A wagonload of visitors arriving at The Geysers, probably around the turn of the century. The exact date is unknown. The "Calistoga" painted on the wagon, beneath the driver's elbow, suggests the visitors may be arriving from that city. The idea seems to be confirmed by Robert Louis Stevenson, who wrote in 1883 in The Silverado Squatters, that the railroad ended at Calistoga and "...the traveller who intends faring farther, to the Geysers or to the springs in Lake County, must cross the spurs of the mountain by stage." Photo from a stereograph by Andrew Price, courtesy of the Library of Congress.
Steam vents at The Geysers, probably around the turn of the century. Exact date unknown. Note pathways, photo right. Photo from a stereograph by Andrew Price. One side of the stereograph reads "Great Geysers Springs." Photo courtesy of the Library of Congress.

Early visitors at The Geysers exploring the steam vent areas, probably around the turn of the century. Exact date unknown. Photo from a stereograph by Andrew Price, inscribed "Witches Cauldron and Devil's Pulpit," Geysers Springs, Sonoma County, California. Photo courtesy of the Library of Congress.

These two pictures may have been taken from almost the same spot, as the scarps, outlined in front of the steam on the right-hand sides of the photos, are quite similar.

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One day in 1847, William Bell Elliott was tracking a grizzly bear northeast of Healdsburg. Following the bear into the The Geysers Geothermal field, he was startled by hissing sounds and by wafts of steam venting from canyon fissures. Later, with his friends, he said "I thought I had come upon the gates of hell itself."

As time passed, more and more people visited The Geysers. By the end of the 1800's, the area was nationally known as a health spa.

A 3-day journey to The Geysers began for one spa visitor on a foggy San Francisco morning aboard the steamboat Rambler. Two paddlewheels moved the little boat out of San Francisco Bay, through San Pedro Bay, and up the twisting passage of Petaluma Creek. In Petaluma, the traveller caught a stagecoach headed for Healdsburg, arriving after dark. "The whole neighbourhood of Mount Saint Helena is full of sulphur and of boiling springs. The Geysers are famous; they were the great health resort of the Indians before the coming of the whites. Lake County is dotted with spas; Hot Springs and White Sulphur Springs are the names of two stations on the Napa Valley railroad; and Calistoga itself seems to reposing on a mere film above a boiling, subterranean lake. At one end of the hotel enclosure are the springs from which it takes its name, hot enough to scald a child seriously while I was there. At the other end, the tenant of a cottage sank a well, and there the water came up boiling. It keeps this end of the valley as warm as a toast."

If your work includes assessments of geothermal resources, researching the historical record of a geothermal area is probably the least expensive and most easily performed resource evaluation technique. In other words, as much as the number and locations of wells, flow rates, temperatures, geothermal surface features, depth to geothermal zones, historical depletion of resource, areal extent of resource, and use made of the resource for the past one hundred years or more, can be extremely useful. All of these are part of the historical record, and readily available in local libraries or archives of local and state historical societies. Oral accounts from long-time community members can provide the information as well.

Len Youngs of the California Division of Mines and Geology has successfully used the historical record as one of the first steps toward assessing the geothermal resources of the City of Calistoga and the City of San Bernardino. With accounts like Stevenson's and others more specific, he has traced changes in water temperature, volumes, flow rates, and mineral content for surface features and "Hot water" wells. From historical accounts, he learned where and when wells were drilled, well depths, and other well data.

For the San Bernardino project, Youngs looked through old water supply papers written around the turn of the century. The papers had "Hot water" well sections with location and temperature data. Not only were the same wells mentioned through the years, providing well histories, but the locations of many "forgotten" wells were uncovered.

When Youngs plotted the wells, he found they were all on the NE side of the San Jacinto fault. He suggests that the fault may act as both a barrier and a heat conduit for the geothermal reservoir.

While exploring the historical records, Youngs was also able to trace the rise and fall of business people that used geothermal resources. For example, today in Calistoga, the Napa Valley Springs Mineral Water Company commercially bottles mineral water collected from a "hot water" well on its property. This property once belonged to a wine bottling company, Sam Brannan - when it was the stable area of his famous spa, opened in 1862.

Youngs says that the historical records of an area should be examined before any geothermal exploration or resource evaluation program is planned. Such an investigation may pinpoint areas of exploration or eliminate certain scientific techniques from an evaluation program, thus saving time and money. Also, research into the historical literature or oral records is free and open to the general public or small businesses. Anyone who may wish to investigate the feasibility of using geothermal resources in their areas.

In early 1981, Youngs' Calistoga historical findings will be published in two formats by the California Division of Mines and Geology. One is part of an open file report titled Resource Assessment of Low- and Moderate-Temperature Geothermal Waters in Calistoga, Napa County, and once in an issue of California Geology.

Variety Typifies the CDMG Geothermal Program Statewide mapping projects, a computerized data storage program, and local resource assessment studies will
are part of the California Division of Mines and Geology (CDMG) contribution to the Department of Energy, State
Coupled Geothermal Program. The purposes of the federal program are to identify and assist in developing areas of low-
and moderate-temperature geothermal resources throughout the United States.

One CDMG project, developed under the program, is a 1:750,000 scale map of California’s geothermal resources on which low- and moderate-temperature resource areas are emphasized. Infor-
mation displayed includes thermal springs and wells, known Geothermal Resources Areas, areas of known or suspected thermal waters suitable for direct use, points of measured heat flow, and land jurisdiction. This map is available, free of charge, from the California Division of Mines and Geology, 2815 "B" Street, Sacramento, California 95816.

In 1982, a second, more detailed map will be published with additional geological and geochemical data.

