the DI\"V\'\\u0000\"ION OF OIL & GAS
M. G. Mefferd, State Oil and Gas Operations
Richard P. Thomas, Geothermal Officer

ER\'\multilinechar{TM}AL
HO\multilinechar{T}\淖LINE
Send Us Your News

The Geothermal Hot Line encourages and welcomes contributions from its readers. We always need news and factual articles on every aspect of high- and low-temperature geothermal development in California and worldwide.

Possible topics include environmental safeguards, exploration, geology, reservoir engineering, research and development, power plants, legislation and regulation, conference notices, and news about new publications, maps, and videotapes.

You can call me with a story or send in an article.

How long should an article be? Most run between 1 and 5 double-spaced, typewritten pages. (Longer ones are used on occasion.) Photographs are always helpful. Black and white photos are preferable, but color photos often reproduce quite well. I will copy and return all photos that you send. Our graphic artist will make line drawings from your sketches.

I look forward to hearing from you. And, please make sure I’m on your company's press release mailing list.

Susan Hodgson
Editor

The GEOTHERMAL HOT LINE is a biannual publication of the Division of Oil and Gas and subscriptions are free. To subscribe, send your name and address to the Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, CA 95814. Phone: (916) 445-9656. Telefax: (916) 323-0424.

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California
Other Western States
Worldwide
Development
Technology Transfer
California Wells
Index, Vol. 18

On the road with geothermal. Page 55.
The IDB makes geothermal plans. Page 76.
The greenhouse effect and geothermal energy. Page 84.
IN MEMORIAM

Barkman C. McCabe
1897 - 1988

On October 24, 1988, Barkman C. McCabe passed away in Los Angeles, California, after a short illness. Mr. McCabe was Chairman Emeritus of Magma Power Company. His work pioneered commercial development of both geothermal steam from The Geysers Geothermal field in Northern California and geothermal hot brine from the Imperial Valley in Southern California.

An Historical Monument marker placed in 1974 by well "Magma" 1, at The Geysers, reads, in part:

"First commercial geothermal steam well in the Western Hemisphere, drilled December 1954 by Magma Power Company under the supervision of B. C. McCabe, President. The successful completion of the well started development of this geothermal project."

Geothermal Section
Department of Conservation
Division of Oil and Gas

The Geothermal Section of the Department of Conservation, Division of Oil and Gas has regulated the state's geothermal wells since 1967. Currently, the Geothermal Section includes six engineers and three clerical support personnel working in the Sacramento, Santa Rosa, and El Centro offices.

The Geothermal Section's mandates resemble those of the division's Oil and Gas Section in the areas of well operations and the protection of life, health, and natural resources. However, differences do exist. For example, for purposes of the California Environmental Quality Act, the Geothermal Section acts as the lead agency for all geothermal exploratory projects on state and privately held lands. In addition, the Geothermal Section regulates well-siting procedures in areas of unstable terrain. Differences among the geothermal projects overseen by the three geothermal offices reflect the variety of geothermal resources and resource-development activities in the state. In fact, California's geothermal projects range from development of the largest geothermal steam field in the world to individual users of low-temperature resources.

In spite of the great resource diversity, all three offices have similar functions. Each collects and files well records and production and injection data. Most well records are open to public inspection.

The records include applications submitted by operators to drill, rework, and abandon geothermal production and injection wells and temperature-gradient holes. Upon receiving the applications, engineers evaluate each project's geological, geochemical, engineering, safety, and environmental components. The engineers then approve, conditionally approve, or deny the applications.
Geothermal engineers also make field inspections in 1986, over 1,000 inspections were made. In addition, they witness injection-well tests and meet annually with each injection well operator to discuss field performance.

What geothermal projects are underway in each district? Those of District G1 (headquartered in Sacramento), which covers most of Northern California except for the Geysers area and the northern coastal counties, are described in this issue of the Hot Line. The next two issues will have similar stories about geothermal activities in Districts G2 and G3, headquartered in El Centro and Santa Rosa, respectively.

THE DIVISION OF OIL AND GAS

Regulates the DRILLING, OPERATION, MAINTENANCE, and ABANDONMENT of oil, gas, and geothermal wells.

Encourages the wise development of oil, gas, and geothermal resources through good conservation and engineering practices.

Requires measures that prevent wall, prevent subsidence.

Prevents, as far as possible, damage to life, health, property, and natural resources.

Ensures that over 12,000 Class II injection wells are operated properly.

Protects underground and surface waters suitable for irrigation and domestic uses.

Requires the use of proper well plugging and abandonment methods.

Geothermal District G1

Geothermal District G1 includes 37 northeastern California counties and six geothermal fields: Lake City, Susanville, Litchfield, Wendel, Amedee, and Casa Diablo. Electrical generation from geothermal resources occurs in three of the fields: Wendel, Amedee, and Casa Diablo. Low-temperature geothermal projects are underway throughout the district. In the road log that follows this article, I have tried to include all the geothermal projects. Let me know if any were omitted.

Most low-temperature wells drilled in District G1 are exploratory wells. An exploratory well is defined, in part, as any well drilled over 1/2 mile from a geothermal well able to produce geothermal fluid in commercial amounts. Under the California Environmental Quality Act, the Division of Oil and Gas acts as the lead agency in the environmental documentation process for all exploratory geothermal well projects. The exception is Imperial County, which has been granted lead agency status by the division.

Environmental documentation for all other wells is handled by city or county planning departments. The documentation is reviewed by the Division of Oil and Gas when a project is on state or private land. In such cases, the division is considered a responsible agency.

For all geothermal projects on state or private land, a division engineer must issue permits for all drilling and production operations. To ensure compliance with permit stipulations, periodic inspections are made of operations and equipment.

The District G1 office receives many technical questions, especially from low-temperature resource developers who begin projects with little or no experience in geothermal development. In such cases, it is especially important that an applicant telephone the Geothermal Section and explain the proposed project to a geothermal engineer. He or she will outline the most expeditious way to proceed.

Road Log: Geothermal District G1, November 1988

Welcome to Geothermal District G1. Our tour starts in the Town of Big Bend, about 50 miles northeast of Redding in Shasta County. Three geothermal projects here, in and around the town.

The first is the Indian Springs School District's direct heating project. Using funds received from the California Energy Commission (CEC), the school district drilled geothermal well 7998 1 to...
250 meters, down to a hot water resource of 50°C. The well is about 80 meters from the school’s main facilities. The entire school, two residential units for school employees, and an indoor swimming pool have been heated with the geothermal fluid for two years. Although the school uses the geothermal water directly (with the exception of the swimming pool and showers, the output is just east of Big Valley High School. The well was drilled to 648 meters, with recorded water temperatures near 60°C. An evaluation is underway to decide whether the hot water could be used for direct-heating projects or to boost temperatures in a heat pump in the high school heating system.

3. BIEBER

Further to the east, in the northeastern corner of Lassen County, is the Town of Bieber. The Pit Resources Conservation District received funds from the CEC to drill several wells in and around the town to assess the area’s geothermal resources. To date, only one well, “BV” 3, has been drilled. It is just east of Big Valley High School. The well was drilled to 648 meters, with recorded water temperatures near 60°C. An evaluation is underway to decide whether the hot water could be used for direct-heating projects or to boost temperatures in a heat pump in the high school heating system.

4. ALTURAS

In the City of Alturas, Modoc County, work started in 1987 on a joint project between the county and the Modoc Joint Unified School District. The project was designed to assess the geothermal potential in Alturas by drilling a geothermal well near Modoc High School. The well, “AL” 1, was drilled on the high school campus to a depth of 738 meters; water temperatures are near 80°C. The well, which underwent limited testing, may be used by the school to help heat most of the campus facilities. Additional work on the project may be needed, including additional drilling to assess more clearly the geothermal reservoir. The past work was funded, in part, by the CEC.

5. CEDARVILLE

Cedarville is at the junction of Highway 299 and Surprise Valley Road, 23 miles east of Alturas. There are four geothermal projects in and around the town. Several years ago, water wells were drilled that produced water above 52°C. One well, “Cedarville” 1, is now being used to heat the decorated “Cedarville” shop and the Cedarville High School. Water from the well has been given to the school. Coopers’ Well Drilling, Inc. will continue to use some of the well water to heat the shop.

6. LAKE CITY

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7. HONEY LAKE VALLEY

Continuing south into Lassen County, one comes to several geothermal projects in Honey Lake Valley. The most widely known geothermal project in the valley is the Susanville District Heating Project. The district-heating system includes two production wells, two injection wells, and about 16,000 feet of insulated pipe connecting 77 facilities to the system.

The two production wells are able to produce about 900 gallons per minute of about 74°C geothermal water. Plans exist to enlarge the system to serve an additional 75 users. Based on 1986 heating costs, the facilities that An inspection well, “BP” 3, of high geothermal flow. The water from the well is produced to 57°C. The U.S. Army drilled several geothermal wells in the area, and the City of Susanville, County of Lassen, U.S. Department of Energy, U.S. Department of Housing and Urban Development, U.S. Bureau of Reclamation, and the Farmer’s Home Administration.

In the southern portion of the Susanville Geothermal field, the commercial operation has been suspended due to drought conditions and the lack of fresh mixing water.
Two wells drilled by Trans-Pacific Corporation, "Nesat" 1 and 2, supply a 2-megawatt binary power plant, Amedee Geothermal Venture 1 (Phase 1), with geothermal water at 107°C. The binary power plant uses Freon 114 as its working fluid and is air-cooled in a manner similar to that of the Winnemucca Power Plant. Phase 2 of the venture will expand the power plant to 5 megawatts, net, if geothermal reservoir tests are favorable. Electricity is sold to Pacific Gas and Electric Company under a Standard Offer 4 contract. The power plant went online in the fall of 1988.

Until a few years ago, the spent geothermal fluids from the Winnemucca Power Plant were cascaded to heat the Honey Lake Hydroponic Farm’s greenhouse operation. Today, the greenhouse operation is no longer in business, so the fluids are discharged into old drainage channels, where they mix with water flowing from nearby hot springs.

An employee need not be on-site 24 hours a day, as the plant is operated by computer, via a telephone line. If an emergency or a shutdown occurs, an employee is notified by the computer.

The first project to be built at the geothermal park is expected to be a geothermally heated aquaculture facility constructed for raising mosquito fish. Experiments will be undertaken here to see if mosquito fish can be raised and bred in low-temperature geothermal fluids. The mosquito fish, which eat mosquito larvae, would be useful in the Sutter-Yuba Mosquito Abatement District’s program in the Sacramento Valley. The project has been funded by the CEC.

The second potential injection well has been drilled. Two potential production wells have been drilled, but neither was completed successfully. The project has been suspended, pending further investigation.

To the southeast of the Winnemucca Power Plant, Amedee Geothermal Field has been studied for geothermal resources from 1960 to 1988. Amedee has long been known for its geothermal hot springs. Several developers have come here looking for a viable geothermal resource.

The community of Mammoth Lakes, through a grant from the CEC, has drilled two geothermal assessment wells inside the town limits as part of a geothermal resource assessment/district-heating project. Temperatures near 79°C were encountered in both wells at about 457 meters. The town is now evaluating drill sites for exploration and/or production wells to further test the geothermal resource. Initial assessment work and feasibility studies for the project were done with the assistance of Mono County and the CEC.

Sierra County has been evaluating the geothermal resources in Sierra Valley for several years. The county recently converted a temperature-gradient well, "393", to an exploration well, which is being evaluated for production potential. The county plans to build a geothermal park near the "393" site, where it owns 40 acres of land with a low-temperature geothermal resource.

The project to be built is a geothermally heated aquaculture facility which uses Freon 114 as its working fluid and is air-cooled in a manner similar to that of the Winnemucca Power Plant. Phase 2 of the venture will expand the power plant to 5 megawatts, net, if geothermal reservoir tests are favorable. Electricity is sold to Pacific Gas and Electric Company under a Standard Offer 4 contract. The power plant went online in the fall of 1988.

The power plant uses a heat exchanger, which uses Freon 114 converted to vapor to maintain a working fluid temperature of 107°C. The Freon 114 is to be injected back into the reservoir tests in the Sacramento Valley. The project has been funded by the CEC.

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$3 Million Bid for Glass Mountain Leases

A Santa Rosa-based geothermal company was the successful bidder for about 12,000 acres in the Glass Mountain geothermal area in Siskiyou County, offered for lease by the Bureau of Land Management (BLM).

Freeport-McMoRan Resource Partners bid $3 million and won the seven tracts at Glass Mountain, which a company official said has the best geothermal potential of any land offered by the BLM in several years anywhere in the United States.

Unocal Drills at Glass Mountain

Unocal Corporation is carrying the search for geothermal resources to northeastern California, almost to the Oregon border.

In July 1988, the company was drilling in the Glass Mountain area, about 25 miles south of Tule Lake and 30 miles south of the Oregon border.

The well, designated “Glass Mountain Federal” No. 68-8 on Sec. 8, 4th R., Siskiyou County, is in the southeastern quarter of the southwestern quarter of the southeastern quarter of the section.

Originally, Unocal drilled the well in 1984 as a temperature-gradient hole, bottoming at 6,500 feet. On the present go-round, Unocal may deepen the well to about 8,500 feet.

When questioned about this in December 1988, Unocal spokesman Harry Bain said the well was completed. “We are testing the well and evaluating the test results. We’re pleased with what we’ve seen so far, but it’s too early to tell whether or not there is a project and what size any potential project would be.”

The drill site lies about two miles southwest of Glass Mountain, a 7,649-foot peak that’s a landmark in the high Modoc Plateau of Northern California. The mountain is composed of black volcanic glass, called obsidian, and pumice. According to geologists, the mountain was formed no more than 1,100 years ago — little more than yesterday in geologic terms — by two separate flows of volcanic rocks.

Pomona, Wintun, and Modoc Indians made arrowheads, spearpoints, crude knives, and razors from the obsidian. They traded some of them with the tribes of the lower Klamath, in Oregon.

In the 1920’s, others turned their attention to Glass Mountain, filing claims for both obsidian and pumice. In the 1930’s, one group of entrepreneurs set up a rock-sawing plant near the northeastern edge of the mountain and tried, unsuccessfully, to cut blocks of black obsidian into tiles for sinks and shower stalls. A more successful venture that followed was cutting scouring blocks from the pumice.

