A typical, high-temperature, geothermal blowout prevention (air) stack. The drawing is reproduced from *Blowout Prevention in California*, a reference manual and guide published by the California Department of Conservation’s Division of Oil and Gas. The new geothermal chapter of the manual is included in this *Hot Line* issue.
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A. D. STOCKTON, Geothermal Officer
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Blowout Prevention for Geothermal Wells in California

by A. D. Stockton
Geothermal Officer
Division of Oil and Gas

Since 1965, the California Department of Conservation's Division of Oil and Gas has regulated the drilling, operation, maintenance, and abandonment of geothermal wells. The purpose of the regulation is to protect the surface and underground environment and to encourage the wise development of geothermal resources. Initially, laws and regulations for drilling geothermal wells were similar to those for oil and gas wells. However, as the geothermal industry has evolved, laws and regulations have been changed to account for the inherent differences between oil and gas well operations and geothermal well operations.

For instance, laws and regulations have been adopted to specifically address measures to ensure geothermal wells do not have failures, such as blowouts. These measures that pertain to drilling operations are explained in the division publication, Blowout Prevention in California.

Very few geothermal wells drilled in California have failed. Blowouts have usually occurred from improper well siting; setting the surface casing at too shallow a depth; cementing surface casing in incompetent rock; or during workover operations on the well.

Most geothermal well blowouts do not occur during drilling operations. Those that do occur during drilling are often caused by improperly planned or executed drilling fluid program. To prevent blowouts during drilling operations, blowout prevention equipment is installed on the well. In an emergency, the equipment is activated to keep the pressure in a well under control. The type of blowout prevention equipment used is regulated by the division, and a test of the equipment is witnessed by a division engineer.

A well-trained crew is a critical element in any blowout prevention program. If crew members cannot recognize the symptoms of a well blowout and how to properly react to them, the proper equipment, itself, is of no use.

A new geothermal chapter on blowout prevention, published in Blowout Prevention in California, is reproduced in this Hot Line issue. However, a geothermal operator will need the entire manual for reference. Copies of the manual are available from the division, free of charge. The geothermal chapter follows.

GEOTHERMAL EQUIPMENT DESCRIPTIONS, OPERATING CHARACTERISTICS, AND REQUIREMENTS

4.1. HIGH-TEMPERATURE BOPE DESCRIPTION

The major BOPE components used while drilling in a high-temperature, water-dominated geothermal system are basically the same as those used on oil and gas wells and are described in the oil and gas sections of this manual. BOPE stacks used for controlling wells drilled with air in a vapor-dominated hydrothermal system contain additional devices not used in oilfield drilling, including a slab gate valve, banjo box, blowout line, muffler, and a rotating head as shown in Figure 24.

The slab gate valve serves as the base for the BOPE stack and is used for pressure control only in emergencies. The banjo box-blowout line-muffler assembly diverts air, steam, and drill cuttings away from the rig floor; the muffler is also used for noise control. The rotating head includes a stripper-packer attached to a ring that rotates on a bearing assembly. The entire rotating assembly turns with the kelly.

In normal air drilling, the packer does not set as a pressure control because the banjo box-blowout line is open to atmospheric pressure. However, if the blowout line is closed, the rotating head becomes a blowout preventer. Normally, the rotating head must be cooled to protect the elastomer seals. Most high-temperature geothermal wells require the installation of a heat exchanger in the drilling-mud circulating system to keep the mud cool.

4.2. HIGH-TEMPERATURE BOPE REQUIREMENTS

The following requirements are mandatory for most high-temperature wells. (Exceptions to the requirements of this section may be made by district engineers on a well-by-well basis, depending on geologic and well conditions.)

a) Mud and Air Drilling

Pressure-control equipment must be installed, pressure tested, and maintained in good operating condition during all drilling operations. Certain components, such as packing elements and ram seals, must be of high-temperature-resistant material. All kill lines, blowout lines, manifolds, and fittings should be made of steel or an acceptable substitute approved by the division, and should have a minimum working pressure rating equivalent to the maximum anticipated wellhead surface pressure.

Pressure-control equipment must conform to the provisions stated in Section 3 of this manual.

1. Drilling Fluid Sufficient drilling mud and materials to ensure well control should be maintained at the drill site and be readily accessible for use at all times.

2. Related Well-Control Equipment A full-opening drill string safety valve must be maintained in the drilling assembly or on the rig floor in the open position at all times while drilling operations are being conducted. A kelly cock may be installed between the kelly and the swivel.

3. Testing and Maintenance The annular and ram-type blowout preventers and auxiliary equipment must be tested in accordance with the provisions set in Section 3 of this manual.

4. Conductor Pipe Before drilling out the shoe of the conductor pipe, at least one remote-controlled, hydraulically operated, annular preventer, or an acceptable substitute (approved by the division), may be required. This installation may include a drilling mud spool with 2-inch side outlets. A kill line and blowout line equipped with appropriate fittings should be connected to the drilling spool. See Section 2 of this manual for the selection of equipment.

5. Surface, Intermediate, and Production Casings Before drilling out the shoe of the surface, intermediate, or production casing during mud or air drilling, the blowout prevention equipment must include a minimum of:

a) An annular preventer or a rotating head. The annular preventer shall be equipped with an actuating system that includes an accumulator.

b) A manually and remotely-controlled, hydraulically operated, double-ram blowout preventer or an acceptable substitute (approved by the division), with a minimum working pressure rating exceeding the maximum anticipated surface pressure at the anticipated reservoir-fluid temperature.

c) A drilling spool with side outlets or equivalent.

d) A kill line equipped with a check valve or power-operated valve.

e) A blowdown line equipped with at least one valve. The line should be securely anchored at all bends and at the end to prevent whipping or material damage during use (not required in vapor-dominated drilling).

The following additional BOPE is required when drilling only with air or other gaseous fluid:

f) At least one valve or slab gate between the banjo box and the wellhead.

g) A blowout line.

6. Air Drilling

Air or other gaseous-fluid drilling systems must have blowout prevention assemblies that include, from top to bottom, a rotating head, a double-ram blowout preventer (pipe and blind) or equivalent, a kelly cock or an approved substitute, and a blind-ram blowout preventer or gate valve (Fig. 24). Equivalent systems may be approved by the district engineer.
4-3. LOW TEMPERATURE BOPE REQUIREMENTS

Low-temperature wells and temperature-observation wells drilled in high-heat-flow areas not previously drilled, or in areas having a moderate- to high-potential for blowouts, require an annular and/or pipe and blind-ram preventer (Fig. 23). A kill line and a blow-down line should be installed below the preventer. In areas where geological conditions are known or where pressures are at or below hydrostatic pressure, the district engineer may approve the use of a single diverter stack. In the diverter stack (Fig. 26), a flow line is installed below a blowout preventer, gate valve, rotating head, or an approved equivalent device. All required low-temperature BOPE equipment must be fully operational at all times. Pressure-control equipment must conform to provisions in Section 3 of this manual. All precautions should be taken to provide for the safety of the drilling crew and other personnel in case of a blowout or unexpected artesian flow.

Statistics

Division CEQA Unit, 1984

The Division of Oil and Gas was designated by the California State Legislature as the lead agency under the California Environmental Quality Act (CEQA) for all geothermal exploratory drilling projects on private and state lands in California.

In 1984, 8 geothermal exploratory project applications were submitted to the CEQA Unit, compared with 11 in 1983. The applications were for 3 deep-test well projects and 5 observation well projects, compared with applications for 7 deep-test well projects and 4 observation well projects in 1983.

One Notice of Preparation was issued in 1984 by the CEQA Unit, compared with 4 in 1983. 7 Notices of Exemption compared with 6 in 1983 and 5 Notices of Determination compared with 2 in 1983. Five draft and 4 final environmental impact reports (DNRP's and FEIR's) were completed in 1984.


"Steam production in The Geysers Geothermal field totaled 80.0 billion kilograms in 1984," said A. D. Stockton, Geothermal Officer for the Division of Oil and Gas. He said this was a 21.4 percent increase from 65.9 billion kilograms produced in 1983.

Injection of condensed steam and water from Big Sulphur Creek, which runs through the field, increased from 19.5 billion kilograms in 1983 to 24.6 billion kilograms in 1984, leaving a reservoir fluid deficit of 55.4 billion kilograms for 1984.

Historical steam production, water injection, and power plant capacity at The Geysers Geothermal field.

Production Statistics,
The Geysers Geothermal Field

Geothermal Electrical Generation Up

In the fourth quarter of 1984, 2,161,924 megawatt-hours of electricity were generated from California geothermal resources. This figure represented a 20.6 percent increase over the same quarter in 1983. The figure represents 6.47 percent of electricity generated by utility companies in the state.
These figures were taken from Energy Watch, published by the California Energy Commission, May 1985.

Geothermal Electrical Generating Capacity Compared

Figures in the following table compare the growth of geothermal power plant electrical generating capacity in California and worldwide (including California).

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**Imperial Valley**

**Imperial Valley Adjusted Relevelling Data Available**

by A. D. Stockton and the County of Imperial, Department of Public Works

The Imperial County Department of Public Works has received and distributed the adjusted level data for the 1980 Imperial County Subsidence Leveling Network. The data adjustment was undertaken by the National Geodetic Survey (NGS).

The data adjustment was necessary because certain leveling instruments were subject to magnetic influence. Thus, some of the primary level lines were influenced.

A spokesman for the NGSC reported that most of the errors occurred in the 1974 and 1976 surveys. They found no error in the 1972 survey and very little error in the 1980 survey. The corrections for the 1974 and 1976 surveys will be released by the Imperial County Department of Public Works.

Imperial County is completing the fifth survey of the geothermal subsidence monitoring network. Unlike the four previous surveys, the fifth is a phased survey that is being performed over a period of several years. Following completion of the final phase of the survey, data will be compared with previous findings to identify the natural tectonic subsidence patterns in the area.

The county-wide survey network provides baseline information for comparison with site-specific surveys performed by geothermal developers. About 10 years of developers' surveys have been performed in the north Brawley, Huber, and Salton Sea areas.

In addition to surface monitoring, the division of Oil and Gas monitors subsurface reservoirs to detect changes that may be indicative of future subsidence.

No localized subsidence has been detected near geothermal project sites to date. Periodic monitoring will continue to be necessary as development proceeds.

**Update: Salton Sea Scientific Drilling Project**

Drilling is scheduled to begin on October 23 at "State Well" 2-14, the Salton Sea Scientific Drilling Project. The 10,000 foot well will be drilled at a site in the Imperial Valley, close to Niland, California. Well temperatures are expected to reach 300°C at a depth between 3,000 to 6,000 feet. The brines are expected to have salinities of 250,000 to 300,000 milligrams per liter. Once completed, the well will be kept open for about a year for scientific experimentation.

The Division of Oil and Gas has issued a report on Proposed Geothermal Operations (essentially, a drilling permit) to Kennecott Corporation for the well. The report includes stipulations for drilling the well. The stipulations follow.

1. Conductor pipe of adequate size and strength shall be cemented at a minimum depth of 45.7m (150').
2. Surface casing of adequate size and strength shall be cemented at a depth not less than 274.3m (900') nor deeper than 304.8m (1000').
3. This well shall be cased in such a manner as to protect or minimize damage to the environment, usable ground waters (if any), geothermal resources, life, health, and property.
4. An annular blowout preventer and a spool, fitted with a low-pressure pop-off and blow-down line, shall be installed on the conductor pipe (30") to ensure against possible gas blowouts during the drilling of the surface casing hole.
5. Division of Oil and Gas Class III A, 3M blowout-prevention equipment shall be installed on the 20" surface casing prior to drilling out the shoe of the surface casing, and be maintained ready for use at all times.
6. Division of Oil and Gas Class III B, 3M blowout-prevention equipment shall be installed on the 12-3/8" surface casing prior to drilling out the shoe of the surface casing, and be maintained ready for use at all times.
7. Division of Oil and Gas Class III B, 3M blowout-prevention equipment shall be installed on the 9-5/8" surface casing prior to drilling out the shoe of the surface casing, and be maintained ready for use at all times.
8. During the drilling of the surface casing (20") hole, the temperature of the return mud shall be monitored continuously. Either a continuous temperature-monitoring device shall be installed and maintained in working condition, or the temperature shall be read manually. In either case, return mud temperature shall be entered into the log book after each joint of pipe...
has been drilled down (every 10 meters).

