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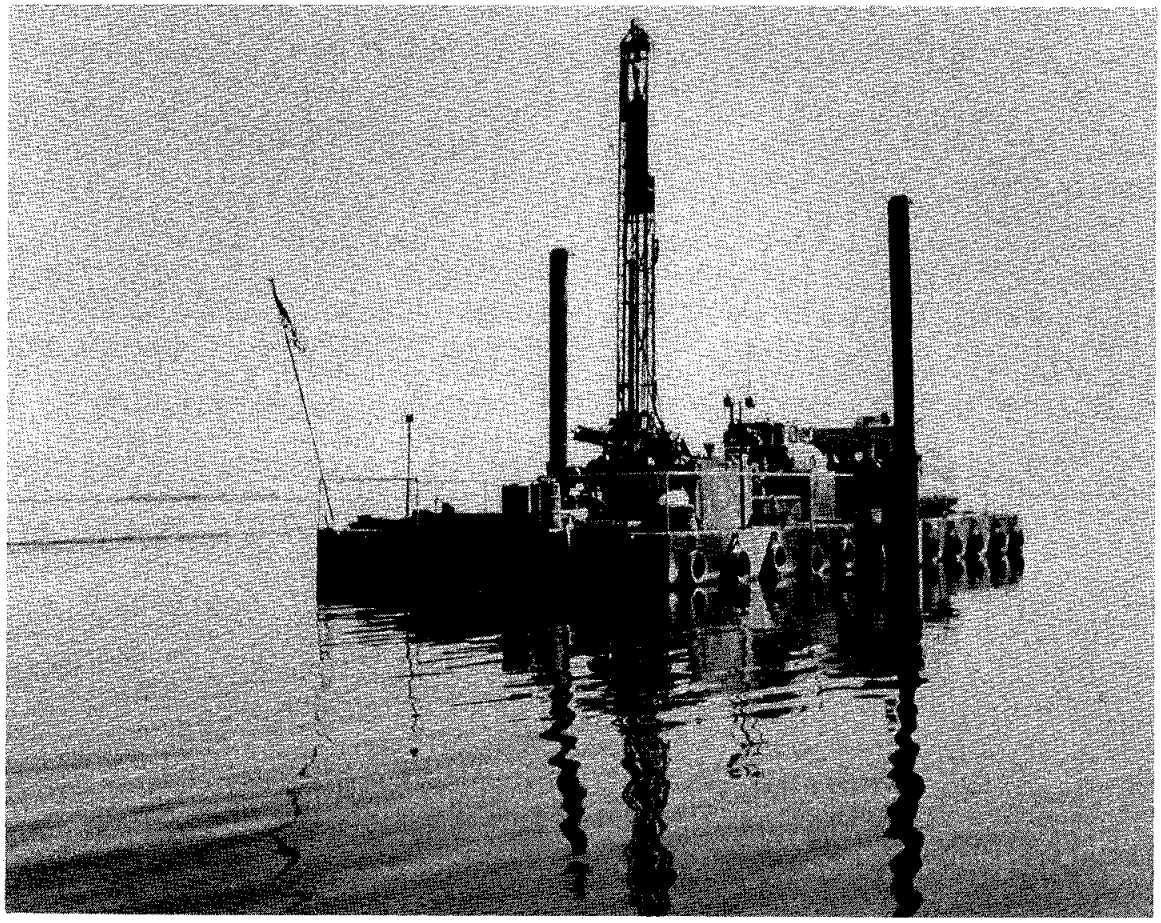

A Louisiana spud barge in the southeastern corner of the Salton Sea. Twenty 250-foot offshore temperature probe holes were drilled from the barge by Bear Creek Mining Company. The holes are California's first geothermal offshore temperature probe holes.

*The free-floating barge, comprised of nine pontoon sections, measures 40 feet- by -60 feet. The barge is anchored by lowering the large shafts on either side of the drilling rig to the sea floor. Photo by Larry Grogan.**(Story on page 62.)*

The *Hot Line* is a biannual publication of the California Division of Oil and Gas. Subscriptions to the *Hot Line* are free. To subscribe, send your name and address to the California Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814.

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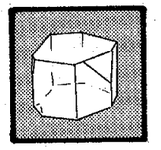
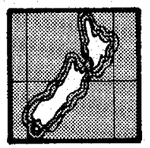
IN THIS ISSUE





Imperial Valley

Geothermal Temperature Probe Holes Drilled in the Salton Sea

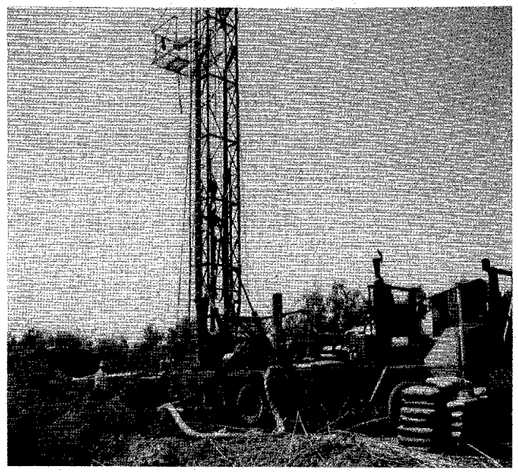
Bear Creek Mining Company, a subsidiary of The Kennecott Corporation, made California history this summer. Twenty of the 40 temperature probe holes drilled by the company in August and September 1982 were on leases beneath the southeastern portion of the Salton Sea. The holes were the first offshore temperature probe holes drilled in California in the search for geothermal resources.

Bear Creek's 20 onshore holes were drilled on leases to the southeast of the Salton Sea. Roger Andrews, Manager of Geothermal Projects for Bear Creek, said that preliminary shallow gradient and heat flow data are being evaluated for all 40 holes. However, he expects that the drill sites eventually chosen for one or several deep exploratory geothermal wells will be at onshore locations.

If a resource is found, the Bear Creek Mining Company plans to sell flashed steam extracted from the geothermal wells to a utility. The utility would generate electricity from the steam at a power plant to be built nearby.

Andrews added that Bear Creek is interested in selling minerals extracted from geothermal brines. Final decisions have not been made on which minerals to market or in what forms to market them.

The minerals would be separated from geothermal brines as by-or co-products of the electrical generation process. Their removal would mean the brines may be injected more easily when the electrical generation process is completed.



In addition to the offshore temperature probe holes drilled in the Salton Sea, Bear Creek drilled 20 onshore temperature probe holes on leases around the southeastern edge of the sea. All the wells were drilled to a depth of 250 feet and widely spaced over the company's lease block. Photo by Larry Grogan.

Making a temperature probe. Once the probe hole was drilled, lengths of plastic pipe were connected, lowered, and cemented into the hole. Then, the plastic pipe was filled with water. A thermister was lowered down the pipe to measure temperatures. Photo by Larry Grogan.

Mineral Recovery from Geothermal Brines

The following references for mineral recovery from geothermal brines were compiled by Larry E. Schultze, research chemist with the U.S. Bureau of Mines.

Schultze and his colleagues will work on aspects of mineral recovery from geothermal brines through September 1983. Results will be published as the tasks are completed.

For further information, contact Larry Schultze at the U.S. Bureau of Mines, 1605 Evans Avenue, Reno, Nevada 89512. (702) 784-5372.

For locations of U.S. Bureau of Mines libraries, see reference #2.

1. Berthold, C. E., P. Hadzeriga, D. H. Christopher, T. A. Applegate, and D. M. Gillespie. Process Technology for Recovering Geothermal Brine Minerals. BuMines Open File Rept. 35-75, 1975, 255 pp.; available for reference during working hours only at the Bureau of Mines libraries and from National Technical Information Service, Springfield, VA., PB 241 867/AS.

2. Berthold, C. E., and F. M. Stephens. Magmamax No. 1 Geothermal Brine Bulk Solids Precipitation Pilot Plant-Engineering Design. BuMines Open File Report 127-78, 1978, 84 pp.; 51-79, 1979, 194 pp.; available during working hours only at Bureau of Mines libraries located in Albany, Oreg., Avondale, Md., Boulder City, Nev., Reno, Nev., Rolla, Mo., Salt Lake City, Utah, Tuscaloosa, Ala., Twin Cities, Minn., and at the National Library of Natural Resources, U.S. Dept. of the Interior, Washington, D.C.

3. Christopher, D. H., Maxine Stewart, and Janet Rice. The Recovery and Separation of Mineral Values From Geothermal Brines. BuMines Open File Report 81-75, 1975, 43 pp., 20 figs., available for reference during working hours only at Bureau of Mines libraries and from National Technical Information Service, Springfield, Va., PB 245 686/AS.

4. Epstein, J., E. Feist, J. Zmora, and Y. Marcus, 1981, Extraction of Lithium From the Dead Sea. Hydrometallurgy, v. 6, No. 3 & 4, pp. 269-275.

5. Farley, E. P., E. L. Watson, D. D. MacDonald, R. W. Bartlett, and G. N. Krishnan. Recovery of Heavy Metals From High Salinity Geothermal Brines. BuMines Open File Report 91-81, 1981, 130 pp., available for reference during working hours only at the Bureau of Mines libraries and from National Technical Information Services, Springfield, Va., PB 81-222218.

6. Schultze, L. E., and D. J. Bauer. Operation of a Mineral Recovery Unit on Brine From the Salton Sea Known Geothermal Resource Area. BuMines RI 8680, 12 pp. Available from authors at U.S. Bureau of Mines, 1605 Evans Ave., Reno, Nev. 89512.

7. Urbanek, M. W., C. D. Hornberg, and B. Lindal. Research on a Geothermal Mineral Extraction Complex, Phase 1, Preliminary Technical and Economic Assessment. BuMines Open File Report 51-79, 1979, 194 pp.; available during working hours only at Bureau of Mines libraries.

SCE Withdraws from Heber Project

After years of leasing, exploring, and drilling exploratory geothermal wells, geothermal developers found 4 geothermal fields in the Imperial Valley: Brawley, Heber, East Mesa, and Salton Sea. Pilot power plants generating 10 megawatts of electricity were built at three of the fields, all except Heber.

At Heber, Southern California Edison (SCE) elected to skip the pilot phase

Well Owner	Location	Power Plant Owner	MWe (Gross/Net)	Plant Type	Startup Date	Electricity Purchaser	Production Depth (feet & meters)	Temperature T.D.S. (ppm)	Map Symbol
Operating Power Plants									
Magma	East Mesa	Magma	12.5/10	Binary	1980	San Diego Gas & Electric Company	4500'- 7500' (1372 - 2286m)	④ ④ (See Field Data)	1
Union	Brawley	Southern California Edison	10/9	Single flash	1980	Imperial Irrigation District	5000'- 8000' (1524 - 2438m)	② ② (See Field Data)	2
Union	Salton Sea	Southern California Edison	10/9	Single flash	1982	Imperial Irrigation District	2000'- 6000' (610 - 1829m)	① ① (See Field Data)	3
Power Plants in Permitting/Planning Stage									
Chevron (Unit Oper.)	Heber	San Diego Gas & Electric Company	65/45	Binary	1985?	San Diego Gas & Electric Company	2000'- 10,000' (610 - 3048m)	③ ⑤ (See Field Data)	4
Republic	East Mesa	San Diego Gas & Electric Company	64/48	Dual flash	1985?	San Diego Gas & Electric Company	5,500'- 7,500' (1676 - 2286m)	④ ④ (See Field Data)	5
Magma	Salton Sea	Magma	28/24	Dual flash	1984?	San Diego Gas & Electric Company	1800'- 3,000' (549 - 914m)	① ① (See Field Data)	6
Magma	Salton Sea	Magma(?)	56/49	Dual flash	-	San Diego Gas & Electric Company	~ 3,500' (1067m)	① ① (See Field Data)	7
MCR	Imperial Co.	MCR(?) DWR(?)	45/?	Dual flash	-	Imperial Irrigation District (?)	~ 13,400' (4084m)	> 500°F (> 260°C) 250,000- 300,000	8
Republic	Salton Sea	Southern California Edison	54/49	Dual flash	-	Southern California Edison	8000'- 10,000' (2438- 3048m)	515°- 560°F (268°-293°C) 150,000- 250,000	9
Direct Use Under Construction									
City of El Centro	El Centro	City of El Centro	Direct heating and cooling	Exchanger	1983	NA	~ 8000' (2438m)	~ 300°F- (~ 149°C)	10
Direct Use in Permitting/Planning Stage									
? (none drilled)	East Mesa or Heber?	Ultra-systems	Produce corn syrup, ethanol	3-stage flash for clean steam	-	NA	?	? ?	11

Field Data

① Salton Sea	370°-680°F (188°-360°C)	200,000-350,000 ppm	TDS	③ Heber	350°-370°F (177°-188°C)	2,000-50,000 ppm	TDS
② Brawley	390°-525°F (199°-274°C)	50,000-250,000 ppm	TDS	④ East Mesa	360°-390°F (182°-199°C)	2,000-28,000 ppm	TDS

Imperial Valley electrical generation and direct use geothermal projects, 1982. Data obtained from the U.S. Geological Survey Circular 790, *Assessment of Geothermal Resources of the United States, 1978;* project environmental reports; and the 1982 Imperial County Annual Geothermal Development Meeting. Compiled by David Curtis, California Division of Oil and Gas.

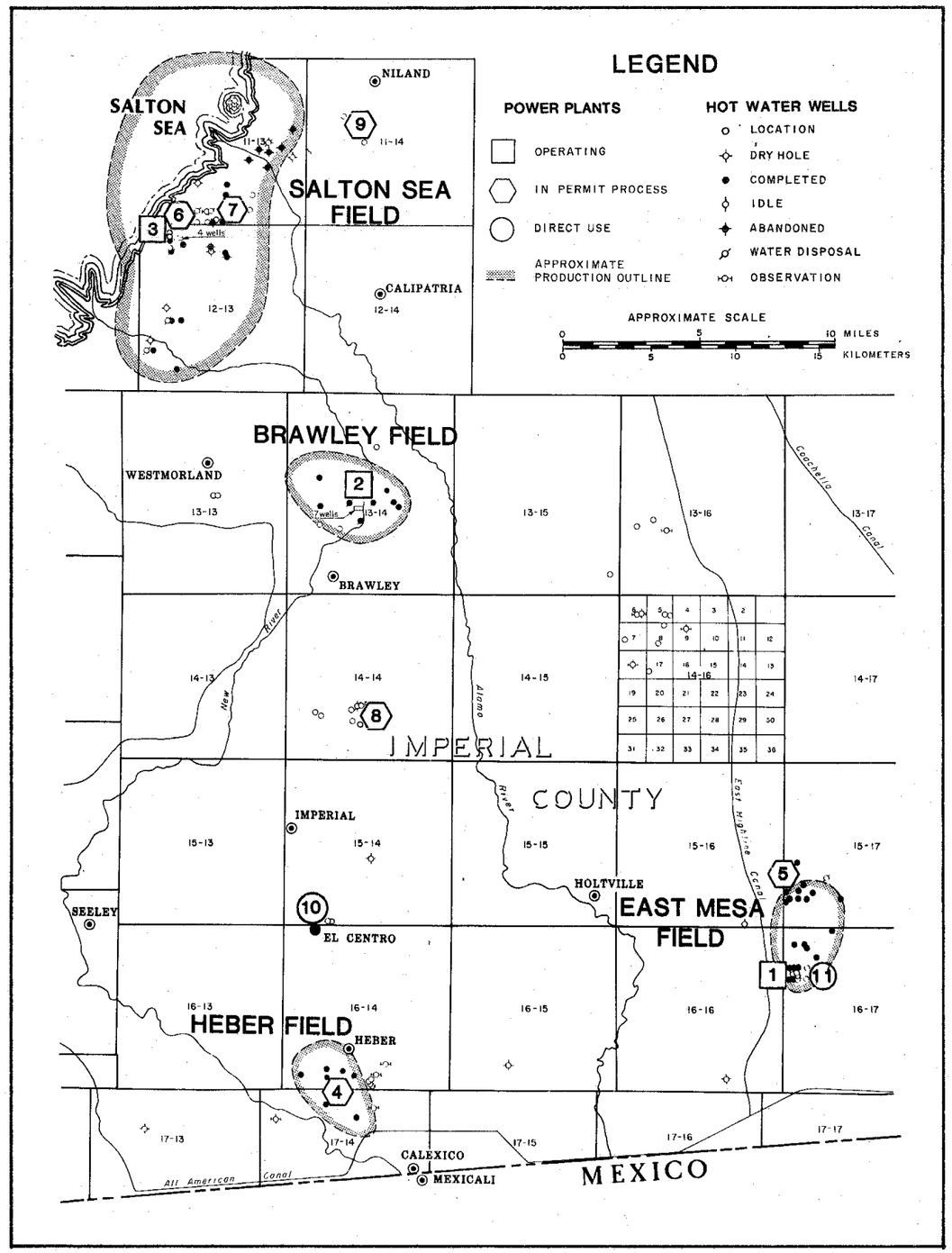
and build a commercial 47 megawatt power plant. After the plant was operating successfully, SCE planned to build additional power plant modules, modifying them as needed. Geothermal water for the entire project would be purchased by SCE from Chevron USA, Inc.

In May 1981, SCE applied to the California Public Utilities Commission (CPUC) for approval to sell electricity generated at the Heber plant to SCE customers. CPUC approval was denied on the grounds that in the SCE-Chevron contract, the payment schedule for geothermal water was tied to the cost of fossil and nuclear fuel. Subsequently, SCE renegotiated its contract with Chevron, disassociating geothermal water from fossil and nuclear fuel prices.

Then, SCE reapplied to the CPUC for plant approval. On October 20, 1982, the CPUC both denied and approved the modified application. The decision stated that SCE could go ahead and build the plant; however, the rates that the SCE charges for electricity generated at the plant cannot reflect plant building and operating costs. The SCE will be allowed to recover through its rates only the costs it avoids by not using fossil or nuclear fuel.

At the November 2 Imperial County Board of Supervisors regular meeting, Emil Hutchins of SCE made a public statement. Hutchins told the board that under the restrictions imposed by the CPUC, it was impossible for SCE to operate the Heber plant as it is presently conceived.

He added that SCE would try to continue to look for new ways to make the project feasible.



Imperial County Geothermal Development Summary Report 1979-1982

Prepared by the Imperial County Public Works Department

This article comprises Section 4 of the Summary Report. For further information, contact Margaret Rands (619) 339-4462.

In September of 1979, Imperial County and the U.S. Department of Energy formed a Cooperative Agreement to assist Imperial County to prepare for and facilitate geothermal commercialization. The Agreement has been extended from year to year to continue the support of county services necessary to develop geothermal energy. The report summarizes the progress of geothermal development during the past 3 years, county activities supporting geothermal development, and current challenges and future needs of the geothermal industry and the county.

Exploration activities have resulted in the identification and definition of three additional "Known Geothermal Resources Areas" (KGRAs) during the grant period: the Westmorland KGRA, the East Brawley KGRA, both in 1980, and the South Brawley KGRA in 1982. Exploration is continuing in other areas of the county as well.