The mining of block pumice still continues in the area.

It’s too early to tell whether or not there is a project and what size any potential project would be.

Bill Woods, an official with Geysers Geothermal, Freeport-McMoRan’s management partner, said the acquisition brings the total acres leased to the company to about 25,000 — 9,700 of which are within the Glass Mountain unit boundary. He said the company leased the tracts to be in a position to explore and develop the geothermal resources when the market improves.

The BLM received bids on 12 of 20 parcels for lease at Glass Mountain. The highest individual bid of $967,201 was submitted by Freeport-McMoRan for a 1,304-acre tract.

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In January 1989, David Lindquist, project manager for Zurn/NEPCO, said that the turbine building and the boiler were erected, and that the fuel-handling system was 50 percent completed. He was awaiting delivery of the steam turbine generator.

**Mono County Update**

On December 6, 1988, the Mono County Board of Supervisors, in a vote of 5 to 0, approved the issuance of a use-permit for the Mammoth-Pacific II geothermal power plant. The power plant will be a binary, air-cooled, 10-megawatt, net, project. The permit was to take effect on January 16, 1989; however, an appeal was filed by the California Department of Fish and Game, and the permit will not take effect until this appeal is resolved.

In February 1988, Mono County issued a project use-permit to proposers of Bonneville Pacific Corporation's Mammoth Chance Geothermal Project, also a 10-megawatt, net, binary and air-cooled project. The permit was appealed by the Sierra Club, Cal-Trout, and the California Department of Fish and Game. In January 1989, as a result of a mandamus hearing originally conducted in July 1988, the Mono County Superior Court issued a decision in favor of the petitioners. It set aside the certification by the Board of Supervisors of the Mammoth-Pacific II and III Geothermal Project EIR and the conditional-use permit issued for the projects. Now, a subsequent EIR must be prepared for public review and comment. The subsequent EIR will address the issue of cumulative impacts and will include a discussion of "new information".

To provide a technical forum for the discussion and evaluation of hydrologic resource data collected in the Long Valley Caldera of Mono County, I formed the Long Valley Hydrologic Advisory Committee (LVHAC) in 1986. When requested, the committee provides comments on such hydrologic resource data to permitting agencies.

In its January 1989 meeting, the committee decided to send a comment letter to Mono County and the Bureau of Land Management regarding the effectiveness of hydrologic monitoring in Long Valley. The committee also discussed data from a preliminary hydrological report by S.S. Papadopulos and Associates, Inc. In a third agenda item, the committee decided to move ahead in compiling a conceptual model/forecast budget analysis of the geothermal resource in the Long Valley area. The Department of Fish and Game will continue to prepare its own model of this geothermal resource.

New Power Plants Operating at The Geysers

The West Ford Flat Power Plant at The Geysers Geothermal field is owned and operated by Freeport-McMoRan Resource Partners/Geyers Geothermal Company. The 27 megawatt, net, geothermal power plant has two, 13.5, net, megawatt units. Unit 1 went on line December 11, 1988. The electricity is purchased by Pacific Gas and Electric Company under a Standard Offer No. 6 contract.

Seven production wells and 1 injection well are used to operate the power plant, which is in the southwestern quarter of Section 23, Township 11N., Range 9W., M.D. B.&M. Plant engineering and design is by SAi Engineers, Inc.

The Bear Canyon Creek Geothermal Power Plant, also at The Geysers, is owned and operated by Freeport Geothermal Resources Company. The 20-megawatt, net, plant has two, 10-megawatt, net, units. Unit 1 went on line September 2, 1988, and Unit 2 went on line September 6, 1988. The electricity is sold to Pacific Gas and Electric Company under the terms of a Standard Offer No. 4 contract.

Five production wells and 1 injection well are used to run the $50 million power plant, which is near the center of Section 36, Township 11N., Range 9W., M.D. B.&M. Plant engineering and design is by Stone and Webster Engineering Corporation.

GEO SELLS AIDLIN GEOTHERMAL PROJECT TO MFE

Geothermal Resources International, Inc. (GEO) has completed the sale of its interest in the 20-megawatt Aidlin Geothermal Project at The Geysers Geothermal field in Northern California.

According to GEO's Chief Executive Officer, Ronald P. Baldwin, GEO sold its interest in the Aidlin Geothermal Project to Geothermal Energy Partners Ltd. (GEP), a California partnership. GEP was represented in the transaction, which has a total value of about $13 million (including $8.4 million in cash), by its general partner, Western Geothermal Company, a wholly-owned subsidiary of Mission Power Engineering Company (MFE).

Baldwin said that in January 1989, GEO had received the option to purchase for $4 million two long-term power-purchase agreements from GEO/Saiga, which Saiga entered into in 1984 with Pacific Gas and Electric Company. Based on the Saiga agreement, GEO had planned to develop the geothermal resources on about 700 acres it has leased at The Geysers from private landowners Joseph W. and Mary A. Aidlin and to contract with MFE to engineer and construct a geothermal power facility containing two 10-megawatt generating units.

Baldwin said the sale of the company's interest in the Aidlin Geothermal Project to MFE provides GEO with a portion of the funds necessary to meet some of its more immediate financial obligations. This includes an interest payment of about $850,000 owed to PacificCorp in Portland, Oregon.

He said the company continues to discuss with its lending institutions and creditors other aspects of a short-term financial plan designed to enable GEO to further reduce its short-term liquidity problems.

DWR GEYSERS UPDATE

"Right now, we're looking for expressions of interest in our geothermal resource around the South Geysers Geothermal Power Plant and in the power plant itself," said Henry Struckmeyer, Chief of the Resources Development Branch, Department of Water Resources (DWR).

"Three steam-production wells and one dry well are at the site," he added.

"At the DWR Bottlerock Geothermal Power Plant, the Department of Water Resources now not only owns the power plant, which it constructed and operates, but the lease, well pad, and steam gathering system," Mr. Struckmeyer added. "These last three items were purchased on July 1, 1988 from MCR Geothermal Corporation, Eniex Petroleum, and Geothermal Kinetics, Inc."

The 35-megawatt Bottlerock plant began full-capacity commercial operation in March 1985. In December 1988, the power plant was operating at about 20 megawatts, net.

Three Power Plant Units Cancelled

"Pacific Gas and Electric Company has cancelled plans to build three geothermal power plants at The Geysers Geothermal field," said Jan Stewart, News Services Representative for the company. The plants are Unit 19 (65 megawatts), Unit 21 (140 megawatts), and Unit 22 (140 megawatts). All the power plants were to be built in Lake County.

Ms. Stewart said that the plants were cancelled "...because Unocal, our primary steam supplier at The Geysers, has determined there is insufficient steam to operate them."

When asked about the field's steam supply in general, she replied, "There's been a slight decline in steamfield production, but we're not having many significant problems."
Steam Prices Drop in 1988

Steam prices at The Geysers, the world's largest producer of geothermal power, have dropped to their lowest level in 10 years and will result in a several-hundred-thousand-dollar loss in property taxes for Sonoma and Lake Counties.

Geothermal industry officials are estimating a price drop of more than 12 percent for 1988. Sonoma and Lake Counties use the price of steam to calculate the value of the steam reserves for property tax purposes.

The price is set by a complicated formula worked out between PG&E and Unocal. One of the key factors is the world price of oil, which has remained low for the past three years. The price is set every spring and is retroactive to January 1.

Steam prices rose steadily and reached a peak of $30.40 per megawatt hour in 1985, but have declined steadily in the last three years. This year's price will be comparable to the $18.50 price set in 1978.

Geothermal tax revenues also climbed with the steam prices, reaching an all-time high in the 1984-85 tax year. They have dropped steadily since. For example, tax revenues from the steam reserves, excluding power plants, dropped from $13.5 million to less than $10 million in Sonoma County last year.

While the price drop is bad news for steam suppliers and public agencies that benefit from geothermal tax dollars, the impact won't be as devastating as last year when the steam price fell 43.6 percent -- from $30.60 a megawatt hour to $17.26.

Losses in Lake County were offset by new development, which caused the tax value of the geothermal industry to increase slightly, Dan Irwin, Lake County's assistant assessor said.

Gary Kronovich, an administrative analyst for Sonoma County, said the impact of the price drop on the county's finances is still being assessed. He and Irwin said they anticipate a drop in geothermal tax revenues in their counties this year. Besides Sonoma and Lake Counties, the Geyserville and Cloverdale school districts benefit the most from geothermal tax dollars.

Hardest hit was Unocal, which lost close to $100 million with the big price drop last year and virtually halted all high-risk ventures, including exploration.

by Don W. Saludes
Reprinted, with permission, from the Santa Rosa Press Democrat, April 1988.

New Unocal Geothermal President

Stephen C. Lipman has been appointed president of Unocal's geothermal division, effective February 1, 1989. He will have responsibility for worldwide geothermal operations.

Mr. Lipman joined Unocal in 1963 as a petroleum engineer working in oil and gas operations. He moved to the geothermal division in 1976 and became district operations manager for geothermal operations in Santa Rosa, California, in 1979. He was named vice president for domestic operations in 1984 and has been executive vice president of the division since July 1986.

Mr. Lipman replaces Dr. Carel Otte, 66, who has led Unocal's geothermal activities since inception. Dr. Otte will continue as a senior advisor to the company until he retires later this year.

Power Plant Notes, October 1988

A well-planned and informative field trip to geothermal power plants in California's Imperial Valley was organized as part of the annual meeting of the Geothermal Resources Council in October 1988. Not only were many power plants running at this time, but many were under construction, as well. The following notes and photographs are from the trip.

SOUTHERN CALIFORNIA

Power Plant Notes, October 1988

Text and photos by Susan F. Hodges

California's Imperial Valley was organized as part of the annual meeting of the Geothermal Resources Council in October 1988. Not only were many power plants running at this time, but many were under construction, as well. The following notes and photographs are from the trip.

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The following notes and photographs are from the trip.
J. J. Elmore power plant under construction. Four Magma Power Company geothermal power plants are either on line or under construction in the Salton Sea Geothermal field: Vulcan (the oldest, on line in 1983), Del Ranch (10/1983), J. J. Elmore (12/1983), and Lehrs (scheduled for the fall of 1988). Red Hill Geothermal, a 100 percent-owned subsidiary of Magma Power Company, operates all four plants.

All of the power plants are dual-flash. However, the Vulcan plant has two turbines (high temperature and low-temperature), each with its own generator. Each of the other three power plants has a single, double-entry turbine.

Temperatures from 450° to 600°F have been measured in geothermal wells drilled to operate the power plants. The Vulcan plant has 12 production wells and 7 injection wells; the Del Ranch plant has 8 production wells and 4 injection wells; the J. J. Elmore plant has 8 production wells and 4 injection wells; and the Lehrs plant will have about the same number of wells as the other plants.

Southern California Edison (SCE) purchases power from all four power plants. The contract with SCE, for all but the Vulcan plant, calls for a firm capacity of 34 megawatts and a peak-load reading of 38 megawatts. The Vulcan power plant produces 32 megawatts, net, of electricity.

Oro Mesa I, a project of Oro Mesa Geothermal, is a 50-megawatt geothermal power plant with 20 Ornait Energy Converter units in the East Mesa Geothermal Resources Area. The project went on line in September 1987 and includes 11 production wells and 6 injection wells. The binary power plant was constructed by Walsh Construction Company, a subsidiary of Guy F. Atkinson Company.

Oro Mesa II is a binary geothermal power plant, and an extension of Oro Mesa I in the East Mesa Geothermal Resources Area. Oro Mesa II went on line in December 1988. The power plant, which includes 10 Ornait Energy Converter units, generates 8 megawatts, net, of electricity. Four geothermal production wells and 3 injection wells are included in the project.

Oro Mesa II is a 30-megawatt, binary geothermal power plant that began generating electricity from moderate-temperature geothermal fluid in March 1988. The geothermal power plant is also in the East Mesa Geothermal Resources Area. The power plant is the culmination of a development partnership between Ornait Energy Systems, Inc., and Harbert International, Inc.

Nine production and injection wells were drilled and tested for the power plant. Each of the 20 Ornait Energy Converters used in the project is a self-contained power plant of 1.3 megawatts.

GEM I is a 37-megawatt, gross, geothermal power plant, 50 percent of which is owned by GED East Mesa Limited Partnership and 50 percent by a wholly-owned subsidiary of Mission Energy Company. The dual-flash power plant, with two, 18.5 megawatt units, is scheduled for completion on June 1, 1989, in the East Mesa Geothermal Resources Area. At the end of January 1989, a company official said that 13 to 16 geothermal production wells would be used to operate the power plant, and that 14 production wells had been drilled. He added that 6 to 8 injection wells would be needed, and 4 injection wells had been drilled.

Heber Binary Demonstration Plant: A Second Law Assessment of Low-Power Tests

Introduction

The Heber Binary Project involves the world's largest power plant of its type—a 65-megawatt, net, geothermal plant that has been described in a series of reports and technical articles. The project sponsors and contributors include: the U.S. Dept. of Energy, Electric Power Research Institute (EPRI), California Dept. of Water Resources, Imperial Irrigation District, Southern California Edison Co., San Diego Gas & Electric Co., State of California, Magma Energy Co., and Pacific Gas and Electric Co.

The results of start-up and low-power testing have been reported by EPRI in Special Report AP-5240-SR.1 It is not the intent of this article to restate the results of that report, but rather to offer an interpretation of the plant's performance during the tests. This is of interest because the plant was limited to no greater than 25.5 megawatts, gross, output due to low brine flow. The question of whether the plant could have achieved its design power output and efficiency had it been supplied with the design brine flow can be addressed using thermodynamic Second Law concepts, i.e., through the use of exergy.

Test Results

Special Report AP-5240-SR contains tables of daily test results for the period of December 8, 1985 through June 20, 1986. For each of the 201 days in the test period, the following data are listed: brine mass flow rate, heat input, number of wells in service, plant availability, plant maximum capacity, gross and net electricity production, brine utilization, heat rate, and wet-bulb temperature. Although the brine inlet and outlet temperatures are not quoted for each day, it is stated that the inlet temperature varied from 360°F to 364°F (182.2°C to 184.4°C), and the outlet temperature was 150°F (65.6°C). In this analysis, I have adopted 360°F (182.2°C) as the average brine inlet temperature.