9. Drilling of the surface casing hole shall not proceed if the temperature of the return mud exceeds 60°C (140°F). If this temperature is reached, a supplemental driling program must be approved by the division.

10. All well records listed in appropriate sections of the Public Resource Code and the California Administrative Code are submitted within 60 days after cessation of drilling operations. Subsequent records such as temperature surveys or required water analysis shall be submitted within 30 days after being run.

11. This division shall be notified:
   a. One day prior to the commencement of drilling.
   b. Before altering the proposed program or suspending operations. Additional requirements will be outlined at that time.
   c. To witness the placing and cementing of each casing string.
   d. To inspect the blowout prevention equipment prior to drilling out the hole of the 5-1/2″ conductor pipe.
   e. To witness a test of the blowout prevention equipment prior to drilling out the hole of the 3-1/2″ casing.
   f. To witness a test of the blowout prevention equipment prior to drilling out the hole of the 2-7/8″ casing.
   g. To witness a test of the blowout prevention equipment prior to drilling out the hole of the 9-5/8″ casing.
   h. To inspect any changes made to the blowout prevention equipment.

The Shallow Salton Sea Drilling Program

Adapted from a report prepared by Sandia National Laboratories.

Introduction

The Continental Scientific Drilling Program is a national endeavor to explore, in a scientific sense, the third dimension of the earth's crust. The implementation of this program is carried out through an Interagency Accord on Continental Scientific Drilling between the National Science Foundation, the Department of Energy/Office of Energy Research, and the Department of Interior/USGS. This document was signed April 2, 1984, and it is the instrument by which the various agencies share resources and provide guidance for the overall program. The primary responsibility for Thermal regime drilling and a substantial portion of the related research is assigned to the U.S. Department of Energy.

To implement the field activities associated with Thermal regime, the Department of Energy Sciences established a Geoscience Research Drilling Office at Sandia National Laboratories. One of the responsibilities of this office is to interface with the scientific, drilling, and permitting communities so as to generate pertinent data in an economic and a physically and environmentally safe manner. These data come in the form of core and fluid specimens as well as the results of surface and subsurface geophysical experiments.

The Shallow Salton Sea Program

The Shallow Salton Sea Drilling Program is part of an initiative put forth by Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia. Previous drilling in this initiative occurred in the Valles Grande Caldera, New Mexico, and Long Valley Caldera, California.

A great deal of work has been done in the Salton Sea area by USGS, national laboratory, and industrial researchers. This interest stems from the fact that the Salton Sea Geothermal field lies within one of the largest and hottest hydrothermal areas in the world. Like other fields in the Salton Trough, this system is apparently related to the right lateral transform fracture system on the western margin of North America. In that regime, wherever faults veer near the domes produces thermal fields.

The geothermal field southeast of the domes has been studied extensively by deep and shallow drilling as well as by several geophysical methods. The portion of the hydrothermal system to the northwest has not been explored as extensively, partly because the shallow sea makes exploration and resource utilization more difficult than it is in the landward part of the system. However, regional studies such as gravity, magnetics, and seismic surveys all indicate that the pull-apart zone extends under the Salton Sea and that the hydrothermal system probably does as well.

Recent efforts, based on the extensive data set for the southeastern part of the system, have resulted in a model that can be used to predict near-surface heat-flow contours from the unexplored part of the system. Two features of the temperature field in the Salton Sea geothermal field put strong constraints on models of the hydrothermal system's development. First, uniform, steady-state heat-flow is observed in a 500 m thick thermal cap over an area of 30-40 km². This observation indicates that the rate of heat delivery to the thermal cap in this area has not changed for at least the time required for the cap to reach equilibrium, about 10,000 years. Secondly, the periphery of the high heat flow zone is abrupt, and the thermal gradient in the cap increases significantly with depth as the hydrothermal zone is approached. These observations suggest that the heat has been delivered to the periphery for a much shorter time than is required for conduction in the cap to spread the boundary layer to reach steady-state equilibrium.

A model of horizontal fluid flow outward from a heat source of hot fluids near the domes produces thermal fields that match these observations. The model is simple enough that analytical results can be evaluated for a broad range of parameters in order to place bounds on the nature of the hydrothermal system. This simple conceptual model for the fluid flow patterns has been used to estimate the age of the system and to evaluate quantitatively the limitations of our understanding of the heat source. More importantly, and in regard to heat flow conditions offshore, the model predicts that:

1. An area of high (4 to 5 times normal) and uniform heat flow will be found offshore to the northeast of the domes.
2. The area of uniform heat flow will be bounded by a narrow (10 km wide) zone of rapid transition to normal heat flow.
3. These regions can be detected and delineated by offshore, shallow heat flow measurements.
4. If the location of the boundary region is determined, then quantitative estimates of the heat source location can be made.

A test of this model requires additional information from shallow offshore heat flow holes. Thus, the Shallow Salton Sea Drilling Program was designed.
The Shallow Salton Sea Drilling Program will consist of 20-30 temperature gradient holes drilled to a depth of 220 feet below the floor of the Salton Sea. Anticipated water depths are 2 to 30 feet. Temperature logs will be made immediately after drilling, and for about three months thereafter. Since the position of the horizontal temperature is unknown, the early temperature logs will be used to site subsequent holes.

The drilling operation will be under the supervision of Jacky Pannain of IV Dimension Technologies, Ltd. Drilling will begin October 1985.

"We are looking forward to the project and are hoping it will answer many questions about the magnetic and gravity anomalies," said Dick Corbaley, Division of Oil and Gas Lead Engineer in El Centro.

For further information, contact Peter Lyons, Geoscience Research Drilling Office, Division 6240A, Sandia National Laboratories, Albuquerque, New Mexico 87185, Phone: (505) 846-6328.

Heber Power Plants On Line

Two power plants in Heber Geothermal field have gone on line. One plant, a geothermal binary power plant, is the first of its size in the United States to use binary-cycle geothermal technology. The second plant is a dual-flash geothermal power plant.

The binary power plant went on line on September 11, 1985. It is currently (October 1) generating 11 megawatts net of electricity. One megawatt of the amount is being delivered to San Diego Gas and Electric Company. The 45 megawatt net plant is expected to be producing at full power on November 15, 1985.

Wells for the power plant were drilled by Chevron Geothermal Company of California. The plant was funded by the U.S. Department of Energy, the Electrical Power Research Institute, San Diego Gas and Electric Company, the Imperial Irrigation District, California Department of Water Resources, State of California, and Southern California Edison Company.

The dual-flash geothermal power plant at Heber Geothermal field has gone on line, as well. The 47 megawatt power plant, about 1 mile east of the binary plant, was started up on July 26, 1985. Currently (October 1), the plant is generating 37 megawatts net of electricity. Of this amount, 35 megawatts is being delivered to Southern California Edison. The plant is expected to be running at full power on November 15, 1985.

Partners in the dual flash project are Chevron Geothermal Company, operator of the Heber Geothermal Unit, a joint venture with Union Oil Company of California; and Heber Geothermal Company, operator of the power plant. Heber Geothermal is a joint venture of Dravo Corporation, and Centennial Geothermal Inc.

The Vulcan Power Plant

by Russ L. Tenney
Manager of Operations
The Magma Power Company

The Magma Power Company is constructing a dual-flash power plant near California, at the northern end of the Imperial Valley. The plant will be owned and operated by the Vulcan Power Company, a wholly owned subsidiary of the Magma Power Company. The plant, named the Vulcan Power Plant, is designed to produce a nominal 36 megawatts gross and 32 megawatts net of electricity. The Vulcan project is financed by a loan from the Morgan Guaranty Trust Company and substantial cash equity from Magma Power. There are no public funds involved.

Engineering, procurement, and construction management were contracted to the Dow Engineering Company of Houston, Texas. Construction is about 99 percent completed, and all systems are scheduled to be released to operations by October 4, 1985. Startup and shakedown are scheduled for October and November, with commercial operation beginning December 2, 1985.

Magma will operate both the brine field and the generating station. Magma's patented crystallizer-clarifier process is being used to handle the high temperature, highly saline brine.

The brine to supply the plant is drawn off the bottom of the clarifier and is filtered to remove any remaining suspended solids before being injected into some combination of the 6 injection wells. The solids are then removed from the bottom of the clarifier. They flow to a thickener, where they are further concentrated. Then, a portion of this sludge is used to seed the brine inlet. The remainder is disposed of.

This is really a very simple and straightforward process, with no batch operations and very little pumping. It uses existing technology, and has been successfully demonstrated. It poses acceptable commercial risk.

The pressure is further reduced to generate sufficient steam to drive the 9.4 megawatt Mitsubishi high-pressure turbine.

The steam exhausted from both turbines is condensed in separate surface condensers and used as the cooling medium. A high efficiency Marley counterflow cooling tower is used to reject unusable heat to the atmosphere. Air and noncondensable gases are removed from the condensers with a hybrid system of air injectors, inner and outer condensers, and vacuum pumps. The noncondensables are then contacted with the brine to react the hydrogen sulfide with the heavy metals contained in the brine. The remaining gases, primarily carbon dioxide, are vented out of the LP crystallizers.

The unflashed brine flows to the reactor-clarifier. The fully developed crystals then begin to settle and are pushed to the center by a rake. Here, they agglomerate and thicken. Clarified brine then flows out the top of the clarifier and is filtered to remove any remaining suspended solids before being injected into some combination of the 6 injection wells. The solids are then removed from the bottom of the clarifier. They flow to a thickener, where they are further concentrated. Then, a portion of this sludge is used to seed the brine inlet. The remainder is disposed of.

Here, the pressure is further reduced to generate sufficient steam to drive the 9.4 megawatt Mitsubishi high-pressure turbine.

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For further information, contact Peter Lyons, Geoscience Research Drilling Office, Division 6240A, Sandia National Laboratories, Albuquerque, New Mexico 87185, Phone: (505) 846-6328.
Republic Geothermal, Inc. has transferred its East Mesa leases and wells to Group Systems, Inc. Ormesa's subsidiary, Ormesa, is planning to develop a 30 megawatt gross, 20 megawatt net facility using 26 interconnected modular binary generating units, each with a gross rating of 1.25 megawatts. A Department of Energy Geothermal Loan Guarantee, previously approved for a Republic project, will be restructured for the revised project.

Ormesa has submitted development plans for approval by the Bureau of Land Management. Current schedules estimate start of construction in the summer of 1985 and completion in 1986.

The power will be purchased by Southern California Edison. The resource temperature is 160°C.

Northern California

Bottle Rock Power Plant On Line

The Bottle Rock geothermal power plant is a 55 megawatt plant owned, constructed, and operated by the California Department of Water Resources (DWR) in The Geysers Geothermal Field. Testing began at the plant in January 1985, and full-capacity commercial generation began in March 1985.

Electrical power is sold to DWR to the number of utilities. The Department of Water Resources is the fifth largest utility in California.

Mammoth Lakes Geothermal Direct Heating Engineering and Feasibility Study by Daniel L. Lyster, Director Office of Energy Management Mono County

On February 5, 1985, the Ben Holt Company entered into a contractual agreement with the County of Mono to provide the preliminary engineering and economic evaluation of a geothermal direct heating project at Mammoth Lakes, California. The primary funding of the project is from a California Energy Commission grant (No. 912-84-006) awarded to Mono County in the latter part of 1984.

