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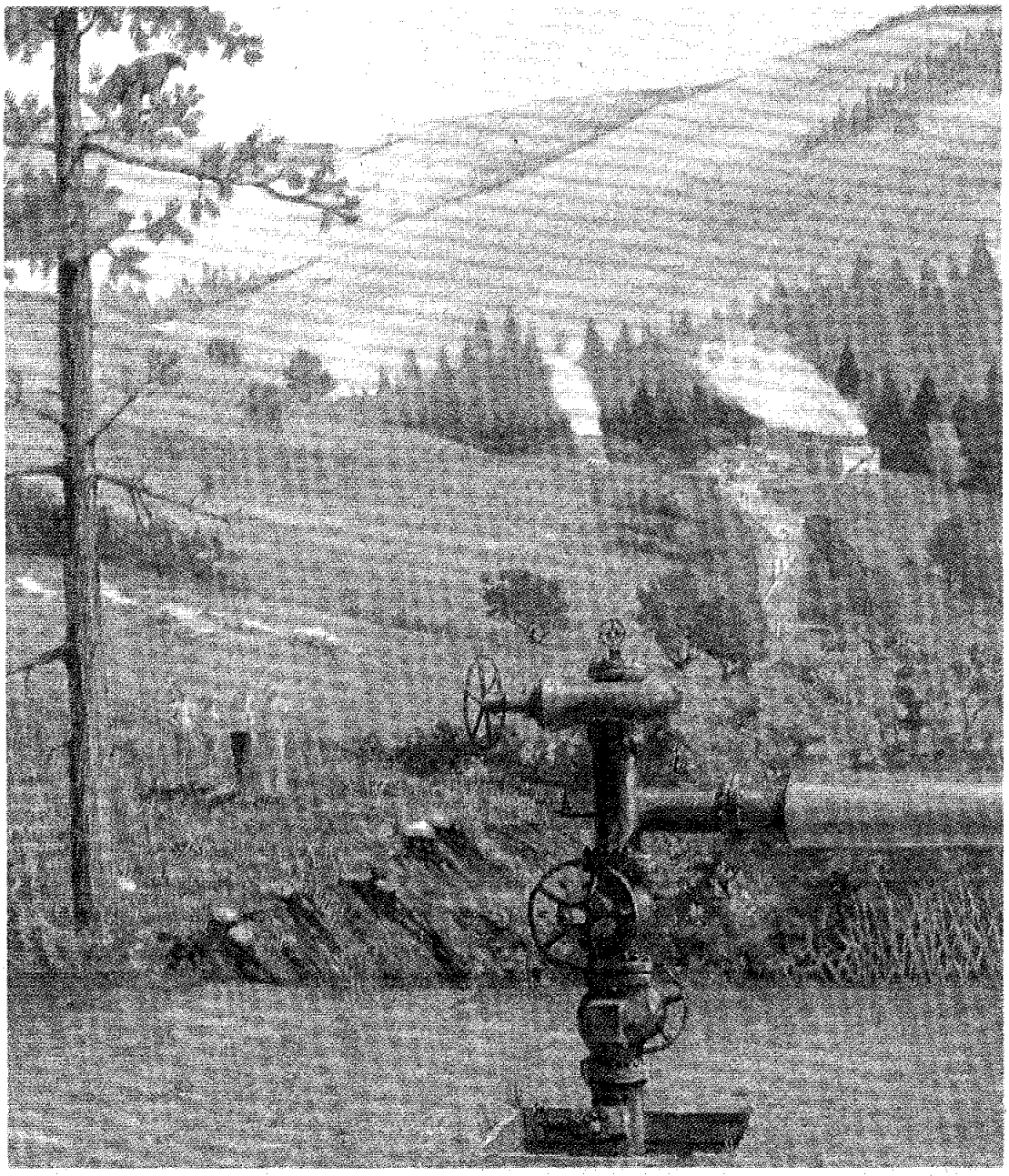

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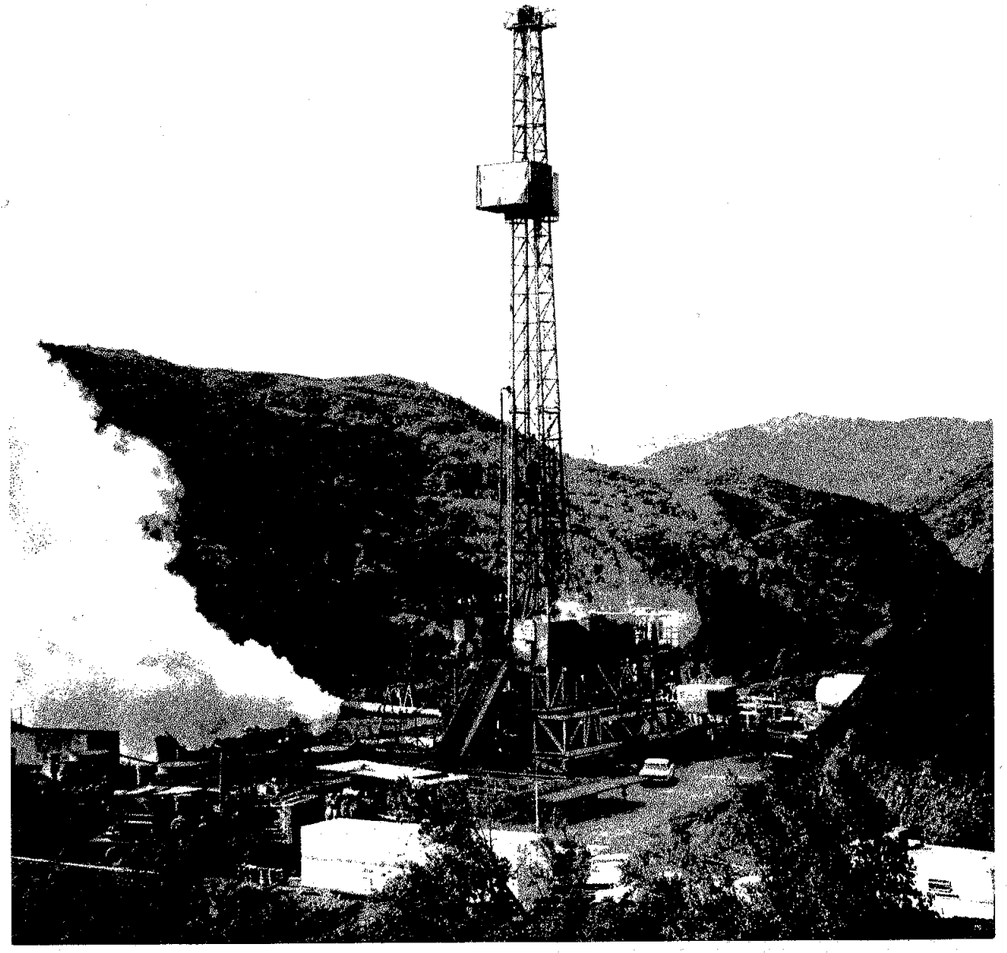
On the cover: *This drawing, by Jim Spriggs, will replace the current cover illustration for* Geothermal in California, *the children's publication about geothermal energy published by the Division of Oil and Gas. Details for ordering are on page 80.*

the
GEOTHERMAL HOT·LINE



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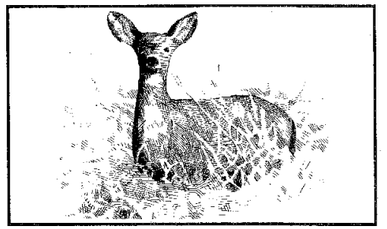

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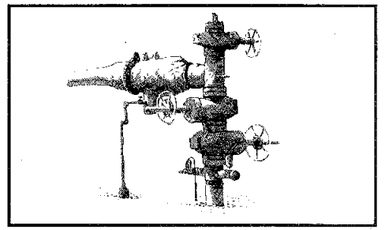

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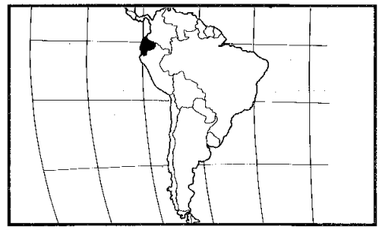

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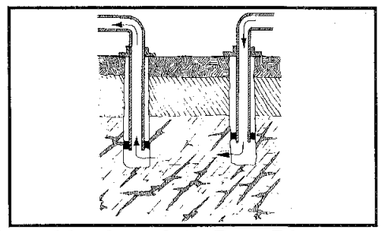

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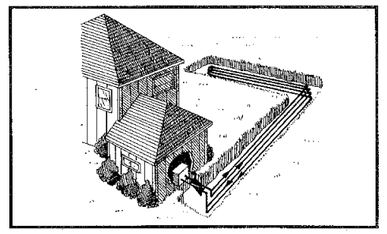


A look at geothermal heat pumps. Page 60.

CALIFORNIA

DEPARTMENT OF CONSERVATION

Edward G. Heidig Views Geothermal Energy

Edward G. Heidig. Photo by Susan Hodgson.

Edward G. Heidig was appointed Director of the Department of Conservation in February 1991 by Governor Pete Wilson of California. In the following interview, Mr. Heidig expresses support for geothermal energy development in the state.

S. H.: Mr. Heidig, Governor Wilson describes you as a person with a strong conservationist record. Would you describe this record and what brought you to this area of interest?

E. H.: I am a conservationist, and I think conservation is an important concept that gets overlooked today. We have to strike a balance. Teddy Roosevelt really was the conservation pathfinder, charting a way to develop America's resources that did not just block everything or exploit resources, but was instead based on wise stewardship.

I got involved in recycling in 1970 when I was 17 years old, and was a youth board member of a local environmental group, an organization that started to take recycling very seriously. My involvement with environmental protection deepened with an appointment by the Board of Supervisors to the Air Pollution Control Advisory Committee of Ventura County, and the Recreational Advisory Committee.

S. H.: I understand you are interested in the development of alternative energy sources. What has been your experience in this area?

E. H.: I was the Governor's principal environmental policy advisor during the 101st Congress. As you may recall, as Senator, Governor Wilson advocated a strong alternative energy policy, particularly in terms of automobiles. In California, we have extensive alternative energy sources: hydroelectrical, solar, wind, geothermal, and even nuclear. The Department of Conservation has basic jurisdiction over the development of geothermal fields.

Today, along with the potential of geothermal, there is the problem of the decreased capacity for electrical generation at The Geysers field. As a conservationist, this causes me a lot of concern, and I want to see if the department can play a constructive role in determining the cause. We are a good purveyor of information. If we can look at why we're losing some production there, we're not only going to help construct a way of conserving the resource, but we might also extend that knowledge to other geothermal areas.

S. H.: Do you believe that geothermal energy is important as a renewable energy resource in California?

E. H.: I think the key to energy development in California in particular, and for the United States in general, is to diversify the energy picture. Geothermal has a place at the table, as does oil and gas. We need to do what we can to encourage the wise and appropriate development and use of these technologies. How important is geothermal energy? Well, it's important. Is it *the* most important? Probably not. But if you pledge to look at diversification, then it is one of the central elements of an energy strategy.

One of the great things about geothermal is that it is generally clean, it's renewable, and it's there. Geothermal allows you a certain elasticity or flexibility that melds into a good energy mosaic.

---

by Susan F. Hodgson

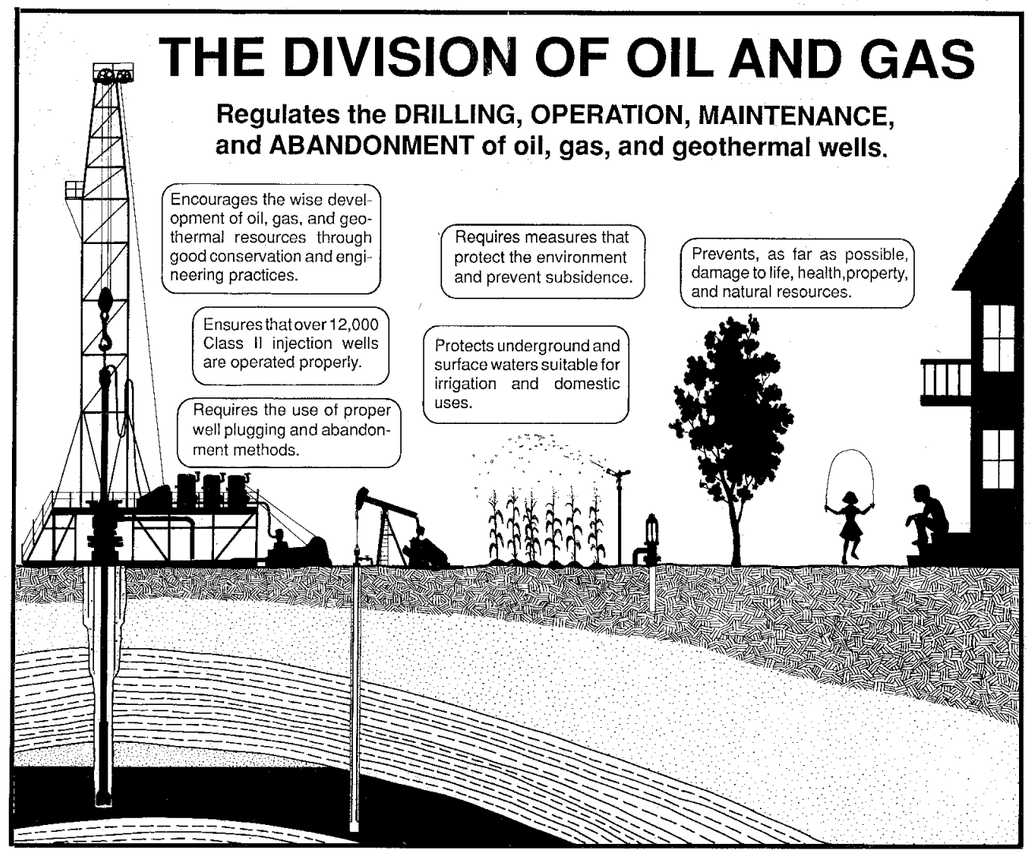
Geothermal District G3

Both high- and low-temperature geothermal wells are regulated in District G3, which extends from the Oregon border to the middle of the Golden Gate Bridge. Five coastal counties (Del Norte, Humboldt, Mendocino, Sonoma, and Marin) and two inland counties (Lake and Napa) lie within district boundaries.

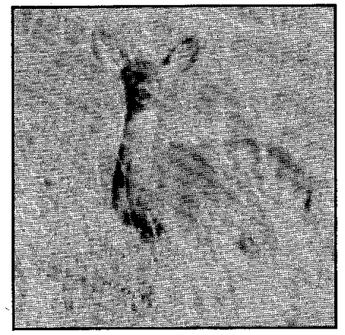
District G3 geothermal well applications range from those for high-temperature steam wells in The Geysers Geothermal field, the largest geothermal field in the world, to those for the low-temperature hot water wells in areas throughout the district. The Geothermal Agricultural Heat Center in Lake County is a unique greenhouse project in the district, involving educational programs and the commercial development of low-temperature geothermal resources. District G3 engineers monitor the use of geothermal water at hot-spring resorts in Lake, Mendocino, Napa, and Sonoma Counties.

District G3 includes a total of 1,401 high-temperature steam wells, low-temperature water wells, and temperature-gradient wells. Six hundred thirty-one of the 766 high- and low-temperature wells drilled remain active, as do 19 of the 635 temperature-gradient wells drilled.

by Kenneth Stelling
Geothermal District Engineer
Division of Oil and Gas



Road Log: Geothermal District G3, November 1990



DAY ONE

Geothermal District G3 takes in all of California's coastal counties from San

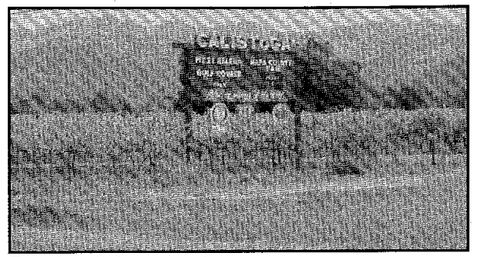
Ken Stelling and Elizabeth Johnson, geothermal engineers.

Francisco to the Oregon border, plus the inland counties of Lake and Napa. The distances are significant between the high-temperature wells and power plants in The Geysers Geothermal field and the many wells in the other areas using low-temperature geothermal resources; thus, we will take two days to record our road log. The first day, we will visit our district's low-temperature wells.

1. Calistoga Geothermal Field

Taking Highway 12 east from our Santa Rosa office, we come to Calistoga Road and head northeast toward the City of

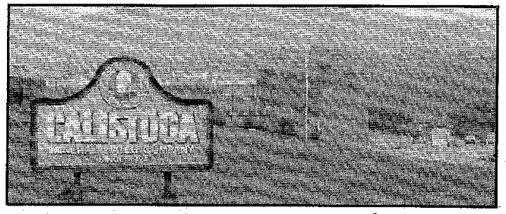
by Kenneth Stelling
Geothermal District Engineer



Entering Calistoga. Grapevines behind the sign.

Calistoga, site of a low-temperature geothermal field in Napa County. Calistoga has over 100 wells capable of producing geothermal fluids within its boundaries. Most of these wells are noncommercial, meaning that they are used by owners of private dwellings for swimming pools, bathtubs, some space heating, and to preheat home hot-water heaters.

Some of these low-temperature wells are classed as commercial by the Division of Oil and Gas. These are used by mineral-water bottling companies and by the city's numerous public spas. We check on some low-temperature, commercial wells we have categorized as idle (not producing fluid at the moment). They are in good condition, and we head north again on Highway 29, toward Middletown in Lake



Site of the Calistoga Mineral Water Company.

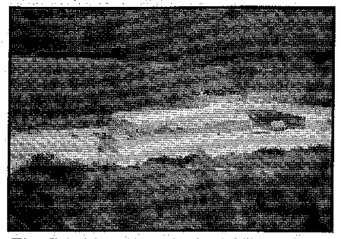
County, where we stop for lunch. Then, we head north on Highway 29 toward the City of Lower Lake and the intersection of Highway 53. Turning west at the junction of Highway 53 and 29, we remain on Highway 29 and travel 7 miles to a geothermally heated greenhouse center called the Geothermal Agricultural Heat Center.

2. Geothermal Agricultural Heat Center

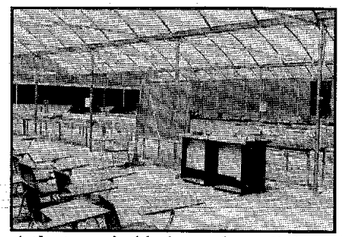
The heat center was built to develop the area's low-temperature geothermal resources and provide a heating distribution system for commercial greenhouse operators and other agricultural businesses. The center also provides vocational training in geothermal-greenhouse operations through the Mendocino-Lake Community College District.

A grant from the California Energy Commission in 1984 allowed Lake County to drill the three wells at the site. The project is also sponsored by Lake County and the Mendocino-Lake Community College District.

The center includes two commercial, low-temperature geothermal production wells and one injection well, which are used to operate the greenhouse. The two production wells, "Ag Park" 2 and 3, are capable of producing water at about 150°F with a flow rate of 150 gallons per minute. The injection well is called "Ag Park" 1. Estimates are that about 25 acres of greenhouse installations can be operated using these three wells.

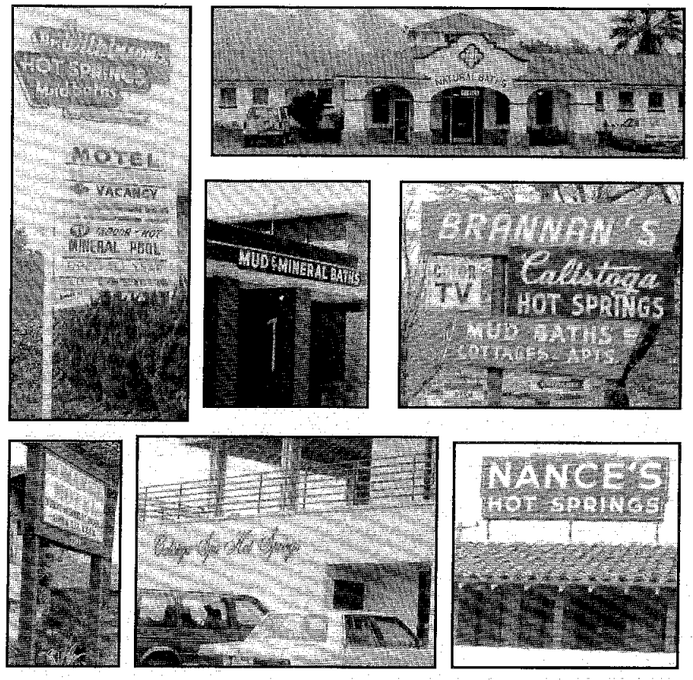


The Geothermal Agricultural Heat Center.



A classroom inside the geothermally heated greenhouse.

Geothermal tomatoes.



Commercial hot springs, Calistoga, California.

3. Witter Springs

After leaving the heat center, we head toward Highway 20 on our way to Mendocino County. Traveling west on Highway 20, we pass the old—no longer used—hot spring resorts of Saratoga and Witter Springs. These resorts were very active around the turn of the century. The appeal of hot mineral baths, clean air, and quiet country surroundings made them a meeting place for the affluent of San Francisco.

4. Ukiah

Intersecting Highway 101, we head south toward the City of Ukiah and active hot-spring resorts in Mendocino County. Many Mendocino resorts have been refurbished from olden days. These resorts generally do not have "wells" as defined by the Division of Oil and Gas. Instead, most get their hot mineral water from natural springs. Orr Hot Springs and Vichy Springs are two active hot springs we will visit around Ukiah.

As a regulator, the Division of Oil and Gas must protect the life, health, and safety of persons using geothermal resources and ensure the ultimate protection of the resource, itself. County Planning Commission members and hot-spring owners contact us informally for advice on the uses of low-temperature resources. Our continued surveillance of these hot springs gives the division first-hand information about the flow rates and temperatures of regional geothermal resources, plus knowledge of any plans to develop the hot-spring sites.

5. Vichy Springs

Vichy Springs is just east of the City of Ukiah. This resort has recently been refurbished and is open for guests. Vichy Springs is advertised as "Jack London's Favorite Hot Spot", touting a famous turn-of-the-century visitor. The old resort has been well and painstakingly restored, and the result is a credit to the owners.

6. Orr Hot Springs

Leaving Ukiah and traveling 16 miles west along Orr Springs Road, we arrive at Orr Hot Springs Resort. In the mid-1800s, Orr Springs was a stage coach stop for folks traveling between Fort Bragg and Ukiah. The sources of the geothermal water here are warm-water vents at the bottom of Big River. The early proprietors of Orr Springs captured this warm water by installing vertical pipes over the vents. They piled rocks around the pipes to support them, and packed cement against the rocks. The water would rise inside the pipes and flow by gravity to the bath houses.

A vineyard.

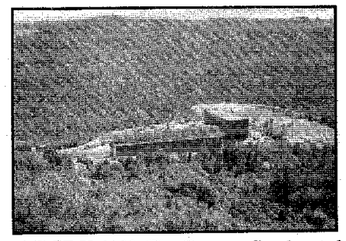
After talking with the owners of Orr Springs, we retrace our route on Orr Springs Road back to Highway 101. Here we head south, driving some 60 miles to the office in Santa Rosa.

DAY TWO

7. The Geysers Geothermal Field

Our second day on the road takes us to The Geysers Geothermal field, the largest commercial, high-temperature geothermal operation in the world, with a total electrical generation capacity of 1,908 megawatts, net, in 1989.

Leaving Santa Rosa around 9 a.m., we pass through the small and beautiful Alexander Valley, known for its grapevines and wineries. Now, in late November, the grapes are harvested and grape leaves left on the vines are a multitude of colors. From the valley floor, we start climbing up towards The Geysers Geothermal field, a trip of 16 miles across a very winding, two-lane road.



PG&E Unit 12, The Geysers Geothermal field.

PG&E Unit 20, The Geysers Geothermal field.

Forty minutes later, we come to the field at the site of Unocal Geothermal Division's Guard Gate One. Here, we sign in and select a road forking south along Big Sulphur Creek. We head towards Pacific Gas and Electric Company (PG&E) Unit 14, one of 29 geothermal power plants in the field, the majority of which are owned by public utility companies.

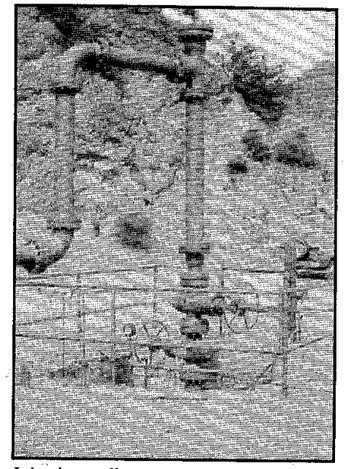
At The Geysers, the terrain is often rugged and unstable. It is very common to have several wells drilled from the same well pad, which is often constructed at a stable area on the top of a hill. We inspect Unocal's injection wells that are used to inject about 28 percent of the extracted fluid back into the reservoir, which helps maintain the reservoir pressure. Before the day ends, we will have inspected visually all 25 of Unocal's nonfederal injection wells (the field has 7 more nonfederal injection wells operated by other companies). Since most of the pads used for Unocal's injection wells also contain production wells, we have included them in our inspections, as well.

A typical well inspection means first, looking at the well pad, itself. The pad

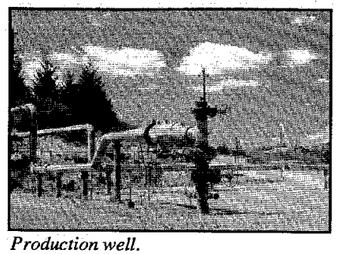
and its sides are checked for stability, and we search for any surface cracks in the ground that might indicate sliding or differential settlement. The wells themselves are checked for casing leakage, excessive steam leakage from the wellhead valves, or any other potential problem. The pipelines at the well sites are checked for leaks. Finally, we check the stands supporting the pipelines for settlement or sliding.

During our injection-well surveillance, we look at general field operations as we drive from one well site to another. At The Geysers, landslides are always a problem because of the steep terrain. Thus, we check all pipelines we pass by, and it is helpful that the pipelines generally follow the roads. Problems are reported to the operator. All of The Geysers field operators have maintenance facilities in the field, so repairs can be made quickly.

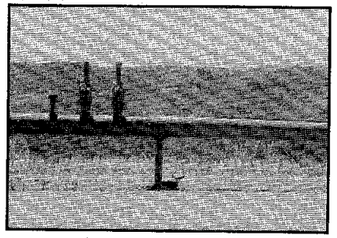
Now, the sun is setting. Checking the injection wells on Unocal's lease and the other facilities has taken the entire day. Driving throughout the field, we have admired the natural beauty of the area. Along the road, by the wells and steam pipelines, deer browse. However, we must leave The Geysers and retrace our way back to the office in Santa Rosa.



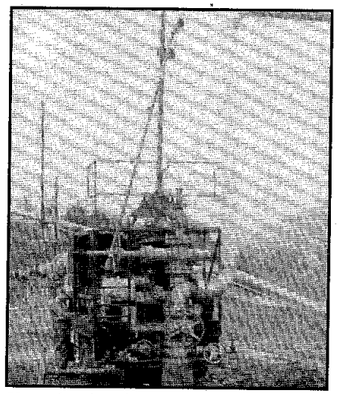
Injection well.



Production well.



A deer rests under a steam line, next to a support stand.



Unocal undertakes an injection well survey.

Deer browsing in a brushy area. The small cartons are covered by wire and protect young pine trees from grazing animals.

The Geysers Technical Advisory Committee: Year One

In the mid-1980s, reservoir pressures and steam supply rates from wells at The Geysers Geothermal field unexpectedly began to decline more rapidly than predicted, yielding a corresponding decline in electrical power generated from the field. In the summer of 1989, representatives from Unocal Corporation discussed the disturbing change with the California Department of Conservation's Division of Oil and Gas, and the California Energy Commission (CEC).

In September 1989, the CEC held an Informational Hearing in Sacramento to determine the impacts of this loss of electrical power and the implications to the CEC's electrical supply forecast, power transmission and power plant cases, geothermal research development projects, and overall state energy policy. The hearing testimony was summarized in the December 1989 issue of the *Geothermal Hot Line*.

As a result of the meeting, a Technical Advisory Committee (TAC) was formed, comprised of representatives from the CEC, Division of Oil and Gas, California State Lands Commission, and utility and steam suppliers at The Geysers.

by Richard Thomas
Geothermal Officer
Division of Oil and Gas

Later, a land owner at The Geysers was added to the committee.

The TAC goals are to:

1. Provide the CEC with projections of capacity and energy from The Geysers, given the present rate of steam decline;
2. Examine options relating to efficient management of The Geysers resource, including research and development, testing, and analyses relating to the reservoir and power-plant operations; and
3. Recommend to the CEC cost-effective alternatives for efficient management of the steam reserves.

At first, the TAC collected data from many organizations, including Pacific Gas and Electric Company (PG&E) and the Sacramento Municipal Utilities District, to complete its capacity and energy projections of The Geysers for the CEC.

Early discussions on the means of evaluating the decline of steam rates at The Geysers focused on reservoir simulation models. It was decided to evaluate existing models and, through cooperative efforts involving the sharing of data and expertise, to develop a generic model of The Geysers reservoir for use in predicting future reservoir performance. Specifically, TAC focused on three existing models of The Geysers:

1. The State Lands Commission model developed by Lawrence Berkeley Laboratory (LBL) as contractor, using the MULKOM computer code;
2. The Unocal model developed by Unocal and Diad Engineering, using the TETRAD computer code; and
3. The Northern California Power Agency (NCPA) model used on the NCPA leasehold.

The TAC members decided to investigate the LBL and Unocal models further. Also, TAC members agreed to fund a study describing possible improvements in power-plant design and operations. The committee also decided that any computer model developed for the power-plant study should be compatible with the computer model developed for the reservoir study.

After a few months, the TAC members decided that a separate Request For Qualifications (RFQ) would be issued by the CEC for the two tasks, and the selected consultants would be subcontractors of CEC's technical contractor, EBASCO Environmental Inc. The RFQ was released in March 1990.

Those wishing to work on the reservoir model evaluation were asked to:

1. Evaluate the reservoir-simulation models developed by Unocal and LBL;
2. Compare and contrast the two models, identifying each model's strengths and limitations; and
3. Recommend the model, or combination of models, most suited for reservoir characterization under different operating scenarios.

Funds would be provided by the TAC's state agency members.

Those wishing to work on power-plant performance and operation evaluation were asked to identify:

1. Potential operational scenarios that could maximize the generating capacity and longevity of the geothermal field;
2. Minor modifications that could increase efficiency of the existing power plants; and
3. Major power-plant modifications or significant operational changes that would maximize the life of the field and make optimum use of the resource.

Funds would be provided by the TAC's corporate members.

In April 1990, TAC members selected Stone and Webster Engineers, Vince Fezmire, principal, to do the power-plant study. In April 1991, Stone and Webster reported it had completed just 10 percent of the work, due to reduced funding commitments by some of the TAC's corporate members.

Also in April 1990, Intera West, Allan Spivak, principal, was chosen to evaluate the two competing reservoir simulators and models. Intera West's work was completed and a final report distributed in March 1991. In general, Mr. Spivak found that either LBL's MULKOM simulator or Unocal's TETRAD, if upgraded to incorporate the strengths of the other and after additional modifications, would be appropriate for understanding the subsurface mechanisms operating at The Geysers and for making future predictions. But, in the final analysis, he recommended using TETRAD.

At the April 1991 meeting, Lake and Sonoma County representatives proposed redirecting a portion of funds, granted to them by the CEC for a water availability study and Geysers-related research, to support an accelerated effort to build the reservoir model. The representatives suggested that Criterion Engineers and GeothermEx, both under contract to Lake and Sonoma Counties, would acquire, interpret, digitize, and input data from all TAC steam suppliers into the TETRAD simulator.

Following calibration of the model, forecasts of reservoir performance would be available to the TAC members and to Stone & Webster Engineers for use in the power-plant study. The estimated completion time is 16 weeks, at a cost of under $100,000. In May 1991, TAC members were reviewing the proposal.

PG&E to Retire Four Oldest Units at The Geysers

Pacific Gas and Electric Company (PG&E) announced that in early 1992, the company will retire its four original generating units at The Geysers Geothermal field in Sonoma County. The equipment will be removed and the sites restored. The work will be completed in 1994.

The power plant units, numbers 1 through 4, are the oldest and least efficient of PG&E's 19 Geysers units. Unit 1 went into commercial operation in September 1960, using a salvaged marine turbine manufactured in 1922.

"Retiring these inefficient units and routing their steam to more efficient units is another example of sound business practice and sound environmental policy going hand in hand," said Jim Macias, The Geysers power plant manager. "These older units generate only about 6 percent of our plant's total electric capacity, but account for 20 percent of our maintenance and operating costs."

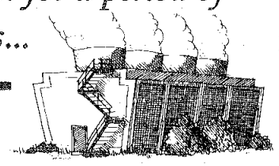
Macias said Units 3 and 4 alone produce 76 percent of The Geysers' chemical-waste solids from hydrogen-sulfide abatement. Their retirement will reduce total generation costs and will result in a significant reduction in shipments of chemicals to The Geysers and in chemical-waste trucking. Shutting down these older units is expected to extend the useful life of the field's steam reservoir.

Since 1973, The Geysers has been the world's largest geothermal field. At their peak, PG&E's power plants at The Geysers generated 1,364 megawatts of electricity, or enough to meet the needs of 1.3 million people. In 1985, the steam reservoir began a gradual but steady decline. PG&E's plants in the field now generate about 900 megawatts.

The Bottle Rock Geothermal Power Plant, A History

Following the energy crisis in the early 1970s, the California Department of Water Resources (DWR) undertook a wide range of projects designed to provide energy sources for the State Water Project, which is used to deliver water to much of California's population. Large amounts of power are needed to lift and drive the water as it flows from Northern California to the Mexican border. One of the projects conceived, designed, and built to supply electricity for this power was a 55-megawatt geothermal power plant, sited at The Geysers Geothermal field in Lake County, Northern California. The plant was named the Bottle Rock Power Plant for the vast amounts of glass-like obsidian found at the plant site.

We expect to suspend operations at the power plant for a period of two- to five-years...



The use permit to drill steam wells at the power plant was issued to DWR by Lake County in February 1980. Construction of the power plant began on May 6, 1981. Electrical generation at the geothermal plant started in February 1985, with the official plant dedication on May 16, 1985. The Bottle Rock Power Plant was designed to operate on 896,000 pounds of steam per hour at full capacity. However, the steam from the wells contained impurities that caused the plant to be shut down soon after start-up. After the plant turbines were serviced and the impurities in the steam removed, the plant again resumed power production. With the second start-up, the plant was faced with another problem: an insufficient steam supply. The production of the steam wells drilled for the plant was declining at a faster rate than had been expected. Many things were tried. Wells were produced, shut in, reworked, and produced again. In spite of the added work on the wells, the steam supply to the power plant and, thus, the power output of the plant continued to decrease. Finally, in October 1990, all the field's wells were shut in by DWR, and the power plant was closed down.

Following is an excerpt from a letter written by the Department of Water Resources to summarize the future of the power plant: "This letter will serve to provide notification of the Department of Water Resources' intent to temporarily suspend our operations at the Bottle Rock Power Plant and Francisco steam field located in Lake County. With the current and near future availability of alternative power sources, it is not economically practical for DWR to continue Bottle Rock operation at this time.

"We expect to suspend operations at the power plant for a period of two- to five-years, during which time the economic feasibility of restarting operations will be assessed. The power plant will be maintained in such condition that it could be returned to service within six months should it prove to be economical and in the best interest of DWR to do so.

"A plan to maintain the power plant during the suspension of operations has been developed. The plan calls for preserving the plant's mechanical and electrical equipment, flushing and cleaning various systems, and removing all toxic and waste materials from the site. A year-round station keeper will be assigned to the power plant with support provided by personnel from our Delta Field Division to:

a. Perform maintenance on the turbine-generator, all prime movers, and other rotating equipment.
b. Inspect and maintain the systems put into storage.
c. Maintain the grounds.

"The steam field wells have been shut in and are temporarily on bleed while DWR evaluates other options for use of the steam. If DWR is unable to complete any arrangements for use of the steam, drillable mechanical plugs will be set in each well and 200 feet of cement placed on top of the plugs. It is anticipated that completion of the well plugging would take place within 60 to 90 days from the time a decision is made to do so. The steam field reinjection system will be kept in service. The steam gathering system will be dried and sealed. DWR will maintain appropriate security at the facilities."

by Kenneth Stelling
Geothermal District Engineer

Calpine Corporation and Freeport-McMoRan Resource Partners Finalize Sale

In July 1990, Freeport-McMoRan Resource Partners, Limited Partnership (FRP) finalized the sale of its producing geothermal properties in The Geysers Geothermal field to a partnership led by Calpine Corporation for $227 million in cash, a promissory note for $27 million, and a residual 55 percent interest in the partnership after a defined payout of the Calpine investment. This transaction makes Calpine one of the country's leading geothermal producers.

Calpine and FRP formed a partnership called Santa Rosa Geothermal Company, L.P., to be the new owner of the geothermal properties. Calpine arranged a $200 million nonrecourse, long-term debt financing for the partnership through Deutsche Bank AG, New York Branch. Calpine will be the managing general partner of the new partnership and will operate and maintain the geothermal properties through its subsidiary, Calpine-Geysers Plant Services, Inc.

The properties include the 20-megawatt Bear Canyon and 27-megawatt West Ford Flat power plants. Energy produced at these two power plants is sold to Pacific Gas and Electric Company (PG&E) under Standard Offer 4 contracts. Also included are three steam fields with a capacity of 319 megawatts. Steam from these fields is sold to PG&E and to the Sacramento Municipal Utility District.

Soon, Calpine will begin negotiations for another partnership with FRP to develop, manage, and operate FRP's undeveloped geothermal energy assets, which were retained by FRP. These assets are located primarily in the Salton Sea area of the Imperial Valley in Southern California and in the Medicine Lake area in Northern California.

In May 1989, Calpine acquired an interest in the 20-megawatt Aidlin geothermal power plant in The Geysers from Mission Power Engineering Company, and a contract to operate and maintain this facility.

Calpine president Pete Cartwright is committed to the development and use of geothermal power in the western states: "We see a major potential for geothermal power as an indigenous resource and an environmentally appropriate resource," he stated.

Calpine, Stone & Webster Sign Agreement

Stone & Webster Development Corporation and Calpine Corporation have signed a nonexclusive agreement to jointly develop a series of power generation projects. The projects include power generation facilities based on geothermal, gas combined-cycle, and solid fuel technologies. The types of projects to be pursued may include either a qualified cogeneration facility under the Public Utilities Regulatory Policy Act or an independent power project.