1, 6 Superior figures refer to a list of Selected References at the end of the article.

Second Law Analysis

The Second Law approach to plant performance centers on the maximum theoretical output associated with a given input stream of geothermal fluid. This is called the exergy, and is found from the following equation:

$$ E = \left[ h_2 - h_1 - T_0 (s_2 - s_1) \right] $$

where $m$ is the mass flow rate of geofluid, $h_1$ and $s_1$ are the geofluid inlet enthalpy and entropy, $T_0$ is the absolute temperature of the available heat sink (in this case, the wet-bulb temperature), and $h_2$ and $s_2$ are the enthalpy and entropy of the geofluid evaluated at $T_0$. To a very good approximation, $h_2$ and $s_2$ can be taken at

by Dr. Ronald D'Agno
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North Dartmouth, MA 02747
saturated liquid conditions.

The net utilization efficiency is simply the ratio of the net power output (i.e., gross power minus all parasitics including brine well pumping power) to the energy:

$$\eta_n = \frac{W_{net}}{E}$$

The figure shows a plot of $\eta_n$ versus the maximum gross power for the TS test points selected for analysis. The curve is a second-order, least-squares fit to the data; the correlation equation is:

$$\eta_n = -0.0084 + 0.0127 W_{net} + 0.00000098 (W_{net})^2$$

According to the correlation, there is a threshold of 8.3 megawatts that must be exceeded before the plant can produce any net power. The dashed portion of the curve is an extrapolation to the design gross power of 65 megawatts. At that value, the correlation predicts an efficiency of 30.5 percent (large circle).

We may compare this predicted value to the design value based on full brine flow of 7.8 million lbm/h (345 kg/s): the energy input under design conditions is 147.43 megawatts; the design net power output is 45 megawatts; thus, the design Second Law efficiency is 30.5 percent.

Therefore, we find that the extrapolated plant performance based on low-power test data agrees with the design performance at full brine flow. This would imply that the Heber plant should be able to achieve its design rating when the production facilities are expanded to full capacity. It must be noted, however, that the tests results were achieved using a brine inlet temperature that was lower (i.e., more favorable) than the design point temperature of 175°F (79.4°C) versus 166°F (74.4°C). Furthermore, some of the excess cooling tower capacity that was available during the low-power tests was used to achieve maximum cooling in the hydrcalor con- denser. This allowed for a lower turbine backpressure, which also improved the performance.

New Imperial Valley Power Line

The Imperial Irrigation District placed its new 104-mile, 230-kV transmission line in service in the Imperial Valley on September 14, 1988. The power line, with a rated capacity of 600 megawatts, transmits electricity generated at geothermal power plants. The line runs from the Midway Substation near Niland to Southern California Edison's (SCE) Couchella Substation near Indio. The southern portion of the line will run from the Hildale Substation east of Holtville to Midway, and is expected to be in service in November 1988. A lesser feeder line will run between Heber and the Hildale Substation.

Selected References

2. DiPippo, R., "Energy Analysis of Combined Electric-

1. Work on the line began in the summer of 1987. Irby Construction Company of Jackson, Mississippi, was the contractor.

The transmission line was financed by 14 geothermal companies, whose participation was based on the amount of line-capacity they expect to use. The 14 participants are: Chevron Geothermal Company of California; Del Ranch, Ltd.; Desert Power Company; Elmore, Ltd.; Earth Energy, Inc.; GEO East Mesa No. 2, Inc.; GEO East Mesa No. 3, Inc.; Heber Geothermal Company; Magna Power Company; Ormesa Geother-

GRI-Mission Energy Partners in East Mesa

On December 6, 1988, Geothermal Resources Interna-

1. GRI-Mission Energy Partners, which includes the 37-megawatt geothermal power-generating facility (GEM 1) currently under construction and the existing 13.4-megawatt McCabe geothermal power-generation facility.

According to GEO's Chief Executive Officer Ronald P. Baldwin, the Mission subsidiary acquired its 50 per-

1. Baldwin said that the sale of the equity in the East Mesa geothermal project is an initial step towards a financial solution to GEO's current cash flow needs, and is part of an overall financial restructuring plan the company has undertaken since August 1988.

To complete the transaction, the Mission Energy Sub-

1. Baldwin said that in the event the East Mesa geother-

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GEOHERAL HOT LINE

Geothermal Helps SCEcorp Earnings

SCEcorp, the parent company of Southern California Edison Company, announced another record year of earnings for 1988, according to Howard P. Allen, chairman of the board and chief executive officer. Mr. Allen stated that the earnings increase was particularly noteworthy because it was achieved despite a reduc-

1. "The reduction, by itself, would have lowered earnings 33 cents per share," he said, "but the company over-

1. geothermal projects expands its power generation capacity up to an additional 36 megawatts, the Mission Energy subsidiary has an option to participate in this project, which includes providing funding for a 50 percent interest.
expenses, approval by the CPUC of expense levels that more accurately reflect Edison’s costs, a CPUC award for favorable coal plant operating performance, and higher earnings from the Mission Group of nonutility subsidiaries.”

Allen reported that 1988 earnings per share for SCEcorp’s nonutility subsidiaries (the Mission Group) were 35 cents or 10 percent of total SCEcorp earnings, compared with 19 cents or 6 percent for 1987. Nonutility earnings were 84 percent greater than in 1987, with earnings growth being achieved in each nonutility business. “Higher earnings resulted from Mission Energy bringing 830 megawatts of new cogeneration and geothermal projects into operation...

SCEcorp and SDG&E Agree to Merge

On November 30, 1988, SCEcorp announced that the boards of directors of both SCEcorp and San Diego Gas & Electric Company (SDG&E) have approved a definitive agreement to merge SDG&E into Southern California Edison Company, the electric utility subsidiary of SCEcorp. “SCEcorp’s board acted a week ago and SDG&E’s board acted today,” said Howard P. Allen, chairman and chief executive officer of SCEcorp. “Approval by the shareholders of both companies is required for the proposed transaction,” Allen added.

“For SCEcorp shareholders, SDG&E offers a service territory with greater projected growth rates than Edison’s, and a better customer mix that provides more stable revenues,” Allen said. “The merger offers the potential for operational savings at least $100 million, which can help keep electric rates down.”

“The combination also offers a number of operational benefits. These include use of current excess generating capacity on the Edison system, more efficient operations and greater economies of scale, direct access to existing and potential generation in Mexico, lower costs to provide service to newly developing areas in South Orange County, and reduced need for capital expenditures in the future.

“Consummation of the merger, which is expected in late 1989 or early 1990, also is subject to approval by the California Public Utilities Commission, the Federal Energy Regulatory Commission, and other regulatory authorities.”

Allen indicated that the San Diego operations of the merged utility will continue to operate as a division, retaining the name San Diego Gas & Electric Company for at least two years following the merger.

The agreement provides that SDG&E chairman, president, and chief executive officer Thomas A. Page will become vice chairman and a director of SCEcorp, and president of the SDG&E division and a director of Southern California Edison Company. In addition to Page, three other members of the current SDG&E board will join the SCEcorp board of directors.

The combined utility will be the largest investor-owned electric utility in the United States, with 8.2 billion annual revenues, 4.8 million customers, 81.2 billion annual kilowatt hour sales, and assets of $17.7 billion. Its service territory will comprise 54,100 square miles.

“The new, combined utility should become the crown jewel of the electric utility industry. It will have excellent growth potential, economic diversity, and balance,” Allen stated.

Allen reiterated his earlier promise that Edison will file a request with the California Public Utilities Commission for a 10 percent decrease in residential rates in SDG&E’s service territory within six months of the completion of the merger of the two utilities. The rate decrease would be separate from whatever rate increases or decreases SDG&E makes independently because of changes in fuel and purchased power costs.

Cosmo Update, November 1988

“Navy Power Plant No. 1, Unit No. 1, began commercial operation in July 1987, the first of nine power plant units planned by California Energy Company (CEC) for its Coso Geothermal Project,” said Charles Condy, board chairman and chief executive officer of CEC. “As of May 5, 1988, Unit No. 1 had generated 167 million kilowatt hours of electricity and earned $13 million in gross project revenues,” he stated.

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In November 1988, 1,000 people were employed at Cosco in power plant construction and well drilling projects. The number is expected to drop to around 1,000 people by the end of 1988, and to remain at that level until 1990.

All nine units at Cosco are expected to be completed and on line by the end of 1985, generating a total of 230 megawatts. Gross revenue will equal about $200 million a year. The project’s electrical output will be purchased by Southern California Edison under three long-term contracts of 24- to 30-years’ duration.

OTHER WESTERN STATES

NEVADA

Steamboat Geothermal I Plant Expanded

In September 1988, Ormat Energy Systems, Inc. began work on its Steamboat Geothermal IA Project in Steamboat Springs, Nevada. This expansion of the Steamboat Geothermal I Power Plant (see June 1988 Geothermal Hot Line) was finished in late 1988, and the power plant acceptance test was completed in early January 1989. The IA Power Plant includes two Ormat energy converters that generate an additional 2 megawatts, gross, of electricity by using the geothermal water prior to injection. An air-cooling system is installed to ensure zero environmental impact.

Stillwater Geothermal I Project Loan

Ormat Energy Systems, Inc. announced it has received a construction loan for the Stillwater Geothermal I Project near Fallon, Nevada. The $83 million loan was provided by Bankers Trust Company and Bank of Nova Scotia. Constellation Development, Inc. is Baltimore Gas and Electric subsidiary will provide the utility equity. Bankers Trust Company, acting as the financial advisor to Ormat, will arrange the balance of the power and the long-term debt. Ormat will construct the power plant, develop the field, and operate and maintain the project under a long-term contract.

By Gerald Lesperance

The new project, which is to be owned by Far West Capital of Midvale, Utah, will sell electricity to Sierra Pacific Power Company under a long-term power purchase contract and will be operated by Ormat Energy Systems, along with the existing Steamboat Geothermal I Power Plant.

Ormat has received the U.S. Dept. of Energy 1988 award for Energy Innovation for its Steamboat Geothermal I Power Plant. The nonpolluting, 7.4-megawatt, gross, binary power plant has operated since 1985.

HAWAII

Coming Soon: RFP for Geothermal Energy in Hawaii

The State of Hawaii and Hawaiian Electric Company (HECO) have announced plans to seek proposals to develop one of the world’s most innovative electrical generation and transmission projects.

The goal is to develop 500 megawatts of electricity from geothermal energy on the Island of Hawaii and transmit it by underwater cable to other islands in the state, primarily to heavily populated Oahu, a distance of about 370 miles.

Successful completion of the project would satisfy with geothermal energy a major portion of Oahu’s electrical demand, and reduce annual oil imports to the island by millions of barrels. Oahu accounts for about 80 percent of the state’s electrical consumption.

The request for proposals (RFP) will be issued in early May 1989. The project calls for a private consortium to finance and develop the geothermal energy resource on the Island of Hawaii, and to transmit electricity from the resource by underwater cable to Oahu, and possibly Maui, as well.

Selection of the developer of the project, which is expected to cost in excess of $1.7 billion, is expected to be made by the end of 1990.

Driven by near-total dependence on oil imports for its energy, Hawaii has included increased energy self-sufficiency as an objective.

“Hawaii’s energy outlook requires positive action now,” said Governor John Waihe’e. “We are fortunate to have our own natural resource for electricity on a commercial scale around the clock, and the technology for using it -- a mature, proven technology -- better suited to our environment than electrical production from fossil fuels.” The governor’s position has received support from the Legislature.

HECO President Harwood D. Williamson said geothermal energy has long been seen by his company as Hawaii’s best renewable energy alternative to fuel oil for generating electricity.

“Without question, geothermal energy is the best near-term renewable energy alternative to meet the base-load needs of our utilities in satisfying our customers’ energy needs,” Williamson said. “Successful completion of this project would be a significant contribution towards making Hawaii more secure and less vulnerable to the uncertainties of the world oil market.”

Although geothermal energy could not be transmitted to Oahu until around 1995, the RFP will be issued this year to allow HECO to consider other alternatives if the response to the RFP shows that commercial geothermal electricity will not be available by then.

The export of large amounts of electricity from the Island of Hawaii to Oahu has been studied for years and is believed to be the best way to reduce the state’s dependence on fuel oil.

Since 1982, HECO has been the prime contractor of the Hawaii Deep Water Cable Project, which is funded jointly by the U.S. Department of Energy and the State Department of Business and Economic Development.

A 6,000-foot electric cable of a type that could be deployed between the islands was manufactured in 1987. Laboratory testing of the cable was concluded in October 1988, and the cable was found to be mechanically and electrically sound.

At sea testing of deployment and retrieval procedures using a new 6,000-foot electric cable will begin during the last three months of 1989 in the Aleutian Islands.

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The cable will be the longest and deepest electrical power cable in the world. The deepest portion of the cable route between the Big Island and Oahu would be about 7,000 feet, in the Alenuihaha Channel.

**Ormat Completes Hawaiian Purchase**

Ormat Energy Systems, Inc. has purchased Manua Energy's 75 percent interest in the Puna Joint Venture in Hawaii. Ormat acquired 25 percent of the same.

Venture from Amfac Energy in March 1986, with the intention of developing a 30-megawatt geothermal power plant on the Island of Hawaii.

**Hawaiian Direct-Heat Grants Encourage Geothermal Creativity**

The Hawaiian Community Geothermal Technology Program is unique. Under its auspices, heat and other by-products of Hawaii's high-temperature HGP-A geothermal well and power plant may be used. Instead, they form the backbone of a direct-heat grant program. Beginning in 1986 with grant of up to $10,000 at the Puna Geothermal Research Center, the grantees experimented with food drying, lumber drying, greenhouse-bottom heating, cloth drying, and glass-making projects.

Now, with the experimental and precommercial work completed, most of the original grantees are looking for ways to continue their projects on a commercial scale by studying the economics of using geothermal heat in a full-scale business and researching potential markets. A geothermal "mini-park" may be built near the research center.