Besides their inclusion on maps, data for all known and newly discovered thermal springs and wells in California are being entered in computerized data storage banks. The banks are stored in the U.S. Geological Survey Office of Resource Analysis, 7800 Alta Park, California, in GEOTHERM, a computer program used to file, process, and re-
trieve the data.

GEOTHERM data may be obtained directly from the General Electric computer network. Persons with no access to the GE network may obtain GEOTHERM data (for a fee, unless they have con-
tributed data to GEOTHERM) by contacting James Rim, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025.

As part of the resource assessment phase, the CDMG is studying the geothermal resources in the northern Napa Valley, to learn the extent and source of the Calistoga hot water reservoir. Of the many geophysical surveys performed at Calistoga, elec-

trical resistivity appears to be the most useful for delineating the resource. A survey of over 200 water wells in the area has also provided data on temper-
atures and chemistry of the groundwater at various depths. Several shallow- and moderate-depth exploratory holes are being drilled to determine the local stratigraphy and reservoir properties.

An open file report titled Resource Assessment of Low- and Moderate-Temperature Geothermal Waters in Calistoga, Napa County, will be available about March 1 from the CDMG "B" Street address.

Preliminary work similar to the Calistoga study is underway in the Paso Robles area, San Luis Obispo County, and in areas near San Bernardino. The Paso Robles area is underlain by an extensive hot water aquifer with temperatures of at least 70°C (167°F). Similar tempera-
tures have been measured in water wells south and northeast of downtown San Bernardino. The extent, quality, and sources of the hot water will be deter-
mined during these two studies.

In addition, a reconnaissance study of the geothermal resources of Los Angeles County is underway. Because surface evidence of geothermal resources in the county is sparse, the study focuses on data from water, oil, and gas wells. Water samples will be analyzed to determine how they may interact with metals used in direct-use geothermal projects. Eventually, a detailed geothermal gradient map will be drawn.

On a smaller scale, studies have been conducted at Kelly Hot Springs, the Bridgeport-Bodie Hills region, Mono Basin, and the area south of San Diego Bay. The Kelly Hot Springs geophysical study is available as an open file re-
port from the CDMG office. For general information on the Bridge-
port study, contact Forrest Bacon (916) 322-9918; for geophysical data, call Rodger Chapman (916) 322-9905. Both are at the "B" Street address.

The CDMG and the California Division of Oil and Gas can answer public inquiries about low- and moderate-temperature geothermal resources in California. The CDMG also assists participants in other U.S. Department of Energy geo-

thermal programs.

Much material for this article has been excerpted, with permission, from "The Search for Hot Water in California!" by Chris T. Higgins, published in the December 1980 issue of California Geology.

U.S. and Canadian Cascades Studied

The Cascade Regional Assessment by the U.S. Geological Survey is well underway. Many reports are being compiled, for later publication.

Canadian geologists are studying the northern tip of the Cascade Range, in-
cluding the Meager Creek and Meager Mountain areas, 150 kilometers north of Vancouver, B.C. There, the geologists are exploring an area of volcanic热 activity 35 kilometers in diameter. The volcanic activity occurred from 1.9 million to 2.4 million years ago, and hot springs with temperatures mea-
suring 60°C (140°F) have been located north and south of Meager Mountain.

Since the late 1970's, the British Columbia provincial government has spent $4 million for geothermal ex-
ploratory activity in the Meager Mountain area. Fourteen core holes have been drilled south of Meager Mountain and 8 core holes north of Meager Mountain. The holes are up to 350 meters deep with temperatures as high as 202°C (396°F).

The provincial government is looking for geothermal resources with temperatures above 200°C (392°F) to use in electrical generation projects.

Legal

Title VI, Geothermal Energy

The following summary of Title VI of the Energy Security Act of 1980 is repeated from the Department of Energy "Energy Insider."

1. Loans are authorized through FY 1986 for geothermal reservoir confirm-

ation drilling projects, with funding limited to $5 million for FY 1981; $20 million for each of the next four fiscal years.

2. This title provides $5 million for loans to support feasibility studies for geo-

thermal projects, such loans to cover up to 90 percent of the cost.

3. Consideration must be given to geothermal energy use in all new federal

facilities.

What do you Think about Geothermal Regulations?

Do you have any comments or suggestions about California Division of Oil and Gas (CDOG) regulations? If you will write them down, the division would like to hear from you.

Your ideas will be part of a statewide review mandated by Assembly Bill 111. The purpose of the review is to simplify and improve the quality of state regulations and to remove any unneces-
sary or unauthorized regulations.

Your suggestions will be used to help the division determine whether or not its regulations are:

1. Necessary to implement, interpret, or make specific a law or court decision;

2. Adopted by agencies authorized to do so;

3. Clearly written so that persons affected by them can easily under-

stand them;

4. Consistent with existing laws; and

5. Referenced to a specific statute or court decision.
Comments on the disclosure and inspection of public records are due prior to 5/1/81; comments on environmental regulations are due prior to 5/1/81; comments on geothermal resource applications are due prior to 5/1/81; and comments on the implementation of the California Environmental Quality Act (CEQA) are due prior to 5/1/81.

Comments on oil and gas regulations may also be submitted. Those concerning offshore well regulations are due prior to 5/1/81; those concerning onshore well regulations are due prior to 11/30/81.

Inquiries or comments should be addressed to Robert Reid, California Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814 (Telephone: (916) 445-9666).

Copies of the current regulations are found under Title 14, Division 2 of the Public Resources Code, available from the State of California, Documents Section, P.O. Box 1015, North Highlands, California 95660. The cost is $6.00.

The State of California will receive $20 million immediately and could receive $31.6 million a year by 1990 from geothermal properties.