Three 10 megawatt power plants have begun operations during the grant period: the Magma East Mesa 10 megawatt binary power plant, the Union/Southern California Edison 10 megawatt flash power plant in Brawley, both beginning operations in 1980, and the Union/Southern California Edison 10 megawatt flash power plant at the Salton Sea, beginning operations in 1982. Operation of these facilities has demonstrated not only the feasibility of geothermal energy production in Imperial County, but also the technological problems blocking its full economic development. (Among these problems are scaling and brine injection techniques. ed.)

Two commercial power plants are scheduled to begin construction during late 1982 or early 1983. Groundbreaking for the Heber Binary Project is scheduled for November 1982. Work on the Magma 28 megawatt power plant at the Salton Sea will begin in early 1983.

Two commercial power plants are in planning stages. MCR Geothermal has applied for a permit for a 45 megawatt power plant in the new South Brawley KGRA. The environmental analysis for this flash power plant has begun, and project operators are now testing their production wells. Republic Geothermal has applied for a County Conditional Use Permit for a 49 megawatt flash power plant to be located near Niland in the Salton Sea Anomaly. The environmental impact analysis for this project has begun.

A major direct heat project is planned. The facility, planned by Ultrasystems Incorporated, will use geothermal heat to process corn for the production of high fructose corn syrup and a number of co-products.

County efforts to develop geothermal planning policies has resulted in efficient and effective processing of geothermal project applications. The planning staff works with developers to explain application requirements. This way, county information needs are met and processing time is minimized.

The geothermal library, developed as part of the Cooperative Agreement, has proven to be very useful. The comprehensive data available from the library on geothermal development provide a valuable base of information for further research on geothermal topics.

Transfer of information on the Imperial Valley Environmental Project (IVEP) is almost complete. Environmental monitoring continues. A portion of the subsidence detection network is being resurveyed. Seismic monitoring is performed by developers as part of the requirements of the geothermal production permits. The County Air Pollution Control District (APCD) hopes to begin continuous monitoring for H_2S by the end of 1982. In addition, the APCD is discussing a proposal with the California Energy Commission in which funding is requested to establish a series of air monitoring stations in geothermal resource development areas. Water quality monitoring in the county has been performed by the California Regional Water Quality Control Board and the United States Geological Survey.

County-industry cooperative efforts include activities in a range of areas, from environmental monitoring and environmental impact analysis to efforts to develop geothermal waste disposal facilities. An annual Geothermal Development Meeting is held to allow persons and organizations involved in geothermal development in Imperial County to review the problems encountered, the progress made, and to discuss prospects for future development. The County Division of Community Economic Development is increasingly active in promoting the development of direct heat utilization projects. Imperial County provides technical assistance to other county and state government agencies and to prospective developers.

The Geothermal Quarterly Report is prepared by the Imperial County Public Works Department. The report summarizes the status of geothermal projects in the county.

The County Geothermal Staff has continued its efforts to meet challenges imposed by geothermal commercialization. Establishment of a geothermal waste disposal site is an important goal in this area. Geotechnical testing of selected potential waste disposal sites has been nearly completed. The next step in site development will include land use determinations, site acquisition, and an initiation of the site permitting process. Preliminary engineering and environmental review will be a necessary part of these proceedings. Imperial County has applied for a grant from the California Energy Commission to support the environmental and preliminary engineering portions of the work.

The County Geothermal Staff has begun study of county water needs for future geothermal development. A preliminary report will be prepared on this topic.

A direct heat utilization study has been initiated to assist Imperial County to promote the development of geothermal resources for direct heating purposes. The study will include a marketing plan and package that can be used to attract direct use industries to Imperial County. The study will also describe county planning policies and procedures used to process use permit applications for direct heat industries. The direct heat study is expected to be completed by the end of 1982.

Magma Power Plant On Line

On October 16, Magma Power Company began a 6 megawatt half-load test on its geothermal power plant at East Mesa in the Imperial Valley. The plant's final commercial output will be 10 megawatts.

The plant was operated for several months before September 1981. At that time, the plant was shut down due to faulty or inadequate equipment. Once the problems were identified, the plant was retrofitted with new heat exchangers, a single wheel radial inflow turbine, a knockout drum, and new isobutane and brine piping.

At the binary geothermal plant, which uses the patented Magmamax Power Process, pure isobutane is heated in tube-and-shell heat exchangers by geothermal brines produced from five wells. The brines, kept in a closed system, remain in a liquid phase. Once the isobutane has been heated, the brines are injected.

Cooling water from ponds by the power plant condenses the isobutane vapor after it has passed through the turbines.

The wells and power plant facilities are owned by Magma Power Company and have been financed entirely by private funds.

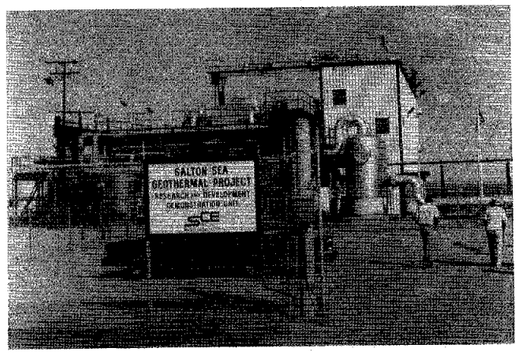
View of the Magma Power Company power plant, Imperial Valley, California. Photo by Susan Hodgson.

Edison, Union Oil Start Up Second Geothermal Facility

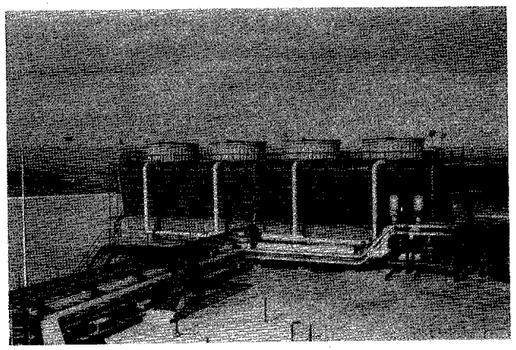
Geothermal energy is powering electrical generating facilities at a new geothermal project near the southern tip of the Salton Sea in California's Imperial Valley.

The Salton Sea Geothermal Project is a joint effort by Union Oil Company of California, as operator for the resource venture, and Southern California Edison Company, which uses the flashed geothermal steam to generate electricity.

Southern Pacific Land Company and an Edison subsidiary, Mono Power Company, each hold a 25 percent interest in the resource venture that includes 30,000



Entrance to the Salton Sea Geothermal Project.



Cooling towers at the Salton Sea Geothermal Project. The Salton Sea is in the background. Photos by Susan Hodgson.

acres of potentially productive geothermal land in the area.

Union, as resource producer, extracts the heat energy in the form of steam flashed from the hot brines and delivers it to Edison, which operates the 10 megawatt electrical generating pilot plant.

The project is in the start-up phase to check all systems. Increasing loads were placed on the electrical generator until full load was realized for the first time on July 12.

Electricity from the project, enough to meet the needs of a community of 9,200 people, will be sold to the Imperial Irrigation District for use in the Imperial Valley.

The Salton Sea project incorporates design improvements based on experience gained at the nearby Brawley Geothermal-Electric Project, a joint development by Union, SCE and Los Angeles Department of Water and Power, which began operation in mid-1980.

Corn Syrup Plant Planned

UltraSweet, Ltd., plans to build a $69 million geothermally powered corn syrup plant in the Imperial Valley. Originally, the company planned to construct the plant at East Mesa, about 5 miles south of Holtville. However, Dr. James Prouty, senior vice president of UltraSystems Engineers and Constructors, Ltd., said the company now favors a site near Heber because of better railroad access.

The plant will be the first geothermally powered corn syrup plant in the United States.

It will produce 182 million pounds of fructose corn syrup each year. The syrup is used as a soft drink sweetner. Industrial alcohol and animal feed will be produced, as well.

A $45 million geothermal loan guarantee has been approved by the U.S. Department of Energy for the project.

The Imperial Irrigation District Board of Directors voted to provide water and electricity to the plant.

Southern California

Experimental Greenhouse At Power Plant To Use Generating Station Waste Heat

Waste heat from Southern California Edison Company's Cool Water Generating Station in the Mojave Desert may help produce large quantities of tomatoes and cucumbers by mid-1983.

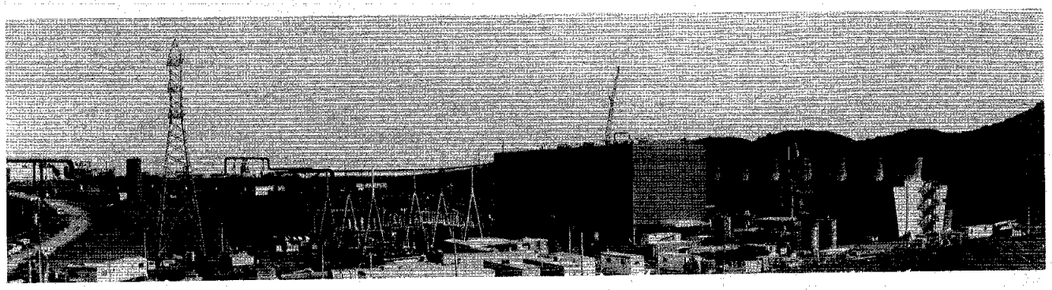
The electric utility, in conjunction with Agri-Resources, a Los Angeles Consulting firm, has begun construction of a half-acre "Waste Heat Greenhouse" adjacent to the power plant, near Daggett and about 12 miles east of Barstow, California.

When completed in late 1982, the greenhouse will use rejected heat -- a by-product of electrical generation -- to offset the increasing costs of fossil fuel consumption normally associated with the greenhouse industry, according to a spokesman from Edison's research and development department.

The experimental facility should be capable of producing 180,000 pounds of tomatoes or 13,000 cartons of cucumbers (or a combination of both).

The test project is scheduled to operate for at least 1 year while engineering and economic data are collected on the feasibility of using waste heat greenhouses in a desert environment.

Northern California



Power plant NCPA #2, The Geysers Geothermal field. Photo courtesy of SAI Engineers Inc.

New NCPA 2 Schedule

On February 22, 1982, an estimated $8 million fire destroyed the 12-cell cooling structure at geothermal power plant NCPA 2, under construction at The Geysers Geothermal field.

The 110 megawatt plant was 80 percent complete when its cooling structure burned to the foundation.

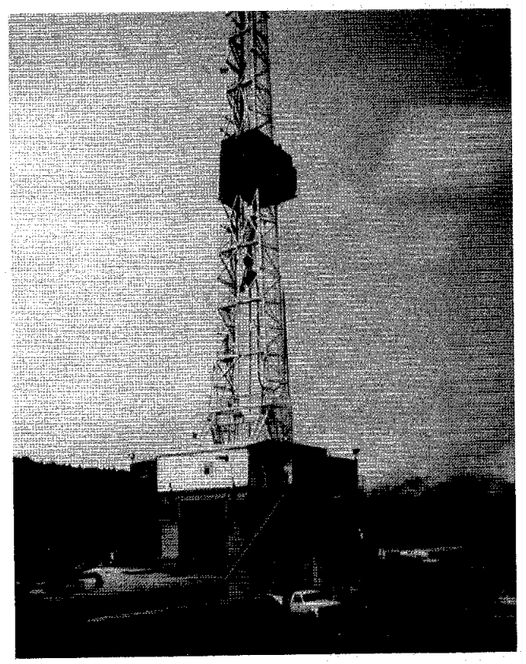
SAI Engineers Inc. provide plant engineering design and construction management for NCPA 2. According to Lorenzo Rios-Castellon of SAI, the fire set back the power plant construction schedule by only 2 months. The present roll-up date to test the plant is December 15. Commercial operations will begin in the first quarter of 1983.

The power plant is owned by the Northern California Power Agency.

New Rig Used at The Geysers

Brinkerhoff Signal's drilling rig No. 87 is one of the geothermal industry's newest and most modern drilling rigs. The rig was used in May to drill a well in The Geysers Geothermal field.

Rig features include an advanced skid system (50 feet in an hour or less) for faster moves between wells; a safety slide; and an elevator from the ground to the rig floor. The rig was built at a cost of $3.6 million. It's rated depth capacity is 16,000 feet.



Brinkerhoff Signal drilling rig No. 87.

Geophysical Study of the Santa Rosa Area, Sonoma County, California

By Rodger H. Chapman, Gordon W. Chase, and Leslie G. Youngs, California Department of Conservation, Division of Mines and Geology. 1982.

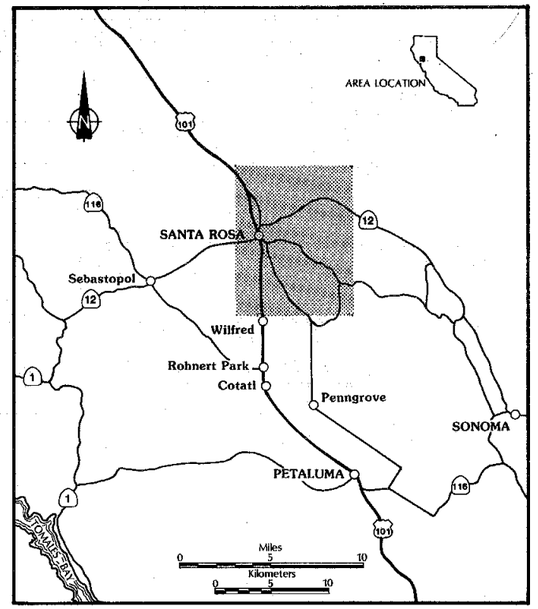
A copy of this report may be read in the library of the California Energy Commission, 1111 Howe Avenue, Sacramento, California (scheduled for relocation in early 1983). For further information, contact Rodger Chapman (916) 322-9305.

A geophysical study was conducted in the vicinity of Santa Rosa, California, by the California Division of Mines and Geology for the California Energy Commission. The purpose of the study was to determine the possibility of locating undeveloped sources of low- to moderate-temperature geothermal energy for use in applications such as space heating and cooling at the Sonoma County Administration Center or other facilities in the area. The known geothermal resource in the area consists of a few wells in Santa Rosa and along the western side of Bennett Valley with water temperatures ranging between 20°C - 35°C (68°F - 95°F).

Magnetic, gravity, and electrical resistivity surveys were conducted in the Santa Rosa study area to determine whether or not the warm water or the warm water reservoirs could be detected and mapped with these methods. The results of the magnetic and gravity surveys indicate that the source or sources of the known low-temperature geothermal resources in the area may lie within a dense mass of volcanic rocks located in the eastern part of Santa Rosa and in Bennett Valley. The known geothermal resources could not be detected directly by any of the methods used except, possibly, electrical resistivity.

The known warm-water wells in Santa Rosa may be associated with a fault or faults located near the southwestern side of the dense mass of possible volcanic rocks. However, the presence of these rocks beneath the eastern part of Santa Rosa and Bennett Valley suggests a large area where additional geothermal resources might be found.

The geophysical data provide no positive evidence that geothermal resources can be found near the Sonoma County Administration Center, except possibly at a depth that would make their development uneconomical. The only reliable means to evaluate this possibility would be to drill test holes.



The Santa Rosa geophysical study area.

Geophysical Study of the Rohnert Park Geothermal Prospect, Sonoma County, California

By Rodger H. Chapman and Gordon W. Chase, California Department of Conservation, Division of Mines and Geology. 1982.

A copy of this report may be read in the library of the California Energy Commission, 1111 Howe Avenue, Sacramento, California 95825 (scheduled for relocation at the beginning of 1983). For further information, contact Rodger Chapman (916) 322-9305.

A geophysical study was undertaken in the vicinity of Rohnert Park, California, by the California Division of Mines and Geology for the California Energy Commission. The purpose of the study was to determine the possibility of locating a source of low-or moderate-temperature geothermal energy for direct applications such as space heating and cooling. Potential users include the City of Rohnert Park, Sonoma State University, and an industrial park.

Warm water with a maximum recorded temperature of 32°C (90°F) has been reported in Rohnert Park municipal well No. 14, about 1½ miles northwest of the Sonoma State University campus. The warm water was produced from a section of Sonoma Volcanics from a depth below 910 feet in this well.

Magnetic, gravity, and electrical resistivity surveys were conducted to determine if either the warm water or the geothermal reservoir could be detected and mapped with these methods. Survey results indicate that although the warm water found in the Rohnert Park municipal well No. 14 apparently could not be detected by the methods used, the buried volcanic rocks that serve as the warm-water reservoir could be mapped by all three methods.

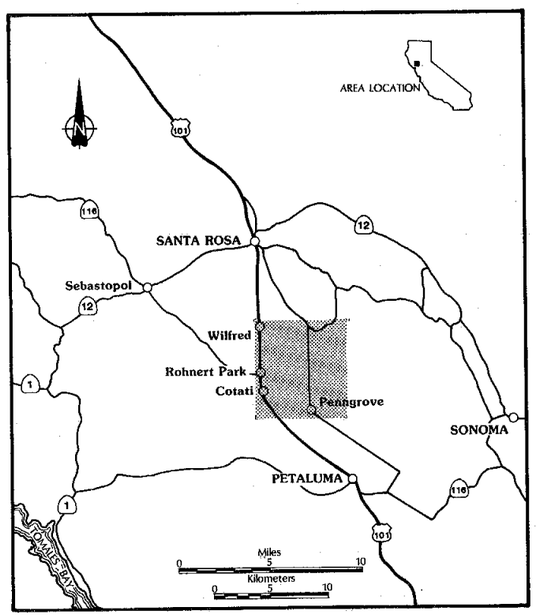
The geophysical data were used to construct models of the buried volcanic rocks (the possible geothermal reservoir). These models show that the volcanic rocks probably underlie a large part of the Sonoma State University campus, as well as a part of the City of Rohnert Park.

The models also indicate that along the northeastern part of the buried mass, the volcanic rocks may be either relatively thick or relatively close to the surface. The most favorable area on the Sonoma State University Campus to test for a geothermal reservoir would probably be along the northern boundary of the property from near Petaluma Hill Road to a point about 1,500 feet to the west.

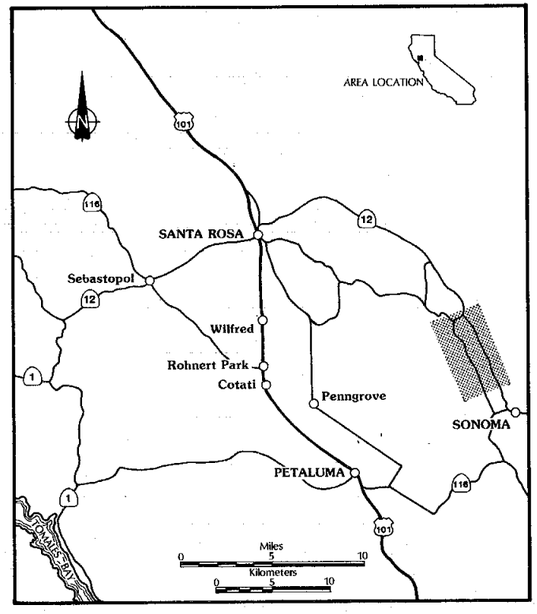
Geophysical Study of the Sonoma State Hospital Area Geothermal Prospect, Sonoma County, California

By Rodger H. Chapman and Gordon W. Chase, California Division of Mines and Geology. 1982. A copy of the report may be read in the library of the California Energy Commission, 1111 Howe Avenue, Sacramento, California (scheduled for relocation in early 1983). For further information, contact Rodger Chapman, (916) 322-9305.