Inspired by this success, additional researchers and entrepreneurs have expressed an interest in developing direct-heat geothermal projects. Some of the state's largest agricultural businesses have visited the research center to discuss cooperative ventures with the grantees.

**Orbitals in this experimental greenhouse, operated by Andrea Gill Beck, Hawaii Energy Extension Service, Dept. of Business and Economic Development, Hilo, Hawaii 96720.**

Portraits of this article are reprinted from the Geothermal Resources Council "Transactions," vol. 12, 1988.

Four small businesses and one artistic partnership were the first program participants. Beginning in 1986 with the funding limit was $15,000. Five projects were selected from 11 applications; work will begin in the summer of 1988 and run for 1 year.

The five new projects are:
- Geothermal Aquaculture Project— an experiment with low-cost propagation of catfish and geothermally heated tanks with a biofilter;
- Media Steam Sterilization and Drying— an application of raw geothermal steam to shredded, locally-available materials such as coconut husks, which would be used as certified nursery growing media;
- Bottom-Heating System Using Geothermal Power for Propagation— a continuation of Leilani Folage's project from the first round of grants, focusing on new species of ornamental palms;
- Silica Bronze— the use of geothermal silica as a refractory material in casting bronze artwork; and
- Electro-deposition of Minerals in Geothermal Brine— a research project aimed at determining the nature and possible utility of minerals deposited from the hot fluid.

**Second Grant Phase**

In 1988, a second round of projects was funded under the program. This time, the funding limit was $15,000. Five projects were selected from 11 applications; work will begin in the summer of 1988 and run for 1 year.

The five new projects are:
- Geothermal Aquaculture Project— an experiment with low-cost propagation of catfish species in geothermally heated tanks with a biofilter;
- Media Steam Sterilization and Drying— an application of raw geothermal steam to shredded, locally-available materials such as coconut husks, which would be used as certified nursery growing media;
- Bottom-Heating System Using Geothermal Power for Propagation— a continuation of Leilani Folage's project from the first round of grants, focusing on new species of ornamental palms;
- Silica Bronze— the use of geothermal silica as a refractory material in casting bronze artwork; and
- Electro-deposition of Minerals in Geothermal Brine— a research project aimed at determining the nature and possible utility of minerals deposited from the hot fluid.

**History of the Puna Geothermal Research Center**

In November 1986, ownership of the Hawaiian Geothermal Plant -- Abbott (BGP-A) well, power plant, and adjacent facilities -- was transferred from the U.S.
Department of Energy to the State of Hawaii. Today, the geothermal power plant is operated by the public Natural Energy Laboratory of Hawaii (NELH).

NELH's four-acre Puna geothermal facility encompasses not only the HCP-A well, power plant, and visitor center, but the state's only geothermal direct-heat research laboratory, called Noi'o O Puna, or the Puna Geothermal Research Center.

As a public facility, Noi'o O Puna is available for both publicly- and privately-funded research, development, demonstration, and commercialization projects. The laboratory consists of a 40' x 80' semi-enclosed concrete test pad, graded land outside the laboratory building, a chemistry laboratory, and an office.

The resources available at Noi'o O Puna include: high-pressure geothermal water (160 psig at 370°F); low-pressure geothermal water (15 psig at 260°F); low-pressure steam (15 psig at 550°F); and hot potable water (50 psig at 210°F). Compressed air, electricity (480 vac single- and three-phase; 240 vac single- and three-phase; and 120 vac single-phase), and a mechanical shop are also available.

New Geothermal Plans for Latin America

"People have preconceived notions that geothermal energy is expensive and risky," said Gustavo Calderón, chief, Non-Conventional Energy Section, Inter-American Development Bank. "This is wrong. Geothermal energy really improves the flexibility of a country's power generation mix and lowers energy expansion costs.

"Even in a country like Costa Rica with high hydroelectric potential and low-cost developments, geothermal power generation has been found financially and economically justifiable. Calculations with standard economic models show this. Besides economic benefits, geothermal energy adds flexibility to energy packages. It's a good idea to have it in your country's development planning," Mr. Calderón continued.

"Now, geothermal engineers might know this, but in Latin American countries, many national energy managers do not. This is a real stumbling block in the development of geothermal energy in Latin America," he said. "To help get the word out, the Inter-American Development Bank is considering a new program in conjunction with the Organización Latinoamericana de Energía (OLADE), titled Preparation of Geothermal Projects for International Financing. Methodologies and Guides. The foundation of the program will be a series of guides documenting each phase of a geothermal project, beginning with the feasibility and feasibility studies and moving through power plant construction and expansion. This is necessary because geothermal projects involve relatively unknown technologies and practices. Two major stumbling blocks for energy managers are:

1. An assessment of the probable energy potential of a geothermal field at the time of reconnaissance, feasibility, and feasibility work.
2. Mathematical models for the simulation of reservoir behavior at various stages and levels of exploitation, with the goal of defining the usable capacity in the known area.
3. Environmental aspects that must be considered in each stage of a project's development.
4. Other special factors that will be considered, such as deposition and corrosion, and their effects on the costs of investment, operation, and maintenance.
5. Methodology and study for planning the expansion of electrical generation when geothermal projects are candidates for such action. Description of the expansion plan of least cost. The planning methodologies are used for the feasibility studies (with risk analysis) and for the studies of investments in geothermal projects, which include the field development.
6. Economic evaluation of geothermal projects, using the results of the planning methods indicated before, but in a different form, according to the level of the geothermal project that is discussed.
7. Economic evaluation of direct-use geothermal projects for a benefit-cost analysis (economic profitability).

Central American Electrical Interconnection

A technical cooperation grant of $2.25 million, designed to strengthen the capacity of Central American countries to operate their regional interconnected electrical systems, was announced by the Inter-American Development Bank (IDB).

The grant, extended from the bank's Fund for Special Operations, will help improve the capacity of the region's electric power companies to achieve economical, safe operation of the interconnected electric power systems. The funds will also be used to finance regional studies of the accords, procedures, regulations, and supervisory mechanisms for the system, as well as program development and data bases.

Six national companies will participate in the program. They include the Instituto Costarricense de Electricidad (ICE); the Comisión Ejecutiva Hidroeléctrica del Río Lempa (CELI) of El Salvador; the Instituto Nacional de Electrificación (INDE) of Guatemala; the Empresa Nacional de Energía Eléctrica (ENEE) of Honduras; the Instituto Nicaragüense de Energía (INE) and the Instituto de Recursos Hidroeléctricos y Electrificación (IREH) of Panama. The project will be coordinated by the ICE; its total cost is estimated at $3.3 million.

Background

The electrical power systems of the Central American countries were developed independently. Over the last three years, however, important strides have been made in electrical power integration through bilateral interconnections, many financed with the help of the IDB. The Nicaragua-Honduras interconnection began to operate in 1976; the Nicaragua-Costa Rica interconnection in 1982; and, in 1986, the interconnected Honduran-Nicaraguan-Costa Rica-Panama system was finished with the completion of the Costa Rica-Panama link. Also in 1986, the Costa Rica-Panama connection and the Guatemala-EI Salvador connections were completed as separate subsystems. In 1986, an agreement was signed to undertake feasibility studies for an electrical interconnection between El Salvador and Honduras.

Through the years, the interconnected countries have been exchanging energy under bilateral contracts, which have been complemented by multilateral agreements. The system has become more complex as the number of interconnected countries has increased and new hydroelectric plants have come on stream. Such complexity has highlighted deficiencies in the exchange mechanisms, in the mechanisms of analysis and integrated cooperation, and in planning methodologies.

To optimize the benefits of a system of electrical power exchange among the various Central American systems, the countries' capacities must be strengthened to plan not only the economical operation of their systems, but also the legal, institutional, and technical frameworks for carrying out the electrical exchanges.
Geothermal Resources of the Alberta Plains

Formation waters of the Alberta Plains are inventoried in a new report prepared for the Renewable Energy Branch, Energy, Mines, and Resources, Canada. The report, titled Geothermal Resources of the Alberta Plains, is written for those contemplating using the waters as sources of geothermal energy. Water temperatures, salinities, depths, and the reservoir capacities of the enclosing rocks are included.

From geological information and present existing temperature and gradient data, 21 maps were drawn of ten rock units and the enclosed fluids. Although some previous site-specific inventories of the geothermal resources of the Alberta Plains have been made, the study is the first comprehensive survey.

The sedimentary envelope of the Alberta Plains ranges in thickness from zero in the northeastern corner of the province to nearly 5000 meters along the edge of the disturbed belt in the southwestern corner. Temperature gradients (degrees Celsius per kilometer) range from over 45 to less than 10 and average about 30. When they are no longer capable of producing oil and gas-well drilling activity is have to be f

Many hydrocarbon exploratory wells are never fully cased. Instead, they are plugged and abandoned after logging and testing is completed. The operators of such wells may be willing to assign interest in the well to a geothermal operator, who would then completely cease the hole and use the resource.

Even successful hydrocarbon wells have a finite life. When they are no longer capable of producing oil and gas, they may still be capable of producing hot water for geothermal purposes. The water may come from the hydrocarbon zone or from another zone penetrated by the well. Perhaps a geothermal operator would be interested in buying such a well.

In the course of producing oil, substantial quantities of water or steam commonly are injected into the oil reservoir to increase production. Often, the water is hot, produced from an aquifer in a nearby well. Perhaps arrangements could be made whereby this hot water could be run through a heat exchanger prior to injection into the oil zone.

In Canada, all oil- and gas-well drilling activity is announced by the Alberta Energy Resources Conservation Board. The board publishes a list of licensed wells every day. The matter of obtaining geothermal rights would also be addressed through the Conservation Board when Crown lands are involved.

Copies of this report are available for the cost of reproduction from George E. Loveseth, Vali Resources Limited, 3632 Ush Drive, Calgary, Alberta, T2V 4X7. Canada telephone (403) 265-2568.

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GREAT BRITAIN

British Electricity Monopoly May Be Sold

On December 1, 1988, British Prime Minister Margaret Thatcher submitted legislation to sell the electricity monopoly. The sale of the power-generating and distribution system in England and Wales is to be completed by mid-1991. Two companies would be set up in Scotland; Northern Ireland would not be affected.

The Hot Dry Rock Project at Cornwall

"Cornwall's hot dry rocks could generate sufficient electricity to maintain the needs of the South West in the next century." That was the optimistic message given by Energy Minister Michael Spicer on March 3, 1988, when he announced additional funding of 8.15 million pounds to take the geothermal hot dry rock research program, centered at the Camborne project in Cornwall, on to a further stage of development.

Mr. Spicer went on to say, "The Camborne project is a world leader in hot dry rock technology. Extracting the heat which occurs naturally in granite rock thousands of metres below the ground in Cornwall could provide electricity at a competitive rate.

The 8.15 million pounds of funds will, over the next three years, be used to take the project to the stage when we will be able to judge the commercial prospects for electricity generation, and plan its exploitation. If prospects are good, an industrial consortium would have to be formed to establish a power station and market the electricity.

"Our decision to take the work forward to the next stage could not have come at a more opportune time, when privatisation of the electricity industry enhances the prospects for renewable sources of energy contributing to the nation's energy needs," Mr. Spicer concluded.

Project History

The United Kingdom's Department of Energy hot dry rock (HDR) programme, the centrepiece of which is the Camborne School of Mines project at Rosemanows Quarry in Cornwall, has been under way since 1976 with the overall aim of assessing the technical and economic feasibility of commercial HDR power installations, primarily for electricity generation. The technical problems of assessing the HDR resource at the 6 to 7 kilometre depths required for commercial exploitation are formidable, and the department's strategy has been to proceed to a full depth prototype system by way of projects at shallow and intermediate levels.

This has allowed the main technical and engineering problems to be addressed without the added complicat ion of the high-temperatures encountered at full commercial depth. Work at the shallow depths, to assess the feasibility of enhancing the permeability of rock, was successfully completed in 1979. The intermediate depth (0 kilometre) experiments, to establish the feasibility of a viable HDR reservoir within the rock fractures, are due to be completed during 1988.

In the first half of 1987, a major programme review was undertaken. It included an economic assessment of the HDR resource, a technical review of the technology, an assessment of the commercial prospects for HDR systems carried out by Taylor Woodrow, and the definition of an appropriate strategy for further work. The picture that emerged from the review can be summarised as follows:

- The HDR resource might make a significant contribution to UK electricity requirements at a cost that could be competitive with conventional sources. The commercial exploitation would be limited by economic and environmental constraints, but, even so, HDR might
supply up to 10 percent of the country's electricity needs for 125 years or more. Most of the resource is in pre-supply up to 10 percent of the count

be regarded as experimental. The way forward lies in the development of stimulation techniques capable of creating commercial HDR reservoirs, together with techniques for manipulating them.

Commercialization prospects for HDR appear to be attractive in the long term, provided the key technical problems relating to reservoir creation and operation can be overcome, but unattractive in the short term because of current technical uncertainties and the long time scale involved in demonstrating the concept at commercial scale.

The future programme strategy should be built around a cautious commitment to a deep prototype HDR project. Continuing work should be aimed at removing the present technical uncertainties and providing the information necessary for a decision on whether or not to proceed with the high-cost drilling phase of a prototype project.

8.5 Million Pounds Extra Funding

The additional funds of £8.5 million pounds for the HDR programme, announced by the Government in March, will allow the continuing work recommended in the 1987 review to go ahead. The main elements in the forward plan are:

- a conceptual design of a deep commercial-size prototype system, commencing in October 1988.
- a change in emphasis in the current work programme of the Camborne project so as to provide necessary detailed technical support of the conceptual design study.
- a new 3-year phase for the Camborne project, commencing in October 1988, aimed at developing and validating techniques for manipulating HDR reservoirs to improve and/or correct their performances.
- a further major review in early 1990 to consider the case for committing the main design and construction phase of the commercial prototype system.

If the results of the 1990 review are positive and the prototype project goes ahead, the estimated cost of detailed design, construction, and monitoring, including a power plant to generate electricity by 1988, is £2 million pounds. Substantial industrial/commercial involvement and commitment would be a prerequisite of any government decision to proceed.

