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RENEWAL ISSUE

GEOTHERMAL HOT LINE

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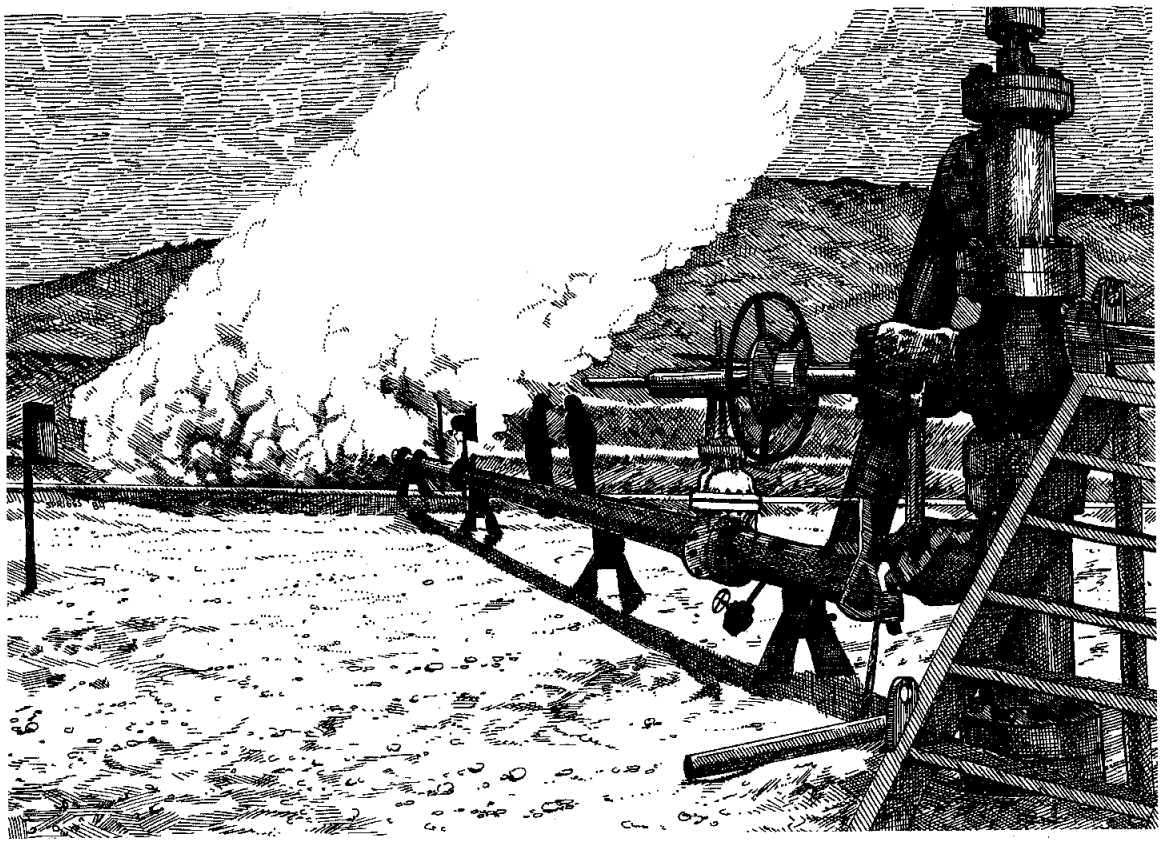
DEPARTMENT OF CONSERVATION

July 1984 Vol. 14 No. 1



California Energy Company, Inc. well 75A-7, Coso Known Geothermal Resource Area, southern Inyo County, California. The well was tested for 81 days in early 1984. During this period, the well was measured for mass flow, enthalpy, pressure, and temperature. The effluent was sampled to determine the composition, including the non-condensibles. Reservoir pressure decrease characteristics were noted, as well. *Drawing by Jim Spriggs from a photo by A.D. Stockton* *(See story on page 4.)*

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RENEWAL ISSUE

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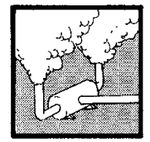

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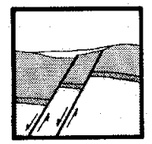

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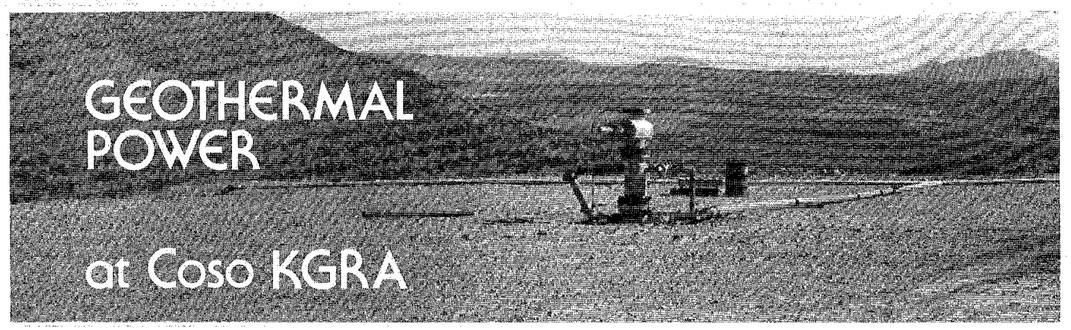
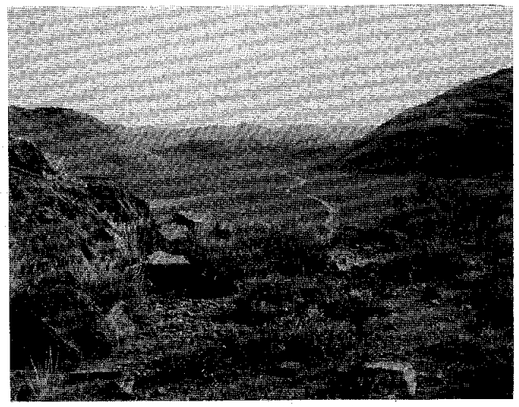


GEOTHERMAL POWER at Coso KGRA

By Susan F. Hodgson

In 1981, California Energy Company, Inc. of Santa Rosa, California, began the exploratory phase of a project at the Coso Known Geothermal Resource Area. The project's scope is unique in California geothermal development. The company contracted with the U.S. Navy to explore for, develop, and produce geothermal fluids. The company will also generate electricity from the fluids, build electrical transmission lines, and transfer the electricity to the Navy. "It's a cradle-to-the-grave project," said Dick Adams, Vice-President of Operations for California Energy.

Coso Known Geothermal Resource Area (KGRA) is located within the China Lake Naval Weapons Center in southern Inyo County, California. The KGRA heat source is considered to be a shallow body of magma, according to a notation on the Technical Map of the Geothermal Resources of California published by the California Division of Mines and Geology. The KGRA is within the Coso volcanic field.

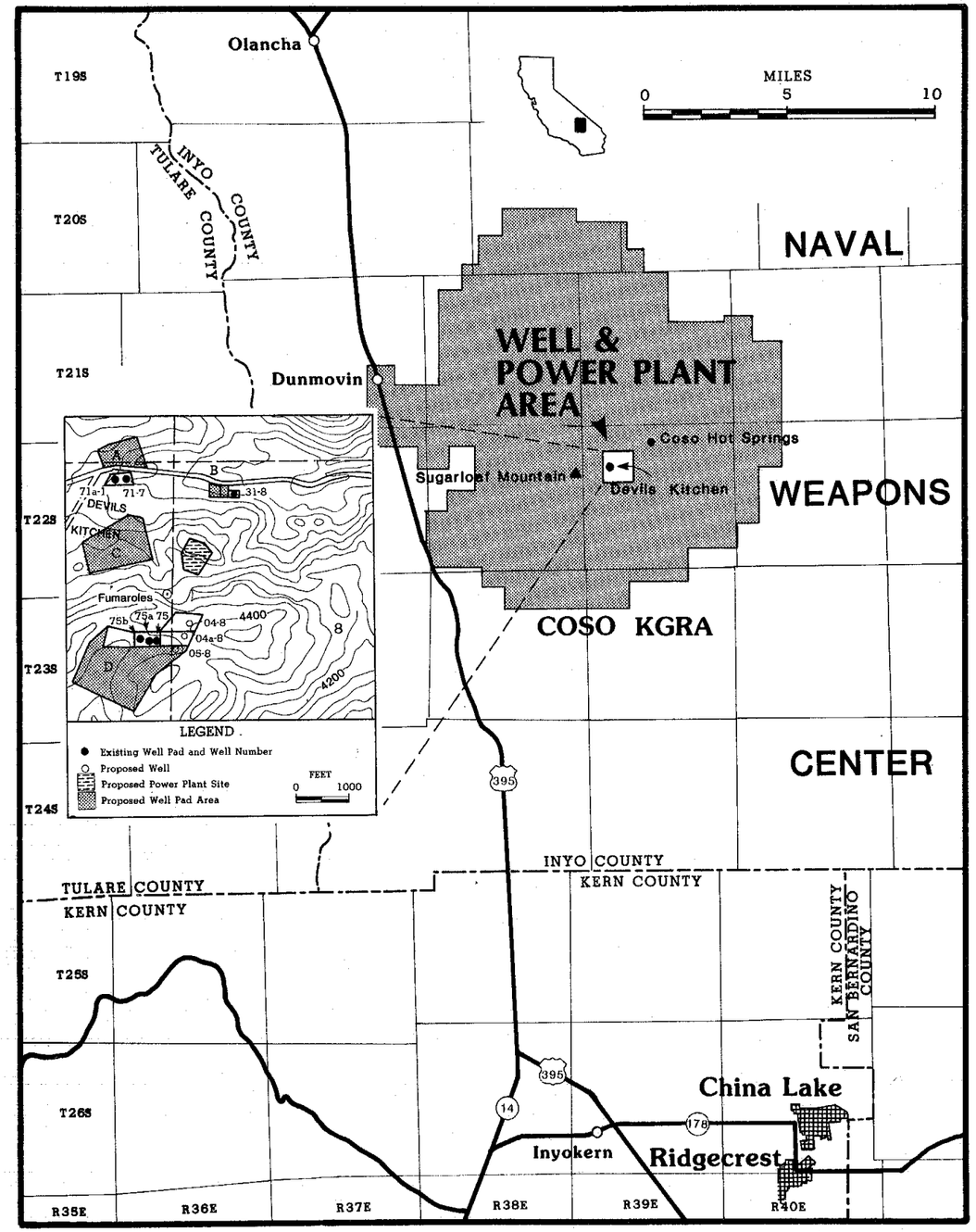


Road to Coso Hot Springs. Sugarloaf Mountain, photo right. Photo by Forrest Bacon, CDMG.

"We're very encouraged over the reservoir at Coso," said Adams. "It's basically a hot water reservoir with some dry steam. Reservoir temperatures range from 400°F to 450°F, and reservoir fluids are low enough in noncondensibles that this is not a problem."

Adams said the reservoir at Coso is quite shallow. The production wells drilled by California Energy are 1,350 feet to 2,200 feet deep. The

Well pad at Coso KGRA. Devils Kitchen is in the background. Trenching equipment (see arrow) on top of the hill marks the power plant site. The site was trenched to find solid rock and locate any evidence of quakes. Photo by Chris Higgins, CDMG.



Location map, Coso KGRA, showing California Energy Company, Inc. well-and power plant-locations.

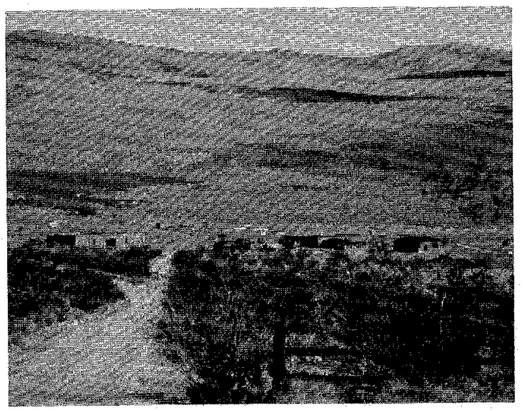
base of the reservoir is still not known. Adams said the base will be looked for later on.

To date, the company has drilled 5 production wells and 1 injection well, well 31-8. A power plant able to generate 75 megawatts of electricity will be constructed near the wells. The plant will be built in 12½ megawatt increments. The first increment is scheduled for completion during the fourth quarter of 1985.

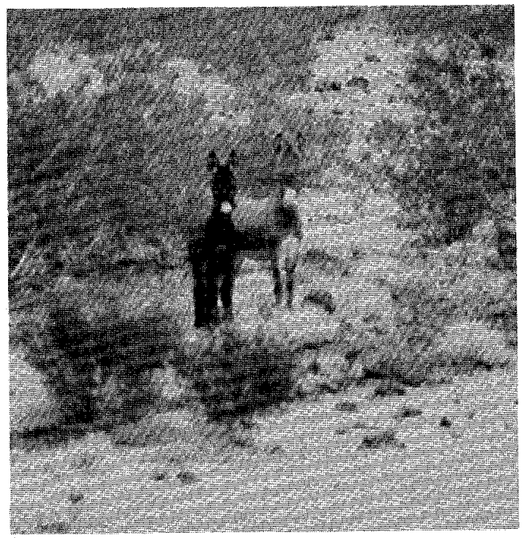
"A wide range of estimates has been made on the amount of electrical power that can be generated from the Coso reservoir," said Adams. "These range from 600 megawatts to 4,000 megawatts. No one knows what's right. California Energy is comfortable with our plan to construct a 75 megawatt power plant in 12½ megawatt increments. We're very encouraged with the reservoir. The whole project is a once-in-a-lifetime experience," he concluded.

California Energy is operating the China Lake Joint Venture on behalf of itself and an investor group headed by the Caithness Corporation of New York. The contract calls for the contractor to complete the resource evaluation, construct the power plant, and operate the plant at no capital cost to the Navy. The Navy retains title to the land, the geothermal resource, and the electricity. The contractor recoups the investment through payments for the conversion of the geothermal energy to electricity, which will be returned to the Navy. The agreement calls for the production of 75 MWe of electrical power for the China Lake Naval Weapons Center and other Naval installations in Southern California.

California Energy is now operating on about 5,000 acres of Navy land. As a result of a cooperative agreement between the Navy and the U.S. Department of the Interior, the lands that were not contracted for development by the Navy were released to the Department of the Interior for a regular lease sale under terms of the Geothermal Steam Act. Three other entities have acquired most field leases: the Los Angeles Department of Water and Power (3 parcels, $6.5 million), California Energy (4 parcels, $173,774), and Grant Lyddon of Santa Monica (14 parcels, $231,113).



Road into old Coso Hot Springs resort area. Movie stars visited the resort in the early part of the century. Photo by Forrest Bacon, CDMG.



Wild burros peer through the brush near Coso Hot Springs. Photo by Forrest Bacon, CDMG.

Northern California

Record PG&E Electrical Generation at The Geysers

Electrical power generated by Pacific Gas and Electric Company (PG&E) in 1983 at its 17 geothermal power plants in The Geysers Geothermal field equaled 6 billion kilowatt-hours. This amount was almost 15 percent of all electrical power produced in PG&E-owned facilities and 8.4 percent of the total power available for sale to PG&E customers.

PG&E geothermal power production in 1983 equaled the annual electrical consumption of almost 1 million typical PG&E households. PG&E's average residential customer last year used slightly more than 6,100 kilowatt-hours of electricity.

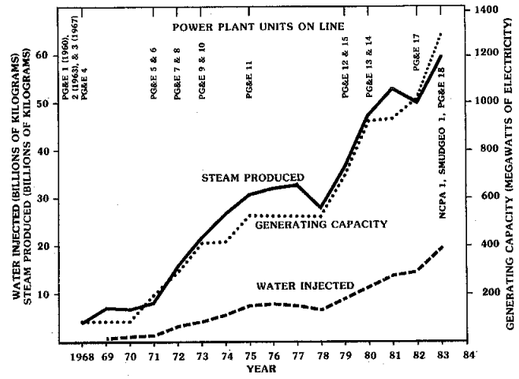
"The importance of The Geysers in providing reliable and economical power to our customers cannot be overstated," said Nolan H. Daines, PG&E vice president-planning and research. "This is particularly remarkable when one remembers that our first small plant at The Geysers began operation only 24 years ago, in 1960."

1983 Geothermal Statistical Summary for California

Steam production in The Geysers Geothermal field totaled 65.9 billion kilograms in 1983, a 33.4 percent increase from 49.4 billion kilograms produced in 1982, M. G. Mefferd, State Oil and Gas Supervisor, announced recently. The steam was used in power plants that have a total generating capacity of 1,309 megawatts (net) of electricity.

Injection of condensed steam and water from Big Sulphur Creek increased from 13.8 billion kilograms in 1982 to 19.5 billion kilograms in 1983, leaving a reservoir fluid deficit of 46.4 billion kilograms.