The decision (Pariani v. State of California, 105, Cal. Ap. 3d, 923, May 20, 1980) found that mineral rights held by the state for certain sites in Lake and Sonoma Counties covered geothermal wells on the properties.

Cory said the state now receives $5 million a year from geothermal wells on 6,500 acres, but has mineral rights on 500,000 acres that have geothermal energy potential.

1916 Homestead Act Lands Geysers Clarified

An informational memo from federal officials favoring surface landowners in geothermal resource areas, but still allowing the use of their property, according to Lakeport, California attorney Peter Windrem. Windrem said the federal opinion "definitely" restricts the use of 1916 Homestead Act surface lands as power plant sites.

Nuclear companies wishing to build power plants on 1916 Homestead Act surface lands will have to negotiate with landowners for their consent to do so.

However, landowner permission is probably not necessary for constructing roads, drilling pads, well pumps, or pipelines needed to transport the geothermal steam.

Inquiries or comments should be addressed to Robert Reid, California Division of Oil and Gas; the geophysical section is by Rodger Chapman of the California Division of Mines and Geology; and the reservoir section is by Sven Dykstra, a private consultant.

The publication schedule is:

Spring 1981 - Text, as an open file report, may be read at CDOG offices. About July 1, 1981 - 1,200 copies may be purchased from the CDOG.

The first study is titled Two Studies of the Geysers Near Completion by R. J. MeLaughlin and J. M. Donnelly-Nolan, it will be published in the spring of 1981. The price is unknown.

The publication will contain an introduction by the editors and 23 research papers written on studies undertaken in The Geysers - Clear Lake area.

Power Plant Unit 14 Begins Operation

On September 25, 1980, power plant Unit 14 began commercial operation at The Geysers Geothermal field. Producing 110 Megawatts of electricity, Unit 14 raises the overall field output to 907 Megawatts of electricity.

The day Unit 14 began production nearly coincides, by chance, with the 20th anniversary of the day electrical power generation began at The Geysers. That event occurred with the inauguration of Pacific Gas and Electric Company's (PG&E) power plant Unit 1, an 11,000 kilowatt installation.

In 1973, according to "P.G. and E. Progress," when the utility added its ninth and tenth units, The Geysers became the world's largest geothermal electrical generating facility.

Total cost of Unit 14, including electrical switchyard costs, is about $35 million. The unit has a primary and secondary abatement system designed to remove hydrogen sulfide, which is present in geothermal steam.

Presently, P.G. & E. has 15 power plant units operating at The Geysers. (Unit 15 began operation in 1979.) Two more units are under construction and expected to begin operation in 1982.

U.S. Banks NCPA Power Plant at The Geysers

A group of small Northern California public power agencies received a $45 million loan guarantee from the U.S. Department of Energy (DOE) to build a 110 megawatt geothermal electrical generating plant at The Geysers Geothermal field. The power plant is the first to be built and owned by the group called the Northern California Power Agency (NCPA), which includes nine small cities and a rural cooperative.

The plant is scheduled for completion in 1982. Steam for the plant will be purchased from Shell Oil Company in August 1980, Ruth M. Davis, assistant secretary of the Department of Energy (DOE) for resource applications, signed the loan guaranty on behalf of her agency at ceremonies in San Francisco. Dr. Priscilla Crew, Director of the California Department of Conservation, attended the ceremonies.

The guaranty means the federal government will back repayment of the 30-year loan, obtained by the NCPA from the California subsidiary of the Bank of Montreal, for 75 percent of the power plant construction costs. The other funds will be raised through nonguaranteed debt revenues.

Under the DOE Geothermal Loan Guaranty Program (GLGP), the federal government pledges to guarantee up to 75 percent of the principal and interest on loans made to businesses whose planned use of geothermal energy will advance the development of geothermal resources.

The GLGP program includes a broad range of projects involved with:

1. Determining and evaluating the commercial potential of geothermal resources.
2. Researching and developing geothermal extraction and utilization technologies.
3. Obtaining rights to geothermal resources.
4. Developing, constructing, and operating facilities for the demonstration or commercial production of electrical energy from geothermal resources.
5. Developing, constructing, and operating equipment or facilities for non-electric application of geothermal resources.

Any organization, public or private, may be granted a geothermal loan guarantee. Loan guarantees of up to 75 percent of the estimated aggregate cost of a project are granted up to 30 years. At least 25 percent of the cost must be provided by the borrower. The maximum loan guarantee for a single project is $100 million, with allowances for larger amounts for projects considered to be in the national interest.

For more information on the GLGP, contact the Geothermal Loan Guarantee Office, DOE-San Francisco Operations Office, 1333 Broadway, Oakland, California 94612 (Telephone: (415) 273-7151).

Erosion Study at NCPA Power Plant Site

An erosion study is underway at the Northern California Power Agency (NCPA) power plant site in The Geysers Geothermal field. Undertaken by David Schwartz of the Department of Conservation and co-funded by the department and the California Energy Commission, study goals include:

1. Visual estimates of sheet and rill erosion on disturbed and undisturbed slopes;
2. Measurement of rainfall and rainfall intensity;
3. Measurement of suspended sediment and discharge and the establishment of sediment rating curves for each stream; and
4. Review and assessment of sediment volume data from the sediment basin at the NCPA site.

The final report is scheduled for completion in June 1982.

FM Power Plant Approved

The California Department of Water Resources (DWR) has received approval for its final plan to build a 55 Megawatt geothermal power plant in The Geysers Geothermal field.

In November 1980, the California Energy Commission approved the $70 million Bottle Rock plant, to be built in the Lake County portion of the field.