Senior management of both firms see a strong benefit in combining their mutual experiences in project development and financing with the strengths of Stone & Webster in power-plant design and construction, and Calpine in power-plant operations and maintenance. Specific projects to be jointly pursued on an exclusive basis under the agreement are under negotiation.

Changes at California Energy Company

David Sokol is the new president and chief executive officer of California Energy Company. He replaces Charles Condy. Mr. Condy remains chairman of the board at California Energy Company.

Mr. Sokol is the former chief executive officer of Kiewit Energy Company, a division of Peter Kiewit & Sons, a large, Omaha-based company involved in construction, mining, and packaging. Under terms of an equity deal signed in February 1991 by California Energy and Peter Kiewit & Sons, four million newly minted California Energy shares will be purchased by Kiewit for $7.25 each. This purchase will give Kiewit an 11 percent stake in the company.

Also, Kiewit has an option to purchase 6 million newly issued shares of California Energy at $10.50 each, thus increasing its stake to 25 percent. The agreement forbids Kiewit from acquiring more than 34 percent of California Energy's outstanding shares.

California Energy Company Files Suit

On January 31, 1991, California Energy Company filed a $780 million suit in San Francisco federal court against SCEcorp, its subsidiaries Mission Energy and Mission Power; Southern California Edison; Kidder-Peabody & Company and others, charging violations of the antitrust laws and unlawful interference with its lender contracts and negotiations for future financing.

California Energy Company generates electricity from geothermal resources from Coso Geothermal field, in Inyo County. Its nine turbine generators in this field produce enough electricity to serve 240,000 households, and its total electrical output is under sales contract with Southern California Edison for a period of 30 years with annual gross sales of $200 million. In addition, California Energy indirectly supplies all of the electricity needs at the Navy's China Lake Weapons Center, where the field is located.

The complaint, filed by Joseph L. Alioto of San Francisco, charges that the defendants conspired to drive California Energy out of business to preclude its development programs in the Cascades, and in the States of Nevada and Utah, where it recently acquired geothermal resources and facilities from the Chevron Corporation.

The suit also names the New York investment banker Kidder-Peabody as a defendant, charging it with organizing a bear-raid on the company's stock to discourage the company's lenders and investors.

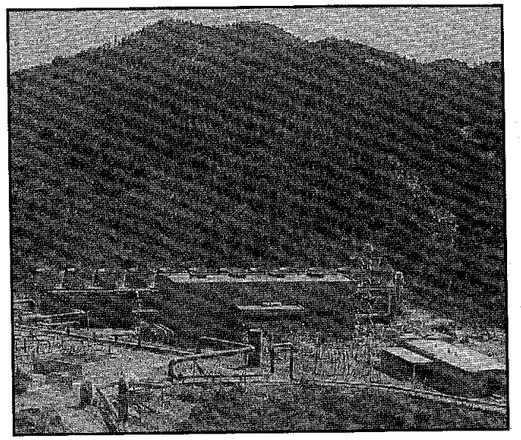
Additionally, the suit asks that a proposed merger between Southern California Edison and San Diego Gas & Electric be enjoined on the grounds that it will result in an unlawful monopoly in Southern California and deprive California Energy of a competitive outlet for its geothermally based production.

NCPA, An Overview

The Northern California Power Agency (NCPA) is a joint power agency established to serve the electrical power supply needs of its members, which are the Cities of Redding, Plumas-Sierra, Biggs, Gridley, Ukiah, Roseville, Lodi, Turlock, Santa Clara, Palo Alto, Alameda, Healdsburg, and Lompoc. At the request of its members, NCPA forecasts electric loads, plans for new resources, constructs and operates power plants and transmission lines, and dispatches power in accordance with member needs. NCPA also represents its members' interests before state and federal regulatory and legislative bodies, and in negotiations with other utilities for the wholesale purchase and transmission of electrical power.

NCPA is governed by a 13-member commission, comprised of one representative for each member. The commission elects a chairman who presides over the monthly commission meetings and appoints NCPA's general manager to supervise the day-to-day operations of the agency. The agency has a home office staff of 42, located in Roseville, California, and a power-plant operating staff of 101 at the various plants.

All information is reprinted from NCPA public information materials.



NCPA Geothermal Plant No. 1.

At The Geysers Geothermal field, NCPA operates two power plants, which provide baseload power for NCPA member utilities. Plant No. 1 was completed in 1983, and Plant No. 2 was dedicated in 1986.

Steam for NCPA's two geothermal plants comes from wells located in several scattered sites within the agency's steam-lease area. The production wells are interconnected with about 7.6 miles of pipeline. Steam can be transmitted from any area of the field to be apportioned between the two power plants according to the immediate needs. The integrated steam-field management systems concept ensures maximum resource utilization and project output.

1990 NCPA Steam-Field Facts

Wells	
Production wells	68 available, directionally drilled from 11 sites
Ave. steam-flow well	58,800#/hour
Total steam deliverability	4,000,000#/hour
Wellhead line pressure	140 psig
Wellhead temperature	360°F
Reservoir pressure	250 psig
Average well depth	7,200 feet
Average well cost	$1,250,000
Injection wells	5 available, directionally drilled from 4 sites
Total injection	750,000#/hour
Average well depth	8,500 feet
Average well cost	$1,275,000
Pipeline Installations	
Steam supply	7.6 miles of 24" to 48" diameter
Injection water	3.0 miles of 12" diameter
Power Plant Requirements	
Inlet pressure	113 psia
Nameplate capacity	220MWe 3,300,000#/hour
Average operating rate	150MWe 2,250,000#/hour
Maximum operating rate	246MWe 3,690,000#/hour

NCPA Geothermal Power Plant Statistics

	PLANT 1	PLANT 2
Rating	2 x 55 MWe	2 x 55 MWe
Gross capacity	2 x 61 MWe	2 x 62.5 MWe
Net capacity	2 x 59 MWe	2 x 60 MWe
Turbine manufacturer	Fuji	Ansaldo
Turbine design	low-pressure reaction double-flow condensing	low-pressure impulse double-flow condensing
No. of stages	2 x 7	2 x 6
Last stage blade length	22.25 in.	23 in.
Speed	3600 rpm	3600 rpm
Guaranteed steam rate	15.57 lbs/kwhr	15.00 lbs/kwhr
Design inlet conditions	113 psia @ saturation	113 psia @ saturation
Exhaust pressure	3.0 in. Hga	2.75 in. Hga
Condenser type	surface	surface
Manufacturer	Ecolaric	Ansaldo
Cooling tower type	Crossflow 2 x 6 cells	Counterflow 2 x 6 cells
Manufacturer	Marley	Reserch-Cottrell
Circulating water flow	63,000 gpm	67,000 gpm
H_2S abatement	Stretford with secondary condensate treatment	Stretford with secondary condensate treatment
Sulphur produced	2 tons/day	2.5-3 tons/day

NCPA Geothermal Operations at The Geysers Geothermal Field, Sonoma and Lake Counties, California

	8 yr. History 1983 - 1990	30 yr. Forecast 1991 - 2020	Total
Amount of electricity generated by steam turbines	10,195,828,000 kilowatt-hours	18,000,000,000 kilowatt-hours	28,195,828,000 kilowatt-hours
Alternatively, if electricity were generated by oil combustion	22,068,890 barrels of oil used	38,961,390 barrels of oil used	61,030,280 barrels of oil used
Royalties paid to federal and state governments	$23,860,000	$50,220,000	$74,080,000

NCPA Load Following Operations

Power Plant Operations

Declining steam reservoir pressures resulted in changing the Northern California Power Agency (NCPA) plant operation from a base loaded operation to a load following operation, where the geothermal units respond to daily peaks. Load following officially began in April 1988, when the average daily load changed from 248 megawatts, gross, to 180 megawatts, gross. Further adjustments to the load-following program eventually led to an average daily load of 150 megawatts, gross. Data show the average capacity has been about 76 percent.

The change in operating philosophy initially brought up many questions as to how the continual cycling of load would affect geothermal power plants over the long term. Both turbine efficiency and maintenance became areas of concern. While maintenance was simply a case of wait and see, efficiency was an area that needed to be evaluated. In November 1988, NCPA undertook an extensive performance testing program for all four units, testing them in 5-megawatt intervals through the entire load range under which the turbines were operating.

Data from these tests were used to establish a set of incremental loading curves for each unit. The incremental loading curves are used in a computer program that allows NCPA to load the units in the most efficient manner during curtailment periods. These curves are updated once a year and following turbine overhauls with new performance data.

To date, each unit has been overhauled at least once since load following was initiated. Equipment inspection during the overhauls has not revealed any abnormal or excessive wear of equipment, including turbine blades and valving that lie directly in the steam path. Minor fifth and sixth stage tie-wire cracks have been found on Units 3 and 4, but the cracking is not due to cycling.

Turbine-end fourth stage blade cracks in the tenon of the blades were found during the Unit 4 overhaul in the spring of 1990. The cause of these new cracks is under investigation, but preliminary inspection does not point to cycling. In November 1988, the Unit 3 main transformer bank failed. Inspection determined that this was due to poor insulation of the windings at the time of manufacture, and was not related to cycling.

NCPA installed a spare bank, and at the same time overhauled the turbine generator, a process scheduled for January 1989. The transformer failure outage time was minimized by rescheduling the overhaul. The failed bank was repaired and is now stored as the spare bank.

While load following does not appear to significantly affect unit maintenance requirements, it does have a significant affect on day-to-day operations of the hydrogen sulfide abatement program. Data show that since load following began, the average, total noncondensible gas concentration has gone up 20 percent at Plant 2 and nearly 65 percent at Plant 1. In general, the gas concentration has increased throughout the reservoir, but especially in a few wells near the southeastern edge of the field.

The increase is in part a result of gas buildup that occurs in the reservoir when wells are throttled for extended periods of time during low-load operation. High gas levels then flow to the units when these wells are opened up during periods of high load operation.

To achieve permitted hydrogen sulfide emission levels at all times, it was necessary to adjust abatement programs to handle worst case conditions in the most economic fashion. Stretford chemistry had to be adjusted to handle the higher gas levels, even though these levels may only occur 30 to 40 percent of the time. Chemistry optimization has been achieved by making operating changes in the Stretford system itself. Changes to the condensate secondary hydrogen sulfide abatement program also needed to be made. In June 1989, roughly one year after the start of load following, hydrogen sulfide levels at Plant 1 had risen to the point that secondary abatement became necessary for the first time. In addition, varying condensate hydrogen sulfide levels due to gas concentration and load changes resulted in changes in the way secondary abatement was achieved. These changes resulted in the economic optimization of the chemicals required for secondary abatement.

In addition to higher gas levels, the incoming steam to Plant 1 continued to see increases in enthalpy averaging nearly 1 percent. Consecutive performance tests were conducted on the Plant 1 turbines with a 1 percent difference in enthalpy between the tests. This increase resulted in a 2.5 percent improvement in turbine steam rate, an unexpected change in the reservoir-pressure decline in the Plant 1 portion of the field.

It has been shown that the wells in the low pressure area of the field are capable of greater mass flow at lower wellhead pressures. To accommodate the lower pressure wells in a manner that will maximize steam flow, certain pieces of equipment and operating procedures were modified in the power plants. The steam jet ejectors for all four units were designed for 100 psig motive steam pressure, which was compatible with the turbine design inlet pressure of 100 psig.

With the advent of load following, the turbines could be operated at much lower pressures when low load operations occurred. To allow for the lowest possible inlet pressure at all times, the nozzles to the ejectors were replaced with 60 psig nozzles in September 1989. In addition, efforts were made to run the turbines with control valves wide open or nearly wide open during high load periods to minimize the pressure drop across the valves and keep wellhead pressures at a minimum.

Future work at the NCPA geothermal units will continue to focus on ways to utilize the steam reservoir in the most cost effective and efficient manner. Studies have been completed to determine the economics of converting one or more of the four turbine generators to low pressure, while still maintaining the turbine rating. This will entail modifying the turbine blading and steam piping both in the plant and in the steam field to accommodate the higher mass flow. This option is very promising and will probably be implemented when energy demand and overall subject economics are optimum. The NCPA has already conducted a detailed economic and feasibility study on possible modifications to the plant cycle to reduce evaporation and increase the amount of water available for reinjection. Preliminary results indicated that major modifications to the cooling tower would be very costly and are not considered economic at this time (Grande and Enedy, 1989). However, these studies may one day lead to actual projects once the effects and economics of enhanced reinjection throughout the reservoir are better understood.

This excerpt is reproduced, with permission, from The Geysers Steamline, *the newsletter of the Geysers Geothermal Association. The article was adopted from a paper written by Steve Enedy, Murray Grande, and J.L. Bill Smith of the Northern California Power Agency, Middletown, California.*

The Geysers 1861 Reconnaissance Survey

A rare legacy of early-day California has been handed down to the citizens of the state by William Henry Brewer, who was a member of the first Geological Survey of California. He was recruited by Josiah D. Whitney, State Geologist of California from 1860 to 1864. Whitney was in charge of making an accurate geological survey of the entire state. Now 130 years later, nature buffs and environmentalists are indebted to Brewer for the detailed records he kept of his observations as a principal assistant during this original attempt to document the geology and geomorphology of California.

In the days when maps, if available at all, were very inaccurate, when few roads existed, and when the prevailing means of transportation consisted mainly of a sturdy mule or horse or one's own legs, Brewer traveled, according to his calculations, 7,564 miles on horseback throughout California; 3,101 miles on foot; and 4,440 miles on public conveyances, such as trains, boats, or horse-drawn vehicles.

Brewer, a native of New York State, described his California adventures in numerous and detailed letters, which he posted regularly to his brother Edgar in the east.

In 1930, these letters were collected for publication by Francis P. Farquher, a well-known editor. Farquhar named the volume to match Brewer's travels--"Up and Down California in 1860-1864, the Journal of William H. Brewer, Professor of Agriculture in the Sheffield Scientific School from 1864 to 1903." The book is published by the University of California Press, Berkeley, California 94720.

After the four-year field survey in California, Brewer returned to academic life. From 1865 to 1903, he was a professor of agriculture at the Sheffield Scientific School, Yale University. After retiring from the Yale University faculty in 1903, Brewer continued to be active in scientific endeavors. He was awarded three honorary degrees of Doctor of Law, one conferred by the University of California in 1910, which was also the year Brewer died.

The following excerpt describes Brewer's visit to The Geysers area in Northern California. The survey party, led by a local guide, approached The Geysers area on November 10, 1862. They ascended a high ridge (3,500 feet) and enjoyed views of Sulphur Mountain to the west, St. Helena to the south, and Mount Cobb to the north, with the Pluton River Canyon below.

"The scene was not merely beautiful, it was truly sublime. But we turned from the ridge, down the steep sides of Pluto's Canyon, and soon lost all this extensive view. The hill was so steep that we walked, leading our mules. On descending the slope, we saw the pillar of steam rising, several miles distant, and when more than a mile, we could see the Geyser Canyon very distinctly and hear the roaring, rushing, hissing steam.

"We were soon on the spot. The principal springs or geysers are in a little side canyon that opens into Pluton Canyon.

"Here let me say, by way of introduction, that the geysers are not *geysers* at all, in the sense in which that word is used in Iceland—they are merely hot springs. Their appearance has been greatly exaggerated, hence many visitors come away disappointed. They were first seen by white men some nine or ten years ago, and such very extraordinary descriptions were given, that it was supposed that the whole world would flock to see the curiosity. All the facts were magnified, and fancy supplied the entire features of some of their wonders. But a company preempted a claim of 160 acres, embracing the principal springs and the surrounding grounds, built quite a fine hotel on a most picturesque spot, and at an enormous expense made a wagon road to them, leading over mountains over three thousand feet high. But the road was such a hard one, the charges at the hotel so extortionate, and the stories of the wonderful geysers so much magnified, that in this land of 'sights' they fell into bad repute and the whole affair proved a great pecuniary loss. The hotel is kept up during the summer, but the wagon road is no longer practicable for wagons and is merely used as a trail for riding on horseback or on mules.

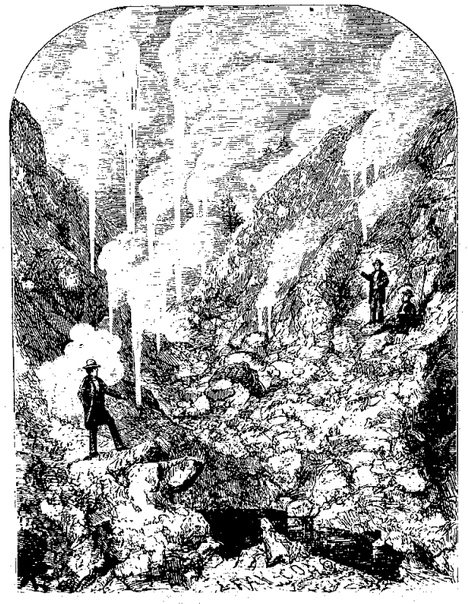
The Geysers are not geysers at all.

"The springs cover an extent of a number of acres, but the principal ones are in a very narrow canyon with very steep sides. They break out on the bottom and along the sides up to the height of 150 or 200 feet, and on a little flat nearby. There are hundreds of springs—of boiling water—boiling, hissing, roaring. The whole ground is scorched and seared, strewn with slag and cinders, or with sulphur and various salts that have either come up in the steam or have been crystallized from the waters.

"Passing over the flat we saw several of these—many in fact—here a boiling spring, there a hole in the ground from which steam issues, sometimes as quietly as from the spout of a teakettle simmering over the fire, but at others rushing out as if it came from the escape pipe of some huge engine. The ground is so hot as to be painful to the feet through thick boots, and so abounds in sulfuric acid and acid salts as to quickly destroy thin leather—it even chars and blackens the fragments of wood that get into it.

"Near some of the springs a treacherous crust covers a soft, sticky, viscous, scalding mud; one may easily break in, and several accidents more or less serious have thus occurred. Quite recently a miner was so badly scalded as to be crippled, probably for life. Sulphur often issues with the steam and condenses in the most beautiful crystallizations on the cooler surface. Specimens of sulphur frostwork are of the most exquisite beauty, but too frail to be removed. We crossed this table and descended into the canyon above the geysers and followed it down. I found some flowers out in the canyon above, in the warm steamy air, of a species that elsewhere is entirely out of flower.

"One can descend into the canyon and follow it down with safety, a feat that seems utterly impossible before the trial. Here is the grand part of the spectacle. Here are the most copious streams, the largest and loudest steam-jets, the most energetic forces, and the most terrific looking places. Standing part way down the bank at the upper end of the active part, where the canyon curves so that all its most active parts are seen at a glance, the scene is truly impressive. It seems an enormous, seething, steaming cauldron. Steam or hot water issuing from hundreds of vents, the white and ashy appearance of the banks, the smell of sulphur and hot steam in our faces, combined to produce an entirely novel effect.

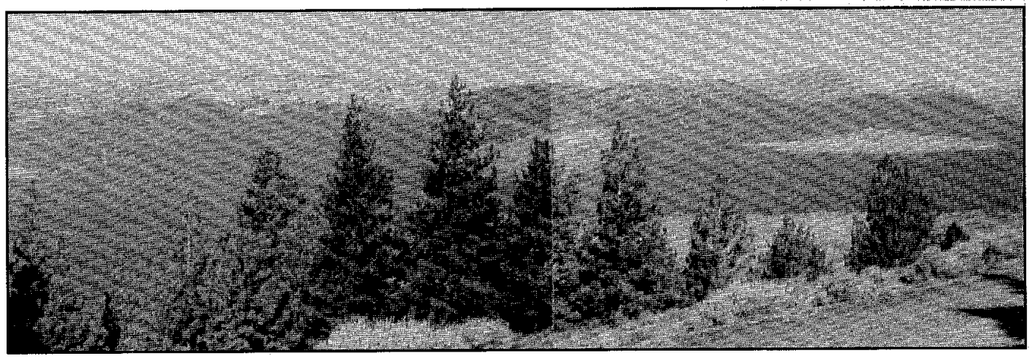


The witches' cauldron.

"We descended and followed down the canyon, threading our way on the secure spots. Hot water or steam issued on all sides—under us, by our side, over us, around us. Sometimes the whole party was enveloped in a cloud of vapor so that we could not see each other, at other times this was blown away by the winds. Once the sun came out from between the clouds and shone through this steamy air down on us, lurid, yet indistinct. In one place a rocky pool of black rock several feet in diameter, filled with thick, black water—black from sulfuric of iron, black as ink—was in the most violent agitation. It is the most peculiar feature of all the geysers and is well called the *Witches' Cauldron*. The water, black and mysterious, boils so violently that it spouts up two or three feet from the surface, enclosed in this rocky wall.

"A considerable stream of hot water issues from this canyon, and a short distance below are sulphur banks where hundreds, or even thousands, of tons of sulphur could be cheaply obtained. A curious fact is that a low order of plant, like confervae or "frog spawn" grows in this hot water, most copiously in water of 150°F, and even on the margins of springs of a temperature of 200°F, and over surfaces exposed to the hot steam. As the springs are at an altitude of 1,600 or 1,700 feet, the water boils at a temperature of about 200°F, so these plants literally grow in boiling water! I have obtained specimens, but owing to their character, they were very unsatisfactorily preserved.

"We returned to the house, where our friends had ordered dinner, but they were very tardy in getting it. We had been a long time without news, and a man brought a recent slip, an 'extra' of telegraphic news, from Petaluma, telling of the bombardment and taking of Charleston (which has since proved untrue), which called forth three hearty cheers. After a tedious wait dinner was announced . . . "



Mono County Update

In December 1990, two new Mammoth-Pacific LP geothermal power plants (MP II and PLES I) went on line in Casa Diablo Geothermal field, Mono County, California. Power plant MP II went on line December 7th, and plant PLES I December 22nd. The two power plants increase the electrical generation capability to 40 megawatts, gross, for Casa Diablo Geothermal field.

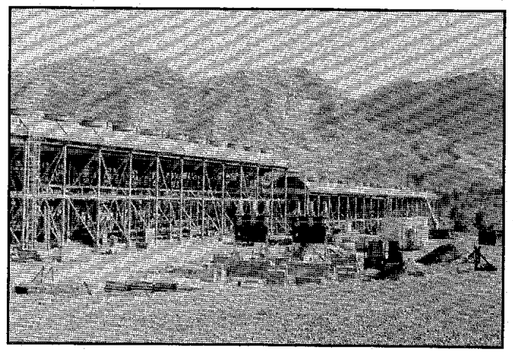
Mammoth-Pacific LP has indicated it will reapply for a use-permit for power plant MP III after six months of production from the two, new power plants. (In October 1987, MP III was initially denied a use-permit "without prejudice," allowing the operator to reapply at a later date.)

by Robert S. Habel
Geothermal District Engineer
Division of Oil and Gas

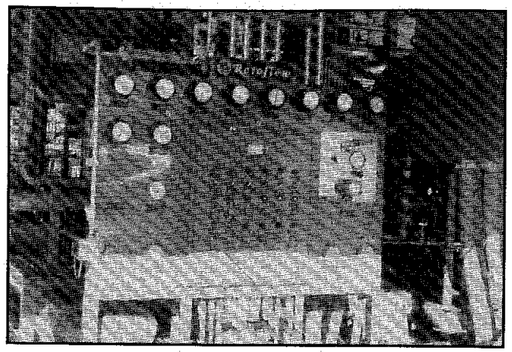
There has been no new progress on a fourth project, the Bonneville Pacific Corporation's Mammoth Chance Geothermal Project. The project's proponents have filed an appeal with the Third District Appellate Court, challenging the December 1988 Writ of Mandamus issued by the Mono County Superior Court setting aside the use-permit prepared for the project by the Mono County Board of Supervisors. A court date for the appeal has yet to be set.

Near Mammoth Lakes in the Long Valley caldera, new work has been delayed on the U.S. Department of Energy (DOE) deep Magma Energy Program scientific well.

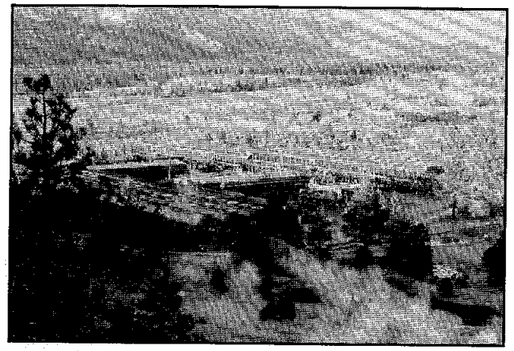
Drilling began in August 1989 on the project, which calls for a four-phase drilling program extending over a four-year period. Phase I was completed in 1989 when the well depth reached 783 meters (2,568 feet), with 20-inch casing. Phase



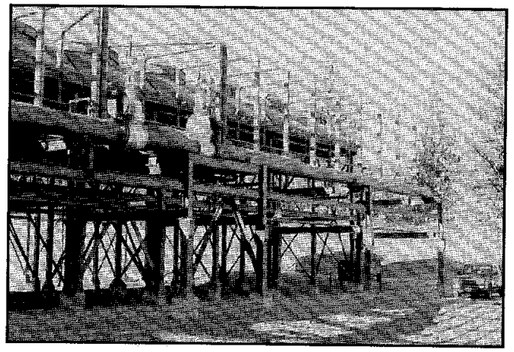
Power plants Mammoth Pacific II (left) and PLES I (right), under construction in 1990. Photos by Robert Habel.



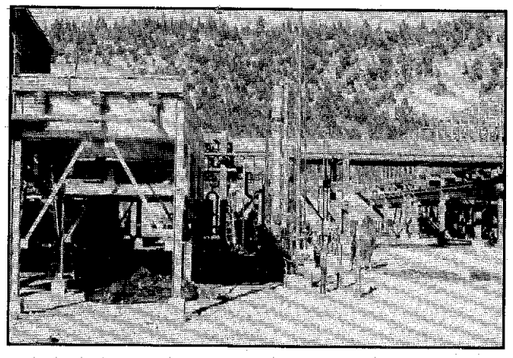
Control panel at the Mammoth Pacific II power plant.



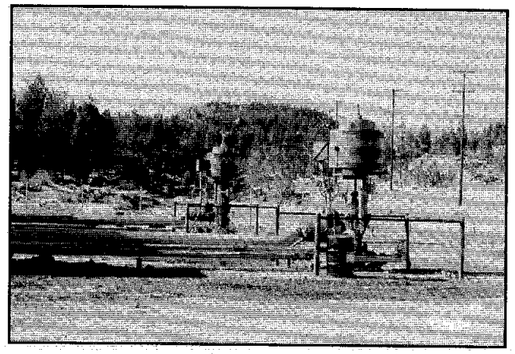
Now under operation, power plants PLES I (left) and Mammoth Pacific II (right). At first glance, they seem to be one large power plant. However, closer inspection shows the two plants are offset (center photo), with the banks of cooling towers at different levels. Steam from a fumarole wafts at photo right, front.



Cooling towers, Mammoth Pacific II power plant.



Looking east at the Mammoth Pacific II power plant.



Two new production wells for the Mammoth Pacific II power plant.

II, which will extend the well to 2286 meters (7,500 feet) with 13 3/8 inch casing, was to begin in the summer of 1990. However, cost overruns and delays with the Sandia Lab/ DOE contracts have brought the postponement of Phase II to the summer of 1991.

The California Energy Commission has allocated a $1.5 million contingent award to the project. The monies are to fund Phase II, except for $300,000 to be spent on Phase III.

The chief scientist for the project is John Rundle of the Lawrence Livermore National Laboratory. Responsibility for overall project management is held by Sandia National Laboratories, with James Dunn as project manager. While the first well is not intended to intersect molten magma, the ultimate goal of the Magma Energy Program is to drill into magma and insert a heat exchanger for long-term experiments.

Regarding low-temperature development, Mammoth Lakes, California, has contracted with Cascadia Exploration Corporation to act as its consultant for the second phase of a geothermal district-heating project to be built in the town. The project is sponsored by the town and funded by an $800,000 contingent award by the California Energy Commission.

After reviewing field study results, the project's advisory committee decided to drill a temperature gradient well near the proposed Juniper Ridge development project site. This temperature gradient well should provide valuable information on the geothermal resource underlying the town. Information obtained from this well and the other field information will be used to site a geothermal production well. The town plans to use the production well as part of a low-temperature demonstration project to promote further development of direct-use geothermal projects.

Trans-Pacific Plans New Power Plant at Lake City Field

Trans-Pacific Geothermal Corporation (TGC) is developing Lake City Geothermal field, located in Surprise Valley in the northeastern corner of California about 35 miles northeast of Alturas. There, the company plans to build a 15-megawatt, gross, 10-megawatt, net, air-cooled, binary power plant.

The project site is the locale of a phreatic explosion that occurred in 1951 near Parman Hot Springs north of Lake City. The explosion caused steam and gas to hurl rocks for hundreds of yards, and drew attention to the geothermal potential of the area (*see* sidebar on next page). From 1959 to 1972, Magma Power Company drilled several exploration wells in the area. These wells confirmed the existence of a moderate-temperature geothermal reservoir.

In 1989, TGC reached an agreement with Magma to develop Magma's Surprise Valley geothermal leases. Detailed resource-evaluation studies are now in progress. Some geophysical and geochemical investigations are being carried out to optimize field development.

Preliminary plans indicate that two production wells and two injection wells will be needed to supply the binary power

by Robert S. Habel
Geothermal District Engineer
Division of Oil and Gas

Geothermal well "Phipps" 2, looking east toward the proposed power plant site.

plant. The design for the new power plant has not been determined. Further investigations of the temperature and pressure of the geothermal reservoir are needed to evaluate the type of power plant best suited for the reservoir. Construction is scheduled to begin in early 1992.

As part of the project, TGC signed a 30-year electrical sales agreement with Puget Sound Power Company, agreeing to a July 1993 date for power plant start-up. Negotiations are in progress with Bonneville Power Administration, Pacific Power and Light, and Surprise Valley Electric Co-op for wheeling passes on existing power lines. Although the power-sales agreement indicates the power will be sold to Puget Sound Power Company in Seattle, Washington, in reality the electricity will be used in Surprise Valley, eliminating the need for Puget Sound Power Company to import to the valley electricity generated in other areas. Power deliveries are scheduled to begin in mid-1993.

TGC is a privately owned geothermal power producer, headquartered in Oakland, California. Previously, TGC carried out the initial development that resulted in the construction and operation of the 50-megawatt Dixie Valley geothermal power project and the 10-megawatt Stillwater geothermal plant. TGC is the managing general partner of the 2-megawatt Amedee geothermal plant in California, which it owns together with the U.S. Energy Corporation and a private investor.

1951 Mud-Volcano Eruptions - Surprise Valley

During the evening of March 1, 1951, and the early morning of March 2, a group of hot springs in a tule marsh about 2 miles northeast of Lake City erupted and mud particles were thrown about a mile into the air. Mud cones were built up and reached a height of up to 15 feet above the valley floor. A total mass of about 300,000 tons was involved in the eruptions, and fine debris was scattered 4 miles to the southeast by the wind. This geothermal activity was described as mud-volcano eruptions. By noon on March 2, 1951, the thermal activity consisted of boiling mud pots with clots of mud occasionally thrown 10 to 20 feet high.

Mud volcanoes can be caused by a sudden release of water and steam under pressure or by the quiet discharge of viscous mud. The "volcanic" cones form as the water and steam pressure extrude and pile up water-saturated fine clays and sediments from shallow depths. The morphology of the mud cones appears similar to that of miniature volcanoes; although, generically the name is inaccurate because no introduction of material, such as lava, occurs from a source at depth.

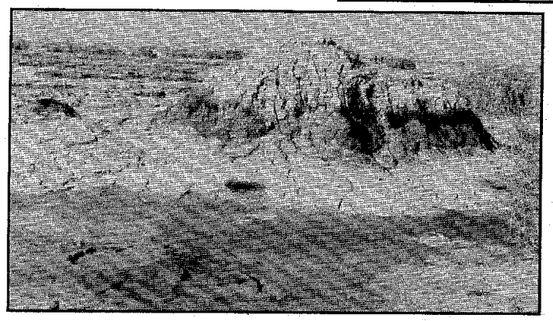
At the time of the mud eruptions, local residents heard loud noises and felt a series of tremors, similar to those felt during an earthquake. However, no earthquake was recorded.

Prior to 1951, the hot springs had been quiescent. Water temperatures and the amount of flow from the hot springs before the eruptions are not known. Although no previous violent eruptions at the Lake City hot springs were recorded, aerial photos taken in September 1946 show the cones of several mud volcanoes, indicating past activity.

The area of the mud eruptions is now a hot-water marsh with some occasionally active mud pots. The unconsolidated sediments that formed the mud cones during the 1951 eruption have been eroded to ridges 4 to 6 feet high. A shallow pool is created seasonally in the residual craters or depressions by surface runoff and by seepage from the springs.

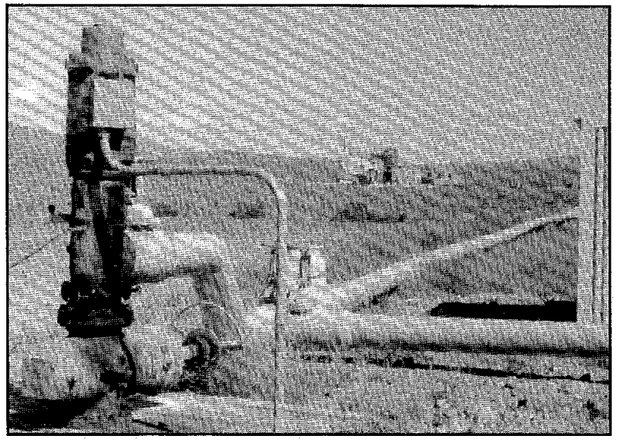
Hot springs that have formed mud volcanoes also are found in Shasta County (Lassen Volcanic National Park), Inyo County (Coso Hot Springs), and Imperial County (near the Salton Sea). All of these mud volcanoes occur in basins similar to Surprise Valley, with fine clastic sediments of Quaternary age.

.....excerpted from "Geothermal Activity in Surprise Valley", by Mary C. Woods, *California Geology*, December 1974.

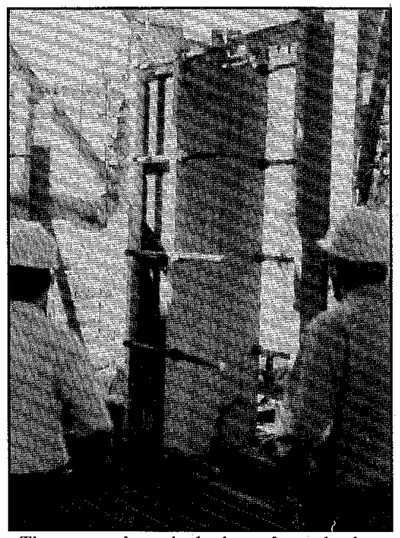


Mud volcanoes near the Salton Sea. Photo courtesy of the Division of Mines and Geology.

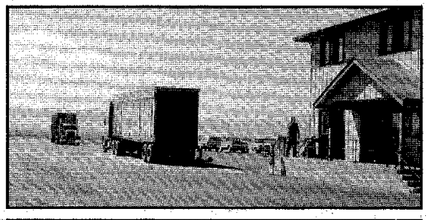
Honey Lake Power Facility, Lassen County

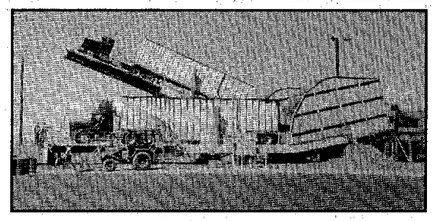


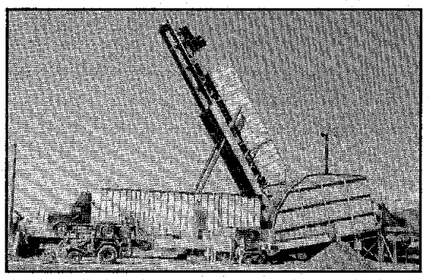
In the distance, the Honey Lake Power Facility, a 30-megawatt, net, hybrid power plant in Northern California, owned and operated by HL Power Company. In the foreground, BLM well "Wen" 2, the geothermal production well for the facility.



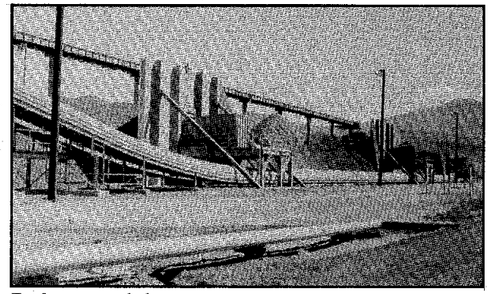
The central vertical plates form the heat exchangers where the geothermal fluid is used to preheat boiler feedwater for the HL power plant.



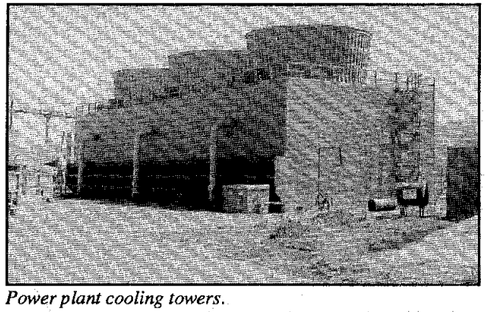




Fuel trucks coming and going from the power plant. The power plant fuel is composed of about 1,300 tons a day of selective forest thinnings, logging residue, and mill wastes. Note how the fuel is unloaded from the trucks.



Fuel conveyer belt system.



Power plant cooling towers.

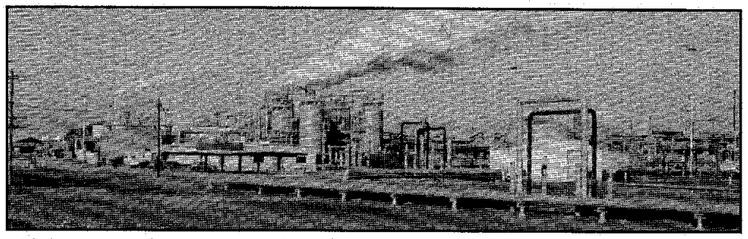
by Robert Habel
Geothermal Engineer
Division of Oil and Gas

Salton Sea Unit 2 on Line

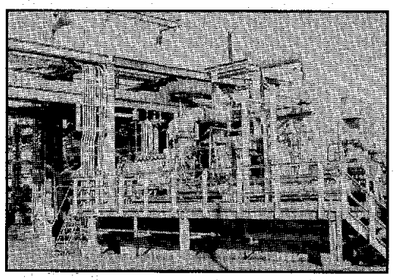
In early 1990, Earth Energy, Inc., a subsidiary of Unocal Corporation, completed construction on an 18-megawatt, net, geothermal power plant in the Imperial Valley's Salton Sea Geothermal field. Designated as Unit 2, the new power plant is operated as an extension of Unit 1, a 10-megawatt, net, geothermal power plant on line since 1982, also owned by Earth Energy. By operating the two power-plant units together, the geothermal resource is used more efficiently.