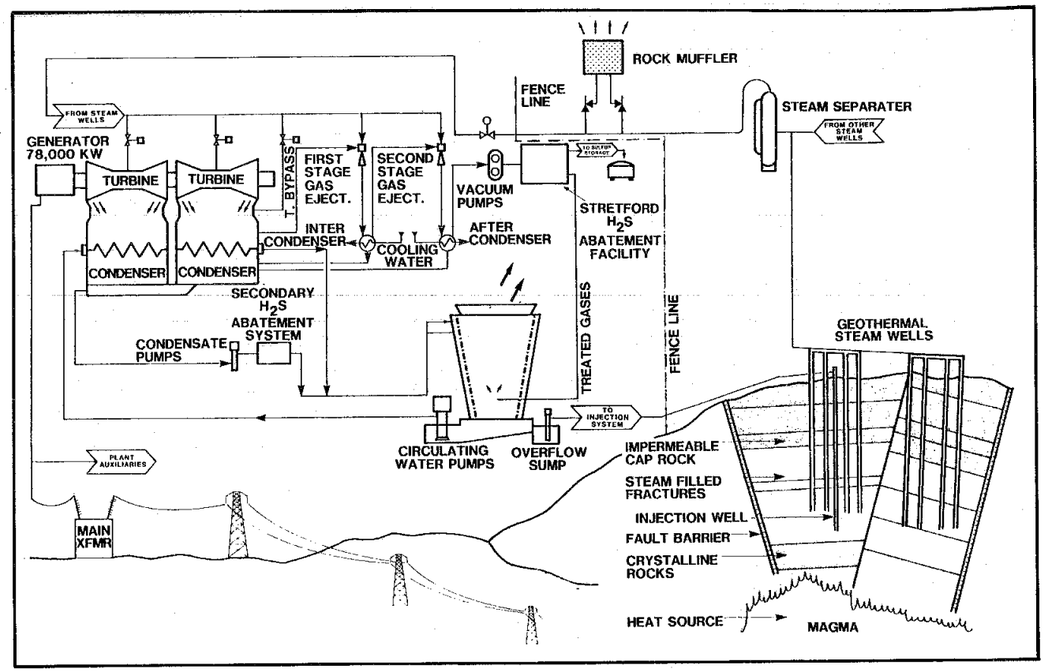
During 1983, the Geothermal Unit of the California Division of Oil and Gas issued 173 reports on proposals to drill, rework, and abandon geothermal wells throughout California, a decrease of 275 reports from the 1982 total. Meters drilled for new wells decreased to 83,761 in 1983 from 111,359 in 1982. The number of exploratory wells drilled decreased to 5 in 1983 from 9 in 1982. The number of wells capable of production that were drilled in 1983 increased to 38 from 28 drilled in 1982.



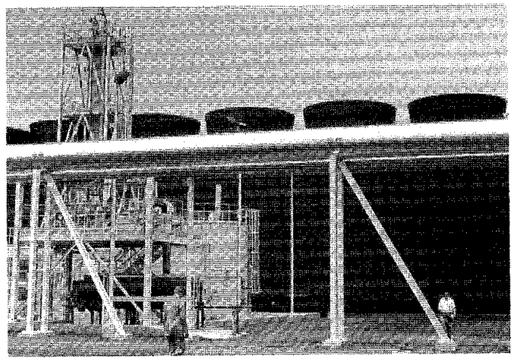
History of steam production, water injection, and power plant capacity at The Geysers Geothermal field through 1983.

SMUDGEO 1 Dedicated

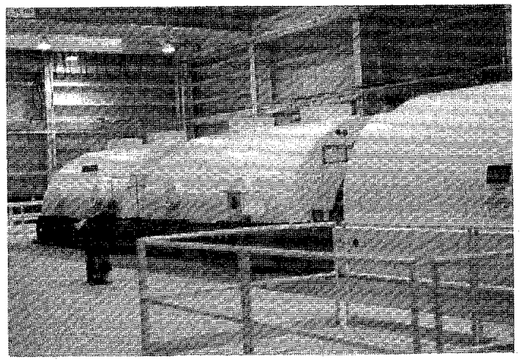
"To see the facility on line below cost, ahead of schedule, is very satisfying," said Paul Carr, President of the Sacramento Municipal Utility District (SMUD) Board of Directors. Carr spoke at the dedication ceremony in May 1984 for SMUDGEO 1, SMUD's first geothermal power plant at The Geysers Geothermal field. The $92 million power plant was designed and constructed by Stone and Webster. Over 1 million pounds per hour of 355°F, 100 psi steam is used to oper-



How SMUDGEO 1 is operated, from geothermal wells to electrical power transmission. Schematic courtesy of SMUD.



SMUDGEO 1, The Geysers Geothermal field. Photos by Susan F. Hodgson.



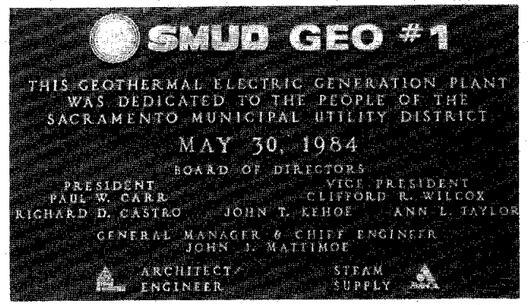
Four-flow Mitsubishi turbines are used at SMUDGEO 1.

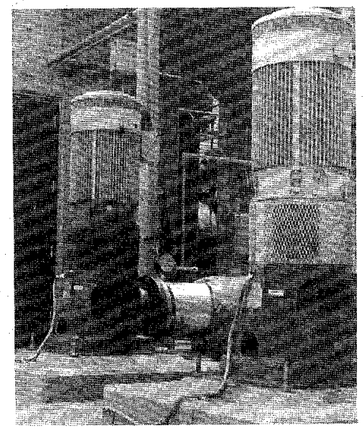
ate the plant. Steam is transported through a 2½ mile network of pipes from 11 geothermal wells owned and operated by Aminoil USA, Inc.

Even though the dedication was in May, the power plant has been in operation since late November 1983. The plant has a gross electrical generating capacity of 78 megawatts and a net capacity of 72 megawatts. It is operated at a cost of about 7 cents per kilowatt-hour produced.

A Stretford system is installed at the plant to remove 99 percent of the hydrogen sulfide in the geothermal steam and condensate.

"SMUDGEO 1 stands as testimony to SMUD directors' foresight in choosing to develop this clean, efficient means of electrical generation for the Sacramento area," said J. D. Coffman, President and Chief Executive Officer of Aminoil USA, Inc.





Injection pumps, rated at 1,500 gpm each, SMUDGEO 1.

Southern California

First Geothermal Unit Agreements Approved

In March 1984, M. G. Mefferd, State Oil and Gas Supervisor, approved unit agreements for the Imperial Brandt and Imperial Brawley Units, Brawley Geothermal field, Imperial County, California. The agreements are the first geothermal unit agreements approved by the division.

Unit agreements usually mean the person with the largest working interest is the unit operator and has full control of lease operations and the responsibility to raise development capital. Other, royalty interest owners participate only by sharing a percentage of the profits.

Unit agreements, especially for an entire reservoir, usually mean more efficient resource production and elimination of an unreasonable waste of resources.

Unit agreement laws are under Chapter 4, Division 3, Section 3756 of the Public Resources Code of California.

Imperial County Geothermal Activities

by Richard Mitchell,
Planning Director for Imperial County

(Excerpted from a presentation delivered at the Imperial County Geothermal Development Annual Meeting, May 3-4, 1984)

The Imperial County Planning Department implements county planning and zoning regulations and enforces the building codes. The planning and zoning regulations usually require discretionary permits, while the building code permits are ministerial.

Discretionary permits require hearings, decisions, and conditions, and the applicant may or may not get approval of the permit. A ministerial permit does not involve hearings and is issued if the code requirements are met.

All geothermal permits at this time are discretionary. Decisions are made by the Planning Commission or by the Planning Commission and Board.

Exploratory, test, and production permits are issued by the Planning Commission while G Overlay Zones take action by both the Planning Commission and Board of Supervisors.

Each geothermal permit requires environmental consideration. The Planning Department is responsible for processing these. An initial study is usually required, and either a Notice of Exemption or a Negative Declaration of Environmental Impact is filed or an EIR is required.

The Planning Department does not have a permit requirement for shallow temperature-gradient holes. However, we do process Notices of Exemption from the California Environmental Quality Act (CEQA) for these holes. The California Division of Oil and Gas may then issue a drilling permit for a temperature-gradient hole.

All discretionary actions and the environmental determinations may be appealed to the Board of Supervisors. Once the board reaches a decision, the only recourse is the courts.

The geothermal permits are site specific actions, i.e., they authorize specific actions on a particular parcel of land. The permit stays with that parcel and cannot be transferred to any other parcel. The permit may be sold to another entity. The new owner may assume the rights of the permit subject to the same original conditions once the county is notified.

The processing of any discretionary permit takes time. Part of the time is mandated by state law, other time is flexible, but the amount of work involved extends over a considerable period. Typical processing times are:

Notice of Exemption	10 days
Exploration	3-6 months
Rezone	6-18 months
Production	6-18 months

My advice is to plan ahead and start early.

The cost of applying for permits includes both the basic fees to the county and the cost of preparing environmental documents. County fees have increased recently and now are:

Exploratory permit	$1,000
Test permit	$1,500
Production permit	$2,000
Zone Change	$750+$5.00/lot

The CEQA and EIR fees are substantial. For CEQA, we charge $200 for an Initial Study and a Notice of Exemption. The EIR's (if required) have ranged from $25,000 to $220,000. The latter figure included state participation.

We are currently involved in a couple of major geothermal projects. We are drafting a completely new Geothermal Ordinance to simplify the issuance of minor permits and to provide better handling of nonelectric geothermal uses. The first draft has been out for several months, and the Geothermal Advisory Committee has reviewed it. I expect to take this to the Planning Commission as part of a complete new Zoning Ordinance.

Imperial County received a grant from the California Energy Commission to rewrite the Geothermal Element. Mr. Richard Cabanilla has been selected for this task. We expect to have a draft by July 1.

In 1983, Imperial County:

- Issued a 15,000 acre rezone and a power plant permit to MCR in the South Brawley KGRA (Mesquite Geothermal field).
- Rezoned 6,000 acres around Niland for RGI/Parsons.
- Processed the EIR for RGI/Parsons.

- Disapproved the Salton Sea KGRA rezoning. As you know, the judge ordered the zone change cancelled until new findings have been prepared. The County Counsel has prepared draft findings. When final, we will have to go back for more public hearings and another G Zone adoption.
- Amended Chevron's Heber Production Permits to update some of the conditions and to eliminate the requirement for concrete ditches below the various pipelines.
- Issued six exploration permits covering 19 wells and a test permit for a downhole heat exchanger.
- Processed four Notices of Exemption for 19 temperature holes.
- Processed the Bear Creek Wister Program twice to cure possible defects in the record.
- Issued building permits for the SDG&E and Dravo Heber plants and, just recently, for Magma's 28 megawatt Salton Sea plant. The building permits do not cover the down-hole steam producing system or the electrical generation and the distribution systems. They do cover structures, foundations, piping, and plant electrical systems. The fees for each of the plants mentioned were over $100,000. It should be realized that the construction spreads over 3 to 4 years and inspection services will be required for that period. Also, a portion of the fee is for plan check.

We have authorized 324 megawatts of power plant construction, and 157 megawatts either are built or under construction. We encourage further development and look forward to solving rate problems so more construction can take place. Imperial County continues to support geothermal development and will work cooperatively with all responsible applicants.

Vulcan Power Generation to Increase

Magma Power Company received permission from the Imperial County Planning Commission on July 25, 1984, to increase the generating capacity of a geothermal power plant the company is building in the Salton Sea Geothermal field. Power Plant No. 2, called the Vulcan plant, will generate 35 megawatts of electricity (net) instead of 28 megawatts as originally planned.

Heber Dual-Flash Plant Progress Update: June 22

"We're right on schedule, and everything is going fine," said Al Cooper, Vice-President of Chevron Geothermal Company of California, when asked how construction was progressing on the dual-flash power plant at Heber.

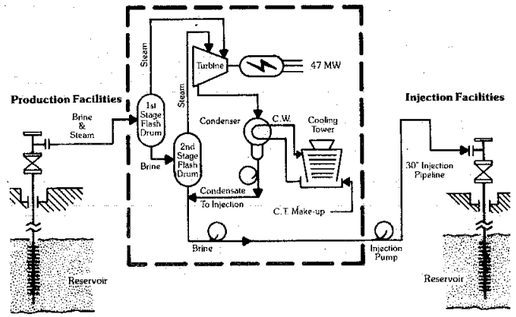
"The flash vessels are in, and power plant construction is well underway."

"We've drilled the 8th well on the production island and have just 1 more to go," he added. "Then we'll start drilling the injection wells." The expected life of project wells is 30 years.

Heber Dual-Flash Plant Dedicated

On May 3, 1984, an open house for the Heber Geothermal Unit Dual-Flash Project Number 1 in California's Imperial Valley was hosted by Chevron Geothermal Company of California, Union Oil Company of California, and Heber Geothermal Company.

"The first well in Heber Geothermal field was drilled in 1982. This dedication represents a long wait for many of us," said Richard F. Schlecht, President of Chevron Geothermal Company of California. "But, if you have something basically sound and good and stay with it, you'll come out ahead. Chevron is pleased to be a part of overall development at Heber. We're going to be here a long time."



Flow diagram, Heber Geothermal Unit Dual-Flash Project No. 1, Heber Geothermal field.

The Heber plant represents the first commercial development of a hot-water resource in the United States. The power plant, scheduled to begin operations in mid-1985, will generate 52 megawatts electricity, gross, and 49 megawatts net.

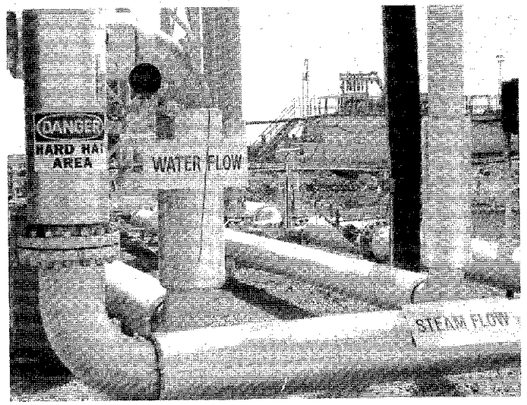
Nine production wells will be drilled in the field's hottest area, where temperatures exceed 360°F. Low salinity brine (14,000 ppm total dissolved solids) will be extracted from the wells at a rate of 26 million gallons a day. The brine will be piped to the power plant, where a dual/flash system will be used to generate electricity.

At the power plant, brine first will enter separator vessels. As pressure is released in the first separator vessel, some brine will flash to steam. The unflashed brine is piped to a second separator vessel, where another drop in pressure allows a second steam flashing. Both steam streams will drive a turbine, which will generate electricity.

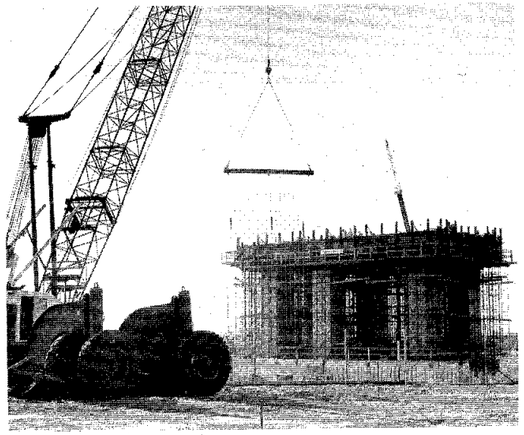
Spent turbine steam will be condensed to water, combined with unflashed brine from the second separator, and pumped through a 30-inch pipeline to injection wells 1¼ miles to the northeast.

The cooled brine will be at the outer limits of the field's geothermal reservoir. The injected brine will circulate back towards the hottest reservoir area, helping to push hotter brine to the production wells.

Project electricity will be purchased by Southern California Edison (SCE). G. J. Bjorklund, Vice-President of SCE said, "The Heber project is an important step towards our goal to be energy sufficient."



Steam and water lines, Heber Geothermal field. Photos by Susan F. Hodgson.



Turbine generator pedestal, Heber Geothermal Unit Dual-Flash Project No. 1.

The Heber Binary Project

(Data provided by the San Diego Gas and Electric Company.)

The binary geothermal power plant under construction at Heber Geothermal field in the Imperial Valley is a demonstration project. The plant will be the first of its size in the United States to use binary-cycle geothermal technology.

In this binary system, moderate-temperature brine will be produced from wells drilled by Chevron USA Inc. in Heber Geothermal field. The brine will be kept under pressure as it flows through piping and heats a second working fluid (90 percent isobutane and 10 percent isopentane) that flows through another set of pipes. The second working fluid will be vaporized, and the vapor will be used to spin a turbine to generate electricity.

Project Participants	Funding	Ownership
U.S. Dept. of Energy	50.0%	--
Electric Power Research Institute	10.0%	--
San Diego Gas & Electric Co.	31.3%	82.5%
Imperial Irrigation District	3.8%	10.0%
Ca. Dept. of Water Resources	1.2%	3.2%
State of California	1.7%	4.3%
Southern California Edison Co.	2.0%	--

Heber reservoir

- Heat content: enough to generate about 500 megawatts of electricity for 30 years.
- Average temperature: 360°F to 375°F.
- Dissolved solid content: 14,000 parts per million.

Production wells

- 13 wells from 4,500 feet to 10,500 feet deep.

Injection wells

- 9 wells 1½ miles northwest of the production wells.
- Injection-brine temperature: 160°F.

Heat exchangers

- 8, weighing 160 tons each.
- 80 feet long and 80 inches in diameter.

Hydrocarbon storage sphere

- Contains working fluid, 90% isobutane and 10% isopentane.
- 43 feet in diameter with a capacity of 300,000 gallons.

Turbine generator

- 70 megawatt rated capacity.
- Generator: 25 feet long, 13½ feet wide, 11½ feet high; Turbine: 15½ feet long, 10½ feet wide, 7½ feet high.
- 230 tons.

Hydrocarbon condensers

- 2, weighing 305 tons each.
- 82 feet long, 11 feet in diameter.

Cooling towers

- 9-cell tower.
- Water flow: 135,000 gallons per minute.
- 432 feet long, 58 feet wide, 51 feet high.

Cost

- $188,500,000.00 (including 2-year demonstration).

Completion

- Start-up in the first quarter of 1985.

Wister Unit Development: A Cautious Beginning

by Don Hoagland
California State Lands Commission

In July 1984, geothermal exploration is expected to begin on a portion of the Wister Waterfowl Management Area in Imperial County under a geothermal prospecting permit issued by the California State Lands Commission. The permit was issued in 1984 to Bear Creek Mining Company of Tucson, Arizona.