DWR has agreed to spend $1.7 million to rebuild Bottle Rock Road and $250 thousand to install a flashboard dam on Kelsey Creek. Compensation will be made for loss of wildlife habitat.

Advanced pollution control technology built in the plant will include a scrubber system and a secondary system to reduce the hydrogen sulfide emissions in the plumes of steam. Site development is scheduled to begin in March 1981. The plant is to be in full operation by June 1984.

SMUD Power Plant Up for Approval

On March 25, the California Energy Commission (CEC) will hold a hearing on the Sacramento Municipal Utility District (SMUD) project—proposed $45 million geothermal power plant to be built in The Geysers Geothermal Field.

Don Martin, SMUD project manager, said that the Environmental Protection Agency (EPA) has expedited its review of SMUD's Prevention of Significant Deterioration Permit (PSD), and the PSD review should be finished in time for the hearing.

If the proposal for the 55 Megawatt project is approved, construction could begin in the spring.

Air Pollution Model Under Development

Scientists from 18 laboratories and institutions, working through the Lawrence Livermore National Laboratory Atmospheric Sciences Division, are designing a computerized air pollution model allowing them to simulate pollutant flow and assess air quality in hilly regions. Three studies at The Geysers Geothermal field—one in November 1980; one at Anderson Creek Valley in September 1980; and one planned for Big Sulphur Creek in August 1981—have been designed to provide data for the model.

The Anderson Creek Valley project considered the basic physics of transport.

The Big Sulphur Creek study is planned to determine whether or not the Anderson Creek data can be generalized to other areas, and to study the relationship of geothermal cooling tower emissions to nocturnal drainage flows. During the study period, traces of several chemicals will be added to steam plumes emitted from geothermal plant cooling towers. The chemical concentrations will then be measured in the Big Sulphur Creek area.

Imperial Valley

Niland Power Plant Contract Awarded

Southern California Edison has awarded a contract to Fluor Power Services Inc., a wholly owned subsidiary of Fluor Corporation, to design and engineer a pilot 10 Megawatt geothermal power plant at the Salton Sea Geothermal field near Niland, in the Imperial Valley.

The contract, estimated at $1 million, is for a power plant with a single-flash, geothermal generating unit. Plant completion is scheduled for spring 1982.

Flashed steam for the plant will be provided by Union Oil Company of California, which has drilled four wells capable of production.
Process Flow diagram, Brawley geothermal project. Capital cost of the plant is about $11 million. Photos by Doug Stockton.

Cooling tower, Brawley geothermal project. A conventional two cell, induced draft, counterflow, wet cooling tower with a rated heat load of 260 MW h/yr. provides 0.908 m³/sec (15,400 gpm) cooling water with a 5.5°C (10°F) approach to wet bulb temperature.

Turbine generator, Brawley geothermal project. The Brawley facility uses a flash steam system to furnish geothermal steam to the turbine. The turbine is a single unit with five impulse stages.

Brawley Power Plant Dedicated

The Brawley Geothermal Electric Project, the first commercial Imperial Valley geothermal power plant, was dedicated on October 15, 1980. Southern California Edison Company, the plant owner, operates the 10 Megawatt electrical generating plant with geothermal energy extracted from the Brawley reservoir through wells owned by Union Oil Company of California. The local electrical utility, the Imperial Irrigation District, purchases the power from Southern California Edison.

Edison is conducting performance and reliability studies on all phases of power plant operations. The company wishes to assess the technical feasibility of generating electricity with high salinity geothermal brines. Total dissolved solids of the brines in the Brawley reservoir is about 100,000 mg/l.

Direct Heat

Direct Heat Data and Workshop

A blueprint for financing Geothermal District heating in California, a study prepared for the California Department of Conservation by Derek Hansen & Associates, has recently been released by the department.

Written to encourage the development of direct heat geothermal systems, the study analyzes the financial and institutional context within which direct heat use is being developed. The paper sets forth a plan for utilizing public and private financing for direct heat projects and recommends changes in current law and regulations that would improve the investment climate.

A workshop on the report, involving representatives from industry and various sectors of the financial community, is planned for the spring.

To receive a copy of the report and workshop information, write or call Michael Gerulch, Deputy Director, Department of Conservation, 1416 Ninth Street, Room 1320, Sacramento, CA 95814 (Telephone (916) 322-1080).

Hot Dry Rock

Hot Dry Rock Producing Electricity at Brawley

Part of the electricity needed at the Department of Energy Hot Dry Rock Geothermal Energy Program research site at Fenton Hill in New Mexico now comes from turbines run by heat from hot granite located two miles underneath the site.

It is the first time electricity has been produced from hot dry rock. The experiment, which produced 60 kilowatts of electricity, is scheduled to operate from mid-1980 to early 1981.

"The fact that we are able to generate electricity demonstrates that the program is now out of the research stage and has entered the engineering development phase," says Gregory Nunn of the Los Alamos Scientific Laboratory, manager of the program. He emphasizes that the electricity generated represents only a small fraction of the potential of the resource at the site.

Alfalfa - Drying Plant Planned for El Centro

A project to build a geothermal alfalfa-drying plant in El Centro, California is underway. WESTRO Services, Inc., San Diego, has signed a contract with Henders, Inc. in conjunction with the California Energy Commission to create a preliminary design and an economic assessment of the project.

The project will be the first commercial application of geothermal power to the alfalfa-drying process in the United States. The world's only other such alfa-processing plant is currently operating in New Zealand.

At the plant, the alfalfa will be dried before it is compressed into pellets for sale as livestock feed.