Unit 2 has three turbines. One is a standard turbine running at 120 psi, one is a low-pressure turbine running at 20 psi, and one is a turbine-expander running at 250 psi. The turbine-expander uses high-pressure steam to generate additional power. The steam comes mostly from Unit 1, which includes one, single-flash, 120 psi turbine.

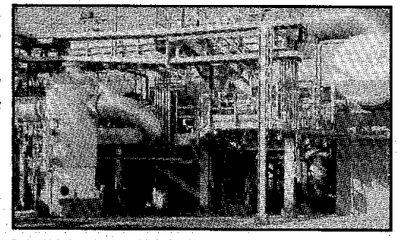
Four production wells and 6 injection wells are used to operate the two power-plant units.



Salton Sea Geothermal Project, Units 1 and 2, owned by Earth Energy, Inc., a subsidiary of Unocal Corporation. Unit 1 is a 10-megawatt, net, power plant; and Unit 2 an 18-megawatt, net, power plant. Photos by Tim Boardman.

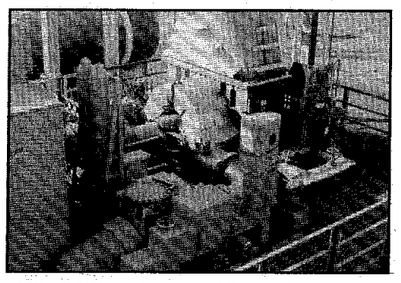


The turbine-expander in Unit 2 uses high-pressure steam, receiving some of this steam from Unit 1. Using this turbine increases the effective use of the resource, as the high-pressure steam in Unit 1 could not be used directly before the turbine-expander was installed.

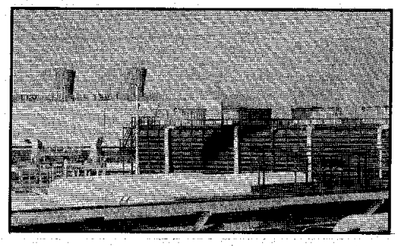


The Unit 2 standard-pressure turbine operates on 120 psi. This turbine was originally used in the Brawley power plant, now dismantled.

Turbine-generator for Unit 1.



The Unit 2 low-pressure turbine operates on 20 psi of steam.



Cooling towers.

by Timothy Boardman
Geothermal Engineer
Division of Oil and Gas

Imperial Valley Class II Monofill Project

Desert Valley Company, a Magma Power Company subsidiary, is completing a Class II monofill facility in Imperial County, California. The monofill will contain geothermal wastes from the four Magma geothermal power plants in the Imperial Valley. Initially, the facility will accept up to 150 cubic yards a day of silica filter cake generated by the power plants, and 150 cubic yards a day of clay drilling muds and cuttings generated during geothermal well-drilling activities. In about a year, the facility will receive about 72 cubic yards a day of silica filter cake and minor amounts of mud sump materials.

Desert Valley Company submitted an Environmental Impact Report (EIR) for this project in May 1990. The Imperial County Planning Commission certified the EIR on June 13, 1990. The Colorado River Regional Water Quality Control Board approved the project in September 1990, and construction began in October 1990. Project completion, along with final certification from the Regional Water Quality Control Board, is scheduled for the spring of 1991.

View of the Desert Valley Company's Class II monofill, 1/15/91. A plastic liner will cover the depression. Photo by T. Boardman.

by Timothy Boardman
Geothermal Engineer
Division of Oil and Gas

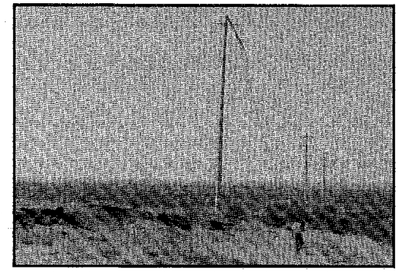
Power Lines Fall

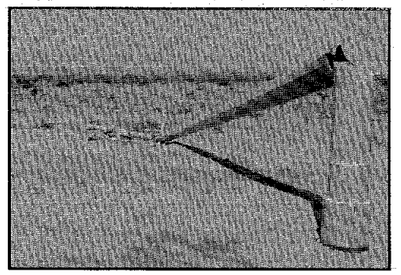
Twice in the summer of 1990, portions of the Imperial Irrigation District's 230kv power line were damaged by high winds of unknown speeds.

During the first event in June, nearly six miles of line fell, including 23 power poles constructed in the style of steel derricks. During the second incident in August, about one and one-half miles of line fell, including seven poles of a single column design (see photos).

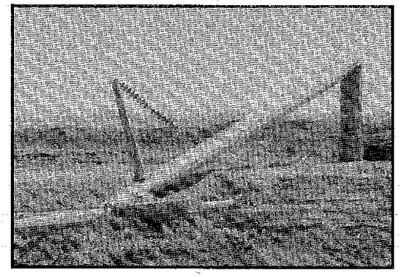
After each failure, geothermal power producers in the Imperial Valley had to curtail the production of electricity.

After each incident, the Imperial Irrigation District installed temporary power poles within two weeks. Numerous studies are underway to determine the exact mechanism for each failure.





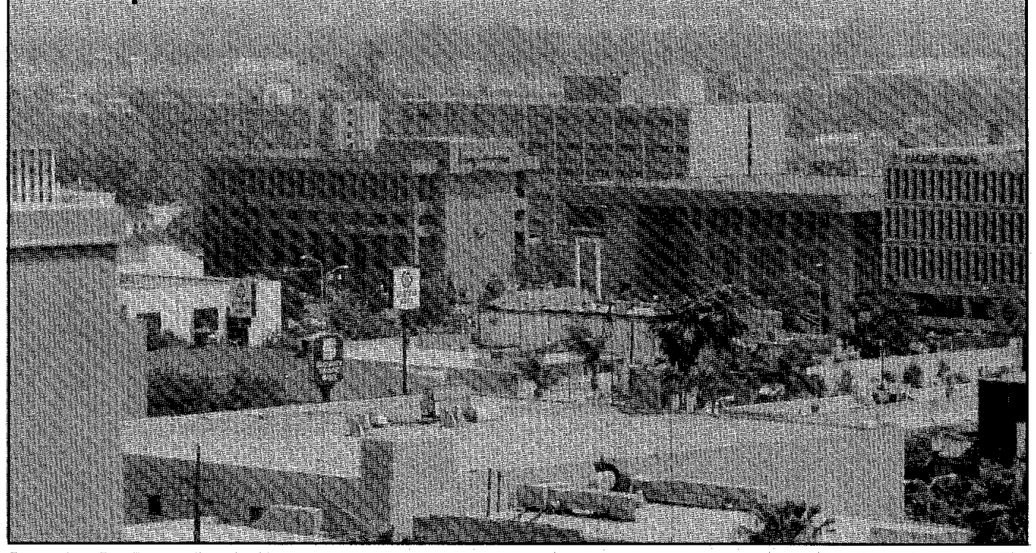
View of downed power pole and lines, August 1990. Photos by T. Boardman.



View of downed power pole and lines, August 1990.

by Timothy Boardman
Geothermal Engineer
Division of Oil and Gas

San Bernardino Geothermal District-Heating System: An Update



Downtown San Bernardino, looking southeast. Many of the buildings are heated by the low-temperature geothermal resource. The photographs are courtesy of the California Energy Commission.

The City of San Bernardino is successfully using an underlying geothermal resource for space- and domestic-water heating in 27 buildings in the downtown area (Table 1). The San Bernardino Municipal Water Department (SBMWD) is demonstrating the use of this low-temperature geothermal fluid as an alternative to fossil fuels. The system, which the water department owns, became operational in May 1986. It is one of the largest geothermal district-heating systems in the United States, providing heat for about 4 billion cubic feet of space.

by Mary C. Woods, Geologist

The SBMWD owns and operates two production wells included in the system: "Meeks and Daley" 66 and "Mill and D" 2 (*see* map). The "Mill and D" 2 well flows under artesian pressure at a rate of 1,000 gallons per minute (gpm); the "Meeks and Daley" 66 well flow is 1,350 gpm. When pumped, each well has a maximum production capacity of 4,000 gpm. Each well maintains an efficiency above 82 percent at production rates between 1,200 and 2,000 gpm.

The "Meeks and Daley" 66 well produces at a temperature of 132°F. The 20-inch diameter well is lined with an 18-inch diameter steel casing to a depth of 700 feet, the production zone of the hot-water aquifer. The "Mill and D" 2 well production temperatures range from 134°F to 136°F. This well is 931 feet deep and produces from a zone 700- to 900-feet deep.

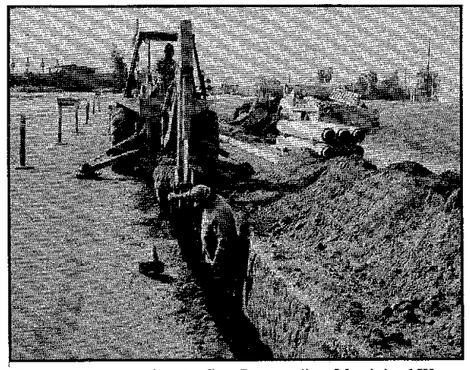
As of January 1991, 27 facilities are served by the system. Facilities recently connected include a state building, the Center for Individuals with Disabilities, the city convention

Table 1. Status of buildings in the City of San Bernardino, showing buildings in the San Bernardino Water Department geothermal district-heating system and those with potential for geothermal retrofit. Table from Geothermal District Heating in San Bernardino *by Kevin Fisher, San Bernardino Municipal Water Department.*

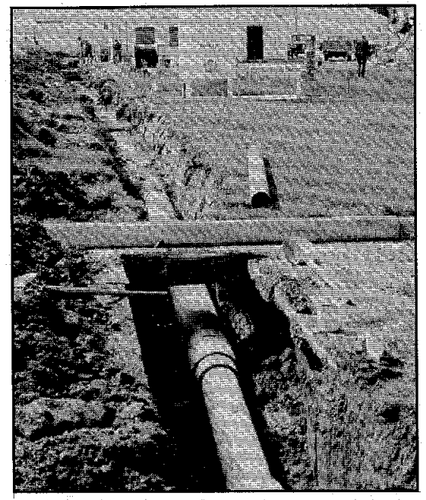
Legend

O = Operational
D = Declined To Use Geothermal Energy
M = Marketing Effort In Progress (as of January 1991)
UR = Undergoing Retrofit

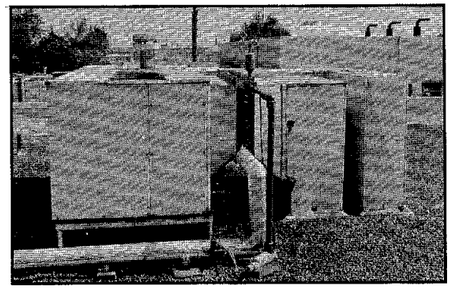
- M Pacific Federal Plaza
- O Cal-Trans Facility
- O State Building
- D City Garage Facility
- D Heritage Building
- O Safeco
- D Warm Creek Apartments
- O Warm Creek Plaza
- O City Hall
- O Convention Center
- M Hilton Inn
- O Baker's Restaurant
- M La Quinta Inn
- D Hot Tub Junction
- O Center for Individuals with Disabilities
- M YWCA
- M Spoons Restaurant
- UR Annex Facility (City Hall)
- O Blood Bank
- O Maruko Hotel (formerly Ramada Inn)
- O Central City Library
- O National Orange Show
- O St. Bernardino Plaza
- O County Law Library
- O City Civic Center
- O Central City Library
- O Jail Facility
- O Sheriff Headquarters
- O Retirement Board
- D Jack La Lanne
- O Sun Publishing
- D Golds Gym
- D Super 8 Lodge
- M YMCA
- M Kettles Restaurant
- M Vanier Tower
- M Goodwill Facility
- O Animal Shelter
- O Waste-Water Treatment Plant (WWTP) facility (5 buildings and 1 digester)



Crew laying pipe for the San Bernardino Municipal Water Department geothermal system along Arrowhead Avenue.

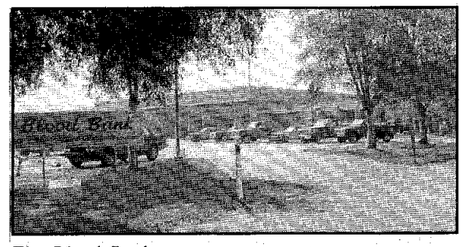


Laying pipe for the geothermal-system connections to the waste-water treatment plant, City of San Bernardino.

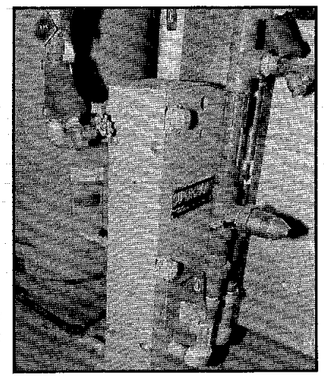


Geothermal-retrofit equipment installed at the waste-water treatment plant personnel building.

Waste-water treatment plant, showing geothermal retrofit-equipment at the maintenance building.



The Blood Bank, San Bernardino, is connected to the geothermal heating system.



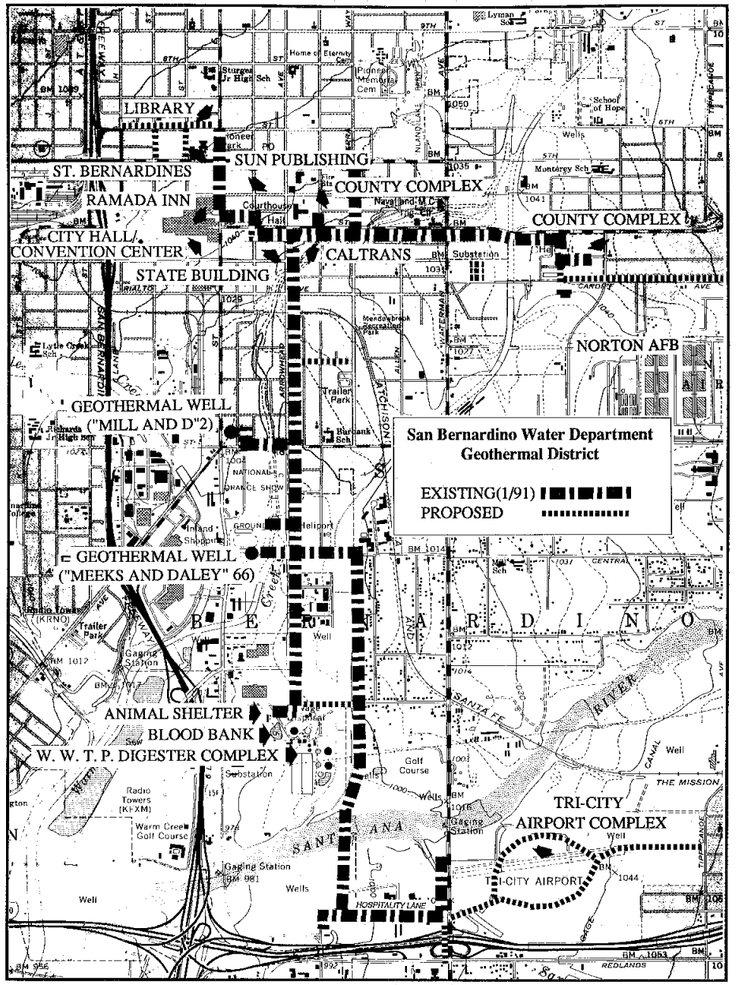
Heat exchanger for the geothermal system at the Blood Bank.

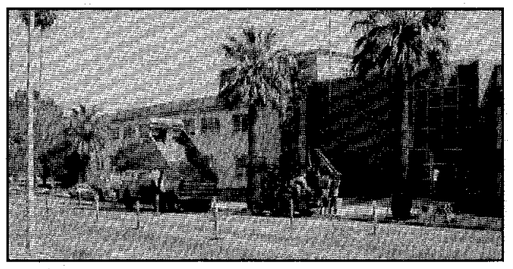
center, the central city library, and three county facilities including the Law Library, the Library Administration Building, and the Civic Center.

The geothermal fluid used in the system is of very good quality; fluoride is the only constituent that is present in concentrations exceeding the maximum levels allowed for safe drinking water. The water quality is monitored, and the total dissolved solids for calcium carbonate is 17 ppm.

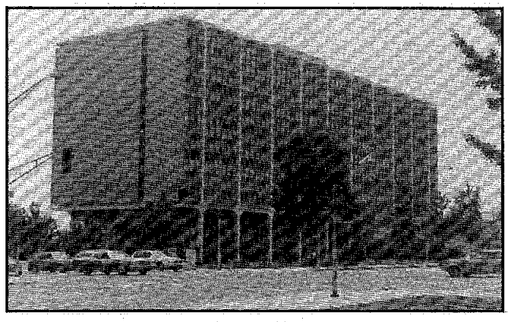
After heat extraction, geothermal fluids are disposed of in storm channels within the City of San Bernardino. Four million gallons per day can be disposed of in this manner, as permitted by the Regional Water Quality Control Board. Currently, the amount of disposed fluid is 1.5 million gallons per day.

The possibility of regionally expanding the use of geothermal resources is now being explored. In a geothermal-assessment study of the San Bernardino area, three active geothermal locations are described; two of the areas are southwest of the City of San Bernardino. The study is entitled *Resource Investigations of Low and Moderate Temperature Geothermal Areas in San Bernardino, California*, and was prepared by

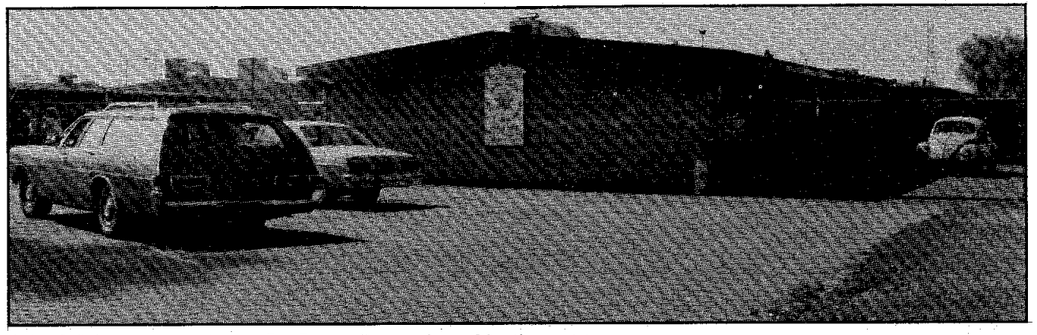




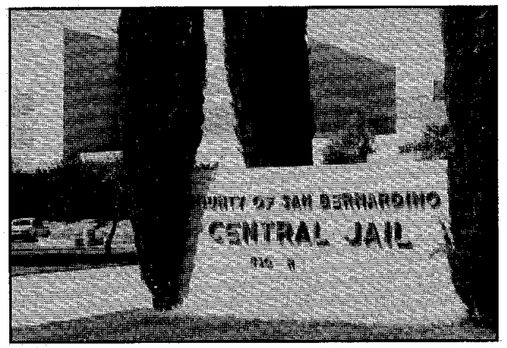
A California Department of Transportation building connected to the San Bernardino geothermal heating system.



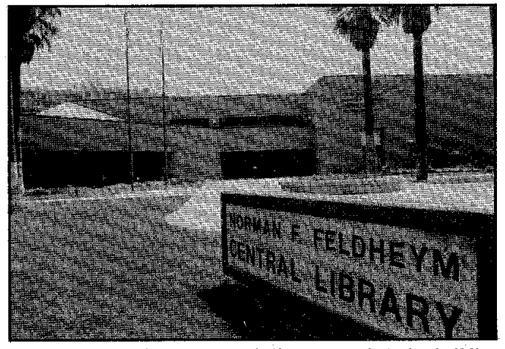
State building, southwest corner of Third Street and Arrowhead Avenue, San Bernardino, California. This building is connected to the geothermal heating system.



Animal shelter, connected to the San Bernardino geothermal heating system.

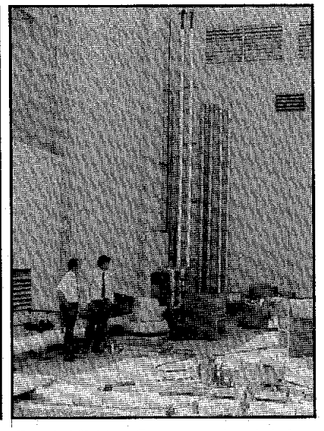


County jail complex, San Bernardino. This facility was the first county building to be connected to the geothermal heating system.



City of San Bernardino central library, another city building retrofitted for the geothermal system.

Covered riser for heat exchanger (indicated by arrows) installed at the Sun Publishing Company.

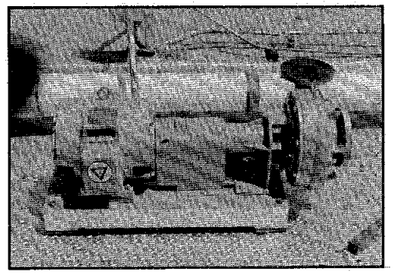


Sun Publishing Company, showing the installation of the retrofitted geothermal heating system.

Portion of the district-heating system installed at the Sun Publishing Company.

the California Division of Mines and Geology.

The California Energy Commission (CEC) provided more than $3.5 million to develop, distribute, and utilize the geothermal resource in the City of San Bernardino. The CEC also is funding resource assessment programs and feasibility studies in the Cities of Loma Linda and Colton, just south and west, respectively, of the City of San Bernardino. The resource assessments include drilling exploratory holes to test the thermal gradients and to define the extent of the resource. It is the goal of the CEC that the three communities use the resources in



a regionally cooperative way for their mutual benefit.

In San Bernardino, users of the geothermal heating system have reported savings in energy costs in amounts ranging from 30- to 50-percent of former gas bills. For most buildings, the cost of connecting to the geothermal system can be recovered from 18 months to 5 years, with an average payback period of 2 1/2 years for most. Local governmental jurisdictions are eligible to apply to the CEC for state funding for these costs through the CEC's Geothermal Grant and Loan Program.

Acknowledgments

Information for this update was provided by Roger Peake, Geothermal Energy Specialist, CEC, who can be reached at (916) 324-3505. Mr. Peake also has information on the CEC's Geothermal Grant and Loan Program. Information was also taken from a recent article by Kevin Fisher, Geothermal Engineer for the City of San Bernardino Municipal Water Department, who can be reached at (714) 384-5405.

GEOTHERMAL INJECTION WELLS

A Brief History

The Safe Drinking Water Act, passed in 1974, charged the U.S. Environmental Protection Agency (EPA) with the task of developing for all types of injection wells a regulatory program to protect the nation's underground sources of drinking water (USDW). In the process, the EPA developed five different classifications for injection wells: Class I included wells that injected hazardous waste; Class II injection wells were related to oil and gas operations; Class III were wells used in in-situ mining processes; Class IV wells were used to inject hazardous or radioactive wastes into USDW's and were immediately banned; and Class V became a catchall class for all the other types of injection wells. Initially, there were 11 broad types that fell into this class: everything from cesspools to recharge wells. Geothermal injection wells were also included in Class V.

During the federal rulemaking process, we in the California Division of Oil and Gas worked very hard to have geothermal injection wells included under Class II. Our reason was that here in California, where the vast majority of these wells exist, the division basically regulates them in the same way as oilfield injection wells. But we were unsuccessful, and geothermal injection wells ended up in this class of uncertainty. And I say uncertainty because neither the EPA, nor anyone else for that matter, had a good handle on Class V wells. How many were out there? How were they utilized? Were they regulated at any level of government? There were a lot of unknowns about Class V wells.

As the EPA continued to collect information on these wells, it found that the estimate of the Class V universe of wells was low. There were many more wells out there than were suspected, and there were many more types. At last count, 31 different types of Class V wells were identified. At the same time, the EPA began to realize, along with the states, that Class V wells, being primarily shallow injection wells, presented the greatest potential threat to the environment and USDW's than any other class, with some exceptions.

One of those exceptions was geothermal injection wells. In California, we knew that they were well regulated and constructed and presented little risk to the environment.

You know, one of the ways the regulators can promote and encourage the development of our geothermal resources is to remove as much regulatory uncertainty and confusion as possible. Therefore, if we can move geothermal injection wells away from this catchall class, this class of uncertainty, then we will have made significant progress.

by M. G. Mefferd,
State Oil and Gas Supervisor,
from an address before the Symposium on Subsurface Injection of Geothermal Fluids

The EPA Looks at Geothermal Injection Wells

"Geothermal wells are environmentally beneficial and give positive benefits to local economies. They are not the environmental risk some people think," said George Hoessel, Special Assistant to the Underground Injection Control Branch of the Office of Drinking Water, in the Environmental Protection Agency (EPA). Mr. Hoessel was speaking at the Symposium on Subsurface Injection of Geothermal Fluids sponsored jointly by the EPA's Region IX and the Underground Injection Practices Council Research Foundation, on October 29-30 in Santa Rosa, California.

At the meeting, M. G. Mefferd, California State Oil and Gas Supervisor, explained that the EPA classifies geothermal injection wells as Class V wells, making them one of 31 types of wells placed in this catchall class.

"Geothermal resources and their development are important to the state and the nation," said Mr. Mefferd. "We need to diversify our energy supply base as a nation. To accomplish this, we need to use our geothermal resources. We should move geothermal wells out of Class V, the class of uncertainty, into a more defining class."

However, after remarks from EPA representatives at the symposium, it became clear that changing the classification of geothermal injection wells from Class V to any other classification, including Class II (presently used for wells used to inject some fluids from oil and gas operations) will not occur soon.

"The EPA won't have a formal proposal (to undertake any change) until federal fiscal year 1992," said Mr. Hoessel.

Mr. Hoessel said the goal of the EPA concerning standards for Class V wells is "to allow stringent standards to be applied generally while allowing for broad variations. This method has little money behind it, but it will maximize the effectiveness.

"When a state can show that they effectively regulate (geothermal injection wells), they don't have to meet every federal requirement for doing so, under the '1425 Effective Program' mandates.

"We want to work towards a creative and flexible approach to Class V well regulations," said Mr. Hoessel. "Geothermal wells are not a priority (among Class V wells). They pose very little risk to underground water. Don't expect additional federal controls on deep geothermal energy wells. The state agencies impose effective controls."

In the interim, Mr. Hoessel said that the EPA will evaluate the injection well regulatory program of the Division of Oil and Gas and, if it is approved, enter into an agreement through an MOU with the division to allow it primacy to regulate geothermal injection wells. However, the EPA will retain authority to step in if mismanagement occurs.

"We won't encourage formal primacy changes until FY 1992 and these regulations are in effect," Mr. Hoessel concluded.

Mr. Mefferd said the division will pursue immediately the development of an MOU with the EPA Region IX office to recognize the division's regulatory program. "Our goal," he said, "is to avoid multiagency complexity in our regulatory program."

DATA REQUIRED BY THE DIVISION OF OIL AND GAS FOR GEOTHERMAL INJECTION PROJECTS

1. One or more cross sections drawn through the sites of the proposed injection well(s), showing structural details and any wells that may be affected by the project.
2. Location of the base of any freshwater strata (water 10,000 ppm or less) or a statement that no fresh water exists.
3. Formation depth and age of the injection zone.
4. A plot map with the following information:
   a. Surface locations, directional plots, bottom hole locations and status of all wells (including the proposed injection well or wells) bottomed within the affected lease area (within 1/4-mile radius of a proposed injection well).
   b. Lease boundary lines.
5. A contour map on the top of the injection zone.
6. Source and analysis of the injection water, and analysis of the water in the injection zone.
7. A letter containing engineering and geologic details of the project, including:
   a. Primary purpose.
   b. Reservoir characteristics of the injection zone: i.e., fracture porosity, permeability, thickness (net and gross), present temperature and pressure.
   c. Number and condition of disposal, producing, idle, and abandoned wells, including cement plugs and the calculated cement fill behind the casing of all wells that may be affected adversely by the project.
   d. Treatment of the water to be injected.
   e. Method of injection (i.e., casing, tubing, tubing with packer, between strings, etc.).
   f. Estimated daily rate of water injection, by well or wells.
   g. Maximum surface injection pressure anticipated (wellhead pressure).
   h. Precautions taken, or to be taken, to ensure that the injection water is confined to the permitted injection zone and to the area controlled by the operator.
   i. Protective methods used, if any, on injection lines and well(s) (i.e., cathodic, etc.).
   j. The well-drilling and abandonment program planned for the entire project, including a flood-pattern map showing all injection, producing, and abandoned wells, and unit boundaries.
8. Copies of letters of notification sent to neighboring operators.
9. Additional data may be required to make a decision, such as a subsidence model, anticipated declines, pressure build-up model, and reserve estimates (with and without injection).

The Geothermal Underground Injection Control Program, Division of Oil and Gas

The California Department of Conservation, Division of Oil and Gas works to ensure that no damage occurs from geothermal subsurface injection projects. The division's primary goal is to make certain the injection fluid is confined to the intended zone to protect any fresh waters. To achieve this, technical surveillance activities are undertaken for the life of the well. Well operators must make all remedial and corrective measures.

Initially, an operator will request permission from the division to inject fluid into a geothermal reservoir. Proof must be presented that the amount of reservoir energy otherwise recoverable will not be reduced, that freshwater strata will not be infiltrated by the injected water, and that no other damage or nuisance will result from the injection project.

A geothermal injection well in the State of California is defined as any well drilled or altered for the purpose of injecting waste geothermal fluids for disposal, or injecting geothermal fluids or other fluids for reservoir pressure maintenance or augmentation of reservoir fluids.

The division approves or disapproves a project based upon this information and other data. Today, after 20 years of operating the division's geothermal injection program, no evidence has been found for any well-fluid migration caused by a lack of geologic confinement.

To prevent injected fluid from migrating through the well bore, properly designed casing and cementing programs are used. The depth of the casing shoe is contingent upon the site's geology and pressures. Generally, surface casing is set at a depth that is 10 percent of the well's total depth, with a minimum of 60 meters (200 feet) and a maximum of 400 meters (about 1,300 feet). All production casing that is lapped into an intermediate string must have an overlap of at least 15 meters (about 50 feet), which is cemented solidly and pressure tested to ensure integrity.

Generally, injection permits issued by the division specify the use of tubing and packer only when fresh waters are penetrated. Valves are required on the tubing and on the casing/tubing annulus to aid in testing.

To evaluate the possible impacts of the injection project to the surrounding areas, the division uses a 1/4-mile area of review (AOR). The applicant submits casing diagrams of wells in the AOR and/or the condition of any AOR wells that have been drilled into the proposed injection interval. All casing, cement tops, and plugs are evaluated to ensure no conduit exists to allow the injected fluid to migrate out of the intended zone.

Once an injection well is operating, a division inspection program is undertaken to ensure that the injection-project permit conditions continue to be met. Environmental inspections are made at least annually by the division on all wells. In addition, the wells are inspected during each mechanical integrity test and again during the annual injection-project review.

Operators do not receive advance notice of field and environmental inspections, unless a pressure gauge must be installed for a test or a sample of water must be collected from an injection line. Operators must calibrate permanently installed gauges at least once every six months and portable gauges every two months.

If a division engineer finds deficiencies at the well, the operator is notified. Enforcement actions may involve the issuance of deficiency notices, notices of violation, and formal orders. In addition, formal orders may be issued to plug and abandon or repair wells, adopt plans for subsidence control, or ensure protection of wildlife, health, and groundwater quality. Usually, orders include a 10- to 30-day compliance period. When an operator either refuses or is unable to comply with the order, the division may do the work, place a lien on the property, and impose penalties.

Civil penalties are issued for failure to file records or notify the district office of work being done, unauthorized injection of fluids, or changes of fluid streams without prior notification and approval. The penalties range from $100 to $1,000 per offense for misdemeanors, and do not exceed $5,000 for each day of violation for civil violations.

The division maintains the same injection control requirements for low-temperature and high-temperature geothermal injection wells. In areas with low-temperature geothermal resources, injection-well approval is always on a case-by-case basis.

Sometimes, as in Susanville, California, low-temperature geothermal injection wells pose no pollution problem to the groundwater because both the geothermal fluid and the injection zone water are potable. If the spent fluid is of good quality and not required for reservoir recharge, a permit may allow it to be discharged at the surface.

by Robert S. Habel
Geothermal District Engineer
Division of Oil and Gas

The Imperial Valley

Both high- and low-temperature injection wells are found in the Imperial Valley, in Southern California. Although the Imperial Valley includes no aquifers classified as underground sources of drinking water, small localized aquifers supported by canal seepage and with average total dissolved solids concentrations of 5,000 ppm are present, but cannot provide the volume necessary for either irrigation or domestic uses. Fluids injected into geothermal injection wells must be confined to the permitted injection zone to prevent any degradation of the local aquifers and for subsidence control.

The Geysers Geothermal Field

At The Geysers Geothermal field in Northern California, aquifers are not large enough to be used as sources of drinking water. Usually, they are less than 100 feet thick and have an aerial extent of only a few acres. The aquifers are scattered in mountainous areas within ancient-to-recent landslides.

Here, freshwater steam condensate is injected into the steam reservoir, along with water from a nearby creek. The injected water helps to maintain reservoir pressures and steam production.

In summary, the Division of Oil and Gas has an established, effective program for regulating geothermal injection wells, and works closely with state, federal, and private agencies to protect geothermal resources, the environment, and underground sources of drinking water.

Groundwater at The Geysers Geothermal Field

Groundwater is found in four geologic units at The Geysers Geothermal field and vicinity. These are, in order of their potential for domestic or agricultural use:

(1) The Clear Lake Volcanics, particularly at Cobb Mountain. Here, the groundwater is discharged along the lithologic contact of the volcanic rocks and the underlying Franciscan Assemblage. Spring discharges from the eastern side of Cobb Mountain form a major source of domestic water used in the region. The water is meteroic in origin and of good quality.

Groundwater is found in four geologic units at The Geysers.

(2) Landslide deposits. Landslides are widespread in the study area. The amount of groundwater they contain depends upon their sizes, which vary widely. Landslides usually provide sustained water flows during the wet season only, unless they are recharged from another water-bearing unit, such as the Clear Lake Volcanics or steam condensate from the geothermal reservoir.

(3) Stream channel deposits. Stream channel deposits within the study area provide a limited source of good quality groundwater, mainly in the drainages for Kelsey Creek and Putah Creek.

(4) Franciscan Assemblage. Groundwater is found in both the nonreservoir and reservoir rocks of the Franciscan Assemblage. The nonreservoir rocks, with low temperature, porosity, and permeability, are essentially nonwaterbearing, generally yielding less than 4 to 12 liters per minute (1 to 3 gallons per minute).

The Franciscan reservoir rocks, with high temperature and high fracture permeability, are saturated with water and steam. Although the rocks may be capable of localized water flow, this flow is usually not sustainable.

The quality of Franciscan Assemblage groundwater ranges from good to poor. Quality generally decreases with depth due to the increased mineral leaching at higher temperatures. In the reservoir rocks, water quality seems to be relatively high in terms of total dissolved solids, but probably exceeds quality standards for trace metals in the southeastern end of The Geysers Geothermal field. Water quality decreases to very poor in the northwestern end of the field.

by Elizabeth Johnson and David Treleaven

Excerpted from the paper "Groundwater: A Resource Evaluation at The Geysers Geothermal Field and Vicinity," published in the Proceedings of the Symposium on Subsurface Injection of Geothermal Fluids, Santa Rosa, California, October 29 and 30, 1990. The symposium was sponsored by the Underground Injection Practices Council Research Foundation and the U.S. Environmental Protection Agency. The proceedings are available for $18.00, including postage and handling, from the Underground Injection Practices Council, 525 Central Park Drive, Suite 304, Oklahoma City, Oklahoma 73105.

Of primary concern to the Division of Oil and Gas is the protection of the usable groundwater from contamination. The California Department of Conservation, Division of Oil and Gas, is mandated to "prepare maps and other accessories necessary to determine the underground conditions in a geothermal area and the location and extent of strata bearing water suitable for irrigation or domestic purposes or surface water suitable for those purposes." *(Public Resources Code (PRC), Chapter 4, Section 3716).* Under the PRC, the division is also mandated to regulate injection wells that are used to dispose of geothermal waste fluids.

With this goal, the Division of Oil and Gas has regulated the state's geothermal development for more than 20 years. It has successfully protected usable groundwater from contamination by enforcing its regulatory procedures. These include specifications for the drilling, operation, maintenance, and abandonment of geothermal wells. As a further precaution, frequently scheduled mechanical integrity tests and mechanical logging techniques are undertaken on all geothermal wells. Well cementing requirements are especially important in protecting usable groundwater.

NOTE: *Other California papers published in the proceedings include "A Walk Through Time: Injection in the Southeast Geysers," by C. L. Crockett and K. L. Enedy, Calpine Corporation; "Geothermal Solids Injection, A Case History," by R. S. Maxwell, Unocal Geothermal Division; "Case Histories of Vale, Oregon, and Susanville, California," by G. Culver, OIT; "Hydrologic Monitoring for Effects of Geothermal and Groundwater Development, Long Valley Caldera, California," by D. C. Farrar and D. L. Lyster; and "The Geothermal Underground Injection Control Program of the California Department of Conservation, Division of Oil and Gas," by R. S. Habel (an excerpt from this paper is on page 28).*

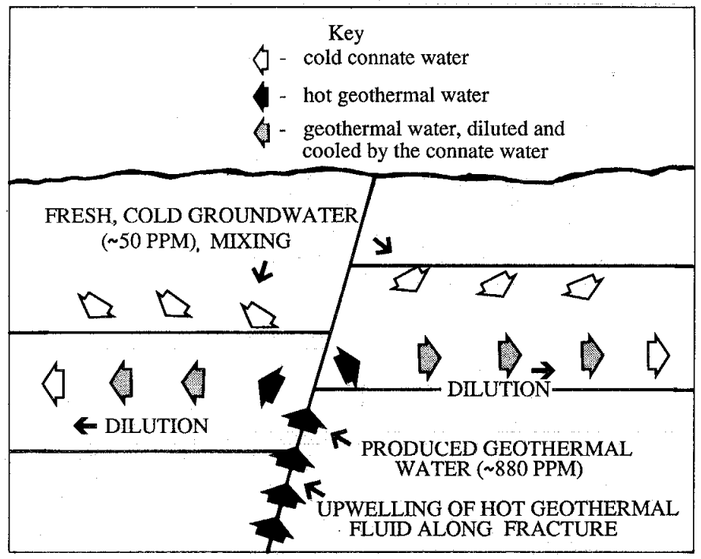
Injection Well Plans Underway at Susanville

Since 1982, the City of Susanville, California, has extracted geothermal fluid from a reservoir beneath the city and used the fluid to space heat a variety of buildings. Currently, the city injects 67 percent of the produced geothermal fluid and discharges the rest into the Susan River. Because the California Regional Water Quality Control Board (RWQCB) would prefer that more of the spent fluid be injected, thus reducing the amount of surface discharge, city officials are searching for a geothermal injection well site.