Opportunities for fruitful collaboration with other countries will continue to be sought. There has been recent UK involvement in a Swedish HDR project and discussions are taking place on possible collaboration on HDR with the European Commission, Japan, and the United States.

Bringing HDR technology to the commercial market presents a huge technological challenge to those involved - but the prize is worth striving for.

The Camborne School of Mines began its initial HDR research in 1973. By 1976, the work had progressed successfully to the stage where it attracted substantial funding from both the Department of Energy and the Commission of the European Communities.

NOTE: For a detailed list of papers written for external venues about Great Britain's hot dry rock project, write to: Mr. J. Pye, Information Officer, Camborne School of Mines, Geothermal Energy Project, Rosemanowes Quarry, Herne, Penryn, Cornwall. Great Britain TBB 3DD.

In my correspondence with Mr. Pye, I asked her about Rosemanowes Quarry. Fittingly for a hot dry rock project, it is a granite quarry. This is how she describes it:

"Rosemanowes Quarry, according to local sources, was working possibly as early as the 1850's, and has operated since on a sporadic basis under various owners and managers. Its busiest time was at the turn of the century, when it supplied stone to the Great Western Railway for viaduct building purposes. It has since supplemented reserves from more major granite quarries nearby, including a period during World War II when it had connections with U.S. troops encamped locally!"

As a final note, the upcoming hot dry rock conference at Camborne in March at the Camborne School of Mines is described in the "Conferences" section of this issue.

Indonesian Project Underway

Unocal Corporation has given the Indonesian Government notice of intent to proceed with a geothermal project to provide steam for a 110 megawatt electrical generating plant.

Under a joint operation contract signed in 1982 with Pertamina, the state oil company, Unocal Geothermal of Indonesia, Ltd., a wholly-owned Unocal subsidiary, discovered a geothermal field in the Gunung Salak area, about 40 miles south of Jakarta. The company has drilled 11 wells, and has confirmed reserves for more than 230 megawatts of generating capacity.

JAPAN

Beppu Geothermal Field and the Geophysical Research Station

Introduction

Bathing in hot springs has always been an important part of life in Japan. There are over 2,000 spas in Japan, visited every year by over 100 million people. In spite of this interest in hot-springs, very few institutions are dedicated to research in the hot-spring sciences. In this respect, the Geophysical Research Station of Kyoto University, Beppu, is unique because of its broad range of scientific studies of geothermal phenomena. The studies include geochemical, geophysical, geological, and hydrological research on geothermal systems in their natural and modified states.

The Geophysical Research Station has an ideal location on the Beppu geothermal system, one of the largest geothermal systems in Japan on the Island of Kyushu. This island is the southernmost of the four main islands of Japan, at the northeastern end of the Philippines-Ryukyu volcanic arc.

Beppu City

The surface thermal activity at Beppu varies from hot springs to superheated fumaroles and steaming ground on the volcanoes behind Beppu City. The city has been built on a large fan deposit on lower flanks of the Tsurumi Volcanic Centre. Lava flows here about 2,000 years ago.
Beppu has a long history as a resort area for its onsen (hot spring bathing) and its jikoku (literally "hell"), fumaroles and steaming ground. To enhance the flow of hot water, wells were drilled as early as 1880 with a flexible bamboo technique known as "Kanza-boat." These may be some of the earliest geothermal wells drilled anywhere in the world. By 1924, over 1,000 wells had been drilled. Today over 3,000 wells are in an area of 5km (E-W) by 6km (N-S), and the total flow of hot water and steam is around 600 kg/s. The wells range up to 700m in depth, and temperatures above 200°C have been measured.

In an experiment in the early 1920s, the Tokyo Electric Light Company generated 2 megawatts of electricity using geothermal steam from a Beppu well. Although a 30-kilowatt geothermal power generation unit was briefly operated in 1951, it was not until 1979 that a permanent power plant began producing electricity from geothermal steam at Beppu. This is a 3-megawatt unit that provides power for the Suginai Hotel.

The Geophysical Research Station
Because of the intensive efforts of the late Professor T. Shida, with special support from Oita Prefecture and Beppu City, the Geophysical Research Station was established at the present site of Beppu City in January 1924 so that comprehensive studies of volcanic and geothermal phenomena could be made. After this beginning, systematic measurements of the Beppu geothermal system started. In March 1926, the Beppu Volcanological Laboratory was established near the active central volcano within the Aso Caldera, about 60km southwest of Beppu, to promote geophysical studies of volcanic activities.

In collaboration with these two institutions, the Geophysical Research Station carries out geothermal research, with the Beppu system as its main research area. To measure geothermal activities, the Handa Observatory, attached to the Geophysical Research Station, was established in 1934 at Kojay which, half-way between Beppu and Aso, is also one of the largest geothermal systems in Japan. To date, over 250 scientific papers have been written by the research workers in the Geophysical Research Station.

Visiting Scientist Program
The Geophysical Research Station has three visiting sections:

1. Geothermal Fluid Research Section (permanent)
The main subjects of study undertaken by this section are the physical and hydrological processes of geothermal fluid flows through underground media, such as potential flow, thermal convection, two-phase flow, etc.

2. Geothermal Structure Research Section (until 1996)
Two members belong to this section. Its main subjects of study are the characteristics and history of underground geothermal formations based on geologic, petrologic, geophysical, and geochemical methods.

Development

ENVIRONMENT
Greenhouse-Effect Spurs Legislation

Senator Timothy E. Wirth (D-Colo.) reintroduced legislation on February 1, 1989, to establish a national energy policy that would slow down the emission of pollutants contributing to the "greenhouse effect.

Wirth's comprehensive bill to combat the greenhouse effect includes initiatives to:
- Increase energy-efficiency in all sectors of the U.S. economy
- Expand research and development of nonfossil fuel sources such as solar
- Encourage technologies to reduce carbon dioxide emission from coal-fired power plants and other sources

For further information, contact Jim Spellman at 220-224-5522.

For table of energy project funding levels, please contact Senator Wirth's office.

This purpose, seismic exploration and deep drilling will be conducted to and around the Beppu area with the collaboration of the Geothermal Fluid Research Section.

3. Geothermal Setting Research Section (until 1996)
This section is open to foreign scientists in any discipline related to geothermal phenomena. Examples of study are comparative studies between the Beppu-Kuju-Aso area and other geothermal and volcanic fields in the world. Each visiting scientist holds a tenure of 3 months to 1 year.

For further information about the Geophysical Research Station or the visiting scientist program, contact the Director, Geophysical Research Station, Kyoto University, Nogichibaru, Beppu, Oita-ken, 874 Japan. Telephone: 0777-22-0713 (JPN); Telefax: 0777-22-0650 (JPN).
Geothermal Energy and the Greenhouse Effect

The greenhouse effect results mainly from the emission of carbon dioxide (CO₂) into the atmosphere. This allows ultraviolet radiation from the sun to pass freely to the earth, but prevents infrared radiation from leaving the atmosphere. The effect is similar to what happens in a glass-enclosed greenhouse.

Any fuel that contains carbon will generate CO₂ when it combines with oxygen in the air that is used for combustion. One of the major sources of CO₂ is the combustion of fossil fuels, or, more generally, carbon-based fuels, which are the main raw-energy sources for electrical power production in the United States. Conventionally used fuels include coal, oil, natural gas, and wood. Alternative, noncarbon-based generation methods include the use of nuclear fuels, water power (hydroelectricity), geothermal energy (direct- or flash-steam and hot-water binary), and solar energy (photovoltaics and solar thermal). Great differences exist among the basic energy sources with regard to the amount of CO₂ emitted per unit of electrical energy produced.

Considering only the final energy conversion process at the power plant (i.e., ignoring the mining, refining, and transporting of the fuels, as well as the energy consumed in the construction of the power plant itself), the following energy sources emit no CO₂ at all:

- Geothermal hot-water binary
- Hydroelectric
- Nuclear fission
- Solar photovoltaics
- Solar thermal

The following raw-energy sources do emit CO₂ and are ranked by the amount of CO₂ emitted per kilowatt-hour of electricity generated:

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>CO₂ Emissions per kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>2.5</td>
</tr>
<tr>
<td>Natural gas</td>
<td>1.5</td>
</tr>
<tr>
<td>Combined cycle steam</td>
<td>1.0</td>
</tr>
<tr>
<td>Steam cycle</td>
<td>1.0</td>
</tr>
<tr>
<td>Simple gas turbine</td>
<td>1.3</td>
</tr>
<tr>
<td>Wood (dry pine, oak)</td>
<td>2.0</td>
</tr>
<tr>
<td>Bagasse*</td>
<td>2.6</td>
</tr>
</tbody>
</table>

The values quoted are typical for each energy source. They are based on typical fuel compositions and heating values, and on state-of-the-art thermal efficiencies for each type of plant. The range of values for geothermal steam plants takes into account typical noncondensable gas concentrations and specific steam consumptions.

Geothermal plants are among the best from a CO₂-emission standpoint: binary plants are emission-free and geothermal steam plants have the lowest specific CO₂ emission of all other types. Furthermore, since there are no ancillary emissions of CO₂ associated with processing and transporting geothermal steam and hot water (as there are with the other energy sources listed in the preceding table and accompanying chart), the advantage of geothermal energy over the other types is even greater than the figures indicate.

Indeed, geothermal steam plants can be designed so that no CO₂ is emitted into the atmosphere provided that the noncondensable gases are compressed and injected with the waste brine. This technique is being tried for the first time at geothermal power plants in the Cose Geothermal Project.

Solar Box Cookers and Geothermal Energy

A major amount of world-wide forest depletion is caused by harvesting cooking wood. Solar box cookers can help to ameliorate this situation in that they use solar energy instead of wood to cook food. Usable year-round in the tropics and for 6 to 8 months of the year in most sunny areas of the world, the cookers can cook almost anything if there is 15 minutes of sunshine every hour. Developed in 1976, solar box cookers represent a major advance over early solar cookers.

Solar box cookers are about the size of an ice chest, easily constructed by the users themselves and inexpensive. The cookers are made of cardboard or wood, and aluminum foil. Each box is topped with a sheet of glass above which an adjustable reflector lid is positioned to angle in sunlight. The food cooks in covered, dark-colored pans.

One cooker can cook 10-15 pounds of food in three to five hours. Fruits, vegetables, meats, and any baked goods can be prepared, and water and milk pasteurized in them. The cooking food doesn’t have to be stirred and won’t burn.

Dr. Robert Metcalf, a microbiologist at California State University-Sacramento, travels throughout the world holding solar box cooker workshops, teaching people to build and use solar box cookers.

Dr. Metcalf’s initial projects in Bolivia and Guatemala were funded by The Pillsbury Company. He has also initiated projects in Ifuza and Michoacán, Mexico with Solar Box Cookers, International, and in Djibouti, East Africa, with the United Nations Food and Agriculture Organization. Dr. Metcalf believes this simple box can slow the destruction of forests and offer user benefits in time and money.

Dr. Metcalf is also looking for ways the geothermal community could interface with solar box cookers. Perhaps the cookers could be included in environmental mitigation plans throughout the world. He can be reached at the Department of Biological Sciences, California State University-Sacramento, Sacramento, California 95814; phone (916) 454-6438.

For general information on solar box cookers, send a stamped, self-addressed envelope to Solar Box Cookers International, 1724 11th Street, Sacramento, California 95814. For construction plans, include $3.00 with your request.

NOTE: Solar Box Cookers International is a nonprofit organization, founded to encourage solar box cooking.
Seismic Activity Noted at Medicine Lake Highlands

The sudden rumble of earthquakes beneath Medicine Lake Highlands this fall gave geologists an early warning that one of Northern California's volcanoes may be stirring back to life.

Researchers stressed that an eruption of the volcano is not expected soon. But the flurry of underground shocks in late September, combined with new evidence of a pool of molten rock beneath the big volcano, has led them to monitor Medicine Lake with new wariness.

“We've added six new seismic monitoring stations,” said geologist Stephen Walter of the U.S. Geological Survey (USGS) in Menlo Park. “We aren't sure at this point exactly what is causing the new activity. But one of the possibilities is that the Medicine Lake volcano is awakening. Certainly, we've never classed it as a dead volcano.”

Medicine Lake, in eastern Siskiyou County, is part of the Cascade chain that includes Mount Shasta and Mount Lassen.

Stephen Harris, a volcano expert at California State University, Sacramento, said that Medicine Lake’s appearance – a gently-sloped shape known as a shield volcano – belies its potential strength.

The volcano has been dormant since 1910, when it ejected a brief flurry of ash -- worrying no one.

However, its earlier history is more dramatic. Geologic records indicate that a little less than 1,000 years ago, it blew apart in a huge eruption, sending ash and rock hundreds of miles. Several hundred years later, it spilled enough lava out to create Glass Mountain. The famous dark flows of Lava Beds National Monument, just south of Tulelake near the Oregon border, are also remnants of a Medicine Lake eruption.

The USGS has estimated that a massive explosion of Medicine Lake -- on the order of the one that created Oregon's Crater Lake -- could destroy life and property within a 50- to 100-mile radius of the volcano and lay a thick blanket of ash over most of the western United States.

“There's no evidence that's an immediate threat,” said Harris whose book, “Fire Mountains of the West,” was published last month. “And, fortunately, it's a very remote and sparsely developed area. If there was an eruption, the worst risks would be in Tulelake and across a few farms in the region.”

Walter said that Medicine Lake has remained so still since the early 1900's that federal geologists attached only a single seismic device to it before this fall, merely rounding out their Mount Shasta monitoring network.

Two years ago, the equipment recorded a single jolt at the edge of the quiet volcano. Then suddenly, in September, tremor after tremor began shaking the ground.

The geological survey recorded almost 200 small earthquakes on its Medicine Lake station from Sept. 29 to September 30. The shocks were as large as 4.2 on the Richter scale. In one hour, on Sept. 29, the seismic monitor recorded 95 small earthquakes.

“For an area to jump from nothing to that, well, it caught our attention,” Walter said. The survey hurriedly added extra shock-sensitive devices to the Medicine Lake network. In early November, the machines recorded two microearthquakes, measuring less than 1 on the Richter scale, directly beneath some of the major lava flows.