New Hampshire Hot Dry Rock Project

A plan for the world's first full-scale commercial hot dry rock geothermal project for the generation of electricity has been submitted by HDR Energy Development Corporation to the Department of Energy (DOE). The project will be developed within the Conway-Osceola granite of New Hampshire where the White Mountain range series is massive enough, hot enough, and close enough to the surface to be reached with current drilling technology. HDR plans to use air- or carbon dioxide circulating fluids. Complex fracturing techniques will be used in the granite to form the vast amount of heat-transfer surface necessary for the project.

The proposed $50 million joint venture with the DOE is based, in part, upon government-sponsored research at the Los Alamos Scientific Laboratory. However, the size of the fracture complex has been increased from that used at Los Alamos, and the resistance to flow decreased between the injection and extraction sides of the high-temperature earth loop.
Utah

Power Plant at Roosevelt Hot Springs

A 20 Megawatt geothermal power plant will be built by Utah Power and Light Company at Roosevelt Hot Springs, Utah, about 200 miles south of Salt Lake City. Electricity will be generated at the plant with steam purchased from Phillips Petroleum Company. Power plant completion is scheduled for 1983. At that time, other power plants may be built, raising field energy production to around 120 Megawatts.

The plant may become the first geothermal power plant in the United States outside the State of California.

Cerro Prieto

SDG&E Buys Geothermal Power from Mexico

An agreement for the first international sale of geothermal power in North America was signed on November 12, 1980 by San Diego Gas and Electric Company (SDG&E), Southern California Edison, and the Comision Federal de Electricidad of Mexico.

Under the agreement, SDG&E will purchase 150 Megawatts of electricity over a 10-year period from Mexico's Cerro Prieto Geothermal field, and Southern California Edison will purchase 70 Megawatts of electricity from the field. Later, the two companies may be able to purchase additional geothermally-generated electricity from Mexico, possibly as much as 300 Megawatts each, if Mexican geothermal reserves are adequate. Negotiations for the additional purchases are underway.

The Mexican electricity will not reach San Diego customers until 1984, when two new power stations will be operating at Cerro Prieto Geothermal field. Presently, two power stations are operating, producing 150 Megawatts of electricity that is used in Mexico.

Cerro Prieto Reserve Studied

Dr. Wilfred Elders is the principal investigator in a study designed to analyze reservoir heating at the Cerro Prieto Geothermal field through isotope geochemistry, geothermometry, and an evaluation of thermal mineral variations in well cores and cuttings.

The latest results of hydrothermal alteration studies at the Cerro Prieto Geothermal field reveal the shape of the reservoir. These data record patterns of hydrothermal circulation prior to production. As shown in the figure, four regions have been defined. It is inferred that a thermal plume, elongated in a NW-SE direction, dips at approximately 45° to the northeast. This plume is discharged at depth from the northeast and discharges to the southwest. Some of the surface discharge is in the Laguna Volcano mud pot and thermal springs region (see photos).

Contour maps of the field based on 128°C in geothermal water from sandstone provide 200°C and 300°C isotherms. The hottest mineral zone yet drilled, the biotite-
Bubbling mud pots at Cerro Prieto Geothermal field. Mud pot water temperatures have registered at 100°C (212°F) with a pH between 6 and 7. Researchers found large concentrations of condensate water in the field's mud springs and geysers. They noted good correlations between fluid emitted in pools and geysers and fluid produced by wells. Photo by Susan Hodgson.

Mud volcanoes at Cerro Prieto Geothermal field. Wafts of steam were venting from several cones as the picture was taken. The mud volcanoes are about 3 feet high. Sierra de las Cucapá is in the background. Photo by Susan Hodgson.

Not spring at Cerro Prieto Geothermal field. According to J. N. Valette, the field's surface emissions may be divided into four groups: hot and warm springs; boiling mud lakes and mud pots; cold pools; and fumaroles of diverse temperatures. Photo by Susan Hodgson.

stilpnomelane zone of ~325°C, is displaced deeper towards the east and northeast relative to the ~225°C epidote zone above it.

Examination of the spacing of mineral zones with depth in individual boreholes permits division into four classes: (1) prograde; (2) telescoping (or compressed); (3) extended (or elongate); and (4) reversed.

Preliminary studies of the annealing of fission tracks in apatite suggest that heating in the area of well T-366 at Cerro Prieto has lasted only tens of thousands of years.
Costa Rica and Peru

Costa Rican Development at Miravalles

Part II

The following information was provided by the Instituto Costarricense de Electricidad.

Costa Rica's geothermal development program is directed by the Instituto Costarricense de Electricidad. Geothermal exploration has been concentrated in the northwestern region of the country, in Guanacaste Province along the flank of a chain of active volcanoes. Particular attention has focused on an area called Las Hornillas de Miravalles.

The first well drilled at Las Hornillas de Miravalles was well "PGM-1", completed in July 1979. The productive reservoir is in a zone of fractured and permeable crystalized, lithic tuff, capped by a stratum of altered tuff. In February 1980, the bottom hole temperature was 241°C (446°F) and the pressure measured substantially over 178 psi. It is estimated that between 7 and 9 MWe can be produced from the well.

Well "PGM-2" was completed in January 1980. Strata penetrated by the well was lithologically similar to that penetrated by "PGM-1", although a different degree of hydrothermal alteration was discovered. The production zone of well "PGM-2" is in fractured tuff. In February 1980, the bottom hole temperature of the well was 210°C (410°F).

A field reservoir evaluation is underway. Results of the study will determine the size of the first generating unit and the number of wells to be drilled in the next few years.

Salinity was low in water samples collected from well "PGM-1", and no problems from scaling or corrosion are expected to occur in well or power plant machinery. TDS of the samples ranged from 6,000 to 7,000 ppm.