The Wister Waterfowl Management Area, commonly called the Wister Unit, is owned and operated by the California Department of Fish and Game. The Wister Unit contains about 5,000 acres of diked ponds where local and migratory birds nest and feed.

In July 1984, Bear Creek plans to begin drilling 5 temperature-gradient holes: 1 in the Wister Unit and 4 on Imperial Irrigation District land near the western boundary of the Wister Unit. The company plans to drill its first exploratory deep well in 1985.

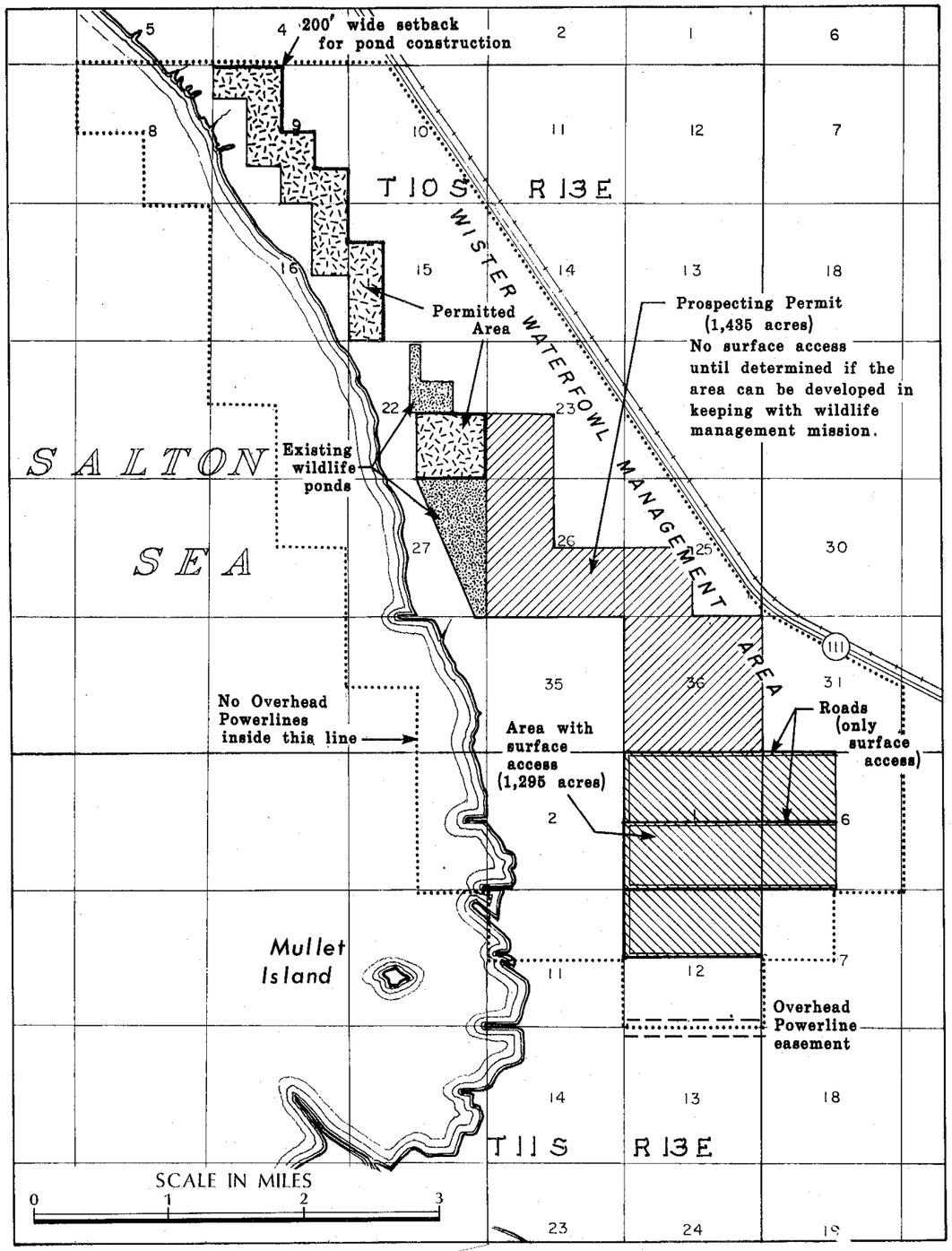
Public Resources Code Section 6924 grants authority to the State Lands Commission to issue leases or permits for development of geothermal resources from lands owned by other state agencies. If the surface is to be utilized, permits or leases may be issued "...only with the consent of and subject to reasonable terms and conditions as may be prescribed by such other department or agency to ensure the adequate utilization of the surface of the lands...thereon for the purposes for which they are then being administered or for which they were acquired..."

Initially, Bear Creek applied for a prospecting permit for the entire Wister Unit. However, the final permitted area covers about one-half of the Wister Unit. Bear Creek's original plan was to develop the Wister Unit by slant-drilling from land to the west of the unit that Bear Creek had leased from the Imperial Irrigation District.

In 1982, Bear Creek drilled several temperature gradient holes near the western boundary of the Wister Unit and in the Salton Sea (Geothermal Hot Line, July 1982). Partly as a result of this drilling program, Bear Creek again attempted to determine what terms and conditions would be required to obtain consent of the Department of Fish and Game to gain surface access to the Wister Unit for exploration. Finally, after 2 years, an agreement was reached that involved the participation of both the Sacramento and Long Beach regional staffs of Fish and Game, the Sacramento and Long Beach geothermal staffs of the State Lands Commission, and the Office of the Attorney General.

Together, these entities created a new geothermal prospecting permit form and what may be the most comprehensive set of controls, mitigation, and compensatory measures ever included in a state geothermal prospecting permit. Included in the permit are the terms and conditions imposed by Imperial County on Bear Creek before allowing Bear Creek to drill 4 exploratory wells on the Wister Unit. The major provisions of the state permit and Fish and Game's terms and conditions follow.

1. The permit area covers approximately 2,375 acres (see map), but surface entry is restricted to the southern portion of the permitted area of 1,295 acres. While the permit and terms and conditions allow slant drilling into the 1,440 acres for which surface entry has been withheld, there will be no surface entry until the Department of Fish and Game has had an opportunity to assess the impacts of development on the southern portion, and the parties have agreed to additional mitigation measures as may be necessary.



Map of the Wister Waterfowl Management Area, Imperial County, California, showing state geothermal prospecting permit areas with and without surface occupancy.

2. All exploration and drilling activities will be restricted to existing roads or rights-of-way, and drilling activities may only be conducted from March 1, to August 31. The number of permanent production or injection drill pads shall not exceed 30, and the acreage of any single, permanent, drill pad shall not exceed one acre without written consent of Fish and Game.

3. Bear Creek will spend up to $100,000 for the construction of up to 500 acres of new wildlife ponds and annually purchase up to 1,200 acre-feet of water for management of the wildlife habitat on the new ponds. Bear Creek will also purchase 3.71 acre feet of water for wildlife habitat management of each of the 1,295 acres of land for which it has the right of surface entry.

4. Bear Creek agrees to allow Fish and Game to maintain existing ponds presently constructed on lands leased by Bear Creek for geothermal exploration. If the land is needed later, Bear Creek will relocate these ponds at its own cost.

5. Any transmission lines that may cross the Wister Unit and a specified area outside the unit will be placed underground. No power plants may be constructed within 1,000 feet of the Wister Unit without written consent of Fish and Game.

6. Bear Creek will fund and conduct biological studies that may be necessary to assess and/or monitor the impact of geothermal development on wildlife resources in and immediately adjacent to Wister.

7. The permit carries a preferential right to a lease upon discovery of geothermal resources in commercial quantities. No such lease shall be issued without additional environmental impact review. Terms of the lease provide for a royalty of 10 percent of gross revenue from the sale of steam and 5 percent for the sale of minerals recovered from brines. Rental is $1.00 per acre the first year, $5.00 the second year, and $25.00 per acre during any extension or until a well has been drilled.

8. If Fish and Game feels Bear Creek is not complying with any of the provisions of the permit or terms and conditions, it must notify the Commission, and the Commission will determine whether the permittee is in breach and whether the permit should be cancelled.

The Bear Creek project will be watched closely by environmental groups, sportsmen, geothermal developers, and state officials to see if geothermal resource development activities are compatible with an area in which the primary concern is wildlife management and enhancement.

Republic Receives DOE Loan Guarantee

The Parsons Corporation and Republic Geothermal, Inc. have received a $99.6 million loan guarantee from the U.S. Department of Energy (DOE) to partially finance a 49 megawatt, dual flash, geothermal power plant near Niland, in the Imperial Valley.

Total project cost is estimated at $135 million. The government-guaranteed portion of the amount will be serviced through the Bank of Montreal in San Francisco. The remainder will be provided by Parsons and Republic Geothermal.

The DOE loan guarantee is the largest ever issued under a program enacted by Congress in 1974 to encourage the development of geothermal projects.

Parsons and Republic Geothermal have signed a 30-year contract to sell electricity generated by the plant to Southern California Edison Company. Geothermal brine will be produced from eight wells at four sites. Three of the wells have been drilled and completed.

Nevada

New Nevada Geothermal Committee

The Nevada Mining Association is initiating a standing NMA Committee on Geothermal Resources. The committee, under the NMA umbrella, will help to represent the geothermal industry before legislative bodies and agencies of federal, state, and local governments. The committee's aim will be to encourage development of geothermal resources in Nevada.

Nevada Minerals Commission Drafts Geothermal Regulations

(Reprinted, with permission, from the Bulletin, a publication of the Nevada Mining Association.)

Nevada's new Commission on Mineral Resources is drafting regulations for control and management of Nevada's extensive geothermal resources. The commission and the Nevada Department of Minerals were created by an act of the 1983 Nevada State Legislature to encourage balanced development of mineral resources within the state and to protect the environment.

Under the direction of Peter Hummel, vice-chairman of the commission, the State of Nevada has asked firms involved in exploration and development of geothermal resources to offer suggestions for the regulations, which must be approved by the commission.

Recognizing a geothermal resource as a mineral, the 1983 legislature transferred primary responsibility for development and regulation of the potentially significant industry from the State Water Engineer to the Department of Minerals. The water engineer, however, still has the responsibility and authority to review all application for use of geothermal steam and to guarantee that state water appropriation laws are upheld.

New Nevada Powerline Planned

In late June 1984, Sun Geothermal of Dallas, Texas, filed applications with Bureau of Land Management offices in Carson City, Nevada, and Bishop, California, to construct a 140 megawatt power line. The proposed 217 mile line would be stretched along a BLM right-of-way extending north from Bishop, California to Dixie Valley, Nevada.

The project would tie Sun Geothermal's Dixie Valley Geothermal field into an existing 50 megawatt Southern California Edison power line in Bishop.

Sierra Pacific Signs 3 Contracts for Geothermal Power

(Reprinted, with permission, from the Bulletin, a publication of the Nevada Mining Association.)

Sierra Pacific Power Company has finalized agreements with three geothermal development firms, opening the way for construction of Nevada's first commercial geothermal power plants within 2 to 3 years.

"These agreements represent a significant milestone in Sierra Pacific's efforts to develop Nevada's geothermal energy resources," said Max Jones, senior vice-president for planning, engineering, and construction. "Knowing that we're going to need new energy resources to accommodate growth in the 1990's, our goal is to prove the economic and technical viability of commercial geothermal development, utilizing Nevada's energy resources and creating jobs for Nevadans."

The first 10-year contract, signed November 18 with Geothermal Development Associates of Reno, enables Sierra Pacific to purchase a maximum of 5 megawatts of electricity generated by a geothermal power plant to be built at Steamboat Springs, 9 miles south of Reno.

Steamboat site development is scheduled to begin within 3 months, and power plant construction should be completed by June 1985.

The second 10-year contract, signed November 18 with Phillips Petroleum Company of Bartlesville, Oklahoma, calls for Sierra Pacific to purchase a maximum of 9 megawatts of geothermal power generated at a plant to be built at Desert Peak, 65 miles northeast of Reno.

Phillips Petroleum Company has been one of the more active geothermal development companies in Nevada in recent years. Between 1972 and 1983, the firm has spent more than $17 million drilling test wells, with successful prospect wells completed at Desert Peak, Steamboat Springs, Soda Lake, and Humboldt House. The company has more than 250,000 acres under geothermal lease or option in Nevada.

A third contract, signed December 8 and covering a 33-year period, enables the partnership of National Energy Associates/Sequoia Thermal of San Francisco and Big Smoky Valley, respectively, to supply Sierra Pacific with 10 megawatts of geothermal power produced at a plant to be constructed in Big Smoky Valley in central Nevada.

Work on the Big Smoky Valley site is expected to begin within 6 months. Low-level power delivery is slated for late 1985 or early 1986.

All the agreements are subject to a Nevada Public Service Commission review, Jones said.

He emphasized that the plants will be small demonstration or "pilot" plants using different technologies, which will provide the company with important information to be used in future geothermal projects.

The contracts call for the private firms to develop the geothermal well fields and construct the plants, thus minimizing the risk to Sierra Pacific and its ratepayers, Jones explained.

"Once the economic and technical viability is proved, we will have the option of developing our own base load generating plants so we can take full advantage of this abundant alternate energy resource," he said. "We hope geothermal resources will meet up to 25 percent of our energy needs by the year 2000."

He noted that one of the key benefits of geothermal plants is that they take only 2-3 years to construct and bring on line, compared to 8-10 years for a coal-fired power plant and 12-15 years for a nuclear plant.

If small geothermal plants can be constructed rapidly at competitive costs, they will allow utility planners to more closely match the addition of energy resources with increases in their customer's electrical demands.

Oregon, Idaho, & Utah

OIT Receives Geothermal Technology Transfer Grant

The Idaho Operations Office of the U.S. Dept. of Energy (DOE) has awarded a $355,000 grant to the Oregon Institute of Technology (OIT) Geo-Heat Center at Klamath Falls, Oregon. The Geo-Heat Center will provide direct, technical, and economic feasibility analyses of geothermal development projects to potential users, consultants, industry organizations, engineers, and state energy offices.

The analyses will include limited resource assessment, conceptual design options, and life-cycle cost estimates for geothermal projects involving direct and heat pump space heating, agriculture/aquaculture applications, industrial processes, and low-temperature wellhead electric power generation.

The center will offer training sessions on request, primarily for state energy offices' staff members, conduct informative talks for lay and technical audiences, and direct tours and field trips. Technical information will continue to be disseminated through a quarterly bulletin, other literature, a geothermal library, and progress-monitoring activities.

EG&G Idaho will continue to provide technical direction for these activities that are similar to but of greater scope than those completed on April 13 by the Geo-Heat Center. The new grant will provide for the provision of technology transfer activities through June 1986.

Hydra-Co. Enterprises Takes Over Raft River Facilities

Hydra-Co. Enterprises, a wholly-owned subsidiary of Niagra Mohawk, was established to develop alternative energy sources. The company has been deeded the Raft River 5 megawatt binary plant, geothermal wells, and 560 acres of federal land according to the Regional Geothermal Progress Monitor published by EG&G Idaho, Inc. Hydra-Co. offered the high bid of $750,000 for the Raft River facility and real property near Malta, Idaho in the General Services Administration disposal sale.

Roosevelt Hot Springs

Utah Power and Light Company contracted with Biphase Energy Systems to install a 14.3 megawatt geothermal power plant unit at Roosevelt Hot Springs in Beaver County, Utah. The power plant unit will use a mixture of pressurized steam and hot geothermal fluids to produce power in one step. The scheduled start-up date is the first quarter of 1986. More units may be added as demand increases.

Mexico

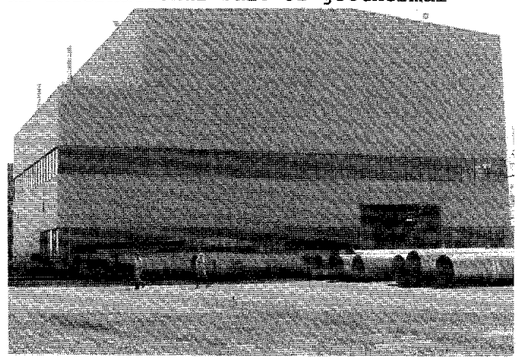
Cerro Prieto Update

In mid-July 1984, turbines will begin spinning at Power Plant Unit 2, Cerro Prieto Geothermal field, about 35 km south of Mexicali, Baja California. Electricity generated by the 220 megawatt plant will be purchased by San Diego Gas and Electric Company (150 MWe) and Southern California Edison (70 MWe).

Under the purchase agreement, both companies will buy the electricity from Mexico over a 10-year period, beginning in October 1984.

Later, the two utility companies may be able to purchase additional geothermally-generated electricity from Mexico, possibly up to 300 megawatts each, if Mexican geothermal reserves are adequate.

The purchase agreement, the first for an international sale of geothermal



Cerro Prieto Power Plant Unit 2, under construction in 1983.

power in North America, was signed on November 12, 1980.

Presently, 180 megawatts of electricity are being generated at Cerro Prieto from Power Plant Unit 1.

SCE and Mexican National Utility Sign Power Exchange Agreement

Southern California Edison Company (SCE) and the Comision Federal de Electricidad, Mexico's national electrical utility agency, signed a power exchange agreement. The agreement was undertaken to help both utilities hold down the cost of electricity and ensure reliable service.

The agreement will enable either utility to buy electricity from the other when the price is lower than the cost of producing the same electricity at its own power plants or purchasing it elsewhere.

Mexican Electrical Grid

The Comision Federal de Electricidad (CFE), Mexico's national electrical utility agency, has released results of a study undertaken to assess electrical service in Mexico.

The CFE provided electrical service to 86.3 percent of its territory in 1983. However, about 70,000 towns remained without electrical power. The towns are in rural areas and house about 12 million people.

CFE hopes to offer electrical service to towns of fewer than 2,500 people in the next 4 years.

