and Western Desert areas.

Sodium	770
Sulfate	704
Total solids	3,560

Minersville (Dotson's or Radium) Warm Springs
Beaver County

	ppm
Calcium	111
Chloride	65
Fluoride	3
Magnesium	23
Silica	32
Sodium and potassium	190
Sulfate	477
Total solids	1,020

Roosevelt (McKean's) Hot Springs
Beaver County

	ppm
Bicarbonate	30
Calcium	31
Chloride	87
Magnesium	10
Nitrate	2
Silica	101
Sulfate	90
Total solids	645

Thermo Hot Springs
Beaver County

	ppm
Bicarbonate	384
Calcium	82
Chloride	212
Fluoride	6
Magnesium	11
Nitrate	1
Potassium	51
Silica	112
Sodium	370
Sulfate	458
Total solids	1,490

Joseph Hot Springs
Sevier County

	ppm
Bicarbonate	426
Calcium	282
Chloride	1,750
Lithium	8
Magnesium	36
Potassium	68
Silica	85
Sodium	1,440
Sulfate	1,270
Total solids	5,150

Monroe Hot Springs
Sevier County

	ppm
Bicarbonate	416
Calcium	288
Chloride	660
Fluoride	3
Magnesium	33
Potassium	67
Silica	54
Sodium	555
Sulfate	833
Total solids	2,860

Hurricane Area

La Verkin (Dixie) Hot Springs
Washington County

	percent
Bicarbonate	7.0
Calcium	10.9
Chloride	31.3
Magnesium	2.4
Sodium	36.7
Sulfate	13.0
Total solids	9,890

Of the two principal belts of thermal springs in Utah, the Wasatch and Western Desert belts, the latter generally has springs with the higher temperatures and lower chloride contents. Except for the Midway Hot Pots, most of the hot springs associated with the Wasatch Range have exceptionally high chloride contents.

Exploration and evaluation of geothermal potential in Utah depends upon systematic drilling of wells under controlled conditions. The Wasatch and Western Desert areas are the most extensive but the latter appears to offer the most hopeful possibilities for development of steam wells. Of particular interest are the following localities: Fumerole Butte and Crater Hot Springs, the vicinity of Neels south of Delta and the vicinities of Roosevelt, Thermo and Minersville Springs in Beaver County. In the Sevier-Sanpete area, springs at Monroe deserve consideration as do the Midway Paint Pots in the Wasatch area.

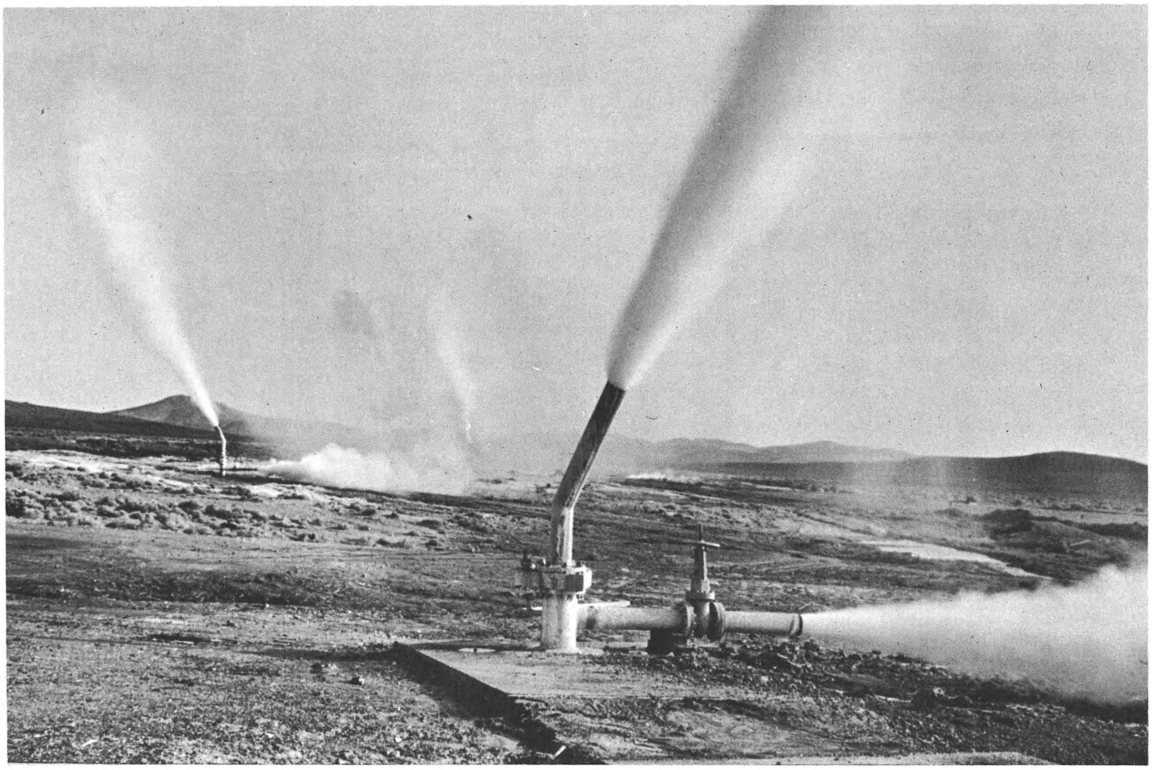

Figure 5. Brady Hot Springs, Nevada, geothermal wells.
(Courtesy Southern Pacific Company)

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