Well PGM-1, while drilling. Miravalles volcano is in the background. Photos courtesy of the Instituto Costarricense de Electricidad.

Well site for well PGM-1, looking towards the Guanacaste plains. Miravalles volcano is behind the photographer.
**Peruvian Geothermal Energy**

Peru may have one of the world's largest reservoirs of geothermal energy, according to "El Comercio," a Lima newspaper.

The article states that Japanese technicians are studying methods of tapping the natural underground steam around the city of Cajamarca and of converting the oil-fired electrical plants in the area to accommodate this form of power.

Cajamarca would be the second city in the region to use geothermal energy. Other volcanic zones are being investigated, as well, for their geothermal potential.

**The Philippines**

**Philippines Geothermal Development**

Geothermal development is well underway in the Philippines. Geothermal energy presently supplies this nation with 500 Megawatts of electricity, or 4.2 percent of its energy needs. The country hopes that by 1985 this number will rise to 12.2 percent.

Further exploration and development activities are underway. The Philippine National Oil Company is developing geothermal fields in Leyte, Northern and Southern Negros, Davao, and Albay. One field recently discovered is the Banlagen field in Benguet. Exploration is also underway in Mount Pinatubo, Zambales.

**Leases**

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

Two sales, previously scheduled, have been cancelled: 1) Island Park, Idaho and Montana; and 2) Corwin Springs, Montana.

<table>
<thead>
<tr>
<th>Location of KGRA</th>
<th>Lease Sale Schedule as of 1/26/81</th>
<th>Latest Sale Date</th>
<th>Original Sale Date</th>
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<tr>
<td>Mono-Long Valley/East Mesa (BLM-FS) CA</td>
<td>05/12/81</td>
<td>02/1/79</td>
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<tr>
<td>Hace Location One/Lightning Dock/San Ysidro/Socorro Peak (BLM-FS) NM</td>
<td>05/19/81</td>
<td>04/15/82</td>
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<tr>
<td>The Geyers (MNL)/Coso Hot Springs (BLM) CA</td>
<td>05/21/81</td>
<td>09/1/79</td>
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<tr>
<td>Gillard Hot Springs and Clifton (BLM) AZ</td>
<td>06/09/81</td>
<td>08/21/79</td>
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<tr>
<td>Lessen Hot Springs (USFS) CA</td>
<td>06/16/81</td>
<td>06/1/79</td>
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<tr>
<td>Belknap-Foley NE/McGredie/Newberry Caldera (USFS) OR</td>
<td>06/25/81</td>
<td>07/06/78</td>
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<tr>
<td>Indian Heaven (USFS) WA</td>
<td>06/25/81</td>
<td>03/19/79</td>
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<tr>
<td>Beckworth Peak (EDM) CA</td>
<td>09/15/81</td>
<td>06/7/79</td>
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</table>
Conferences and Courses

Community Geothermal Meeting Organized

Geothermal potential and state regulatory procedures are the topics to be discussed before the Callistoga Planning Commission at a meeting scheduled for March 3, 1981. Participating in the discussion will be representatives from the California Division of Oil and Gas, California Division of Mines and Geology, State Water Quality Control Board, State Lands Commission, and the Department of Health Services, Food and Drug Administration.

The meeting will be held at 7:00 p.m. in the Callistoga Community Center.

United Nations Sponsors Geothermal Training

Presently, the United Nations and its agencies sponsor geothermal training programs in four countries: Iceland, Italy, Japan, and New Zealand. There are three types of programs: a diploma course at the University of Auckland, New Zealand, sponsored by UNDP; comprehensive, group oriented courses at Kyushu University, Fukuoka, Japan and at the International Institute for Geothermal Research, Pisa, Italy, both sponsored by UNDP; and practical training courses in specialties developed for individuals at the National Energy Authority of Iceland, in cooperation with the University of Iceland, Reykjavik, sponsored by the UN University.


Third Symposium on the Cerro Prieto Geothermal Field, St. Francis Hotel, San Francisco, California, March 24-26, 1981.

Discussions of ongoing programs investigating geology, geophysics, geochemistry, subsidence, and reservoir engineering will occur at the symposium. New technical topics and geothermal areas in the Mexicali Valley will be covered.

A field trip for up to 120 people is scheduled from The Geysers Geothermal field on March 27, 1981.

For information, contact Werner Schu, University of California, Lawrence Berkeley Laboratory, Earth Sciences Division, Berkeley, California 94720. Phone (415) 486-6795, PRT 451-6795.


Geothermal resource types and uses will be discussed in this basic course. For further information, contact the Geothermal Resources Council, P.O. Box 98, Davis, California 95616.


The conference is sponsored by the United Nations and China Consulting Group, Inc. The conference agenda, along with coal, hydropower, solar, oil, gas, and several other energy sources.

For information, contact Mohamed Ghorab, Secretary General of the Conference on New and Renewable Energy, United Nations, New York, New York 10017.


Conference co-sponsors are the State of California, the United Nations Institute for Training and Research, the United Nations Development Programme, the United Nations Environment Programme, the Federal Government of Mexico (through the Commission Federal de Electricidad), the United States Department of Energy, and the Interstate Oil Compact Commission.

Over 100 countries will be represented at the conference. The participants will be specialists in the fields of geology, engineering, economics, environmental analysis, planning, and energy.

Electrical and direct heat uses of geothermal energy are on the conference agenda, along with coal, hydropower, solar, oil, gas, and several other energy sources.

Much of the conference will cover institutional problems—including technology transfer, environmental issues, and economic and financial issues.

Conference participation is by invitation only. For further information, contact UNITAR, 801 U.N. Plaza, Room 316, New York, New York 10017.