“This may be a result of movement in the Earth’s crust unrelated to the volcano, itself,” Walter stressed. “We still need more information. This has reminded us that we really don’t have good base-line data for this volcano. And if Medicine Lake were to come to life tomorrow or next week, we want to be better prepared.”

The federal team plans to take measurements of Medicine Lake, testing for changes in its shape caused by underground pressures. The work is scheduled for spring because snows have made the volcano inaccessible.

by Deborah Blum
Sacramento Bee Science Writer

Excerpted, with permission, from the November 19, 1988 edition of the Sacramento Bee.

Coring An Active Hydrothermal System

“We got virtually everything we started out for in this project,” said Dr. Peter Lyon of the Geoscience Research Drilling Office, Sandia National Laboratories. “We worked from our estimates, and it all came out.”

Dr. Lyon was talking about the Valles Caldera corehole VC-2B, drilled through an active hydrothermal system at Valles Caldera in New Mexico.

The corehole is part of the Continental Scientific Drilling Program, funded by the U.S. Department of Energy, Office of Basic Energy Services, Division of Geosciences. The program is undertaken in cooperation with Los Alamos National Laboratory, Sandia National Laboratories, Tonto Drilling Services, and the University of Utah Research Institute.

In September 1988, Sandia and Tonto Drilling Services sponsored a seminar on the corehole project. Topics discussed at the seminar included the wireline coring operation, the need for continuous core in exploring for geothermal and hydrocarbon resources, and an overview of the design and construction of the VC-2B well, including cost analysis. A Universal 5000 drilling rig was used both to core and to drill open hole.

Jeff Hulen of the University of Utah Research Institute and Jamie Gardner of Los Alamos National Laboratory are the Principal Scientific Investigators for the VC-2B project, although about 50 additional scientists are involved. At the seminar, Dr. Hulen reviewed the project goal: to core entirely through an active hydrothermal system.

The Valles Caldera hydrothermal system consists of a series of interconnected high-temperature geysers above 500°F. As the fluids move through the formation, they dissolve minerals in the high-temperature areas and redeposit them in the low-temperature areas. The study was designed to examine the active ore-deposit process. Study data are gathered from cores taken from the surface to total depth at 5,780 feet, including about 600 feet of Precambrian granite rock at the bottom of the hole.
silver ores had been precipitated. Interestingly, at the bottom of the hole, fractures at least accepting flow were found in the Precambrian granite. "Next summer," Dr. Lysne said, "the well will be cleaned out and we will try to take fluid samples from the Precambrian granite. We set the last casing at 5,567 feet, so that a little over 200 feet of open hole remains at the bottom of the well."

Dr. Lysne and Ron Jacobson of Sandia National Laboratories, and Larry Palo of Tonto Drilling Services designed the VC-2B well. At the seminar, Dr. Lysne discussed the well design, which was influenced by the needs of the scientific team, permit requirements, cost, and safety. Penetration rates for coring reached 210 feet a day. Problems with a breakdown of the polymer drilling fluids at high temperatures (275°F + ) limited the rotational speed of the drill string, so penetration in the Precambrian granite was reduced to about 50 feet a day.

A revised scientific plan for the corehole will be made in the spring of 1989 and issued through Los Alamos National Laboratory.

For further information about the project or about deep wireline coring techniques, contact Peter Lysne, Geoscience Research Drilling Office 6240A, Sandia National Laboratories, Albuquerque, New Mexico 87115.

Deep-Sea Vents Studied

"Deep-sea hydrothermal vents have been discovered at a number of places, but not everywhere," said University of California-Davis seismologist James McClain. "Why are they where they are, how they work, how long they last, these are things we're trying to learn. About 15 to 30 percent of the earth's released internal heat is lost through such vents. But this is a huge range and there are no good measurements, yet. Naturally, the amount of heat released depends on how many vents there are and how long they last. Thus, these two issues become key questions."

Dr. McClain participated in two studies of deep-sea hydrothermal vents during the summer of 1988. One, sponsored by the National Science Foundation, was in areas along the Juan de Fuca Ridge, 200 miles off the coast of Washington and British Columbia. Here, researchers found vents at depths of about 7,000 feet, with temperatures at about 400°F.

The second study, sponsored by the States of California and Oregon and the Minerals Management Service, was conducted along the Gorda Ridge, off the California and Oregon coasts. Here, vents were found at depths of about 9,000 feet, emitting water of about 200°F.

Dr. McClain said that the vents are called "black smokers", although there is no smoke. An appearance of dark smoke forms as disordered sulfides precipitate out of the hydrothermal waters. The "smoke" is black in the Juan de Fuca Ridge area and grey in the Gorda Ridge area.

Perhaps the first demonstrations of fiber-optic sensors in a geothermal well occurred in early 1988 on the Island of Hawaii. The first of two fiber-optic optrode tests was at the HGP-A well and 3-megawatt power plant facility managed by the Hawaii National Energy Institute at the University of Hawaii. The second test was in a nearby geothermal exploratory well, Geothermal Test Well 2 (GTW-2, USGS No. 2686-02). Both sites are in the Rattlesnake East Rift Zone.

A fiber-optic temperature sensor test will be undertaken soon in a deeper, hotter geothermal well. Problems will be examined that may occur with a stainless steel-sleeved, fiber-optic cable.

Dr. Lysne said that a great deal of mineralization was found in the upper part of the system -- in one case even

**TECHNOLOGY**

Fiber-Optic Sensors and Geothermal Reservoir Engineering

**Summary**

Fiber-optic fiber is classified as wire. It has rapidly taken over nearly a third of the telecommunications wiring field, formerly dominated by copper wire. At the same time, the fiber-optic industry is developing here-before-unthought-of applications. Until fiber optics, it was impossible to view inaccessible spots in the human body without surgery, to see inside working engines, or to look directly into hostile environments, such as the deep oceans. Scientists have been studying fiber optics for more than a decade, but it is only in the past few years that they have developed the technology to use it for industrial applications... and now fiber-optic technology is being applied to monitor geothermal reservoirs.

A revised scientific plan for the corehole will be made in the spring of 1989 and issued through Los Alamos National Laboratory.

**Background: What Are Fiber Optics?**

Fiber-optic fiber is classified as wire. It has rapidly taken over nearly a third of the telecommunications wiring field, formerly dominated by copper wire. At the same time, the fiber-optic industry is developing here-before-unthought-of applications. Until fiber optics, it was impossible to view inaccessible spots in the human body without surgery, to see inside working engines, or to look directly into hostile environments, such as the deep oceans. Scientists have been studying fiber optics for more than a decade, but it is only in the past few years that they have developed the technology to use it for industrial applications. **Fiber Optics?**

Workers take preliminary temperature readings with the thermocouple. Later, the optrode was lowered on the same pulling system.

A laser fluorescence spectrometer, similar to the one used in the field work.

A worker lowers an optical fiber into the well to a depth of 500 feet. The temperature response was continuously displayed on the computer as the probe was raised or lowered. More time could be spent at any area of interest and temperatures could be remeasured for any area. The results of these tests indicated that fibers up to 1,500 meters long can be used.

**Photo lower left:** The end of the temperature optrode that is lowered into the well. A thermocouple is attached to it. Photo upper right: A two-pound lead weight used to get the optrode into the well against the steam pressure.
vacuum or steam chambers. Until fiber optics, no one thought of using robots for remote viewing.

Fiber-optic technology is instrumental in converting optical images into digital signals for computer use so that we can explore space without being there, map a virus without seeing it, and design a boat on a flat screen and see how it looks in three dimensions. Fiber optics' advantages are small size, light weight, and speed in handling communications. Fiber-optic fibers can be drawn so small that 600 fibers can fit inside a 1/2-inch carrier tube. This is a disadvantage, however—high installation costs.

Making Fiber Optic Measurements **

Optical fiber fluorescence measurements are made in the following way. A laser is focused onto the end of an optical fiber through an especially designed mirror with a small hole in it or through a dichroic beam splitter. The laser light travels through the fiber and excites fluorescence in the fiber at the distal end. The resulting fluorescent light travels back through the same fiber. The returning diverging fluorescent light impinges on the mirror or dichroic beam splitter rather than passing through the hole, and is focused into a monochromator, where the fluorescence is analyzed.

Uses in Geothermal Reservoir Engineering

Optical fibers (epitrodes) have been used to develop programs at Lawrence Livermore National Laboratory and at many other laboratories for several years. The ability to make chemical and physical measurements over optical fibers offers certain advantages, the most important of which is real-time, in situ monitoring. This is possible because of the rapid response time of certain types of sensors and the noninvasive nature of the device. The fiber is small in diameter (.1 to 1.0 mm) and made of glass. Thus, it can be placed in a small protective tube along with other types of instrumentation already in the well. The optical fiber cable is passive, and all of the measurement instrumentation is above ground.

The key in developing a useful geothermal fiber optic sensor is in making sensor materials that can withstand the corrosive well environment. The optical fiber itself, is not a problem here because fiber optic materials can withstand temperatures above 500°C, if kept dry. The sensor that attaches to the optical fiber must be made of an inert material capable of producing an optical signal in response to the parameter to be measured. Most of our work involves the use of ceramic-based sensors (for temperature) and high-temperature polymers (for pH and Eh measurements). These materials are doped with indicators that change their fluorescence or absorption properties in response to the parameter of interest.

A pH optrode is in the preliminary stages of development. It is based on a high-temperature, inert matrix doped with inorganic indicators. The absorption properties of the indicators change as a function of pH. This type of sensor has been shown to respond reversibly to pH changes over a wide range. Sensors have been shown to be stable in water at 190°C for 20 hours and in 100°C geothermal brine for seven days.

In addition to developing new geothermal optrodes, we have made progress in demonstrating these devices in "real world" geothermal applications. We chose to use a temperature optrode for its ease-of-use and for the fact it has been well characterized in our laboratory. The purpose of the field demonstrations was to solve engineering problems associated with putting long optical fibers in a well and developing a field-portable spectrometer. Tests were carried out in a geothermal exploratory steam well on the island of Hawaii. Temperature profiles were obtained to a depth of 500 feet using a 1,000-foot optical fiber. The accuracy of the measurements was compared with side-by-side thermocouple measurements. The most important aspect of these tests was to demonstrate real-time interactive depth profiling. The response of the sensor was monitored in real time, allowing interesting regions in the well to be examined closely.

**The information under this heading is reproduced from an article by Michael Angel in Transactions, vol. 11, October 1987, p. 105, published by the Geothermal Resources Council.

FINANCE

U.S. Department of Energy
FY 1990 Congressional Budget Request
Conservation and Renewable Energy
(Dollars in Thousands)

Key Activity Summary

Geothermal Technology

I. Preface: Geothermal Technology

The Geothermal Energy Program seeks to lessen the nation's dependence on foreign energy supplies by fostering the use of indigenous, uninterruptible sources of geothermal energy. This goal of improved energy security is accomplished by developing technology needed to exploit a wide variety of geothermal resources. Such technology enables the unencumbered, competitive use of geothermal energy by the private sector. To the extent practicable, the Program emphasizes R&D activities whose costs are shared with the private sector. These activities include the joint development of instruments, equipment, materials, technologies, models, and systems; they provide means of rapid, efficient technology transfer. By employing a strategy that couples applied R&D with timely technology transfer, the program enhances the security and flexibility of the nation's energy markets.

II. A. Summary Table

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<th>Activity</th>
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B. Major Laboratory and Facility Funding*

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*NOTE: Three laboratories active in geothermal research for over 10 years have been eliminated from blanket funding. They are Brookhaven National Laboratory, and Lawrence Berkeley and Lawrence Livermore Laboratories.

DIVISION OF OIL AND GAS

GEOTHERMAL HOT LINE
Geothermal Grant and Loan Program for Local Jurisdictions

Through the Geothermal Grant and Loan Program for Local Jurisdictions the California Energy Commission (CEC) provides funding to cities, counties, special districts, Indian tribal governments, regional planning agencies, and certain municipal utility districts for geothermally-related projects.

The CEC will accept applications from local jurisdictions for any of the following types of projects:

1. Resource Development. This category includes projects to assess and explore for geothermal resources; to drill production and injection wells; and to design and construct geothermal heating, cooling, and electrical generation systems.

2. Impact Mitigation. This category includes projects to identify and mitigate impacts to the environment and public services caused by geothermal development.

3. Planning. This category includes projects to develop general plan elements, ordinances, or other policies relating to the planning, development, and operation of geothermal power plants and direct-use projects.

For further information, contact Michael Smith, CEC, (916) 324-3502.

LEGISLATION

Federal Legislation

The following material is a federal legislative report, with information on the status of geothermal legislation from the 100th Congress, current as of November 21, 1988. It was compiled by Senate LEGIS.

H.R. 235
DATE INTRODUCED: 01/06/87
SPONSOR: Quillen
SHORT TITLE AS INTRODUCED: Geothermal Energy Control Act of 1987

A bill to create the National Geothermal Energy Commission to grant exclusive franchises for the exploration and development of geothermal energy and for the right to market any such energy in its natural state, and for other purposes.

DIGEST:
Requires the Commission to determine those areas in the United States that have a potential for the extraction of geothermal resources and to publish a list of such areas in the Federal Register. Directs the Commission to grant exclusive 99-year licenses to persons capable of carrying out exploration and development of geothermal resources in such areas. Sets forth conditions for the granting of such licenses and for extensions of license terms. Authorizes the termination of a license for any violation of the terms of the license prescribed by the Commission. Permits a licensee under this Act to apply for a license to market the geothermal resources from the licensee's area in their natural state. Requires the Commission to grant a marketing license for a geographic area that is the most reasonable area to market successfully the geothermal resources. Provides that there shall be only one marketing license per geographic area. Provides that a marketing license shall be valid for as long as the licensee holds the exploration and development license.

Permits the transfer of exploration and development licenses and marketing licenses with the Commission's approval.
Requires that a licensee under this Act be a U.S. citizen or person owned or controlled by a U.S. citizen.

Restricts the sale of geothermal resources that have been converted to electrical or other energy forms to existing utility companies or other persons licensed to transmit such energy. Permits the sale of geothermal resources to such a company or person for conversion into other energy forms.