A geophysical study was conducted in central Sonoma Valley, near Sonoma, California, by the Division of Mines and Geology for the California Energy



The Rohnert Park geophysical study area.



Sonoma State Hospital area geothermal prospect study site.

Aerial view of the Sonoma State Hospital grounds. Photo courtesy of Gene Culver, Oregon Institute of Technology.

Commission. The purpose of the study was to determine the possibility of locating undeveloped sources of low- and moderate-temperature geothermal energy for use in applications such as space heating and cooling at Sonoma State Hospital or at other nearby facilities. Wells at Boyes Hot Springs, Aqua Caliente, and Fetters Hot Springs in this part of the valley have water temperatures ranging from about 36°C to 60°C (97°F to 140°F), and a shallow well on the grounds of the Sonoma State Hospital has a water temperature of 20.3°C (68.5°F).

Magnetic, gravity, and electrical resistivity surveys were conducted in the Sonoma Valley study area to determine whether or not the known warm water or the warm-water reservoirs could be detected and mapped by these methods. The results of the surveys indicate that although the known warm water could not be detected directly by any of the methods used, the geothermal resource is found close to the location of a possible fault that was mapped by gravity and magnetic methods on the northeastern side of Sonoma Valley. Most, but possibly not all, of the known geothermal resources in the area are apparently found in units of the Sonoma Volcanics on the northeastern side of the proposed fault.

A model of the possible fault based on the geophysical data indicates that units of the Sonoma Volcanics on the northeastern (upthrown) side of the fault may have been faulted against younger sediments on the southwestern (downthrown) side. The fault may be either a barrier to the movement of groundwater, or it may provide a pathway for the geothermal fluids to rise towards the surface. Additional geothermal resources might be found by drilling northeast of the trace of

this fault in other parts of the area, including the Sonoma State Hospital property.

Other possible faults were indicated by the gravity and magnetic data in the Sonoma study area, but these faults are not known to be associated with geothermal resources. A knowledge of the locations of these faults, however, may be important in future studies of the geothermal resources in the area.

Hospital Retrofit

George S. Nolte and Associates of San Jose contracted with the Sonoma State Hospital to study the feasibility of using geothermal heat at the hospital to supplement the present steam-heating system. The geothermal heating system analyzed in the study could displace about 70 percent of the natural gas currently used by the hospital. Construction costs of the geothermal fluid distribution and collection system and the retrofits required within the buildings are estimated to be $1,777,000. However, the proposed geothermal heating system could be paid for in 32 months from savings on natural gas purchases.

First Well

On July 24, Santa Rosa driller Larry T. Durkin, under a permit issued by the State Lands Commission, began drilling well "SS" 3 at Sonoma State Hospital. Drilling was suspended in September due to lack of funds.

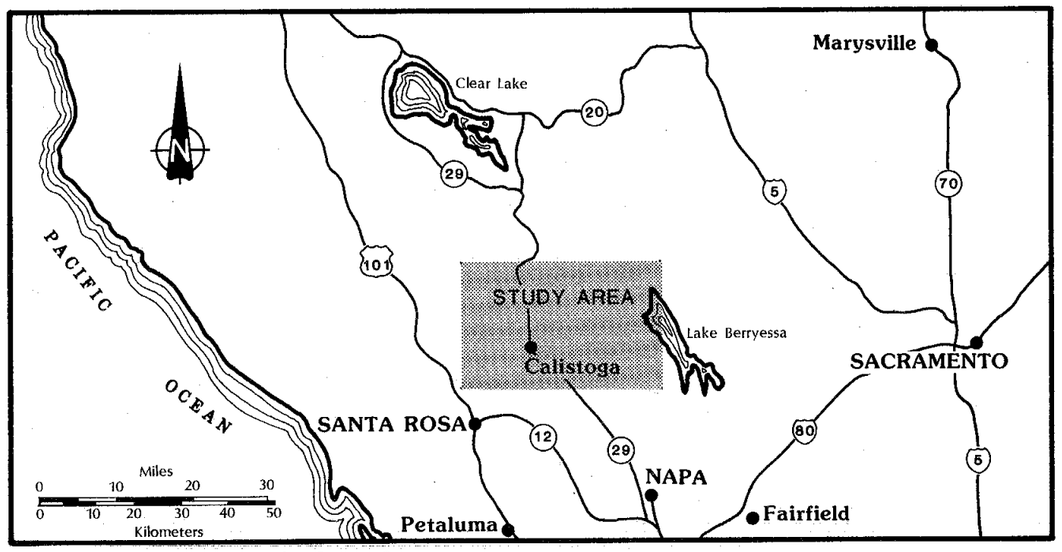
The well marks the state's first effort to utilize geothermal resources from beneath state-owned lands to heat existing state facilities, according to the State Lands Commission.

Gravity, Structure, and Geothermal Resources of the Calistoga Area, Napa and Sonoma Counties By Rodger H. Chapman, Leslie G. Youngs, and Gordon W. Chase

Published in the August 1982 issue of California Geology. $.35. Available from the California Division of Mines and Geology, P.O. Box 2980, Sacramento, California 95812.

The following conclusions from the study are reprinted, with permission.

Gravity data indicate that the axis of a large syncline or graben filled with Sonoma Volcanics and possibly other sediments and sedimentary rocks exists southwest of Calistoga. The known hot water geothermal resource is found in Napa Valley in the vicinity of Calistoga along the apparent northeastern limb of this structure. Evidence from drilling in Napa Valley also indicates that hot water is present in certain permeable volcanic units at depth within these southwest-dipping beds. It is proposed that the hot water may originate either as meteoric water that enters permeable beds in the hills on the southwestern limb of the syncline or as juvenile or connate water that enters the structure from below. The hot water then rises to the surface in Napa Valley. If this is true, an additional geothermal reservoir of possible economic importance may exist at depth in the area southwest of Calistoga, defined by the large gravity low.



The Calistoga geophysical study area.

Calistoga Space-Heating Project Studied

The feasibility of developing geothermal space-heating systems for elementary and high schools under the jurisdiction of the Calistoga, California, School Board is under investigation by the Oregon Institute of Technology.

A preliminary study, funded by the California Energy Commission, found that a downhole heat exchanger would be the system most appropriate for local reservoir conditions.

Mono—Long Valley

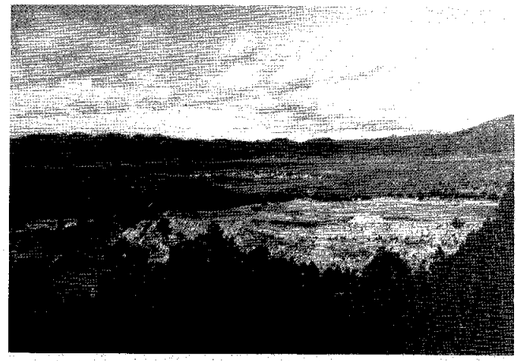
Bridgeport District-Heat Project
By Nancy Libonati
California Energy Commission

An analysis of a proposed district heating system for Bridgeport, California, has been completed by Lahanton, Inc. under a contract to the California Energy Commission. According to the analysis, the Bridgeport Geothermal Project is feasible providing a successful supply well, a commercially-viable wellhead generator, and simultaneous financing from private investors, a commercial lender, and a granting agency are available.

The geothermal supply well for the Bridgeport project will be near Travertine Hot Springs, about 1½ miles southeast of town. The well should yield 1,000 gallons per minute of 96°C-121°C (205°F-to 250°F) hot brine. First, the hot brine will be used to drive a 0.5 MWe binary cycle generator. Effluent from the process will be used for the district heating system. The initial system will include 15 public and private buildings.

The capital cost of the installed project will be about $4.1 million, to be raised through equity, commercial debt, and grant funding. The system revenues are projected to result in a positive cash flow in the 8th year of operation. Over a 20-year payout, the revenues are projected to yield an internal rate of return of 23+% to the private investors.

Bridgeport, the county seat of Mono County, California, is on U.S. 395 about 100 miles south of Reno, Nevada, and about 20 miles north of Mono Lake.


Bridgeport, as seen from Travertine Hot Springs (lighter area, photo foreground). Photo by Dick Thomas.

Volcanic Hazard Alert for Mammoth Lakes Area

Beginning in 1978, an area centered near Mammoth Lakes, California was shaken by an unusual series of earthquakes. In May 1980, four earthquakes occurred with a magnitude of 6 within 48 hours of each other. An earthquake hazard watch is still in effect for the area.

However, based on recent decisions by scientists, the U.S. Geological Survey has issued a notice of potential volcanic hazard for the area. This means, "the outbreak of volcanic activity is a possibility but by no means a certainty."

According to an article in the June 18 issue of Science, Roy Barley of the U.S.G.S. in Reston, Virginia said "We had been treating it strictly as an earthquake hazard. There's really good evidence now that there's magma moving around at depth and it could reach the surface."

Volcanologists reached this conclusion after realizing the intense swarms of earthquakes, accompanied by spasmodic tremors at the Mammoth Lakes area, were concentrated in a relatively small area. Volcanologists generally believe spasmodic tremors result from rocks fracturing from the movement of magma or magmatic gases.

If this is true, the magma may be nearing the surface, as the quakes were at a depth of 9 kilometers in 1980, 5 kilometers in 1981, and today at 3.5 kilometers.

To explain the U.S.G.S. Volcanic Hazard Alert, the "Long Valley Public Officials Conference on Volcanic Hazards and Preparedness" was held in Mammoth Lakes on August 25-27. Scientists, governmental representatives, and individuals from private agencies met to discuss geologic investigations in the Long Valley-Mono Lake area as well as emergency responsibilities and procedures.

The conference was organized by the State of California Office of Emergency Services, Department of Conservation, Division of Mines and Geology, and the U.S. Geological Survey (U.S.G.S.).

U.S.G.S. circular 877, Potential Hazards from Future Volcanic Eruptions in the Long Valley-Mono Lake Area, East-Central California and Southwest Nevada--A Preliminary Assessment, is available free of charge. Write the Branch of Distribution, U.S.G.S., 604 South Pickett Street, Alexandria, Virginia 22304.

An article by Richard T. Boylan titled "Mammoth Lakes/Long Valley Microearthquake Project," is printed in the September 1982 issue of California Geology. The article describes a joint CDMG-U.S. Department of Energy project in which earthquakes with a Richter magnitude of 2 or less were measured to determine the effectiveness of detailed microearthquake monitoring as a tool for geothermal resource exploration. The relationship of microseismicity to hydrothermal activity in the Long Valley Known Geothermal Resources Area (KGRA) was also explored.

Casa Diablo Geothermal field, where many geothermal wells have been drilled, is within the boundaries of this KGRA.

Additional, current geological information on the Long Valley-Mono Lake area is available in the September and November 1982 issues of California Geology, published by the California Division of Mines and Geology. Send a check or money order for $.35 per issue to the C.D.M.G., P.O. Box 2980, Sacramento, California 95812.

Nevada

Nevada Information

The Nevada Bureau of Mines and Geology (NBMG) recently acquired additional space to store its extensive collection of unpublished open-file geologic maps and reports, including geothermal data. Anyone wishing to donate materials or use the files should contact Becky Weimer-McMillion at NBMG, (702)784-6691, for an appointment. (Usually the files are open every day between 8:00 a.m. and 4:30 p.m., but an attendant is not always available.)

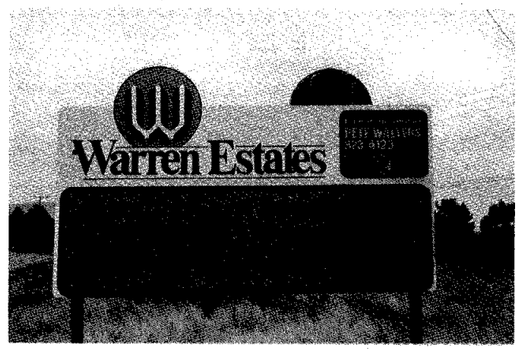
A free publication list is available by writing the NBMG at MacKay School of Mines, University of Nevada, Reno, Nevada 89557-0088.

Nevada Geothermal Plans

Eleven geothermal area development plans have been completed by the Nevada Department of Energy. The plans were made in an effort to facilitate Nevada's geothermal development.

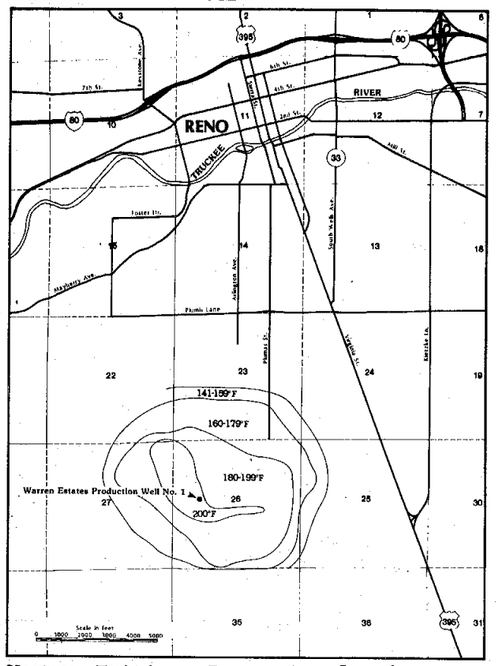
The plans cover the entire state. For further information, contact Bob Loux, Nevada Department of Energy, (702) 885-5157.

Warren Estates, A Geothermal Subdivision



Sign at the entrance to Warren Estates, Reno, Nevada. Warren Estates is believed to be the first subdivision of its size in the United States with single-family dwellings heated by geothermal energy.

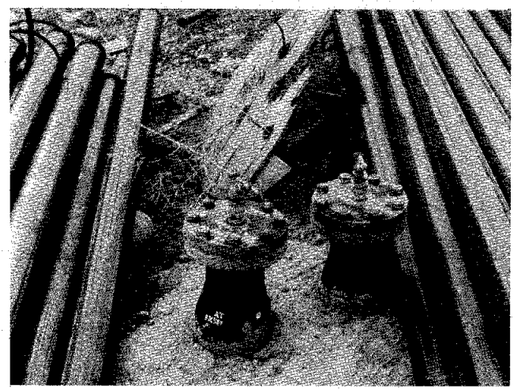
Homeowners can choose their own space-heating and hot-water heating systems that will be connected with the main subdivision geothermal system. Each homeowner is charged a flat monthly rate for this heat. An additional charge is levied for geothermal heat used for swimming pools, hot tubs, or spas. For further information, contact Phil Colburn, P.O. Box 915, Rancho Santa Fe, California 92067; phone (714) 756-3711. Photos by Susan F. Hodgson



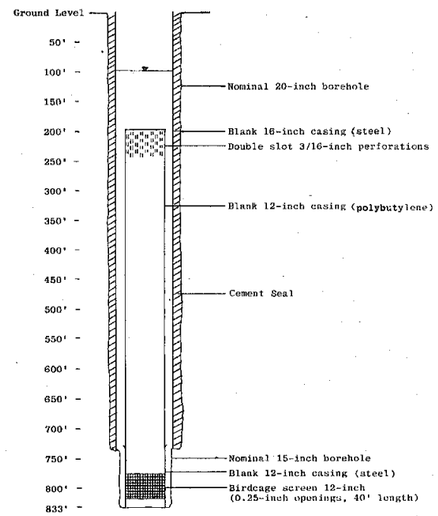
Warren Estates, Reno, Nevada, is a 60-lot subdivision situated within the Moana Geothermal Resource Area (KGRA).

This diagram illustrates temperature gradients in the Moana KGRA, calculated by David E. Carlson of William E. Nork, Inc. The Warren Estates subdivision will be constructed on the land around Warren Estates production well No. 1.

Warren Estates production well No. 1, photo left-of-center. Based on present information, including extrapolation of test data, the well is estimated to be able to produce 150gpm for an indefinite period of time with no adverse effects on the existing geothermal resource.

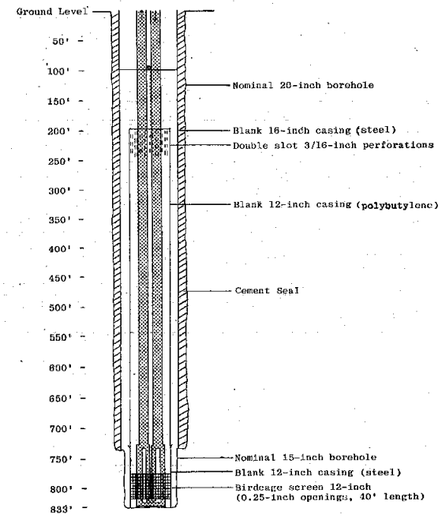


Well site, Warren Estates well No. 1. Surface completions of the closed, downhole heat exchanger loop. City water will pass into the well from the pipe on the left at 110°F and leave the well in the pipe on the right at 180°F.

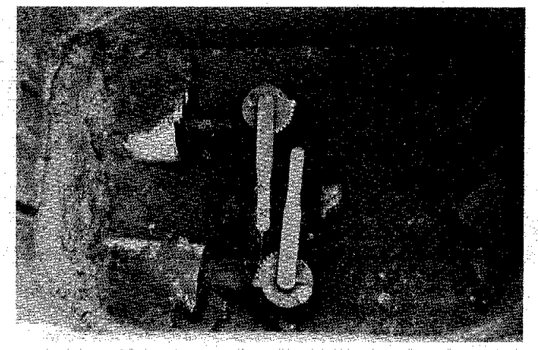


Warren Estates production well No. 1, proposed construction diagram. The well was drilled in the Moana KGRA to a depth of 833 feet using the air rotary method. Hot water was found at a depth of 791 feet with yield potential at about 200gpm. After a two-step drawdown test was conducted, transmissivity (the ability of the aquifer to transmit water) was determined to be 47,000 gpd/ft.

The hottest water to be measured so far in the Moana KGRA is the 211°F water in this Warren Estates well. Drafted by David E. Carlson.



Warren Estates production well No. 1, construction diagram, showing the proposed downhole heat exchanger. City water, fed into a closed-loop system, will be circulated through this heat exchanger and then passed throughout the subdivision. Drafted by David E. Carlson.



Hook-up into the closed loop geothermal system for a lot in the Warren Estates subdivision. The geothermal well, designed and tested by William E. Nork, Inc., is capable of meeting the heating requirements for 10-12 homes in the subdivision with the proposed downhole heat exchanger.

If a pump and a surface heat exchanger are installed, and an injection well drilled, the well will meet the heating requirements for 25-30 homes in the subdivision.

If a pump and loop system are installed and an injection well drilled, the well will meet the heating requirements for 50-60 homes in the subdivision.