Europe

European Geothermal Development

"A renewed interest in geothermal energy has been noticed worldwide by the Stanford staff this year," said Dr. H. J. Ramey, Jr. at a gathering of the Ninth Annual Geothermal Reservoir Engineering Workshop at Stanford in December 1983. "It's happening now."

A paper describing developments in the European Community was delivered at the workshop by Pierre Ungemach, head of the Research and Development Program in Geothermal Energy for the Commission of European Communities (Rue de la Loi 200, 1049 Brussels, Belgium).

Material for the paper was obtained by Dr. Ungemach from the 2nd Research and Development program of the Commission of the European Communities. A summary follows.

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Exploration and development of geothermal resources in the European Communities (EC) is largely dictated by the geodynamics of the Eurasian lithospheric plate that defines the main European geothermal provinces shown in the illustration.

Present and prospective development objectives concern three types of geothermal resources.

(a) *low enthalpy resources*. Exploitation of warm water aquifers (30-150°C) is a goal common to all EC member states because of the presence of widespread - intracratonic and foredeep - sedimentary basins displaying near-to-normal heat flow (50 to 100 MW/m^2) and of hydrothermal convection systems (hot springs) of more local occurence in tectonised areas close to border faults of tertiary grabens and to orogenic belts. Highly compartmentalized tertiary grabens, subjected to distensive transverse faulting, may constitute an objective intermediate between low and high enthalpy uses.

There are about 10 proven regional aquifers with dependable reservoir performance, among which the Jurassic limestones in the Paris suburban area and Cretaceous sandstones in Aquitaine (Southwest France) are the most extensively developed for district heating purposes. In the Paris area, exploitation of saline waters with production-injection doublets is the rule. In Aquitaine, singlet production wells are used instead (fresh water). Currently, about 450 megawatts thermal are extracted from the low enthalpy resources, mostly in the Paris Basin.

In the Paris Basin, where about 50 doublets will be operating in late 1984, serious risks exist of interferring wells with subsequent cooling breakthroughs. To meet this situation, two strategies are being considered: using horizontal wells that allow for larger heat capacities and longer system lifetimes, and/or using wells drilled into the underlying Triassic sandstones. The latter process depends on procedures used to inject large quantities of cooled brines, over often limited net-pay intervals. Two test sites in the Paris Basin experienced severe problems: sand face bridging due to atypical well completions (partial or no gravel packing) and formation invasion by fine particles. Suitable engineering technologies will be developed through core tests and pilot filtering hardware to master the process of injection in clastic sedimentary rocks.

In Aquitaine, excessive pressure depletions are feared in the near future. Hence, the implementation of adequate reservoir management policies becomes urgent and regional simulation of heat and mass transfer is underway to optimize heat extraction and reservoir life. Injection wells will be required to sustain reservoir pressure above the critical matrix "crushing" threshold.

(b) *high enthalpy resources*. Dry and wet steam resources are limited to those Mediterranean areas where the collision of the Eurasian and African plates give rise to subduction trenches, active volcanic island arcs, marginal basins, anatectic magmatism, and extensional horst and graben structures (e.g. in Central and Southwestern Italy and Eastern Greece).

The three dry steam fields of Larderello, Travale, and Monte Amiata in Central Tuscany and Northern Latium are a long established geothermal asset with an installed capacity amounting to 440 MWe.

At Larderello, the recent injection of steam condensates should prove beneficial.

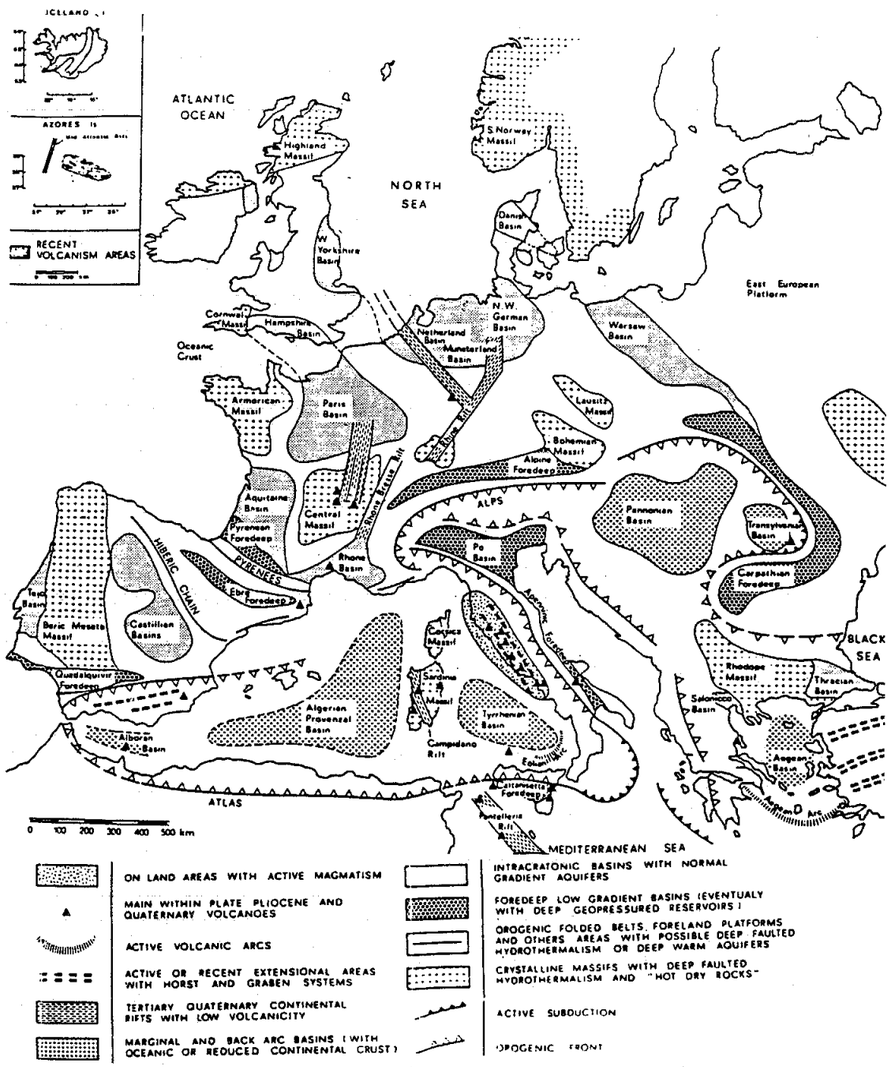
Elsewhere, most problems are posed by liquid dominated sources such as in Torre Alfina (high CO_2 content): Cesano where thermochemistry of a near saturated brine is very similar to that encountered in the Imperial Valley of California; and Latera, a volcanic-sedimentary field with a puzzling, fracture dominated, porosity pattern, which works against commercial production (and injection).

The Mofete and San Vito fields near Naples illustrate the foregoing difficulties and environmental risk of investigating and developing a field in an active volcanic, seismic, and densely populated area.

As a result, EC-supported research has focused on the following topics: injection and well stimulation, well testing, reservoir stimulation, induced seismicity, geophysics, and geochemistry.

(c) *hot dry rock (HDR)*. HDR research has combined early laboratory experiments and model calculations with field fracturing and circulation tests at shallow depths prior to undertaking large-scale intermediate depth, stimulation project at the Rosemanowes Quarry site in British Cornwall.

It is possible to draw some tentative conclusions from early loop circulation tests: (1) over 300,000 m^3 of water have been injected in the HDR reservoir at Cornwall and hardly 100,000 m^3 is recovered so far; (2) the system can be circulated at 30 l/s ca. (below 10 MPa WHP), but at the expense of severe losses resulting from, mainly downward, fracture growth away from the recovery well; (3) because of a peculiar situation where the well axis and the major natural joint strike are misaligned with the maximum in-situ horizontal stress, shearing instead of tension (jacking) appears as the dominant factor in fracture propagation; (4) although pressure records tend to indicate natural joint re-



Geothermal provinces of Europe. (Source: EC and Sommaruga). Reprinted from the preprints of the Ninth Annual Geothermal Engineering Workshop at Stanford University.

activation, reservoir growth has proceeded normal to the minimum horizontal stress, and not along a known joint direction. Connections consist of reactivated joints contained by in-situ stresses; (5) There is evidence of a large stimulated volume (1 km^3 ca.) displaying rock/fluid contact areas of at least 1 km^2. However, neither seismicity nor tracers can define either fluid-filled fractures or heat-exchange areas. Aseismic (quiet) zones are manifest within the pressurized volume, and a number of events are triggered far beyond the hydraulically stimulated area in the early fracturing stages. (6) The HDR loop operates as a large, volumetric diffusive system between two, weakly connected, performant wells rather than as a connection through a highly conductive fracture.

In summary, nothing worked as anticipated. Fractures grew downwards, and not upwards, the major fractures did not propagate along the planes of weakness of the natural joints, and no indications of channelling or well shortcircuiting were found.

Stage 2 of the Cornish program will consist of drilling a third well to intersect the main reservoir structure.

An alternative process for stimulating jointed rocks, known as the oriented hydraulic fracturing concept, has been tested in the laboratory and in the field at shallow depth. Validation at greater depth could be given a chance on a second large-scale experiment in Central France.

(See the publications section of the December 1983 Hot Line issue for information on how to order the proceedings of the Second International Seminar on the results of EC geothermal energy research.)

Geothermal Reservoirs

High-Temperature Geothermal Reservoirs, Part 2

(Conclusion of a two-part series on the formation and character of geothermal reservoirs.)

Donald White, a geologist with the U.S. Geological Survey, has spent many years studying the evolution and nature of geothermal reservoirs. He feels all geothermal reservoirs pass through natural life cycles, and all begin as hot water systems. Only by changing in a special manner will a few special hot water systems ever become vapor-dominated systems. Other special hot-water systems, now "fossil", have become hydrothermal ore deposits.

White has published several articles on the topic. Abstracts follow from three of his papers: *Geochemistry Applied to the Discovery, Evaluation, and Exploitation of Geothermal Energy Resources; Active Geothermal Systems and Hydrothermal Ore Deposits;* and *Active and Fossil Hydrothermal-Convection Systems of the Great Basin*.

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Introduction from *Geochemistry Applied to the Discovery, Evaluation, and Exploitation of Geothermal Energy Resources* by D.E. White, published in Geothermics (1970) - Special Issue 2.

The application of geochemistry to geothermal energy resources requires an understanding of the sources of fluid constituents and a recognition of the major types of geothermal systems(1). For geochemical and

(1) A geothermal system is a part of the earth's crust that contains a source of heat (regional heat flow or local igneous intrusion) and the rocks and fluids affected (Continued on the next page.)

most other purposes, the fundamental basis for classifying these systems is the physical state of the continuous fluid phase, whether liquid or vapor. The two contrasting types are called hot-water and vapor-dominated («dry-steam»; White 1964; White et al, 1971). The geochemical behavior of substances of high and low volatility obviously must differ greatly, depending on the physical state of the dominant fluid. Many constituents are useful in evaluating the hot-water systems, but only a few volatile constituents are significant to the vapor-dominated systems.

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Abstract from *Active Geothermal Systems and Hydrothermal Ore Deposits* by Donald E. White, published in Economic Geology, 75th anniversary volume, 1981.

During the past 25 years, our understanding of hydrothermal ore deposits has progressed remarkably because of combined approaches through detailed study of actual deposits, laboratory experimental study of ore and gangue minerals and fluid inclusions, and study of active geothermal systems. My review emphasizes the active systems, which have recently become a focus of interest in a worldwide search for alternative energy sources.

(Footnote continued from previous page.) by that heat. Geothermal systems that involve circulating waters are also called hydrothermal systems. The hot part of each hydrothermal system is commonly emphasized but in its broader meaning the marginal parts generally involve convective down-flow of cold water, and are also included. A hot spring area is the surface expression of a geothermal system and contains hot springs, fumaroles, and other obvious hydrothermal phenomena.

Sulphur Bank, California, and Ngawha, New Zealand, have provided several keys for understanding the generation of many mercury deposits. Major requirements probably are: deep source regions of fluids and Hg at temperatures more than 200°C; metamorphic environments above subduction zones on continental margins; a through-going (rather than local) vapor phase enriched in CO_2 or other gases, migrating along with liquid water; and instability of HgS at high temperatures, decomposing to Hg^o and S^o, with the migrating vapor required for major transport of Hg at temperatures less than 200°C; a coexisting liquid phase is generally required to transport SiO_2 and other nonvolatile constituents. This two-phase mechanism best explains the general absence of other significant ore metals. Vapor-phase transport of the Hg associated with other metals at higher temperatures is probably not essential.

Epithermal precious metal ore deposits are probably the fossil equivalents of high-temperature geothermal systems like Broadlands, New Zealand, and Steamboat Springs, Nevada. The evidence suggests that the fossil and active systems are similar in their rare chemical elements, ranges in temperature, pressure, compositions of fluids, isotope relationships, and mineralogy of ore, gangue, and alteration minerals. Broadlands and Steamboat Springs show a depth zoning of the "epithermal" chemical elements, Au, As, Sb, Hg, Tl, B, and some Ag, that selectively concentrate near the surface. Much Ag, base metals, and probably Se, Te, and Bi precipitate at somewhat greater depths and higher temperatures.

Nolan (1933) divided the epithermal precious metal deposits into a gold-rich group (Au greater than Ag by weight) and a silver-rich group. The concepts of depth zoning in active geothermal systems, if applied to epithermal deposits, suggest that some gold-rich deposits (including

the recently recognized Carlin-type) form at relatively shallow depths and low temperatures. These may grade down into deposits enriched in Ag and base metals, perhaps in places separated by a relatively barren zone resulting from changes in the dominant complexing agent, Cl vs. S. This possibility, even if remote, justifies close examination.

Active systems that might form base metal ore deposits were virtually unknown 25 years ago. Discovery of the Salton Sea, Red Sea, and Cheleken thermal chloride brines in the early 1960's focused on Cl as the probable critical agent, permitting transport of base metals as metal-chloride complexes. Also, some oilfield waters were found to have Pb and Zn contents in the range of a few parts per million (ppm) to many tens of ppm. The low-temperature brines have no sulfide within detection limits; only at temperatures more than 200°C can small quantities of sulfide coexist with the base metals in solution. All of these metal-bearing brines are deficient in sulfide; most of their metals can precipitate as ore deposits only where supplemental sulfide can be provided by any one of several proposed mechanisms. Comparable brines in the past probably formed low-temperature epigenetic deposits like those of the Mississippi Valley, as well as many marine sediment-hosted syngenetic and early diagenetic ore deposits.

Ore fluids rich in both base metals and reduced sulfide species probably require very high salinity, high temperature, and rock-water reactions buffered at low pH (thus, with little free S^{-2} immediately available). Hostile environments of extreme temperature and salinity, such as those indicated in generating porphyry copper deposits, cannot be drilled by present methods, even if we knew where to drill. Visual observation of comparable environments seemed unlikely until early in 1979, when Cu and Zn sulfides were found to be precipitating from spring vents on the spreading axis of the East Pacific Rise at temperatures exceeding 350°C. Low-temperature discharges on the sea floor had been known for a few years, but the activity in this hydrothermal area, known as Twenty-One North, is the first that bears directly on the origin of volcanogenic massive sulfide deposits (and indirectly on other deposits formed at extreme temperatures and salinities).

Brines of many origins can form base metal deposits; origin of the water may be less important than the physical and chemical environments of the brines and source rocks. Ocean water alone, ocean and fresh waters plus evaporites, evolved connate waters of marine sedimentary rocks, and magmatic waters are all effective solvents of base metals in suitable environments. Precipitation of metals from these brines can occur by decreasing temperature, mixing with low-salinity water, access of supplemental sulfide, and neutralizing reactions with wall rocks, as well as various combinations of these.

Suggestions for exploration for concealed deposits of the major groups considered here are offered, resulting from improved understanding of various genetic models.

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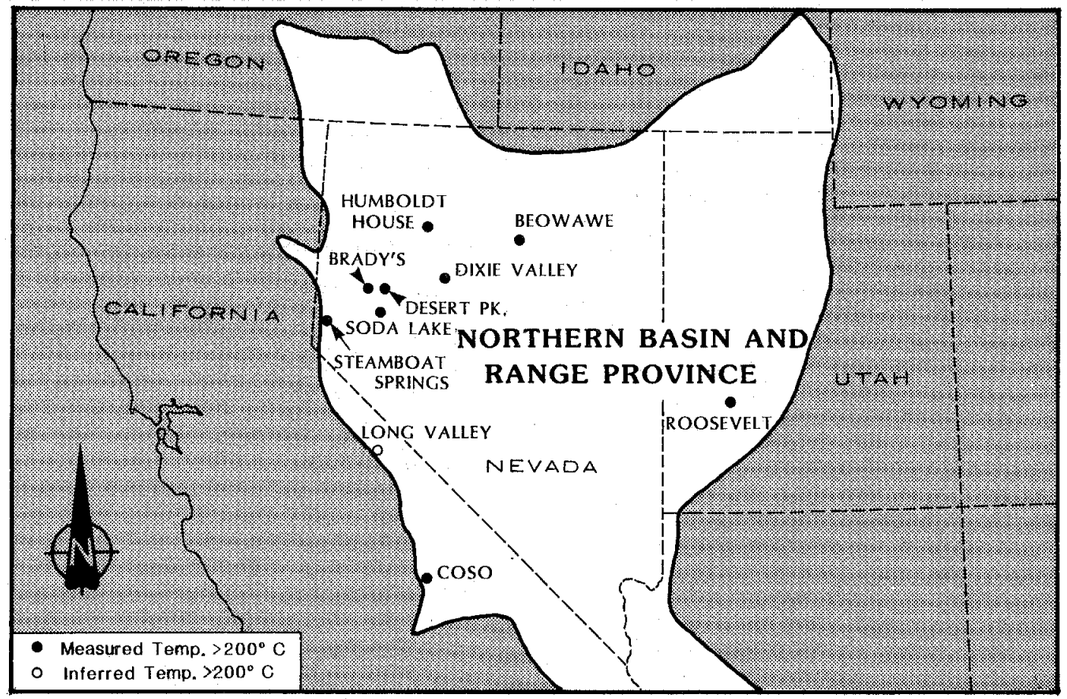
Abstract from *Active and Fossil Hydrothermal-Convection Systems of the Great Basin* by Donald E. White and Chris Heropoulos, published in The Role of Heat in the Development of Energy and Mineral Resources in the Northern Basin and Range Province, the Geothermal Resources Council, 1983.