Several factors restrict the selection of an adequate injection site for the project. Land to which the city has either access or owns is one of the primary issues, as is locating the proper geologic setting for an effective injection well. To complicate the situation, the RWQCB has expressed an opinion that the quality of an injected geothermal fluid cannot be lower than that of the fluid occurring naturally in the reservoir at the point of injection.

A complication arises because the cooled production fluid would have to be injected into the area of equal or lower water quality, which is the hottest reservoir area. Such a procedure, unfortunately, could cool the fluids near the production well, causing what scientists term a thermal breakthrough. Usually, to avoid thermal breakthrough, geothermal project planners strive to site injection wells at a distance from the production wells.

As an illustration, a simplified model of the Susanville reservoir's hydrology has been prepared (Fig. 1). In the figure, hot geothermal fluid (78°C with 880 ppm TDS) migrates up fractures into the reservoir and eventually flows laterally into a zone of high permeability. Here, geothermal fluid mixes with the much higher quality and colder groundwater (12°C with 50 ppm TDS). As the fluid flows laterally, the dilution process continues, both cooling the geothermal fluid and increasing the TDS level of the zone to around 700 ppm, while simultaneously decreasing the TDS level of the geothermal fluid, itself.



Generalized model of the Susanville geothermal reservoir. Normally, the production wells are sited in the hot, upwelling zone, and the injection wells in the cooler, peripheral areas.

by Robert S. Habel
Geothermal District Engineer
Division of Oil and Gas

Many agencies are working to resolve the situation at Susanville. One solution, supported by the Division of Oil and Gas, is to have the RWQCB classify the produced geothermal fluid as a designated waste and allow this lower-quality water to be injected into the cooler portion of the reservoir where the slightly better fluid quality exists. (A designated waste is defined as a nonhazardous waste that consists of or contains pollutants that, under ambient environmental conditions at the waste-management unit, could be released at concentrations in excess of the applicable water quality objectives.)

The division supports this recommendation because no clear boundaries exist in the reservoir between the geothermal water and the fresh, cold groundwater. Instead, there appears to be an area in the reservoir where the waters commingle, allowing fluids of different qualities to exist within the same zone. The division believes such mixing will continue to occur whether or not an injection well is used. Also, division engineers believe that by allowing the injection to occur, surface discharge could be eliminated, or reduced, and the produced fluids would be returned to the zone from which they originated.

OTHER WESTERN STATES

HAWAII

Information Campaign Started for Upcoming Geothermal Well Venting*

HILO - County of Hawaii and state officials have begun a public information effort to advise the community about the process of venting geothermal wells.

The joint county and state campaign is designed to reach Big Island residents before an upcoming vertical venting by Puna Geothermal Venture of its first commercial well, tentatively set for Monday, March 25, 1991.

Officials describe the upcoming vertical venting as a "normal and necessary step in the process of putting a geothermal well to work to produce electricity." County and state personnel from several agencies will be on hand to monitor the process closely to ensure compliance with permit conditions.

Officials will mail an information bulletin to Puna area residents, put posters on bulletin boards, place paid announcements in daily newspapers, and provide public service announcements to radio stations.

The information bulletin states, "Vertical ventings have taken place for geothermal wells elsewhere in the United States and around the world without any adverse effects to the public's health and safety. County and state officials are working to see that the upcoming venting is done with a minimum of disruption to the surrounding community, and with a maximum degree of safety for everyone."

***NOTE:** Barry Mizuno, Managing Director, County of Hawaii; and Michelle Wong-Wilson, Economic Development Coordinator for Hawaii County issued this press release on March 18, 1991. The information in the release was widely distributed.*

Hawaiians Polled on Geothermal Development

In July of 1990, the *Honolulu Star Bulletin* and KGMB-TV conducted a joint survey of Hawaii residents on the issue of geothermal energy. They found that the majority of those polled were in favor of developing the alternative energy resource. A second survey conducted in September revealed still a larger majority in favor of geothermal development. The poll was made of 626 likely voters statewide from August 29 to September 2 by Political/Media Research Inc. The margin of error is plus or minus 4 percentage points.

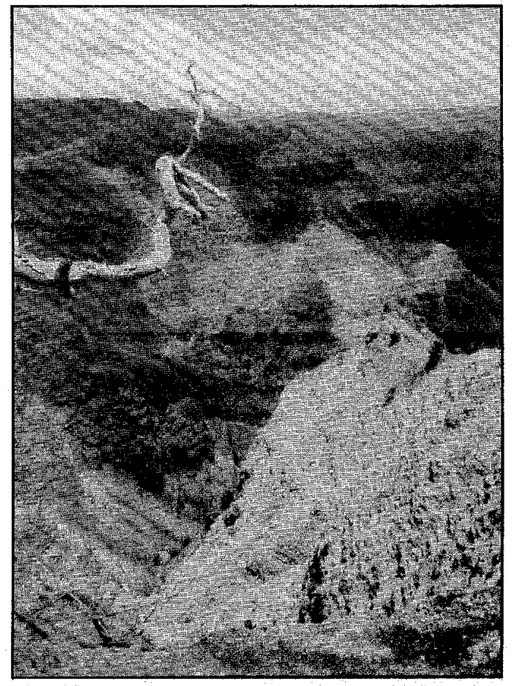
Comments by residents seem to indicate that this increase in favorable opinion is linked directly to the Middle East crisis. Most residents appear to be concerned that such events are beyond the state's control and have the capacity to wreak havoc on oil prices that will in turn affect the economic conditions of the state. To these residents, geothermal is a

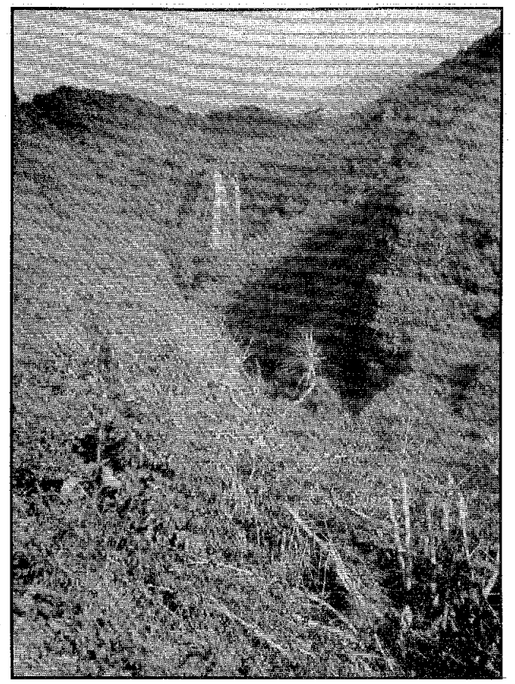
resource that ought to be pursued as a viable, alternative energy source that has the potential to free Hawaii from its dependency on imported oil.

Other survey results are:

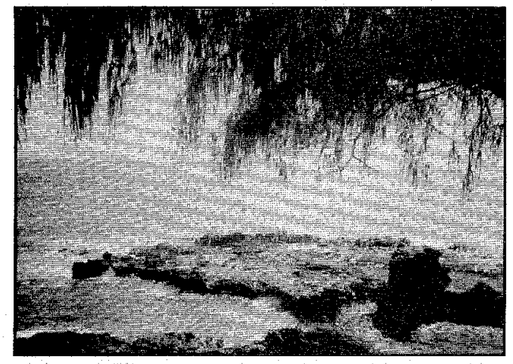
- Geothermal opposition dropped markedly from 26 percent in July to 11 percent in September.
- The "no opinion" category stabilized at 19 percent in September, only a 1 percent increase from the July survey.
- Fourteen percent believe the state should encourage development only on the Big Island.
- Fifty-six percent believe geothermal development should occur on the Big Island and be used on all the islands.

Reprinted from a publication called, as is this publication, the Geothermal Hotline, *published by Pro-GEO, the Pro-Geothermal Alliance, Honolulu, Hawaii.*





Views of the Island of Kauai. Photos by Susan Hodgson.



Geothermal Development Activity in Hawaii

Governmental Activity

The State of Hawaii's current activities are focused on several elements: verification and characterization of the geothermal resource; determination of the economics of large-scale development, including an interisland electrical transmission system; and environmental and social concerns.

In 1989, the state contracted with the University of Hawaii to drill and test about five scientific observation holes (SOH) within the predesignated Geothermal Resource Subzones in the Kilauea East Rift Zone on the Island of Hawaii. The primary purpose of the program is to perform relatively deep analyses to discover the locations of potentially viable geothermal resources at less cost and with fewer potential environmental and negative social impacts than those resulting from full-scaled, deep exploration wells.

Private developers interested in Hawaii were in agreement with the concept. The permitting efforts were more comprehensive than anticipated. Since most of the proposed SOH sites were on agricultural land, the primary permitting agency was the County of Hawaii Planning Commission. Because of the lack of prior geothermal development in Hawaii and considerable local resident concern, the planning commission proceeded slowly and conservatively. An Environmental Assessment was required for the SOH's, and the project sponsors were required to meet with residents and others in a two-month mediation process. Numerous conditions placed in the permit were comparable to those required for full-scale wells. Among other conditions, the project proposers agreed not to flow test the SOH's and to install casings more suited to a full-scale well.

The initial SOH was completed in May to a depth of 6,562 feet, at the edge of the Wao Kele O Puna forest in the middle portion of the rift zone. The bottomhole temperature was 563°F. The second hole, with a bottomhole temperature of 403°F, was completed at the end of 1990 near the government's HGP-A well. These two holes had good permeability at shallow depths but not at deeper depths. Additional permeability tests will be conducted. On March 1, 1991, the third SOH near the east end of the Kilauea East Rift was almost to 2,000 feet, with no temperature anomaly.

The program has cost more than twice the original estimate of $600,000 per hole. The high costs were due to the comprehensive permitting requirements, the decision to drill deeper than the 4,000 feet planned initially, and the difficult subsurface drilling conditions. Efforts are underway on the third hole to keep costs below $1 million per hole. (By comparison, full-scale exploration wells in Hawaii are now estimated to cost in excess of $2.5 million.)

The Hawaii State Legislature has appropriated almost $9 million and the Congress added $5 million to the U.S. Department of Energy's FY 1991 appropriation for Hawaii's geothermal exploration program.

The state government has taken the lead in resolving environmental and social issues relating to geothermal development. These efforts include: public information—the conduct of predevelopment baseline surveys for noise, air, and water quality as well as human health, biota, archaeological, and Hawaiian cultural concerns and the preparation of a comprehensive master development plan including an Environmental Impact Statement (comparable to a California EIR) for large-scale geothermal development.

The state's Geothermal Project Office devotes much of its time to environmental and social issues. We feel we have developed the data to demonstrate that geothermal development can be accomplished in an environmentally sound and socially acceptable manner; however, we need to improve our ways of getting this message to Hawaii's residents, especially the people who live in or near the geothermal resource subzones, as well as to environmental groups and native Hawaiians.

A second effort of the state government is concerned with the economic feasibility of large-scale geothermal development, including the construction of an interisland cable system to transmit electricity from the Island of Hawaii to Oahu and possibly Maui. (Oahu, which has 90 percent of the state's population and electricity demand, is 98 percent dependent on imported petroleum for its electricity, with little likelihood of replacing oil with island resources in the mid-term.) The technical and environmental feasibility of the interisland cable system was demonstrated by the 8-year Hawaii Deep Water Cable Program, completed in late 1989 with federal and state funding. However, the cost of the cable will be significant - between $0.5 and $1.0 billion - adding several cents to the cost of each delivered kilowatt-hour.

The state government has participated with the Oahu utility in a process to select a consortium to finance, develop, own, and operate a large-scale geothermal program on the Island of Hawaii and the interisland cable system. The response from five international consortia indicates that the undertaking will be economically difficult without significant state support, particularly regarding the cable component. The utility is currently negotiating with Kilauea Energy Partners,

by Gerald Lesperance
Department of Business and Economic Development
Honolulu, Hawaii

headed by Mission Energy Company, to determine if this company can accomplish the large-scale project. Recently, Hawaii's energy officials realized that an interisland cable system may be needed within the next two decades, with or without large-scale geothermal development, to increase the overall state energy reliability (at least one major island is currently experiencing rolling blackouts) and to stabilize overall rates (residents on the Island of Molokai are currently paying over 20 cents per kilowatt-hour). The utilities, the government, and the independent power producers will need to be quite creative in finding ways to develop an interisland cable system with a negligible impact on Hawaii's taxpayers or ratepayers.

Private Activity

Puna Geothermal Venture (PGV), whose operating component is OESI Power Corp. (formerly Ormat Energy Systems Inc.), is working toward fulfilling a 25-megawatt utility contract on the Island of Hawaii by installing power plants and by drilling production and injection wells. The project site is near the government's HGP-A well in lower Puna. PGV anticipates delivering the first block of power about May 1991. The power system consists of 10 modules, each with a 1.8-megawatt back-pressure turbine feeding off to a 1.2-megawatt binary plant. Air cooling and injecting all geothermal fluids, including noncondensible gases, are plant features. A production well completed by PGV in late 1991 shows initial indications of higher electrical capability than any well yet drilled in Hawaii. With the demise of the government's HGP-A wellhead generator plant in December 1989, this PGV facility will be the only operating geothermal power plant in Hawaii.

The PGV project is on agricultural, primarily papaya-growing land in the Kapoho Geothermal Resource Subzone in lower Puna. Although the area is sparsely settled, a significant number of people live in its inexpensive and pristine environment. Major local concerns with geothermal development in lower Puna relate to a potential disruption of this rural lifestyle.

The Wyoming-based company, True/Mid-Pacific Geothermal Venture, is exploring for up to 100 megawatts of geothermal energy in the Wao Kele O Puna forest within the Kilauea Middle East Rift Geothermal Resource Subzone. The company completed five directional wells from the same borehole in 1990. Although most of the data are proprietary, the company has indicated that the wells reached temperatures of up to 700°F, that a resource was encountered in 4 of the 5 directional wells, that some of the resource is 100 percent steam, and that an extremely high entry pressure was observed.

The concerns expressed about the True/Mid-Pacific project are cultural and botanical. A small group of native Hawaiians has protested this project, particularly because it violates the volcano goddess Pele, interferes with the worship of Pele, and interferes with traditional native Hawaiian rights to gather natural materials such as flowers for leis and medicinal herbs, even though the land may be or is privately owned by others. This religious issue was resolved in favor of development in a legal case that the U.S. Supreme Court decided to let stand. However, the court case in no way reduced the strong opposition of some native Hawaiians to all geothermal development in Hawaii. Their concerns are a particularly sensitive part of an increasingly strong statewide activist movement to return traditional rights and practices to the Hawaiian people.

The botanical issue relates primarily to geothermal development within the Wao Kele O Puna rain forest. In 1985, with approval of both chambers of the state legislature, the state exchanged about 25,000 acres of this forest with the privately owned Kahauale'a forest. The purpose of this exchange, which was initially recommended by the local community, was to relocate proposed geothermal development to the less-pristine Wao Kele O Puna forest from the pristine Kahauale'a rain forest, which abutted on the Hawaii Volcanoes National Park and was close to the Village of Volcano.

At the time of the land exchange, it was considered a win-win move by the community, local environmentalists, developers, and federal, state, and county governments. However, the Pele Defense Fund remained opposed to all geothermal development. In 1989, the Pele Defense Fund invited the San Francisco-based Rainforest Action Network to Hawaii, which was the beginning of a rain forest-geothermal debate that is likely to exist for a long time.

Hawaiian Rain Forest Resolution

On September 14, 1990, California Senate Joint Resolution No. 75, Chapter 163, was filed with the Secretary of State. The resolution, titled "Relative to Hawaiian Rain Forests," also concerns the interisland cable project. The resolution was introduced by state Senator Art Torres of Los Angeles.

NEVADA

Nevada PSC to Compute Environmental Costs

The Nevada Public Service Commission, Las Vegas, Nevada, has adopted a rule that gives preference to clean alternative energy sources, such as solar, wind, and geothermal.

It is predicted that passage of the rule would expand the use of wind, solar, and geothermal energy, and bring a decline in the use of oil and coal.

The new rule amends existing commission regulations that spell out the formula for deciding whether to approve a proposed power plant.

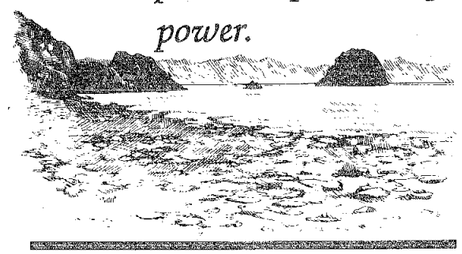
In the past, considerations included whether a plant could provide the public with affordable power while allowing utility stockholders a fair return on their investments.

The new regulation calls for utilities to consider environmental costs when planning new plants or purchasing power from other sources.

Reprinted from the Geothermal Resources Council Bulletin, *Feb. 1991.*

Only three state utility regulatory agencies, in New York and Massachusetts, have systems for analyzing the environmental costs of power plants. Nevada is the only state that permits consideration of economic factors beyond construction and operations, commission officials said.

Utilities must consider environmental costs when planning new plants or purchasing power.



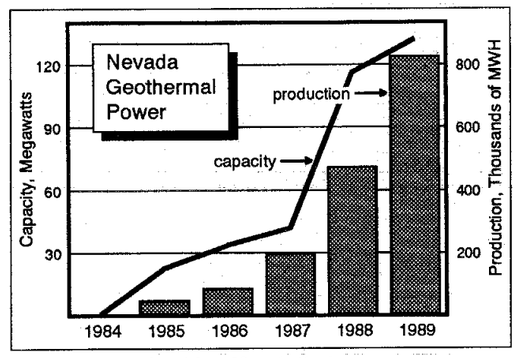
Geothermal Electrical Generation in Nevada

"Sierra Pacific Power Company has about 60 megawatts of Qualifying Facility (QF) electrical generation on line, 45 of which are geothermally generated. The remaining 15 megawatts are from biomass and hydroelectrical QF's," said Noreen Leary, Manager of the Power and Fuel Contracts Department at Sierra Pacific.

"In addition, the company has long-term contracts in place for another 115 megawatts of geothermal generation. This electricity is due on line from June 1991 to November 1995.

"By 1995, the company should have over 175 megawatts of QF-generated electricity on line. At that time, about 20 percent of Sierra Pacific's energy requirement will be met with purchases from QF's, the majority of which (160 megawatts) will be from geothermal power plants," Ms. Leary concluded.

According to *Nevada Geology*, the quarterly newsletter of the Nevada Bureau of Mines and Geology, the first geothermal power plant in Nevada was constructed in 1984 at Wabuska, 45 miles southeast of Reno. Its capacity was 600 kilowatts, initially, but has been increased to 1.8 megawatts. Since 1984, seven more geothermal power plants have been built in Nevada, also in the northwestern and the north-central parts. With the completion of the 13-megawatt Stillwater plant in 1989, Nevada's commercial geothermal generating capacity stands at 131.5 megawatts. These eight plants produced over 800,000 megawatt-hours of electrical energy in 1989.



The graph is reprinted from Nevada Geology.

Sierra Pacific Signs Contracts for Power Supplies

Sierra Pacific Power Company has finalized seven contracts with four western energy suppliers to produce over 100 megawatts of power to the company; some power will begin flowing to the Reno-based utility in the spring of 1991. Contracts were signed with three independent power producers using geothermal resources and one utility company to supply varying amounts of electricity to Sierra Pacific Power's 235,000 customers in northern Nevada and northeastern California over the next 30 years.

San Emidio Resources, a Nevada independent power producer, signed two, 30-year contracts with Sierra Pacific Power to begin supplying 5 megawatts of electricity in 1992 and an additional 20 megawatts in 1995 from geothermal sources near Gerlach, Nevada.

The Sparks-based OESI signed two, 30-year contracts for 13 megawatts each to supply power beginning in 1992 and 1993 from its geothermal resources in Soda Lake, Stillwater, and Ryepatch, Nevada.

Far West Capital, a Salt Lake City, Utah, company, will supply 12 megawatts of power to Sierra Pacific beginning in 1992, plus an additional 12 megawatts beginning in 1994 from its geothermal resources at Steamboat, south of Reno. Far West's contracts are also 30 years in duration.

The only utility among the group, Colorado-Ute Electric Association, of Montrose, Colorado, has contracted to supply 25 megawatts of power to Sierra Pacific beginning in June 1991, under a 17-year contract.

The contracts between the utility and the suppliers are now subject to approval by the Nevada Public Service Commission (PSC) before they become effective. Sierra Pacific Power will submit the contracts to the PSC as part of its amended resource plan. In addition, the contract with Colorado-Ute must also be approved by the U.S. Bankruptcy Courts.

Binary Unit Added to Caithness Steamboat Springs Power Plant

In February 1988, Caithness Steamboat Springs Power Plant began generating 12.5 megawatts, net, of electricity at Steamboat Springs, near Reno, Nevada. The power plant is run with steam extracted from 3 production wells. The wells have an average temperature of 430° F and an average depth of 2,500 feet.

About 5,000 feet from these wells, 1 injection well about 3,500 feet deep accepts 290°F spent hot water at a rate of 3,500 gallons a minute.

By late 1991, Caithness hopes to be putting this spent hot water to use by adding binary units to the power plant. The 290°F spent brine will run through these binary units and generate an additional 6 to 8 megawatts, net, of electricity.

The binary units are being designed and constructed by Barber-Nichols Engineering and will use Freon 22 as a working fluid. No new wells will be required to operate the plant.

"We're building the additions with the goal of making more efficient use of the Btu's coming out of the ground before injecting them," said Ted DeLong, General Manager of Yankee/Caithness Joint Venture L.P.

"One of the prime considerations for a project like this is the possibility of silica deposition," Mr. DeLong continued. "Heat exchanger tests were conducted to determine what would happen with silica deposition once the fluid was cooled to temperatures required for binary operation.

"This type of binary addition only works for a high-liquid content reservoir," Mr. DeLong explained. "At Steamboat, the reservoir is about 85 percent liquid and 15 percent steam, making operation of such a unit feasible. Also, most dual flash plants drop the temperature via the second flash to a level where the low-temperature brine would not be usable in binary units. However, if an existing plant is a single flash, chances are something more might still be gotten out of the fluid temperature," Mr. DeLong concluded.

California Energy Company and Chevron Sale Update

Further to its announcement on May 3, 1990, of the acquisition from Chevron Resource Company of certain geothermal operations in Utah and Nevada, California Energy Company (CEC) reports the completion of acquisition financing through a $35 million, 6-year unsecured term loan from Credit Suisse Bank and National Westminister Bank. An additional nonrecourse project finance term loan is being arranged for a wholly owned subsidiary company formed for the purpose of operating the acquired properties and the other properties and leasehold interests California Energy Company already owns in the region. The take down of this loan will coincide with the closing of the Chevron transaction and will be for the balance of the purchase price of $16.2 million or $33.7 million, depending upon whether the third party option is exercised on the power plant at Beowawe, Nevada.

This new business unit includes two geothermal operating properties in Nevada: Desert Peak (power plant and wells) and Beowawe (wells—CEC has a 20-year advanced sale contract for steam purchase with Sierra Pacific Power Company), and one in Utah: Roosevelt Hot Springs (power plant and wells). The business unit also includes an interest in the wells of the Oxbow Dixie Valley unit, and five confirmed geothermal prospects, primarily in Nevada, covering 129,690 leasehold acres plus an option on a further prospect, primarily in Nevada, covering 6,000 acres. The acquisition also includes the purchase of Chevron's overriding royalty interest in its Newberry Crater, Oregon, leaseholds. This royalty will be assigned to CEC's wholly owned northwestern subsidiary, CE Exploration Company.

Financing Closed for Ormat Power Plant in Nevada

In October 1990, Ormat Energy Systems (OESI) announced the close of financing for its Nevada geothermal power plant installation, Soda Lake Geothermal No. 2. It formed Soda Lake Resource Partnership with Constellation Energy, Inc., to acquire the geothermal properties from Chevron Resources. The acquisition included geothermal leases located on about 11,000 acres.

In addition, Constellation Energy agreed to combine Soda Lake Geothermal No. 1 and the new Soda Lake project, with a wholly owned subsidiary of OESI called AMOR 9 Corporation as the lessee under a 21-year lease. Prudential Power Funding Associates will provide up to $32 million for construction and long-term fixed rate notes.

The new Soda Lake project will consist of seven Ormat Energy Converters generating about 13 megawatts of power to be sold to Sierra Pacific Power Company under a 30-year contract.

OESI, through its affiliates, has already installed geothermal power plants producing over 100 megawatts of electricity in the United States. In addition, OESI, through the Puna Geothermal Venture, is developing a 30-megawatt geothermal project on the Island of Hawaii. This power plant is expected to begin producing electricity in early 1991.

Ormat Energy Systems now OESI

Officials of Ormat Energy Systems, Inc., have announced that effective February 1, 1991, the company will change its name to OESI Power Corporation. The decision to change the company name was made to better identify OESI as an emerging power company specializing in geothermal energy. Company operations and personnel will remain the same.

OESI Initial Public Offering

On May 10, 1991, OESI Power Corporation announced an initial public offering of 2,250,000 shares of common stock at $14.00 a share. Kidder, Peabody & Company Inc. is sole manager of the underwriting group. Proceeds from the offering will be used to fund development costs and project investments, to repay indebtedness, and to provide working capital. The company strategy is to continue growth through project development and to retain greater equity interests in future projects.

After this offering, the company will be approximately 40 percent owned by an affiliate of LFC Financial Corporation, 21 percent owned by Ormat, and 35 percent owned by the public. The balance of the shares, in general, will be owned by management.

WORLDWIDE

CANADA

Meager Creek Update

Canadian Crew Energy Corporation holds the rights to develop the geothermal resources underlying 410 hectares on the southern side of the Meager Creek volcanic complex, about 160 kilometers north of Vancouver, near Whistler, B.C. The project is the first of its kind in Canada.

The Meager Creek project has been developed over 15 years, with expenditures in excess of $30 million. Identified as a result of the B.C. Hydro and Power Authority's alternate power program, which commenced in the 1970s, the Meager Creek resource was deemed the most economically significant geothermal resource in the Province of British Columbia, on the basis of an extensive geological and geophysical study.

Work by B.C. Hydro and Energy, Mines & Resources Canada included some 80,000 feet of diamond bit drilling, together with environmental, geological, engineering, and other related studies for the project. In the early 1980s, three deep exploration/production wells, drilled to depths of between 3000 and 3500 meters (9,800 to 11,500 feet), intersected zones of geothermal energy. The bottom-hole temperatures range from 230°C to 270°C (445°F to 520°F) and indicate a very significant geothermal resource. One of these exploration wells has been capable of producing some 30,000 kilograms of steam and hot water per hour. Production from this well is expected to increase considerably upon recompletion. Canadian Crew Energy advanced these geothermal investigations by studying the isotopic characteristics of deep thermal waters. These data confirm the presence of abundant, high-temperature fluids at Meager Creek at an accessible depth.

The Meager Creek resource, when developed, is thought to be capable of producing about 260 megawatts of electricity, enough to meet the total electrical power requirements for a population of about 250,000 people. The overall potential may be well in excess of this figure. The anticipated total costs involved in fully developing the project are estimated at about $500 million, with the development taking seven years and power production beginning as early as 1992/3. The recent initiative by the B.C. government in encouraging power production by private enterprise, the Free Trade Agreement, the bilateral energy treaties, and the inter-tied transmission systems between Canada and the U.S. are all beneficial to the project at Meager Creek.

In June 1990, B.C. Hydro & Power Authority announced a specific request for proposals from independent power producers to supply electricity from geothermal resources. Canadian Crew Energy Corporation submitted such a proposal, together with Calpine Corporation and Sandwell, Inc.

B.C. Hydro has confirmed that the Canadian Crew Energy proposal was the only response to its June 1990 request for proposals relating specifically to the development of geothermal resources. The company's proposed 30-megawatt demonstration plant, together with two additional 30-megawatt increments, did not meet B.C. Hydro's current requirements. However, B. C. Hydro said it is prepared to consider a revised proposal for a geothermal pilot project that would meet its pricing guidelines. Consequently, Canadian Crew is preparing a revised proposal for a smaller pilot plant that, it is believed, will be acceptable to B.C. Hydro.

Canadian Federal Geothermal Funds To Be Eliminated

Reprinted from the *Canadian Geothermal Energy Association Newsletter*.

The Canadian Geothermal Association has learned that the Canadian Office of Energy Research and Development of the Federal Department of Energy, Mines and Resources, which has provided funds for geothermal energy resource assessment, development, and exploitation for many years, has decided to eliminate the funding as of the end of March 1991. There will be no federal government program in geothermal energy after that time, unless the decision is reversed. The federal program has been in existence since 1976.

Current Geothermal Projects in Canada

Reprinted from the *Canadian Geothermal Energy Association Newsletter*.

There are seven geothermal projects in Canada with which the Department of Energy, Mines and Resources, primarily through the Geological Survey of Canada, has involvement.

Springhill: Warm water (at about 20°C) from abandoned coal mines is being used to heat commercial and industrial buildings, with expansion to municipal buildings planned.

Ottawa: Several buildings on the campus of Carleton University are being heated using as a resource lukewarm (9.5° C) groundwater flowing through faults and fractures underlying the campus.

Moose Jaw: The feasibility of using warm water from an aquifer underlying the city to heat municipal buildings and a public swimming pool is being examined.

Summerland: The feasibility of using warm water from an aquifer underlying the town to heat agricultural buildings is being examined.

Mayo, Y.T.: Warm water from an aquifer underlying the village is being used to heat public buildings, and also to prevent freezing of the water main.

Lakelse, B.C.: The Government of British Columbia has recently awarded a permit for exploration of an anticipated low- to high-temperature (60°C to 100°C) resource.

Mt. Meager: In the Mt. Meager volcanic area 160 kilometers north of Vancouver, exploration and development of a high-temperature resource for electrical power generation is underway. It is anticipated that the project may eventually provide about 260 megawatts of electricity.

CENTRAL & SOUTH AMERICA

Incident at Zunil

NOTE: *The following press release was issued by the Geothermal Resources Council on January 9, 1991, to correct an erroneous, but widely printed version of an event that occurred in the Zunil Geothermal field, near Quetzaltenango, Guatemala, on January 5, 1991. On this day, a landslide moved downslope against a geothermal well in Zunil field, probably breaking off the well head and shearing casing, thus allowing steam to flow from the well.*

The erroneous, but widely circulated version of the event, distributed by the Associated Press and written by Alfonso Anzueto, suggests that a well blowout, not a landslide, was the initial event to occur at the site. The article begins "A well exploded at an unfinished geothermal power station in western Guatemala . . . The explosion let loose a number of landslides in nearby mountains . . ."

The GRC press release follows:

Guatemala Landslide and Geothermal Well Damage

At 10:30 pm on Saturday, January 5, 1991, a massive landslide moved downhill into and through part of the Zunil Geothermal field, near the city of Quetzaltenango, about 70 miles northwest of Guatemala City. The slide, which came at the end of the rainy season, damaged a geothermal well, No. ZCQ-4, located beneath the toe of the slide area. Several buildings were destroyed by the landslide. To date, it has been reported that 17 bodies have been recovered from the slide debris.

Proyecto Geotérmico de Zunil.

The slide area is estimated to be about two thirds of a mile long, from 600- to 1,000-feet wide, and 10- to 30-feet thick. Reports that the geothermal well, or a geothermal power plant, exploded or in some way caused this landslide, are erroneous.

The well site is now buried under several feet of debris. The well head probably was knocked off by the slide, and the casing below the well head may have been sheared off. Presently, steam is flowing upward through the slide debris over the well site; in this condition, which is similar to a natural fumarole in appearance, there is little if any danger


The landslide at Zunil and Thomas Flynn, from the Division of Earth Sciences' video. The top arrow points to the steam billowing from the well damaged by the slide. The lower arrow points to the road that was partially covered by the slide.

to life or property. The well was completed in early 1981 and remained intact at the toe of the long identified slide for over 10 years. An earlier movement on the slide on Friday, December 28, 1990, covered the drill pad and filled the well head cellar with debris. There was no damage to the well at that time.

Geothermal exploration at Zunil has occurred for more than a decade with help from geothermal experts from Italy, Japan, and the United States. A 15-megawatt power plant has been planned for Zunil by the Guatemalan Instituto Nacional de Electrificación (INDE), the national electrical utility, with financing from the Inter-American Development Bank. Plant construction has not begun. At the time of the landslide, drilling was underway at a new well away from the landslide area. This well was undamaged. However, drilling operations were suspended due to the closure of the highway by the slide, thus cutting off supplies of water, fuel, and other necessary materials to the drill site.

The landslide and the subsequent loss of life is tragic. However, this tragedy was not caused by the geothermal field activities; the landslide would have occurred—and caused the same levels of damage and loss of life—even if no geothermal development had taken place.

The slide was caused by groundwater trapped in the slide material itself. Accounts of this tragedy citing a geothermal blast at an unfinished geothermal power plant or a geothermal well exploding are fictitious. In truth, there is no geothermal power plant in the area; a vegetable dehydration facility on the site neither produces steam nor electrical energy.

FINAL NOTE: VIDEOTAPE AVAILABLE

The Division of Earth Sciences, University of Nevada, Las Vegas, announces the completion of a 22-minute videotape that documents a scientific investigation of the January 5, 1991, landslide at Zunil Geothermal field.

The landslide occurred along the Zunil fault zone, in an area of active fumaroles and extensive hydrothermal alteration. The slide is about 800 meters long, 300 meters wide, and claimed the lives of 23 people. The 22-minute video includes aerial views of the slide and expert and eyewitness testimony of the slide and devastated area.

Copies of the video are available on VHS format for $25.00. Contact Thomas Flynn, Division of Earth Sciences, 100 Washington Street, Suite 201, Reno, Nevada 89503. Phone (702) 784-6151 or Fax (702) 784-4549.

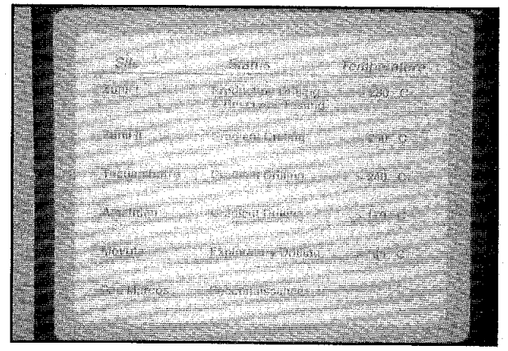
Geothermal in Guatemala

In Guatemala, 33 volcanos, several still active, run along the southern edge of the central mountain chain. From Tajumulco, the highest volcano in Central America (13,812 feet) near the Mexican border, down to El Salvador, the volcanos trace a major fault line almost parallel to the Pacific Coast.

Moyuta Geothermal field was the first geothermal area to be explored in Guatemala. Geological, geochemical, and geophysical prospecting were performed in 1972. After surface studies were completed, two exploratory wells were drilled to depths of 1000m each. Maximum temperature reversals were observed below that point. Exploration at Moyuta has lagged following the exploratory drilling.

Zunil Geothermal field is 120 miles northwest of Guatemala City in western Guatemala's volcanic province, near the Cerro Quemado and Volcán Santa María volcanoes. Preliminary exploration at Zunil began in 1973 and continued through 1977. Technical assistance was provided by the government of Japan through geophysical studies.

Deep drilling began in 1977 by the National Electrification Institute (INDE) as a prelude to a power-plant feasibility study. The drilling program encountered a high temperature reservoir at 1130m. A total of 6 exploratory wells were drilled, with 4 eventually producing steam in commercial quantities. The Inter-American Development Bank is funding a project for the development of the Zunil geothermal site, which includes the installation of a 15-megawatt power plant. A joint effort of INDE, the Guatemalan Ministry of



From the exhibit by Dr. Caicedo at the Geothermal Resources Council International Symposium. Photo by Susan Hodgson.

by Ing. Andrés Caicedo,
Executive Director of the Energy Development Unit,
National Institute of Electricity (INDE)

Energy and Mines, and the U.S. Agency for International Development/Los Alamos National Laboratory provided a demonstration geothermal dehydration plant to process fruits and vegetables from the agricultural areas near Zunil.

Amatitlán Geothermal field is within the volcanic belt of south-central Guatemala. Preliminary surface geoscience investigations have shown that high-temperature resources may be present at depth. Geothermometers applied to fluid chemistry data have indicated a possible reservoir temperature of 280°C. Shallow thermal-gradient drilling has revealed a temperature of 140°C at a depth of 80m within the field.

Other geothermal areas in Guatemala have been assessed in a preliminary manner. Surface geologic mapping and geochemistry have been performed by INDE in the areas of Atitlán, Palencia, Tecuamburro, Los Achiotes, Laguna de Ayarza, and Laguna de Retana.

NOTE: The November-January 1989-90 issue of the University of Utah Research Institute's *UURI Outlook* summarizes recent fluid inclusion studies of active geothermal systems at Zunil Geothermal field. Only in the last few years have such studies been applied to geothermal development. The article states that fluid inclusions are a powerful tool for obtaining chemical data for regions of the reservoir where the fluids cannot be sampled directly.

The article ends with the following information:

The fluid inclusion data show that the upper kilometer of the geothermal reservoir at Zunil is compositionally stratified and enriched in CO_2. The relatively high temperatures and gas contents of the fluids are indicative of steam-heated groundwaters. These groundwaters form a cap over the system that becomes progressively thicker to the east as the fluids move down the local hydrologic gradient. The geometry of the cap suggests that the main upwelling center of the thermal system is located on the western side of explored portions of the field where the cap is thinnest.

For further information of how fluid inclusion studies can be applied to geothermal development, contact Joseph N. Moore at UURI, (801) 524-3428.

Hydrothermal Explosion at Ahuachapan

According to officials of the Comisión Ejecutiva Hidroeléctrica del Rio Lempa, a natural hydrothermal explosion occurred on Saturday, October 13, 1990, at about 1:30 am in a village called El Barro, about 1.5 kilometers outside the southern boundary of the Ahuachapán Geothermal field in western El Salvador. By October 15, 14 people had been reported as dead and 21 as injured, some seriously.

During the explosion, an area 2 to 3 meters in diameter of fumaroles, mud pots, and boiling ground, called Agua Shuca, erupted violently, producing a blast of wind, stones, and boiling water that affected an area of 100-meter radius around the fumaroles, destroying several huts, and crushing people inside the huts. The affected area is outside the well field, about 2 kilometers south of the Ahuachapán power plant and 100 meters south of well AH-9, a dry hole drilled in 1971. A now quiet boiling mud pond, 10 meters in diameter, has formed where the fumarole field was previously.