The calculations assume each home will have a BTU requirement of at least 100,000 BTU's/hour, and allows for a system efficiency of 85 percent. All estimates are provided by William E. Nork, Inc.

For further information, see "District Space Heating from a Single Geothermal Well, Warren Estates, Nevada" by David E. Carlson, in Geothermal Resources Council Transactions, Vol. 6. Available from the Geothermal Resources Council, P.O. Box 1350, Davis, California 95617. $33.00 plus $3.50 for postage and handling.

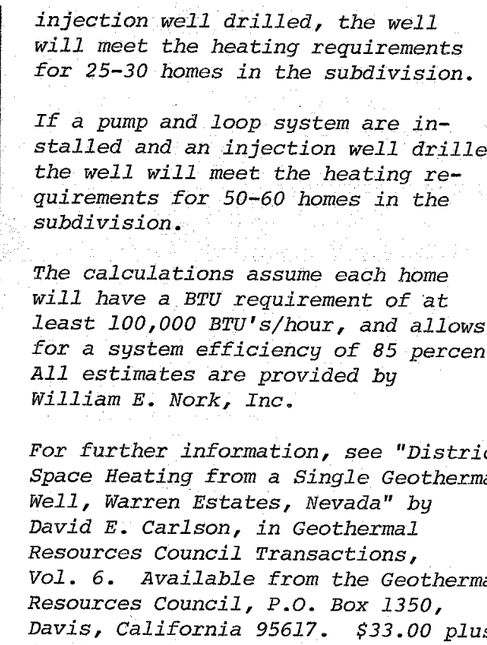
Hawaii

Descent Into Kilauea Iki

By Gerald Katz
U.S. Department of Energy

November 14, 1959: Lava erupts from Kilauea Iki crater located to the east of Mauna Loa on the Big Island of Hawaii. Lava fountains in an 800 meter line develop on the crater's south wall. As the eruption progresses, activity concentrates at one point. Lava blasts 580 meters in the air. A cinder-pumice cone forms overlooking a 126-meter deep lava lake bounded by the crater's walls. Volcanic activity stops, and the slow cooling process begins.

Since that eventful sequence, there has been considerable scientific activity at Kilauea Iki. Reginal (Reggie) Okamura of the U.S. Geological Survey (USGS) Volcano Observatory and I met on April 27, 1982, at the Observatory in Hawaii



Kilauea caldera and chain of craters, Hawaii Volcanoes National Park, Hawaii.

Kilauea Iki crater, looking to the west, Hawaii Volcanoes National Park, Hawaii. Light vertical line across the crater floor is a walkway. Steam puffs to the right of the walkway are from boreholes drilled into the crater as part of the Magma Energy research project. Photo by Gerald Katz.

Volcanoes National Park to discuss research at Kilauea Iki. The USGS had been studying the slowly cooling magma body below the lava lake's surface since the 1959 eruption. A Magma Energy Project, sponsored by the U.S. Department of Energy and managed by Sandia National Laboratories, was begun in 1975 to determine the scientific feasibility of extracting energy directly from buried magma sources within the top 10 kilometers of the earth's surface (Hot Line, January 1982). Kilauea Iki served as an ideal field laboratory for the study. Sandia drilled through the lens-shaped magma body, kept a borehole open, and extracted energy during April 1981 experiments. The results were very encouraging.

I wanted to climb down to the site of last year's drilling and energy-extraction experiments. Reggie told me that there was not much to see, but the climb down to and across the lava lake was worthwhile. He gave me directions and a map of Kilauea Iki with borehole locations identified. Then, suddenly, a thought crossed my mind. I asked Reggie when the next eruption would occur in the park. He said there had been a shallow, moderate earthquake earlier that morning in the floor of the large Kilauea caldera near Halemaumau. An eruption could occur any time. I felt little comfort knowing that the epicenter of this earthquake was only about 2 kilometers from Kilauea Iki.

My wife Betty and I began the slow descent from the Thurston Lava Tube parking lot to the surface of Kilauea Iki. A thick jungle of plants encroached upon the steep, winding trail. A heavy mist hung over the crater. In 30 minutes we reached the surface of the lava lake. An eerie, black, lunar-like landscape spread out before us. In contrast to the trail, the lake seemed lifeless. Only a few scattered brown wisps of plant life spotted the surface. The cinder-pumice cone that was active in 1959 stood a kilometer away at the opposite side of the lake. We crossed the rough basaltic terrain looking for boreholes. A combination of steam plumes and the USGS map led us to the spot, close to the center

Close-up of a borehole drilled in 1981 in an experiment to extract energy directly from buried magma. A pebble is on top of the well pipe. Photo by Gerald Katz.

of the crater. I recalled a briefing on the Magma Energy Project I attended just a few weeks before. John Colp of Sandia National Laboratories had shown a slide of red glowing magma at the bottom of one of these boreholes. I looked down into a nearby borehole, disappointed that the red glow of magma was no longer apparent. Obviously, the magma had cooled and solidified.

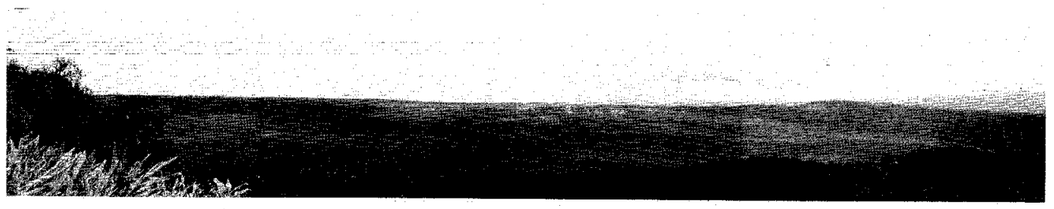
The Magma Energy Project consisted of five main tasks: Source Location and Definition, Source Tapping, Magma Characterization, Material Compatibility, and Energy Extraction. Kilauea Iki played an integral part in this project as a source of magma. This source was tapped by new water-jet nozzle drilling techniques that allowed researchers to drill and core through Kilauea Iki's magma body or melt zone.

A partial melt (40 volume percent) was encountered between 58 and 89 meters deep. Further magma measurement was accomplished by downhole seismic shots detonated in and below the melt zone. This was the first in situ seismic source to be measured through a well-defined partial melt zone. Drilling materials' compatibility with magma was given the ultimate test at Kilauea Iki by being exposed to real magma.

Energy extraction experiments produced very encouraging results. Water injected into the melt zone yielded high downhole steam temperatures (670°C), high energy transfer rates (93 to 980 kW/m^2) and full water recovery (100% ± 5%). Sandia National Laboratories has demonstrated, by means of theoretical calculations with supporting laboratory and field measurements, that there are no insurmountable theoretical or physical barriers invalidating the concept of extracting magma energy. The Western United States is estimated to have approximately 10^5 quads of magma energy resource within 10 kilometers of the surface. The energy potential of this resource is enormous. All this seemed unbelievable as I stood in the middle of Kilauea Iki.

After further exploration of the crater and discovering at least a dozen bore-

February 1982



April 1982

Caldera of Kilauea Volcano in February 1982 (photo by Roscoe Martin) and on April 27, 1982, 3 days before the eruption (photo by Gerald Katz). Steam is venting from Halemaumau Crater, just right of photo center. The eruption occurred along the fissure indicated by the short, whitish line at centers of both photos on the distant side of the caldera in front of Halemaumau Crater.

holes, we walked to the cinder-pumice cone. The area surrounding the cone was extremely fractured and buckled, evidence of a once-active eruption. We backtracked towards the trail and encountered two people. They took our picture and we took theirs. After exchanging a few words, Betty and I began the ascent up the jungle trail. Two and a half hours later we were back in our condominium in Kailua-Kona,not expecting to return to Hawaii Volcanoes National Park for some time to come.

Flash: Eruption at Kilauea

April 30, 1982: Lava erupts from Kilauea Volcano located to the east of Mauna Loa on the Big Island of Hawaii. A 300-meter long continuous curtain of lava fountains develops on a northeast-trending fissure on the summit caldera floor. Lava blasts to 20 meters in the air and spreads out over a moderate area during the 21-hour benign eruption.

The eruption occurred on Friday at 11:37 a.m. Hawaii Standard Time. At that time, my wife and I were waiting for brunch at the Mauna Kea Beach Hotel. We overheard a bellboy tell a guest the volcano just erupted. Betty knew what I was thinking and immediately said "There's no way I'm going back up there." Of course I had different feelings. After brunch we enjoyed the hotel beach. I planned to visit the volcano in the early morning hours to observe the eruption in both nighttime and daytime settings.

The Mauna Kea Beach Hotel beach is perfect. Picture a pure white sand beach against a crystal clear blue Pacific Ocean with palm trees gently bending in the wind. That's Hawaii. We grabbed our skin diving equipment and headed out to sea. After we had been skin diving for a half an hour, many schools of fish began speeding by us. My heart pounded. I thought a shark might have scared them, and I looked in all directions. The only sign of life was in the direction of the fleeing fish.

Suddenly, we come upon a most unusual sight: 15 white fish with black speckles lay dead, motionless on the sea floor in parallel rows of five that formed a rectangle. We swam back, gathered our belongings, and went up to the hotel. We sipped tropical drinks silently until a black beetle dived onto our table. It spun around on its back for a moment and flew off the table. Something strange was going on. I wondered if it was the eruption and the associated earthquake swarms.

I awoke at 1:30 a.m. on May 1 after a few hours of sleep. My wife thought I was crazy. My earth science background had finally gotten to me. I drove off in a torrential rainstorm on State Highway 11. The rain stopped by South Point (the southernmost point in the U.S.). The sky cleared as I approached Hawaii Volcanoes National Park. Once in the Park's boundary, I noticed a red glowing mist in the direction of Kilauea Volcano.

A dozen people were standing in the Volcano Observatory parking lot at 3:30 a.m. when I arrived. It was then that I witnessed my first volcanic eruption. It was magnificent. A jagged line of fire perhaps 2 kilometers down and away from me was blasting lava up from various points. Right at the junction of the active fissure and the caldera floor, a bright yellow-orange glow delineated the magma vents. The people around me were silent and obviously in awe. Nature was shaping the environment. I felt small and helpless. My trance was suddenly broken when I noticed Reggie inside the Observatory busy answering the phone and checking the seismographs. He motioned for me to come in.

Reggie was quite busy. He had to respond to many questions from tourists, the tourist industry, the news media, and scientists. Most questions centered on the longevity of the eruption. The seismic amplitude data was tapering off

gradually. This indicated that the eruption would be shortlived. Tilt measurements, however, suggested some possible, near future eruptions. Rapid inflation of Kilauea had occurred 2 hours before the eruption, but did not subside after the lava extruded at the surface. Now, magma appeared to be refilling the chamber below.

I met many friendly people at the Volcano Observatory that night. We sat around and drank coffee for hours discussing volcanoes and geothermal energy. I was intrigued by stories from those scientists that actually visited the eruption site to take samples and measurements. I wanted to get down there and see the eruption first hand. Reggie told me that the National Park Service might be willing to take me down to the eruption area at sunrise. The Park Service had to photograph the eruption's flows and also decide how to best manage tourist access to the eruption area without jeopardizing tourist safety. At sunrise, Reggie introduced me to David Ames, Superintendent of Hawaii Volcanoes National Park. Dave agreed to take me down; Kepa Maly, also of the Park Service, agreed to escort me to the lava.

By 6:30 a.m., the eruption activity had ceased. We drove down to the Halemaumau Crater parking lot that is within the Kilauea caldera. Surface hydrothermal activity was intense.

Swirls of steam eminated from Halemaumau Crater and along the fissure northeast of Halemaumau. Heat waves rose from the new lava. Kepa and I headed for the new flows. First, we encountered Pele's Hair: fine black strands of blown, volcanic glass spread across the Halemaumau Trail.

We left the trail and crossed piles of round, gravel-sized volcanic debris that crunched with every step. Then we came upon the young lava rock. Mounds of ropy-textured pahoehoe spread out for hundreds of meters before us. It had a bright, shiny-

New pahoehoe lava with a golden sheen, extruded during the April 27 eruption of Kilauea Volcano. The boundary of the new lava flow with older flows can be seen upper photo left. Photo by Gerald Katz.

gold sheen reflecting the morning sun. The rock was still hot, and intense heat waves distorted our view of the caldera's walls. The only available sound was the crackling from cooling rock movements.

We walked around the hot lava, looking for a relatively cool, short, and solid path to the lava vents on the fissure. Kepa and I tried many paths, only to backtrack in the face of fragile or hot rocks below our feet. Walking on lava is like walking on red-hot egg shells. We eventually found a path that appeared reasonable. Kepa led the way, testing the strength of the rock under his boots one step at a time.

Unfortunately, I was not dressed properly for the occasion. My Eatonic running sneakers were beginning to get soft and my feet were getting hot. On our way to the vents, we photographed evidence of life surrounded but not touched by new lava. Some crevices were still glowing red as we continued across the new lava flow. Fortunately, the area around the vents had an oasis of cool, vintage 1975 lava. We rested there for a while. Kepa had a job to do and it was time for me to return to my condominium. I made my way back alone. I left the park in high spirits with an experience

of a lifetime. I am forever indebted to Reggie Okamura, Dave Ames, and Kepa Maly.

NOTE: A list of publications, prints, films, and slides, (several on volcanoes) available from the Hawaii Natural History Association may be secured by writing the association at P.O. Box 74, Hawaii National Park, Hawaii 96718.

Fractured Reservoirs

Fractured Rock System Reservoirs Studied

A better understanding of the characteristics of geothermal reservoirs in underground fractured rock systems is the goal of a research program at the Department of Energy (DOE) Raft River geothermal site in southcentral Idaho.

The Hydrothermal Injection Program is designed to develop new techniques to help determine flow characteristics of geothermal waters in fractured rock systems such as those found at the Raft River site. Information from the program will be used to generate a model that industry can use to manage such energy resources.

According to program manager Jim Pletscher of EG&G Idaho's Energy Programs Division, more knowledge is needed about the way geothermal systems behave in underground fractured rock formations. Especially needed are methods to determine flow characteristics of water moving through fractured formations and to monitor the effects of injected water on the formation.

The program is being conducted as a joint project by EG&G Idaho's Energy Programs Division and Earth and Life Sciences Office, and the University of Utah Research Institute (UURI). Also participating in the program are Lawrence Berkeley Laboratory and Stanford University. EG&G Idaho is a prime operating contractor for the DOE at the Idaho National Engineering Laboratory.

The program includes a series of tests conducted at the same geothermal field once used to supply water to the Raft River geothermal plant. Before it was closed in fiscal year 1982, the plant was used to demonstrate that moderate temperature (below 300°F) geothermal water can be used to produce electricity.

Phase one of the Hydrothermal Injection Program started in June 1982 and will last until December 1982. In Phase two, to be conducted at another geothermal site not yet selected, the techniques developed at Raft River during phase one will be verified.

During these experiments, water is injected into Raft River Geothermal Production Well No. 5, 1 of 7 geothermal wells at the site. Well No. 5 is an artesian flowing well about 4,800 feet deep. Water in the well is at about 270°F.

During the experiments, water from another production well with slightly different chemical characteristics is pumped into Well No. 5. The injected water is allowed to backflow up the well bore while researchers measure return rates. Information on the flow characteristics comes from measurements of how much injected water doesn't return.

Well No. 5 is equipped with highly sensitive instruments that can detect subtle changes in water temperatures and chemical conditions. This allows researchers to differentiate between injected water and natural well water.

As part of the program, Lawrence Berkeley Laboratory is conducting microseismic studies to determine flow direction patterns. The studies will monitor seismic activity from noise generated by injecting water into the well.

In addition to helping to formulate the test program and evaluate test data, UURI is investigating the use of electrical voltage and resistance monitoring equipment to determine direction of flow through the formation.

Legislation

Legislative Update

The 1981-82 California Legislative session has ended. The following bills comprise the geothermal legislation considered by the legislature.

Chaptered Legislation

AB 828, Bosco
Geothermal Resources: Low-Temperature Wells

Under terms of this bill, the State Oil and Gas Supervisor may exempt from certain requirements any low-temperature geothermal well used domestically or in a noncommercial manner. These requirements include 1) notifying the State Oil and Gas Supervisor of monthly production rates, 2) notifying the State Oil and Gas Supervisor of transactions concerning the operation, sale, or transfer of the well, and 3) filing indemnity bonds with the State Oil and Gas Supervisor. The bill also specifies that a well need no longer be drilled in a Geothermal Resource Area to be classified as a low-temperature geothermal well.

AB 2785, Kapiloff
Public Utilities: Heat Corporations: Geothermal or Solar Resources, Cogeneration Technology

This bill exempts from the definition of public utility, for these purposes, every corporation and person engaged directly or indirectly in developing, producing, transmitting, distributing, delivering, or selling heat derived from geothermal or solar resources or from cogeneration technology to any private or publicly owned utility or to the public or any portion thereof.

Failed Legislation

AB 3442, Levine
Energy: State Policy: Implementation

This bill would have defined the energy policy of the state to be one where any rate, fuel, or siting proceeding must be consistent with priorities dealing with conservation, renewable resources, generating resources utilizing waste heat, and other resources. The bill would have required the State Energy Resources Conservation and Development Commission, the Public Utilities Commission, and representatives of municipal and other publicly owned facilities to establish these policies.

AB 296, Kapiloff
Sales and Use Tax: Exemptions: Geothermal Resources

This bill would have exempted from state and local sales and use taxes geothermal resources that were developed for purposes of electrical power generation and would have contained a statement of legislative intent related thereof.

AB 3443, Levine
Energy: Power Plant Sites and Facilities Certification

This bill would have prohibited the State Energy Resources Conservation and Development Commission from approving a notice of intention to file an application for certification of any thermal power plant site and facility unless the appli-

cant met the prescribed conditions dealing with designate energy targets.

SB 2081, Alquist
Income Taxation: Intangible Drilling and Development Costs

This bill would have removed the deductibility of certain intangible drilling and development costs and would have required a study to be made of the fiscal effects of this bill on state revenues.

Funding

SAFE-BIDCO Offers Funding for Energy

SAFE-BIDCO is the State Assistance Fund for Energy, California Business and Industrial Development Corporation. It was established by the California State Legislature in 1981 to provide financial assistance to small businesses in alternative energy.

Senate Bill 16 (authored by Senator David Roberti) mandates the corporation to assist qualified businesses that provide or purchase alternative energy and energy conservation products, systems, and services.

SAFE-BIDCO can make loans to small businesses in one of the alternative energy fields, or to small businesses who want to invest in conservation or an alternative energy system.

The basic SAFE-BIDCO legislation defines alternative energy as follows:

> "... any device or combination of devices which conserves or produces heat, process heat, space heating, water heating, steam, space cooling, refrigeration, mechanical energy, electricity, or energy in any form convertible to these uses, which does not expend or use conventional energy fuels, except when such conventional energy fuels are used as a back-up energy system or in conjunction with an alternative energy system."

Capitalized by a $2.5 million line of credit from the state, SAFE-BIDCO is authorized to provide several types of financial assistance to qualified small businesses. Initially, the corporation will stress direct loans which can qualify for guarantee by the U.S. Small Business Administration or other federal or state agencies.