The proposed direct heating system will use hot water from one of three possible geothermal resources in or near the mountain-resort town of Mammoth Lakes. The heat from the hot water in the closed-loop circulating system is returned to the geothermal well area where the water will be reheated with a heat exchanger.

Considering the relatively remote location of this mountain community, in which many of the homes are currently provided by electricity

City of El Centro Well

Reprinted from the Imperial County Geothermal Development Status Report prepared by the County of Imperial, Department of Public Works.

El Centro geothermal direct-use project was terminated, partly due to well problems. El Centro and the U.S. Department of Energy modified their contract to allow brief testing of the production and injection wells. The project was abandoned. The abandoned was completed in August 1984.

Although the El Centro project was terminated, the project may result in the discovery of a potentially valuable low temperature resource (240°F) at a depth of 7,000 feet.

with the remainder met by wood and liquefied petroleum gas), the need for a more dependable and benign source of space heating is apparent. Additionally, the need for snow melting on roads, walkways, and parking lots provides further justification for such a project.

Of the three possible geothermal resources that may provide the hot brine to be used in the heat exchanger, only the resource currently fueling the Mammoth Pacific 7 megawatt power plant at Casa Diablo (about 5 miles from the proposed project area) is proven. The other two are believed to be within the federal geothermal leasehold recently acquired by the Union Oil Company of California (just outside the town limits) and within an unexplored area of the town.

To test the latter potential resource, a proposed scientific research well will be drilled on U.S. Forest Service land within the Mammoth Lakes town limits. The well will be funded primarily by the U.S. Department of Energy, with some contribution from the Mono County Geothermal Fund. The depth of the research well, which may be more accurately described as a monitoring piezometer, is proposed to be 1,500 feet.

Although the primary purpose of this relatively shallow well is to provide downhole temperature measurements, repeated fluid sampling, and to monitor changes in fluid pressure, the incidental well log data and information relating to local geology and stratigraphy will provide information necessary to assess the feasibility of drilling a production well closer to the point of use. Thus, if the drilling data appear encouraging, the Town of Mammoth Lakes may choose to solicit private funds for drilling the production well to provide geothermal brine to the direct heating project. If the drilling of the Department of Energy project well to a depth of 1,500 feet does not provide enough data to immediately justify the pursuit of a production well within the town limits, the town may approach the California Energy Commission for grant funds to deepen the well to a depth of 2,500 feet.

Oregon, Idaho, & Washington


In 1984, as in 1983, geothermal drilling in Oregon was at a very low level and was centered chiefly on Newberry Volcano. Drilling by California Energy in the Crater Lake area was delayed when the National Park Service (NPS) voiced concerns about possible negative environmental impacts. The total acreage of leased geothermal lands in Oregon decreased by 18 percent as developers winnowed out the less attractive prospects or left geothermal exploration in Oregon in response to unfavorable market and regulatory conditions.

Pump testing and monitoring of wells in Klamath Falls continued as the city finally began to utilize the geothermal district heating system constructed earlier by U.S. Department of Energy (USEDOE) funds. The thermal aquifer at Klamath Falls appears to be little affected by the large-scale pumping.

Data from an 8,080-ft. (2463m) well drilled in 1981 near Bremen with Spruces were put in the
The well intercepted sheared tuffs carrying fluids with temperatures in excess of 136 °C from 2,467 ft. (752m) to 2,566 ft. (782m). Temperature-gradient surveys in the area indicate that this aquifer may dip to the east where even higher temperature fluids probably occur. Temperatures were in excess of 141 °C at 8,060 ft. (2,457m), resulting in a probable conductive gradient in excess of 56 °C/km. These data support the following hypotheses: (1) the High Cascade heat-flow anomaly inferred from shallow gradient data is representative of deep conductive heat flow, (2) the heat-flow anomaly affects a significant part of the Western Cascade Range, and (3) significant geothermal resources may exist in the Western Cascades far removed from the major High Cascade volcanoes.

**BPA Studies Western Geothermal Sites**

At least 13 geothermal sites in Oregon, Washington, Idaho, and Montana offer good potential for development, according to a study recently completed for the Bonneville Power Administration (BPA). Eight sites appear technically capable of generating a total of at least 1,000 megawatts of electricity. Geothermal energy in five other sites could be used directly for water or space heating. The better sites tend to be concentrated in Oregon.

Thirteen sites ranked "high" in both developmental and economic potential. Of those, the eight areas with highest potential are:

- Egan Gap, Oregon
- Raft River, Idaho
- Newberry Volcano, Oregon
- Crane Creek, Idaho
- Klamath Falls, Oregon
- Glass Buttes, Oregon
- Klamath Hills, Oregon
- Big Creek, Idaho

The five areas that could be used best for water or space heating are:

- Boise, Idaho
- Yakima, Washington
- Pullman, Washington
- Pocatello, Idaho
- Klamath Falls, Oregon

The report is titled *Evaluation and Ranking of Geothermal Resources for Electrical Generation or Electrical Offset in Idaho, Montana, Oregon, and Washington*. The principal investigator is R. Gordon Bloomquist. For a free executive summary of the report or further information, contact John R. Godin, BPA, P.O. Box 3621, Portland, Oregon 97208. Phone (503) 230-5327.

**Utah & Nevada**

Geothermal Energy in five other sites: Newberry Volcano, Oregon could be used directly for water or space heating. Klamath Falls, Oregon also mainly below 1,000 feet. as a satellite wellhead separator to one of at Olene Gap, Oregon. Klamath Falls, Oregon. Pre-construction drilling has been geothermally operated on steam alone. Short term testing of a shallow production well indicates excellent flow rates and temperatures higher than anticipated.

**Biphase Systems in Utah and Nevada**

"For 3½ years," said Walter Studhalter, Manager of Marketing for Biphase Energy Systems, "a 1.3 megawatt geothermal turbine generator wellhead unit has provided Utah Power and Light Company with its first geothermally produced electricity. The generator is installed next to a well at Roosevelt Hot Springs Geothermal field in SW Utah. The electricity, first produced in October 1981, is generated from both the hot water and steam portions of the resource.

The generating unit includes a Biphase, rotary separator turbine that produces 20 percent more kilowatts per pound of geothermal fluid as compared with a geothermal system operating on steam alone.

"In commercial practice, the rotary separator turbine can be used either as a satellite wellhead separator to supply steam to a central plant and supplement the total electrical output, or as a wellhead generator in combination with a small steam turbine," noted Vasel Roberts, manager of the Electric Power Research Institute's Geothermal Power Systems Program. "As a wellhead unit," he added, "It can be used in the early stages of geothermal field development to provide information on the production characteristics of geothermal reservoirs. The information can also be used to compare the economics of the wellhead approach with that of alternative, centralized plants."
The mobile wellhead unit was developed by Biphase Energy Systems, a joint venture of Research-Cottrell and Transamericana Delaval. Additional development and fabrication funding was from the Electric Power Research Institute and the U.S. Department of Energy.

Steam for the Roosevelt Hot Springs project is provided by Phillips Petroleum Company, Utah Power and Light supplied materials and operating personnel.

"At the present time," said Studhalter, "Transamericana Delaval has contracted with Utah Power and Light to supply to the utility seven, 145 megawatt units at times selected by the utility. Thus, the plants may be brought on line according to demand and well schedules."

"At Desert Peak, 65 miles northeast of Reno, Nevada," he continued, "Phillips Petroleum Company is engineering and building a 9 megawatt geothermal power plant. Included in the power plant is what we call the power skid, a biphase rotary separator turbine and a Delaval steam turbine, generator, and accessories.

Rothamstel separator turbine, installed at Roosevelt Hot Springs Geothermal field in SW Utah, near Milford. At the plant, 1.3 megawatts of electricity is generated.

The Hawaii Geothermal Project

1975 to April 1976 when it was completed to a depth of 6,450 feet (1966 meters). With a bottom hole temperature of 676°F (358°C), HGP-A was one of the hottest geothermal wells in the world.

The production of steam is believed to come primarily from aquifers located at 4,500 feet (1372 meters), 5,800 feet (1768 meters), and bottom hole. The well produces 110,000 lbs/hr. (49,900 kg/hr.) of a mixed phase fluid (57 percent liquid and 43 percent steam) at a wellhead pressure of 175 psia (12.3 kg/cm²) and 366°F (186°C).

Construction of the power plant was undertaken with major support from the U.S. Dept. of Energy and a development group consisting of the State of Hawaii Department of Planning and Economic Development, the County of Hawaii, and the University of Hawaii's College of Engineering.

Rogers Engineering Company of San Francisco designed the power plant and provided construction management services. The plant was completed in mid-1981 at a cost of about $10 million. The plant design incorporates a single flash wellhead separator operated at a pressure of 175 psia, a 3 megawatt turbine generator set, and a shell and tube surface condenser. Noncondensible gases are removed from the condenser with a dual-stage steam ejector and are incinerated and scrubbed with a 10 percent solution in a packed tower. Off gases from the scrubber are vented to the cooling tower intake. Separated brine is discharged to the atmosphere in a muffler. It is allowed to percolate into the ground. Steam stacking conditions are handled using a caustic injection system to abate H,S, and a rock muffler to control noise.

A number of mechanical problems were encountered with the major subsystems, including turbine control valves and turbine vibration, which necessitated a suspension of operations about 90 days after start-up. After turbine repair and a subsystem recheck, start-up operations were resumed in December 1981 and commercial operation began in March 1982. Since commercial operation, the plant has had an availability factor exceeding 95 percent. Electrical output has been steadily increasing 19.3 x 10⁶ kWh in 1983, 20.6 x 10⁶ kWh in 1984, and a projected 24.7 x 10⁶ kWh in 1985. Total production has averaged about 2.6 megawatts gross/2.4 megawatts net.

Several changes in the chemical composition of the fluids produced by HGP-A brine have occurred during the nearly 4 years of continuous discharge from the well. Total dissolved solids concentrations have increased from 3500 mg/Kg to nearly 20,000 mg/Kg. Total noncondensible gas concentrations have declined by about 10 percent. The chemistry of the brine phase indicates that seawater is infiltrating into the part of the geothermal reservoir penetrated by HGP-A, possibly induced by fluid withdrawal. Disparities between the brine and steam chemistry and their calculated geothermometers also suggest that two or more aquifers are supplying fluids to the well: one producing dry steam and the other a saturated brine-steam mixture.

The major maintenance problems encountered in the generator plant have resulted from deposition of silica from the geothermal brine phase. Initial silica deposition rates were relatively slow, but, as salinities of the fluids increased, deposition rates in valves and discharge lines also increased. Scale deposition in the steam supply system has been minimal and has consisted predominantly of iron sulfides and oxides. Exterior corrosion and maintenance of electrical equipment has also been aggravated by a combination of the very humid environment and the small amounts of H,S discharged at the plant site.
Lid to the concrete bunker built around well HGP-A.

Development After HGP-A

This article is reprinted from a report distributed at the 1985 Symposium on Geothermal Energy convened by the Geothermal Resources Council.

Private interest in geothermal exploration and development in Hawaii increased substantially after the successful completion of well HGP-A. Privately financed exploration drilling was undertaken on the northwestern flanks of Hualalai volcano on the western side of the Big Island in the early part of 1976 by the Puna Waawaa Steam Company. Prior to drilling, several geophysical surveys were conducted around the Puna Waawaa cinder cone by a mainland-based exploration group; several geophysical anomalies were observed in this area; and two exploratory wells were drilled. Neither well encountered significantly elevated temperatures to depths of more than 2000 m, and both were abandoned shortly after completion.