The Great Basin contains hundreds of active thermal spring systems. Most discharge at temperatures much below boiling and generally lack characteristics likely to be pre-



Locations of high-temperature geothermal reservoirs in the Northern Basin and Range Province (modified from Edmiston, 1982), from The Role of Heat in the Development of Energy and Mineral Resources in the Northern Basin and Range Province published by the Geothermal Resources Council.

served. Twenty-eight systems have measured or geochemically indicated subsurface temperatures from 150°C to 265°C.

The epithermal group of Au-Ag vein deposits of the Great Basin are the "fossil" equivalents of some active systems, including Steamboat Springs, Nev., and Broadlands, New Zealand. Other active systems of nearly equal temperature are not known to be depositing Au and Ag.

This paper compares the characteristics of the active and fossil epithermal vein systems, including their present distribution, physical and chemical characteristics, and evolution through space and time. The fossil systems ranged from 0.2 to 7% salinity and averaged at least 1% (about twice the present systems).

Many epithermal Au-Ag deposits are also enriched in As, Sb, and Hg, and some contain Tl, Bi, Se, Te, and B. We are analyzing hot-spring sinters for these "mobile" elements as well as Au and Ag. Steamboat Springs is the only presently active Great Basin system whose sinters commonly exceed our detection limits of 0.1 ppm Au and Ag and also are highly enriched in most other mobile elements. Long Valley, Calif., is another possible example, but Roosevelt Hot Springs, a volcanic-centered system in the eastern Great Basin, is high in most of the mobile elements except Ag and Au.

Ages of the "disseminated" or "sediment-hosted" gold deposits (such as the Carlin and Getchell) are not well established, but may generally be older than most epithermal veins.

The Carlin and Getchell are enriched in the same "mobile" element group, but our data are inadequate for a clear understanding of interrelationships.

Testing and Development of the Beowawe Geothermal Field

by I. J. Epperson
Chevron Resources Co.

(Much of this paper is reproduced with the permission of the Society of Petroleum Engineers of AIME.)

Beowawe Geothermal field is in north-central Nevada in the Basin and Range province at the boundary between a plateau of volcanics and the down-faulted Whirlwind Valley, about 65 miles southeast of Winnemucca. Geysers, fumaroles, and boiling springs have deposited a large sinter terrace about 300 feet (91 m) high at the northern base of the plateau (Fig. 1). The numerous geothermal surface manifestations led Magma Power Company and Sierra Pacific Power Company to drill 11 shallow wells in the field from 1959 through 1965 (Fig. 2). Chevron acquired the leases in 1973-1975 and began an extensive geologic study of the area. Chevron's first well, Ginn 1-13, was drilled in 1974 to a depth of 9,600 feet (2925 m). Since then, Chevron has drilled three more wells (plus numerous shallow temperature holes).

The Beowawe system is a complicated combination of fractured and faulted horizons fed from a deep carbonate reservoir. Several shallow charged productive intervals underlying the Beowawe Area have been identified as commercially productive with temperatures near 370°F (188°C).

Deeper fault production (8,000 ft. to 10,000 ft./2438-3048 m) with +420°F (216°C) temperatures has also been identified as commercially productive with potential two-phase rates exceeding 1,000,000 lbs./hr. (126 kg/s).

Interference testing indicates all existing hot Beowawe wells are hydraulically interconnected, even though completed in different geologic intervals.

Permeability-thickness products calculated from the interference testing agree with the values calculated from the individual well flowtests and confirm the prolific capability of the Beowawe reservoir.

The porosity-compressibility-thickness product is fairly constant within the tested area.

No reservoir flow barriers were observed in any of the test data.

The interference data suggest that the Rossi 21-19 well, the only non-productive hot evaluation well, may be completed in a zone of restricted permeability of limited areal extent.

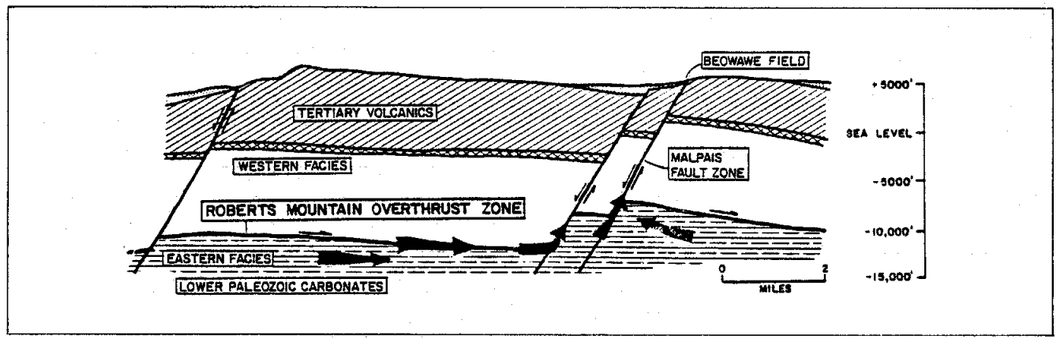


Figure 1. Conceptual geology, Beowawe Geothermal field.

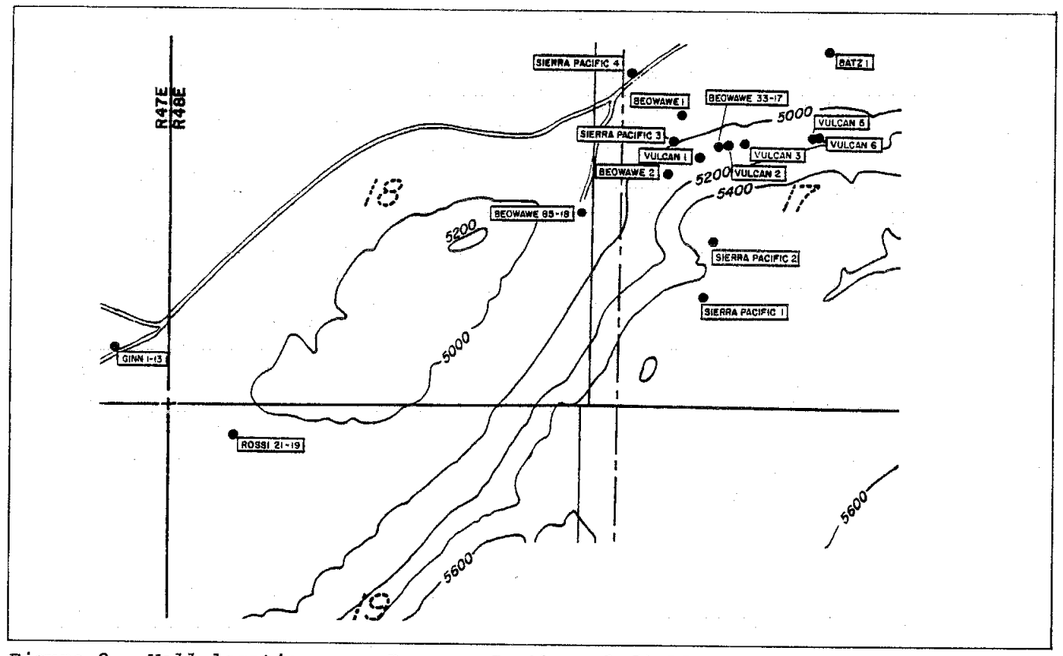
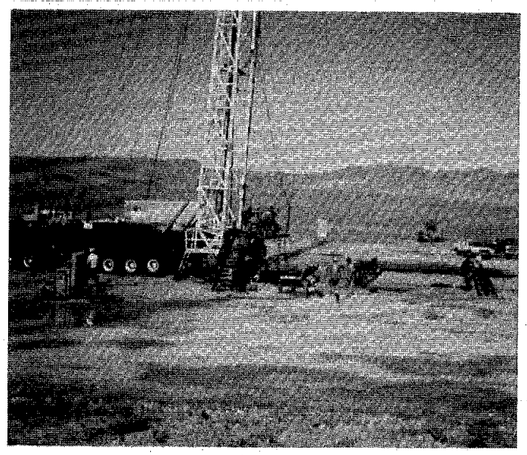


Figure 2. Well location map, Beowawe Geothermal field.



On the workover rig during acid stimulation operations, Beowawe Geothermal field. The field is about 65 miles southeast of Winnemucca, Nevada.

Photos courtesy of the U.S. Dept. of Energy.

Acid water storage tanks used in the acid stimulation tests in Beowawe Geothermal field.

Eight of the field wells were included in tests undertaken by the U.S. Department of Energy (DOE) and Chevron USA, Inc. Some of these wells were acid stimulated, including Rossi 21-19.

The acid stimulation tests were designed to open up wells plugged by silicate and carbonate deposits.

At Rossi 21-19, hydrochloric and hydrofluoric acid were injected. Reservoir acid migration was traced in two ways: Variations in the electrical field caused by migrating fluid were measured, and microseismic disturbances caused by rocks collapsing into reservoir cavities formed from the acid flow were recorded.

David Allen, DOE Program Manager of the Geothermal Hydropower Technologies Division, called the Rossi 21-19 test a partial success. He said that although the well was not opened as much as hoped for, the method may have uncovered a previously unknown fault in the field that should help in plans for field exploratory and production activities.

Further definition of the Beowawe resource is needed before committing to large scale power generation. In conjunction with additional evaluation drilling and testing, development plans include installation of a small power generation unit.

While producing 5-7 megawatts of electrical power, this step will allow acquisition of long term production data and minimize the number of evaluation wells needed to define the resource. Additionally, valuable data on well performance, plant operating factors, etc., will be attained.

Reflections on the Nature of The Geysers Geothermal Field

by Jeffrey J. Hebein
Principal Geothermal Geologist
MCR Geothermal Corporation

Jeffrey Hebein has worked in exploratory and developmental geology at The Geysers Geothermal field and at the South Brawley prospect area in the Imperial Valley.

The views expressed in this article are those of the author and do not necessarily represent those of any public agency or of MCR Geothermal Corporation and its affiliated companies.

REFERENCE

Hebein, J.J., 1983, Exploration, drilling, and development operations in the Bottle Rock area of The Geysers steam field, with new geologic insights and models defining reservoir parameters: Proceedings, Ninth Workshop on Geothermal Reservoir Engineering - Stanford University, Stanford, California, p. 135-144.

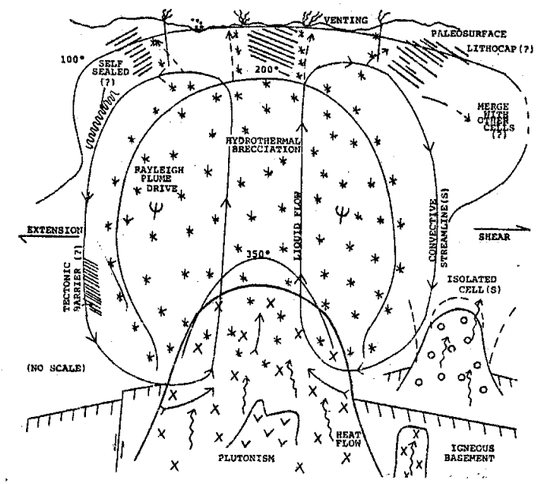


Figure 1. A conceptual illustration depicting the driving of an ancestral liquid system(s) after the emplacement of felsic intrusives beneath The Geysers Geothermal field, based on scenarios by Hebein (1983). Extent of cells was probably dependent upon localized tectonics and/or the formation of self-sealing around and within individual cells. Hydrothermal brecciation consists of continuous-to sporatic-zones of fracturing on a microscopic scale to matrix blocks larger than house-size. Many of these episodes probably existed throughout late Quaternary time, across the entire steam field. Upward penetration of the thermal plume is dependent upon the thickness of the overlying lithocap, it being very thin at the Big Geysers and thick at Bottle Rock/High Valley region.

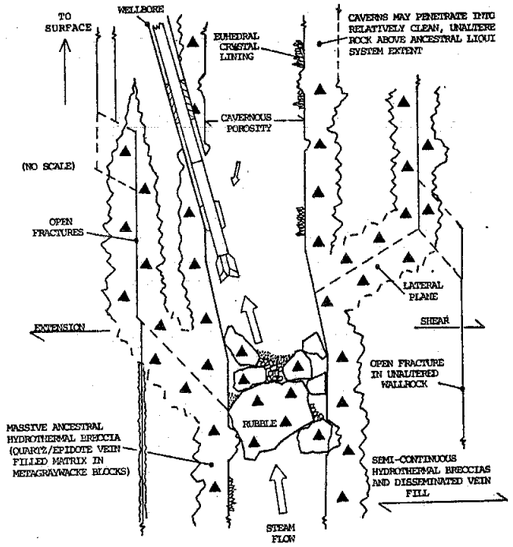


Figure 4. A conceptual illustration of a cavernous reservoir steamfeeder formed by continual episodic tectonic extension and shear within or around an ancestral hydrothermal breccia trend. Such caverns probably exist in unaltered rock nearer the surface in the main regions of the steam field. Rapid penetration through tectonic rubble breccia accompanied with large steam entries are witnessed. Small rubble may discharge through the wellbore. Feeders may extend downward or upward for some distances or terminate abruptly and be replaced by subordinate lateral (vertical) fractures.

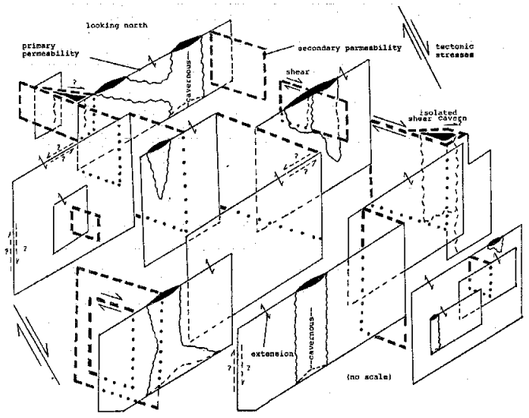


Figure 5. A conceptual three-dimensional view of Bottle Rock reservoir fracturing showing primary and secondary permeability. Extensional fractures (faults/joints) are near vertical and form a layer. Other layers may be offset and stacked above and below this layer to visualize composite reservoir fracturing from top to eventual bottom. Distribution, aperture width, and spacing of fractures is totally dependent on tectonic forces and the tensile strength(s) of the rocks.

Technology

Geothermal Wellbore Cooling Studied

At the Sandia National Laboratories, a numerical fluid-heat transfer simulation program, GEOTEMP2, was used to determine the amount of cooling within a geothermal wellbore due to circulation fluid. The wells studied were at the Baca and East Mesa geothermal areas. A shallow and a deep well were from the Salton Sea geothermal area. Calculations were made for 1 day of water circulation at flow rates of 100, 250, 500, and 1,000 gal./min. Additional calculations were made with the Baca and Salton Sea models.

In the Baca model, the effect on cooling due to different soil thermal conductivity values and different drilling fluid (high-viscosity mud and air) was investigated. In the Salton Sea model, the number of casings in the wellbore and the tubing diameters were varied.

In general, the results demonstrated that high flow rates and shallow well depths produce cooler downhole temper-

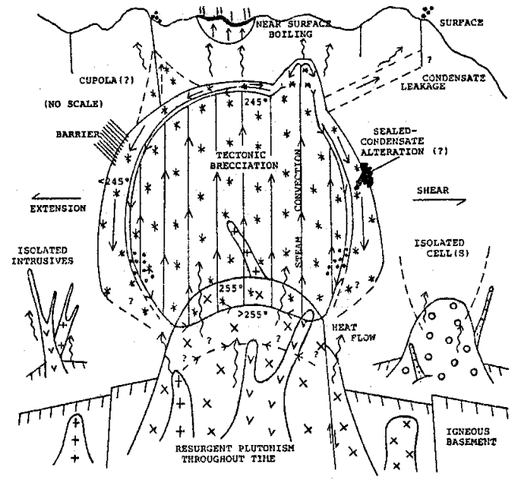


Figure 2. A conceptual illustration depicting a steam convection cell(s) and surrounding condensation zone, resulting from the boiled-down transformation of an ancestral liquid system (Fig. 1). Tectonic brecciation has and currently is fracturing rocks within and across the vein-filled imprints of the ancestral system(s). Steam bearing fractures may now overlap and extend above the range of the ancestral system in the form of isolated vertical joint zones, taking the shape of a cupola. The base of the convection cell may be very deep (≥14,000 ft. subsurface).