These guarantees will make it possible for SAFE-BIDCO to increase its lending capital to more than $20 million by selling the guaranteed portion of its loans to private investors.

Although SAFE-BIDCO is a nonprofit corporation, in effect wholly owned by the State of California, it is not a state agency in the usual sense. It must be self-supporting. Its lending capital must be repaid to the state and its employees are not civil servants. Its Board of Directors, appointed jointly by the Governor, Senate Rules Committee, and Speaker of the Assembly, is independent and represents both state government and the private sector.

For further information, contact David Phillips at SAFE-BIDCO, 2021 N Street, Suite C, Sacramento, California 95814; (916) 442-3321.

Local Government Assistance Program

By Nancy Libonati
California Energy Commission

The Local Government Assistance Program, established by Assembly Bill 1905, is now well under way. This legislation established the Geothermal Resources Development Account in the General Fund. It provides for the equitable distribution of funds received by the State of California from geothermal leasing on federal lands. The California Energy Commission (CEC) distributes this money. The CEC awards grants to local governments through a competitive application process.

The CEC awarded a total of $366,800 in first round grants to seven local jurisdictions throughout the state. Grants were awarded to:

1. The City of Susanville to design and construct a geothermal space heating system for the Roops Fort Complex. The CEC provided $24,405 with $12,805 local matching funds.

2. The City of Huntington Beach and County of Orange for resource assessment, potential end use identification, examination of possible demonstration projects, and preliminary feasibility studies for oilfield associated geothermal resources. The CEC provided $22,600 with $18,630 in matching funds.

3. Imperial County for field work to update vertical subsidence leveling in selected areas of the county. The CEC provided $40,000 with $52,871 in matching funds.

4. Lassen County to construct a geothermal heating system for the Courthouse Annex, replacing the existing electrical heating system as the primary heat source. The CEC provided $95,000 with $103,946 in matching funds.

5. Indian Valley Hospital for the resource assessment leading to design and construction of a geothermal space heating system for the hospital. The CEC provided $44,800 with $2,123 in matching funds.

6. The Inyo/Mono Association of Governmental Entities for a planning effort focused on streamlining the permitting process, including environmental and mitigation assessment and identification of direct use projects. The CEC provided $33,994 with $33,169 in matching funds.

7. Anderson Springs Community Services District to develop a water system master plan including plans and specifications for system improvements. The CEC provided $76,000 with no matching funds.

Round two grant applications are currently under review. Awards of about $600,000 are expected to be made in December 1982. The third funding round is expected to begin in January 1983.

For further information or assistance in applying for a grant, contact Andy Coughanour, Grant Program Manager, (916) 924-4895.

Geothermal Demonstration Proposals Under Review

By Nancy Libonati
California Energy Commission

The California Energy Commission is providing $250,000 to cost share in projects that will demonstrate the use of lower-temperature geothermal resources for direct use and small-scale electric applications. The commission has received eight proposals for a wide range of geographical and technological applications.

Six of the proposals include small-scale electric applications. Three of those cascade to direct use and one proposal includes a hybrid geothermal-biomass plant in conjunction with a small-scale electric generator. The remaining two proposals employ direct use technologies.

Projects that are chosen to be funded will serve as models for replication throughout the state. A decision on the final contract(s) is expected in December 1982. For further information contact Frederick Tornatore, Contract Manager, (916) 924-4898.

Proposed Energy Commission Activities

The following activities are those proposed by the California Energy Commission for the 1983-1984 fiscal year. This plan is tentative, and some activities are subject to funding approval by the California Legislature. For further information, contact Ralph Chandler at (916) 924-2615.

Geothermal Resource Assessment

1. Preliminary Resource Quantification

   Identify and map lower-temperature resources in existing water wells in priority resource areas identified in the CEC's market study, Geothermal Energy, Opportunities for California Commerce, as a preliminary activity to more extensive geophysical assessment. Also, investigate opportunities of using capped geothermal wells for lower-temperature, direct use applications.

2. Resource Assessment Assistance

   Provide regional and site-specific market data developed from Preliminary Resource Quantification and State-wide Direct Use Market Development activities to California Division of Mines and Geology staff and other resource assessment groups to ensure that geophysical and geological assessments are performed in priority areas with the highest, near-term development potential.

3. Resource Development Fund

   Establish low-interest revolving loan fund to cost share with industry for well development in selected areas in both the CEC's direct use market study and Resource Assessment activity.

Geothermal Technology Feasibility and Demonstration

1. Advanced Technology Demonstrations

   Cost share with industry for development of direct use and small-scale electric generation projects to adequately demonstrate viability of new uses for low-temperature resources.

2. Technical Assistance

   Provide: preliminary engineering and economic feasibility assessment of lower-temperature applications; technical training for CEC staff; technical support for AB 1905 Local Government Grant Program; support for Alternative Energy Task Forces; and materials and publications to assist market development activities.

3. San Bernardino District Heating System

   Provide funds for construction of a district heating system for the City of San Bernardino.

4. Bridgeport District Heating System

   Cost share with private industry and local government to develop 0.5 MWe small-scale, binary cycle, geothermal power plant and district heating system for the community of Bridgeport.

5. Greenhouse Industry Assistance

   Establish a low-interest revolving fund to cost share with the greenhouse industry for the construction of geothermally-heated greenhouses in high-priority resource areas.

Geothermal Market Development and Commercialization

1. Los Angeles Area Market Development

   Contract with consultant to identify end users for the hot water resources associated with the Los Angeles oil fields and assist in developing projects.

2. Local Government Management

   Facilitate local government development of geothermal planning elements, coordinator positions, permit and siting authority.

3. Statewide Direct Use Market Development

   Implement marketing strategies in priority resource areas for the agricultural, industrial and commercial sectors. Provide regional and site-specific market data to the State Lands Commission and the Federal Government to identify new leasing and direct use development opportunities.

4. Local Government Assistance Program

   Provide funds to local jurisdictions for planning and developing geothermal resources and impact mitigation.

Resource Assessment

Reconnaissance Geothermal Resource Assessment of 40 Sites in California

By Eddie Leivas, Roger C. Martin, Chris T. Higgins, and Stephen P. Bezore, under the direction of C. Forrest Bacon. California Department of Conservation, Division of Mines and Geology. 1981. Open File Report 82-4SAC. The report may be viewed at any Division of Mines and Geology district office.

In this report, information is included on as many as possible of the known occurrences of natural hot springs and thermal wells in California. Data are also included for selected oil, gas, and water wells with reasonable potential for development as a geothermal resource. From these data, hot springs and wells with a strong potential for development into significant sources of useable energy may be identified.

Such information comprises Phase I of the 1980-81 Geothermal Resource Assessment Program of the California Division of Mines and Geology. Phase II of the program will be a series of detailed area investigations.

San Bernardino, California

Resource investigation of low-and moderate-temperature geothermal areas in San Bernardino, California. By Leslie G. Youngs, Stephen P. Bezore, Rodger H. Chapman, and Gordon W. Chase, California Department of Conservation, Division of Mines and Geology. 1981. Open File Report 82-11SAC. The report may be viewed at any Division of Mines and Geology district office.

The San Bernardino area was selected as the site for a detailed geothermal resource investigation because it contains promising geothermal resource sites, has a large population center, and wishes to develop the geothermal resources.

Ninety-seven geothermal wells and springs were identified and plotted on a compiled geologic map of the 40-square mile study area. The wells are concentrated in three areas, for which detailed geophysical, geochemical, and geological surveys were undertaken.

Data from these surveys indicate the presence of a major geothermal fluid up-welling, or "plume" along a segment of the Loma Linda fault. The segment is slightly southwest of the previously reported location of the fault in the south San Bernardino geothermal area. The data also suggest other geothermal fluid plumes in association with faulting are in the three areas.

New Zealand

New Zealand Geothermal Development

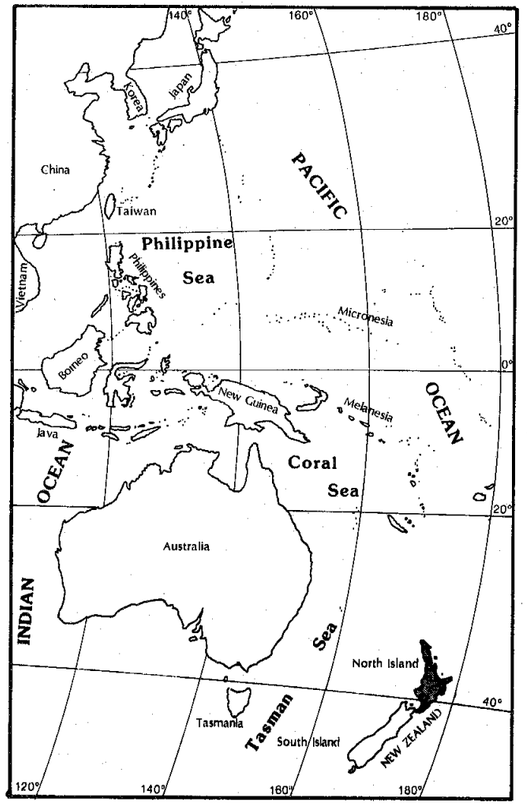
By Susan F. Hodgson, California Division of Oil and Gas
and
Roland N. Horne, Stanford University

Low Temperature

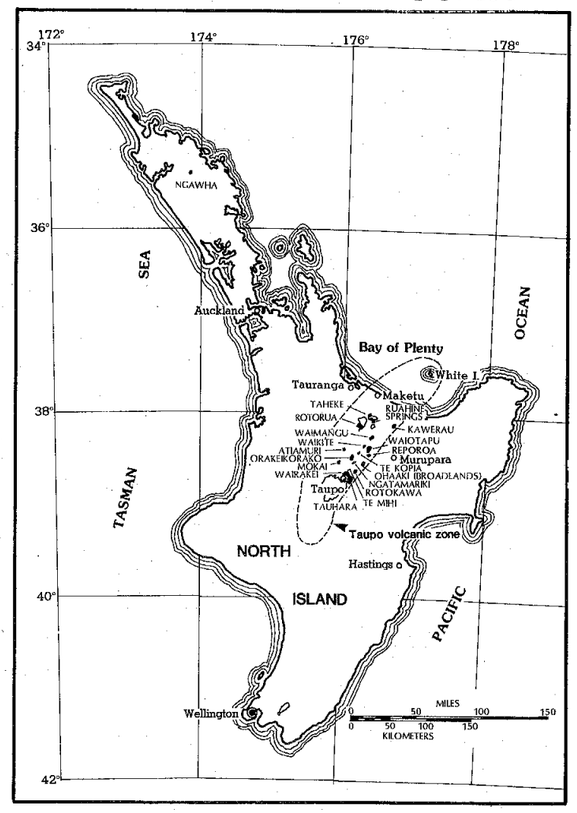
Low-temperature geothermal energy is not widely used in New Zealand. However, there is considerable low-temperature development of geothermal energy in high temperature fields. Such development occurs at Kawerau, Ohaaki (Broadlands), Rotorua, and Taupo. Most small-scale utilization is for public or private bathing.[3]

Recently, wells in the Tauhara field in the City of Taupo have been tapped to heat public buildings. Tauhara Geothermal field is adjacent to Wairakei Geothermal field (see Wairakei Geothermal field). The two fields have very similar temper-

[3] *Superior figures refer to entries in a list of Selected References on page 93.*



Location map of North Island, New Zealand.



North Island, New Zealand, geothermal fields.

atures, although Tauhara has higher pressures.[2] Some linkage between Wairakei and Tauhara is indicated by the pressure decline at Tauhara due to Wairakei production.

High Temperature

As of June 1982, the Electrical Power Research Institute estimates New Zealand's geothermal electrical power generation to be 203 megawatts.

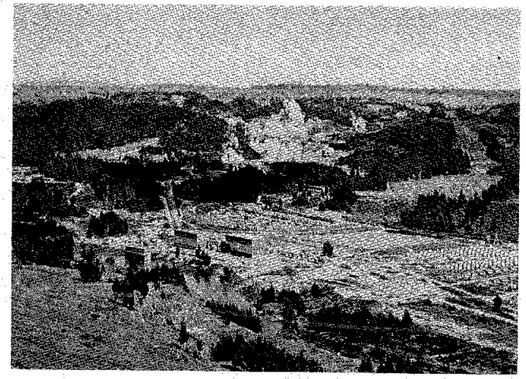
Wairakei Geothermal Field

The use of liquid-dominated geothermal resources to produce electricity on a commercial basis was pioneered in New Zealand. New Zealand's Wairakei Geothermal field has been exploited longer than any other liquid-dominated geothermal reservoir in the world. Studies undertaken in the 1930's culminated in the construction of the Wairakei station.[5] Geothermal power from Wairakei has equaled 7-1/2 percent of New Zealand's electrical power supply over the last 21 years.

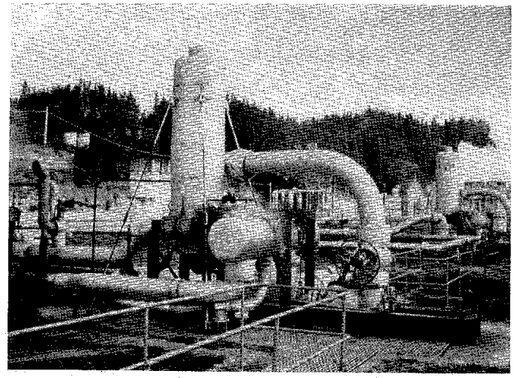
Wairakei Geothermal field is in an extensive thermal area in New Zealand's North Island. The field is near the middle of a thermal belt 31 miles wide and 155 miles long trending northeast-southwest across North Island. Called the Taupo volcanic zone, the belt extends from a central group of volcanic mountains to the White Island volcano in the Bay of Plenty. Wairakei field, itself, is in a region of Cenozoic subsidence.

The reservoir at Wairakei consists of a pumice breccia aquifer (Waiora formation) between 460m and 900m (1,500 feet to 3,000 feet) thick. The reservoir is capped by layers of relatively impermeable lacustrine mudstones that are mostly overlain with loosely consolidated breccias topped by a layer of pumice. The main productive zone is the contact area between the Waiora formation and the underlying Wairakei ignimbrite. Most of the field's production comes from the Waiora aquifer.

Development of electrical generation from liquid-dominated geothermal resources was pioneered at Wairakei. The first well to tap steam was drilled in the field in 1951. First stage construction of the country's first geothermal power plant was completed in March 1960. By 1963, the plant's installed capacity was 192.6 megawatts. Today, plant installed capacity is still 192.6 MWe, although the field output has declined to 142 MWe.



Wairakei Geothermal field (background), power station (center), and Waikato River (foreground). Photo courtesy of New Zealand Ministry of Works and Development.



Typical Wairakei wellhead configuration. Photo by H. J. Ramey, Jr.

The Wairakei power plant is a multi-pressure, separated-steam, double-flash system. About 80 percent by weight of wellhead high-pressure geothermal fluid is liquid. One hundred two wells have been drilled in the field; 68 of these supply steam to turbines.

About a 38 percent drop in pressure from steam wells at Wairakei occurred between 1953 and 1975. Nearly all pressure was lost since the first power plant was put on line. Today, the Wairakei reservoir has passed its productive peak. Reservoir pressure continues to decline, but at a lower rate. Withdrawn fluid has never been injected into this field; however, some experience has been gained from "accidental" injections in down-flowing wells.[4] Reinjection tests were initiated in 1982, and reinjection remains a possibility.

Kawerau

Kawerau Geothermal field is 97 kilometers (60 miles) northeast of Wairakei. Steam and hot water from Kawerau wells are used for electrical production; for generation of clean steam (with heat exchangers); and for low temperature processes, including timber drying, recovery boiler shatter spray, liquor heaters, and log-handling equipment.

The Tasman Pulp and Paper Company owns a pulp and paper mill, sawmill, and drying kilns built inside the field, where these activities are undertaken. The nonelectrical uses of geothermal energy account for about 21 percent of the energy needed for process applications at the Tasman Company. Field steam and hot water are used to operate one 10 megawatt electrical generating unit. All the electricity is used by the Tasman Company.

The field basement rock, an ignimbrite, is overlain by an extensively fissured andesite that serves as the lower aquifer. The andesite is capped by a rhyolite that may act as an insulator between this aquifer and a cooler aquifer just above it. The upper aquifer is pumice breccia imbedded with sandstone.

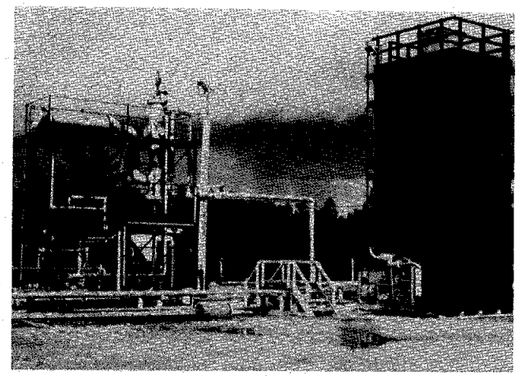
Today, the Kawerau production wells (about 25) and steamfield installations are owned by the Ministry of Energy and operated by the Ministry of Work and Development. These agencies supply steam to the Tasman Pulp and Paper Company. A level network check made in 1972 revealed a subsidence rate of 15mm/year in the area of maximum fluid drawoff. Unfortunately, the area of greatest subsidence in the field is at the mill site, where the subsidence rate is 28mm/year.

Ohaaki (Broadlands)

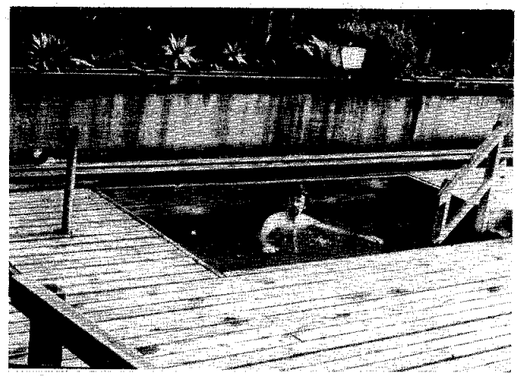
Exploratory drilling began at the Ohaaki (Broadlands) Geothermal field in 1965. By 1982, 38 investigation-production wells had been drilled in the field.

Even though construction approval has been received for a field 100 megawatt power plant, construction has not begun. A third 50 megawatt unit addition is planned if reservoir conditions warrant such development. All units will be separated-steam/hot-water flash systems.

The shallowest aquifer of the Broadlands field is a pumiceous tuff-breccia. A deeper strata, the Broadlands rhyolite,



Ohaaki (Broadlands) demonstration plant (used for condenser and cooling tower configuration design). Photo by R. N. Horne.



Direct use-bathing at Ngawha Springs. Photo by Y. Kawashima.

is the field's main cap rock. This rock overlies a vitric-crystal-lithic tuff and tuff-breccia aquifer in the Rautawiri formation, spanning the entire field. The zone thickness ranges from 180m to 335m (600 feet to 1,100 feet).