In 1980, GEDCO, now a subsidiary of Barnwell Industries, drilled the Ashida-1 well at a site about 3 km WSW of the HGP-A well. This well has been reported to be deeper than 2000 m.

GEDCO also drilled Lanipuna 1 about 750 m south of the HGP-A well in 1981, and Lanipuna 6, about 1 km SE of the HGP-A well in 1984. No results of these wells have been publicly released.

Puna Geothermal Venture (PGV), consisting of Thermal Power Company as operator, Dillingham Geothermal, Inc. and Amfac Energy, Inc. has drilled two exploratory wells adjacent to the HGP-A property, as stepout wells to the HGP-A discovery. In August 1985, a third well was being drilled on the same drill site as the first.

The PGV stepout wells, Kapoho State-1 (KS-1) and Kapoho State-2 (KS-2) were drilled in the rift near the trace of the 1955 fissure eruption. KS-1 was completed on November 12, 1981 to a total depth of 7,290 feet after 65 days of drilling. KS-2 was drilled immediately after KS-1, without any appreciable intervening flow tests. With only 56 days of drilling operations, KS-2 was completed at a total depth of 8,005 feet on April 2, 1982.

Puna Geothermal Research Center Dedicated

On August 24, 1985, the Puna Geothermal Research Center was dedicated. The laboratory is adjacent to well HGP-A and the 3.0 megawatt power plant facility in the Kilauea East Rift Zone, Island of Hawaii.

The $325,000 project was funded through the Hawaiian State Department of Planning and Economic Development. It will be managed by the Hawaii Natural Energy Institute of the University of Hawaii.

Research in the following areas will be emphasized:

- Well and reservoir analyses of the Kapoho geothermal reservoir;
- Silica inhibition, extraction, and use;
- Hydrogen sulfide removal and use;
- Use of geothermal heat and fluids for dehydration, food processing, cold storage, and icemaking;
- Monitoring and determining effects of geothermal liquids and gases on plants and animals;
- Producing liquid fuel from biomass through use of geothermal heat;
- Hydrogen production using geothermal heat; and
- Geothermal brine injection.
In addition to a basic research program with international participation, a Community Geothermal Technology Program will allow individual grants of up to $10,000 to individuals and firms to develop applications of geothermal energy.

Moss said that perhaps up to 50 megawatts of electricity could be generated from the area. "There's been very limited geological work done in this subzone," he explained.

"People in Hawaii are generally supportive of geothermal development. They just want to make sure it's done right," said Rod Moss, Vice President of Mid-Pacific Geothermal, Inc. Moss was referring to geothermal projects planned for the Islands of Maui and Hawaii. Both projects are at the permitting stages but face different situations.

On Maui, the proposed area for development is a lease of about 4,000 acres owned by Ulupalakua Ranch, Inc. on the southwest rift zone of Haleakala volcano. The project will be a joint venture of True Geothermal Energy Company and Mid-Pacific Geothermal, Inc. True will be project operator once all the project permits are acquired.

The companies are awaiting publication of geothermal regulations by the County of Maui. Then, they will apply for drilling permits.

The county regulations will be based on recently enacted State of Hawaii laws governing county geothermal permitting procedures. The laws (Act 296, SLA 1983 and Act 151, SLA 1984) require the State Board of Land and Natural Resources to designate land areas, called Geothermal Resource Subzones, in which geothermal development activities will be permitted.

The electricity generated by the project will be purchased by Maui Electric Company, Ltd., in 12 to 15 megawatt increments.

Mid-Pacific Geothermal, Inc. and True Geothermal Energy Company have signed a lease with the Estate of James Campbell for land on the flanks of Kilauea volcano on the Island of Hawaii, according to O. R. Stender, Chief Executive Officer of the Estate of James Campbell. The lease is on the Kuhmaus parcel, on 25,000 acres of the estate on the east rift zone of Kilauea volcano. The site is about 15 miles up the rift zone from the Hawaii Geothermal Project, site of well HGP-A and the 3.0 megawatt power plant.

The geothermal lease, signed by a representative of the estate in 1981, is for land included in a State Conservation Zone. Thus, a state conservation district use permit is needed before the property can be developed. "Many hearings were held on the issue and environmental concerns expressed," said Stender. The situation has not been resolved.

"The geothermal resource potential of Central America appears to be outstanding," said Bob Hanold, a Program Manager for Los Alamos National Laboratory. "Through the Central American Energy Resources Project, begun in March 1985, we are working to help develop geothermal resources in Honduras, Costa Rica, El Salvador, and Guatemala. Geothermal development in these countries," Hanold continued, "should have a very positive impact on them, helping to relieve them from the purchase of imported oil. Geothermal development, of course, already is underway in most of these countries of Central America."


Central American Energy Resources Project

by Susan P. Hodgson
countries," he added. "We tailor our assistance to match the needs of each nation, individually."

"In every country," said Hanold, "we are assisted by counterpart scientists. Whenever appropriate, we offer them training in recent geothermal technology as an additional facet of our project.

"Honduras has no geothermal projects underway. There, we will sponsor geologic, hydrogeochemical, and geophysical studies in areas of the country with surface geothermal features.

"We have sent high-temperature logging equipment and tools to Costa Rica. Right now, this September, the equipment is being used to log five wells at Miravalles Geothermal field in the northeastern area of the country (see Update: Miravalles Geothermal Field, this Hot Line issue). Reservoir pressure, temperature, and fluid flow are being measured; downhole brine samples are being collected; and inside diameters of wells calibrated.

"Some reconnaissance studies of promising geothermal areas in the country will be made, similar to the studies in Honduras. However, present lower funding levels for this work in Costa Rica means fewer of these studies will be undertaken.

"The first geothermal power plant in Central America was put into service at Ahuachapan Geothermal field in El Salvador in June 1975. Today, three power plant units are operating in the field. However, production from the geothermal wells there has declined. This may be due both to mechanical problems in the wells and to the fact that no fluid is being injected in the field. Staff on the Central American Energy Resources Project will address these problems.

"Once the high-temperature logging equipment and tools are no longer needed in Costa Rica, they will be brought to Ahuachapan. Then, a battery of tests similar to those run in Costa Rica will be made.

"The results from these and additional tests will be used in an effort to help develop an injection program for the field. Project and El Salvadoran scientists will look for ways to regain field reservoir pressure.

"In Guatemala, the project has a different focus. Here, economic feasibility studies will be made for possible direct heat applications of low-temperature geothermal fluids in geothermal areas throughout the country. Emphasis will be placed on a geothermal area called Amatitlan, near Guatemala City.

"Funds for the Central American Energy Resources Project," said Hanold, "are issued to Los Alamos National Laboratory by the United States Agency for International Development. Los Alamos is assisted in parts of the project by staff from the U.S. Geological Survey," he concluded.

For further information, contact Robert J. Hanold, Program Manager, Earth and Space Sciences Division, Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, New Mexico 87545. Phone (505) 667-1698.

Update: Miravalles Geothermal Field by Susan F. Hodgson

"The power plant for Miravalles Geothermal field, a 55 megawatt single-flash unit, is scheduled to be constructed and operating by the early 1990's," said Manuel Corrales, Chief of the Electric Planning Directorate of the Instituto Costarricense de Electricidad. "We are doing everything we can to ensure it will be an efficient plant," he added. "Geothermal energy is the best alternative Costa Rica has to oil-fired power plants."

Electricity generated at the power plant will be added to the Costa Rican electrical grid, to help meet the country's increasing demand for electricity. A second power plant is tentatively scheduled for 1994.

The Instituto Costarricense de Electricidad is looking for ways to finance its foreign currency expenses that occur from developing Miravalles field. Possible methods include a loan from the Interamerican Development Bank and/or a government-to-government loan.

In August 1985, well PGM 12 was completed at a total depth of 1560 meters.

Testing well PGM 1, drilled in 1978, the first geothermal well drilled in Costa Rica.
It is a successful production well, bringing to 8 the number of production wells completed in the field. Drilled (in Sept. 1985) as a step-out on the western edge of the field, it will be used for injection. In any event, injection will occur at the field's western edge, to keep the injected waters as far as possible from the production area.

Concurrent with the drilling activity at PGM 15, many well and reservoir engineering tests are being made in the field. The tests are undertaken to the south, well PGM 15 is being drilled as a successful step-out well. The tests are undertaken with geophysical and geochemical equipment brought to the field under the auspices of the Central American Energy Resources Project, managed by Los Alamos National Laboratory (see article, this Hot Line issue).

After the tests are run, preliminary power plant designs will be made.


Miravalles Geothermal field anomalies, redrawn from a map by the Instituto Costarricense de Electricidad. The field temperature anomaly seems to run northeast-southwest.
Developing Low-Temperature Geothermal Projects: Some Advice
An interview with Gene Culver, Geo-Heat Center, Oregon Institute of Technology.

by Susan P. Hodgson

What factors should be considered in planning a low-temperature geothermal project? How should a project consultant be chosen? I asked Gene Culver of the Oregon Institute of Technology. His reply follows.

Low-temperature geothermal resources can be used in space-and domestic hot water heating, agricultural, aquacultural, and industrial projects. Geothermal water quality, temperature, and quantity are unique for every project. Matching project needs to low-temperature resources is the primary step in project design.

How are geothermal projects and conventional projects similar? The principles of heat transfer, thermodynamics, and fluid dynamics are the same.

Geothermal projects differ from conventional projects in the ways the resource and project must be approached and how the project is constructed. Every site is different: different geologic conditions, well depth and size, water temperature, water pumping level, and water chemistry.

Water needs vary for all aquaculture, space-heating, and greenhouse projects, especially when the plants and animals come in contact with the water. Several multi-million dollar projects have failed due to failure to run complete water chemistry breakdowns at the parts per million and billion levels on geothermal water. Recently, one such project failed before it went on line.

The water analysis problem arises when water samples are taken to a laboratory geared to water potability analysis. After potability is determined, no further tests are made.

Water may be correctly judged potable and still be unfit for direct contact with heating equipment and some pipeline materials. Heat exchangers and other special arrangements are necessary.

To avoid this problem, a special chemical analysis of geothermal water must be requested from a laboratory. The pH should be measured at the site immediately after the fluid is produced. Constituents of special interest are chloride, sulfate, total alkalinity (mostly bicarbonate and carbonate), and total sulfide. The dissolved gases, ammonia, oxygen, and hydrogen sulfide require special sampling. Analysis should be accurate at the parts per billion level.

Boron, fluoride, and the heavy metal concentrations must be determined for surface disposal or because of plant and animal compatibility considerations.

Not only may these water constituents control whether or not a project is feasible, but they determine what type of system, including the disposal unit, must be constructed.

Geothermal energy isn’t free. Low-temperature projects can require high up-front costs for wells, pumps, and special equipment. Pumping costs are usually relatively low but can be significant in overall, life-of-the-project costs. For these reasons, it is important to use water efficiently. This requires considerations not important in conventional systems.

When hiring a consultant for a geothermal project, ask for references. Check past projects for satisfactory operation over a long period. Problems usually occur within 2 to 12 years.

When a consultant’s past projects have not been on line very long, ask how the most efficient use of resources and equipment was achieved. What was done about scaling and corrosion?

Low-and moderate-temperature geothermal resources have been used in this country well over 100 years. Are the consultant familiar with projects built in the past? The mistakes as well as the successes? A good consultant will have a thorough knowledge of such matters.

The Geo-Heat Center at the Oregon Institute of Technology offers advice on the construction of low-temperature geothermal projects. Such advice may be free-of-charge for applicants who apply through various state or federal programs. For further information, contact Gene Culver, Geo-Heat Center, Oregon Institute of Technology, Klamath Falls, Oregon 97601, (503) 882-6321.
PHOTOS FROM OREGON INSTITUTE OF TECHNOLOGY GEOTHERMAL PROJECTS

Shell and tube heat exchanger, in service for one year, showing scaling. Total dissolved solids, 1,200 ppm.