The crater at Agua Shuca, on January 9, 1991. Photo by Ronald DiPippo.

A hydrothermal explosion is defined as an explosion produced when high-temperature water contained near surface rock flashes to steam and violently disrupts the confining rock. These explosions are so violent that a large proportion of solid debris is expelled, along with steam and water. This definition is from the paper by Muffler et al. (1971), "Hydrothermal Explosion

Craters in Yellowstone National Park," GSA Bull. vol. 82, pp. 723-740.

El Salvadoran officials emphasize that the hydrothermal explosion was not a well blowout, but a normal, natural phenomenon, although not one found frequently in geothermal fields. Such explosions occur over faults, as may have happened in this case with the Agua Shuca fault.

To prevent possible future damage from hydrothermal explosions, officials are undertaking various studies at the site, such as seismic monitoring; geochemical well monitoring for water and gases; and temperature monitoring in wells, fumaroles, and geysers.

The integration and interpretation of all these data will show the exact origin of the hydrothermal explosion and the risks from such events in the area of Agua Shuca.

The following information is from a display entitled "Country Update Report of El Salvador" by Gustavo Cuellar, presented at the Geothermal Resources Council International Symposium, August 1990.

Geothermal Situation				
Field	Present Activity		Future Activity*	
Ahuachapán	95MW	Exploitation stage		
Berlin	10MW	Under construction	1990-1999	90MW
Chipilapa		Feasibility stage - · 10MW under development	1991-1997	60MW
Coatepeque		Prefeasibility stage	1996-2000	35MW
San Vicente		Prefeasibility stage	1995-1999	40MW

**US $430 x 10^6 Investment in services, technical assistance, materials, and equipment.*

Costa Rican Update

"We are finalizing the bid-judging process and will soon purchase electrical-generation equipment for Power Plant Unit 1 in Miravalles Geothermal field," said Alfredo Mainieri, Chief of Geothermal Resources for the Instituto Costarricense de Electricidad. "This is a 55-megawatt, single-flash power plant with only one turbine. We are funded and ready to start construction. The power plant is scheduled to go on line during the first half of 1994.

"Power Plant Unit 2 will be added onto the southern side of Unit 1," Dr. Mainieri continued. "Unit 2 will be a 55-megawatt, single-flash unit, which is scheduled to be completed in 1995. The solicitation documents for constructing and equipping Unit 2 will be published at the end of 1991.

"We are also completing the contracting process for drilling 20 additional wells," Dr. Mainieri continued. "Some of these wells will be production and injection wells for Unit 1, and some will be drilled to explore the reaches of Miravalles field to the north, south, and southeast. All the injection wells will be on the western side of the field.

"To date, 9 wells have been drilled in the field. The wells are capable of producing about 37 megawatts of electricity. Two of these wells will be used as injection wells. Both power plant units will need 11 production wells and 5- to 6-injection wells. Ten additional wells will be drilled to supply steam to Unit 2.

Private ownership is possible for Costa Rican electrical power-generating facilities.

"We have to study the possibility of installing perhaps two other power plant units at Miravalles. The number and the type will be decided after we learn the reservoir characteristics in the new areas," Dr. Mainieri said.

I met with Dr. Mainieri just before he and four Costa Rican colleagues made featured presentations at a Costa Rica Reverse Trade Mission Workshop sponsored by the California Energy Commission.

Dr. Mainieri said that he and his colleagues were at the workshop and undertaking a schedule of meetings with US geothermal company representatives because of their interest in temporarily affixing small, back-pressure power-plant units to production wells between the time the wells are drilled and the time they begin passing steam into the 55-megawatt units. The first two wells that would be involved in the plan are at the present north-northeastern border of the field. One well would become the production well, and one the injection well.

As a final item of interest, a workshop participant mentioned that a new law was just passed in Costa Rica allowing for private ownership of electrical power-generation facilities. The electricity will be transmitted through the grid of the Instituto Costarricense de Electricidad. However, 40 percent of the shares of such companies must be owned by Costa Ricans.

by Susan F. Hodgson

High-Temperature Geothermal Development in Ecuador

"Within the last 10 years, Ecuador's Quaternary volcanic terrain has been mapped for the first time. The country's old geological maps, although of good quality and quite useful, had been drawn from the point of view of a sedimentologist, and more detail was needed in the volcanic regions," said Bernardo Beate, a geologist with the Geothermal Project of the Instituto Ecuatoriano de Electrificación (INECEL), the institution in charge of geothermal exploration and development for electrical uses.

"In the early 1980s, a reconnaissance study was made of Ecuador's high-temperature geothermal resources," Dr. Beate continued. "Three areas were chosen for a more detailed, prefeasibility study: the sites known today as Tufiño, Chalupas, and Chachimbiro Geothermal fields.

"Tufiño Geothermal field straddles the border of Ecuador and Colombia, in an area about 30 kilometers west of Tulcán, Ecuador, and Ipiales, Colombia. In 1982, geological and geochemical studies were made of the field. In 1987, geophysical and magnetoteluric surveys were performed, and a preliminary field model was created. Tufiño field is related to the dacitic Chiles volcano. Field temperatures are in excess of 180°C at a depth of 1500 to 2000 meters; and acidic sulfate springs are scattered around and upon the volcano. The development of Tufiño field became a binational project, under the coordination of the Organización Latinoamericana de Energía (OLADE) and both countries' national electrical companies: INECEL for Ecuador and the Instituto Colombiano de Electricidad (ICEL) for Colombia. Field studies were carried out with technical assistance funds from the Italian Government.

"Sites for three shallow wells in Tufiño field have been located and funding for drilling requested through OLADE from the Italian Government.

"Chalupas Geothermal field is in the eastern cordillera, 60 kilometers southeast of Quito, Ecuador's capital. The field lies close to Cotopaxi, an active andesitic volcano, and is lodged within a caldera 20 kilometers in diameter, formed during a huge rhyolitic eruption in Pleistocene times. Detailed geological and geochemical surveys support the presence of a deep and hot geothermal reservoir to be proven by drilling.

"The Chachimbiro Geothermal field, located about 70 kilometers north-northeast of Quito on the western cordillera, is related to Pleistocene explosive dacitic and andesitic volcanic activity and recent tectonics, permitting hot chloride-rich waters to reach the surface. Geothermometry indicates deep temperatures of about 230°C. No drilling has been attempted, due to lack of funds.

"During the last years, INECEL has identified about 10 other geothermal areas, including Cuenca, Papallacta, and Chimborazo, which need detailed geoscientific studies to be properly assessed," Dr. Beate concluded.

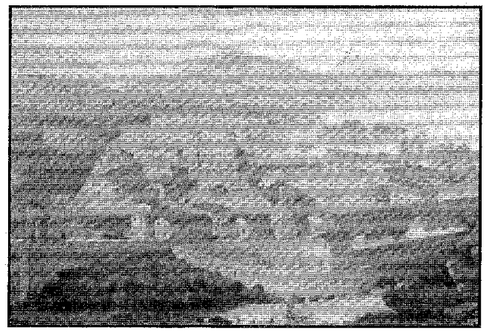
For further information, contact Dr. Beate at INECEL-Geothermal Project, PO Box 111-12 Oct., Quito, Ecuador. Phone 593-2-447108.

NOTE: Low-temperature geothermal development in Ecuador is described in the December 1989 issue of the *Geothermal Hot Line*.

by Susan F. Hodgson

Historical Vistas of Larderello

The following lithographs, reprinted from the originals by the Ente Nazionale per L'energia Elettrica (ENEL) and reproduced here with permission, are from a set of 20, drawn in the last century to depict life and geothermal development in the Larderello, Italy, area. Information in the captions is from two ENEL publications: *Il Museo di Larderello*, and *Larderello and Monte Amiata -- Electric Power by Endogenous Steam.*



The Tabula Itineraria Pentingeriana (3rd century A.D.) offers the most reliable and earliest documentation of knowledge of geothermal manifestations in Italy's Larderello region.

In 1777, boric acid was discovered in the water of the hot springs there by F. U. Hoefer, Director of Pharmacy of the Grand Duchy of Tuscany.

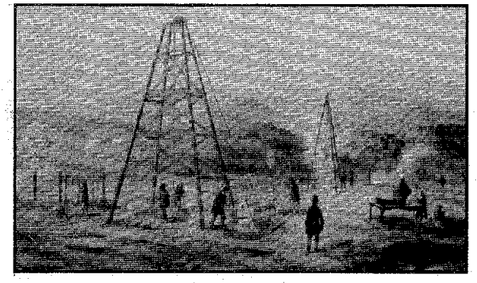
In 1818, the extraction of boric acid from these waters was undertaken by Francesco Larderel, a recent emigre from France.

This lithograph is of the first factory, built by Larderel near the ancient Castle of Montecerboli. In 1846, it was given the name Larderello, after its founder.

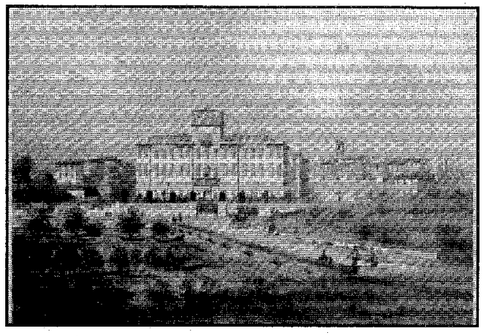
It was Larderel who used the steam from the hot springs, instead of wood, to provide thermal energy to extract the borax.

A steam collection device, called a lagone coperto, was built over the hot springs. Pipes leading from the structure were for the adduction of steam and boron-bearing water to evaporation tanks for the extraction of boric acid.

View of Larderello.



Exploration for steam by means of drilling, at first concentrated at the sites of geothermal manifestations, was later extended throughout the boraciferous region with the use of constantly improved drilling equipment.



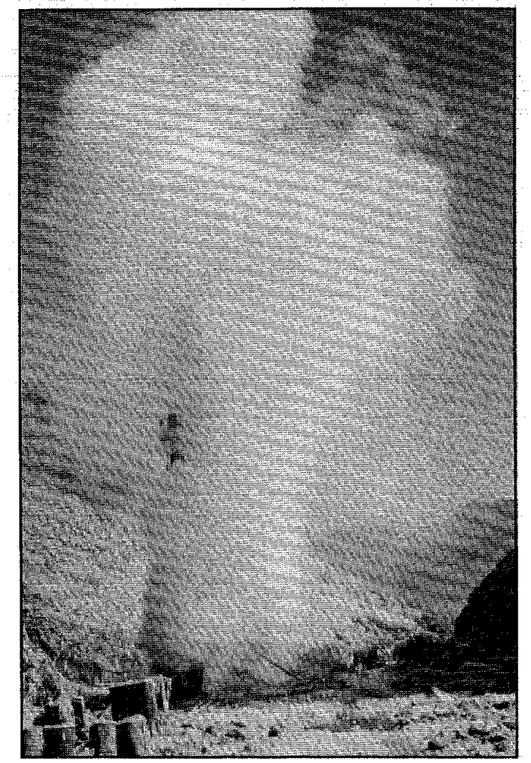
Chateau of the Conte de Larderel.

Another High-Temperature Geothermal Field on the Roof of the World

Yangyi Geothermal field is another high-temperature, high-pressure reservoir on the Xizang (Tibet) Plateau, China, on the southwestern end of the Yangbajain basin. Its development will follow that of Yangbajain Geothermal field. It is about 55km from Yangbajain Geothermal field, and about 75km west of Lhasa City. Yangyi Geothermal field is characterized by a hydrothermal convection reservoir with tectonic fractures.

Yangyi Geothermal field is in the Damxung-Yangbajain-Doqenco Active Tectonic Zone, and occurs in the horsts and grabens formed by Tertiary volcanic lava. The hydrothermal manifestations are quite strong in the field area, and are concentrated in an area of several square kilometers. The major hydrothermal manifestations include hydrothermal eruptions, intermittent fountains, boiling springs, hot springs, warm springs, heated ground, steaming ground, travertine, siliceous sinter, and strong hydrothermal alterations.

We have finished the primary investigation, detailed investigation, and exploration of the thermal field area that were begun in 1981. We've conducted a geological and hydrogeological survey, chemical analyses of rock, soil, hot fluid, and steam, geophysical exploration, geochemical exploration, geothermal drilling, geophysical logging, and reservoir testing.



The spurting sight of the hot fluid in well No. 208. Photo by Mr. Qin Changlong.

In two of the geothermal wells drilled, temperatures over 200°C were measured at depths from 250 to 350m. The measured temperatures are over 201°C (well No. 203) and 204°C (well No. 208), the pressure is over 12 atmospheres, and the rate of flow is over 402,000 kg/h. That is rare in China and in all of Asia, including the island areas. The sight of the spurting hot fluid in well No. 208 is shown in the photo.

by *Mr. Yan Shishu, Research Centre of Chengdu Hydrogeology and Engineering-Geology, Xi Bei Qiao, Chengdu, Sichuan, The People's Republic of China,*
and
Mr. Wang Daichang and Mr. Cai Degen, Geothermal Geology Team of Tibet Autonomous Region, Lhasa, Xizang (Tibet), The People's Republic of China

Because of their special geographical location and special type and cause of formation, Yangyi Geothermal field and Yangbajain Geothermal field, both on the roof of the world, are important not only as energy resources for the Lhasa area, but more so as part of geothermal and earth science in China and the world.

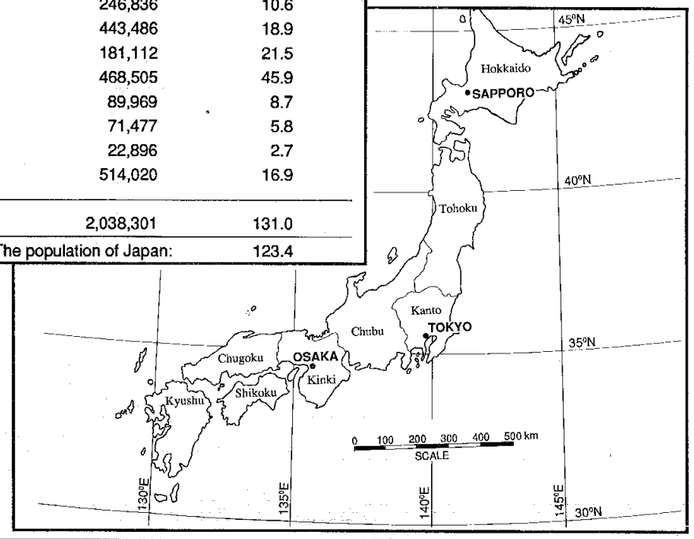
JAPAN

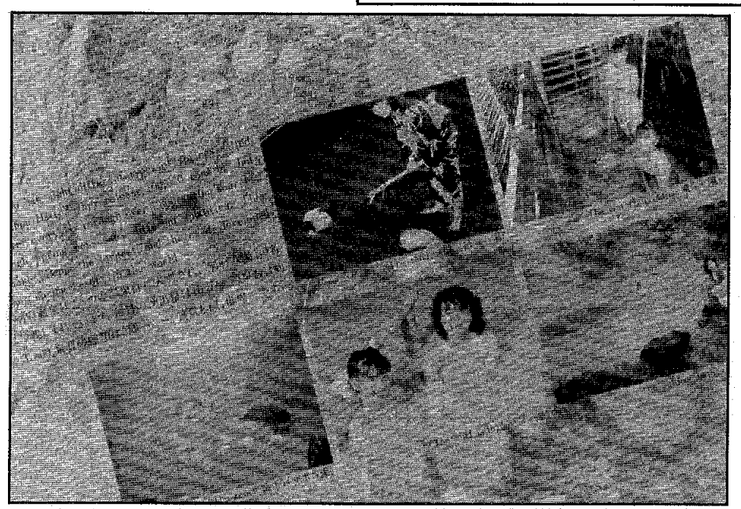
Potential Installed Thermal Power of Geothermal Direct-Use Projects in Japan

by Dr. Mitsuru Sekioka
The National Defense Academy
Department of Geoscience
Yokosuka, Kanagawa, Japan

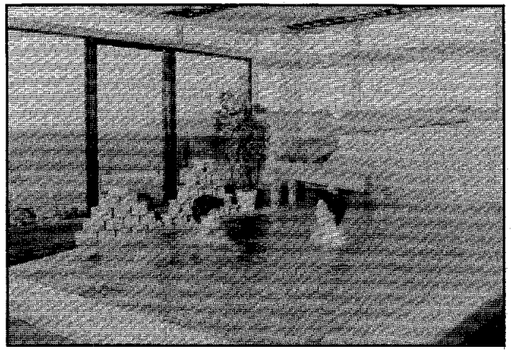
Spas in Japan.

REGION	NUMBER OF SPAS	NUMBER OF HOT SPRINGS	FLOW RATE (l/min)	NUMBER OF GUESTS (in millions)
Hokkaido	207	1,729	246,836	10.6
Tohoku	536	3,087	443,486	18.9
Kanto	248	1,673	181,112	21.5
Chubu	617	4,508	468,505	45.9
Kinki	161	936	89,969	8.7
Chugoku	164	1,044	71,477	5.8
Shikoku	77	273	22,896	2.7
Kyushu	244	8,086	514,020	16.9
TOTAL	2,254	21,336	2,038,301	131.0
			The population of Japan:	123.4





Beppu has eight different types of springs called "Beppu Hatto." They release 100,000 tons of hot water every day through over 3,800 spring sources. Each spring possesses different qualities. This makes Beppu the largest, most developed hot-spring resort in the world.



Typical Japanese-style wooden bath.

Typical outdoor open-air bathing in spas in Japan.

The January 1990 version of the installed thermal power of direct uses of geothermal energy in Japan.

Prefecture*	Space Heating MWt	Agriculture MWt	Aquaculture MWt	Snow Melting MWt	Pools MWt	Industry MWt	Stock Breeding MWt	Total MWt
Hokkaido district								
HK	9.47	23.09	0.92	3.81	0.65	0.45		38.39
Tohoku district								
AO	0.73	0.12	0.03	1.40				2.28
IW		3.22						3.22
MY	0.19	1.65	0.03	0.74				2.61
AK	0.65	7.19	1.21	1.18	1.33	0.82		12.38
YT	0.08	0.00	3.29	1.81				5.18
FS					1.95			1.95
Kanto district								
GM	4.44			1.81	0.39			6.64
TG	0.09	0.05		0.05				0.19
Chubu district								
NN	1.85	0.40		1.14	0.01			3.40
SZ	0.86	1.27	3.58				0.10	5.81
GF	16.37	0.05	1.41	0.52	0.21			18.56
Kinki district								
HY					0.09			0.09
WK			0.17					0.17
Chugoku district								
OK	0.12	0.02						0.14
SN			0.01	0.35				0.36
YG		0.20						0.20
Shikoku district								
Kyushu district								
SG		0.01						0.01
KM	0.96	0.93	1.06					2.95
OI	12.55	20.52	4.24					37.31
KG	3.45	8.24	12.92		0.08	0.02	0.10	24.81
TOTAL	51.81	66.96	28.87	12.81	4.71	1.29	0.20	166.65

*Abbreviation of names of prefectures is as follows.
HK: Hokkaido, AO: Aomori, IW: Iwate, MY: Miyagi, AK: Akita, YT: Yamagata, FS: Fukushima, TG: Tochigi, GM: Gunma, NN: Nagano, SZ:Shizuoka, GF: Gifu, HY:Hyogo, WK: Wakayama, OK: Okayama, SN: Shimane, YG: Yamaguchi, SG: Saga, KM: Kumamoto, OI: Oit, KG: Kagoshima.

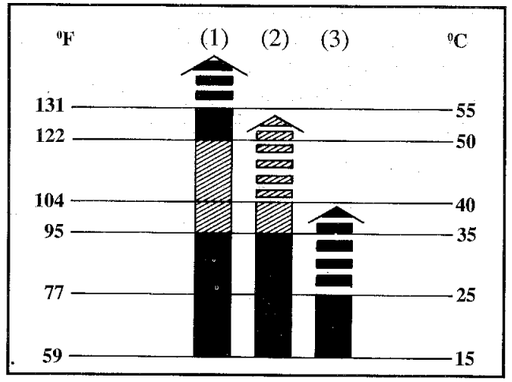
As a step towards expanding geothermal direct-use activities in Japan, the extractable heat, without interferring with bathing, has been estimated from thermal springs all over the country. The estimate is carried out only for existing thermal springs without drilling new geothermal wells.

An estimate is carried out under the following assumptions:

(1) Thermal-spring water with temperatures greater than or equal to 55°C is usable for direct uses down to 50°C before bathing uses, which occur between 50° and 35°C. Also, usable for direct uses between 35° and 15°C by filtering after bathing.

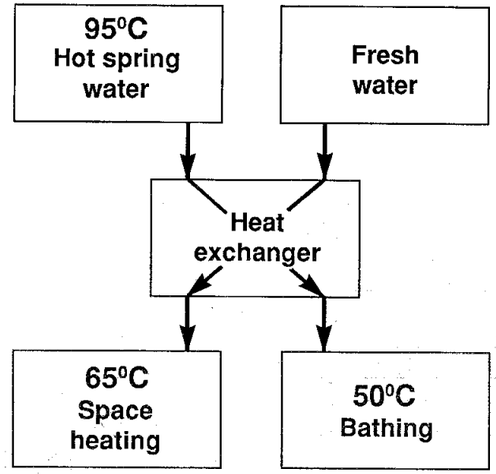
(2) Thermal-spring water usable for bathing, to 35°C. Usable for direct uses between 35° and 15°C by filtering after bathing.

(3) Thermal-spring water, 25°C. Usable for direct uses down to 15°C.

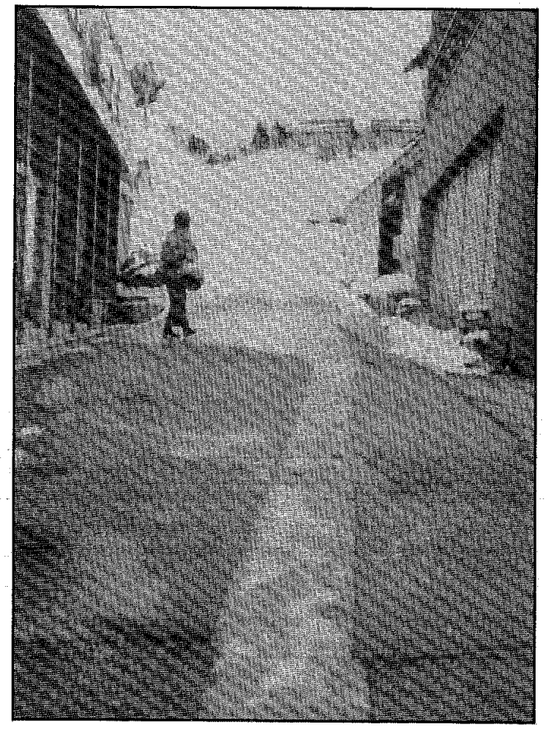


Temperature ranges of extractable heat from thermal spring water at different well head temperatures for direct uses in coexistence with bathing. Dark bands indicate the extractable range, and shaded areas indicate the range for bathing.

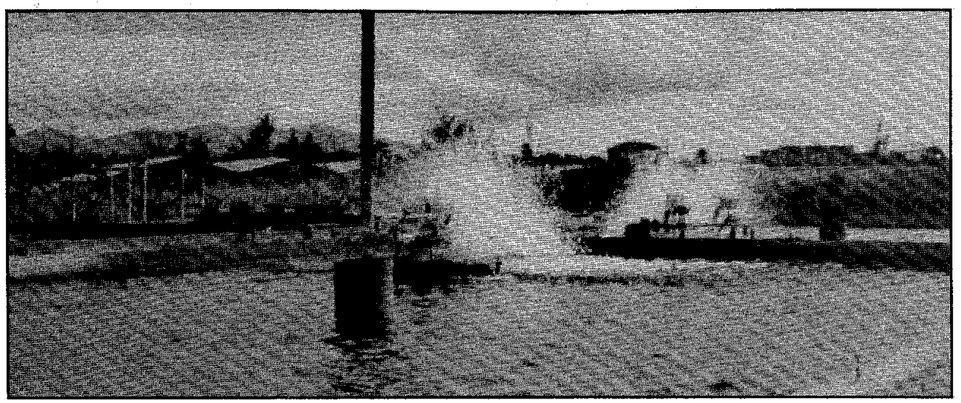
EXAMPLES



Kamitakara (space heating).



Okura (snow melting).

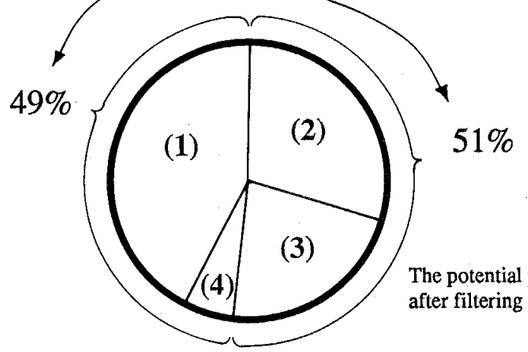


Ibusuki (fish breeding).

Extractable heat from existing thermal springs, classified by well head temperature (in MWt).

Region	Well head Temperature (T°C) 55≦T Usable Temperature Range 50≦T	15≦T≦35	40≦T<55 15≦T≦35	25≦T<40 15≦T	Total	Installed Thermal Power (MWt)	Rate of Utilization
Hokkaido	95.03	64.40	146.22	14.09	319.74	38.39	12%
Tohoku	156.12	241.92	29.28	25.33	452.65	27.62	6%
Kanto	153.05	136.95	31.48	8.69	330.17	6.83	2%
Chubu	330.38	192.62	147.23	38.28	708.51	27.77	4%
Kinki	33.24	22.65	1.62	18.41	75.62	0.26	1%
Chugoku	21.14	23.18	11.97	8.73	65.02	0.70	1%
Shikoku	0	0	3.58	2.60	6.18	0	0%
Kyushu	445.19	230.25	40.50	23.33	839.27	65.08	8%
TOTAL	1234.15(1)	911.97(2)	411.88(3)	139.46(4)	2797.16	166.65	6%

1323.85 (MWt)



The potential power from the water after filtering is greater than expected.

- Potential installed thermal power = 2797 MWt
  (Extractable heat under the assumptions)
- Assumed disqualifying factor: 30%
  2797 MWt x 0.30 = 840 MWt
- Total average load factor: 63%
  840 MWt x 0.63 = 530 MWt (potential thermal energy used)
- Thermal energy used = 105 MWt
  (About 5 times larger than the present value)

The January 1990 version of the thermal energy used and the oil saved with direct uses of geothermal energy in Japan.

Prefecture*	Space Heating MWt	Agriculture MWt	Aquaculture MWt	Snow Melting MWt	Pools MWt	Industry MWt	Stock Breeding MWt	Total MWt	Fuel Oil Sales Volume 10^6 kl	Oil Saved %
Hokkaido district										
HK	6.91	15.54	0.92	1.34	0.55	0.23		25.49	12.3	0.24
Tohoku district										
AO	0.37	0.05	0.03	0.70				1.15	2.6	0.05
IW		1.43						1.43	1.8	0.09
MY	0.13	1.15	0.03	0.20				1.51	3.9	0.04
AK	0.35	3.51	1.21	0.33	1.07	0.47		6.94	1.8	0.09
YT	0.04	0.00	3.29	0.50				3.83	1.5	0.29
FS					1.95			1.95	4.1	0.05
Kanto district										
GM	1.44			0.65	0.20			2.29	2.5	0.11
TG	0.03	0.03		0.02				0.08	2.7	0.00
Chubu district										
NN	0.98	0.21		0.31	0.00			1.50	2.7	0.06
SZ	0.38	0.66	2.69				0.04	3.78	5.7	0.08
GF	8.19	0.03	1.23	0.16	0.07			9.68	2.7	0.41
Kinki district										
HY					0.01			0.01	6.9	0.00
WK			0.07					0.07	3.3	0.00
Chugoku district										
OK	0.07	0.01						0.08	8.2	0.00
SN			0.01	0.09				0.10	0.9	0.00
YG		0.05						0.05	5.0	0.00
Shikoku district										
Kyushu district										
SG		0.00						0.00	1.1	0.00
KM	0.38	0.48	1.06					1.92	1.9	0.12
OI	9.43	14.22	4.24					27.89	4.3	0.75
KG	3.34	3.73	7.65		0.08	0.01	0.03	14.84	2.2	0.78
Total	32.05	41.10	22.43	4.30	3.93	0.71	0.07	104.59	208.2**	0.06
Load Factor %	62	61	78	34	84	55	35	63		

* For names of prefectures, see the second table in this article.
** This amount includes the fuel-oil sales volumes from other prefectures with no geothermal direct use.

CONCLUSION

Japan, therefore, has an abundance of geothermal water to use for various direct-use projects without developing additional resources. This will increase the amount of oil saved by using direct-use geothermal projects from 0.06 percent to 0.35 percent.

Japanese High-Temperature Update, 1990

Geothermal power plants in Japan are all in good condition and operating well. The operation status and wells of each power plant are given in Tables 1 and 2, respectively. No new geothermal power plants went into service in 1989, but the Hatchobaru Power Plant Unit II of Kyushu Electric Power Co., Inc., was completed and placed in service on June 22, 1990.

Among the power plants listed in the construction plan, Uenotai (Akita Geothermal Energy Co., Ltd.) aims at starting operation in March 1994. Sumikawa (Mitsubishi Metal Corporation), Okuaizu (Okuaizu Geothermal Co., Ltd.), and Kakkonda No. 2 Unit (Tohoku Geothermal Energy Co., Ltd.) are now under development.

Power plants now under development in Kyushu are Fushime (Japex Geothermal Kyushu Co., Ltd.), Ohgiri (Nittetsu Kagoshima Geothermal Co., Ltd.), and Takigami (Idemitsu Geothermal Co., Ltd.), for which basic agreements on development have been concluded. Oguni (Electric Power Development Co., Ltd.) has been preparing for development.

Table 3 shows the geothermal areas designated by the New Energy Development Organization for a survey to promote geothermal development. The depth and number of wells completed in those areas during FY 1989, under the subsidy of the Agency of Natural Resources and Energy, are included. Research on technologies for developing geothermal resources and energy were conducted by the Geological Survey Institute of Japan, the National Research Institute for Pollution and Resources of the Agency of Industrial Science and Technology, the New Energy Development Organization (NEDO), and the Central Institute of Electric Power Industries under the leadership of the Agency of Natural Resources and Energy and the Sunshine Project Promotion Headquarters of the Agency of Industrial Science and Technology. Emphasis was placed on the following items.

(1) Exploration techniques for geothermal energy.
(2) Utilization of hot water in geothermal power plants.
(3) Verification of geothermal exploration techniques.
(4) Comprehensive investigation on geothermal resources throughout Japan.
(5) Development of power plants utilizing hot water, etc.
(6) Evaluation techniques for reservoir layer structures.

The three-month International Group Training Course on

Excerpted from the Annual Report on Geothermal Energy Development in Japan, January 1990, *published by the Japan Geothermal Energy Association.*

Geothermal power plants on operation in Japan.

(As of March 31, 1990)

Name of Power Plant (Name of Owner)		Installed Capacity (MW)	Annual Energy Production (MWh)	Maximum Power (MW)	Operation Factor (%)	Load Factor (%)	Utilization Factor (%)	Auxiliary Power Ratio (%)
Matsukawa	(Japan Metals & Chemicals Co., Ltd.)	22.0	173.367	22.0	96.2	90.0	90.0	7.5
Otake	(Kyushu Electric Power Co., Inc.)	12.5	104,618	12.5	95.9	95.5	95.5	9.3
Onuma	(Mitsubishi Metal Corporation)	9.5	76,911	9.6	95.6	91.5	92.4	7.6
Onikobe	(Electric Power Development Co., Ltd.)	12.5	100,054	12.5	95.9	91.4	91.4	10.0
Hatchobaru I II	(Kyushu Electric Power Co., Inc.)	55.0 55.0	465,299 (June 22, 1990~)	55.0	97.3	96.6	96.6	6.4
Kakkonda	(Japan Metals & Chemicals Co., Ltd. and Tohoku Electric Power Co., Inc.)	50.0	347,813	46.7	95.3	85.0	79.4	5.4
Suginoi	(Suginoi Hotel)	3.0	12,432	1.85	100.0	76.7	47.3	21.1
Mori	(Donan Geothermal Energy Co., Ltd. and The Hokkaido Electric Power Co., Inc.)	50.0	97,802	21.0	91.5	53.2	22.3	23.1
Kirishima International Hotel	(Daiwabo Kanko Co., Ltd.)	0.1	683	0.1	96.1	77.9	77.9	0.3
Total		214.6	1,378,979	181.25	—	86.9	73.4	—

Note:

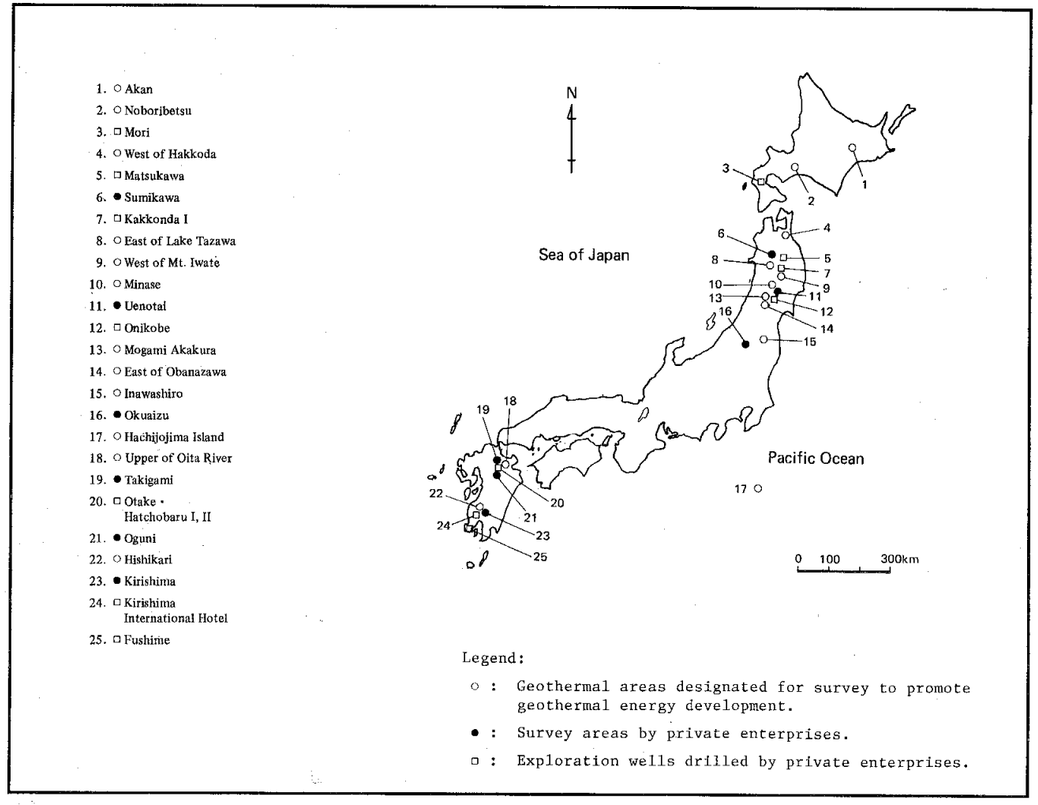
1. "Annual Energy Production" covers energy production for one year from April 1, 1989 to March 31, 1990.
2. "Maximum Power" indicates the maximum power generated for one hour.
3. "Operation Factor" is equivalent to: $\left(\frac{\text{Number of Operating Days}}{\text{Number of Calendar Days}}\right) \times 100\%$
4. "Load Factor" is equivalent to: $\left(\frac{\text{Average Power through the year}}{\text{Maximum Power}}\right) \times 100\%$
5. "Utilization Factor" is equivalent to: $\left(\frac{\text{Average Power through the year}}{\text{Installed Capacity}}\right) \times 100\%$
6. "Auxiliary Power Ratio" is equivalent to: $\left(\frac{\text{Auxiliary Power}}{\text{Annual Energy Production}}\right) \times 100\%$

Wells drilled for geothermal power plants in operation in Japan.

(As of March 31, 1990)

Name of Power Plant	Installed Capacity (MW)	Steam Conditions (Turbine Inlet) Temp. (°C)	Press. (kg/cm²g)	Flow Rate (t/h)	Production Well In Use (number)	Spent (number)	Reserve (number)	Total (number)	Depth (m)	Press. (kg/cm²g)	Steam Flow Rate (t/h)	Hot Water Flow (t/h)	Injection Well In Use (number)	Spent (number)	Reserve (number)	Total (number)	Depth (m-m)
Matsukawa	22.0	147	3.5	211.7	10	1	0	11	945–1,507	3.9–4.5	226	0	0	0	0	0	–
Otake	12.5	127	1.5	135	6	8	0	14	350–1,912	3.9–7.2	126	516	11	12(2)	0	23(2)	484–1,500
Onuma	9.5	127	1.5	107	5	1	0	6	1,485–1,767	1.11–1.32	90	399	3	3(2)	0	6(2)	636–1,200
Onikobe	12.5	138.2	2.5	141.7	7	5	0	12	228–1,500	2.5–10.0	114	395	4	1	0	5	550–800
Hatchobaru	55.0	164/109	6.0/0.43	345/124	13	9	1	23	550–1,971	7.8–11.2	323/81	1.214	13	12(2)	0	25(2)	329–1,184
Kakkonda	50.0	147.4	3.5	478	20(3)	0	0	20(3)	897–1,820	4.9–10.5	390	2,755	17	3(3)	0	20(3)	521–1,600
Suginoi	3.0	142.9	3.0	40	5	5	0	10	150–400	2.2–4.0	27	4	0	0	0	0	–
Mori	50.0	162.4/119.6	6.0/1.0	356/137.8	6	0	3	9	635–2,733	7.7–9.4	197/78	832	8	0	5	13	998–2,283
Kirishima	0.1	142.9	3.0	6	2	0	1	3	70–400	1.8–3.0	13	2	0	0	0	0	–
Total	214.6	–	–	–	74(3)	29	5	108(3)	–	–	1,506/159	6,117	56	31(9)	5	92(9)	–

Note: 1. Steam conditions (turbine inlet) indicate designed values.
2. "/" indicates primary steam/secondary steam.
3. Number in ( ) in the list of injection well indicates number of wells converted from production wells.



Areas where geothermal survey by drilling has been conducted (from April 1, 1989 to March 31, 1990).

Geothermal Energy, sponsored by the Japan International Cooperation Agency, was held from September to December 1989. There were 11 participants in this course from 10 countries: Indonesia, Philippines, Thailand, Turkey, Nicaragua, Guatemala, El Salvador, Colombia, Kenya, and Ethiopia. This was the 20th and last course. The total number of participants during the last 20 years was 262 from 32 countries.