Between 1976 and 1980, hundreds of thousands of tons of separated geothermal water has been injected at Broadlands. Test data suggest that 150°C water may be the optimum injection temperature to minimize silica deposition. If subsidence trends at Broadlands continue, serious innundation from the Waikato River could occur. From May 1968 to March 1974, maximum subsidence at the field was about 190mm.

Ngawha

Ngawha Geothermal field is in North Auckland, North Island. Through 1982, 11 wells have been drilled in the field and more are planned.

Field strata include calcareous siltstones, argillites, and greywackes. Bottom-hole temperatures have equaled 236°C (457°F), but there appears to be low reservoir permeability and porosity. Many of the recent wells have yet to be discharged, and the evaluation of Ngawha field is still in progress.

Other New Zealand Geothermal Fields

(Data reprinted from reference Number 2 except for Mokai Geothermal field.)

Orakeikorako: few producing wells, low-quality steam, infiltration of cold water.

Reporoa: unimpressive temperature and low reservoir permeability.

Rotokawa: bottom-hole temperature ∽306°C (583°F); high steam quality, but high noncondensables and only moderate reservoir permeability.

TeKopia: field aligned with fault scarp; steam output is moderate but of low quality; highest temperatures occur in upper formation, become indifferent at depth.

Te Mihi: extension of Wairakei field; at least one well has been connected to Wairakei system.

Waiotapu: area of considerable thermal potential; shallow wells rapidly develop calcite deposits; deep wells are more promising.

Mokai: recently drilled; the exploratory well, MK2, produces 40 tons/hour of high enthalpy fluid. Reservoir temperatures are in excess of 290°C. Water chemistry is similar to Wairakei, and there appears to be little gas. Mokai looks very promising as New Zealand's newest geothermal discovery.

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2. DiPippo, Ronald, 1980, Geothermal energy as a source of electricity, DOE/RA/28320-1. Washington, D.C.: U.S. Department of Energy.

3. Gudmundsson, Jon Steinar, and Palmason, Gudmundur, 1981, World survey of low-temperature geothermal energy utilization. Reykjavik, Iceland: National Energy Authority, Geothermal Division.

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5. Kestin, Joseph, Editor in Chief, 1980, Sourcebook on the production of electricity from geothermal energy, DOE/RA/28320-2. Washington, D.C.: U.S. Department of Energy.

6. Thain, Ian A., 1980, "Wairakei-the first twenty years," in Proceedings of the fourth annual geothermal conference and workshop TC-80-907. Palo Alto, California Electric Power Research Institute.

Cerro Prieto

Recent Results of the Well Drilling Program at Cerro Prieto

Summarized from the report by Bernardo Domínguez A., Marcelo J. Lippmann, and Francisco Bermejo M. LBL-13635. $5.00. Available from the National Technical Information Service, U.S. Dept. of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

During the last two years, significant advances have been made in the development of the Cerro Prieto geothermal field. The installed electrical power capacity at the field continues to be 150 megawatts (MWe) (four 37.5-MWe high-pressure turbogenerators). A 30-MW lower-pressure unit has been undergoing testing since mid-1981. Before going into full operation, some installations of the flashing plant for this unit will have to be modified to improve its performance. At this plant, water at about 169°C, separated from the high-pressure steam, is flashed at 4.36 and 2.11 kg/cm^2 abs. The construction of two 220-MW power plants, each with two 110-MW turbogenerators, has begun. These plants are scheduled to go into operation during 1983 and 1984, respectively.

Drilling program

In November 1981, five drilling rigs and two work-over rigs were active in the field, and about 96 deep wells have been completed. Between December 1979 and November 1981, 27 wells were drilled.

In the eastern part of the field, the purpose of the drilling activity has been to increase the number of production wells to service the power plants under construction and to find the boundaries of the geothermal system. The wells drilled during 1980 and 1981 have essentially delineated the northern, eastern, and southeastern boundaries of the thermal anomaly. Outside of this region, the 1977 Prian well (3496 m depth) and the recent G-1 well (3000 m depth) have shown very low temperatures.

In the western part of the field, new production and stand-by wells were drilled for the existing power plant. In that region, the wells of the deeper "E-series" (average total depth: 1900 m) have confirmed the presence of a hotter aquifer (about 335°C) below the reservoir under development since 1973, whose average temperature and depth are about 280°C and 1250 m, respectively.

Well pressure and production rates

Shut-in wellhead pressures in the northwestern part of the field (CP I Norte), excluding the E-wells, have reached up to about 800 psi; in the southwestern part (CP I Sur) about 900 psi; in the southeastern part (CP II) about 1300 psi; and in the northeastern region (CP III) about 1200 psi.

In CP I Norte (excluding the deeper E-wells) the maximum steam production ever measured in a well was 125 t/h. In CP I Sur, some wells reached 140 t/h of steam. In CP II, where the reservoir is at 2700-3000 m depth, steam productions of up to 300 t/h have been measured. IN CP III, the reservoir is at 2000-2500 m depth, and some wells have produced above 100 t/h of steam (Dominguez and Sanchez, 1981).

Well completion

A number of modifications have been made in the way the wells are completed at Cerro Prieto, partly because deeper production and exploration wells are being drilled, and partly to reduce mechanical and corrosion problems in the casings.

Casing completion using API N-80 production casings was not very successful. The lifetime of these casings is about 6 months (Domínguez et al., 1981). Corrosion, collapses, and fractures have been detected.

Up-to-date results have shown that the wells completed during 1977-78 using API K-55 production casings have performed well. These heavier, soft-steel casings have shown greater resistance to mechanical stresses and corrosion. The damages observed in some of the 1977-78 wells are believed to be related to faulty cementing of the casings caused by circulation losses and/or failure of casing accessories during the cementing operations.

Presently, API C-75 grade production casings are being installed at Cerro Prieto. Because of the recent installation, it has as yet not been possible to evaluate the performance.

Low-density cement slurries have been used in the field to reduce circulation losses while cementing long strings of casings (up to 2000 m long). Recently, good results have been obtained by adding small-diameter ceramic spherules to the slurry, reducing its specific gravity to about 1.3 (10.8 lb/gal).

Final remarks

The drilling of production and exploration wells will continue at Cerro Prieto. The immediate goal is to drill enough wells to satisfy the long-term steam requirements of the power plants. It is estimated that the existing plant will need 30 wells (6 MW-well), while each of the two power plants under construction will require the flashed steam from about 25 wells (8.8 MW-well) to reach a total generating capacity of 620 MWe by 1984.

To establish the areal extent and the energy potential of the southern parts of the field (CP I Sur and CP II) a number of wells are planned to be drilled soon in the area between wells M-101, 93, 189 and 92.

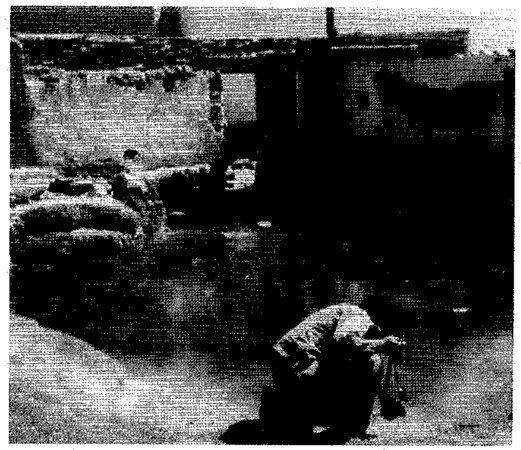
Bolivia

Bolivia's Geothermal Resources

Summarized from a report by Raul Carrasco, Servicio Geológico de Bolivia, Proyecto de Prospección Minera en la Cordillera, La Paz, Bolivia.

In Bolivia, geothermal manifestations occur only in the western, or Andean, region within three main physiographic units--the Western Andean Cordillera, the Altiplano, and the Eastern Andean Cordillera.

Data from about 30 thermal springs (UN Mineralogical Project, 1965) indicate temperatures in these areas range from 37°C to 77°C (99°F to 171°F), the only exception being at Luluni, where water close to 80°C discharges at high pressure.



Capachos hot spring, 57°C (135°F), 3707 meters altitude, near Oruro, Bolivia. In this area of the Eastern Andean Cordillera physiographic province, hot springs are related to subvolcanic bodies that intrude folded Paleozoic rocks. The hot springs are used for bathing. The spring in the photo is enclosed by an adobe brick wall. Photo by Mary C. Woods.

Insufficient data exist on the chemical composition of the waters to evaluate their potential at this time. For the most part, the data are limited to mineral waters bottled at plants in Viscachani and Chaquí.

Many of the hot springs are used for bathing, an indication of moderate acidity or alkalinity. Discharge rates are estimated to range from 1 to 40 liters/sec.

In evaluating the following conclusions and recommendations of this preliminary report on Bolivia's geothermal resources, it must be remembered that data from diverse sources were used.

1. At present no specialized reports on geothermal resources in Bolivia exist.

2. In western Bolivia, there are areas of prospective interest with regard to the development of geothermal resources for the generation of electricity.

3. The majority of the hot springs located in the Eastern Andean Cordillera are not recommended for prospecting as they are in zones of folded Paleozoic sediments, in which it would be difficult to locate aquifer reservoirs.

Conferences, Seminars, and Meetings

Eighth Annual Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, December 14-16, 1982.

The workshop brings together for mutual discussions researchers, engineers, and managers involved in geothermal reservoir studies and developments. Papers based on current geothermal reservoir engineering research will be presented.

The workshop will be held in the CERAS building (LGI Room). A registration fee of $125 will cover the Workshop Proceedings, three luncheons, and a banquet.

Participants must register before December 7.

For further information, contact Dr. Jon Steinar Gudmundsson, Petroleum Engineering Dept., Mitchell Building, Room 360, Stanford, California 94305.

Third ASTM Symposium on Water for Subsurface Injection, Fort Lauderdale, Florida, January 17-18, 1983.

Focus of the symposium will be water injection problems and solutions. A special technical publication on the symposium proceedings will be issued.

For further information, contact the ASTM at 1916 Race Street, Philadelphia, Pennsylvania 19103.

Consumer Seminar of Nondestructive Testing of Oilfield Tubular Goods, Marriott Hotel, Anaheim, California, April 7-8, 1983.

Users of tubular goods testing services can learn current methods and practices of the pipe inspection industry at this seminar. The seminar is sponsored by the International Pipe Inspectors Association. For further information, contact the IPIA, P.O. Box 42821, Houston, Texas 77042.

The Role of Heat in the Development of Energy and Mineral Resources in the Northern Basin and Range Province, Pioneer Theater, Reno, Nevada, May 16-18, 1983.

The symposium will include papers and discussions on geothermal energy, hydrocarbon resources, and ore deposits. Papers will be presented on regional tectonics, magmatism, structure and stratigraphy, active and fossil hydrothermal systems, and the geological, geophysical, and hydrological expressions of energy and ore resources of the Northern Basin and Range Province.

For further information, contact the Geothermal Resources Council, P. O. Box 98, Davis, California 95617.

Stanford Seminar Schedule

The Stanford Geothermal Program Seminar Schedule for Autumn Quarter 1982 is as follows. The seminars are held on the Stanford University campus, Room B67, Mitchell Building, on Thursdays from 1:15 to 2:30 p.m. There is no charge.

November 11, "Silicic Volcanic Centers Supporting Geothermal Systems in the Mexican Neo-Volcanic Belt," Gail A. Mahood, Geology.

November 18, "Heat Extraction Modeling," Stephan T. Lam, Mechanical Engineering.

December 2, "Geophysical Monitoring of Vapor-Liquid Interfaces in Reservoirs," Amos M. Nur, Geophysics.

California Geothermal Coordinating Council

The California Geothermal Coordinating Council (GCC) is composed of state and local government officials and representatives from the private sector. The GCC provides a forum where affected interest groups meet to discuss concerns and recommendations related to geothermal energy development activities in California and to identify and resolve issues in a timely and efficient manner. Past activities have led to better coordination among agency programs, policies, and regulatory activities affecting geothermal development.

Recent GCC speakers include representatives of Union Oil Company, Occidental Geothermal, the Department of Energy, Energy Planning and Research Institute (EPRI), the Division of Oil and Gas, and the California Energy Commission Geothermal Program. Periodic updates of state geothermal activities are presented as well as monthly state and federal legislative updates.

The GCC meets on the last Wednesday of each month in Sacramento. Agendas are available prior to the meetings. If you have any questions about the GCC or wish to attend a meeting, contact Frederick Tornatore, GCC Chairman, at (916) 924-4898.

Leasing

State Lands Lease Sale at The Geysers

Four bids were submitted to the State Lands Commission July 29 for lease of geothermal resources from six tracts of state-owned reserve mineral lands in The Geysers Geothermal field in Lake and Sonoma Counties. The bids were opened in the State Lands Commission's Sacramento office.

Terms of the sale were a royalty of 12.5 percent of gross revenue, annual rent of $1 per acre, and the biddable factor was the highest percentage of net profits. Bids ranged from a high of 22.80 percent to a low of 12 percent of net profits. Two parcels of 45 and 122 acres drew no bids.

MSR Public Power Agency of Modesto was the apparent high bidder for Lease Sale 1 of about 320 acres in Mendocino County with a bid of 12 percent of net profits.

Aminoil was the apparent high bidder for Lease Sale 2 of about 163 acres in Mendocino County with a bid of 22.80 percent of net profits; Lease Sale 3 of about 1133 acres in Lake and Mendocino Counties with a bid of 22.70 percent of net profits; and Lease Sale 5 of about 659 acres in Lake County with a bid of 21.85 percent of net profits.

No bids were received for Lease Sale 4 of about 45 acres in Lake County and Lease Sale 6 of about 122 acres in Lake County.

Bids will be analyzed by the commission staff, and recommendations will be made as to the highest qualified bidders.

$11.5 Million Bid for Geysers Lease

High bids totaling $11,557,713 were received by the California State Office, Bureau of Land Management, when bids were opened in July on 41 parcels of land in Known Geothermal Resource Areas of Lake, Mendocino, Napa, Sonoma, and Yolo Counties. Total acreage offered was 64,493.

Thirty of the 41 parcels drew no bids. High bid of the day was made on a 440-acre parcel in the Geysers-Calistoga Known Geothermal Resource Area. Three companies joined together to bid more than $4.8 million.

Parcel 1, MSR Public Power Agency, Modesto, California, $1,000,000, 1,879 acres.

Parcel 2, Aminoil USA, Santa Rosa, California, $700,062, 869 acres.

Parcels 3 and 4, no bids.

Parcel 5, Anadarko, Inc., Houston, Texas, $896,607, 597 acres.

Parcel 6, Union Oil/Magma Geyser/Thermal Power Los Angeles/San Francisco, California, $1,527,142, 462 acres.

Parcel 7, Union Oil/Magma Geyser/ Thermal Power, $4,842,200, 440 acres.

Parcels 8 through 12, no bids.

Parcel 13, Josef Wally, Santa Rosa, California, $1,720, 2,077 acres.

Parcels 14 through 25, no bids.

Parcel 26, Ford Engineering and Construction, Newport Beach, California, $2,043, 1,021 acres.

Parcel 27, Union Oil/Magma Geyser/Thermal Power, $1,576,596, 1,573 acres.

Parcel 28, Central California Power, Sacramento, California, $891,989, 2,548 acres.

Parcels 29 through 35, no bids.

Parcel 36, Black Hills Oil and Gas, San Francisco, California, $105,467, 2,524 acres.

Parcel 37, no bid.

Parcel 38, W. H. Hunt, Dallas, Texas, $13,836, 1,318 acres.

Parcels 39 through 41, no bids.

Bids were opened at the BLM headquarters at 2800 Cottage Way, Sacramento, California.

Lease Sale Schedule as of 11/82

Lease sale dates are provided by the state directors of the U.S. Bureau of Land Management (BLM). Lease sale dates are tentative until public notice is issued 30 days prior to sale. Lease sale notices may be obtained by contacting the appropriate BLM office.

Location of KGRA	Latest Sale Date Scheduled	Original Sale Date
Vulcan Hot Springs (USFS) ID	Cancelled	09/07/82
Belknap-Foley Hot Springs OR	11/16/82	07/06/78
Breitenbush Hot Springs/Carey Hot Springs/Mount Hood (USFS) OR	03/16/83	07/ ?/78
Kennedy Hot Springs (USFS) WA	03/16/83	12/15/82
Bruneau/Castle Creek/Crane Creek ID	02/23/83	
Raft River ID	03/30/83	

Computerized Data

Geoindex. By Patricia Fulton and Harold Johnson. P1172. 1982. $8.50. Available from the Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.

Descriptions of a data base and data-base management system that will 1) rapidly generate geologic index maps for publication, 2) offers immediate access to all data base items, and 3) offers nation-wide summary information. The system is complete and in production.

●

FORTRAN program to compute chemical geothermometers for geothermal fluids. By A. L. Rapport. Open File 82-0308. 1982. 27p. Microfiche or paper copy, $3.50. Available from the Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

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FLUIDEX Database

FLUIDEX Database is an online bibliographic database for the field of fluids engineering. Created by BHRA Fluid Engineering, the database extensively covers the performance, design testing, application, and operation of machinery and equipment, industrial plant, systems, and structures associated with the behavior and application of liquids, gases, and multiphase conditions.

FLUIDEX is comprised of a single, machine-readable file of classified and indexed bibliographical records. Covering from 1974 to the present date, FLUIDEX contained 65,000 abstracts at the end of 1980. To maintain the file and provide access to up-to-date material, approximately 12,000 items are added annually, by quarter.

Access to FLUIDEX can be arranged easily through the Library/Information Centers of industrial organizations, or directly by using online, dial-up techniques.

FLUIDEX is available as File 96 through Lockheed DIALOG. Detailed instructions on accessing FLUIDEX are available on application. DIALOG File Rates for FLUIDEX are: $65.00 per connect hour; $0.15 per offline print.

To access FLUIDEX, it is necessary to obtain a password from: DIALOG Information Retrieval Service, P.O. Box 8, Abingdon, Oxford, OX13 6EG. U.K.; Lockheed Retrieval Service, Dept. 52-80, 3400 Hillview Avenue, Palo Alto, California 94304.

Search Aids

To assist in obtaining the best results, BHRA offers users aids:

Guide to the Use of FLUIDEX Database
$5.00

Periodicals Scanned and Abstracted
$5.00

FLUIDEX Notes, Free

FLUIDEX Newsline, Free

For further information, write FLUIDEX Database Support Team, BHRA Engineering, Cranfield, Bedford. MK43 OAJ U.K.

Drill Hole Data Base at L.L.L.

The Continental Scientific Drilling Program data base at Lawrence Livermore National Laboratory is a central repository in which data are catalogued from about 1,860 U.S. drill holes of scientific interest. Most holes were either proposed or drilled by a federal agency.

The data base is funded by the Office of Basic Energy Sciences of the U.S. Dept. of Energy, and public use is free of charge. The data base is maintained on the Livermore Computer Center CDC 7600s through the Master Control Program. There are 24 textual and numerical parameters for each hole. Any of the categories can be sorted on and ordered.