For further information, contact Beverly Hall, Geothermal Resources Council, P.O. Box 98, Davis, California 95616.

Audiovisual

The following list of geothermal films were compiled by the Geothermal Resources Council. They are available for rent or loan.

Power Generation

"Harnessing the Earth's Energy" (20 minutes/16mm), Union Oil Company, contact Sandy Barlow, (213) 977-6625.

"Geothermal: Energy from the Earth" (25 minutes/16mm & video), Thermal Power Company, contact Jake Rudisill, (415) 981-5700, x 445.

Audiovisual

"Harnessing the Earth's Energy" (20 minutes/16mm), Union Oil Company, contact Sandy Barlow, (213) 977-6625.

"Geothermal: Energy from the Earth" (25 minutes/16mm & video), Thermal Power Company, contact Jake Rudisill, (415) 981-5700, x 445.

"The Ballad of Steamy Valley" (The Geysers, 25 minutes/16mm), Pacific Gas & Electric Company, contact George Coeard, (415) 782-6211, x 3481.

"Mitsubishi Geothermal Power Plant" (Hatcboharu Power Station, 25 minutes/16mm), Mitsubishi International Corporation, contact Bill Yamada, (415) 981-1910.

"Challenge Geothermal Energy" (Construction Record of Hatchobaru Geotheraic Power Plant, 20 minutes/16mm), Mitsubishi International Corporation, contact Bill Yamada, (415) 981-1910.
"A Challenge to Geothermal Development" (Construction Record of 10 MW Ouma Geothermal Power Plant, 20 minutes/16mm), Mitsubishi International Corporation, contact Bill Tsuchiki, (415) 981-1910.

"Buried Thunder" (14 minutes/16mm), Phillips Petroleum Company, available from Geothermal Resources Council, contact Elaine Clark, (916) 758-2360.

"A Gift from the Earth!" (20 minutes/16mm), Argonne National Laboratory, (312) 971-5771.

Publications

We have learned of two newsletters and a journal not included in the list of geothermal newsletters and small journals compiled for the July 1980 issue of the Geothermal Hot Line.

Hungarian Film (20 minutes/16mm), produced by the Hungarian government, available from the Geothermal Resources Council, contact Elaine Clark, (916) 758-2360.

The Geysers is available at $135 per year or $150 for foreign subscribers wishing airmail service. Write to The Geysers, P.O. Box 1738, Santa Monica, California 90406.

Geothermal Materials Review, prepared by Radian Corporation under a DOE contract, is free. Write to Bill Bohnett, Radian Corporation, P.O. Box 9948, Austin, Texas 78766.

Geothermics, an international journal reporting research and development of geothermal energy, is published quarterly. 1980 subscription rates were $61.00 for one year, $115.90 for two years, and $30.00 for an individual if the person's library or organization subscribes.

Every month, the Earth Sciences Division of Lawrence Berkeley Laboratory publishes reports describing the development of geothermal resources. For a free, up-to-date bibliography, write to Ms. Orah Goldstein, U.C. Lawrence Berkeley Laboratory, Earth Sciences Division Reference Room, Building 90, Room 1070, Berkeley, California 94720.

Two of the current LBL reports on geothermal topics, available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161, are:

- Analysis of production decline in geothermal reservoirs, LBL-11225 (GREN-10), by Elliot J. Zais and Gunnar Bodvarsson, September 1980, $8.00; and


Part I is a directory listing U.S. governmental agencies. Part II contains articles on geothermal topics.


Cities in eight western states within 5 miles or less of a confined thermal spring or well measuring 50°F or more are included. City population growth and heating load characteristics are tentatively identified.

The states included are Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, and Washington. The report is intended as a preliminary aid for geothermal resource planning and commercialization projects.


The Imperial Valley of California has vast hot water reservoirs, nearly one-third of the nation's identified hot-water resources. It is hoped these volumes, assessing the impacts of geothermal development in the Imperial Valley, will be used as models for understanding geothermal impacts from liquid-dominated resources in other regions of the country.

- A short history of the development of direct-use geothermal energy in Susunville, California, is available from the City of Susanville, 66 N. Lassen Street, Susanville, California 96030. The description should be of interest to other cities considering similar developments.

- Quantitative assessment of low-temperature geothermal resources of the United States under 100°F. U.S. Geological Survey Circular, number not assigned. Planned for December 1981. The format will be similar to that used for Circulars 726 and 790.

About 500 chemical analyses of thermal water samples from the Clear Lake volcanic area. Collection and analytical methods are discussed.


- Natural surface hydrothermal feature locations and temperatures, arranged alphabetically by state. Included are springs, pools, mud pots, mud volcanoes, geysers, fumaroles, and geyser vents at temperatures of 20°C (68°F) or greater.


The Atiyrag Geothermal Coordinating Council established by Congress to facilitate residential, commercial, and utility use of geothermal power. The report summarizes the federal program's goals, strategy, plans, and achievements.


- The interplay of heat, water, and rock that form geysers is described. Emphasis is on the hydrologic and geologic settings and structures of geysers, their function, and interaction with the environment.