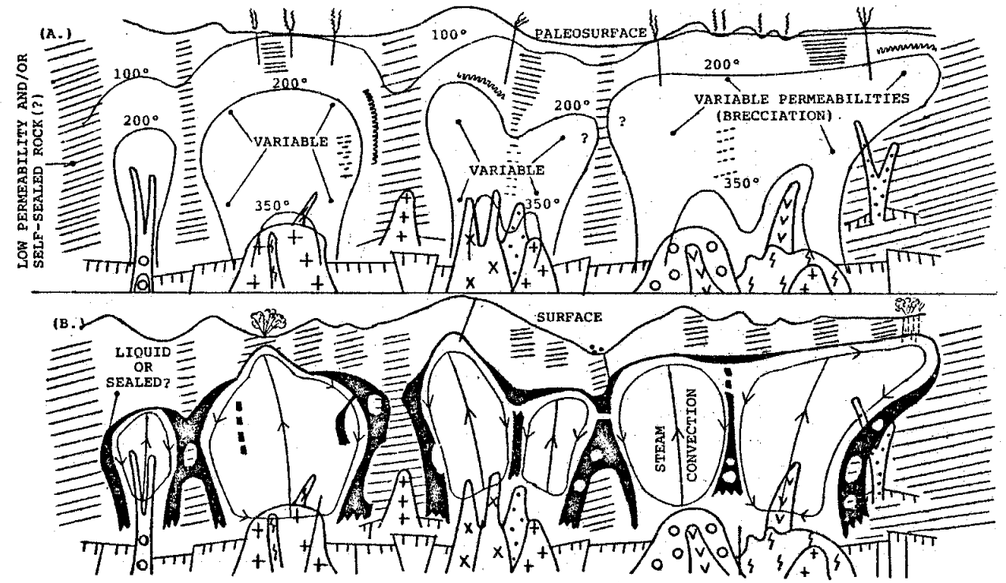


Figure 3. A conceptual illustration along the axis of the steam field depicting (A) intrusive episodes and several concurrent or successive episodes of liquid hydrothermal systems (cells). Variable tectonics could leave impermeable zones between cells with enhancement through self-sealing. Transformation to steam cells (B) allows development of condensation zone seals (sericitic alteration) which may further isolate cells. Impermeable barriers could develop within individual cells due to condensate accumulation and migration. Steam cell boundaries are probably irregular and complex.

atures. Temperatures were found to rise quickly after the wells were shut in. These temperatures reached values midway between the minimum temperature attained during circulation and the undisturbed temperature from 3 to 5 hours after the well is shut in. A detailed report on the study is being prepared for publication. For further information, call L. Duda (505) 844-2377.

SEP System Developed

Researchers at Sandia National Laboratories have successfully tested a technique useful for increasing the efficiency of geothermal energy systems. The technique is called the Surface Electrical Potential (SEP) system.

SEP calls for injecting a conductive fluid into the earth. The areas where the fluid flows have a different electrical resistivity than the surrounding rock. (Electrical resistivity is a measure of the resistance of a material to an electrical current.)

With the SEP process, electrical resistivity measurements are taken as an electrical current travels through the borehole, into fractures containing conductive fluid, and into a current-return well several kilometers from the test site. Whenever fluid is present, the probes measure higher electrical potential levels than when no fluid is present. Then, a map is drawn showing the direction that fluid has traveled.

SEP appears to be one of the most promising diagnostic techniques for determining the direction that the fluid travels, says Dr. Dennis Engi, supervisor of Sandia's Geo Systems Division. Its developers hope to refine the technique so that it produces real-time details about artificially induced discontinuities within geologic formations. Presently, several hours of computer analysis are needed to produce meaningful information.

The SEP system was field tested in conjunction with an acid stimulation of the Chevron well in the Beowawe Geothermal field in north-central Nevada (see article on Beowawe, this Hot Line issue). Results of the Beowawe acid wash/SEP operation showed conclusively that resistivity changes resulting from flow of the conductive acid wash into the reservoir's fracture system can be reliably measured by SEP equipment. "This means that SEP can identify areas of the geothermal reservoir reached by the acid wash," Engi says. "The information can be useful in determining operations for producing the reservoir."

Surface electrical potential data were obtained at the Beowawe field from 65 stainless steel probes placed circumferentially around a geothermal drill hole at distances of 750 feet, 2000 feet, and 4000 feet. The probes, 18 inches long and a half inch in diameter, were driven about 6 inches into the ground. A wire from each probe connected it to a "potential measurement box," and output from this device was sent over cable to an instrumentation/data-acquisition trailer. Tests before, during, and after the stimulation demonstrated SEP's strong sensitivity to the acid treatment.

SEP is based on a concept originated by Schlumberger, Ltd., as a means of locating deeply-buried ores. Sandia adapted that procedure and developed hardware and analytical techniques so it could be applied to geothermal acid washes and enhanced oil and gas recovery.

Legislation

State Legislative Update

The following bills comprise the geothermal legislation considered by the California State Legislature for the 1983/84 session.

Pending Legislation

SB 2102, Dills
Geothermal revenues; loans.

Under existing law, the Geothermal Resources Development Account is created in the General Fund, specified revenues are required to be deposited in the account, and the money is continuously appropriated for specified purposes. The State Energy Resources Conservation and Development Commission is authorized annually to expend 30% of the revenues deposited in the account during the preceding fiscal year to provide grants to cities, counties, and districts having geothermal resources to carry out specified geothermal resources development activities.

The bill would specify that regional planning agencies and public utility districts are included within the districts eligible for these funds and would allow the funds to be used for loans, with prescribed terms and conditions, in addition to grants, *thereby making an appropriation*. The bill would require the commission to hold the funds within the Local Government *Geothermal* Resources Revolving Subaccount, which the bill would create within the Geothermal Resources Development Account.

AB 432, Goggin
Energy resources, reports, state fuel set-aside program, private energy producers.

(1) The Warren-Alquist State Energy Resources Conservation and Development Act provides for, among other things, planning and forecasting of energy resources, and for site certification of designated power plants and related facilities by the State Energy Resources Conservation and Development Commission. Under the act, the commission is required to transmit to the Governor and the Legislature a comprehensive report on energy supply, demand, and conservation every 2 years.

This bill would require, among other specified criteria, that the report estimate the cost of electricity or fuels produced by each technology compared to conventional sources of energy, as defined, over specified periods and discuss the commission's priorities for research, development, and demonstration projects in relation to those comparative cost estimates.

The bill would require every electric utility, with exceptions, having specified installed electrical capacity to submit designated information dealing with projections of oil and gas fuel cost, as prescribed. The bill would require the commission to adopt the projections of the cost of oil and gas fuels, as prescribed, which would be binding upon the decisions of the Public Utilities Commission regarding the prices offered by electric utilities for electricity generated by private energy producers, as defined.

The bill would permit any private energy producer to apply to the commission for certification of a site and related facility, which meet designated conditions, without requiring the filing of the notice of intent to file an application

for certification with the commission.

(2) The existing law does not provide for a state fuel set-aside program.

This bill would require the State Energy Resources Conservation and Development Commission to administer the state fuel set-aside program provided for by the bill. The commission would be authorized to determine when an emergency or economic hardship exists, or is imminent, and provide for implementation of a set-aside program by regulation, as specified.

The bill would require the commission to establish an advisory committee to advise it with respect to specified matters dealing with the fuel set-aside program.

(3) Existing law provides for the Public Utilities Commission to regulate the terms and conditions of the purchase by electrical corporations of electricity produced by private energy producers employing other than conventional power sources.

This bill would revise the methods by which payments by electrical corporations to private energy producers for electricity are calculated by making provision for payments pursuant to standard offer contracts, as defined, and would require electrical corporations to prepare and submit them to the commission for approval.

The bill would require the commission to establish charges for gas utilized for cogeneration technology projects at a rate no higher than that applicable to gas used in conventional steam-powered generating facilities.

The bill would redefine "conventional power source" to exclude the generation of electricity using remote gas reserves, as described, and certain low-heat-value gas, as stated.

The bill would require the commission to establish and approve charges for the operation and maintenance by an electrical corporation of interconnection facilities between a private energy producer and the corporation.

(4) The bill would state the intent of the Legislature in enacting these provisions.

Chaptered Legislation

AB 2941, Clute
Geothermal wells, fees, exemption.
Signed by the Governor. Effective July 10, 1984.

The bill excludes from annual assessment by the California Division of Oil and Gas all low-temperature geothermal wells (including wells used for spas and human immersion) and geothermal observation wells.

AB 3379, Costa
Omnibus bill. Procedural changes to activities of the California Division of Oil and Gas. Effective January 1, 1985.

AB 3560, Wyman
Oil, gas, and geothermal energy operations; enforcement; civil penalties.

The bill would increase civil penalties to an amount up to $5,000 per violation for any person who violates any statute or regulation enforced by the California Division of Oil and Gas. The bill would also streamline the civil penalty process.

Federal Legislative Update

Status of federal legislation affecting geothermal energy, as of July 16, 1984.

1. H.R.21 : SPON=Kastenmeier; STTL=Energy Competition Act LATEST ACTION=Feb 4, 83 Referred to Subcommittee on Monopolies and Commercial Law.

2. H.R.278 : SPON=Quillen; STTL=Geothermal Energy Control Act of 1983 LATEST ACTION=Feb 16, 83 Executive Comment Requested from Interior.

3. H.R.576 : SPON=Fish; STTL=Business Energy Tax Credit Act of 1982 LATEST ACTION=Jan 6, 83 Referred to House Committee on Ways and Means.

4. H.R.1341 : SPON=Lehman, of CA, et. al; LATEST TITLE=A bill to establish the Mono Lake National Monument in the State of California, and for other purposes. LATEST ACTION=May 17, 84 Subcommittee on Public Lands and Reserved Water. Hearings held.

5. H.R.1381 : SPON=D'Amours, et. al; LATEST TITLE=A bill to amend the Ocean Thermal Energy Conversion Act of 1980 to provide for additional authorizations, and for other purposes. LATEST ACTION=May 3, 83 Placed on Union Calendar No: 44.

6. H.R.1568 : SPON=Cheney; STTL=Wyoming Wilderness Act of 1983 LATEST ACTION=May 4, 83 Executive Comment Requested from USDA.

7. H.R.1596 : SPON=Bedell, et. al; STTL=Renewable Energy Small Business Development Act of 1983 LATEST ACTION=Feb 23, 83 Referred to House Committee on Ways and Means.

8. H.R.1775 : SPON=Fuqua, et. al; STTL=Renewable Energy Tax Credit Act of 1983 LATEST ACTION=Mar 2, 83 Referred to House Committee on Ways and Means.

9. H.R.1884 : SPON=Fuqua, et. al; STTL=Renewable Energy Tax Credit Act of 1983 LATEST ACTION=Mar 3, 83 Referred to House Committee on Ways and Means.

10. H.R.1966 : SPON=Frank; LATEST TITLE=A bill to amend the Internal Revenue Code of 1954 to repeal the option to expense intangible drilling and development costs in the case of oil, gas, and geothermal wells, to repeal percentage depletion in the case of such wells, and to repeal certain benefits enacted by the Economic Recovery Tax Act of 1981 with respect to the windfall profit tax on domestic crude oil. LATEST ACTION=Mar 8, 83 Referred to House Committee on Ways and Means.

11. H.R.2058 : SPON=Marriott; STTL=Geothermal Steam Act of 1983 LATEST ACTION=Apr 7, 83 Executive Comment Requested from Interior.

12. H.R.2520 : SPON=Panetta, et. al; STTL=Income Tax Simplification Act of 1983 LATEST ACTION=Apr 13, 83 Referred to House Committee on Ways and Means.

13. H.R.2587 : SPON=Fuqua; STTL=Department of Energy Civilian Research and Development Authorization Act for ;Fiscal Year 1984 LATEST ACTION=May 16, 83 Received in the Senate and read twice and referred to the Committee on Energy and Natural Resources.

14. H.R.2927 : SPON=Hall, of OH, et. al; LATEST TITLE=A bill to amend the Internal Revenue Code of 1954 to clarify the definition of geothermal energy, and for other purposes. LATEST ACTION=May 5, 83 Referred to House Committee on Ways and Means.

15. H.R.3072 : SPON=Heftel, et. al; STTL=Renewable Energy Incentive Act of 1983 LATEST ACTION=May 19, 83 Referred to House Committee on Ways and Means.

16. H.R.3132 : SPON=Bevill; STTL=Energy and Water Development Appropriation Act, 1984 LATEST ACTION=Jul 14, 83 Became Public Law No: 98-50.

17. H.R.3153 : SPON=Chappie; LATEST TITLE=A bill to amend section 35 of the Mineral Lands Leasing Act to provide for the disposition of certain revenues under the Geothermal Steam Act of 1970. LATEST ACTION=Jun 10, 83 Executive Comment Requested from Interior.

18. H.R.3168 : SPON=Heftel, et. al; LATEST TITLE=A bill to amend the Internal Revenue Code of 1954 to provide that the energy investment tax credit shall be allowed for certain U.S.-produced energy property used predominantly in any beneficiary developing country. LATEST ACTION=May 26, 83 Referred to House Committee on Ways and Means.

19. H.R.3271 : SPON=Gephardt, et. al; STTL=Fair Tax Act of 1983 LATEST ACTION= Jun 9, 83 Referred to House Committee on Ways and Means.

20. H.R.3356 : SPON=Seiberling, et. al; LATEST TITLE=A bill to establish the Mono Basin National Forest Scenic Area in the State of California, and for other purposes. LATEST ACTION=Jun 16, 83 Referred to House Committee on Interior and Insular Affairs.

21. H.R.3358 : SPON=Shannon, et. al; STTL=Energy Security Tax Incentives Act of 1983 LATEST ACTION=Jun 16, 83 Referred to House Committee on Ways and Means.

22. H.R.3363 : SPON=Yates; LATEST TITLE=A bill making appropriations for the Department of the Interior and related agencies for the fiscal year ending September 30, 1984, and for other purposes. LATEST ACTION=Nov 4, 83 Became Public Law No: 98-146.

23. H.R.3585 : SPON=Downey, et. al; STTL=Tax Equity Act of 1983 LATEST ACTION= Jul 18, 83 Referred to House Committee on Ways and Means.

24. H.R.3766 : SPON=Richardson; STTL=San Juan Basin Wilderness Protection Act of 1983 LATEST ACTION=May 23, 84 Ordered to be Reported (Amended).

25. H.R.4078 : SPON=Heftel, et. al; STTL=Alternative Energy Tax Incentives Act of 1983 LATEST ACTION=Oct 4, 83 Referred to House Committee on Ways and Means.

26. H.R.4198 : SPON=Jeffords; STTL=Vermont Wilderness and Recreation Area Act of 1983 LATEST ACTION=May 24, 84 Passed Senate with amendments and an amendment to the Title by Voice Vote.

27. H.R.5244 : SPON=Fuqua; STTL=Department of Energy Civilian Research and Development Authorization Act for ;Fiscal Years 1985, 1986, and 1987 LATEST ACTION=May 22, 84 Rules Committee Resolution H.Res.509 Reported to House.

28. H.R.5245 : SPON=Fuqua; STTL=Department of Energy Civilian Energy Programs Authorization Act for Fiscal ;Years 1985, 1986, and 1987 LATEST ACTION= Apr 12, 84 Reported to House (Amended) by House Committee on Science and Technology. Report No: 98-688 (Part I).

29. S.96 : SPON=Melcher; STTL=Lee Metcalf Wilderness and Management Act of 1983 LATEST ACTION=Oct 31, 83 Became Public Law No: 98-140.

30. S.543 : SPON=Wallop, et. al; STTL=Wyoming Wilderness Act of 1983 LATEST ACTION=May 4, 83 Executive Comment Requested from USDA.

31. S.558 : SPON=Jackson; STTL=Geothermal Steam Act Amendments of 1983 LATEST ACTION=Jun 8, 83 Committee on Energy and Natural Resources received executive comment from Agriculture Department. Favorable.

32. S.616 : SPON=Durenberger, et. al; STTL=Renewable Energy Small Business Development Act of 1983 LATEST ACTION=Mar 7, 83 Committee on Finance

requested executive comment from OMB, Treasury Department, Energy Department.

33. S.883 : SPON=McClure, et. al; STTL=Geothermal Steam Act Amendments of 1983 LATEST ACTION=Jun 8, 83 Committee on Energy and Natural Resources received executive comment from Agriculture Department. Favorable.

34. S.1237 : SPON=Symms, et. al; LATEST TITLE=A bill to amend the Internal Revenue Code of 1954 to clarify the definition of geothermal energy, and for other purposes. LATEST ACTION=Jul 18, 83 Subcommittee on Energy and Agricultural Taxation. Hearings held. Hearings printed: S.Hrg. 98-457.

35. S.1305 : SPON=Packwood, et. al; STTL=Renewable Energy Tax Incentive Act of 1983 LATEST ACTION=Jul 18, 83 Subcommittee on Energy and Agricultural Taxation. Hearings held. Hearings printed: S.Hrg. 98-457.

36. S.1331 : SPON=Cranston; LATEST TITLE=A bill to establish the Mono Lake National Monument in the State of California, and for other purposes. LATEST ACTION=May 17, 84 Subcommittee on Public Lands and Reserved Water. Hearings held.

37. S.1396 : SPON=Domenici, et. al; STTL=Energy Security Tax Incentives Act of 1983 LATEST ACTION=Jun 17, 83 Subcommittee on Energy and Agricultural Taxation. Hearings held. Hearings printed: S.Hrg. 98-365.

38. S.1421 : SPON=Bradley, et. al; STTL=Fair Tax Act of 1983 LATEST ACTION=Jun 23, 83 Committee on Finance requested executive comment from OMB, Treasury Department.

39. S.1740 : SPON=Bingaman; STTL=San Juan Basin Wilderness Protection Act of 1983 LATEST ACTION=Dec 6, 83 Committee on Energy and Natural Resources requested executive comment from Interior Department, OMB.

40. S.1767 : SPON=Mitchell; STTL=Personal Income Tax Reform Act of 1983 LATEST ACTION=Aug 20, 83 Committee on Finance requested executive comment from OMB, Treasury Department.

41. S.1939 : SPON=Wallop, et. al; STTL=Alternative Energy Tax Incentives Act of 1983 LATEST ACTION=Oct 18, 83 Committee on Finance requested executive comment from OMB, Treasury Department.

42. S.2442 : SPON=McClure; STTL=Civilian Energy Programs Authorization for Fiscal Years 1985 and 1986 LATEST ACTION=Mar 19, 84 Read twice and referred to the Committee on Energy and Natural Resources.

43. S.2538 : SPON=Packwood; STTL=National Oceanic and Atmospheric Administration Ocean and Coastal Program ;Authorization Act LATEST ACTION= May 16, 84 Placed on Senate Legislative Calendar under General Orders. Calendar No. 877.

44. S.AMDT.NO.2998 : ASPON=Symms; SUBMITTED FOR H.R.2163; CONG REC S4656; APURP=Providing a special rule for geothermal energy equipment. LATEST ACTION=Apr 12, 84 Amendment SP 2998 agreed to in Senate by Voice Vote.