For further information, contact Gayle Pawloski, Lawrence Livermore National Laboratory, L-222, Box 808, Livermore, California 94550. Phone (415)423-0437.

Maps

Sacramento Quadrangle, Map 1A. 1982. $12.00. Available from the California Division of Mines and Geology, P.O. Box 2980, Sacramento, California 95814.

The new geologic map, covering over 8,200 square miles of Central California, is the first release of the division's new Regional Geologic Map Series. The map covers geologic features of the Sierra Nevada, Great Valley, and Coast Ranges Provinces.

●

Geothermal Resources of Oregon. By Ronald H. Smith. 1:500,000. $3.00. Available from the Oregon Department of Geology and Mineral Industries, 1005 State Office Bldg., Portland, Oregon 97201.

The map includes an inset map of the City of Klamath Falls with thermal wells, an inset map of the geomorphic divisions of Oregon, and an inset map with Oregon heat flow contours. Digital heat flow data are available from GEOTHERM Project, U.S. Geological Survey, 345 Middlefield Road, MS-84, Menlo Park, California 94025.

●

Geologic map of Newberry Volcano, Deschutes, Klamath, and Lake Counties, Oregon. OF 82-0847. By MacLeod, Sherrod, and Chitwood. Microfiche $4.00, paper copy $6.00. Available from the OFSS, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

●

Geothermal resources of Arizona, 1982. By J. Witcher, C. Stone, and W. Hahman, Sr. Free. Scale 1:500,000. Available from Arizona Bureau of Geology and Mining Technology, 845 N. Park Avenue, Tucson, Arizona 85719.

●

Geothermal Resources of Nebraska, 1982. Scale 1:500,000. Free. Map available from the Conservation and Survey Division, 113 Nebraska Hall, University of Nebraska, Lincoln, Nebraska 68588 0517.

●

Geothermal Resources Map of Montana. By John L. Sonderegger and R. N. Bergantino. 1981. Hydrogeologic Map 4. $1.00 when mailed; free when picked up. Available from the Montana Bureau of Mines and Geology, Science and Technology, Butte, Montana 59701.

●

Geologic atlas of the Rocky Mountain Region. Reprinted by the Rocky Mountain Association of Geologists. $200.00. For further information contact: RMAG, 1615 California Street, Room 217, Denver, Colorado 80202.

Content will be the same as the first edition, with over 350 illustrations plus discussions on regional geology, geophysics, energy, and mineral resources.

Areas covered are Montana, the Dakotas, Wyoming, Eastern Idaho, Western Nebraska and Kansas, Colorado, Utah, and northern sections of Arizona and New Mexico.

●

Energy Resources Map of New Mexico. Published by the U.S. Geological Survey in cooperation with the New Mexico Bureau of Mines and Mineral Resources. Map I-1327. 1:500,000. $2.50. Available from the Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, Colorado 80225.

The map includes New Mexico's oil, gas, and coal fields; geothermal and uranium resources; and energy-related facilities such as power plants, pipelines, oil refineries, and major electrical transmission lines.

●

Topography of the southern Hawaiian Islands. OF 81-0120. By T. E. Chase, C. P. Miller, B. A. Seekins et al. 3 over-sized sheets. Microfiche $1.50, paper copy $19.00. Available from the OFSS, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

●

New U.S.G.S. Maps

Structural map of the summit area of Kilauea Volcano, Hawaii. MF-1368. By Patrice de Saint Ours. 1982. Scale 1:24,000. $1.25.

Map showing distribution, composition, and age of late Cenozoic volcanic centers in California and Nevada. By R. G. Luedke and R. L. Smith. I-1091-C. 1981 (1982). Two sheets. $6.00 per set.

The map was designed as a guide for exploration and evaluation of igneous-related geothermal resources. Emphasis on type and number of vents.

Map showing geothermal resources of the Lake City-Surprise Valley known geothermal resource area, Modoc County, California. By C. W. Hedel. MF-1299. 1981 (1982). 1 sheet. $1.25.

Energy resources map of Colorado. By the U.S.G.S. and Colorado Geologic Survey. I-1039. 1977. $2.50.

Geologic map of the Mt. Hood Wilderness, Clackamas and Hood River Counties, Oregon. By Robison, Keith, Beeson, and Bargar. MF-1379-A. 1 sheet. $1.25.

Map showing geothermal investigations in the vicinity of the Mount Hood Wilderness, Clackamas and Hood River Counties, Oregon. By Robison, Keith, Beeson, and Bargar. MF-1379-B. 1982. $1.25.

Order maps from the Western Distribution Branch, U.S. Geological Survey, Box 25286, Federal Center, Denver, Colorado 80225.

●

Geothermal Gradient Data and Map for the United States (exclusive of Alaska and Hawaii). 1982. Available in early 1983. Scale 1:2,500,000. $5.00 folded or $7.00 flat. Digital data used in making the map are available in the same format as the list shown on the map. Output may be obtained on magnetic tape for $100.00. Make check or money order payable to COMMERCE/NOAA/NGDC. Orders may also be charged to an American Express card. Order from the National Geophysical Data Center, NOAA, Code D62, 325 Broadway, Boulder, Colorado 80303. Phone (303) 497-6125.

The map replaces a 1980 map, now out of print, published by the Los Alamos National Laboratory. Data on the map were compiled from over 1,700 wells measured for temperature at depths below 50 meters. Temperature/depth profiles of the wells are linear or composed of linear segments that reflect changes in the thermal conductivity of the rocks rather than hydrology.

●

Geologic Map of the Southern Hemisphere. By R. A. Mills. 1:28,000,000. $40.00. Available from PennWell Maps, P. O. Box 21288, Tulsa, Oklahoma 74121.

●

Geothermal gradient map of Southeast Asia. Edited by Ken J. Rutherford and M. Khaliq Qureshi. 2nd edition. Two maps. SEAPEX members $25.00 air mail, $15.00 surface mail; nonmembers $35.00 air mail, $25.00 surface mail. Available from SEAPEX, P.O. Box 423, Tanglin Post Office, Singapore, 9124.

Includes data for 773 wells plotted on a map scaled 1:5 million. Data for the northwest shelf of Australia and offshore western Thailand are included. Not included are data from Burma and Vietnam.

Publications

EIA publications directory, a user's guide. DOE/EIA-0149 (77-81). 1982. $7.50. Published by the Energy Information Administration. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Contains abstracts of publications issued by EIA from October 1977 to December 1981. Updated semiannually. Monthly information is available free, from a publication called EIA Publications New Releases. Published by and available from the National Energy Information Center, 1000 Independence Avenue, S.W., Washington, D.C. 20585.

●

The Environmental Protection Agency's Office of Research and Development (ORD) publications announcement. Free. Available from ORD Publications, P.O. Box 14249B, Cincinnati, Ohio 45214.

The publications include project summaries, research summaries, decision series, and program summaries and plans.

●

Geothermal energy: investment decisions and commercial development. By Peter D. Blair, Thomas A. V. Cassel, and Robert H. Edelstein. Alternate Energy Series.

$33.81. Available from John Wiley and Sons, 605 Third Avenue, New York, New York 10158.

●

Security Pacific Bank, Monthly summary of business conditions. Free. Available from the Research Department, Security Pacific National Bank, Box 2097, Terminal Annex, Los Angeles, California 90051.

The June 1982 issue of the summary included an article titled "Geothermal Projects in the Imperial Valley-An Update."

●

Handbook of geothermal energy. Edited by L. M. Edwards, G. V. Chilinger, H. H. Ricke III, and W. H. Fertl. 1982. $69.95 plus $1.50 for shipping. Texas residents add 6 percent sales tax. Available from the Gulf Publishing Company, P.O. Box 2608, Dept. I6, Houston, Texas 77001.

National and worldwide geothermal resources are discussed. The geologic, engineering, and economic aspects are emphasized.

●

Geothermal energy, a hot prospect. By Augusta Goldin. 1981. $10.95. Available from Harcourt Brace Jovanovich, 757 Third Avenue, New York, New York 10017.

Young adults-- and older ones learning about geothermal energy-- will enjoy this well-illustrated book. In a relaxed and accurate manner, Augusta Goldin relates the history and development of geothermal resources throughout the world.

●

Geothermal log interpretation handbook. SPWLA Member - $38.00, all others - $43.00. Available from the Professional Society of Well Log Analysts, 806 Main Street, Ste. 1017, Houston, Texas 77002.

●

Geothermal energy resources chart. 1982. 24" x 36". $10.00. Available from PennWell Books, P.O. Box 21288, Tulsa, Oklahoma 74121.

Descriptions and illustrations of hydrothermal reservoirs; subsurface diagrams; direct and indirect uses; and inset map with United States GRA's.

●

Guide to some volcanic terranes in Washington, Idaho, Oregon, and Northern California. Edited by David A. Johnston and Julie Donnelly-Nolan. U.S.G.S. Circular 838. 1981. Free. Available from the Branch of Distribution, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.

A well illustrated series of field trips and roadlogs.

●

Principle facts for 397 gravity stations in the vicinity of Newberry Volcano. OF 82-0652. By Andrew Griscom and C. W. Roberts. Microfiche $3.50, paper copy $1.25. Available from the OFSS, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

●

Thermal springs of the United States and other countries of the world - a summary, PO492. By G. A. Waring. Revised by R. R. Blankenship and Ray Bentall. 1965. Reprint. $12.00. Available from the Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.

●

Radioactivity and geochemistry of selected mineral-spring waters in the Western United States - basic data and multivariate statistical analysis. By J. K. Felmlee and R. A. Cadigan.

OF82-0324. 1982. 107p. $13.75; microfiche $3.50. Available from the Open-File Services Station, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

●

Methods for collection and analysis of geopressured geothermal and oil field waters. By M.S. Lico, Y. K. Kharaka, W. W. Carothers, and V. A. Wright. 1982. Water Supply Paper W2194. $3.50. 21p. Available from Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.

●

Health and environmental effects document on geothermal energy, 1981. UCRL-53232. By David W. Layton, Lynn R. Anspaugh, and Kerry D. O'Banion. $7.00 (microfiche $3.50). Available from the National Technical Information Services, U.S. Dept. of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

In the report, the public health risks are assessed for hydrogen sulfide, benzene, mercury, and radon for 1) a single reference 100 MWe power plant, 2) a hypothetical 3,000 MWe development in California's Imperial Valley, and 3) production of 21,000 MWe over a 30-year period at 51 geothermal resource areas in the United States. In addition, the health risks were studied for drinking water contaminated with arsenic derived from geothermal fluids.

●

Publications. Free. Published by and available from Petroleum Information, P.O. Box 2612, Denver, Colorado 80201.

Includes descriptions of the many types of geothermal, oil, and gas information offered by this company, including the National Geothermal Service and a publication titled The Geothermal Resource.

●

List of publications. Free. Published by and available from the Geothermal Resources Council, P.O. Box 1350, Davis, California 95617. Phone (916) 758-2360.

Publications of the GRC include Special Reports, Study Guides for GRC courses and meetings, Transactions of GRC meetings, and the Bulletin (11 issues a year).

●

World energy industry information services. Free description. Available from World Energy Industry Information Services, 4202 Sorrento Valley Blvd., San Diego, California 92121. Phone (714) 452-7675.

The services include a Quarterly, with over 400 pages per issue, $750 a year; a monthly Bulletin and Outlook, over 100 pages, $1,450 a year; a publication titled the Energy Decade: 1970-1980, over 500 pages, $125 plus postage; and On-Line Database Services.

●

Books and journals from BHRA Fluid Engineering. Free. Available from BHRA Fluid Engineering, Cranfield, Bedford, England.

A list of journals, reports, symposium proceedings, bibliographies, and books.

●

A guide to obtaining information from the U.S.G.S. By Clarke, Hodgson, and North. (Revised 1982 edition). Circular C0777. Available from the Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.

●

EPRI Guide, Summer 1982. Free. Published by and available from the Electric Power Research Institute, Research Reports Center, P.O. Box 50490, Palo Alto, California 94303.

A guide to EPRI publications, with lists of technical reports, computer programs and data bases, licensable inventions, the Electric Power Database (EPD/RDIS), and other EPRI information materials.

●

Catalog of specialty books and bibliographies for earth science professionals. By the American Geological Institute. Free. Available from the American Geological Institute, 5205 Leesburg Pike, Falls Church, Virginia 22041.

●

Standards InfoBriefs, a quarterly newsletter published by the American Society for Testing and Materials. Free to ATSM members and customers. Available from ATSM, 1916 Race Street, Philadelphia, Pennsylvania 19103.

●

Catalogue sciences de la terre, Bureau de Minières. 1980. Free. Published by and available from the U.S. distributor of the Bureau: SMPF, 485 5th Avenue, Room 518, New York, New York 10017.

Extensive, interesting list of geologic publications, mostly about France, including a Geothermal Atlas. In French.

●

67th Annual Report of the State Oil and Gas Supervisor. 1981. Free. Published by and available from the California Division of Oil and Gas, 1416 9th Street, Room 1310, Sacramento, California 95814.

Statistical and verbal summaries of 1981 California geothermal activities.

Also available from the division, free of charge, are updated copies of California Laws for Conservation of Geothermal Resources, publication PRC02.

●

Latitude, longitude, and California Lambert Coordinates for 229 wells in The Geysers Geothermal field. By Marshall J. Reed. U.S.G.S. Open File Report 82-410. $1.25 paper copy, $3.50 microfiche. Available from the Open File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

Locations of wells in The Geysers Geothermal field.

●

Data for geothermal wells in The Geysers-Clear Lake Area of California as of 11/80. By Marshall J. Reed. Special Report No. 11. $6.50. Available from the Geothermal Resources Council, P.O. Box 98, Davis, California 95617.

The report contains the location, altitude, total depth, dates of drilling, and status for 336 geothermal wells drilled in The Geysers-Clear Lake area of California as of 11/80. The report also summarizes the development of The Geysers Geothermal field from 1921 through November 1980.

●

Geothermal energy development: problems and prospects on the Imperial Valley of California. By Edgar W. Butler and James B. Pick. 1982. $39.50. Available from the Plenum Press, Plenum Publishing Company, 233 Spring Street, New York, New York 10013.

●

Preliminary heat-flow investigations of the California Cascades. By C. W. Mase, J. H. Sass, A. H. Lachenbruch, and R. J. Munroe. OF82-0150. 1982. $31.25; microfiche $3.50. Available from the Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

●

San Diego Geology

Geologic studies in San Diego. Edited by Patrick L. Abbott. 1982. $8.50. 160 pages.

and

Geologic investigations of the San Diego Coastal Plain. Edited by Patrick L. Abbott and Shannon O'Dunn. 1982. $8.50. 165 pages.

Both publications are available from the San Diego Association of Geologists, 8145 Ronson Road, Suite H, San Diego, California 92111.

●

Energy Commission Publications

These publications are available from Accounting, M.S. 53, California Energy Commission, 1111 Howe Avenue, Sacramento, California 95825.

Cost estimates and cost forecasting methodologies for selected nonconventional electrical generation technologies. Publication P300-82-006. $11.25, payable in advance.

Status summaries, technology descriptions, reference systems, and component cost estimates for liquid-dominated geothermal systems.

Geothermal energy: opportunities for California commerce. Publication P500-82-008. $3.30, payable in advance.

California's end-use markets that could directly use low-and moderate-temperature geothermal resources are ranked and described.

Geothermal energy: opportunities for California commerce, Phase II. Publication P500-82-049. $2.70, payable in advance.

A preliminary engineering and economic assessment of five direct-use projects using low-and moderate-temperature geothermal resources.

A guide to financial assistance for geothermal energy. Publication P500-81-030. Free.

A summary of state and federal financial programs and incentives.

●

List of publications. The Virginia Division of Mineral Resources. Free. Available from the Virginia Division of Mineral Resources, Box 3667, Charlottesville, Virginia 22903.

One publication of special interest is the May 1982 issue of Virginia Minerals that features an article titled "Geothermal Energy for the Eastern United States."

●

Geothermal resources in the Banbury Hotsprings area, Twin Falls County, Idaho. By R. E. Lewis and H.W. Young. W2186. $3.75. Available from the Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.

●

Open-file materials, Earth Science Laboratory, University of Utah Research Institute. Free. Published by and available from Publications, Earth Science Laboratory, 420 Chipeta Way, Suite 120, Salt Lake City, Utah 84108.

Most material in the publications is raw exploration data from industry sources. Prices are low, covering minimum reproduction and mailing costs. All material is available for public viewing at three Salt Lake City, Utah, sites (a fourth Salt Lake City site has Utah open-file materials only) and at Reno, Nevada, and Reston, Virginia.

Publications are listed for the following areas:

Cove Fort - Sulphurdale Area, Beaver and Millard Counties, Utah,

Roosevelt Hot Springs, Beaver County, Utah,

Baltazor Hot Springs, Humboldt County, Nevada,

Beowawe Area, Lander and Eureka Counties, Nevada,

Colado Hot Springs, Pershing County, Nevada,

Desert Peak, Churchill County, Nevada,

Dixie Valley, Churchill County, Nevada,

Humboldt House, Pershing County, Nevada,

Leach Hot Springs, Pershing County, Nevada,

McCoy Area, Churchill and Lander Counties, Nevada,

San Emidio, Washoe County, Nevada,

Soda Lake, Churchill County, Nevada,

Stillwater, Churchill County, Nevada, and

Tuscarora, Elko County, Nevada.

●

New Nevada Gravity Data

Five open-file reports on the gravity data for the Wells, Reno, and Millett 1 by 2° Sheets, Nevada, by John W. Erwin are available from the Nevada Bureau of Mines and Geology. All prices refer to Xeroxed copies of the reports.

NBMG Open-file Report 82-1, "Principal facts for a set of regional gravity data for the Wells 1 and 2° Sheet, Nevada," $13.35.

NBMG Open-file Report 82-2, "Principal facts for a set of regional gravity data for the Reno 1 by 2° Sheet, Nevada, $5.25.

NBMG Open-file Report 82-7, "Discussion of a set of regional gravity data for the Reno 1 by 2° Sheet, Nevada", $0.75.

NBMG Open-file Report 82-3, "Principal facts for a set of regional gravity data for the Millett 1 by 2° Sheet, Nevada," $9.00.

NBMG Open-file Report 82-8, "Discussion of a set of regional gravity data for the Millett 1 by 2° Sheet, Nevada," $0.60.

All reports may be inspected at NBMG offices (Room 311, Scrugham Engineering-Mines Building, University of Nevada, Reno). They may be purchased at the sales office in Room 310, Scrugham Engineering-Mines Building or by mail from the Nevada Bureau of Mines and Geology, University of Nevada-Reno, Reno, Nevada 89557-0088. Add 10 percent for postage and handling.

●

Geochemical and geostatistical evaluation, Wilderness Study Areas, Winnemucca District, Northwest Nevada. Prepared by Barringer Resources, Inc., Golden, Colorado. Available for public inspection at the Nevada State Office, BLM, 300 Booth Street, Reno; Winnemucca District Office, BLM, 705 E. 4th St., Winnemucca; Susanville District Office, BLM, 705 Hall St., Susanville, CA; and Nevada Bureau of Mines and Geology, Scrugham Engineering-Mines Building, Room 311, University of Nevada, Reno.