The geothermal-water side plates of a plate heat exchanger after two year's service. The exchanger was installed to replace the shell and tube exchanger shown in the first two photos.

FRP (fiberglass reinforced plastic) insulated geothermal water distribution pipes, before installation in the Oregon Institute of Technology (OIT) system.

OIT and Merle West Hospital and nursing home.

The same exchanger after cleaning.

Drilling a shallow, geothermal well in an urban setting. Klamath Falls, Oregon.

Sloting the casing for a downhole heat exchanger well at a private residence, Klamath Falls, Oregon.

Kingswood Apartments and Lucille O'Neil School are both heated with geothermal energy. Kingswood uses 114°F water for space heating. Klamath Falls, Oregon.

Trout being harvested from geothermal ponds. The ponds are fed with water that has passed through the OIT campus heating system.

A male Macrobrachium Rosenbergii (Fresh water prawn) grown in geothermal ponds at OIT.
### Technology

**Bargain Days: Geothermal Equipment Available**

The Tennessee Valley Authority (TVA) is selling $1.4 billion of new equipment purchased for the construction of eight nuclear reactors. Because the nuclear projects were cancelled, the equipment is now for sale at discounts up to 80 percent. All the equipment was constructed and is being maintained to standards used for nuclear plants.

Ron Ogle, manager of the equipment sales, says he's sure that items such as heat exchangers, pumps and valves, and electrical equipment are suitable for use in geothermal projects. In addition, Ogle says that he has five, 7 megawatt steam turbines.

Ogle says geothermal developers should give him a call. One of his engineers will work with a developer's project engineer, finding ways to design the TVA equipment into a geothermal project. He says that besides the low price, an advantage of TVA equipment to a developer would be that no lead time is necessary for an order—all the equipment is in stock.

Ron Ogle may be contacted at TVA Investment Recovery Project, 400 W. Summit Hill Drive, Knoxville, TN 37902; phone (615) 632-7750 / Telex: En Des K55-437 / Teletype: 615-632-4280.

**ITEMS AVAILABLE FROM THE TVA**

- **Bowl Generators**
- **Bowl Steam, and Flygpy**
- **Door Generator**
- **Rear-Wedge**
- **Turbine**
- **Rear-Wedge**
- **Turbine**
- **Rear-Wedge**
- **Turbine**
- **Rear-Wedge**
- **Turbine**
- **Rear-Wedge**
- **Turbine**

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Haywood Industries wooden dog and sash plant is heated with 115°F geothermal water. The plant uses almost 100 percent make-up air, due to sawdust collection. Winter temperatures of -10°F are not uncommon.

The control console for the district heating system in downtown Klamath Falls, Oregon.

Snow melting in an underpass in Klamath Falls, Oregon, using a geothermal wall.

The plate heat exchangers and pumps for the district heating system in downtown Klamath Falls, Oregon.

A milk pasteurizer that uses geothermal heat, Klamath Falls, Oregon.
Lost Circulation Studied at Sandia

Recycled plastic scrap may be an ideal material to prevent the loss of drilling fluids during geothermal drilling operations. Two other possibilities are ground automobile battery cases obtained from salvage yards and volcanic glass. All are abundant, inexpensive, and capable of surviving the harsh environments encountered in geothermal drilling operations.

Scientists at Sandia National Laboratories are experimenting with these materials. The results of these experiments, combined with information gathered by a special high-temperature geothermal well-logging tool (also developed at Sandia), are expected to make it possible to choose these lost circulation materials with confidence before geothermal drilling operations begin.

"Being able to do this would be an economic plus," said Dr. James Kelsey, supervisor of Sandia's Geothermal Technology Development Division. "Presently, choosing an effective lost circulation material can be hit-and-miss because there have been no major advancements in lost circulation material science for many years."

Sandia's Lost Circulation Test Facility was built at the suggestion of an industry technology review panel to support Sandia's geothermal research and development programs. At the facility, the performance of lost circulation materials is evaluated under a controlled environment that simulates downhole geothermal conditions.

The facility includes two test vessels that operate at temperatures up to 400°F and 1,000 psi. One vessel, 10 feet tall and 8 inches in diameter, simulates a length of well bore and provides a realistic annular flow of mud at rates up to 200 feet per minute. The other, 3 feet tall and 20 inches in diameter, can hold actual rock or soil that is formed into a simulated lost circulation zone.

During testing, mud and lost circulation material flow past slots that simulate different fracture widths or into actual rock or soil. The amount of material and particle size (sand to 1 inch diameter) mixed with the mud vary with each test. A computer controls pressures, temperatures, flow rates, and records data.

To date, six commercially available lost circulation materials have been tested in the facility. At this time, only one appears to be suitable for geothermal applications — ground battery casings.

"Next year we will begin testing other materials, for instance, high-temperature elastastics that have been salvaged after their original use," said Glen Loepke of Sandia's Geothermal Technology Development Division. "There are several criteria that a material must satisfy. Besides being able to survive high temperatures, it must be plentiful and inexpensive."

The test results will provide a data base that can be used with borehole logs to develop computer codes for predicting the best material for a given case.

These logs are made with a tool developed at Sandia. Called an acoustic borehole televiewer, it is based on a Mobil Research & Development Corporation design used originally to log oil and gas wells. Sandia adapted the tool to materials and electronics that survive harsh geothermal environments.

As the televiewer is pulled up the borehole, it emits bursts of acoustic energy from a rotating transducer. The energy travels through an acoustic window, hits the borehole wall, and is reflected back to the transducer.

The time required for pulses to return to the transducer and the amplitude of these reflections are recorded and processed with surface equipment to yield a black-and-white picture of the wall. Light areas represent smooth surfaces; dark zones represent rough surfaces or fractures.

Rigid Foam Appears To Be Good Lost Circulation Material

A rigid polyurethane foam, developed at Sandia National Laboratories as a temperature-tolerant packaging for electronics, may prove to be a very good material for preventing the leakage of drilling mud into surrounding rock formations.

The foam remains rigid even when heated to about 450°F. It was developed about 20 years ago for nuclear weapons use.

In the late 1970's, Sandia researchers who were working on techniques to improve the efficiency of geothermal drilling and well completions began to look at the foam in another light. Their idea was to have it plug fractures and voids in geothermal formations. "The most efficient way of accomplishing this appeared to be with a tool that could be lowered down the borehole," said Glen Loepke of Sandia's Geothermal Technology Development Division. "Separating components in the tool could contain chemicals that, when mixed, generate foam that expands through openings in the tool's tip and into the cracks and voids."

Sandia completed a successful demonstration of a prototype tool last year. A new, slightly larger version will begin a long-term field test later this year. The test will be conducted by Poly Plug, Inc., Bedias, Tex.; NL Industries, Houston; and Union Geothermal, Los Angeles.

The aluminum alloy foam emplacement tool is 30 feet long and 8 inches in diameter. It attaches to the end of a drill string with standard threaded couplings. Once lowered into a lost circulation zone, chemicals in the tool's separate storage chambers are forced by mud pump pressure into a mixing chamber where they react to form foam that expands at a 7 to 1 ratio as it squirts out of holes at the bottom of the tool. Work is underway on development of a foam that will be able to form in deep boreholes where temperatures are between 600°F and 650°F.
Federal Programs

New DOE Core Repository

Grand Junction, Colorado, will be the site of a repository for cores, samples, and other materials obtained from the continental scientific drilling program. The repository will be established by the U.S. Department of Energy, and operated by the DOE, U.S. Geological Survey, and the National Science Foundation.

Samples and routine logging data gathered at drill sites will be protected and kept available for study.

Investigators who wish to obtain samples for study should apply to these persons: For Inyo Domes - J.C. Bichelberger, Geochemistry Division, Orr 1454, Sandia National Laboratories, Albuquerque, N.M.; phone (505) 846-0398; for Valles Caldera - J.S. Coff, MS 4642, Earth and Space Sciences Division, Los Alamos National Laboratory, Box 1663, Los Alamos, N.M. 87545, phone (505) 667-7200; for Salton Sea Scientific Drilling Project - W. Elders, Institute of Geophysics and Planetary Physics, University of California, Riverside 92521, phone (714) 787-4349.

PERSONNEL IN FEDERAL GEOTHERMAL RESEARCH AND DEVELOPMENT PROGRAMS

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Mr. James H. Dem - Estimation Geothermal Resources Station 592 Sandia National Laboratories Albuquerque, New Mexico 87123 (505) 486-4974

Dr. Wilford N. Adkins - Salton Sea Scientific Drilling Project Field Office of Science SDP - University of California Riverside, California 92521

Dr. Robert L. Hicken - Domeville Pumps P.O. Box 1981 Los Alamos National Laboratory Los Alamos, New Mexico 87545 (505) 482-2511

Mr. Donald B. Ramsey - Steam Injection, Boise Idaho Department of Geology and Geophysics University of Idaho, Boise, Idaho 83725

Dr. John T. Menton - Steam Pumps P.O. Box 1813 Boise, Idaho 83702 Los Alamos National Laboratory Los Alamos, New Mexico 87545 (505) 482-3441

UNESCO Geothermal Research Program

In FY 1985, the United States Geological Survey conducted a wide variety of studies conducted in the Cascade Range of Northern California, Oregon, and Washington. The goal of the effort is to understand the active volcanic, tectonic, and hydrothermal processes of the Cascades as a framework for characterizing and quantifying the region’s geothermal resources.

The current trends for the Geothermal Research Program are increasing emphasis on understanding the interaction...
of magmatic heat sources and geothermal systems and assessing thermal energy in all types of geothermal energy sources associated with young igneous centers—magma, hot dry rock, and related hydrothermal systems. For example, the Queta calderas in northern New Mexico is being investigated to characterize magmatic/hydrothermal processes in the roots of an older, well-exposed igneous system. Advanced seismic techniques are being refined to identify and characterize subsurface magma bodies. Geophysical studies on the Big Island of Hawaii are delineating subsurface magmatic conduits of two active volcanoes, Kilauea and Mauna Loa; and geologic mapping is being compiled into a new geologic map of the entire island. Geologic mapping of young silicic volcanic centers is underway in Alaska.

An important component of the FY 1985 program continues to be research to understand the dynamics and evolution of hydrothermal systems. Inorganic and chemical studies are carried out, particularly at the Cerro Prieto field in Mexico, Larderello in Italy, The Geysers in California, and Yellowstone National Park to refine geothermometers, describe hydrothermal processes, and determine the origin of chemical constituents in geothermal fluids. Geoelectrical techniques are being developed and applied to determine the location and geometry of hydrothermal convection systems. Mineralogical studies are underway to characterize chemical interactions of geothermal fluids and the rocks through which they circulate, as exemplified by a study of hydrothermal alteration in core from a hole drilled in 1981 by the Geothermal Research Program at Newberry Volcano, Oregon.

The Geothermal Research Program also supports projects that evaluate selected geo-environmental concerns. Earthquake monitoring and analysis continue at The Geysers Geothermal field. Also, how thermal features in National Parks might be affected by nearby geothermal development is studied by numerical, seismic, and geochemical modeling techniques.

BLM

Bureau of Land Management Mineral Resources Policy

The following principles will guide the Bureau of Land Management (BLM) in managing mineral resources on public lands. They are part of the BLM Mineral Resource Policy signed by BLM Director Robert Burford on May 29, 1984.

1. Except for Congressional withdrawals, public lands shall remain open and available for mineral exploration and development unless withdrawal or other administrative action is clearly justified in the national interest.