Survey of geothermal energy resources areas in 1989.

Name of Geothermal Development Areas	Approx. Depth and Number of Wells
1. Areas newly designated	
(1) West of Hakkoda (Aomori Pref.)	1,000m × 3
(2) West of Mt. Iwate (Iwate Pref.)	1,000m × 2, (1,000m × 1)*
(3) Hachijojima Island (Tokyo)	1,000m × 2, 1,300m × 1
2. Continued from 1988	
(1) Akan (Hokkaido)	1,200m × 2, 1,500m × 1
(2) East of Lake Tazawa (Iwate Pref.)	1,500m × 1, (1,000m × 1)*
(3) East of Obanazawa (Yamagata Pref.)	(1,500m × 1, 1,700m × 1)*
(4) Upper of Oita River (Oita Pref.)	866m × 1, 1,500m × 1, (1,700m × 1)*
(5) Noboribetu (Hokkaido)	1,387m × 1, 1,500m × 2, (1,700m × 1)*
(6) Hishikari (Kagoshima Pref.)	1,500m × 1, (1,500m × 1)*
(7) Minase (Akita Pref.)	700m × 1
(8) Inawashiro (Fukushima Pref.)	1,500m × 2

( )* shows wells under drilling

USSR

Soviet Geothermal Development

"The Soviet Union has a very long history in using geothermal energy," said Dr. Yuri D. Dyadkin, Head of the Ore Mining and Thermophysics Department, Leningrad Mining Institute. Dr. Dyadkin was discussing this matter during an interview in the fall of 1990 on his visit to the United States.

"We don't emphasize electrical production from geothermal resources," he said. "We have geothermal electrical power generation on the Kamchatka Peninsula, but it is too far from the central parts of the country. However, there are plans to raise power-generation levels at Kamchatka to 70 megawatts, maybe more.

"The most important thing for the USSR now is to use low-temperature geothermal resources for domestic, industrial, and agricultural heating systems. We will save fuel by improving our geothermal systems, which occur in several districts—in the Caucasus, Ukraine, and the Asian republics.

"We need to improve well-flow rates for our low-temperature systems. To this end, we are looking at downhole pump technology, and we want to work with the United States, Japan, and other countries to learn how to use this improved technology.

"Also, we do not now inject spent geothermal water, a practice that is not good for the environment. Currently, we are in the process of injection development. However, injection will take one half of the productive wells, plus the energy to pump the water. Thus, the final economics of this practice are not too good.

"We are also interested in hot dry rock development. We have less experience in this field of extracting solid hot rock energy. We are also interested in extracting heat from magma. It is our aim in the Stanford program to improve our geothermal technology and all phases of petrogeothermal production."

By mentioning the Stanford program, Dr. Dyadkin referred to a cooperative agreement between the Leningrad Mining Institute and Stanford University to prepare a 3-volume Monograph on Geothermal Energy. Dr. Dyadkin and Dr. Paul Kruger of Stanford will be the chief editors, and 26 Russian and US geothermal experts will write a chapter each on Resources (Volume 1), Extraction (Volume 2),and Utilization (Volume 3). Publication distribution is scheduled for 1992.

Besides the Stanford project, Dr. Dyadkin is working to formulate geothermal joint ventures with United States governmental agencies and private businesses. One project is the establishment of a joint venture to develop geothermal

by Susan F. Hodgson

resources on the northern side of the Black Sea in Crimea. The resources in this area are at 70°C at 1 kilometer of depth. The Oregon Institute of Technology may join in this project, as may Los Alamos National Laboratory.

"However, our most important task," said Dr. Dyadkin, "is to improve hot dry rock technology. We are working on a cooperative agreement with Los Alamos for joint Soviet Union and US work in hot dry rock exploitation.

"In the Soviet Union, we have drilled wells for a hot dry rock project in Tirniaus in the Elbrus Mountains. We are preparing to hydrofracture. We hope to work with Los Alamos to devise a measurement system and to define the geology of the hydrofracture zone.

"In return, the USSR will help Los Alamos undertake a hot dry rock project in Clearlake, California, or in Utah. We will assist them to calculate the parameters by an economic model calculation.

"As an additional project, the USSR would like to work to combine geothermal energy extraction and in situ combustion of coal seams. Under this plan, water will be injected and extracted from the failure zones of rocks near the burning coal seams. The water will be extracted as 550°C steam and have 20 megapascals of pressure. The pressured steam will be used to drive turbines and generate electricity. Seventy percent of the energy will come from the hot rock and 25 to 30 percent from the coal combustion.

"Los Alamos will join us in creating the technology. At the present time, we have undertaken laboratory experiments for coal combustion and water injection. From this, we've learned enough to prove our ideas and to prepare other experiments in the US and Russia," Dr. Dyadkin concluded.

DEVELOPMENT

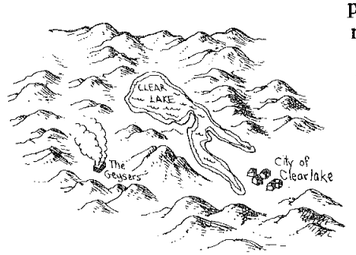
HOT DRY ROCK

Hot Dry Rock Development in California

A large hot dry rock resource has been recognized in Northern California. It underlies the region extending northeast of The Geysers Geothermal field to an area north of the City of Clearlake. The long-range productive potential of the resource is one of thousands of megawatts.

The Geysers-Clear Lake geothermal anomaly is a distinctive heat resource in the Coast Ranges of Northern California. It is a major geothermal resource of great economic significance to California, one apart from The Geysers Geothermal field.

The heat in the anomaly probably originates from latent heat of crystallization of magma at a depth of 6 km under Clear Lake. It is transported to the surface by both conduction in impermeable rock, and convection up permeable fault zones. The transporting fluid is probably connate water from the Great Valley sequence. The differing rates of transport, and possibly movement of the source, result in a complex pattern of heat flow. Isotope geochemistry and numerical modeling of transport processes will be used to evaluate the commercial potential of the resource.



The long-range productive potential of the resource is one of thousands of megawatts.

U. S. Department of Energy research indicates that a hot dry rock project can be built at Clearlake and, given fair trading conditions, could be an economic supplier of electrical power to the California electrical grid.

A potential obstacle is the shortage of water for fill and for make-up water in the hot dry rock power plant. However, the problem of disposing of sewerage water in Northern California offers the prospect of cooperative water management, to the mutual benefit of both the hot dry rock energy producer and the nearby county sewerage treatment plant.

Various economic studies put the cost of producing hot dry rock energy at a level that is economically feasible for electrical power on the California grid. The sustainable production rate, using high back pressure or cyclic operation, may be higher than the previous studies suppose, increasing the rate of return. At Clearlake, the investment costs are below the model assumptions because of higher temperatures at shallow depth, and might be reduced still further by refurbishing abandoned exploration wells. The return on production of geothermal fluid could be enhanced by direct uses in the adjacent city. These are all favorable possibilities.

The geothermal resource in the Clear Lake area turns out to be heterogeneous. There are three types of resources occurring in proximity, namely steam fields, hot springs, and hot dry rock. Hot dry rock production methods are characteristically high pressure, which does not sit well with the other resources. However, a mixed resource should be manageable.

Clearlake has the potential to become the world's first commercial hot dry rock energy producer.

NOTE: The California Energy Commission (CEC) is contributing funding towards the search for a hot dry rock resource in the Clear Lake area. For Phase 1 of the project, the CEC contributed $30,000 towards a literature review and a rudimentary survey. Phase 2, begun in February 1991, is scheduled to run for 12 to 15 months. For this phase, the CEC contributed $225,000 towards the completion of six tasks: a surface-water evaluation study; an evaluation of thermal gradients and heat flow; a study of subsurface geological structures; a study of the deep hydrology; a study of seismicity; and the compilation of all this material into a model of the geothermal regime.

In a third phase for the project, currently pending before the CEC, a contribution of $55,000 of CEC money would be used to study the permeability associated with regional faults; the evaluation of resistivity data; a tritium isotope analysis; and a borehole stability analysis.

The goal of all these efforts is to prepare a subsurface evaluation of the Clear Lake region to identify and define the hot dry rock reservoir. Included in this project will be the evaluation of a hydrothermal reservoir, which is thought to be above and around the edges of the hot dry rock reservoir.

For further information on the project, contact Roger Peake, CEC Project Manager, at (916) 324-3505.

Much of this article is excerpted from "HDR Technology Transfer Activities in the Clear Lake Area, California" by Kerry Burns and Robert Potter, Division of Earth & Environmental Sciences, Los Alamos National Laboratory.

Hot Dry Rock Development in Sweden

The Swedish geothermal program involves research and development work in three direct-use areas, including a hot dry rock (HDR) program in Western Sweden. The HDR project is sponsored by the Energy Research Commission and operated by Chalmers University of Technology. About 10 researchers are actively involved in the project.

The HDR program emphasizes good control of such site characteristics as geological structure, geohydraulic interconnections, and rock stress situations. Great emphasis is therefore put on the scientific control of these factors in the ongoing HDR development program.

The site for the HDR program is in the central part of a granitic massif (Bohus granite) on the Western Coast of Sweden, near Fjallbacka, on the southeastern flank of a granitic hill.

The site was chosen because earlier investigations by Landstrom et al. had shown that the Bohus granite is highly heat-generating, and a potentially suitable rock mass for HDR geothermal energy extraction.

The ongoing research program started in April 1984. Wells Fjb0, Fjb1, and Fjb2 were drilled by percussion drilling. The wells have diameters of 165 mm. The selected depth for the wells is at about 450 to 500 meters, where rock temperatures are about 17°C. For a commercial operation in Sweden, the economical depth will most likely be greater.

The selection of the target depth was based on economics: the value of the heat versus the drilling costs. In Sweden, with low electrical power costs, it will be economical to limit the drilling depth and to use electrical heat pumps at the HDR project to achieve desired temperature levels for space-heating purposes.

The heat pumps will bring down the temperature of the produced water to about 4°C, before it is injected into the second well. The heat pumps will use this temperature drop of 13°C to produce warm water for space heating at a temperature of about 70°C.

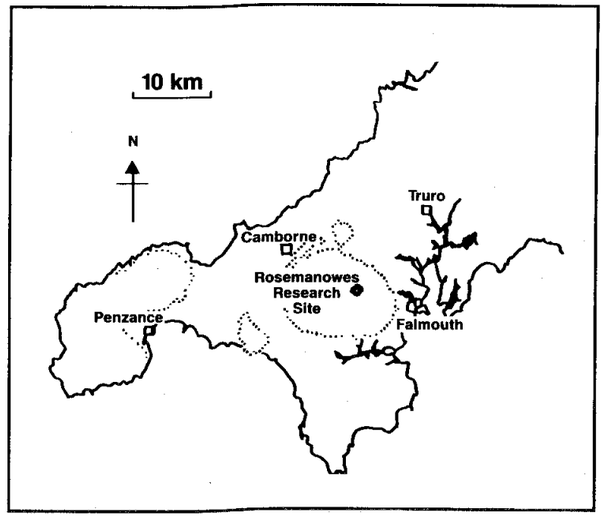
By using design models based on rock-mass investigations, reasonable predictions of stimulated zones seems to have been achieved in the Swedish HDR field experiment. By means of microseismic determination, a good forecast of the location of the induced fracture system has been developed.

Excerpted from "Some Recent Developments in the Swedish Hot-Dry-Rock Project" by Eliasson, Lindblom, Slunga, Sundqvist, and Wallroth. Reprinted from the Geothermal Resources Council Transactions, *Vol. 11, October 1987.*

Great Britain's HDR Programme

The Department of Energy's £40M program of research to assess the technical and economic feasibility of using heat from hot dry rock (HDR) to generate electricity has now been running for 14 years. Most of the experimental work has been carried out at Rosemanowes in Cornwall, and formal reviews of progress have been undertaken at significant points — in 1984, 1987, and 1990.

The 1984 Technical Status Review was instigated by the Camborne School of Mines research team. At this time two 2km deep wells had been drilled and experiments carried out, but the "reservoir" or heat exchanger between the two wells had been shown by circulation experiments to have disappointing hydraulic properties. The review concluded that 'a good level of understanding had been reached on many aspects of HDR reservoir development through a well directed series of experiments', but recognized that important major technical questions remained.



Rosemanowes research site location Cornwall, UK.

Subsequently, a third well was drilled at Rosemanowes and further circulation experiments followed in the new "reservoir" between the third well and one of the original pair.

During the first half of 1987, a second program review was carried out. This again concluded that considerable progress had been made in understanding the technology. Uncertainty remained about some of the key aspects, however, and it was concluded that HDR was still very much an experimental technology. A number of specific problems were identified:

•The new "reservoir" was almost a hundred times smaller than the size calculated to be necessary for a commercial reservoir.

•Its thermal performance was unsatisfactory (because of excessive temperature reduction due to short circuiting), and water losses were too large.

A reliable reservoir design process had not been validated, although it had become apparent that a commercial HDR system was likely to require the creation of several reservoir 'modules' at different depths along the inclined wells. This process itself required validation.

Despite these uncertainties, HDR was still seen to be commercially attractive in the longer term and funding was agreed for a further three years of experiments and engineering studies. The intention was to remove uncertainties and so enable a decision to be made on the merits of drilling wells to full commercial depth (i.e. 6km) in the 1990s.

At the end of this period, in January 1990, a third review was held in the form of a two-day HDR Workshop. This brought together the major contractors to the program and independent members of the Geothermal Energy Steering Committee, which advises on the program. The main conclusions of the workshop were:

•A satisfactory procedure for creating a commercial-scale reservoir had still not been demonstrated.

•There was no reliable information available about the properties of the rock likely to be encountered at the 6-7km depths needed for a commercial reservoir.

•A satisfactory method of sealing short circuits had not been demonstrated.

•Despite the early promise of the technology, HDR was still at an early stage of development. It was unlikely to attract private sector funding in the short term.

During the period covered by these three reviews, a number of assessments have been made of the size of the HDR resource in the UK and the likely cost of electricity generated from it. Early estimates suggested an economically recoverable resource (reserve) of 10,000 - 100,000TWh, but the latest estimates suggest a figure of little more than 1,000TWh.

The cost of electricity from HDR is likely, in the short term at least, to be substantially more than the cost of electricity generated by conventional means.

So where does the HDR R&D Program stand immediately after this third review? The range of options discussed at the January workshop included, at one extreme, the closure of the program and, at the other, drilling the 6km deep wells needed for a full-scale commercial prototype. The workshop also discussed the possibility of a collaborative effort within a European research program with the aim of resolving some of the technical uncertainties at a lower cost to the UK. The decision now rests with Department of Energy Ministers.

by Michael Wright
Reprinted from Review, the Quarterly Journal of Renewable Energy, *Issue 13, Autumn 1990, Department of Energy, Great Britain*

International Programs in Hot Dry Rock Technology Development

It has long been known that the crust of the earth gets ever hotter as one drills deeper, and that the total amount of energy in this earth heat is enormous. The primary factor in determining the quality of a hot dry rock (HDR) resource is the depth at which it lies, as indicated by the local geothermal gradient. This is especially important because drilling is very expensive. In areas of high geothermal gradient, temperatures increase as much as 70°C or more per kilometer of depth. In regions of low geothermal gradient, the increase in temperature is more on the order of 20°-30°C per kilometer of depth.

No serious attempts were made to develop technology to mine a hot dry rock resource until a project known as the Hot Dry Rock Geothermal Energy Development Program was begun by the U.S. Department of Energy in the early 1970s at the Los Alamos National Laboratory. As progress in the Los Alamos HDR Program became apparent, other nations began to take an interest in the development of HDR technology. The United Kingdom started its own HDR program in 1977. In 1980, the Federal Republic of Germany and Japan entered into agreements to participate both financially and technically in the HDR Program in Los Alamos. German participation in the U.S. effort continued through 1985, while the Japanese remained active participants in the project a year longer, terminating their direct involvement, though not their intense interest, in 1986.

Today, a number of nations have significant hot dry rock technology development programs, and several ambitious projects are in the planning stages. This report summarizes international activities in the development of HDR heat mining programs in the various countries around the world.

Fenton Hill, New Mexico

The western part of the United States has many areas of high thermal gradient terrain. In the eastern U.S., low thermal gradients are the rule, but isolated pockets of land with moderate thermal gradients are found. Virtually all of the hydrothermal industry in the U.S. is located in the west. Initial commercial development of HDR is, therefore, likely to occur in one of the western states.

Today, the United States has the most advanced HDR development program in the world, although it is no longer the largest in terms of dollars committed to the effort. The world's first HDR reservoir was completed at Fenton Hill, New Mexico, in 1977, and operated for over a year between 1978-1980. From 1980-1986, a deeper heat mine, the so-called Phase II HDR reservoir, was developed on the same site, with the participation of German and Japanese scientists and technicians. It is the largest and hottest heat mine in the world.

This heat mine is about 3.5 kilometers deep, in rock with temperatures about 240°C. As part of the program to create and characterize the HDR reservoir, major advances in reservoir engineering, tracer technology, computer simulation, and seismic science have been achieved. The ability to locate underground reservoirs has been improved greatly, and the understanding of fluid flow in fractured rock has grown markedly. Preliminary testing of this reservoir in

by David Duchane,
Hot Dry Rock, Program Manager
Los Alamos National Laboratory

1986 gave extremely positive results. Energy production increased continually over the 30-day trial period, while water consumption and flow impedance decreased.

During the last several years, work has been directed toward preparations for extended testing of the Fenton Hill HDR heat mine. A surface plant has been designed for operation of the facility in a closed-loop mode. Water will be injected into the HDR reservoir by high-pressure pumps, pass through hot-rock fractures to a second well, and be returned to the surface as hot fluid. It will then be cooled and reinjected in a continuous cycle. The system includes extensive monitoring and analysis tools for collecting thermal, chemical, and other process information.

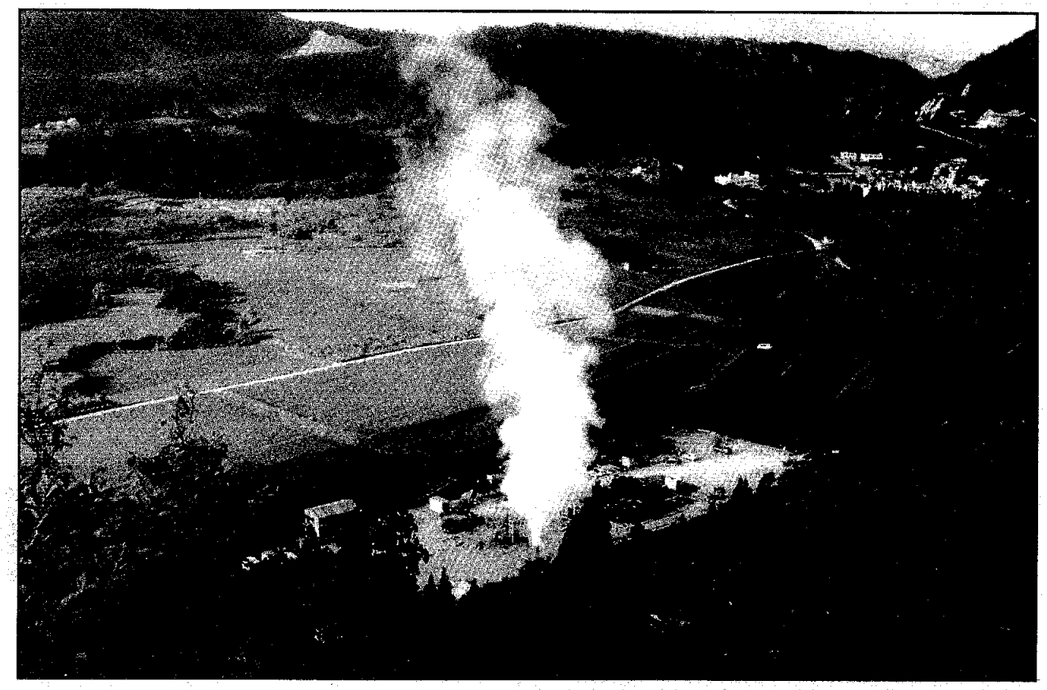
This long-term flow testing (LTFT) will be used to answer critical questions regarding the productive lifetime of HDR reservoirs, such as operating parameters, sustainable energy production, and water consumption. The construction of the surface plant has been driven by funding considerations and, consequently, the schedule for the startup of the LTFT has slipped several times. At present, it appears that all necessary facilities will be in place by mid-summer 1991. The actual starting date of the LTFT will depend upon the allocation of augmented funding needed to run the Fenton Hill plant on a 24-hour basis for a continuous period of a year or more.

California and Arizona

Two other sites in the United States are worthy of mention. The California Energy Commission is funding a detailed assessment of the HDR resource at Clearlake, California, an area close to the The Geysers Geothermal field. This effort could eventually lead to the development of a pilot scale or even a full-scale commercial HDR facility at Clearlake. In addition, a site near Nutrioso, Arizona, is being proposed for commercial HDR development by a private organization, Kaufman & Associates. The company hopes to begin a detailed resource assessment of the Nutrioso site in 1991, under the auspices of the local electric utility cooperative, with a combination of federal and state funding.

Japan

High thermal gradients are found in many parts of Japan. The Japanese hydrothermal energy industry is well developed, and has strong governmental support. Active Japanese interest in HDR began with Japan's participation in the program at Los Alamos in 1980. The Japanese started their own program in 1984 and, after 1986, they applied the resources that were allocated formerly to the U.S. project to their domestic efforts. Nearly 30 Japanese scientists and engineers participated in various phases of the Los Alamos



Circulation test at the Hijiori HDR site, August 1988. Photo courtesy of NEDO.

project. Almost all of them are now involved in various aspects of the Japanese HDR program.

Today, the Japanese effort is more than twice the size of the U.S. program on the basis of budgeted dollars. The program is engineering oriented, with an emphasis on field work in reservoirs at temperatures high enough to permit useful energy production. It seems fair to say that the initiative in the technical aspects of HDR development is moving to the Far East.

Currently, the Japanese are working at three locations. First, field work in the domestic Japanese HDR program was begun at the site of an abandoned hydrothermal well near Hijiori on the Island of Honshu, under the sponsorship of the Japan New Energy Development Organization (NEDO). The Japanese have drilled two additional HDR wells at this site and have created a reservoir at a depth of 1800 meters. (One of these wells, "HDR"1, was extended to 2200 meters.) Using the first hydrothermal well as the injection well, they have established a good connection to one of the new wells, but only a very poor connection to the other. High water losses (in excess of 60 percent) have been a consistent problem in the flow tests of this system.

Yet another HDR well was drilled in 1990 to a depth of about 1900 meters. The hydrothermal well will be abandoned, but the other two HDR wells will be extended to this depth, and a new reservoir will be created to establish a three-well HDR system. After completion of a number of preliminary experiments, an extended flow test will begin in 1993.

NEDO is also working at a test site called Iitate, where it has drilled some shallow wells that are being used for scientific HDR experiments in geology, geophysics, and instrumentation development.

A third Japanese HDR project is underway at a location about 65 km north of Hijiori, on the Island of Honshu. Work at this site, which is near the village of Akinomaya, is being sponsored by the Central Research Institute of the Electric Power Industry. It has been concerned primarily with the development of hydraulic fracturing technology, especially techniques for producing multiple HDR reservoirs by repetitive fracturing operations at different depths in a single well.

Early experiments at Akinomaya were done in a shallow well with rock temperatures of only 60°C. A sequential fracturing procedure was developed that entails fracturing in the bottom of the wellbore, plugging back the casing to a shallower depth, milling away the wall of the casing, and producing another fracture zone at a higher level. This process can be repeated to yield several, vertically displaced fracture zones in one well. After all of the fracturing operations, the plugs are drilled out, and a second well is sunk to penetrate through all the fracture zones, thus creating a multiple-reservoir HDR system.

To minimize disturbance to the local populace, the work has been moved recently to a site a few kilometers away to an area known as Ogachi. There, a well has been drilled to 1000 meters into rock with a temperature of 200°C. Multiple zone-fracturing experiments will be conducted during 1991-1993, and circulation tests will begin. Seismic techniques will be employed extensively to determine the extent and shape of the fractures created. A production well will be drilled at Ogachi in 1994. After flow testing experiments in 1994-1995, long-term testing of the reservoir will start in 1996.

The Japanese HDR effort is vigorous and well-funded, with the work supported by a variety of government and research organizations. While the Japanese are drawing heavily on the experience they gained from their participation in the Los Alamos program during the 1980s, they also have developed some innovative ideas with regard to the creation of economic HDR systems.

To date, the Japanese HDR experiments have been consistently plagued by high water losses. In no case have they recovered even as much as 50 percent of the injected water. They are developing an understanding of this problem, however, and are moving toward the creation of tighter reservoirs with better connections between the injection and production wells. Presently, the Fenton Hill HDR facility has the only HDR reservoir in the world capable of useful operation over an extended time with low water consumption, but it appears certain that by the mid-1990s Japan will bring on line one or more HDR sites capable of long-term assessment of the technical and economic viability of HDR energy.

European Community

A joint HDR scientific program involving France, Germany, Great Britain, and Switzerland, has been underway for several years with the backing of the European Community. Field work has been carried out at a location near the town of Soultz sous Forets, about 40 kilometers north of Strasbourg in northeastern France. Here, a well has been drilled to 2000 meters and temperatures of 140°C have been encountered. Further work will involve drilling a second well to a depth of 3500 meters, where temperatures of 180°C are expected. A reservoir will be developed at this depth.

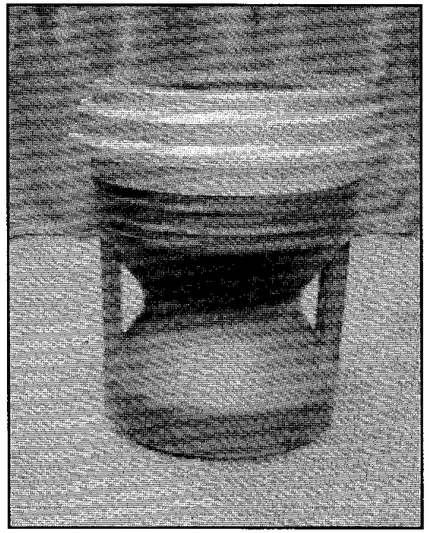
Recently, a very ambitious HDR development program has been under development by a consortium of German, French, and British companies. An organization known as "European Hot Dry Rock Industries" has been formed to manage a European HDR demonstration project. The work would be

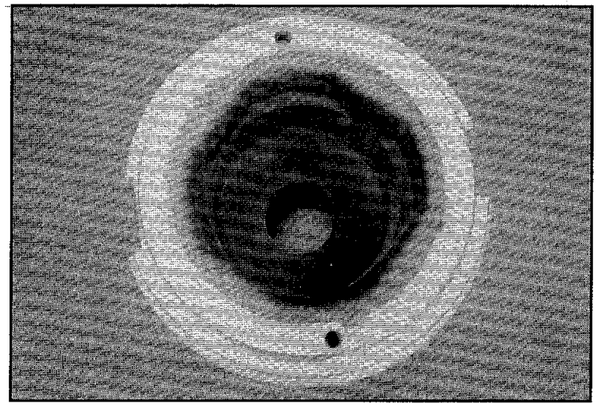
Promising Stripper Rubber R & D

A new stripper rubber for rotating heads that can be used in both geothermal and oil- and gas-drilling operations is under research and development at Sandia National Laboratories, through a contract with the U. S. Department of Energy.

The new design combines the stripper rubber and the drive bushing elements into one piece. Currently, these items are manufactured separately. In addition, a newly designed hour-glass shape for the item has been developed to increase efficiency. The new shape will prevent the stripper rubber from inverting while pipe is being pulled from the hole.The new design should increase the life of the stripper rubber and be able to withstand higher pressures and temperatures.

Sandia has contracted with A-Z/Grant International (formerly Grant Oil Tool Company) to help develop and test this item. Currently, the design is being field tested in The Geysers Geothermal field as part of the research and development phase. If testing is successful, the item may soon be on the market for use in oil, gas, and geothermal development.





The stripper rubber and the drive bushing form one piece. Side and top views. Note the hour-glass shape. Photos by Susan Hodgson.

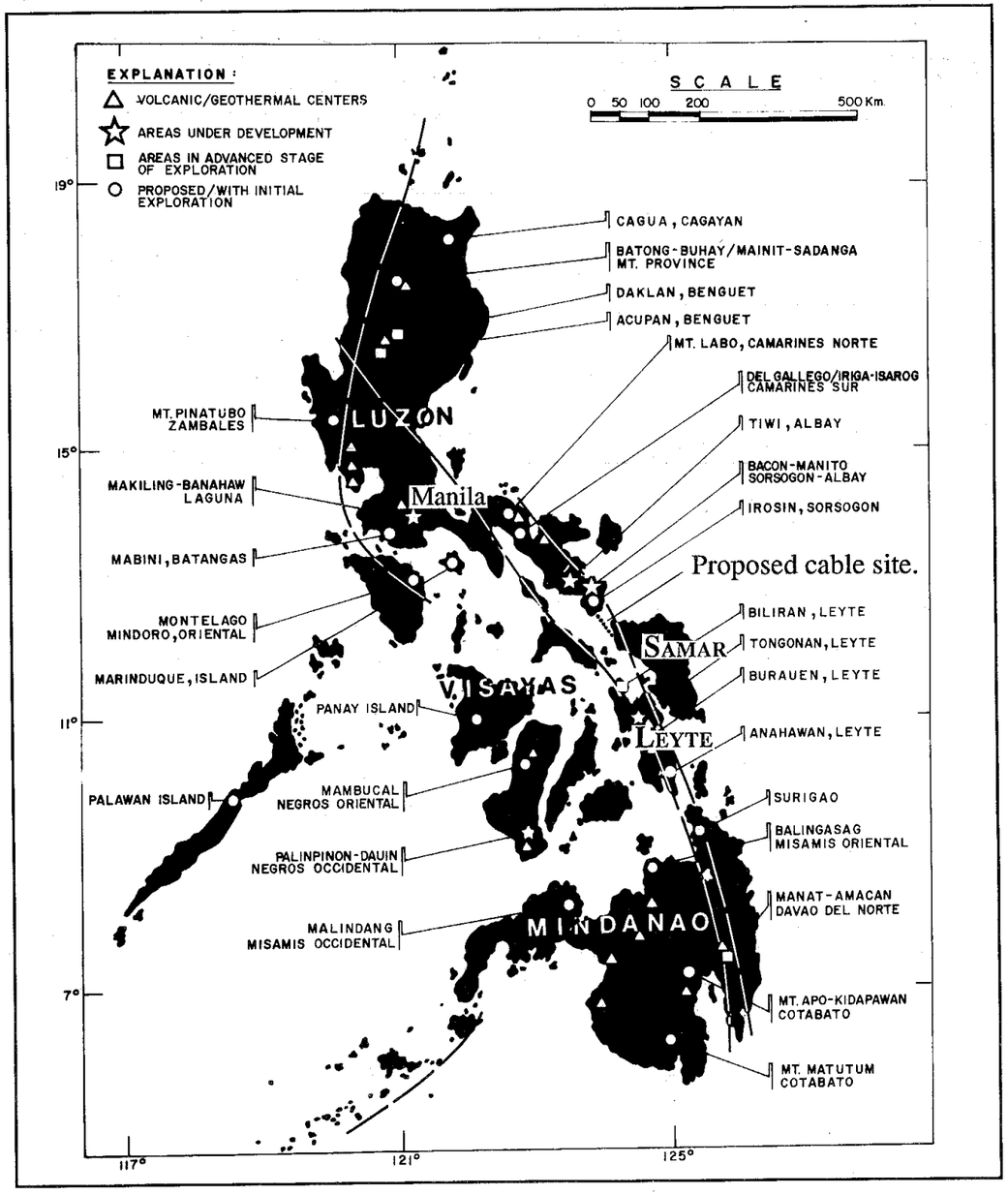
by Robert S. Habel
Geothermal District Engineer

Philippine Submarine Cable

"The Philippines has 894 megawatts of geothermal capacity," said Leonardo Ote, general manager, Geothermal Division, Philippine National Oil Company.

"A submarine electrical transmission cable 27 to 30 kilometers long is proposed connecting the Islands of Samar and Luzon, the second such submarine cable in the country. Study results show the project as economically and technically viable for the transmission of at least 500 megawatts. The cable should take five years to construct, assuming the parallel construction and development of the geothermal field.

"The Islands of Leyte and Samar, less than one kilometer apart, are connected electrically by an overhead wire. Tongonan field on Leyte Island has a 112.5 megawatt capacity, with 12 producing wells and 6 injection wells. However, only 75 percent of this capacity is used because of a lack of customers," Dr. Ote concluded.



The proposed cable site and Philippine geothermal areas. The map is adopted from "The Philippines' Geothermal Potential and its Development: An Update," by B. S. Tolentino and B. C. Buning, published by the Geothermal Resources Council in the 1985 International Symposium on Geothermal Energy.

Submarine Cable in New Zealand

A submarine high-voltage, direct-current cable connects the North and South Islands of New Zealand. The electricity generated at hydroelectrical plants in the South Island is relayed to the North Island through the cable. However, at times electricity from the North Island is relayed south, and such electricity includes that generated at geothermal power plants.

The high-voltage link between the two islands is owned and operated by Trans Power New Zealand Limited, a subsidiary company of the Electricity Corporation. The link was completed in 1965 with one-way transmission from the South Island to the North Island. However, in 1976 the link was modified to allow transmission from the North Island to the South Island, as well.

Work has begun recently on repairing and upgrading the link. When completed, the capacity of the new link will be 1,240 megawatts, instead of the present 600 megawatts.

Unlike the remainder of New Zealand's transmission system, the link uses direct rather than alternating current. Electricity is converted at the originating terminal (Benmore on the South Island or Haywards on the North Island) from alternating to direct current for its onward transmission, and reconverted to alternating current at the opposite terminal station.

Direct current transmission was chosen over alternating transmission because its use was technically more attractive, and it was 30 percent less costly.

For further information on the submarine cable, contact the Electricity Corporation of New Zealand, Limited, P. O. Box 930, Wellington, New Zealand.

RESEARCH

Geothermal Research Within the European Community

EC research policy

The EC's research and technological development policy is mainly aimed at:

- stimulating cross-border cooperation
- coordination of national projects
- exchange between science and industry and
- supporting basic research.

In many research fields a close collaboration has been established especially with EFTA countries and the US.

At present the Third Framework Programme (1990-1994) is under way.

Its focal areas are:

- enabling technologies
- information and communication technologies
- industrial and materials technologies
- management of natural resources
- environment
- sciences and technologies of living organisms
- energy
- exploitation of intellectual resources.

A total amount of 5.7 billion ECU (US$6.8 billion) is available for this programme. Projects are supported on a cost-shared basis with the Commission providing up to 50% of the funding.

Geothermal research

Geothermal energy research started in 1975 after the first oil crisis and has continued since then with an average Commission expenditure of 4-5 MECU (about US$5-6 million) per year. The main topics of interest have been:

- data collection
- exploration by geophysical and geochemical methods
- improvement of instruments
- study of low and high enthalpy fields
- reservoir assessment
- hot dry rocks
- corrosion and scaling.

Future work in geothermal energy research will concentrate on

- corrosion and scaling in low and high enthalpy wells
- hot dry rock studies, including the development of a European pilot project
- handling of high enthalpy, high salinity brines.

For further information on the geothermal work, contact:

Erika Staroste,
DGXII, Commission of the European Communities,
200 Rue de la Loi, B-1049 Brussels, Belgium.

Tel: (02) 235 6352 Fax: (02) 236 3024

Geothermal Research in Algeria

The Center for the Development of Renewable Energy, in Bouzareah, Algeria, is very near the City of Algiers.

The goal of the center's Thermal Laboratory is to study and develop the means of converting solar and geothermal energy into heat, mechanical, or electrical energy, where the main applications will be the production of healthful warm water, water distillation, space-heating for greenhouses and buildings, drying agricultural products, production of cooling systems, bioclimatical habitats, production of industrial steam, and the production of electricity.

For further information, contact CDER Route de L'observatoire, BP 62 Bouzareah, Algeria. Phone (02)78 12 08.

ENERGY STRATEGIES

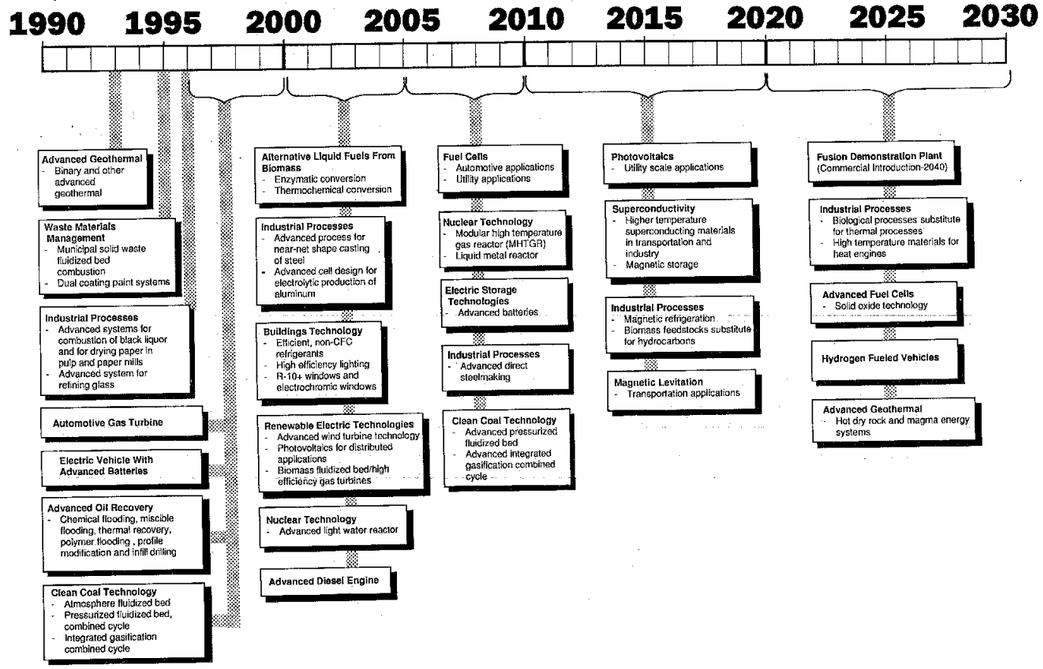
The National Energy Strategy

Copies of the *National Energy Strategy*, subtitled *Powerful Ideas for America*, are available to the general public. The entire document is $16.00 (number 061-000-00754-7) and the executive summary is $2.25 (number 061-000-00755-5). These items may be ordered from the U.S. Government Printing Office, 710 N. Capitol Street, Washington, D.C. 20401. Phone (202) 275-2091.