In the report, the mineral potential of 26 Wilderness Study Areas and adjacent land in Humboldt, Pershing, and Washoe Counties, Nevada are evaluated. Twenty anomalous areas within the 2-million acre area are of significant mineral interest. Over 1,900 stream sediment and heavy mineral samples were collected and analyzed for 33 different elements. Significant mineral potential areas were identified in the Fox, Black Rock, Pine Forest, and Tobin Ranges, and Calico, Jackson, and August Mountains.

The report consists of five volumes with 72 pages of text, geochemical

sample analysis results, and 24 plates, including maps and charts.

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New Mexico's energy resources '81. Edited by Emery C. Arnold and James M. Hill. 1981. $4.00. 62 pages. Available from the New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, New Mexico 87801. Phone (505) 835-5420.

The publication is divided into four parts: geothermal energy, uranium, oil and gas, and coal. Also available from the bureau is a list of its publications.

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"Extracting geothermal energy can be hard," by Richard Kerr. Published in the Nov. 12, 1982 issue of Science, vol. 218, no. 4573. $2.50.

Summary of development at the Baca Geothermal field. Includes discussion of a reservoir definition review team's findings, which are available as report LBL-14132, published in June 1982. Order the report from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161; $8.00.

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The Nevada mineral industry, 1981. By John Schilling. Special Publication Ml. $5.00. Published by and available from the Nevada Bureau of Mines and Geology, University of Nevada, Reno, Nevada 89557-0088.

An interesting chapter on geothermal energy is included in this report.

●

1981 geothermal gradient data for Oregon. By D. D. Blackwell, G. L. Black, and G. R. Priest. Open File Report O-82-4. 430p. $15.00. Available from the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, Oregon 97201.

Data and temperature depth plots for about 100 drill holes throughout Oregon. Included are new measurements in the Cascades and eastern Oregon.

●

The geothermal hydrology of Warner Valley, Oregon: a reconnaisance study. By E. A. Sammel, Q. W. Craig, and R. W. Crary. 1981 (1982) P1044-I. $4.00. Available from the Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.

●

These publications are available, free, from the Washington State Energy Office:

Energy conservation resource directory (WAOENG-82-06) -includes about 500 energy conservation contacts in the State of Washington;

Institutional and financial guide to geothermal district heating (WAOENG-82-03) prepared by Elliot Allen and Associates, Inc.;

Guide to a community heat plan: a geothermal energy application (WAOENG-82-04) prepared by Elliot Allen and Associates; and

Guide to financing small-scale geothermal energy projects.

For single copies, write Ms. Ginger Alexander, Washington State Energy Office, 400 E. Union Avenue, ER-11, Olympia, Washington 98504. Phone (206)754-0778.

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Self-potential surveys related to probable geothermal anomalies, Hualalai Volcano, Hawaii. By D. B. Jackson and M. K. Sako. OF82-0127. 1982. $2.25; microfiche $3.50. Available from the Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

California Wells

Drilling Permits for Geothermal Wells Approved Jan.-Oct. 1982 by the California Division of Oil and Gas

Date Notice Received	Operator & Well No.	API No.	Sec.	T.	R.	Location & Elevation
	LAKE COUNTY					
1/18/82	MCR Geothermal Corp. "Coleman" 2-6	033-90429	6	11N	8W	Fr. NE cor. 1153m S, 153m W. 909m KB.
3/15/82	Union Oil Co. of Calif. "Tocher" 3	033-90430	27	11N	8W	Fr. NW cor. 226m S, 280m E. 975m KB.
6/21/82	MCR Geothermal Corp. "Coleman" 2-5	033-90436	5	11N	8W	Fr. NW cor. 773m S, 301m E. 813m KB.
6/21/82	MCR Geothermal Corp. "Coleman" 3-6	033-90437	6	11N	8W	Fr. NE cor. 1142m S, 147m W. 909m KB.
	SONOMA COUNTY					
1/12/82	Union Oil Co. of Calif. "GDC" 53A-13	097-90534	13	11N	9W	Fr. NE cor. 531m S, 640m W. 486m KB.
2/23/82	Union Oil Co. of Calif. "D & V" 3	097-90535	34	11N	8W	Fr. NW cor. 433m S, 50m E. 907m KB.
3/29/82	Union Oil Co. of Calif. "DX State 4596" 72	097-90539	7	11N	8W	Fr. SE cor. 559m N, 105m W. 963m KB.
4/2/82	Union Oil Co. of Calif. "D & V" 4	097-90540	34	11N	8W	Fr. NW cor. 436m S, 55m E. 907m KB.
5/7/82	M-S-R Public Power Agency "Abril" 1-2	097-90542	15	11N	9W	Fr. E¼ cor. 213m S, 288m W. 740m RT.
5/21/82	Union Oil Co. of Calif. "GDC" 20	097-90549	19	11N	8W	Fr. SE cor. 320m N, 274m W. 613m KB.
6/2/82	Union Oil Co. of Calif. "D & V" 5	097-90545	33	11N	8W	Fr. NE cor. 633m S, 677m W. 826m KB.
8/25/82	Union Oil Co. of Calif. "GDC Federal" 94-19	097-90555	19	11N	8W	Fr. NW cor. 716m due S, 1600m E. 802m KB.
9/8/82	Union Oil Co. of Calif. "D & V" 15	097-90556	33	11N	8W	Fr. SE cor. 325m N, 134m W. 868m KB.
	LASSEN COUNTY					
10/8/82	City of Susanville "Richardson" 1	035-90067	32	30N	12E	Fr. SW cor. 715m N, 230m E. 1210m GR.
	IMPERIAL COUNTY					
2/27/82	Union Oil Co. of Calif. "I.I.D." 9	025-90506	5	12S	13E	Fr. SW cor. 579m N, 395m E. -63m KB.

Date Notice Received	Operator & Well No.	API No.	Sec.	T.	R.	Location & Elevation
7/3/82	Chevron Geothermal Corp. "HGU" 11	025-90536	34	16S	14E	Fr. NW cor. 1026m S, 266m E. 3m KB.
7/3/82	Chevron Geothermal Corp. "HGU" 12	025-90537	34	16S	14E	Fr. NW cor. 1031m S, 238m E. 3m KB.
7/3/82	Chevron Geothermal Corp. "HGU" 14	025-90538	34	16S	14E	Fr. NW cor. 1039m S, 241m E. 3m KB.
7/3/82	Chevron Geothermal Corp. "HGU" 16	025-90539	34	16S	14E	Fr. NW cor. 1047m S, 244m E. 3m KB.
9/18/82	Chevron Geothermal Corp. "HGU" 13	025-90540	34	16S	14E	Fr. NW cor. 1034m S, 269m E. 3m KB.
10/9/82	Occidental Geothermal "Emmanuelli" 2	025-90542	20	13S	16E	Fr. SE cor. 305m N, 235m W. -4m KB.
10/23/82	Union Oil Co. of Calif. "Veysey" 15	025-90543	16	13S	14E	Fr. SW cor. 128m N, 745m E. -38m KB.

CDOG Well Data Available

A computer-generated file of geothermal production and injection statistics for wells with records open to public inspection is available from the California Division of Oil and Gas. All data are in metric units. The file may be purchased for $50.00 from the California Division of Oil and Gas in Sacramento.

Geothermal Well Records That May Be Inspected and Copied in the Sacramento Geothermal Office

Well Designation	API Number	Sec.	T.	R.
AMAX EXPLORATION, INC.				
B-1 (Shallow)	---	29	39N	9E
B-2 (Shallow)	---	21	38N	9E
B-4 (Intermediate)	035-90009	30	38N	8E
B-5 (Intermediate)	035-90010	29	38N	7E
B-6 (Intermediate)	035-90011	3	38N	7E
B-7 (Intermediate)	035-90012	34	39N	8E
AMERICAN THERMAL RESOURCES				
"Goodwin" 1-11	049-90010	11	41N	16E
CITY OF SUSANVILLE				
"Susan" 1	035-90063	31	30N	12E
WESLEY D. DAVIS, JR.				
"Davis" 2 (Shallow)	---	32	30N	12E
CHARLES W. GADDA				
"Sierra Valley" 1	063-90011	32	22N	15E
GEOTHERMAL POWER CORPORATION				
"Kelly Hot Springs Ranch" 1	049-90003	29	42N	10E

Well Designation	API Number	Sec.	T.	R.
GULF OIL CORPORATION				
"Honey Lake" 1-ST	035-90001	5	29N	16E
"Surprise Valley" 2-ST	049-90002	13	43N	16E
HONEY LAKE FARMS				
"Mapes" 1	035-90040	23	29N	15E
LATTER DAY SAINTS CHURCH				
No. 1 (Intermediate)	035-90013	5	29N	12E
MAGMA ENERGY, INC.				
"Casa Diablo" 1	051-90010	32	3S	28E
"Chance" 1	051-90012	35	3S	28E
"Parman" 1	049-90005	24	44N	15E
"Parman" 2	049-90006	24	44N	15E
"Phipps" 1	049-90008	24	44N	15E
"Water Well" 1	051-90003	32	3S	28E
MAGMA POWER COMPANY				
"Amedee" 1 (Intermediate)	035-90005	8	28N	16E
"Amedee" 2	035-90006	8	28N	16E
"Amedee" 3 (Shallow)	---	4	28N	16E
"Cedarville" 1 (Intermediate)	049-90012	6	42N	17E
"Wendel" 1	035-90004	23	24N	15E
PHILLIPS PETROLEUM COMPANY				
B-1 (Intermediate)	051-90017	32	5N	25E
B-2 (Intermediate)	051-90018	8	4N	25E
B-3 (Intermediate)	051-90019	21	4N	25E

Geothermal Well Records That May Be Inspected and Copied in the El Centro Geothermal Office

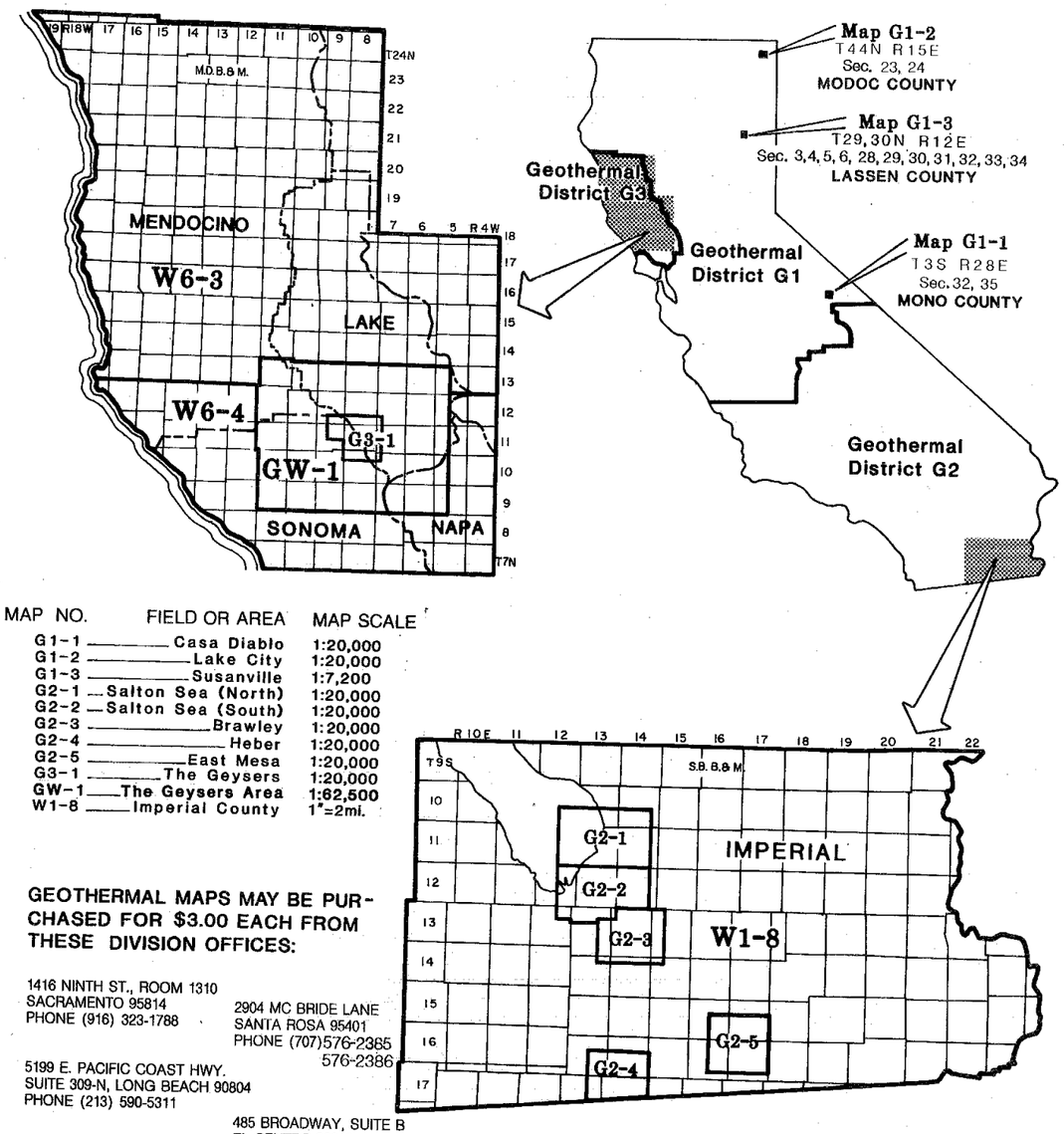
Well Designation	API Number	Sec.	T.	R.
AQUAFARMS INTERNATIONAL INC.				
"Aqua" 1	065-90001	3	8S	11E
"Aqua" 2	065-90002	3	8S	11E
"Aqua" 3	065-90003	3	8S	11E
AMERADA HESS CORPORATION				
"Timken" 1	025-00006	28	16S	14E
"Veysey" 1	025-00007	9	13S	14E
CALIPATRIA SPA				
"Well No." 1	025-90169	16	12S	14E
DEPARTMENT OF WATER RESOURCES				
"Well No." 1	025-90031	33	15S	19E
GEOTHERMAL ENERGY AND MINERAL CORPORATION				
"Sinclair" 1	025-90015	10	12S	13E
"Sinclair" 2	025-90016	4	12S	13E
"Sinclair" 3	025-90017	10	12S	13E
"Sinclair" 4	025-90018	4	12S	13E
IMPERIAL MAGMA				
"Hudson" 1	025-90028	13	11S	13E
"River Ranch" 1	025-90029	24	11S	13E

Well Designation	API Number	Sec.	T.	R.
IMPERIAL PRODUCTS, INC.				
"I.I.D." 1	025-90019	23	11S	13E
"I.I.D." 2	025-90020	22	11S	13E
"I.I.D." 3	025-90021	23	11S	13E
"Sportsman" 1	025-90023	23	11S	13E
"State of California" 1	025-90022	23	11S	13E
MAGMA ENERGY, INC.				
"Bonanza" 1	025-90008	22	15S	14E
"Dearborn" 1	025-90003	30	12S	13E
"Fed-rite" 1	025-90009	8	17S	13E
"Sharp" 1	025-90004	35	15S	15E
"Sharp" 2	025-90005	34	16S	16E
MAGMA POWER COMPANY				
"Randsburg" 1	071-90001	25	29S	41E
McCULLOCH OIL CORPORATION				
"Hot Mineral" 1	025-90050	13	9S	12E
PIONEER DEVELOPMENT COMPANY				
"Well No." 1	025-90024	10	11S	13E
"Well No." 2	025-90025	10	11S	13E
"Well No." 3	025-90026	10	11S	13E
PHILLIPS PETROLEUM COMPANY con't.				
"Filippini-A" 1	063-90001	32	22N	15E
HL-1 (Intermediate)	035-90021	32	28N	15E
HL-2 (Intermediate)	035-90022	4	27N	15E
HL-3 (Intermediate)	035-90023	8	27N	15E
HL-4 (Intermediate)	035-90024	3	27N	15E
HL-5 (Intermediate)	035-90025	16	27N	15E
HL-6 (Intermediate)	035-90026	11	27N	15E
HL-7 (Intermediate)	035-90027	15	27N	15E
HL-8 (Intermediate)	035-90028	24	27N	15E
HL-9 (Intermediate)	035-90029	7	27N	16E
HL-10 (Intermediate)	035-90030	25	27N	15E
HL-11 (Intermediate)	035-90031	17	27N	16E
HL-12 (Intermediate)	035-90032	1	26N	15E
HL-13 (Intermediate)	035-90033	31	27N	16E
HL-14 (Intermediate)	035-90034	29	27N	16E
HL-15 (Intermediate)	035-90035	21	27N	16E
HL-16 (Intermediate)	035-90036	2	26N	15E
HL-17 (Intermediate)	035-90037	12	26N	15E
HL-18 (Intermediate)	035-90038	6	26N	16E
HL-20 (Intermediate)	035-90039	30	27N	15E
"Walker O" 1	063-90002	36	30N	5E
SALTON SEA CHEMICAL PRODUCTS CORPORATION				
"No." 1	025-90033	28	11S	13E
U.S. WATER AND POWER RESOURCES SERVICE				
"Mesa" 5-1	025-90040	5	16S	17E
"Mesa" 6-1	025-90032	6	16S	17E
"Mesa" 6-2	025-90034	6	16S	17E
"Mesa" 8-1	025-90041	8	16S	17E
"Mesa" 31-1	025-90042	31	15S	17E
VANHUISEN AND GRIFFEN				
"Grace" 1	025-90030	19	12S	13E

(Geothermal well records that may be copied in the Santa Rosa Geothermal office appear in the January 1982 Hot Line.)

1982 Index

California Division of Oil and Gas
GEOTHERMAL MAPS



MAP NO.	FIELD OR AREA	MAP SCALE
G1-1	Casa Diablo	1:20,000
G1-2	Lake City	1:20,000
G1-3	Susanville	1:7,200
G2-1	Salton Sea (North)	1:20,000
G2-2	Salton Sea (South)	1:20,000
G2-3	Brawley	1:20,000
G2-4	Heber	1:20,000
G2-5	East Mesa	1:20,000
G3-1	The Geysers	1:20,000
GW-1	The Geysers Area	1:62,500
W1-8	Imperial County	1"=2mi.

GEOTHERMAL MAPS MAY BE PURCHASED FOR $3.00 EACH FROM THESE DIVISION OFFICES:

1416 NINTH ST., ROOM 1310
SACRAMENTO 95814
PHONE (916) 323-1788

2904 MC BRIDE LANE
SANTA ROSA 95401
PHONE (707)576-2365
576-2386

5199 E. PACIFIC COAST HWY.
SUITE 309-N, LONG BEACH 90804
PHONE (213) 590-5311

485 BROADWAY, SUITE B
EL CENTRO 92243
PHONE (619) 353-9900

TR02(11-82-DWR-13C)

CALIFORNIA DIVISION OF OIL & GAS
1416 NINTH STREET, ROOM 1310
SACRAMENTO, CA. 95814