H.R. 1662
DATE INTRODUCED: 03/17/87
SPONSOR: Shumway
SHORT TITLE AS INTRODUCED:
Federal Lands Receipts Clarification Act

DIGEST:
Federal Lands Receipts Clarification Act - Amends the Mineral Lands Leasing Act, the Mineral Leasing Act for Acquired Lands, and other federal law to specify that the states' share of certain revenue from National Forest System timber sales, from oil and gas royalties, and from mineral and geothermal leases be determined on the basis of gross receipts.

H.R. 1421
DATE INTRODUCED: 06/25/87
SPONSOR: Wilson
SHORT TITLE AS INTRODUCED:
Federal Lands Receipts Clarification Act

DIGEST:
Federal Lands Receipts Clarification Act - Amends specified federal laws, including the Mineral Lands Leasing Act and the Mineral Leasing Act for Acquired Lands, to specify that gross receipts shall be used to calculate the amount of the state and local share of natural resources (minerals, oil, gas, and timber) receipt payments derived from federal lands.

S. 1689
DATE INTRODUCED: 11/20/87
Signed by the President to become Public Law No. 100-443, 9/22/88.
SPONSOR: Melcher

SHORT TITLE AS REPORTED IN THE SENATE:
Geothermal Steam Act Amendments

AMENDMENTS PROPOSED:
S. AMDT. NO. 2830
DATE: 8/09/88
PROPOSED BY: Byrd
DIGEST:
6/13/88 (Measure passed House, amended, in lieu of H.R. 2709)

Geothermal Steam Act Amendments of 1988 - Amends the Geothermal Steam Act of 1970 to remove bona fide sales of geothermal steam as a requirement for geothermal lease extensions. Amends the commercial production or utilization requirement of geothermal steam leases to include wells capable of producing geothermal steam in commercial quantities only if the Secretary of the Interior (the Secretary) determines that diligent efforts are being made towards geothermal steam utilization. Permits extension of lease terms for up to two successive five-year periods even though geothermal steam has not been produced or utilized in commercial quantities by the end of its primary or extended term if the lessee can show bona fide production or utilization efforts and: (1) make annual payments in lieu of the production of commercial quantities; or (2) demonstrate significant expenditures on an annual basis.

Requires the Secretary to review cooperative or unit plans of development on a five-year periodic basis in order to eliminate those leases that are not regarded as reasonably necessary to operations.

Requires the Secretary to maintain a list of National Park System units with significant thermal features, and to maintain a monitoring program for such features. Specifies units to be listed. Directs the Secretary to determine if operations proposed by a lease applicant would likely subject significant thermal features within the National Park System to significant adverse effects. Prohibits the issuance of a lease upon such a finding. Mandates that stipulations designed to protect significant thermal features be included in leases and drilling permits.

Requires the Secretary of Agriculture to consider the effects on significant thermal features within units of the National Park System in determining whether to consent to leasing land under his jurisdiction.

Prohibits the Secretary from issuing a lease for land within the Island Park Geothermal Area. Requires the Secretary to report to the Congress regarding the presence or absence of significant thermal features within Crater Lake National Park. Suspends all geothermal resource production (including leases and drilling permits) in the Corwin Springs Known Geothermal Resources Areas until 180 days after the United States Geological Survey has submitted to the Congress an impact study of present and potential geothermal resource development in such areas on thermal features within Yellowstone National Park.

S. 1006
DATE INTRODUCED: 04/09/87
SPONSOR: Fletcher
SHORT TITLE AS INTRODUCED:
Geothermal Steam Act Amendments of 1987

DIGEST:
Geothermal Steam Act Amendments of 1987 - Amends the Geothermal Steam Act of 1970 to provide that if geothermal steam is produced or utilized in commercial quantities under an approved operation within any lease or administrative lease extension period, such lease shall continue for so long as geothermal steam is produced for utilization in commercial quantities, for a maximum continuation of an additional 40 years.

Sets forth conditions under which geothermal leases in effect as of the date of enactment of this Act shall be extended for a maximum of three successive five-year periods.

Requires the Secretary of the Interior to review any cooperative or unit plan of development every five years after approval in order to eliminate any lease or part of lease not regarded as reasonably necessary to cooperation or unit operations. Requires such elimination to be based on scientific evidence, and only upon the Secretary's determination that it is for the purpose of conserving and properly managing the geothermal resource.

TECHNOLOGY TRANSFER

GEOTHERMAL ASSOCIATIONS

IGA Update

The International Geothermal Association (IGA) is a scientific, educational, and cultural organization established to operate worldwide. It is a nonpolitical, nongovernmental, nonprofit organization, with no political affiliation. Its aim is to encourage, facilitate, and, when appropriate, promote coordination of activities related to worldwide research, development, and application of geothermal resources.

"We want to involve the whole international geothermal community in the IGA," said Dr. Raffaele Cadelli of ENEL. "We also wish to stimulate the development of national geothermal organizations. Most countries don't have such organizations. Only a few. There is none in Italy," he added.

After many years of informal discussion about forming the IGA, efforts to do so were undertaken in January 1986 by an ad hoc committee of the Geothermal Resources Council. In October 1986, this leadership was transferred formally to an Independent Organization Working Group (OWG) of interested people from around the world.

The Geothermal Steam Act of 1970 to provide that if geothermal steam is produced or utilized in commercial quantities under an approved operation within any lease or administrative lease extension period, such lease shall continue for so long as geothermal steam is produced for utilization in commercial quantities, for a maximum continuation of an additional 40 years.

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"The IGA was incorporated in New Zealand in the spring of 1988 by 15 New Zealanders in accordance with recommendations of the OWG," said Dr. James R. Roellig, president of GRI. "These 15 people comprise the current membership of the IGA."

"A rotating Secretariat has been established by the OWG for the IGA," said Bob Greider, director of GRI, Inc. It will be headquartered in Pisa, Italy until 1991, and headed by Dr. Enrico Barbier. The OWG has recommended rotating the Secretariat site every 4 years. It would be moved from Italy to the United States in early 1991. From there, the IGA would sponsor an international geothermal meeting in 1994. In 1995, the Secretariat would be relocated again.

At a meeting May 2-4, 1988 in Pisa, Italy, the OWG will hand over to the IGA its recommendations to date. In addition, the IGA by-laws, finance plan, work program, and membership program will be created.

For additional information, contact Dr. Barbier at CNR/IRG, Piazza Solfertino #2, 56100 Pisa, Italy.
The Canadian Geothermal Energy Association

The Canadian Geothermal Energy Association (CGEA) was founded in 1976. It is the only organized group representing the geothermal community in Canada, and stands as a forum for scientists; regulatory personnel; local, regional, provincial, and federal governmental officials; and private developers to promote an awareness and use of Canadian geothermal resources.

The objectives of the CGEA are to:

- Encourage research, exploration, and development of geothermal energy;
- Hold regular meetings and technical sessions to exchange scientific, engineering, and economic data;
- Provide support and assistance to members;
- Serve as a source of information to prospective developers and interested parties;
- Encourage sound legislative and administrative policies for the development and utilization of geothermal energy; and
- Ensure that the development of geothermal resources is compatible with the protection of the natural environment.

**CONFERENCES**


**Symposium on Cooperative Geothermal Research of the United States and Mexico, The Seapoint Hotel, San Diego, California, April 4 and 5, 1989.**

The U.S. Department of Energy and the Mexican Comisión Federal de Electricidad are conducting cooperative research at Cerro Prieto and Los Anfifes Geothermal field. The results from the first three years of this research will be presented during the symposium. The technical papers will deal with geology, geophysics, geochemistry, and reservoir engineering at both Los Anfifes and Cerro Prieto.

If you would like to receive further information concerning the technical presentations and accommodations, or a copy of the technical papers, contact Joel Horners - MS 3526, Idaho National Engineering Laboratory, P.O. Box 1625, Idaho Falls, ID 83404; phone (208) 526-9824.

**Fourth International Seminar on the Results of EC Geothermal Energy Research and Demonstration, Conference Centre, Florence, Italy, April 27-30, 1989.**

The conference is organized by the Commission of the European Communities and ENEGA Elettrica. EC contractors will make formal presenta-

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World's Oldest Geological Map Confirmed

A 3,100-year-old papyrus scroll, depicting gold mines in ancient Egypt, is probably the oldest surviving geological map and earliest evidence of geological thought, two American researchers have concluded.

The scroll, known as the Turin Papyrus and kept at the Egitto Museum in Turin, Italy, is familiar to Egyptologists and historians of cartography as one of the earliest maps from the ancient world.

It portrays roads, quarries, gold mines, a well, and some houses. Pink, brown, black, and white were used to illustrate mountains and other features.


That was before two geologists from the University of Toledo in Ohio examined the map and went into the field to compare it with the site. The area mapped is a wadi, or ravine, in the mountains of Egypt's eastern desert between Gilf on the Nile, down from Thebes, and Quseir on the Red Sea... The geologists recognized topographical features from the map, a roadway still in use, and the mountains on both sides, shown as cones.

But the geologists, James Harrell and V. Max Brown, also noted that the colors were apparently not added for aesthetic reasons. In a report at the recent annual meeting of the Geological Society of America in Denver, they said the colors "...correspond with the actual appearance of the rocks making up the mountains".

Sedimentary rocks in one region, which range in color from purplish to dark gray and dark green, are mapped in black. Pink granite rocks correspond with the pink and brown-streaked mountain on the scroll.

The scroll notes the locations of the mine and quarry, the gold and silver content of surrounding mountains, and the destinations of the roadways.

"The streaks may thus represent the iron-stained gold-bearing quartz veins that the ancient Egyptians were mining, or they may depict mine tailings," said Dr. Harrell, who is chairman of the geology department at the University of Toledo.

The scroll map was apparently prepared around 1150 B.C. in the reign of Ramses IV.
William Smith, an English surveyor, is generally credited with initiating modern geologic mapping in 1615.

USGS Map Booklet Due

In 1988, the U.S. Geological Survey expects to complete a topographic map index and catalog booklet for all 50 states, Puerto Rico, the Trust Territory of the Pacific, American Samoa, and Guam. The publications are designed to assist in selecting and purchasing maps. They list 37 different USGS map products, including planimetric, topographic, and photo-image maps. They also contain USGS order forms and a list of local map dealers.

Casa Diablo/Long Valley Caldera Area, Map G1-1. $3.00 a copy. Available from the Division of Oil and Gas, 1416 Ninth St., Rm. 1310, Sacramento, CA 95814.

PUBLICATIONS

73rd Annual Report of the State Oil and Gas Supervisor. 1987. Free. Published by and available from the Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814.

Statistical and verbal summaries of 1987 California geothermal activities.

The volumes are designed so that a utility engineer familiar with conventional methods can use them and learn how geothermal projects differ from fossil-fuel projects. For example, people running a coal-fired plant never worry about reservoir development. If the coal they use is not satisfactory, they purchase different coal. With geothermal development, if reservoir difficulties arise, the power plant may have to close.

USGS and BLM Expand Public Outreach

Earth science information has become more accessible to the general public, governmental agencies, and the scientific and industrial communities with the new Minerals Information Center, opened recently in Washington, D.C. The U.S. Geological Survey and the Bureau of Mines jointly operate the center in the Main Interior Building, 18th and E Street Entrance, 2000 Corridor, Washington, D.C.

The center is staffed by mineral experts, who offer a variety of mineral-related information and publications. Statistics on mineral production are also available for every country in the world.

Two computer databases in the center have information on mineral occurrences and mining operations. They are the Bureau of Mines "PC/ AIX Mineral Deposit Database" and the U.S. Geological Survey "Resource-Oriented Computer System".

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Forecasts of annual capacities of the supply of electricity likely to be available from qualifying facilities—revised forecasts based on Delphi gas price projections. No. 87-ER-7. By the California Energy Commission, 1988. Free. Available from the CBC, 1510 Ninth St., MS-21, Sacramento, CA 95814.

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Earth science information has become more accessible to the general public, governmental agencies, and the scientific and industrial communities with the new Minerals Information Center, opened recently in Washington, D.C. The U.S. Geological Survey and the Bureau of Mines jointly operate the center in the Main Interior Building, 18th and E Street Entrance, 2000 Corridor, Washington, D.C.

The center is staffed by mineral experts, who offer a variety of mineral-related information and publications. Statistics on mineral production are also available for every country in the world.

Two computer databases in the center have information on mineral occurrences and mining operations. They are the Bureau of Mines "PC/ AIX Mineral Deposit Database" and the U.S. Geological Survey "Resource-Oriented Computer System".


In recent years, the technology of pressure vessels and of pressure-ized components has changed. More vessels are in use in the chemical and petrochemical industries, in fossil and nuclear power stations, and in aerospace and marine engineering areas. Many new applications call for vessels operating under extremes of high or low temperatures, high internal or external pressure, and in severe environments. These developments have caused much attention to be given to the safety and reliability of pressure vessels, particularly emphasis has been placed on vessel design, fabrication, and inspection methods. Important specifications, additional to those included in practical applications for pressure vessels and their components and to recent R & D activities by prominent specialists. The publication should be of interest to process and chemical engineers, mechanical engineers, materials scientists, and specialists in nuclear engineering, plant designers, and safety officers.


A two-page geothermal resource assessment for Central America by W.A. Duffield is included in this publication.

Vulcanic hazards at Mount Shasta, California. (1986 publication code: 58.) By D.R. Crandell and D.R. Nichols. Free. Published by and available from the USGS, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, Colorado 80225.


This excellent new book, written for the general reader, is a complete revision of Fire and Ice published in 1976. It includes a full account of Mount St. Helens' latest activity and an up-to-date, complete picture of the other fire mountains in the Cascade Range and other parts of the west. It surveys all the west's volcanic centers viewed as potential danger spots and offers a biography of each of the major Cascade volcanoes, as well as those in California's Mono-Mammoth Lake area (all good geothermal areas).

The book incorporates the wealth of new material on volcanoes published since the Mount St. Helens eruption. Concentrating on the individual mountains—from Long Valley and Mammoth Mountain in California to Garibaldi in British Columbia—the book also includes discussions of specific hazards involved when volcanoes erupt. Many geologists prominent in geothermal research are cited. The illustrations and photos are done extremely well.