2. BLM actively encourages and facilitates the development by private industry of public land mineral resources in a manner that satisfies national and local needs and provides for economically and environmentally sound exploration, extraction, and reclamation practices.

3. BLM will process mineral patent applications, permits, operating plans, mineral exchanges, leases, and other use authorizations for public lands in a timely and efficient manner.

4. BLM’s land use plans and multiple-use management decisions will recognize that mineral exploration and development can occur concurrently or sequentially with other resource uses given. The Bureau further recognizes that land use planning is a dynamic process and decisions will be updated as new data are evaluated.

5. Land use plans will reflect geological, energy and mineral values on public lands through more effective geology and energy and mineral resource data assessment.

6. BLM will monitor salable and leaseable mineral operations to ensure proper resource recovery and evaluation, production verification, diligence and inspection and enforcement of the lease, sale or permit terms. BLM will ensure receipt of fair market value for mineral commodities unless otherwise provided for by statute.

7. The Bureau will maintain effective professional, technical, and managerial personnel knowledgeable in mineral exploration and development.

Proposal to Streamline BLM Bonding Requirements

To reduce public confusion and cut financial losses by the federal government, the 12 types of bonds currently required for oil, gas and geothermal activities on federal lands would be consolidated into only four and increased in dollar amount, under a proposal announced in May 1985 by the Department of the Interior’s Bureau of Land Management (BLM).

BLM Director Robert P. Burford said the bonding requirements have been adjusted only once since 1929, and do not reflect current reclamation costs or royalty liabilities.

Legislation

State Legislative Update

The following bills comprise the geothermal legislation considered by the California State Legislature for the 1985/86 session. The status of the bills is that of October 2, 1985.

Chaptered Legislation

AB 899, Hauser
Leases: reduced royalty

The bill authorizes the State Lands Commission to issue leases for direct
heat application of geothermal resources for non-electrical purposes for a royalty of less than 10 percent of gross revenue if it determines that such a royalty would be in the best interest of the state. (Chapter No. 434)

AB 1666, Hausar
Geothermal power plant development

The bill requires the State Energy Resources Conservation and Development Commission to include, in its written decision approving a geothermal site and related facility, findings on whether there are sufficient commercial quantities of geothermal resources to operate the proposed facility for its planned life. (Chapter No. 807)

AB 1960, Waters, N.
Geothermal revenues

The bill would authorize the revenues disbursed to counties of origin to also be expended for repair and maintenance of capital assets, as specified. (Chapter No. 800)

SB 593, Royce
Penalty established

The bill provides the Division of Oil and Gas the authority to establish by regulation the amount of penalty a geothermal well operator must pay for failure to pay annual well fees on specified geothermal wells. (Chapter No. 391)

SJR 13, Presley
Federal mineral leasing: revenue sharing

The measure urges the President and the Congress, the Secretary of the Interior, the Director of the United States Minerals Management Service, and the Director of the Office of Management and Budget to revise the Federal Government's mineral leasing royalty management system to ensure that states receive their full entitlement of revenue sharing funds and to refrain from implementing budgetary initiatives that would reduce those funds. (Chaptered by Sec. of State Resolution Ch. 81)

Federal Legislation

The status and content of federal legislation on geothermal energy from the 99th Congress follow. The information was current as of September 13, 1985.

H.R. 418
Quillen

Referred to:
House Energy and Commerce
House Interior and Insular Affairs

Short Title as Introduced:
Geothermal Energy Control Act of 1985

Latest Official Title:
Geothermal Energy Control Act of 1985

Federal Legislation

The status and content of federal legislation on geothermal energy from the 99th Congress follow. The information was current as of September 13, 1985.

H.R. 418
Quillen

Referred to:
House Energy and Commerce
House Interior and Insular Affairs

Short Title as Introduced:
Geothermal Energy Control Act of 1985

Latest Official Title:
Geothermal Energy Control Act of 1985

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 a person owned or controlled by a U.S. citizen.

Restricts the sale of geothermal resources which 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. 843
Sponsor: Selden

Referred to:
House Ways and Means

Latest Official Title:
Official Title as Introduced as of 01/31/85:
A bill to amend the Internal Revenue Code of 1954 to clarify the definition of geothermal energy, and for other purposes.

Legislative Actions:
01/30/85 - Referred to House Committee on Ways and Means.

Abstract:
Amends the Internal Revenue Code to revise the definition of geothermal energy for purposes of the residential energy income tax credit and the investment tax credit for energy property.

Digest:
Amends the Internal Revenue Code to define "geothermal energy" as the natural heat of the earth at any temperature. (Present regulations require that such heat exceed a specified temperature.)

Provides that an energy system that uses geothermal energy and a source of energy that does not qualify for investment and residential energy credits, shall qualify for the tax credits for energy property, if the geothermal energy provides more than 80 percent of the energy for the system.

Provides that an energy system that uses both geothermal energy and
another energy source (such as biomass solar, wind, ocean thermal, or hydroelectric) qualifies for the investment tax credit for energy property, if the combination of such energy sources provides more than 80 percent of the energy for such system.

Provides that in the case of a taxpayer who claimed a geothermal credit on a return for any taxable year beginning before January 1, 1985, in reliance on the advice of an employee of the Internal Revenue Service that such credit would be allowable. The amendments made by this Act shall apply for purposes of determining whether such credit is allowable.

H.R. 1315

Sponsor: Latte

Referred to: House Ways and Means

Latest Official Title: Official Title as Introduced as of 02/28/85

A bill to amend the Internal Revenue Code of 1954 to clarify the definition of geothermal energy, and for other purposes.

Legislative Actions: 02/27/85 - Referred to House Committee on Ways and Means.

Abstract:

Amends the Internal Revenue Code to revise the definition of geothermal energy for purposes of the residential energy income tax credit and the investment tax credit for energy property.

Digest:

Amends the Internal Revenue Code to define “geothermal energy” as the natural heat of the earth at any temperature. (Present regulations require that such heat exceed a specified temperature.)

Provides that an energy system that uses geothermal energy and a source of energy that does not qualify for investment and residential energy tax credits shall qualify for the tax credits for energy property if geothermal energy provides more than 80 percent of the energy for such system.

Provides that energy systems that use both geothermal energy and another energy source (such as biomass, solar, wind, ocean thermal, or hydroelectric) qualify for the investment tax credit for energy property if the combination of such energy sources provides more than 80 percent of the energy for such system.

Impacts of existing geothermal development.

With respect to such projects, the CEC encourages joint proposals by public and private entities and proposals for projects that will provide a direct economic stimulus to a community.

Beginning this funding cycle, the CEC will require repayment of all funds awarded for resources development projects that produce revenue or energy savings. These loans will carry an interest rate of up to 8 percent, a maximum term of 6 years, and will not exceed 80 percent of the project cost. A feasibility study for these projects must be submitted with the final application.

The schedule for the sixth funding cycle is as follows:

Projects Receiving CEC Grants

The following California Energy Commission grant proposals have been approved by the Legislature for inclusion in the 1985-86 state budget. The grants became effective on July 1, 1985.

Heber Public Utility District, Imperial County ($44,605)

Complete engineering plans to extend water and sewer collection systems necessary to accommodate geothermal development in Heber.

City of Clearlake, Lake County ($81,520)

Conduct a temperature-gradient survey of local geothermal resources including five temperature gradient wells as part of a planned economic development program.

Lake County Planning Department ($100,000)

Prepare the geothermal resource and transmission element for inclusion in the Lake County General Plan.

Middletown Unified School District, Lake County ($73,653)

Purchase a bus to mitigate the impacts on school transportation services due to continuing development activities in the Geysers geothermal area.
Lake County Air Pollution Control District ($36,000)

Develop a more effective air quality impact assessment model for the Geysers geothermal area.

Pit Resources Conservation District, Lassen County ($91,300)

Continue the Energy Management Department to coordinate geothermal development in Mendocino County.

Mendocino County Air Pollution Control District ($32,376)

Conduct an air-quality baseline study and particulate-dispersion model for southeastern Mendocino County.

Surprise Valley Hospital District, Modoc County ($135,106)

Construct a geothermal space-heating and hot-water heating system for the hospital and medical clinic in Cedarville.

Mono County ($51,031)

Continue the Energy Management Department to coordinate geothermal development in Mono County.

Plumas Unified School District, Plumas County ($229,240)

Construct a geothermal space-heating system for the elementary and high schools in Greenville. Complete a feasibility study for a district-heating system in Greenville.

Indian Valley Hospital District, Plumas County ($19,000)

Complete modifications to the hospital’s geothermal space-and water-heating system.

Sierra County ($431,000)

Drill a production and injection well on a 40-acre site in Sierra Valley for a horticultural commercial park as part of a county-sponsored economic development program.

Northern Sonoma County Air Pollution Control District ($6,200)

Purchase and test a microprocessor-based controller to upgrade the air emission particulate sampling system capability.

Sonoma County ($54,910)

Complete study to analyze the extent of chemical trace elements and parasites found in selected wildlife in the Geysers geothermal area.

Sonoma County ($23,987)

Construct a sediment control basin as part of the Healdsburg-Geysers Road project to protect fish spawning habitats in Little Sulphur Creek.

Sonoma County ($100,000)

Prepare the Geothermal Resources Management Plan for inclusion in the Sonoma County General Plan.

Assessing Geothermal Properties: An Interview with Harold Bertholf

by Susan F. Hodgson

“People think that what we do is to place a value on geothermal reserves. That’s only a part. Our job is to determine the market values and tax-able values of commercial geothermal properties,” said Harold Bertholf, President of Harold W. Bertholf, Inc.

“Geothermal properties are subjected to the local property tax, local and state severance taxes, and income taxes at the state and federal levels,” he continued. “Of those taxing vehicles, the largest tax burden in terms of dollars—other than income tax—usually is the local property tax, which is a function of the concept of market value. Our job is to do evaluations to estimate the market value. The vast majority of our company’s geothermal work is in high-temperature geothermal resources, those used to generate electricity,” Bertholf stated.

Finding the market value includes evaluating the reservoir. This means looking at the extent of a reservoir, the amount of steam or hot water in it, and at the rate at which these resources can be produced. This, along with future product prices and production costs, determines the size, shape, and duration of a property’s future income stream. In addition, determining the market value also includes estimating the value for all site development items, such as wells, power plants, and electrical transmission lines. Factors such as contracts to sell the hot water, steam, and electricity and the economics of alternate fuel prices, including the world price of oil, are also important in the appraisal (see Table A).

Table A. Hypothetical Steam Property Cash Flow Analysis

<table>
<thead>
<tr>
<th>Year</th>
<th>Btu/yr</th>
<th>Steam</th>
<th>Power</th>
<th>Net Present Value</th>
<th>Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100,000</td>
<td>50.00</td>
<td>50.00</td>
<td>1,000,000</td>
<td>750,000</td>
</tr>
<tr>
<td>2</td>
<td>100,000</td>
<td>50.00</td>
<td>50.00</td>
<td>1,000,000</td>
<td>750,000</td>
</tr>
<tr>
<td>3</td>
<td>100,000</td>
<td>50.00</td>
<td>50.00</td>
<td>1,000,000</td>
<td>750,000</td>
</tr>
<tr>
<td>4</td>
<td>100,000</td>
<td>50.00</td>
<td>50.00</td>
<td>1,000,000</td>
<td>750,000</td>
</tr>
<tr>
<td>5</td>
<td>100,000</td>
<td>50.00</td>
<td>50.00</td>
<td>1,000,000</td>
<td>750,000</td>
</tr>
</tbody>
</table>

The market value of a property is the price the assessor concludes would be agreed upon by a willing buyer and seller, each trying to maximize their gains, and both having full knowledge of all the uses to which the property may be put. Whether or not the assessor personally believes the market value price to be high or low is not important. By state law, the assessor must follow and reflect current market conditions.