The following material on geothermal energy is reprinted from the 12-page "Renewable Energy" portion of the strategy.

"Geothermal. A major problem for the geothermal industry is identifying, characterizing, and managing hydrothermal resources (resources that consist largely of hot water, rather than steam that can be released by drilling). R&D will emphasize improving technology for identifying and developing hydrothermal resources, including advanced drilling technology to reduce the cost of field development; reduced fluid-collection costs through modular energy conversion systems; and improved performance of geothermal heat pumps "(p. 125).

In addition, a very interesting article on the history of U.S. national energy strategies is in the January-February 1991 issue of the *EPRI Journal*. The issue is available free of charge from EPRI Journal, Electric Power Research Institute, P.O. Box 10412, Palo Alto, CA 94303.



Governor Wilson and Geothermal Energy

On January 15, 1991, California Governor Pete Wilson met with members of the Sacramento Press Club. Although most questions concerned the crisis in the Middle East, the Governor did discuss his administration's policy on the use of alternative energy.

He said that to achieve clean air, he supports movement towards using alternative fuels, especially in vehicles. "We will look at any suggestions from the California Energy Commission or others to alleviate the problem. Most of the impacts will concern the use of vehicles," Governor Wilson said.

I asked the Governor if he supported the use of alternative energy sources to generate electricity, especially geothermal.

He replied, "I am interested in all kinds of energy, and the California Energy Commission is keenly interested in and aggressively supporting alternative energy development."

by Susan F. Hodgson

FINANCE AND LEGISLATION

True Costs of Energy Production

"The Real Cost of Energy," by Harold M. Hubbard, is the title of an article in the April 1991 issue of *Scientific American* (p. 36).

A point made by Mr. Hubbard is that the U. S. Department of Energy Policy Office has commissioned both Oak Ridge National Laboratory and Resources for the Future to analyze all net social costs for the different methods of energy production. Researchers will measure all resource impacts, including requirements for labor, capital, and materials, effects on air and water quality, and national security.

Similar studies are being undertaken by the European Community and other nations. Study completion is scheduled for 1992.

Mr. Hubbard mentions two preliminary studies that were made in 1989 on the external cost of electrical power. The studies were conducted by the U. S. Department of Energy, Office of Conservation and Renewable Resources. Study results offer a way to compare the environmental impacts of energy technologies with very different characteristics.

Geothermal Division Budget, U.S. Department of Energy

(In Thousands of Dollars)

	FY-90	*FY-91*	*The President's Request to Congress for FY-92*
Hydrothermal Systems	5,806	15,328	12,286
Hard Rock Penetration	2,205	2,385	3,400
Reservoir Technology	2,074	11,000*	6,000
Conversion Technology	1,527	1,943	2,886
Geopressured Research	5,755	6,000	2,500
Advanced Systems	5,039	4,967	3,600
Hot Dry Rock	3,390	3,967	3,600
Magma	1,649	1,000	0
Capital Equipment	444	405	821
Program Direction	814	900	963
TOTAL	17,858	27,600	20,170

* This amount was broken down into:

Reservoir Technology Research:	$4,500,000
Hawaii Resource Verification:	$5,000,000
Low-Temperature Resource Assessment:	$1,500,000

FY 1990 Annual Report on Geothermal Energy, Bureau of Land Management, California Office

Geothermal Leasing and Operations in California

	1990
Total number of leases	206
Competitive leases issued or extended	1
Noncompetitive leases issued or extended	3
Federal production (megawatts)	928
Producing leases	20
Producing wells	237
Plans of operations approved	4
Drilling permits issued	43
Site inspections conducted	425
Total revenues (royalty, bonus, and rents)	$16,621,964
(royalty = $14,795,245)	
(bonus bids from a previous competitive sale, such as East Mesa and Glass Mt. = $1,238,555)	
(rents = $588,164)	

In 1990, production of steam and hot water from existing Bureau of Land Management (BLM) geothermal leases reached 928 megawatts. This level of production brought $14.8 million in federal royalties in 1990, an increase of 26 percent over 1989 levels.

East Mesa geothermal area in the Imperial Valley continued to expand, now producing 117 megawatts of electricity. The Ormesa IH 10-megawatt power plant came on line in January 1990. Now on line in the East Mesa area are the four OESI facilities (I, IE, IH, and II) along with GEO I and GEO II/III.

Near Mammoth Lakes, California, construction began on the PLES I 10-megawatt power plant, and commercial operation is scheduled to begin by early 1991. The BLM will continue to monitor the production/injection wells and surrounding hot springs carefully to ensure that the operation of this facility will not affect other water users in the area.

Inspection and Enforcement. With 206 leases, 20 of which are in production, over 237 wells, 12 power plants on federal leases, and over 20 power plants on private lands utilizing federal resources, the number-one job of the BLM's California Division of Mineral Resources is inspection and enforcement.

During 1990, over 425 surface inspections were conducted to ensure compliance with lease and permit requirements. Of this total, over 175 inspections were conducted to verify production in terms of steam/hot water and electricity. The meters associated with this production are checked for accuracy on an annual basis. Meter calibrations are witnessed by BLM inspectors.

Monthly production data are submitted to the BLM by the operators and these data are checked against field operations. With California's leases generating almost $15 million in royalties during 1990, the BLM's production verification plays an important role to ensure federal resources are being accurately measured and accounted for.

Lease Extensions. Under provisions of the 1988 Geothermal Steam Act Amendments, 1 competitive and 3 noncompetitive leases were granted five-year extensions beyond their primary terms in 1990.

Without this Act, these leases would have expired. The Act assists the lessee by allowing up to 2-five year extensions if the lessee has been and continues to be diligent in exploring for and developing geothermal resources. We anticipate that over 10 such extensions will be authorized in 1991.

Exploration/Plan of Operations. Two plans for geothermal exploration activities were approved during 1990. One plan was to drill two exploration wells on the flanks of Mt. Shasta; the second plan was to drill a single exploration well near Glass Mountain, in the northeastern portion of the state.

In addition, new wells were approved for The Geysers, Coso, and East Mesa Geothermal fields, thereby bringing the total well approvals to 43 in 1990. With increased energy prices due to the Iraqi crisis, we anticipate that geothermal exploration will increase during 1991.

Meanwhile, in the largest producing geothermal area in the world, The Geysers Geothermal field in northwestern California, the BLM continues to work with other federal, state, and private companies to extend the life of the reservoir. Two new experiments—a selective injection study and attempts to operate the power plants at various power levels—show promise in reducing the overall pressure decline in portions of the reservoir. Still, additional cooperation is needed from all parties involved if reasonable solutions are to be identified and implemented.

by Sean Hagerty
Geothermal Program Lead
BLM
California State Office (916) 978-4735

FUNDING

IDB Grants $1.91 Million to OLADE

The Inter-American Development Bank (IDB) approved a $1.91 million technical cooperation grant to support the Latin American Energy Organization (OLADE) program to strengthen the capacity of Latin American and Caribbean countries to produce and use additional energy.

The project will help to transfer and spread advanced techniques to develop and use the regions' geothermal energy resources. The project will also prepare guidelines on environmental impact assessments for energy projects, develop planning instruments for expanding electrical systems, and test and publicize a method to control and reduce the electrical utility losses.

The total grant amount is estimated at $2,506,000. The executing agency will be OLADE's Permanent Secretariat.

The IDB's technical cooperation will be extended in several currencies from the resources of the Fund for Special Operations.

Geothermal Development Part of Mexican IDB Loan

On June 27, 1990, the Inter-American Development Bank (IDB) announced the approval of a $330 million loan to help finance a program of investments in the electrical sector in Mexico. The project, which will be carried out over a two-year period by the Mexican Federal Electricity Commission, will have an estimated total cost of $5.88 billion. This is the first IDB loan to Mexico's electrical sector. It is also the largest IDB loan to this country in the bank's 31 years of operation. The main objectives of the Mexican project are to meet energy demands at minimal cost; diversify sources of energy generation; take into account the financial and energy capabilities of Mexico in planning the expansion program, and effectively manage the societal and environmental aspects of electrical sector projects.

The Mexican program includes: the completion of new geothermal, hydroelectric, and thermal-electric generating plants; the completion of transmission facilities that include substations and lines with voltages ranging from 138 kV to 400 kV; the construction of distribution facilities for the present-day network and its extension; and the reconditioning of thermal electrical plants to restore capacity, reliability, and operating effectiveness economically. The program also includes environmental impact studies and training.

The loan resources will finance equipment and materials for electrical transmission and distribution projects, as well as for the rehabilitation of power plants. The loan was extended from the resources of the bank's ordinary capital for a term of 20 years, at a variable rate of interest and a credit fee of 3/4 of 1 percent per annum on the undisbursed amount.

ETAP Update

In February 1991, managers of the Energy Technologies Advancement Program (ETAP) of the California Energy Commission (CEC) were in the midst of evaluating the program's Sixth-Round General Solicitation and the Fifth-Round Local Jurisdiction Solicitation. As always, the Local Jurisdiction Solicitation is open only to local jurisdictions, and the General Solicitation is open to both the public and private sectors.

Through the ETAP, the CEC co-funds advanced energy projects that increase the energy-efficiency or cost-effectiveness of energy technologies, or help to develop new, cost-effective alternative sources of energy. Projects must include hardware development. Nearly any type of advanced energy technology is eligible for ETAP funding, including those based on energy production, energy conservation (including advancements in recycling technology), load management, etc.

Up to $3 million is anticipated to be available in Fiscal Year 1990-91 to co-fund qualifying proposals for both solicitations. Projects can qualify for one of three types of ETAP funding: loans, primary research contracts, or repayable research contracts. Up to 80 percent of the total project cost can be funded by an ETAP loan. For research contracts, ETAP can co-fund up to 50 percent of the total project cost. Loans are repayable at approximately an eight percent simple interest rate. Primary and repayable research contracts are also repayable under certain conditions and will also accrue simple interest at about eight percent.

For information on the next solicitation round, contact the CEC at the end of August 1991. Phone (916) 324-3490.

The International Energy Development Grant Fund

"Most applications were for geothermal projects," said Jane L. Heinz, California Energy Commission (CEC). Ms. Heinz was referring to the second round of grant solicitations for the CEC's International Energy Development Grant Fund under its Energy Technology Export Program.

"The entries were of high quality," she said. "We had 21 applications, a total of about $1 million worth of projects, four times the amount of our $250,000 allocation. The projects that are selected for funding will be announced in the middle of April 1991. Solicitations for the third round will begin at the end of July."

The International Energy Development Grant Fund was started in 1989 to offer risk capital for California firms to conduct preconstruction work on international energy projects.

Activities considered for funding include resource assessment, preliminary engineering or economic analysis, regulatory and financial infrastructure evaluation, engineering design, and procurement and project bid development.

Minimum eligibility criteria are: the applicant must be a California firm; the host country must express written agreement or support for the project; the project is consistent with host country and World Bank environmental standards; the firm has developed a project implementation plan consistent with its international marketing plan; and a 50 percent matching fund requirement is met.

Fund evaluation criteria and application forms may be obtained by calling the Energy Technology Evaluation Office at (916) 324-3444. For questions regarding the procedural or technical aspects of the program, contact Jane L. Heinz at (916) 324-0449.

LEGISLATION

Federal Legislation

H. R. 4808 by Sharp (D-IN) -- Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990 (Pub. L. 101-575, approved 11/15/90)

> A bill to encourage solar, wind, waste, and geothermal power production by removing the size limitations contained in the Public Utility Regulatory Policies Act of 1978. Introduced on May 14, 1990.

S. 2415 by Domenici (R-NM) -- Uranium Enrichment Act of 1990; Uranium Security and Tailings Reclamation Act of 1990; Solar, Wind, Waste and Geothermal Power Production Incentive Act of 1990.

S. 3085 by Johnston, Bennett (D-LA) -- Vehicular Natural Gas Jurisdiction Act of 1990; Uranium Enrichment Act of 1990; Uranium Security and Tailings Reclamation Act of 1990; Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990.

ORGANIZATIONS

In Memoriam

On October 19, 1990, Fred L. Hartley, chairman emeritus of the board of Unocal Corporation and president and chief executive officer of the company, died at his home in Southern California. Mr. Hartley worked for 50 years with Unocal.

IGA Moves to Berkeley

Starting April 1, 1991, the Secretariat of the International Geothermal Association will be located at Lawrence Berkeley Laboratory in Berkeley, California.

Program on Workable Energy Regulation

The Program on Workable Energy Regulation, POWER, is a partnership of the University of California's Energy Research Group and the Davis campus' Institute of Governmental Affairs.

The organization's newly created Board of Advisors will advise POWER directors on the development of long-range goals related to research and program development, serve as a liaison between the POWER leadership and the energy industry, and promote understanding, participation, and support of POWER's programs among the business community and government policymakers, statewide.

The group publishes a newsletter. For further information, contact the Institute of Governmental Affairs, University of California, Davis, California 95616-8617.

What is CEERT?

The Coalition for Energy Efficiency and Renewable Technologies (CEERT) is a group of the leading developers of solar, wind, and geothermal technologies, and energy efficiency programs, as well as key environmental organizations and energy services companies.

CEERT's members include the Natural Resources Defense Council, Sierra Club, LUZ International, Ltd., U.S. Windpower, California Energy Company, Inc., Portland Energy Conservation, and SYCOM Enterprises.

CEERT's goal is to move California, and the nation, toward providing for more of its own energy needs through the use of energy efficient and renewable energy technologies that are clean, safe, economically feasible, and socially desirable.

For further information, contact CEERT at 1100 11th Street, Suite 321, Sacramento, California 95914. Phone (916) 442-7785.

The Energy Foundation

A new foundation, The Energy Foundation, has been formed as a joint initiative of the John D. and Catherine T. MacArthur Foundation, The Pew Charitable Trusts, and the Rockefeller Foundation. With headquarters in San Francisco, the foundation motto is "Toward a sustainable energy future."

The Energy Foundation gives grants and takes direct initiatives in five areas: utilities and industry, buildings, transportation, renewable energy, and integrated issues. Its geographical focus is within the United States, with special emphasis on regional initiatives.

Within these five areas, the Energy Foundation will support four broad types of activities: (1) research and analysis; (2) advocacy of promising strategies; (3) implementation and replication of successful models; and (4) training.

The foundation generally makes grants to nonprofit charitable organizations that are classified as 501(e)(3) public charities by the IRS.

The foundation does not provide grants to individuals. The foundation does not support local projects, unless they have been consciously designed for further replication or have regional or national implications. The foundation does not make grants to support candidates for political office, to influence specific acts of legislation, or support sectarian or religious purposes. The foundation does not fund the research and development of new technologies.

The foundation does not support endowments or debt reduction. The foundation does not support general fundraising campaigns or capital construction. Nor does it support the planning, renovation, maintenance, or purchase of buildings; the purchase of equipment; or the acquisition of land, even if the intent is to save energy.

The executive director of the Energy Foundation is Hal Harvey, an energy engineer. For further information, contact Mr. Harvey at The Energy Foundation, 75 Federal Street, San Francisco, CA 94107. Telephone (415) 546-7400. Fax (415) 546-1794.

U. S. Geothermal Industries Corporation

U. S. Geothermal Industries Corporation (USGIC) was incorporated in the State of Delaware on March 21, 1990. USGIC shareholders are companies holding memberships in the National Geothermal Association that have received Certificates of Review (COR) from the U. S. Departments of Justice and Commerce to obtain substantial antitrust immunity.

"The USGIC enables U. S. firms to compete worldwide on an equal basis with other firms, by having one entity that can undertake an entire project," said president Gerald Huttrer. "The USGIC provides a vehicle through which firms engaged in the sales of goods and services to the geothermal industry within the United States can sell their products profitably on the international market.

"The U. S. Government has recently implemented policies that will provide financial incentives for companies wishing to export their geothermal goods and services. An increasing number of federal agencies and lending institutions can now make available mixed credits and loan guarantees that, when combined with strong technical proposals, should essentially level the playing field for U. S. geothermal exporters. The initial focus of the USGIC is on the development of geothermal electrical generation projects," Mr. Huttrer concluded.

For further information, contact Gerald R. Huttrer, president, P. O. Box 2980, Evergreen, Colorado 80439. Phone (303) 670-3454.

Natural Resource Specialists in U.S. Embassies and Consulates

The U.S. Department of State operates a Regional Resource Officer program in U.S. Embassies and Consulates in 10 key mineral- and energy-producing countries. These officers can be of considerable help to U.S. mining and petroleum companies.

Each of the 10 missions has an officer who specializes in mineral, energy, and closely related industries. These officers report on developments in the natural resources sectors in their areas of assignment, and provide information whenever possible to assist U.S. industry and commerce. The specialists also seek to foster private- and public-sector cooperation and informational exchanges where that serves the U.S. interest. They visit mining and energy installations in the area, and maintain frequent contact with local and foreign companies. In this way, they provide support for U.S. business as well as maintain their knowledge of local business conditions.

Before American company representatives travel overseas, the Office of International Commodities can arrange meetings with persons who can brief them on the general economic and political climate in the country, and even schedule appointments with embassy personnel.

For further information, contact the:

Regional Resource Officer Coordinator
Office of International Commodities-
EB/ERF/ICD Room 3638, N.S.
U.S. Department of State
Washington, DC 20520
Telephone: (202) 647-3812

U.S. Missions that have Natural Resource Officers:

- Jakarta, Indonesia
- Tokyo, Japan
- New Delhi, India
- Johannesburg, South Africa
- Brussels, Belgium
- Caracas, Venezuela
- Mexico City, Mexico
- Rio de Janeiro, Brazil
- Santiago, Chile
- Canberra, Australia

by Eldwine DeSantis
U.S. Department of State
Reprinted from Newsletter, *USGS Office of Mineral Resources*

Swiss Geothermal Society

The Swiss Geothermal Society was founded on April 20, 1990, in Bern, Switzerland. In October 1990, in Laveyles-Bains, the society held a technical workshop on the geothermal resources of the Rhône valley. The first issue of the bulletin of the society, *GEOTHERMIE CH*, was published in September 1990. The president of the society is Mr. Jules Wilhelm, the vice-president is Dr. Rene Blau, and the treasurer is Dr. Lukas Hauber, who is also a member of the International Geothermal Association. Those interested in joining the society should contact the secretary, Mr. Hans Rickenbacher, Buro Inter-Prax, Dufourstrasse 87, 2502 Biel-Bienne, Switzerland, phone Switz+32+414565.

Soviet Geothermal Association

The Soviet Geothermal Association (SGA) is an independent engineering society, acting as a part of the International Geothermal Association (IGA).

The SGA is an association of USSR and foreign institutions, independent groups, and individuals, who are interested in research on all aspects of geothermics, development of geothermal technology, improving economic and environmental efficiency, expanding the realm of geothermal resources, spheres and scope of geothermal applications in the USSR, and distribution of Soviet advanced experience to other countries.

SGA membership gives you a free copy of the SGA quarterly geothermal bulletin; a free copy of the SGA annual geothermal transactions; free participation in the SGA annual conference or symposium; free short SGA reviews on any geothermal problem; SGA lists on references or patents on any required specific topic from the SGA geothermal computer bank of information; and the opportunity to announce, publish, and distribute among geothermal people your scientific and commercial information by printing these materials in SGA publications.

SGA membership charges for foreign members are $10.00 annually. The SGA headquarters is in the Research Laboratory of Mining Thermophysics (PNIL GTPh) of the Leningrad Mining Institute (LMI).

Mailing Address:
LMI-PNIL GTPh-SGA
2, 21st Linia
Leningrad, 199026 USSR
LMI Telex: 121 494 LGIP SU
SGA Tel: 355-0113, 355-0112, 218-8652

The president of the SGA is Prof. Yuri D. Dyadkin, head of the Ore Mining and Mining Thermophysics Dept., Leningrad Mining Institute, Supervisor of PNIL GTPh LMI. The foreign cochairperson is Professor Paul Kruger, Stanford University.

You, your group, or your institute are welcome to join the Soviet Geothermal Association.

LEASES

Newberry Caldera Geothermal Lease Sale

The Bureau of Land Management (BLM), Oregon State Office, has put up for geothermal leasing through competitive sealed bid, 13 parcels of land totaling 6,822.19 acres of the Newberry Caldera KGRA in the Deschutes National Forest. The sealed bids must be submitted to the BLM Oregon State Director before 1:00 p.m. on June 20, 1991.

To obtain a copy of "Detailed Statement of Geothermal Lease Sale OR 46597 June 20, 1991," contact Jack Feuer, BLM, Oregon State Office, 1300 NE 44th Ave., PO Box 2965, Portland, OR 97208. Phone (503) 280-7043.

Background: Newberry Volcano, in the Cascade Range in central Oregon, is one of the largest volcanoes in the conterminous United States. A US Geological Survey research drill hole in the volcano encountered 509°F temperatures at a depth of 3,051 feet.

On November 5, 1990, Congress created the Newberry National Volcanic Monument, covering part of the volcano and adjacent areas of interest. That legislation called for a competitive geothermal lease sale covering KGRA lands with high geothermal resource potential outside the monument.

TECHNOLOGY TRANSFER

MEETINGS AND COURSES

CALL FOR PAPERS

SYMPOSIUM ON THE GEOTHERMAL SYSTEM IN THE LONG VALLEY CALDERA

Background: Once geothermal development was proposed in the Long Valley caldera, the need became apparent for systematic monitoring of the geothermal operations. In late 1986, it was proposed to the Mono County Board of Supervisors that an advisory committee be formed to help formulate and implement a hydrologic monitoring program within the Long Valley caldera, focusing upon early detection of changes in unique hydrologic and thermal features in the caldera. In 1988, the Long Valley Hydrologic Advisory Committee (LVHAC) was formed, and the committee's bylaws were ratified. The committee's role is to provide permitting agencies and developers with information and data necessary to monitor new or existing activities that might affect the hydrology of the Long Valley caldera.

Symposium: The LVHAC is sponsoring a **"Symposium on the Geothermal System in the Long Valley Caldera"** in Mammoth Lakes, mid-October 1991, to encourage discussion and expand knowledge about geothermal development in the caldera.

Objective: The Symposium will focus on the geology and hydrology of the Long Valley caldera, as well as the monitoring activities in the Long Valley caldera and other similar geothermal systems.

Presentation Selection

Those interested in making presentations should submit an abstract of no more than 500 words to the LVHAC by July 31, 1991. Mail the abstracts to:

Robert Habel
Department of Conservation
Division of Oil and Gas
1416 Ninth Street, Room 1310
Sacramento, California 95814

An Advisory Committee will review the abstracts and select the presentations deemed most relevant to the symposium objectives.

For further information, contact Robert Habel at (916) 323-1786 or Dan Lyster at (619) 934-6704.

Course on Geothermal Energy--An Introduction to Risk Analysis for Entrepreneurs and Investors, June 11-12, 1991, the Capitol Plaza Holiday Inn, Sacramento, California. This course is designed for bankers and investors who would like to learn more about analyzing the risks, potentials, and longevity of geothermal projects. Cost: $300, GRC members; $350 nonmembers.

For further information, contact the Geothermal Resources Council at (916) 758-2360.

Infocast Inc., 18425 Burbank Boulevard, Suite 509, Tarzana, California 91356. Phone (818) 609-9145.

Infocast Inc. organizes and presents meetings and conferences on topics including the independent power industry and project finances, corporate finance, lending law, environmental issues, and public policy as it relates to these fields. Cosponsors include the Geothermal Resources Council, Independent Energy Producers Association, Institute of Resource Recovery, *Cogeneration and Resource Recovery* magazine, and *Wheeling and Transmission* monthly. Continuing education credit is offered to participants. Tuition for each individual course is $695.00; for members of cosponsoring organizations, tuition is $347.50. For complete details, contact Infocast Inc.

The following course is scheduled for June 3-4, 1991 (Boston); June 13-14 (San Francisco).

Project Finance: the Network Conference. This conference allows representatives of financial institutions and equity investors to meet project sponsors and developers and have one-on-one discussions regarding specific projects. Geared to those involved in project finance, such as project sponsors, developers, commercial and investment bankers, lessors, venture capitalists, investors, joint-venture partners.

ISEE 1991, International Symposium on Energy and Environment, Centre of Energy Technology, Helsinki University of Technology, in cooperation with the Ministry of Trade and Industry, Energy Department, Espoo, Finland, August 25-28, 1991.

Topics will include global atmospheric change; energy strategies for a better environment; pollutant generation and control; and regional and urban global planning. For information, contact the Centre of Energy Technology, Otakaai 4, 02150, Espoo, Finland. Phone +358-0-451-3580.

Energex '91, Second International Conference on Energy for the Americas, Caribe Hilton International Hotel, San Juan, Puerto Rico, September 24-29, 1991, in conjunction with the Second Pan American Chemical Congress.

Topics include cogeneration, conservation, economics, environmental issues, and various energy technologies. Papers will be presented in Spanish, English, French, and Portuguese. Registration fee before July 1, 1991, is $150.

For further information, contact The Puerto Rico Chemists' Association, Calle Penuelas, Esq., Hatillo, Hato Rey, Puerto Rico 00918, U.S.A. Phone (809) 763-6070.

GRC Courses and Meetings

(For further information on the following five courses and events, contact the Geothermal Resources Council, P. O. Box 1350, Davis CA 95617. Phone (916) 758-2360)

Low-Temperature Uses of Geothermal Energy and Ground-Source Heat Pumps, October 5-6, 1991, Nugget Hotel, Sparks, Nevada, in conjunction with the 1991 Annual Meeting (October 6-9) of the Geothermal Resources Council and the National Geothermal Association (NGA) Trade Show. The heat-pump program will include lectures and discussions on the types of direct-heat applications, engineering, financing, management, and future development and installation, advantages, and potential for both domestic and industrial size heat-pump installations. These applications are a key component of the future of geothermal development in the United States. Cost to be announced.

●

1991 Annual Meeting of the Geothermal Resources Council, October 6-9, Nugget Hotel, Sparks, Nevada. The annual meeting will include technical programs, poster sessions, a trade show, social events, and field trips (Coso Geothermal Field, and Mono County, California, October 4-5; and Soda Lake Geothermal Field, Churchill County, Nevada, October 10-11). Cost to be announced.

●

Carbonate Scale Inhibition, October 10-11, 1991, Nugget Hotel, Sparks, Nevada, in conjunction with the 1991 GRC Annual Meeting. The course will include a study guide, background information on carbonate scale deposition and inhibition, and the tools, techniques, and chemicals necessary to control deposition. Also included is a tour of a local geothermal power-generation facility to observe scaling inhibition equipment in use. Cost to be announced.

Electric Utility Systems and Practices (Southern California), three days in November 1991, Los Angeles, California. The technical lectures and a handbook will cover basic components, procedural techniques, developmental issues, and operations activities in the utility systems. The course will be directed to utility contract specialists, geothermal developers, financial firms, and state and federal regulating and planning personnel. Sponsored by the GRC.

●

Electrical Utility Systems and Practices (Northern California), three days in December 1991, San Francisco, California. The course content and intended audience will be the same as for the Southern California course presented in November. Sponsored by the GRC.

13th New Zealand Geothermal Workshop, Auckland, New Zealand, November 6 to 8, 1991.

The workshop is organized by the University of Auckland Geothermal Institute in conjunction with the Centre for Continuing Education, University of Auckland. For information contact: Dr. C. C. Harvey, Geothermal Institute, University of Auckland, Private Bag, Auckland, New Zealand. Telephone: NZ+9+737999. Fax: NZ+9+3033429. Telex: 21480UNILIBNZ.

III Congreso Latinoamericano de Historia de la Ciencia y de la Tecnologia, January 12-16, 1992, Mexico City, Mexico.

This congress will be held as part of the celebration of the Fifth Centennial of Columbus' discovery of the Americas. A symposium on the history of geothermics will be included. The congress is being organized by the Latin American Society for the History of Sciences and Technology and its Mexican branch.

Geothermics Taught

The Universidad Autónoma de Baja California offers a major in Geothermics, in conjunction with the Comisión Federal de Electricidad, the Instituto de Investigaciones Eléctricas, and the National Council on Science and Technology.

The program is geared towards creating specialists in this area with a body of information that includes the principal stages of a geothermal project, and with specific focus in earth science or engineering.

For further information, contact the Universidad Autónoma de Baja California, Instituto de Ingeniería, Mexicali, Baja California, Mexico.

MAPS AND DIGITAL DATA

Geologic map and structure sections of the Little Indian Valley - Wilbur Springs geothermal area, northern Coast Ranges, California. I-1706. By R.J. McLaughlin, H.N. Ohlin, D.J. Thormahlen, D.L. Jones, J.W. Miller, and C.D. Blome. 1990. $6.20. Available from U.S. Geological Survey, Map Distribution, Federal Center, Box 25286, Denver, Colorado 80225.

The map consists of two sheets (latitude 39° to 39° 15', longitude 122° 22' 30" to 122° 37' 30"). Each sheet is drawn at a scale of 1:24,000 (1 inch=2,000 feet). Sheet 1 is 38 1/4 by 51 1/4 inches; Sheet 2 is 39 by 47 3/4 inches (all in color). The map I-1706 supersedes open-file report 85-285.

New Nevada Land Status Map

Nevada land status map. By the Bureau of Land Management. 1990. Available in two sizes: map scale 1:1,000,000 (sheet size is 2 feet wide by 3 feet long), $3.00; and map scale 1:500,000 (sheet size is 4 feet wide by 5 1/2 feet long), $7.00. Add $3.50 for mailing (in tube). Available from the Bureau of Land Management, Nevada State Office (NV-943), P.O. Box 12000, Reno, Nevada 89520-0006.

Types of land defined on the map include public lands; national forests; national parks, monuments, and recreational areas; Indian reservations; state lands; patented lode mining claims; Department of Defense facilities; Department of Energy facilities; federal wildlife refuges and management areas; Bureau of Reclamation withdrawals; and private lands.

The BLM's Branch of Cadastral Survey estimates that about 19 million acres in Nevada are unsurveyed. Another 29 million acres surveyed prior to 1911 are in need of resurvey because of little remaining evidence of the original corner monuments placed at that time.

Seismic Reflection Data for Dixie Valley and Stillwater, Nevada

(To order, *see* page 77)

Two geothermal basins were surveyed as part of the Department of Energy's (DOE) Industry Coupled and Exploration Technology programs. The data were contributed by the University of Utah Research Institute (UURI), which managed this portion of the project for DOE. The surveys include stacked, migrated, and deconvoluted Vibroseis data.

The data, sections, and documentation which are available from the National Geophysical Data Center, together with open-file data available separately from UURI, constitute case study data that are very useful for research and educational purposes.

Data contributors and academic researchers should call 303-497-6120 for information about obtaining data by special arrangement.

Dixie Valley Prospect

The Dixie Valley prospect spans three townships in Churchill and Pershing Counties (150 km east of Reno, Nevada). A report included with the documentation discusses the correlation of the seismic data with information from a thermal power well located within the survey area. The thermal fluids are heated during deep circulation along basin-and-range faults in an area of high thermal gradient. The interpretation report suggests locations of the thermal aquifer and a pluton within the basement at the edge of the basin.

Analog data include four finite-difference migrated sections, and four final stack sections. Data are available in three formats:

Product Number	Cost	Format
637-G18-001	$ 30	Blackline paper
637-G19-001	$ 32	Sepia paper
637-G20-001	$ 42	Sepia plastic

Digital date consist of 35 digital tapes of field data, in SEG-B format. Surveyor's notes and Vibroseis operator's reports are included with digital data.

Product Number	Cost	Description
912-G07-001	$ 5,320	Field data (35 magnetic tapes, SEG-B format)

Stillwater Prospect

The Stillwater prospect spans four townships in Churchill County, about 120 km east of Reno. No interpretation report is included, but the area is also a geothermal field nearing production, and thought to be in a similar setting to that of Dixie Valley.

Analog data include one relative amplitude stack section (line 2 only); three scaled final stack sections (lines 2, 3, and 4); three finite-difference migrated final stack sections (lines 2, 3, and 4); and a seismic line location map. Data are available in three formats.

Product Number	Cost	Format
637-H18-001	$156	Blackline paper
637-H19-001	$167	Sepia paper
637-H20-001	$217	Sepia plastic

Digital date include a variety of data on magnetic tape. Observer's reports, surveyor's notes, and a location map are included with the digital data.

Product Number	Cost	Description
912-H07-001	$2,888	Raw field data (19 magnetic tapes; SEG-B format)
912-H07-002	$456	Field correlated data (3 tapes, SEG-C format)
912-H07-003	$152	Final stack sections (1 tape, SEG-Y format)

Documentation for analog and digital data includes a list of additional publications from UURI, and the AAPG abstract noted before.

Decade of North American Geology

(To order, *see* page 77)

The DNAG Project has resulted in published synthesis volumes and wall maps summarizing the geology, tectonics, magnetic and gravity anomaly patterns, regional stress fields, thermal aspects, seismicity, and neotectonics of North America and surrounding ocean areas. Together, the synthesis volumes and maps represent the first coordinated effort to integrate all available knowledge about the geology and geophysics of a crustal plate on a regional scale.

Magnetic tapes will be provided at 6250 bpi in ASCII format. All diskettes are IBM-PC compatible, high density, 5 1/4". Other formats may be requested.

Data, contributors and academic researchers should call 303-497-6591 for information about obtaining data by special arrangement.

	Product Number	Price	Description
The Geophysics of North America Compact Disc	975-B27-001	$580	Entire data set. Includes compact disc, access and display software, tutorial, and User's Manual
	975-B27-002	$235	Additional compact disc.
	975-B14-001	$65	Additional User's Manual.
Magnetics Data	980-A07-001	$329	Entire data base on 6250 bpi magnetic tape.
	980-A07-002	$392	Entire data base on 1600 bpi magnetic tapes.
	980-A25-CUS	$99	Retrieval of data by geographic area; output on one diskette. Each additional diskette is $30.
Gravity Anomaly Data	980-B07-001	$329	Entire data base on magnetic tape.
	980-B25-CUS	$99	Retrieval of data by geographic area; output on one diskette. Each additional diskette is $30.
Seismicity Data	980-D07-001	$152	Entire data base on one magnetic tape.
Crustal Stress Data	980-E07-001	$152	Entire data base on one magnetic tape.
	980-E25-001	$89	Entire data base on one diskette.
*Thermal Aspects Data**	980-C07-001	$152	Entire data base on one magnetic tape.
	980-C25-001	$149	Entire data base on three diskettes.

*A comprehensive data base of heat flow and ancillary measurements for North America was compiled as a basis for the DNAG *Thermal Aspects Map* of *North America* (in press). Information about each site includes hole location and date of temperature measurement, range of values, gradient and heat flow results per depth interval, lithologic information, and comments. Data were compiled by David D. Blackwell, John L. Steele, and Larry S. Carter, Southern Methodist University.

U.S.S.R. Magnetic Anomaly Data

(To order, *see* below)

U.S.S.R. magnetic anomaly data are now available from the National Geophysical Data Center. The data set contains a wealth of information useful to Earth scientists studying global tectonic processes and the deep crustal composition of major continental cratons.

Data Set History

In 1974, the Ministry of Geology of the U.S.S.R. published a mosaic series of 18 sheets at 1:2,500,000 scale showing the residual magnetic intensity over the land mass of the U.S.S.R. The data were compiled by a group of scientists (representing broad organizational support) under the leadership of Z. A. Makarova. Much of the source material originated from data collected between 1949-1962, during which time the entire territory of the U.S.S.R. was surveyed using aerial magnetic survey techniques. These surveys were adjusted based on many methods including secular variation linked to magnetic observatories. Anomalies were computed with reference to a normal field map for 1964-65 constructed from equally accurate total field measurements along control network strips.

Digitization of the U.S.S.R. *Magnetic Field Anomaly Maps* was accomplished in 1982 by the U.S.Naval Oceanographic Office under contract to Computer Science Corporation. To insure proper quality control, both contours and singular points contained on published maps were digitized in an organized grid. The "BRIGGS cubic spline" method was used to compute the grid values. A one-minute grid was created by properly matching the boundaries of the digitized sub-sections. The units of the original map are milli-Oersteds and the units of the resulting digital grid are milli-Oersted/100. (Note: one milli-Oersted 100 nT).

Available Digital Data

The digital magnetic anomaly data are available on four magnetic tapes. The data are divided into four regions, each of east-west extent of 43 or 45 degrees longitude. The one minute grid values are sequenced beginning from the lower left corner of each region, row-by-row proceeding to higher latitudes (i.e., left to right then up). Documentation which accompanies the data tapes include an English translation of a Russian publication titled "Map of the Anomalous Magnetic Field, (AT)., of the Territory of the U.S.S.R. and of some Adjacent Water Areas" by A. A. Smyslov, N. B. Dortman and Yu.I.Sytin, published in 1978.

Product Number	Price	Description
999-A07-001	$431	Entire data set on four 6250 bpi magnetic tapes, ASCII format.

You may also order data for individual regions:

999-B07-001	$152	**Region 1:**	18°E -	60.98°E;	35.4°N - 77-65°N
999-B07-002	$152	**Region 2:**	61°E -	103.98°E;	35.4°N - 77-65°N
999-B07-003	$152	**Region 3:**	104°E -	146.98°E;	35.4°N - 77-65°N
999-B07-004	$152	**Region 4:**	147°E -	191.98°E;	35.4°N - 77-65°N

Data contributors and academic researchers should call 303-497-6128 for information about obtaining data by special arrangement.

TO ORDER THE NEVADA, DNAG, OR USSR DIGITAL DATA

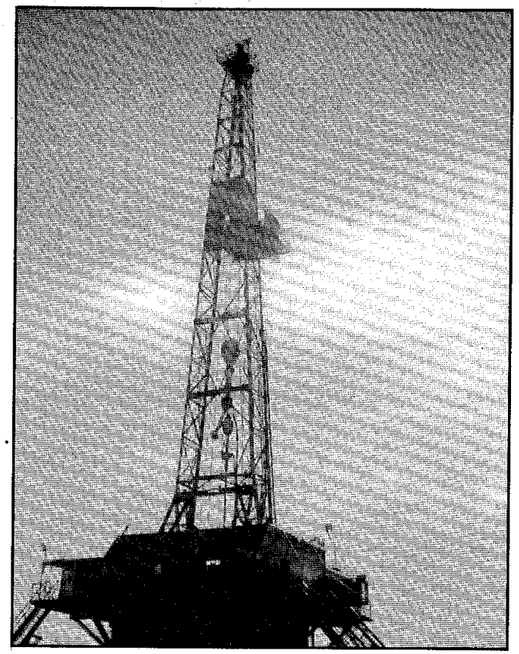
U.S. DEPARTMENT OF COMMERCE REGULATIONS REQUIRE PREPAYMENT ON ALL NONFEDERAL ORDERS. Please make checks and money orders payable to COMMERCE/NOAA/ NGDC. All foreign orders must be in U.S. Dollars drawn on a U.S.A. bank. Do not send cash. Orders may be charged to American Express, MasterCard, or VISA by telephone, letter, fax, or Order Form. Please include credit card account number, expiration date, telephone number, and your signature with the order.