An additional item that's fun to read, and free, is the Mountain Press publication list. This company publishes the Roadside Geology Guides to Alaska, Wyoming, New Mexico, Vermont, New Hampshire, New York, Virginia, Montana, Washington, Oregon, Northern California, Arizona, Colorado, and Rocky Mountain National Park. It also publishes many other books on geology, western history, and nature: truly a unique selection.


Norris Geyser Basin is adjacent to the north rim of the Yellowstone Caldera, one of the largest volcanic features of its type in the world. Hydrothermal activity may have been continuous there for >100,000 years before present. Norris Basin includes the highest erupting geyser of all, a mobile hot water basin, geologically, particularly metallurgy and hydrocarbon genesis; stratigraphy, structure, and basin evolution; geophysics and geochimistry; volcanology; and tectonics and Quaternary history. This complete reference book, reviews, conferences, and workshop reports will also be included.

Revue Chaleur: The international magazine on heat networks and geothermal energy. Published quarterly. Each issue includes an abstract in English. One-year subscriptions are $30. No checks payable to SFDDD Review Chaleur. The magazine is published by the French Energy Agency (Agence Francaise pour la Maîtrise de l'Environnement), heat networks and geothermal energy service. The articles discuss heat networks, urban heating systems, and geothermal energy.

Worldwide news is included, as well as conferences, regulations, and a large bibliography.

The journal will publish scientific work concerned with all aspects of the earth sciences in the South American continent and the surrounding oceans. Work will also be accepted from the adjacent regions of the Caribbean, Central America, and the Antarctic Peninsula.

Research papers will be featured that deal with the regional geology of South American cratons and mobile belts: economic geology, particularly metallogeny and hydrocarbon genesis; stratigraphy, structure, and basin evolution; geophysics and geochimistry; volcanology; and tectonics and Quaternary history. This complete reference book, reviews, conferences, and workshop reports will also be included.

Nevada geology. Quarterly newsletter of the Nevada Bureau of Mines and Geology. Free. Published by and available from the Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada - Reno, Reno, Nevada 89557-0086.

This new, attractive publication will be used to disseminate news of the activities and publications of the Nevada Bureau of Mines and Geology and other organizations and individuals concerned with Nevada geology and mineral resources.

The Nevada mineral industry - 1987. Publication Mi-1097. $6.00 to purchase or $5.50 by mail. Make checks payable to "UNR Board of Regents". Published by and available from the Nevada Bureau of Mines and Geology, Univ. of Nevada-Reno, Reno, Nevada 89557-0086.

Mining, oil, and geothermal activities in Nevada are summarized in the following issues.

Low-Temperature Development Compiled

Two interesting publications on low-temperature geothermal development in the United States, one by W.A. Duffield, the other by P.A. Lienau, G. Culver, and J. Lund, it is requested.

The information is from a Bulletin article titled "Direct-Use Development in the United States", by Paul Lienau.

The Oregon Institute of Technology found 44 states to have substantial low-temperature geothermal development, representing an estimated annual energy utilization of over 18,000 billion Btu/yr.

Wyoming uses low-temperature geothermal energy the most. It uses ten times more than the next two largest user-states of California and Nevada, due to its enhanced oil recovery operations (9,500 x 10^9 Btu/yr) from the Willow Basin in central Wyoming. However, fluctuating oil prices may impact this use.

The publication summarizes the results of geological energy resource assessment work conducted in cooperation with the New Mexico Statewide Geothermal Energy Program between September 1984 and February 1988.

The program was sponsored by the U.S. Department of Energy and the New Mexico Research and Development Institute, administered by NMRDI, and conducted by professional staff members at New Mexico State University and Lightning Dock Geothermal, Inc.

The report extends the knowledge of the geothermal energy resource base with a potential for commercial applications in southern New Mexico. The report is divided into four chapters:

- Geologic, Geohydrologic, and Thermal Settings of Southern New Mexico Geothermal Resources
- New Mexico State University Geothermal Exploratory Well
- Temperature, Water Chemistry, and Lithologic Data for the Lightning Dock Known Geothermal Resources Area, Animas Valley, New Mexico
- Preliminary Geothermal Resource Assessment of the Orogrande, New Mexico area.

Design and construction of the NM State University geothermally-heated greenhouse research facility. NMRDI Report No. 2-72-42. 44 pages. Free, New Mexico residents; free, nonresidents. $8.35. Available from the New Mexico Research and Development Institute, Communications Office, 457 Washington S.E., Suite M, Albuquerque, New Mexico 87108.

The report describes the design, construction, and performance of the New Mexico State University (NMSU) Geothermal Greenhouse Research Facility. Funded jointly by the New Mexico Research and Development Institute (NMRDI) and NMSU, the facility was built to stimulate geothermal greenhouse development in New Mexico.

Two 6,000-square-foot greenhouses were built in late 1985 and early 1986 on the eastern side of the NMSU campus near Tortugas Mountains. The greenhouses roof and wall surfaces are double-glazed with four different film materials. One greenhouse is cooled using a traditional fan and pad cooling system, and the other is cooled with a high-pressure fog system and natural ventilation through roof and side vents. The facility has been heated geothermally since December 18, 1986.

The geothermal greenhouse heating system consists of the geothermal production system, the heat exchanger, the heat delivery system, a disposal pond, and a gas-fired emergency backup heater. Geothermal fluids are pumped from wells producing water at temperatures ranging from 14°F to 140°F. Water from the geothermal wells enters a plate-and-frame heat exchanger. Heat transferred to fresh water circulating through the heat exchanger is pumped in a closed loop to the greenhouses, where it is delivered to the greenhouse space with four overhead fan-coil unit heaters.

Geothermal fluids from either of two production wells can be utilized by the system, effectively giving the greenhouses a geothermal backup as well as the gas-fired water heater backup. This proposed system was used exclusively until the greenhouses were switched over to the geothermal system in December 1986, and has only been used twice for short periods since then.

The greenhouse facility was leased as incubator space to two commercial tenants in 1986. In mid-June 1986, Flores de New Mexico, Inc. leased the southernmost greenhouse, and during the summer produced several hundred Bosessor potted miniature carnations from cuttings. Alex R. Masson, Inc. leased the other greenhouse in August 1986, growing more than 50 different varieties of chrysanthemums. The Institute maintained and monitored the greenhouses for these tenants.

A telephone line installed in both greenhouses allowed for the remote sensing of temperatures and power use, and for automatic warning when an emergency condition arises. A data acquisition system installed to sample temperatures was programmed to take temperature readings every 20 seconds, average these temperature readings over 6 minutes, store the 6-minute averages once per day on magnetic tape for later evaluation, and display the current temperature on screen. Twelve temperatures are monitored constantly: six greenhouse air temperatures (three in each bay) at plant level, outside air temperature, water temperature at the inlet and outlet of each of the two heaters, and soil temperature in one of the planters.

Results from the tenants' pilot-scale studies in the NMSU greenhouse facility were applied to two commercial greenhouse ranges that were built in southern New Mexico. During the fall of 1986, Flores de New Mexico began building a 10-acre commercial range in Las Cruces, and, in December 1986, Alex R. Masson, Inc. began construction on a new four-acre geothermally-heated and fog-cooled greenhouse range in Ruidus Springs. The geothermal greenhouse research facility allowed these clients to evaluate the heating, cooling, ventilation, and control technologies involved, and provided experience with the southern New Mexico climate and growing conditions.

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 March-December 1988 by the Division of Oil and Gas

Date Notice Received Operator and Well Name & No. API Number Sec. T. R. Location & Elevation

DIVISION OF OIL AND GAS
<table>
<thead>
<tr>
<th>Date Notice</th>
<th>Operator and Well Name &amp; No.</th>
<th>API Number</th>
<th>Sec. T. R.</th>
<th>Location &amp; Elevation</th>
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**D I S T R I C T G 2**

**Imperial County**

**UNION OIL CO.**

11/21/88 “River Ranch” 5 025-90886 25 11B 13E Fr SE cor 41m N, 247m W, el -69m gr

12/1/88 “River Ranch” 6 025-90889 25 11B 13E Fr SE cor 320m N, 53m W, el -69m gr

12/1/88 “River Ranch” 11 025-90890 25 11B 13E Fr SE cor 737m N, 1282m W, el -69m gr

**RED HILL GEOTHERMAL, INC.**

4/20/88 “Testhole” 3 079-90002 34 26S 12E Fr NE cor prop, 73m S, 191m W, el 323m gr

**CITY OF PASO ROBLES**

**RED HILL GEOTHERMAL, INC.**

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**10/1/88 “PDC” 3** 033-00696 22 11N 8W Fr SE cor 317m N, 173m W, el 778m kb

**10/4/88 “PDC” 3** 033-00697 22 11N 8W Fr SE cor 716m N, 489m W, el 856m kb

**10/19/88 “Moody Unit” 3** 033-00698 22 11N 8W Fr SE cor 311m N, 161m W, el 778m kb

**UNION OIL CO.**

5/16/88 “Tocher” 4 033-00702 27 11N 8W Fr NW cor 233m S, 283m E, el 964m kb

**FMRF**

8/7/88 “Moody Unit” 4 033-00706 22 11N 8W Fr SE cor 306m N, 163m W, el 779m kb

**San Luis Obispo County**

**RED HILL GEOTHERMAL, INC.**

9/19/88 “River Ranch” 12 025-90876 25 11B 13E Fr SE cor 736m N, 1221m W, el -68m gr

**ENGLER, WILLIAM E. “Niland” 2** 025-90877 1 9S 12E Fr SW cor 550m N, 289m E, el -30m gr

**FMRF**

8/24/88 “Moody Unit” 3 033-00698 22 11N 8W Fr SE cor 311m N, 161m W, el 778m kb

**UNION OIL CO.**

5/16/88 “Moody Unit” 3 033-00698 22 11N 8W Fr SE cor 311m N, 161m W, el 778m kb

**UNION OIL CO.**

4/1/88 “Sinclair” 23 025-90871 21 11N 8W Fr SE cor 716m N, 481m W, el 778m kb

**FMRF**

4/1/88 “PDC” 3 033-00697 22 11N 8W Fr SE cor 716m N, 489m W, el 856m kb

**FMRF**

5/16/88 “Moody Unit” 3 033-00698 22 11N 8W Fr SE cor 311m N, 161m W, el 778m kb

**UNION OIL CO.**

4/1/88 “Sinclair” 23 025-90871 21 11N 8W Fr SE cor 716m N, 481m W, el 778m kb

**FMRF**

5/16/88 “Moody Unit” 3 033-00698 22 11N 8W Fr SE cor 311m N, 161m W, el 778m kb

**FMRF**

8/7/88 “Moody Unit” 4 033-00706 22 11N 8W Fr SE cor 306m N, 163m W, el 779m kb

**DIVISION OF OIL AND GAS**

**GEOTHERMAL HOT LINE**

**Lake County**

**FMRF**

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**FMRF**

4/1/88 “Moody Unit” 2 033-00696 22 11N 8W Fr SE cor 317m N, 173m W, el 778m kb

**FMRF**

4/18/88 “PDC” 3 033-00697 22 11N 8W Fr SE cor 716m N, 489m W, el 856m kb

**FMRF**

8/7/88 “Moody Unit” 4 033-00706 22 11N 8W Fr SE cor 306m N, 163m W, el 779m kb

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10/1/88 “PDC” 3 033-00697 22 11N 8W Fr SE cor 716m N, 489m W, el 856m kb

**FMRF**

10/4/88 “PDC” 2 033-00695 22 11N 8W Fr SE cor 716m N, 481m W, el 856m kb

**DIVISION OF OIL AND GAS**

106
1988 INDEX

Volume 18, Nos. 1 (pages 1 through 52) and 2 (pages 53 through 111)

a
Aidlin Project 10, 63
Ahsachapan 26
Alberta Plains 78
Amedee Hot Springs 15
Amedee Power Plant 61

f
Fiber-optic sensors 89

b
B.C. McCabe Power Plant 19
Bear Canyon Creek Power Plant 62
Beppu Geothermal field 81
BLM environmental plan 36
BLM geothermal energy summary 37

G
Geopressured development 29
Geothermal Ag Heat Center 11
Glass Mountain 60
Gourmet Prawns Inc. 20
Great Britain 79
Greenhouse effect 83, 84
GRI (GEO) grants options 32
GRI-Mission Energy partnership 69

h
Hawaiian geothermal development 24, 72, 74
Heber Binary Demonstration Power Plant 67
Honey Lake Power Facility 61
Hot dry rock in Cornwall 79

i
IGA 95
Indonesia 81
Industry review panel 28

j
J.J. Elmore Power Plant 66

l
Latin America 76
Leathers Power Plant 66
Legislation, federal 30, 93

m
Maassen, Bruce 1
Mammoth Geothermal Power Plant 14
Mammoth-Pacific II Project 12
Maps 51, 97
McCabe, B.C. 53
Medicine Lake Highlands 86
Mono County Update 12, 62

n
Nevada PSC, Notice of Petition 32
New Mexican geothermal development 22, 24
New Mexican publication 23
New Zealand 27

o
Ormesa I 66
Ormesa IE 66
Ormesa II 19

p
Petroleum violation escrow funds 92
PC&S 63
Power line 68
Publications 43, 99
Puna Joint Venture 74

r
Reservoir development, The Geysers 27
Rock bits tested at The Geysers 28

s
Salton Sea Geothermal Project 65
San Diego Gas & Electric Co. 70
Significant Thermal Features 36
Solar box cookers 85
Southern California Edison 69, 70
Stillwater Geothermal I 72
St. Lucia 25
Steamboat, NV Hydrothermal Power Plant 21, 72
Steam prices 64
Steam ruling upheld 32

T
The Geysers Geothermal field 1
Thermal Power Company 11
Truitt, Glen 9

U
UNITAR/UNDP 38
Unocal 64
USGS Nevada office 38

V
Valles Caldera hydrothermal system 87
Videos 46, 98
Vulkan Power Plant 66

W
Well data 46, 105
Wells 47, 105
West Ford Flat Power Plant 62