Geothermal properties are assessed each year. Like all other California property, the geothermal industry is protected by Proposition 13, the Jarvis-Gann Initiative.

During the construction phase of geothermal property, when wells are being drilled and other improvements installed (normally 6 to 8 years), the yearly assessments are a function of the market value of the property. However, in the year operation goes into commercial production, a base-
What do geothermal projects cost? In 1985 dollars, excluding steam costs, revenue at the Geysers Geothermal power plant with a lifetime of 30 years is estimated at $4.4 billion. With steam costs included, the estimate rises to $7.9 billion.

The cost of a 20-megawatt geothermal power plant, with a lifetime of 30 years and $6 million in state funds, is $1.4 billion. With hot water costs included, the estimate rises to $1.9 billion.

Although all of the above properties were developed at a different time, the benefit of Proposition 13 was added to the market value of each property. Property A had already been assessed to the "lower" valuation. However, Table B-3 shows that the value of the property would fall below the Proposition 13 base-year value, and annual tax liability would increase.

Table B-3: Effects of Proposition 13 on three similar properties.

<table>
<thead>
<tr>
<th>Property</th>
<th>Tax Liability Before Proposition 13</th>
<th>Tax Liability After Proposition 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$100,000</td>
<td>$150,000</td>
</tr>
<tr>
<td>B</td>
<td>$150,000</td>
<td>$200,000</td>
</tr>
<tr>
<td>C</td>
<td>$200,000</td>
<td>$250,000</td>
</tr>
</tbody>
</table>

The California Board of Equalization has raised the minimum market value for various properties to $3.5 billion. Unfortunately, the full benefit of Proposition 13 was not realized.

The value of the property would fall below the Proposition 13 base-year value, and annual tax liability would increase by 2% of the property's market value.

Even before tax time, requiring the payment of the tax on the property's market value led to a saving of more than $150,000.

In summary, the amount of taxes paid for similar properties before the passage of Proposition 13 was much higher than after the passage of Proposition 13.
US AGENCIES PROVIDING ASSISTANCE TO FOREIGN BUSINESS OPPORTUNITIES

US AGENCY FOR INTERNATIONAL DEVELOPMENT

- The mission of USAID is to conduct assistance programs directed toward satisfying basic needs and improving economic growth in developing countries.
- Over the past five-year period, AID has spent approximately $1 billion on renewable energy activities.

Contact:
Dr. Alan Jacobs
Director, Office of Energy
Bureau for Science and Technology
Room 508 SA-18
Agency for International Development
Washington, D.C. 20523
(703) 235-8902

DEPARTMENT OF COMMERCE

- The mandate of the Department of Commerce (DOC) is to promote and develop the foreign and domestic commerce of the United States. Within DOC, programs involving international trade and export are primarily the responsibility of the International Trade Administration (IT). ITA determines policy, directs programs, and coordinates all issues concerning trade administration, trade development, and trade/investment policy.
- Since 1981, the Trade Development Program within ITA has maintained a full-time renewable energy industrial specialist who has conducted trade promotion activities both within the United States and abroad.

Contact:
Les Garden
Renewable Energy Specialist
Office of International Major Projects
International Trade Administration
Room 2811
U.S. Department of Commerce
Washington, D.C. 20230
(202) 377-0556

EXPORT IMPORT BANK

- The mission of the Export-Import Bank (EXIMBANK) of the United States is to aid in the financing and facilitation of U.S. exports.
- In 1982 and 1983 EXIMBANK provided financial assistance amounting to $648 million for renewable energy projects.

Contact:
James Crist
Vice President, Exporter Credits and Guarantees
811 Vermont Ave., N.W.
Export-Import Bank
Washington, D.C. 20571
(202) 566-8819

OFFICE OF THE UNITED STATES TRADE REPRESENTATIVE

- The mission of the U.S. Trade Representative (USTR) is to serve as the President's chief advisor on foreign trade policy. It has primary responsibility for developing international trade policy and coordinating its implementation.
- USTR is available to assist U.S. renewable energy companies in mitigating trade barriers established by foreign countries relating to the importation of U.S. equipment and technology.

Contact:
Director, Private Sector Liaison Division
600 17th Street, N.W.
Office of the U.S. Trade Representative
Washington, D.C. 20506
(202) 395-6120

OVERSEAS PRIVATE INVESTMENT CORPORATION

- Mission of OPIC is to serve as the key federal agency for promoting mutually beneficial American business investment in the developing world.
- In 1983, OPIC supported the provision of insurance to Union Geothermal of Indonesia, Ltd., for geothermal exploration and development in Indonesia.

Contact:
R. Douglas Greco
Manager, Natural Resources
1129 20th St., N.W.
Overseas Private Investment Corporation
Washington, D.C. 20527
(202) 653-2956

SMALL BUSINESS ADMINISTRATION

- The mission of SBA is to assist and counsel small businesses.
- Special business loan program for the startup, continuation, or expansion of small business that is developing, manufacturing, selling, installing, or servicing specific energy conservation or solar energy equipment.

Contact:
Office of Public Information
Central Office
U.S. Small Business Administration
1441 L Street, N.W., Room 100
Washington, D.C. 20416
(202) 653-6365
MULTILATERAL LENDING INSTITUTIONS

AFRICAN DEVELOPMENT BANK (AFDB)
- The African Development Bank promotes the economic and social progress of regional member countries - individually and jointly.
- In 1984, AFDB provided $2.2 million for the financing of a geothermal project in Djibouti.
- Contact:
  African Development Bank Group
  B.P. No 1387
  Abidjan, Ivory Coast

ASIAN DEVELOPMENT BANK (ADB)
- The Asian Development Bank is dedicated to the task of assisting the economic development of its developing member countries (DMC's) and of fostering economic growth and cooperation in the region of Asia and the Far East, including the South Pacific.
- As of the end of 1983, ADB lending for energy amounted to $3.4 billion for 133 loans in 19 DMC's, representing 25.3% of the total assistance to all DMC's. During the same period, the ADB provided technical assistance grants for the energy sector amounting to $19.6 million.
- Contact:
  Office of the U.S. Director
  Asian Development Bank
  P.O. Box 789
  Manila 2800
  Republic of the Philippines

CARIBBEAN DEVELOPMENT BANK (CDB)
- Caribbean Development Bank is a regional financial institution established for the purpose of "contributing to the harmonious economic growth and development of the member countries in the Caribbean and promoting economic cooperation and integration among them, having special and urgent regard to the needs of the less developed countries (LDC's) of the Region."
- CDB finances the Caribbean Alternative Technology and Energy Program.
- Contact:
  The Bank Secretary
  Caribbean Development Bank
  P.O. Box 408
  Wilday
  St. Michael
  Barbados
  (809) 426-1152
  Telex: WB 2287

INTER-AMERICAN DEVELOPMENT BANK (IDB)
- Inter-American Development Bank is an international financial institution created to help accelerate the economic and social development of its member countries.
- From 1961-1984, 27% of the Bank's lending has gone to energy projects.
- IDB has provided financing for geothermal projects in Panama, Guatemala, and Costa Rica.
- Contact:
  Office of the U.S. Executive Director
  Inter-American Development Bank
  Room 1032
  808 17th Street, NW
  Washington, D.C. 20577
  (202) 834-8044

UNITED NATIONS (UN)
- The United Nations is an international organization formed to promote peace, security, and cooperation.
  - United Nations Development Programme's (UNDP) central energy activity is the UNDP/World Bank Energy Sector Assessment Program (ESSAP) and the accompanying Energy Sector Management Assistance Program (ESMAP). Both programs are directed toward energy sector planning and include new and renewable energy resource options in developing country energy planning.
- United Nations Department of Technical Cooperation carries out fieldwork in natural resources and energy and in economic and social infrastructure development.
- Contact:
  Derek Lovejoy
  Technical Advisor, Renewable Energy
  Division of Natural Resources and Energy
  U.N. Department of Technical Cooperation for Development
  United Nations
  New York, New York 10017
  (212) 754-8597

WORLD BANK GROUP
- International Bank for Reconstruction and Development (IBRD)
  - Mission is to promote the economic development of member countries primarily by extending loans on concessional terms for specific high-priority projects.
- International Development Association (IDA)
  - Mission is to promote the economic development of less-developed member countries by making credits on concessionary terms, thereby reducing the burden on the recipient countries' balance-of-payment positions.
Negotiated Geothermal Lease

International Finance Corporation (IFC)
- Encourages growth of productive private enterprise in developing countries by extending loans and non-controlling equity capital, providing underwriting and stand-by commitments, and attracting and acting as catalyst for outside financing.
- For renewable energy technology projects financed by the World Bank, emphasis has been placed on large hydro-electric, geothermal power grid extension projects, or biomass resource development (reforestation).
- The World Bank has financed $34.5 million of the geothermal project in Kenya, and has given it a $240 million line of credit over the next 50 years.
- The World Bank also is the executive agency for the Joint UNDP/World Bank Energy Assessment Program (BSAP) and the accompanying Energy Sector Management Assistance Program (ESMAP).

Contacts:
Richard Dostik
World Bank
Energy Department
1818 H Street, N.W.
Washington, D.C. 20433
(202) 477-6894

Leases

BLM Lease Sale Information
On September 24, 1985, the Bureau of Land Management (BLM) had no tentative or scheduled geothermal lease sale dates for land in KGRA's.

As of October 1, 1985, a centralized source will no longer exist where geothermal lease sale schedules can be obtained for land in KGRA's. To collect such information, contact the Adjudication Department of each state BLM office.

Negotiated Geothermal Lease Issued
by Don Hoagland
State Lands Commission

In May 1985, the California State Lands Commission (SLC) issued a negotiated geothermal lease to Union Oil Company. The lease was for about 3,681 acres in the Truckhaven area on the west side of the Salton Sea, Imperial County. It is the first negotiated geothermal lease to be issued by the state.

Terms of the lease provide for a 5 year primary term and a 5 year drilling term; royalties of 12.5 percent of gross revenue from the sale of steam and 30 percent of gross revenue from the sale of minerals or chemical compounds recovered from the brines; an annual rent of $25 per acre; and a minimum royalty of $2 per acre.

Union, Phillips Petroleum, and Southern Pacific Land Company had formed a federal geothermal unit in the Truckhaven area, and had placed all of the federal and private lands within the unit under lease. They wished to lease the state lands, as well, if a longer length of time were available before drilling must begin. The company were willing to pay a larger rental fee in exchange for this longer exploration time.

Because only the state lands within the unit were not under lease, the SLC agreed to the conditions and offered the companies the negotiated lease. The SLC was able to do so under a law passed in 1983 allowing negotiated leases in specified circumstances.

Seminars and Conferences

A Talk With Dave Anderson
by Susan F. Hodgson

"I feel the international geothermal community has accepted the Geothermal Resources Council as a focal point for professional interaction—as a source of geological information and a way to connect with people and organizations involved in geothermal energy," said Dave Anderson, Executive Director of the Geothermal Resources Council.

"We had 630 registered attendees at the 1985 International Symposium on Geothermal Energy in Hawaii this August. About 200 were from countries other than the United States. It was an exciting chance for everybody to meet and discuss projects throughout the world. A more intensive interaction of the geothermal community will result from the discussions," Dave added.

"The August symposium was our ninth," he said. "People have told me some of the highlights were the poster sessions, the overall international nature of the conference, and the high quality of the technical papers.

"In addition, the three GRC publications have been well received. These would be the two volumes of transactions (available for $80.00 from the GRC) and the International Symposium tour of the geothermal power plant on the Island of Hawaiian.

Volume (presently free of charge). The International Volume soon will go into its second printing, and a price will be set once the book is reprinted.

"If you would like information on the GRC, write me at P. O. Box 1350, Davis, CA 95617-1350," Dave said.