Maps

New DOE Geothermal Maps

- Idaho, New Mexico, Utah, and California geothermal energy maps. Issued under a Department of Energy (DOE) program in cooperation with the National Oceanic and Atmospheric Administration and the U.S. Geological Survey Geothermal Assessment Program. Available from:
  - Idaho map (free) - Idaho Department of Water Resources, 850 State Street, Boise, Idaho 83702
  - New Mexico map (free) - New Mexico Energy Institute, New Mexico State University, Box 383, Los Cruces, New Mexico 88003
  - Utah map (free) - Utah Geological and Mineral Survey, 606 Black Hawk Way, Salt Lake City, Utah 84108
  - California Division of Mines and Geology, 2815 W 6th Street, Sacramento, California 95816

- Arizena, Nevada, and Oregon maps are available from addresses printed in the January 1980 Geothermal Hot Line.
The Geyser Springs, commonly known as the Geysers, are one of the world's largest and most known geothermal fields. They produce about 250 MW of electricity, which is more than any other geothermal field in the world. The Geysers are located in the North Coast Geothermal District in Sonoma County, California, about 30 miles north of San Francisco. The Geysers are fed by the hot water and steam from a volcanic system beneath the earth. The Geysers consist of about 600 active thermal vents and water wells, with the highest temperature being over 200°C. The Geysers are named after the eponymous geysers, which are high-temperature thermal features that have erupted regularly for centuries. The Geysers are a major source of geothermal energy for California and the United States, providing about 3% of the state's electricity. The Geysers are managed by the California Geothermal Energy Association, which was established in 1981 to promote the responsible development and use of geothermal energy. The Geysers continue to be a major source of geothermal energy, and new projects are under development to increase the field's capacity.
**California Wells**

A computer-generated file of production and injection statistics may be purchased from NGSDC in a digitized format. For details, contact:

Paul J. Grim
Code 564
NOAA/EDIB/NGSDC
Boulder, CO 80303

Telephone: (303) 499-1000, ext. 6418; FAX 323-6418

Most of the data shown on the maps are also available from NGSDC in a digitized format. For details, contact:

Los Alamos Scientific Laboratory
Los Alamos, New Mexico 87545.

*T* S. 323-6418

**Well Data Available**

For all California geothermal wells with records open to public inspection, the list includes records for about 75 wells and costs $95.00.

**LASL Geothermal Gradient Map**

Los Alamos Scientific Laboratory has published a "Geothermal Gradient Map of the Conterminous United States." Color-coded regional conductive gradients are plotted on the map. The gradients were calculated from down-hole temperatures measured at regular intervals.

Copies of the map are available from the Hot Dry Rock Geothermal Program Office, MS 972, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545.

### Well Data Available

Available from the California Division of Oil and Gas in Sacramento, the list includes records for about 75 wells and costs $95.00.

**Well Notice**

<table>
<thead>
<tr>
<th>Date Notice</th>
<th>Operator, Well No.</th>
<th>API No.</th>
<th>Sec. T. R.</th>
<th>Location, Elevation</th>
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<tr>
<td>3/13/80</td>
<td>Phillips Petroleum Company</td>
<td>033-90287</td>
<td>8 12N W</td>
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<td>12/13/80</td>
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<td>033-90339</td>
<td>34 12N W</td>
<td>Fr. SE cor. 285m, N. 45m, W. 1006m, GR.</td>
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**Los Angeles County**

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<th>Operator, Well No.</th>
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<td>Union Oil Company of Calif.</td>
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<td>Anadarko Production Co.</td>
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<td>Fr. SE cor. 335.2m, N. 538.4m, W. 637.7m, KB.</td>
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<td>Fr. SW cor. 30m, N. 259m, E. 1006m, KB.</td>
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<td>Well No.</td>
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<td>Location, Elevation</td>
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<td>McCulloch Geothermal Corp. &quot;Laciez&quot; 1-28</td>
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<td>Fr. NW cor. 91m. E, 1200m E. 56m. KB.</td>
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<td>Fr. NW cor. 55m. E, 67m. E. 55m. KB.</td>
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<td>Fr. SW cor. 120m. N, 800m. E. 38m. KB.</td>
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<td>Fr. SE cor. 856m. N, 59m. W. -67m. KB.</td>
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<td>3 13S 14E</td>
<td>Fr. SW cor. 675m. N, 366m. E. 97m. KB.</td>
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<td>9/6/80</td>
<td>Constance S. Wilson &quot;Wilson&quot;</td>
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**GEOTHERMAL MAPS**

California Division of Oil and Gas

**MAP NO.** | **FIELD OR AREA** | **MAP SCALE** |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>G1-1</td>
<td>Casa Diablo</td>
<td>1:20,000</td>
</tr>
<tr>
<td>G1-2</td>
<td>Lake City</td>
<td>1:20,000</td>
</tr>
<tr>
<td>G1-3</td>
<td>Susanville</td>
<td>1:7,200</td>
</tr>
<tr>
<td>G2-1</td>
<td>Salton Sea (North)</td>
<td>1:20,000</td>
</tr>
<tr>
<td>G2-2</td>
<td>Salton Sea (South)</td>
<td>1:20,000</td>
</tr>
<tr>
<td>G2-3</td>
<td>Heber</td>
<td>1:20,000</td>
</tr>
<tr>
<td>G2-5</td>
<td>East Mesa</td>
<td>1:20,000</td>
</tr>
<tr>
<td>G3-1</td>
<td>The Geysers</td>
<td>1:20,000</td>
</tr>
<tr>
<td>G3-2</td>
<td>The Geysers</td>
<td>1:20,000</td>
</tr>
<tr>
<td>W1-8</td>
<td>Imperial County</td>
<td>1&quot;=2ml</td>
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</tbody>
</table>

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

1418 NINTH ST, ROOM 1310 SACRAMENTO 95814 PHONE (916) 323-1786
5150 E. PACIFIC COAST HWY. SUITE 306-N, LONG BEACH 90804 PHONE (310) 999-5011

(Oregon Division of Oil and Gas (OR) 1:20,000, 1:40,000; California Division of Oil and Gas (CA) 1:20,000, 1:40,000; Nevada Division of Oil and Gas (NV) 1:24,000, 1:48,000; Washington Division of Oil and Gas (WA) 1:62,500)