Grants

CEC Geothermal Grants Awarded

In 1984, the California Energy Commission (CEC) awarded $4,554,000 in geothermal grants in its fourth funding round. Of the 33 projects funded, 22 were in the area of resource development, 5 were planning studies, and 6 were mitigation studies.

Applicant	Project Description	Funding Recommendation
MITIGATION		
County of Sonoma	Revegetation of Geysers road	$ 32,132
Kelseyville Unified School Dist.	Purchase of a school bus	68,490
County of Lake APCD	Continuous H_2S monitoring	32,700
County of Lake	Middleton traffic bypass study	30,000
County of Sonoma APCD	Continuous H_2S monitoring	22,395
Konocti School Dist.	Purchase of a school bus	65,000
PLANNING AND FEASIBILITY		
Great Basin APCD	Monitoring of air quality	88,288
County of Mono	Feasibility study of small scale electric and dist. heating	81,500
County of Lake	Land mapping in The Geysers	21,277
Mendocino County Resource Conservation Dist.	Watershed assessment	33,930
County of San Bernardino	County Center feasibility, design & retrofit	36,000

Applicant	Project Description	Funding Recommendation
RESOURCE AND DEVELOPMENT		
City of San Bernardino	Retrofit City Hall & Convention Center	$ 23,450
City of Calipatria	Resource confirmation	404,054
County of Siskiyou	Heat Pump System for courthouse and jail (Phase I)	311,755
City of Lake Elsinore	Resource confirmation and community center retrofit	134,750
County of San Bernardino	GSA Design and retrofit	33,450
Indian Springs School Dist.	Space heating for high school	148,512
County of San Bernardino	Jail design and retrofit	26,850
County of Lake/Mendocino Lake Community College	Geothermal agri-industrial center	385,297
City of San Bernardino	Retrofit Loan Program	200,000
California Pines Community Services Dist	Hot water & space heating	22,050
City of Paso Robles	Swimming pool retrofit & TG well(s)	127,745
Fort Bidwell	Deep resource confirmation well	19,800
County of Modoc	Resource assessment	95,000
County of San Bernardino	Resource assessment 29 Palms	75,000
Surprise Valley School District	Retrofit of high school & elementary school	192,387

Applicant	Project Description	Funding Recommendation
County of Sierra	Resource confirmation	74,388
City of Calistoga	Round two grant augmentation	3,800
Bridgeport PUD	Small scale electric and district heating	937,411
City of Desert Hot Springs	Resource assessment	182,000
City of Susanville	Pipeline extension	143,437
County of San Bernardino	EPWA design and retrofit	50,540
City of San Bernardino	Retrofit grant program	325,000
County of Sierra	Resource confirmation	125,612

Leases

SLC to Lease Parcel at The Geysers

by Don Hoagland
California State Lands Commission

On June 21, the State Lands Commission (SLC) was asked to authorize a competitive lease sale for geothermal resources on a portion of Cobb Mountain in Lake County, California.

The parcel selected for competitive bidding contains about 440 acres and is on the eastern side of Cobb Mountain just west of the community of Whispering Pines. The parcel is one of the few state-owned parcels within the Geysers KGRA where the state owns both surface and the mineral rights.

After the Environmental Impact Report is adopted and the competitive lease sale is authorized, SLC will publish a Notice of Intention to Lease by Competitive Bidding, and bids will be received. The bids will be opened about 2 months later. While the schedule is still tentative, the lease sale probably will occur in the fall of 1984.

Terms of the sale have not yet been determined. Persons interested in receiving a notice of intention to lease should write to Don Hoagland, State Lands Commission, 1807 13th Street, Sacramento, California 95814 or call (916) 322-7804.

Lease Sale Schedule as of 7/19/84

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
Lightening Dock/Radium Springs/Socorro Peak, New Mexico	8/23/84
Brady-Hazen/Dixie Valley/Double Hot Springs/Elko Hot Springs/Kyle Hot Springs/Leach Hot Springs/ Trego Hot Springs, Nevada	9/18/84

Courses, Workshops, and Meetings

Engineering and economic assessment of geothermal resources. Clarion Hotel (San Francisco International Airport), October 24-26, 1984. Cost to be determined.

The short course is offered by the Geothermal Resources Council. For further information, contact the GRC, P.O. Box 1350, Davis, California 95617-1350.

The 6th New Zealand Geothermal Workshop, Auckland, New Zealand, November 7-9, 1984.

The workshop is hosted by the Geothermal Institute at the University of Auckland. Three days of technical sessions are planned along with presentations of papers and discussions. The meeting is intended to be a forum for exchange of information about all aspects of geothermal development.

The Geothermal Institute, founded in 1979, offers a 1-year geothermal course for earth scientists and engineers. The institute is sponsored jointly by the United Nations Development Programme and the New Zealand Government. In 1984, 28 fellows from 12 countries are studying at the institute for the Diploma in Energy Technology (Geothermal), and 15 students are reading for higher degrees.

For further information, contact D.H. Freeston and R. McKibbin, Geothermal Institute, University of Auckland, Private Bag, Auckland, New Zealand.

Tenth Annual Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 22-24, 1985.

The workshop brings together researchers, engineers, and managers involved in geothermal reservoir studies and developments.

Abstracts and tentative titles of proposed papers should be submitted for the consideration of the Workshop Program Committee by September 18, 1984.

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

Geothermal Resources Council 1985 Annual Meeting, Kona Surf Hotel, Kailua-Kona, Hawaii, August 26-30, 1985. A workshop, Drilling of High Temperature Geothermal Wells, will be held on August 23-25 before the meeting. A second workshop, Fractures in Geothermal Reservoirs or Geothermal Exploration, will follow the meeting and be held from August 31-September 1. Workshop and meeting costs have not been determined.

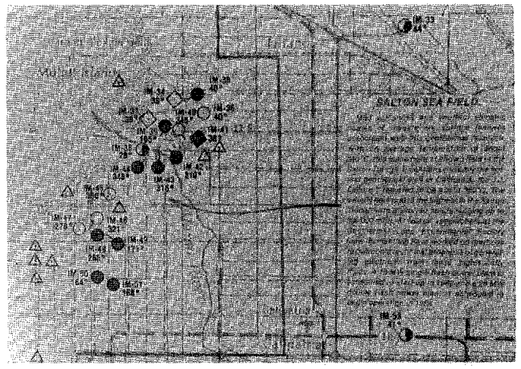
For further information, contact the GRC, P.O. Box 1350, Davis, California 85617-1350.

Maps

Technical Map of the Geothermal Resources of California. 1983. Map No. 5. By H. Majmundar. Scale 1:750,000. $8.50, rolled. Published by and available from the California Division of Mines and Geology, P.O. Box 2980, Sacramento, California 95812.

The map is the second map produced as part of a state-wide CDMG inventory and evaluation of California's geothermal resources.

The first map, No. 4, Geothermal Resources of California, depicts in a single source, the occurrence of California's geothermal resources.



Portion of the Imperial Valley, photographed from the Technical Map of the Geothermal Resources of California.

Map No. 5 focuses on developing the relationship of volcanics and tectonics to the occurrence of geothermal resources. It provides a chemical characterization of already-identified occurrences of low-and moderate-temperature subsurface water.

New Mexico Maps Available

The National Geophysical Data Center has published four New Mexico maps in the "Geothermal Resources of New Mexico: Scientific Map Series."

Map	Format	Price* Folded	Rolled
Late Tertiary and Quaternary Tectonics and Volcanism	Paper	$ 8	$ 10
Bouguer Gravity Anomaly Map of New Mexico	Clear Plastic	----	$ 20
Composite Residual Total Intensity Aeromagnetic Map of New Mexico	Clear Plastic	----	$ 20
Hydrology and Geochemistry	Clear Plastic	----	$ 20
Complete set	Paper base & 1 copy of each plastic overlay	----	$ 50

Digital data used to compile the aeromagnetic map are available on magnetic tape for $110.

How to Order

U.S. Department of Commerce regulations now require prepayment on all non-federal orders. Telephone pre-orders are accepted, but data will not be shipped until payment is received. Checks and money orders should be made payable to COMMERCE/NOAA/MGDC. Please add handling fee for non-USA orders as follows: $5 for orders up to $50; 10% of cost of total order for orders $50 and over. Please pay in U.S. dollars drawn on a USA bank. Orders may be charged to an American Express, MasterCard, or Visa card, by telephone or letter; please include card account number, expiration date, telephone number, and your signature with order. Inquiries, orders, and payment should be addressed to:

National Geophysical Data Center
NOAA, Code E/GC1
325 Broadway
Boulder, Colorado 80303

Direct telephone inquiries to:

Commercial: (303) 497-6125
FTS: 320-6125
Telex: 45897 Solterwarn

* These prices are valid through September 30, 1984. Prices applicable after that date may be obtained by calling (303) 497-6541, FTS 320-6541.

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Geothermal resources of Wyoming. 1983. By H. Heasler, B. Hinckley, K. Buelow, S. Spencer, and E. Decker. Scale 1:500,000. Free over-the-counter; $2.00 by mail. Available from the Wyoming Geological Survey, P.O. Box 3008, Laramie, Wyoming 82071.

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Geothermal resources of Kansas. By S. Stavnes and D. Steeples. 1982. Scale 1:500,000. Free. Available from the Kansas Geological Survey, 1930 Avenue "A", Campus West, the University of Kansas, Lawrence, Kansas 66044. (913) 864-3965.

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Geothermal resource assessment in Oklahoma, 83-1. By W. Harrison, K. Luza, M. Prater, and P. Cheung. 42p. $8.00. Available from the Oklahoma Geological Survey, the University of Oklahoma, Norman, Oklahoma 73019.

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Geothermal resources of Alaska, 1983. By R. Motyka, M. Moorman, S. Liss, D. Turner, R. Forbes, M. Albanese, J. Macbeth, A. Lockhart, and S. Seed. Scale 1:2,500,000. $5.00. Available from ADGGS, 794 University Avenue (Basement), Fairbanks, Alaska 99701. (907) 474-7062.

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Carta Geológica de Mexico (continuing series). 1:1,000,000. Color. Compiled by the Dirección General de Geografía del Territorio Nacional 1980(?). Available from the Secretaría de Programación y Presupuesto, San Antonio Abad 124, 5° Piso, Mexico 7, D.F. Set of 8 sheets (Tijuana, La Paz, Chihuahua, Monterrey, Guadalajara, D.F. Mexico, Villa Hermosa (Oaxaca), and Merida).

Publications

Geothermal world directory. 1984. Published by and available from Geothermal World Directory, 5762 Firebird Court, Mission Oaks, Camarillo, California 93010. $40.00, prepaid. Overseas orders add $2.00. California residents add 6 percent sales tax. 10 percent discount for educational institutions and libraries.

A reference guide to geothermal development worldwide.

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Geothermal news portion of the Energy saving and alternative energy sources newsletter. Free. Write the Commission of the European Communities, Directorate General XII, Directorate General XVII, Rue de la Loi, 200, B-1049 Brussels, Belgium.

The newsletter emphasizes European geothermal activities.

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New publications of the U.S. Geological Survey. Monthly. Free. Write to the USGS, 582 National Center, Reston, Virginia 22092.

New maps and publications. Indexed.

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U.S. Dept. of Commerce energy data files. Free. Write the U.S. Dept. of Commerce, NTIS, Springfield, Virginia 22161.

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DOE Information Exchange Program

The U.S. Department of Energy, through its Office of Scientific and Technical Information (OSTI), maintains specialized information exchange programs with other government agencies, state energy offices, research organizations, colleges and universities, and foreign governments and organizations. The primary objective of these programs is to ensure that worldwide energy R&D results are available for DOE research programs to improve their productivity and to prevent duplication of research. Exchanges include journals, reports, books, and other documents; data bases; magnetic tapes--energy research information in almost any form.

Federal and state agencies, colleges and universities, nonprofit organizations, and foreign agencies may send two copies of their energy reports to the Technical Information Center, which enters them into its processing cycle. The reports are permanently archived, and are announced in OSTI publications as available from the originator or as available for sale through the National Technical Information Services (NTIS). In exchange, participating organizations receive energy information from OSTI--for example, Energy Research Abstracts (ERA), a semimonthly abstract journal covering DOE energy information; a monthly abstract journal dealing with their specific research area; or access to the Department of Energy's computerized information retrieval system DOE/RECON.

Data bases--both bibliographic and numeric--and magnetic tapes may also be exchanged for information of comparable value.

If your organization has energy information that you feel would be useful to a wider audience, to arrange an exchange contact:

Customer Services Division
Office of Scientific and Technical Information
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37831

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DOE Geothermal Mailing Lists

The Technical Information Center (TIC) distributes the results of U.S. Dept. of Energy research and development programs to department program managers and contractors. A subject category scheme ensures distribution of the reports in the contractor's area of interest. The category code for Geothermal Energy is UC-66. Several subsections are described in the following list.

For further information, call Ms. Ramona Nelson, (615) 576-1267, U.S. Department of Energy, Technical Information Center, Oak Ridge, Tennessee. Department of Energy contractors should be prepared to give their contract number.

UC-66
Geothermal Energy

Reports in this category include information on all aspects of the Geothermal Energy program. All geothermal reports are distributed to the addresses in the basic list with additional distribution as appropriate to supplemental list(s).

UC-66a
GE-Resource Development

Reports in this category include information on:

1. Present status of resource development
2. Resources and Reservoir Assessment
3. Geology, Hydrology, and Geothermal systems.

UC-66b
GE-Exploration Technology

Reports in this category include information on:

1. Geophysical exploration techniques and surveys
2. Geochemical exploration techniques and surveys
3. Exploratory drilling technology and well logging
4. Downhole and surface instrumentation.

UC-66c
GE-Drilling Technology

Reports in this category include information on:

1. Advanced drilling systems and methods of drilling
2. Drilling fluids and cementation
3. Downhole drill motors
4. Other well hardware.

UC-66d
GE-Utilization Technology

Reports in this category include information on:

1. Materials development, corrosion studies, scaling control
2. Heat exchangers, pumps, advanced conversion systems
3. Extraction technology, reservoir stimulation
4. Fluid transmission pipeline design.

UC-66e
GE-Environmental Research

Reports in this category include information on:

1. Ground subsidence, seismic effects
2. Noise, blow-outs, gaseous emissions
3. Emission control and abatement
4. Surface and groundwater effects.

UC-66f
GE-Experimental and Commercial Electricity Production from Geothermal Resources

Reports in this category include information on:

1. Closed thermal loops
2. Pilot and demonstration plants
3. Commercial power plant design and operation.

UC-66g
GE-Direct Applications of Heat from Geothermal Resources

Reports in this category include information on:

1. Agricultural applications
2. Medical treatment
3. Aquaculture
4. Industrial applications
5. Residential and commercial applications.

UC-66h
GE-Legal and Other Institutional Aspects of Geothermal Energy Exploitation

Reports in this category include information on:

1. Effects of federal, state and local laws and regulations on geothermal development
2. Social implications
3. Taxation policies
4. Land use criteria.

UC-66i
GE-Economic and Financial Aspects of Geothermal Energy Exploitation

Reports in this category include information on:

1. Cost projections
2. Market analyses and projections
3. Federal Loan Guaranty Programs
4. Economic incentives to lease, explore and exploit geothermal energy.

UC-66j
GE-Federal Energy Plans

Reports in this category include information on:

1. Annual update of National Energy Plans
2. Geothermal Definition Report.

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The following publications are available from the National Technical Information Service, U.S. Dept. of Commerce, Springfield, Virginia 22161. All microfiche copies are $3.50 each. Costs for printed copies vary.

Information Sources

Geothermal progress monitor: system status and operational experience. DOE/CE-0108. By R. Gerstein and D. Medville. Nov. 1983. $6.50. 20p. The publication briefly describes the Geothermal Progress Monitor System. Through this system, trends in geothermal development are identified and studied.

Geothermal progress monitor 8. DOE/CE-77011-1. $9.50. 84p. A very useful compendium of technology transfer data, including computer programs, descriptions of DOE Technical Information Center mailing lists, state geothermal projects, a list of federal laboratories involved in geothermal energy research and development, and names and addresses of individuals involved in the Geothermal Progress Monitor System.

Geothermal energy technology. PB83-914700. Published semimonthly. $40.00 a year (domestic); $80.00 a year (outside the North American continent). Back issues are $5.00 each.

Descriptions of current geothermal data available worldwide on technology developed for geothermal development. The summaries and all citations in the publication are available for on-line searching and retrieval using the DOE/RECON system. Citations from June 1976 to the present are available on the Energy Data Base (EDB).

NOTE: For information about the EDB, write the Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830. Ask for publication DOE/TIC-4613, which is free of charge.

Geopressured

Technical support for geopressured-geothermal well activities in Louisiana. Annual Report for 11/1/81-11/1/82. DOE/NV/10174-2. By D. Bebout, Z. Bassiouni, D. Carver, C. Groat, A. Johnson, and F. Wrighton. $32.00. 453p.

Geopressured geothermal bibliography, vols. I and II. DOE/ET/27112-5 (Vol. 1). K. Sepehrnoori, F. Carter, R. Schneider, S. Street, and Kira McGill. 1983. Contact NTIS for price. 757p.

Geopressured geothermal bibliography. DOE/ET/27112-5 (Vol. 2). By K. Sepehrnoori, F. Carter, R. Schneider, S. Street, and K. McGill. 1983. 200p. $17.00.

Hydrogen Sulfide

The potential effects of H_2S gas from geothermal energy conversion on two plant species native to northern New Mexico. LA-9984-T Thesis. By G. Gonzales. 1984. 117p. $11.00.

An experimental study of electron beam induced removal of H_2S from geothermal fluids. By D. Helfritch, R. Singhvi, R. Evans, and W. Reynolds. 1983. 90p. $9.50.

Western U.S.