A ten-dollar ($10) handling fee is required on all orders; an additional ten-dollar ($10) charge is required for non-U.S.A. orders. Overnight delivery is available at an additional cost; please call for details.

Send orders to the National Geophysics Data Center, NOAA, Code E/GC1, 325 Broadway, Boulder, Colorado 80303.

VIDEOS

Before the Drilling Begins



The environmental documentation process and well pad engineering practices used at The Geysers Geothermal field are the topics of a videotape available from the Division of Oil and Gas. The videotape is about 13 minutes long and was taped on location at The Geysers Geothermal field.

The videotape, titled *Before the Drilling Begins*, may be purchased for $25 in 1/2" VHS format.

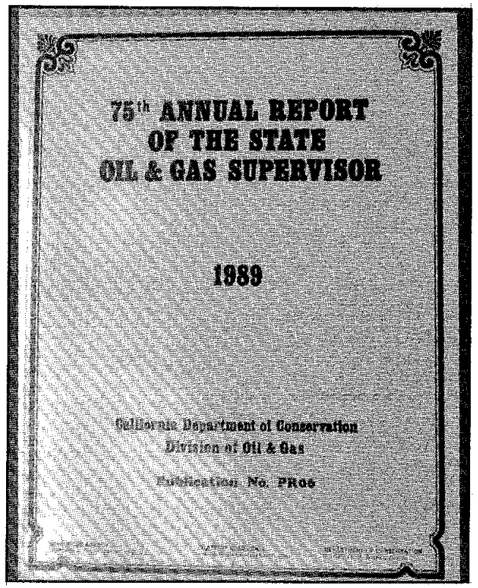
Contact Susan Hodgson for further details at (916) 323-2731.

Zunil, Guatemala, Landslide is the latest videotape produced by the Division of Earth Sciences, University of Nevada, Las Vegas. The 22-minute videotape documents a scientific investigation of the January 5, 1991, landslide at Zunil Geothermal field.

Copies of the video are available on VHS format for $25.00. Contact Thomas Flynn, Division of Earth Sciences, 100 Washington Street, Suite 201, Reno, Nevada 89503. Phone (707) 784-6151.

For further information, *see* "Incident at Zunil" in this issue.

PUBLICATIONS

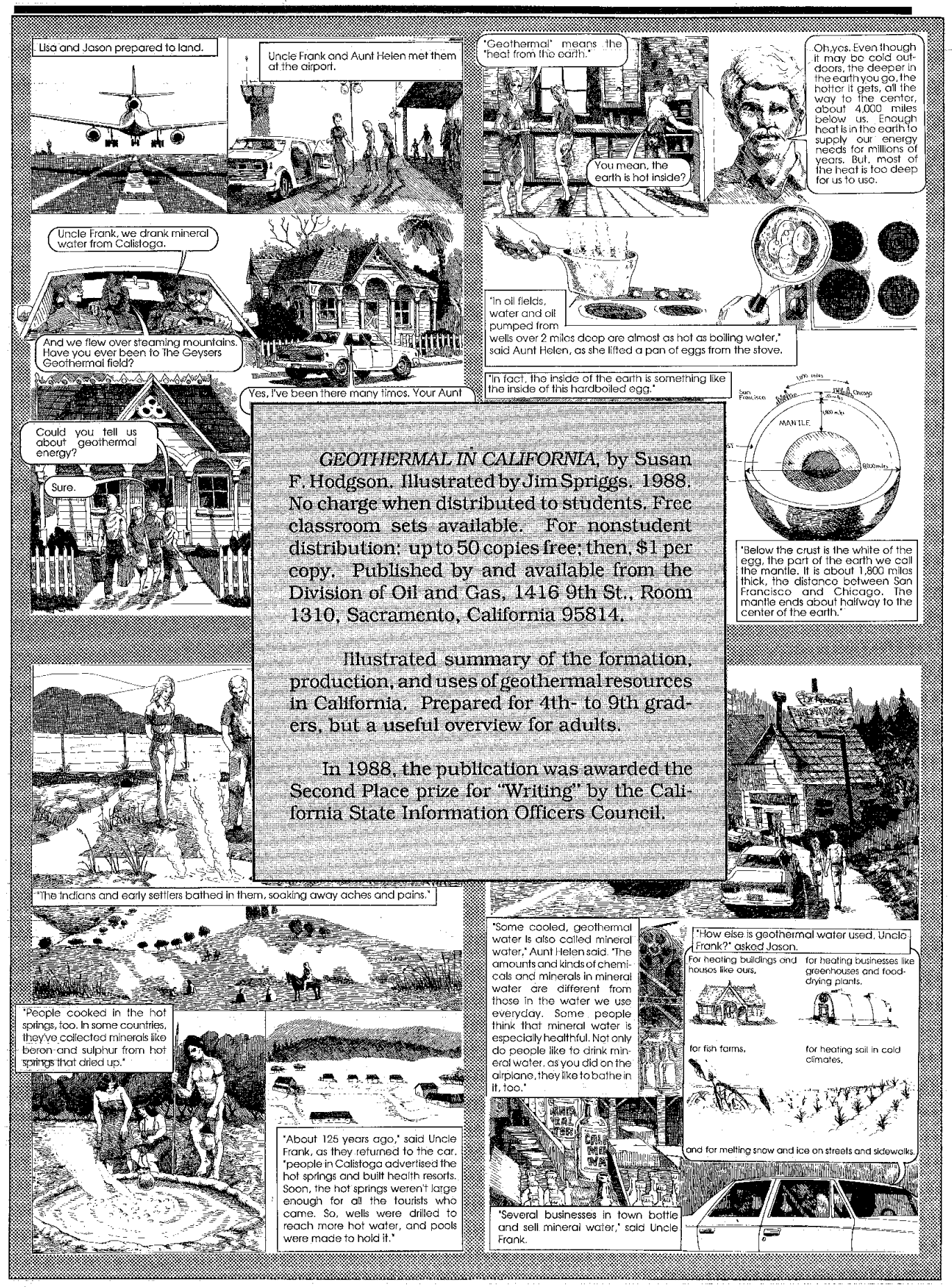


75th Annual Report of the State Oil and Gas Supervisor. 1989. Free. Published by and available from the Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814.

Statistical data and summaries of 1989 California geothermal activity.

Index, oil, gas and geothermal publications, California Division of Oil and Gas, PR3S. 1990. Free. Published by and available from the Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814.

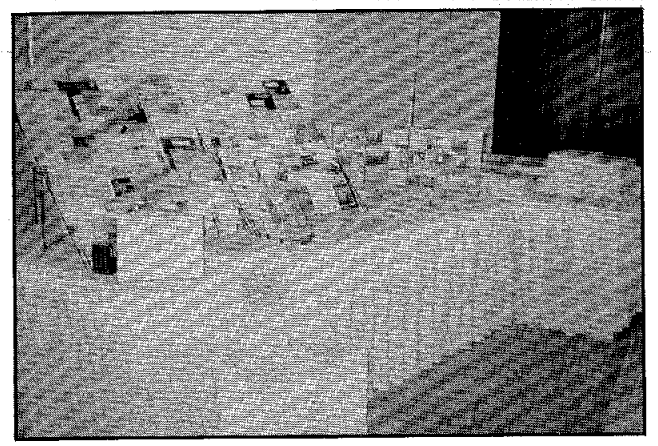
References are cited from division publications, including the *Geothermal Hot Line* and the Annual Report of the State Oil and Gas Supervisor. Geothermal citations begin in 1965, the year the Division of Oil and Gas undertook its geothermal responsibilities.



GEOTHERMAL IN CALIFORNIA, by Susan F. Hodgson. Illustrated by Jim Spriggs. 1988. No charge when distributed to students. Free classroom sets available. For nonstudent distribution: up to 50 copies free; then, $1 per copy. Published by and available from the Division of Oil and Gas, 1416 9th St., Room 1310, Sacramento, California 95814.

Illustrated summary of the formation, production, and uses of geothermal resources in California. Prepared for 4th- to 9th graders, but a useful overview for adults.

In 1988, the publication was awarded the Second Place prize for "Writing" by the California State Information Officers Council.



Display of nontechnical geothermal public information at the Geothermal Resources Council Symposium in Hawaii, August 1990.

Survey of nontechnical geothermal public information—worldwide, 1990. By Susan F. Hodgson. Free. Order from the Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, Ca. 95814.

The publication is the only anthology of nontechnical geothermal public information. It lists the results of a survey undertaken in 1990 through the Geothermal Resources Council and the Division of Oil and Gas. Each item in the publication is described, and information on ordering each item is included.

To help keep the publication up-to-date, please send the author two copies of any nontechnical public information items prepared by your organization. One of the copies will be given to the Geothermal Resources Council for its files, and one will remain with the Division of Oil and Gas.

An updated publication will be printed each year.

California's energy agenda: 1989-90 biennial report, P-106-89-001. One copy free; additional copies, $5.20. Published by and available from the California Energy Commission, Publications Unit, 1516 Ninth Street, MS-13, Sacramento, Calif. 95814-5512.

This publication is the commission's principal planning document. It identifies the emerging trends in energy supply and demand, and is the state's official energy policy.

The agenda is supported by five commission technical documents: the Conservation Report, the Fuels Report, the Energy Development Report, the Electricity Report, and the California Contingency Plan.

Geologic excursions in Northern California: San Francisco to the Sierra Nevada, special publication 109. Edited by Doris Sloan and David L. Wagner. $10. 130 pages. Published by and available from the California Division of Mines and Geology, 660 Bercut Drive, Sacramento, Ca. 95814.

The 11 excursions described in this attractive publication include a "Field Trip Guide to the Geology of Sonoma County," the "Franciscan Complex, Coast Range Ophiolite and Great Valley Sequence: Pacheco Pass to Del Puerto, California," and "Sutter Buttes Field Trip Guide."

Schlumberger soundings near Lassen Volcanic National Park, California. OF89-0670. By A.A. Zohdy and R.J. Bisdorf. 1989. Microfiche, $4.00; paper copy, $6.50. Available from U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, Colorado 80225. Phone (303) 236-7476.

California: an environmental atlas and guide. Compiled by Bern Kreissman. 1991. 255 pages. $20.65 (includes tax and a $6 contribution to the Planning and Conservation League). Available from the Planning and Conservation League, 909 12th Street, Suite 203, Sacramento, CA 95814.

Learn about the natural environment of California -- the locations of the most important rivers and national forests; areas that are preserved, and the conservation groups involved in preservation efforts; and how to contact federal, state, and local environmental agencies. The volume offers a myriad of useful information.

Energy development report. August 1990. Free. Published by and available from the California Energy Commission, 1516 Ninth Street, Sacramento, California 95814.

The report describes the state energy trends and outlines technology development, with associated challenges and opportunities. The four basic types of geothermal resources are considered in the context of their distinct characteristics affecting the extent of their commercial uses plus research and development requirements.

Energy technology status report. June 1990. Free. Published by and available from the California Energy Commission, 1516 Ninth Street, Sacramento, California 95814.

The report describes fuel-cycle technologies that are commercially available, and lists those that are not. It provides technology evaluations for over 230 electrical-generation and end-use technologies.

Investing in California's energy future, a report to the legislature on the Energy Technologies Advancement Program -- the first five years. Free. Available from the California Energy Commission, Publications Unit, 1516 Ninth Street, Sacramento, California 95814-5512.

California has developed many energy technology innovations. In the report, 35 projects are described that have been funded to encourage new energy technologies.

California Energy Commission publications catalog. 1990. Free. Published by and available from the California Energy Commission, Attn. Publications, MS-13, 1516 Ninth Street, P.O. Box 944295, Sacramento, California 94244-2950.

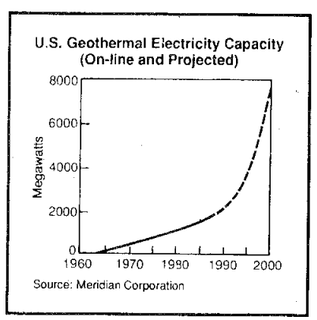
Nine geothermal publications are listed, including opportunities for California commerce, Phases 1 and 2; Geothermal NOI/AFC Regulations; and reports on The Geysers and Calistoga KGRA's.

Energy sector management assistance program (ESMAP) information and status report. Available from the Division for Global and Interregional Programmes, UNDP, One United Nations Plaza, New York, New York 10017.

ESMAP is funded jointly by The World Bank and the United Nations Development Program. It is supported by other UN agencies and various countries. The report identifies several renewable energy opportunities and implementation projects.

Energy for today, renewable energy. March 1990. Free. Prepared for the U.S. Department of Energy. For a copy of the report, write to Technical Inquiry Service, Solar Energy Research Institute, 1617 Cole Boulevard, Golden, Colorado 80401-3393.

This report describes the federal and private renewable energy research programs. The geothermal energy program is summarized briefly at the end of the report, in a three-sentence paragraph.



U. S. Department of Energy Publications

The following documents are available, free of charge, from the Geothermal Division, Mail Code CE-122, U.S. Department of Energy, 1000 Independence Avenue SW, Washington, D.C. 20585 or the Meridian Corporation, Attention: Perle Dorr, 4300 King Street, Suite 400, Alexandria, VA 22302.

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Geothermal technology evolution rationale for the National Energy Strategy. 1990. 45 pages. Prepared for U.S. Department of Energy by Meridian Corporation.

The document contains the rationale for projections of cost, performance, and market penetration by geothermal electric technologies in various case studies described in the National Energy Strategy.

Section 1 reviews the nature and extent of geothermal resources, basic components of geothermal energy systems, achievements to date, status of the industry, and market conditions for geothermal development. Section 2 addresses figures of merit for evaluating the economic viability of geothermal electric projects, and technology trends affecting cost. Section 3 examines three scenarios of projected change in cost and performance based on various potential cases in hydrothermal technology. Section 4 presents the rationale for achieving the improvements in the near-to-long terms.

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Salton Sea Scientific Drilling Project, archival reference. 1990. 25 pages. Prepared for U.S. Department of Energy by Meridian Corporation.

The Salton Sea Scientific Drilling Project was designed to investigate (through drilling and testing) subsurface physical and chemical conditions of rocks and fluids of the Salton Sea geothermal area in the Imperial Valley of California, including evaluation of the geothermal potential beneath the known hydrothermal system of the Salton Sea Geothermal field.

The archival reference process ensures that valuable technical data and scientific information obtained during the project can be retrieved, organized, and maintained as a historical record for future reference.

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Geothermal Energy R&D Program, annual progress report for fiscal year 1990. 1991. 111 pages. Prepared for U.S. Department of Energy by Meridian Corporation.

This report provides a record of progress made toward meeting the research objectives previously established for the Geothermal Program. It describes significant accomplishments achieved in research in the categories of hydrothermal, geopressured-geothermal, hot dry rock, and magma energy.

Energy Information Administration (EIA) publication directory. 1977-1989. Free. Published by and available from the Energy Information Administration, National Energy Information Center, EI-231, Forrestal Building, Washington, D.C. 20585. Phone (202) 586-8800.

This directory contains citations and abstracts arranged by broad subject categories. Only one reference is listed under the heading of geothermal energy: "Selected Federal Tax and Non-Tax Subsidies for Energy Use and Production, Energy Policy Study, Volume 6 (selection number 828) (DOE/EIA-0201/6)."

U.S. Geological Survey research on energy resources, 1990; program and abstracts. Edited by L.M.H. Carter. C1060. 1990. 99p. Free. Available from U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, Colorado 80225. Phone (303) 236-7476.

The abstracts in this circular summarize papers presented at the sixth V.E. McKelvey forum on mineral and energy resources. They provide an overview of USGS scientific research on energy resources. Of interest to people in the geothermal resources field is a paper titled "Evidence for a geologically rapid increase and stabilization of vitrinite reflectance in response to a short-term temperature increase, Cerro Prieto geothermal system, Mexico," by C.E. Barker, USGS, p. 4-5.

Energy facts 1989. $1.50 (GPO Stock No. 061-003-00678-7). Published by the Energy Information Administration. Available from the National Technical Information Service, Document Sales, 5285 Port Royal, Springfield, Virginia 22161.

The publication, organized by energy source, is a compilation of a broad range of domestic and international energy data prepared for the general public and the technical community. The report provides a quick reference to dates, trends, and facts about energy, and contains a section on major energy legislation.

The power of states: a fifty-state survey of renewable energy. 1990. Volume 1, $20; Volume 2, $15; or $30 for both. Available from Public Citizen, Critical Mass Energy Project, 215 Pennsylvania Ave., SE, Washington, D.C. 20003. Phone (202) 546-4996.

The publication discusses the nation's energy needs as they relate to direct solar, wind, geothermal, hydroelectric, wood, and other renewable energy technologies. Volume 1 contains the analysis portion of the survey; Volume 2 the raw data, with a state-by-state breakdown.

Power plays, profiles of America's independent renewable electricity developers (1989 edition), and "Power" database, a companion tool. 1990. $150, softbound; Database $350 (R:Base format) and $300 (ASCII file). Available from IRRC, 1755 Massachusetts Avenue, NW, Suite 600, Washington, D.C. 20036. Phone (202) 234-7500.

Power plays is an in-depth data base (456-page volume) that includes the commercial companies with renewable electricity sources; projects that are on-line or planned; technologies and their prospects in light of the greenhouse effect; utilities purchasing power from qualifying facilities; states where renewable energy development is most active; and costs of projects and financing methods.

LBL geothermal program, list of publications, 1986-1989. Free. Published by and available from Earth Science Division, Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720.

The main technical areas covered by the publications listed are exploration and delineation of geothermal systems, reservoir assessment, and brine injection.

Earth Sciences Division, annual report 1989. LBL-27900,UC-403. $16.95. Published by and available from Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720.

The reservoir engineering and hydrogeology section of the report contains papers describing research on geothermal systems and the complex physics that controls such systems.

Geothermal Resources Council membership roster, with registry of services and equipment. 1990. Free. Published by and available from Geothermal Resources Council, P.O. Box 1350, Davis, California 95617-1350. Phone (916) 758-2360. Fax (916) 758-2839. Telex 882410.

The publication offers general information about existing geothermal associations and contains the 1990 membership roster of the Geothermal Resources Council. A register of services and equipment is included.

EPRI Geothermal Information Series

Three volumes have been written in the Electric Power Research Institute's Geothermal Information Series, according to Evan Hughes of EPRI. All three volumes were prepared by the Radian Corporation, general contractor for the effort. Peter Ellis of Radian is the project manager. The books will be published by EPRI.

Volume 1, Methods of Chemical Sampling and Analysis, is by Peter Ellis, Anne Behl, Nancy Gates, and Donald Michels.

Volume 2, A Guide to Power Cycle Selection, is by Ronald DiPippo and Peter Ellis.

Volume 3, A Data Base on U.S. Geothermal Power Plants, is by Peter Ellis and Ronald DiPippo.

Dr. Hughes expects all three volumes to be available in early 1991.

Proceedings, volumes 1 and 2, industrial consortium for the utilization of the geopressured geothermal resource. Edited by J. Negus-de Wys. 1991. Free. Available from Dr. Negus-de Wys at EG&G Idaho, Inc., P.O. Box 1625, Idaho Falls, Idaho 83415. Phone (208) 526-1744.

The proceedings include some of the latest data and ideas for using geopressured-geothermal resources. It is anticipated that Department of Energy program wells will begin to be made available to industry at the end of FY 1991.

Hot Dry Rock Information

Several new public information items on hot dry rock development are available, free of charge, from John Gustasson, Public Information Office, Los Alamos National Laboratory, MS-A177, Los Alamos, New Mexico 87545.

They are titled, "Los Alamos mini-review, the hot dry rock geothermal energy program" LALP-87-16; "The view from Los Alamos" by Siegfried S. Hecker, Director; "Hot dry rock geothermal energy - -a new energy agenda for the 21st century" LA-11514-MS; and Energy and technology at Los Alamos National Laboratory."

"Hot dry rock - geothermal energy". Edited by Roy Baria. 1990. $140 per copy. 613 pages. Available from James & James, 75 Carleton Road, London N7 OPS England.

An international conference on hot dry rock (HDR) was sponsored by the Camborne School of Mines in June 1989. The volume contains the complete papers presented at the symposium by specialists from industry, universities, and governmental institutions, to review the latest developments in HDR technology.

Economic predictions for heat mining: a review and analysis of hot dry rock (HDR) geothermal energy technology. By J.W. Tester and H.J. Herzog, Massachusetts Institute of Technology Energy Laboratory. July 1990. $17.00. Final report for the U.S. Department of Energy Geothermal Technology Division (MIT-EL90-001). Available from MIT-Energy Laboratory, Room E40-468, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139.

The main objectives of this study were to review and analyze several economic assessments of Hot Dry Rock (HDR) geothermal energy systems and reformulate an economic model for HDR with revised cost components.

HDR development is associated with regions of hot rock beneath the earth's surface without sufficient natural porosity or permeability for extracting hot water or steam. Heat is extracted from such rocks by using hydraulic stimulation techniques to propagate and open joints or fractures, thus creating artificial permeability. The resulting fracture network is penetrated by a set of injection and production wells. Heat is removed from the hot rock by circulating water through it. The cold water enters the system via the injection well and is extracted as hot water or steam from the production well. Now, electricity and/or process steam is generated in a power plant. This heat mining concept is done with a closed loop so there are no effluents.

Because HDR systems do not require natural indigenous hot fluids and high permeability, the HDR resource itself can be defined by the accessible thermal energy in the earth's crust above some minimum temperature level. Thus, the size of the HDR resource is very large and more widely distributed throughout the world than are natural geothermal systems. For example, in the U.S., the amount of thermal energy in place is equivalent to about 180 million barrels of oil. This calculation assumes a 10km depth and an average geothermal temperature gradient of 25°C/km and a minimum initial rock temperature of 150°C.

Geothermal heating, a handbook of engineering economics. By R. Harrison, N.D. Mortimer, O.B. Smarason. 1990. $102.00, 558 pages. Published by and available from Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, New York 10523.

The authors present case studies for 31 geothermal heating systems. Examples are from France, the USA, and Iceland, where geothermal energy is most widely used. The studies show both the ways that thermal waters can be used for space heating and the advantages as well as disadvantages of each method. New concepts of using geothermal resources are introduced.

Colorado Geological Survey publications list. January 1990. Free. Published by and available from the Colorado Geological Survey, 1313 Sherman Street, Room 715, Denver, Colorado 80203. Phone (303) 866-2611.

Numerous publications on geothermal resources are noted in the index under the listing for geothermal resources (hot springs).

The hydrothermal system in central Twin Falls County, Idaho. By R.E. Lewis and H.W. Young. Prepared in cooperation with Idaho Department of Water Resources. WRI 88-4152. 1989. 44p. 1 over-sized sheet. Microfiche, $4.75; paper copy, $7.75. Available from U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, Colorado 80225. Phone (303) 236-7476.

Integration of earth science data sets to estimate undiscovered geothermal resources of the Cascade Range. OF89-0178. Redbook conference on the geological, geophysical, and tectonic settings of the Cascade Range. Proceedings of workshop XLIV. December 1989. Microfiche, $4.50; paper copy, $107.50. Available from U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, Colorado 80225. Phone (303) 236-7476.

Oregon geology. July 1990 issue, v. 52, no. 4. $6.00 for 1 year subscription; single copies $2.00 each. Published by and available from Oregon Geology, 910 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201.

This issue contains an article titled "Hydrothermal alteration in geothermal drill hole GTGH-1, High Cascade Range, Oregon" by Keith E. Bargar, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025. The maximum reported temperature at the bottom of the hole (at a depth of 1463 meters) was 96.4°C. The drill hole is about 14 kilometers northeast of Breitenbush Hot Springs, Oregon. The minerals found in the cores in the andesitic-to-basaltic lava flows, tuffs, and volcanic breccia are compatible with the present low-temperature hydrothermal conditions.

Catalogue of publications. 1989. Free. Published by and available from Department of Industry, Technology and Resources, P.O. Box 173, East Melborne, VIC 3002, Australia.

Under "Publications Available in Microfiche":

Geothermal resources of Victoria. May 1987. $6.60.

Geothermal resources of Victoria: a discussion paper by King, Ford, Stanley, Kenley, Cecil. 1985. $6.60.

Renewable energy strategy: Government energy policy statement. December 1985. $6.60.

Current energy information, weekly bulletin, produced by the United Kingdom Department of Energy Library and Information Center. £25 per year. For information, contact Susan Martin, Department of Energy Library and Information Centre, 1 Palace Street, London, SW1E 5HE.

The bulletin reproduces the contents of over 60 energy periodicals and includes notices on forthcoming conferences, UK Department of Energy news releases, new publications, and abstracts from selected science and energy journals.

Geothermal science and technology. Edited by J.C. Bresee, R.S. Bolton, J. Suyama, and J.L. Varet. 1990 (volume 3); 4 issues per volume. Subscription rate per volume, $222.00. Available from STBS Marketing Department, P.O. Box 786, Cooper Station, New York, New York 10276.

This journal offers the geothermal community a forum to discuss geothermal technology.

Geothermics, International Journal of Geothermal Research and its Applications. 1990. Regular subscription: $310.00 (U.S.). Members of the International Geothermal Association are eligible for the following 1991 rates: Individual/student member: $40 (U.S.) and Corporate/Institutional member: $90 (U.S.). Make checks payable to Pergamon Press. Available from Pergamon Press Inc., Headington Hill Hall, Oxford OX3 0BW, U.K.

Geothermics is published six times per year.

Volume 19, number 5 (1990) contains information about geothermal areas in Kenya, Morocco, and Japan, as well as two articles describing research in geothermal technology.

National Energy Foundation, annual report. Free. Available from the National Energy Foundation, 5160 Wiley Post Way, Suite 200, Salt Lake City, Utah 84116.

The National Energy Foundation was created in the mid-1970s to address the energy educational challenges during times of energy supply shortages and fluctuating prices.

Science education directory, 1989. Compiled and edited by Barbara Walthall and Janice Merz. Published by and available from the American Association for the Advancement of Science, Office of Science and Technology Education (OSTE), 1333 H Street NW, Washington, D.C. 20005.

This directory is a resource for persons involved in science, mathematics, or technology education. It lists science associations, museums, academies, educational research centers, and state and federal government agencies that provide information for earth science educational activities. Alphabetical listings are given for organizations. There is no resource listing by topic subject (such as geothermal).

The Geothermal Education Office

The Geothermal Education Office (GEO) has printed the first issue of its new annual newsletter, *Steam Press, the Journal of Geothermal Education.* A sample copy is available without charge, as are classroom sets of 30.

Also available from GEO is the small, orange children's pamphlet called "About Geothermal Energy", published by the Channing L. Bete Co., Inc. GEO charges about 50 cents a pamphlet, depending on the quantity requested.

For further information, contact GEO at 1-800-866-4GEO, or write Marilyn Nemzer, Director Educational Services, GEO, 664 Hilary Drive, Tiburon, California 94920.

Earth science education connection. A newsletter edited by M.T. Schmidt. 1990. Free. Published by and available from National Center for Earth Science Education, American Geological Institute, 4220 King Street, Alexandria, Virginia 22302-1507. Phone (703) 379-2480.

This newsletter from the American Geological Institute provides guidance to science educators for selecting materials to ensure that students are literate in earth sciences. Guidelines for earth science curricula from kindergarten through the twelfth grade are being developed in cooperation with professional societies, federal agencies, educational institutions, corporations, and individuals.

Geobase, an online bibliographic database for international earth science literature. For information, contact Elsevier/Geo Abstracts, Regency House, 34 Duke Street, Norwich NR3 3AP, England.

Geobase includes over 350,000 records dating from 1980. Over 40,000 are added annually. Each record includes an informative abstract and a bibliographic citation. Subjects include cartography, climatology, ecology, economic geography, geology, geomorphology, geophysics, hydrology, paleontology, planning, stratigraphy, and tectonics.

Geobase is available on the Dialog service as file 292. During 1990, the file will be loaded on the Maxwell Orbit Infoline service. Access to these services is available through most libraries.

Geological speller. 1990. $59.95 plus $3.00 shipping. Available from Xlerate Software Co., P.O. Box 23814, Airport Postal Outlet, Richmond, S.C., Canada V7B-1X9.

The computer software, called Geological Speller, consists of over 10,000 geological words, including those in the geological time scale and terms from mineralogical, igneous, metamorphic, sedimentological, and economic geology.

CALIFORNIA WELLS

Division Well Data Available

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

Drilling Permits for Geothermal Wells Approved January-December 1990 by the Division of Oil and Gas

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
	DISTRICT G1			
		Lassen County		
LITCHFIELD DEVELOPERS				
09/07/90	"Virginia" 2	035-90092	2 29N 13E	Fr NW cor 845m S, 645m E, el 1,240m gr
09/07/90	"Virginia" 3	035-90093	2 29N 13E	Fr NW cor 990m S, 925m E, el 1,240m gr
09/07/90	"Virginia" 5	035-90094	2 29N 13E	Fr NW cor 1,340m S, 385m E, el 1,240m gr
09/07/90	"Virginia" 9	035-90095	2 29N 13E	Fr NW cor 1,520m S, 735m E, el 1,240m gr
09/07/90	"Virginia" 10	035-90096	2 29N 13E	Fr NW cor 1,435m S, 1,240m E, el 1,240m gr
09/07/90	"Virginia" 11	035-90097	11 29N 13E	Fr SW cor 1,455m N, 1,050m E, el 1,240m gr
09/07/90	"Virginia" 12	035-90098	11 29N 13E	Fr SW cor 1,440m N, 710m E, el 1,240m gr
09/07/90	"Virginia" 13	035-90099	11 29N 13E	Fr SW cor 1,475m N, 290m E, el 1,240m gr
		Mono County		
MAMMOTH-PACIFIC				
01/03/90	"MP" 23-32	051-90134	32 3S 28E	Fr ctr Sec 32, 364m N, 541m W, el 2,258m gr
01/03/90	"MP" 24-32	051-90135	32 3S 28E	Fr ctr Sec 32, 146m N, 556m W, el 2,225m gr
01/03/90	"MP" 24A-32	051-90136	32 3S 28E	Fr ctr Sec 32, 33m N, 453m W, el 2,225m gr
01/03/90	"MP" 6	051-90137	32 3S 28E	Fr ctr Sec 32, 180m N, 428m W, el 2,227m gr
01/03/90	"MPI" 43-32	051-90138	32 3S 28E	Fr ctr Sec 32, 364m N, 175m W, el 2,228m gr
01/03/90	"MPI" 43A-32	051-90139	32 3S 28E	Fr ctr Sec 32, 365m N, 43m W, el 2,223m gr
01/03/90	"MPI" 52-32	051-90140	32 3S 28E	Fr ctr Sec 32, 535m N, 54m E, el 2,211m gr
01/03/90	"MPI" 52A-32	051-90141	32 3S 28E	Fr ctr Sec 32, 562m N,

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
				37m E, el 2,211m gr

DISTRICT G2

Imperial County

UNION OIL CO. OF CALIF.				
03/12/90	"IID" 30	025-91177	5 12S 13E	Fr NE cor 45m S, 850m W, el 72m gr
03/12/90	"Sinclair" 30	025-91178	4 12S 13E	Fr SE cor 759m N, 759m W, el 72m gr
05/17/90	"IID" 14	025-91188	22 11S 13E	Fr SE cor 710m N, 1,450m W, el 65m gr
07/16/90	"IID" 8	025-91189	32 11S 13E	Fr SE cor 1,280m N, 671m W, el -65m gr
BARTLETT, FRED F.				
10/15/90	"Imperial" 2	025-91190	1 9S 12E	Fr SW cor 488m N, 181m E, el 30m gr
RED HILL GEOTHERMAL, INC.				
11/16/90	"River Ranch" 13	025-91191	25 11S 13E	Fr SE cor 350m N, 114m W, el -69m gr
SCHWANDER, ERNEST				
11/28/90	"Imperial" 20	025-91192	1 9S 12E	Fr SW cor 382m N, 540m E, el -20m gr

Riverside County

LINDA VISTA LODGE				
05/16/90	"Linda Vista Lodge" 1	065-90165	32 2S 5E	Fr SW cor 42m N, 392m E, el 350m gr
MOHNSEN, ROBERT				
12/31/90	"Mohnsen" 1	065-90166	4 3S 5E	Fr NW cor 630m S, 160m E, el 52m gr

San Bernardino County

CITY OF TWENTYNINE PALMS				
04/20/90	"TNP" 4	071-90065	14 1N 9E	Fr NW cor 1,554m S, 46m E, el 549m gr
04/20/90	"TNP" 1	071-90062	29 1N 9E	Fr NW cor 23m S, 172m E, el 655m gr
04/20/90	"TNP" 2	071-90063	29 1N 9E	Fr NW cor 960m S, 366m E, el 634m gr

DISTRICT G3

Lake County

SANTA ROSA GEOTHERMAL CO.				
08/15/90	"Davies Estate" 9	033-90726	36 11N 8W	Fr NW cor 1,072m S, 452m E, el 585m kb

Napa County

CITY OF CALISTOGA				
05/21/90	"CDHS" 1	055-90123	36 9N 7W	Fr SE cor 290m N, 270m W, el 116m gr

Sonoma County

GEOTHERMAL ENERGY PARTNERS, LTD.				
09/21/90	"Aidlin" 7	097-90817	4 11N 9W	Fr SE cor 1,101m N, 1,433m W, el 383m kb

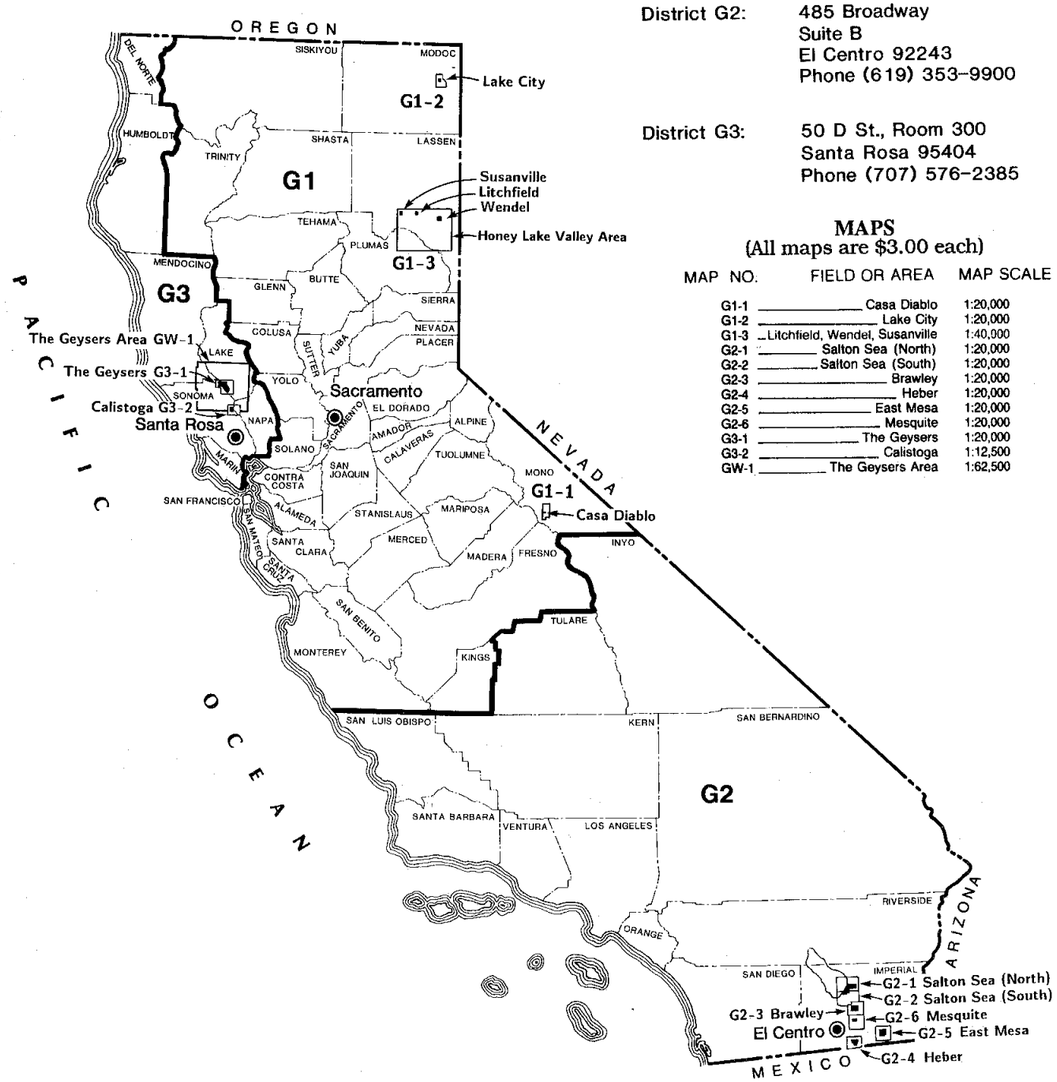
DIVISION OF OIL AND GAS
GEOTHERMAL OFFICES AND MAPS

OFFICES

Headquarters & District G1: 1416 Ninth St., Room 1310, Sacramento 95814, Phone (916) 323-1788

District G2: 485 Broadway, Suite B, El Centro 92243, Phone (619) 353-9900

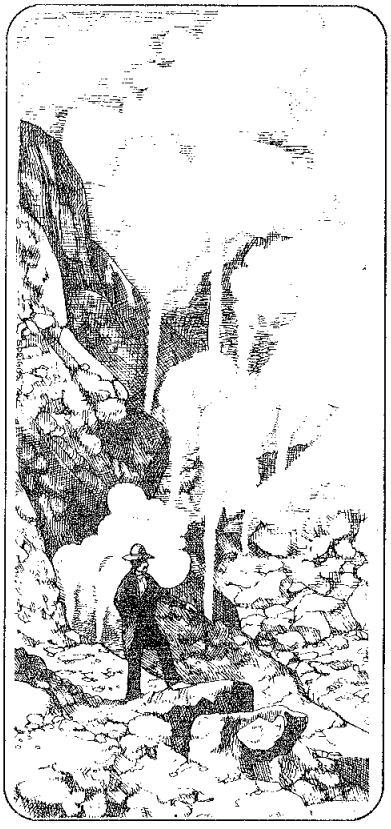
District G3: 50 D St., Room 300, Santa Rosa 95404, Phone (707) 576-2385



MAPS
(All maps are $3.00 each)

MAP NO.	FIELD OR AREA	MAP SCALE
G1-1	Casa Diablo	1:20,000
G1-2	Lake City	1:20,000
G1-3	Litchfield, Wendel, Susanville	1:40,000
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

Division of Oil and Gas
1416 Ninth Street, Room 1310
Sacramento, CA 95814



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