Field trip guide to the Valles Caldera and its geothermal systems. LA-9963-OBES. By F. Goff and S. Bolivar. 1983. 53p. $8.00.

The Baca geothermal demonstration project: PNM's overview of project objectives, plant design, project completion of status, maintenance storage and marketing of equipment, site restoration, and project benefits. DOE/ET/27163-T4. 1983. By Public Service Company of New Mexico (PNM). 43p. $6.50.

Baca project: geothermal demonstration power plant. Final report. DOE/ET/27163-T2. 1982. 456p. $32.00.

Drilling and thermal gradient measurements at U.S. Marine Corps Air Ground Combat Center, Twentynine Palms, California. DOE/SF/11956-1. 1984. By D. Trexler, T. Flynn, and G. Ghusn, Jr. $9.50.

Final phase testing and evaluation of the 500 kw direct contact pilot plant at East Mesa. DOE/SF/11700-T1. By R. Olander, S. Oshmyansky, K. Nichols, and D. Werner. 1983. 164p. $14.00.

Thermal groundwater flow systems in the thrust zone in southeastern Idaho. DOE/ET/28407-4. By D. Ralston and A. Mayo. 1983. $26.00.

Petrographic analysis and correlation of volcanic rocks in Bostic 1-A well near Mountain Home, Idaho. LA-9966-HDR. By B. Arney, J. Gardner, and S. Belluomini. 29p. $6.50.

The 1980-82 geothermal resource assessment program in Washington State. DOE/ET/27014. By M. Korosec, W. Phillips, and J. Schuster. 1983. 299p. $23.00.

Direct utilization of geothermal resources at Warm Springs State Hospital, Warm Springs, Montana. DOE/ET/27055-10. By MultiTech, Inc. 1983. $12.50.

Technology

Evaluation of borehole electromagnetic and seismic detection of fractures. SAND84-7109. By Hsi-Tien Chang, S. Suhler, and T. Owen. 1984. 75p. $9.50.

Development of a borehole directional antenna at VHF. SAND84-0254. By Hsi-Tien Chang and L. Scott. 1984. 109p. $11.00.

Review of shell and tube heat exchanger fouling and corrosion in geothermal power plant service. DOE/SF/11503-2. By P. Ellis. 1983. 64p. $8.00.

Federal Government

Federal Government royalty income derived from the benefits of government-sponsored R & D. DOE/SF/11727-T1. By C. Amundsen, T. Cassel, and D. Kathan. 1984. 43p. $8.00.

Proceedings of the geothermal program review 11. CONF-8310177. 1983. 443p. $24.50.

Direct use geothermal PON and PRDA projects under DOE-ID administration annual report FY 1983. IDO-10118(84). By F. Childs. 1984. 30p. $6.50.

Suggested drilling research tasks for the Federal Government. SAND84-0436. By Charles C. Carson. 1984. 40p. $8.00.

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AAPG bookstore (publications of the American Association of Petroleum Geologists). Free. Available from the AAPG Bookstore, P.O. Box 979, Tulsa, Oklahoma 74101.

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The Nevada mineral industry, 1983. MI-1983. $5.00; $5.50 by mail. Includes a section on geothermal exploration and development.

Nevada Bureau of Mines and Geology publications, 1984. Free.

Available from the Nevada Bureau of Mines and Geology, University of Nevada Reno, Reno, Nevada 89557-0088.

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Two Interesting Basin and Range Reports

The role of heat in the development of energy and mineral resources in the Northern Basin and Range Province, Special Report No. 13. 1983. $33.50 postpaid. 384p. Published by and available from the Geothermal Resources Council, P.O. Box 1350, Davis, California 95617-1350. Phone (916) 758-2360.

This useful volume includes sections on An Overview of the Northern Basin and Range Province (5 papers), Active Hydrothermal Systems (6 papers), Thermogenics and Hydrocarbon Resources (4 papers), Fossil Hydrothermal Systems (6 papers), and Regional Geophysics of the Northern Great Basin (6 papers).

The comprehensive, detailed descriptions of the Northern Basin and Range province were prepared for a GRC symposium convened in Reno in 1983, cosponsored by the American Association of Petroleum Geologists. Several excerpts from the volume are used throughout this Hot Line issue.

The Geothermal Resources Council meeting in Reno at the end of August includes field trips to many geothermal reservoirs mentioned in the publication including Dixie Valley, Beowawe, Desert Peak, and Steamboat Hot Springs.

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The Nevada Bureau of Mines and Geology has a new open-file report available to the public containing information compiled for the U.S. Geological Survey Task I Basin and Range Province Working Group.

NBMG Open-file Report 83-13, "Thirty-two Geologic Cross Sections, Clark, Esmeralda, Lincoln, and Nye Counties, Nevada, and Adjacent Areas in California," by T. L. T. Grose, contains information on 32 geologic cross sections from eastern Nevada and southwestern Nevada and adjacent California areas. Cross-section location maps are included, as well as a chart of lithologic units and a reference summary for each cross section.

NBMG Open-file Report 83-13 is available for public inspection in the Nevada Bureau of Mines and Geology unpublished-information office, Room 311, Scrugham Engineering-Mines Building, the University of Nevada Reno campus. For further information, contact Becky Weimer-McMillion, (702) 784-6691.

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"Geothermal exploration in Oregon, 1983." By George R. Priest. Article in the May 1984 issue of Oregon Geology, a monthly publication. $6.00 a year. Available from the Oregon Dept. of Geology and Mineral Industries, 1005 State Office Bldg., Portland, Oregon 97201.

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Texas geothermal RD&D program planning support document. By R. Davis, M. Conover, R. Keeney, M. Personett, and D. Richmann. Free. Available from the Texas Energy Extension Service, Office of the Director, Texas A & M University, College Station, Texas 77843. (713) 845-8025.

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Geothermal, A Special Souvenir Edition of The Clear Lake Observer describing development at The Geysers Geothermal Field. $3.00. March 1984. Published by and available from the Clear Lake Observer, P.O. Box 6328, Clearlake Highlands, California 95422.

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Feasibility of geothermal power plant efficiency improvements at The Geysers. P700-84-001. $4.10. Published by and available from the California Energy Commission, Accounting Office, 1516 Ninth Street, MS-2, Sacramento, California 95814.

The report describes a study of technical feasibility, environmental impacts, and economic merits associated with efficiency improvements of geothermal power plants. Included are capital costs for types of geothermal plants, levelized costs for 30 years of electrical production (1988-2018), and assessment of cumulative savings through displacement of oil-and gas-generated energy.

California Wells

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.

Drilling Permits for Geothermal Wells Approved Jan.-June 1984 by the California Division of Oil and Gas

Date Notice Received	Operator & Well No.	API No.	Sec.	T.	R.	Location & Elevation
	LAKE COUNTY					
12/30/83	Union Oil Co. of Calif. "NE Geysers Unit" 12	033-90481	8	11N	8W	Fr. SW cor. 776m N, 673m E, 1,028m KB.
1/13/84	GRI Operator Corporation "NWG" 2	033-90482	16	12N	9W	Fr. SE cor. 732m N, 418m W, 686m GR.
1/13/84	GRI Operator Corporation "NWG" 5	033-90483	22	12N	9W	Fr. NE cor. 412m S, 778m W, 747m GR.

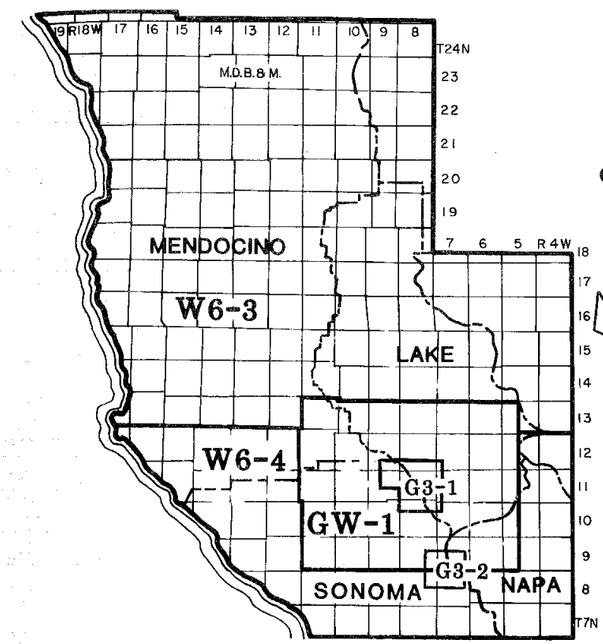
Date Notice Received	Operator & Well No.	API No.	Sec.	T.	R.	Location & Elevation
1/25/84	Union Oil Co. of Calif. "California St" 92-6	033-90484	6	11N	8W	Fr. NE cor. 284m S, 668m W, 871m KB.
4/12/84	GRI Operator Corporation "H" 22	033-90491	12	13N	10W	Fr. NW cor. 122m S, 750m E, 427m GR.
4/13/84	GRI Operator Corporation "H" 20	033-90490	24	13N	10W	Fr. NE cor. 280m S, 244m W, 549m GR.
5/21/84	Aminoil USA, Inc. "Davies Estate" 4	033-90492	36	11N	8W	Fr. NW cor. 451m S, 363m E, 597m GR.
5/30/84	GRI Operator Corporation "H" 21	033-90493	16	13N	10W	Fr. SE cor. 641m N, 732m W, 854m GR.
	MENDOCINO COUNTY					
1/13/84	GRI Operator Corporation "MTV" 3	045-90052	19	12N	9W	Fr. NE cor. 884m S, 701m W, 732m GR.
1/13/84	GRI Operator Corporation "MTV" 8	045-90051	18	12N	9W	Fr. NE cor. 610m S, 686m W, 762m GR.
	NAPA COUNTY					
6/11/84	City of Calistoga "Calis" 1	055-90082	36	9N	7W	Fr. SE cor. proj. sec., 25m N, 335m W, 121m RT.
	SONOMA COUNTY					
1/6/84	GRI Operator Corporation "WW" 3	097-90606	4	11N	9W	Fr. SE cor. 91m N, 1,098m W, 366m GR.
1/17/84	Union Oil Co. of Calif. "GDC" 21	097-90607	28	11N	8W	Fr. SE cor. 300m N, 387m W, 749m KB.
3/7/84	GRI Operator Corporation "Aidlin" 5	097-90609	4	11N	9W	Fr. NW cor. 442m S, 292m E, 393m KB.
4/4/84	Union Oil Co. of Calif. CA-5639, No. 42B-33	097-90611	33	11N	8W	Fr. NW cor. 200m S, 694m E, 777m KB.
4/17/84	Union Oil Co. of Calif. "GDC" 26	097-90612	13	11N	9W	Fr. NE cor. 581m S, 9m W, 514m KB.
5/2/84	Union Oil Co. of Calif. CA-5639, No. 36A-28	097-90613	28	11N	8W	Fr. SE cor. 253m N, 1,178m W, 749m KB.

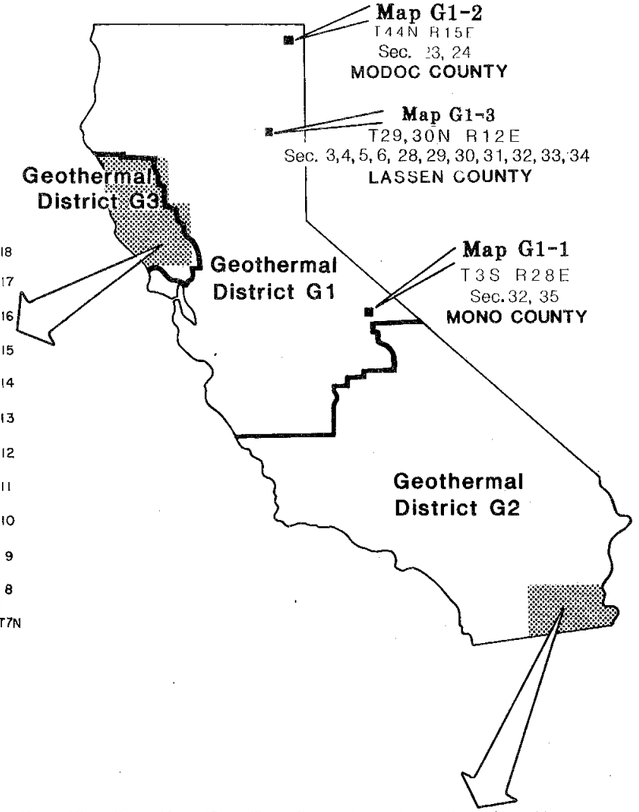
Date Notice Received	Operator & Well No.	API No.	Sec.	T.	R.	Location & Elevation
5/4/84	Union Oil Co. of Calif. "DX State 4596" 68	097-90614	7	11N	8W	Fr. NW cor. 640m S, 1,471m E, 1,021m KB.
6/8/84	GRI Operator Corporation "Prati State" 26	097-90617	2	11N	9W	Fr. NW cor. 1,067m S, 549m E, 785m KB.
6/8/84	GRI Operator Corporation "Prati" 39	097-90618	35	12N	9W	Fr. SE cor. 1,106m N, 599m W, 718m KB.
6/8/84	GRI Operator Corporation "NWW" 6	097-90616	24	12N	9W	Fr. NW cor. 702m S, 101m E, 671m GR.
6/11/84	Union Oil Co. of Calif. "Beigel" 2	097-90615	29	11N	8W	Fr. SW cor. 655m N, 573m E, 727m KB.
6/15/84	Union Oil Co. of Calif. "GDC" 19	097-90620	20	11N	8W	Fr. SW cor. proj. sec. 93m N, 14m E, 619m KB.
	LASSEN COUNTY					
1/12/84	Carson Development Co. "Wineagle" 1	035-90069	23	29N	15E	Fr. SW cor. 983m N, 640m E, 1,224m DF.
	MONO COUNTY					
4/13/84	Wood & Associates "Chance" 6	051-90042	33	3S	28E	Fr. SW cor. 38m N, 30m E, 2,100m GR.
	PLUMAS COUNTY					
3/2/84	Plumas Unified School District "GHS" 1	063-90014	2	26N	9E	Fr. SE cor. 10m N, 20m W, 1,068m GR.
	IMPERIAL COUNTY					
1/3/84	Lahontan, Inc. "Calipatria" 1	025-90576	16	12S	14E	Fr. NW cor. 122m S, 805m E, -56m GR.
1/3/84	Lahontan, Inc. "Calipatria" 2	025-90577	6	12S	14E	Fr. SE cor. 61m N, 61m W, -57m GR.
1/11/84	Chevron Geothermal Co. of California "HGU" 10	025-90578	34	15S	14E	Fr. SW cor. 656m N, 205m E, +2m GR.

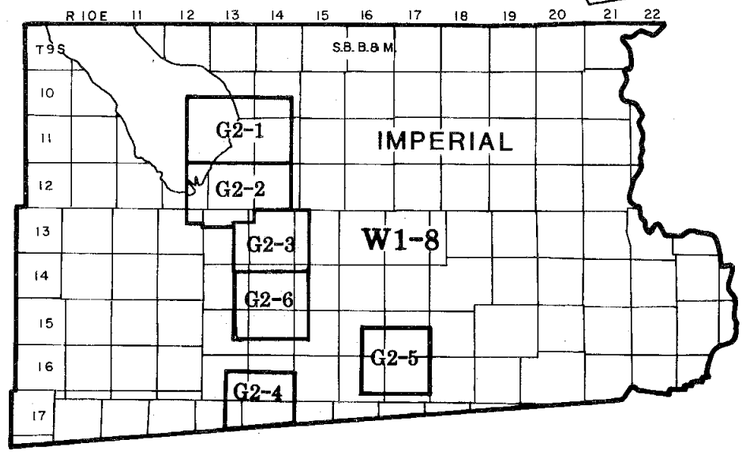
Date Notice Received	Operator & Well No.	API No.	Sec. T. R.	Location & Elevation
3/22/84	Chevron Geothermal Co. of California "HGU" 7	025-90582	34 16S 14E	Fr. SW cor. 678m N, 225m E, -2m GR.
3/22/84	Chevron Geothermal Co. of California "HGU" 8	025-90583	34 16S 14E	Fr. SW cor. 665m N, 202m E, -2m GR.
3/22/84	Chevron Geothermal Co. of California "HGU" 102	025-90584	33 16S 14E	Fr. SW cor. 357m N, 282m E, -2m GR.
3/22/84	Chevron Geothermal Co. of California "HGU" 105	025-90585	33 16S 14E	Fr. SW cor. 357m N, 290m E, -2m GR.
3/23/84	Republic Geothermal, Inc. "Fee" 5	025-90581	17 11S 14E	Fr. NW cor. 715m S, 760m E, -59m GR.
5/11/84	Imperial Energy Corp. "Imperial Brandt" 1	025-90586	35 12S 13E	Fr. SE cor. 61m N, 543m W, -58m GR.
5/21/84	Chevron Geothermal Co. of California "HGU" 101	025-90587	33 16S 14E	Fr. SW cor. 385m N, 231m E, -2m GR.
5/21/84	Chevron Geothermal Co. of California "HGU" 106	025-90588	33 16S 14E	Fr. SW cor. 385m N, 254m E, -2m GR.
6/18/84	Chevron Geothermal Co. of California "HGU" 5	025-90589	34 16S 14E	Fr. SW cor. 685m N, 227m E, -2m GR.
	SAN BERNARDINO COUNTY			
5/16/84	Bd. of Water Commissioners, Municipal Water Dept., City of San Bernardino "Mill & D" 2	071-90048	10 1S 4W	Fr. SW cor. 73m N, 386m E, 305m GR.

TR02(8-84-DWRR-14C)

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
G2-6	Mesquite	1:20,000
G3-1	The Geysers	1:20,000
G3-2	Calistoga	1:12,500
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

50 D ST., ROOM 300
SANTA ROSA 95404
PHONE (707) 576-2385 576-2386

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

TRO2 (8/84/DWRR/15C)

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