Stanford Seminar Schedule

The Stanford Geothermal Program (SGP) seminar schedule for Autumn Quarter 1985 is as follows. The seminars are held on the Stanford University campus, Room 124, Noble Building, on Thursday afternoons from 1:15 to 2:30 p.m. There is no charge.

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October 3, "Tracer Dispersion Experiments," Roland N. Horne, SEP.

October 10, "Linear Boundary Detection in a Single Interference Test," Jonathan Leaver and Avram Sageev, SEP.

October 17, "Application of the 1-D Linear Heat Sweep Model," Paul Kruger, SEP.

October 24, "Reservoir Testing," Henry J. Ranney, Jr., SEP.


November 14, "Geological and Mineralogical Evaluation of Surface Geothermal Manifestations," Y. Yamaguchi and Ronald Lyon, AES.


The purpose of the symposium is to exchange experiences in using computers in the search for energy resources. Among the topics covered will be the evaluation of sedimentary basins, remote sensing, geochemistry, geohydrology, and marine geology.

There will be simultaneous translations of the proceedings in English and Spanish.

The cost, until September 30, 1985, is $212.50 for Peruvians and $255.00 for others; after this date, the cost will be $250.00 for Peruvians and $300.00 for others.

The symposium is arranged by the committee on Storage, Automatic Processing and Retrieval of Geological Data of the International Union of Geological Sciences. For further information, write PETROPERU S.A., OICACO, Apartado Postal 1081, Lima 27, Peru. Telephone: 41-1919, extension 4850, 4855, or 4858.

Annual Meeting of the Geothermal Research Society of Japan, Kyushu University, Fukuoka, Japan, December 4-6, 1985. Free.

Authors are invited to present original papers at the oral and poster sessions. On December 7, a one-day bus tour will be undertaken to the geothermal power plants at Hachobaru and Suginoi.

For further information, write the Geothermal Research Society of Japan, c/o Geological Survey of Japan, 1-3-1 Higashi, Yatabe, Tsukuba, Ibaraki, 305 Japan.

Eleventh Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 21-23, 1986.

The workshop, sponsored by the Stanford Geothermal Program, is designed to bring together researchers, engineers, and managers involved in geothermal reservoir studies and developments to discuss their progress and exchange ideas.


Current USGS research activities in geothermal energy in the Cascade Range and Salton Sea are included among the 75 oral and poster presentations planned for the forum.

For further information, write the Training and Research Assistance Corporation, P.O. Box 6100, Denver, Colorado 80206; phone (303) 393-7061.

Fifth International Symposium on Water-Rock Interaction, Reykjavik, Iceland, August 8-17, 1986.

The symposium is sponsored by the International Association of Geochemistry and Cosmochemistry. For further information, contact Halldor Arnarsson, Ornheimur- The National Energy Authority, Grensasvegur 9, 108 Reykjavik, Iceland.


The meeting will include a technical program, special sessions, exhibits, a photo contest, field trips, and special events.

Contact the GRC for further information at P.O. Box 1350, Davis, California 95617.

Videotapes

Before the Drilling Begins

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

The videotape, titled "Before the Drilling Begins," may be purchased for $150 in $1 (VHS or Beta) or 3/4" format. It may be rented for $25 plus a $25 deposit refundable upon return of the tape.

Contact Susan Hodgson for further details (916) 323-2721.

Maps

Geodynamic map of the Circum-Pacific Region. The map consists of 5, full-color, adjacent, equal-area sheets at a scale of 1 to 10 million, and a summary Pacific Basin sheet at a scale of 1 to 17 million. Individual sheets are $15 each, and the set of 6 sheets is $46.00. They are available from the AMS Bookstore, P.O. Box 979, Tulsa, Oklahoma 74101.

The Geodynamic Maps focus on present geologic processes. They complement other Circum-Pacific map series depicting the geology, energy resources, and mineral resources.

The Geodynamic Maps contain information on the current movements of the earth's outer layers and on mass differences and strata within the earth that will tend to cause future movement. Estimates of plate motion derived from magnetic lineations and hotspot traces, earthquake epicenters and focal mechanisms, historic faulting, and active volcanoes illustrate processes that are taking place now. Gravity anomalies, seismic measurements of crustal thickness, and the state of stress within rocks illustrate static inhomogeneities related to the motion within the earth's crust and mantle.

The GRC videotape surveys development of geothermal energy at The Geysers Geothermal field. The videotape was prepared for the Geysers Geothermal Association.

The videotape (or a 16 mm film of the production) may be rented, free of charge, with a $25.00 deposit refundable upon return of the tape. Video-taped copies may be purchased, as well. Fees are $25.00 for a $1 VHS videotape or $50.00 for a $1 Beta or 3/4" videotape.

For further information, contact Judy Evans, ThermaSource Inc., P.O. Box 1236, Santa Rosa, California 95402; telephone (707) 523-2960.
The thermal water localities of the Colorado Delta Province are vective rather than conductive. Each issue features articles on California's geological environment, such as hot springs, geothermal development, minerals, and gems.


The map is the first to show subdivisions of Wyoming's Precambrian rocks. The map locates kimberlite pipes and intrusives in diatremes, a subsurface impact structure, and subsurface thrust faults that are based on new seismic and drill-hole data.


Geographical, historical, demographical, economic, and natural history maps. The maps are free of copyright restrictions.

70th Annual Report of the State Oil and Gas Supervisor. 1985. Free. Published by and available from the California Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814.

Statistical and verbal summaries of 1984 California geothermal activities.

New Division of Oil and Gas Open File Report

Reconnaissance study of thermal springs and wells and the deposits of recently extinct thermal springs in the Peninsula Ranges, Province of Southern and Baja California is the title of a new Open File Report available from the Division of Oil and Gas. The report may be copied in the headquarters, Long Beach, El Centro, and Santa Rosa offices. It was written by R. Gordon Gastil and Kathleen T. Bertine of the Department of Geological Science, San Diego State University. The abstract of the report follows.

The thermal and thermal-related waters of Southern and Baja California can be subdivided into seven provinces, each with a distinctive geochemical identity. Of these, only the Salton Basin–Colorado Delta Province is clearly related to volcanic activity (small spreading centers along the plate boundary). The thermal water of seismic epicenters, shows a positive correlation between the concentration of thermal water localities, and the frequency of seismic events. If thermal water abundance is a measure of elevated geothermal gradient at depth, it may be the elevated gradient that limits the ability of the upper crustal rocks to accommodate strain. Thus, areas of little thermal water along major plate boundaries may be areas capable of accumulating large strain, and thus are potentially hazardous.


Estimates of annual energy consumption at the state and national levels are presented, computed by major economic sector and by principal energy type for 1960–1983.

Geology and geothermal energy of the Salton Trough, a field guide. Compiled by Lawrence J. Heber, 1985. $7.00 (send payment with order; include tax and postage). Published by and available from the Historian, Far Western Section, National Assoc. of Geology Teachers, Dept. of Geological Sciences, Univ. of California, Santa Barbara, CA 93106.

The guide to the geothermal areas of the Salton Trough and to Cerro Prieto includes a road log and 16 articles.
Three open-file geothermal reports of the Sonoma Valley in Northern California are available from the California Department of Conservation's Division of Mines and Geology. The reports are available for reference in the Sacramento, San Francisco, and Los Angeles district offices. Copies may be purchased from the Sacramento District Office only. Mail orders to DMG, P.O. Box 2960, Sacramento, CA 95812.

The reports are:


In addition, the November 1985 issue of California Geology will include an article about aspects of the reports.


The study is described in an article in this Hot Line issue.

- Catalogue des ressources géothermiques de la terre, 1985. Published by the Bureau de Recherches Géologiques et Minières, Paris 6009-45060, France. 169 pages; $85.00.

- Many geological publications and posters are available on the geography of France.

- Proceedings of "Geothermal Reservoir Engineering Workshop"; set of 6 hardbound volumes. $100.00 per set, United States; $110.00 per set, foreign orders. Payment must accompany order. Published by and available from the Stanford Geothermal Program, Dept. of Petroleum Engineering, Stanford University, Stanford, California 94305.


- To purchase, write Ms. Izard Baune, Earth Sciences Division, Lawrence Berkeley Laboratory, Building 50E, Berkeley, California 94720.

- Experience at several geothermal fields has shown that reservoir fluids are produced in important volumes only where a well has intersected narrow and infrequent zones containing fractures that are both open and well-connected hydraulically. The location and characterization of open fractures within specific geothermal wells is also vitally important to engineers for interpreting wellhead pressure and flow test data and for designing a proper reinjection scheme to avoid premature thermal breakthrough of injected fluids into production wells.

- Commercial status of electrical generator technologies. No. F300-85-003, by the California Energy Commission staff, 1985. $6.55. Published by and available from the CEC, Accounting Office, 1516 Ninth Street, MS-2, Sacramento, CA 95814.

- The commercial availability status and deployment issues of 48 electrical generation and associated fuel technologies are identified. Twenty-one of these technologies are found commercially available based on the following three criteria: demonstrated feasibility, existence of suppliers, and reasonable electrical generation costs. For the other technologies, an early date of commercial availability is estimated, when possible.


- According to the brochure, PURPA Lines was created to cite those cases where the most and least attractive rates exist; details of current contracts under PURPA; the latest information on wheeling; the location of potential markets for power sales; the best places for project development; the lease and regulatory decisions that could impact power sales; and other matters relating to PURPA.

- Geothermal energy program, list of publications and reports of E.M. Leivas. Free. Published by and available from the Earth Science Division, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720.


- The locations are given for hot springs and hot pools in California, Nevada, Arizona, New Mexico, and West Texas.


- The Bureau of Mines devised a technique to recover a Zn-Pb concentrate from a geothermal brine. More than 99 percent of the Zn and Pb was precipitated by treating the brine with石灰和控制的pH with lime. The precipitate was then processed to recover Zn and Pb as metallic products.
State Projects


Magma


Hot Dry Rock


Geopressed


Geochemistry


The well-organized publication reviews geochemical literature, the majority of which was compiled from an extensive, computer-assisted search. The search included data from the COMPENDEX online data services provided by Engineering Information, Inc., 345 East 47th Street, New York, New York 10017: a tabulation of USGS Geothermal Research Program publications available from the USGS, Menlo Park, California 94025 and the usage database called GEOTHERM (call (415) 323-6111, ext. 2906); the Lawrence Berkeley National Laboratory on-line remote access database, called GRADE; Geothermal Resources Council publications; geothermal files of the U.S. Dept. of Energy, San Francisco office; and annual bibliographies published by the Electric Power Research Council (EPRI), 341 Hillview Avenue, Palo Alto, California 94304.

Technology


Direct Use


Typical sulfide precipitate contained 53 percent ZnS, 8 percent PbS, 24 percent Pbs, and 15 percent FeS. Addition to sulfide as Pbs or Cds was not effective in precipitating Zn and Pb, but Zn in the brine was selectively removed with a strongly basic ion-exchange resin. A proposed flowsheet for metals recovery is discussed.

Tectonostratigraphic terranes of the Circum-Pacific Region. Earth Science Series, Number 1. Compiled by D.G. Howell, et al. $32.00. Includes a copy of the new AAPG map, "Preliminary Tectonostratigraphic Terrane Map of the Circum-Pacific Region" (The map is $15.00 when sold separately). Published by and available from the AAPG, P.O. Box 979, Tulsa, Oklahoma 74101. Phone (918) 584-2555.

The publication includes 42 papers on principles and applications of terrane analysis, and on tectonostratigraphic terranes in the circum-pacific region.

The following NTIS Reports are available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

Program Review


Models

The City of El Centro geothermal energy utility core field experiment. DOE/GO/10274-1. By R.G. Province and P.B. Sherwood. 1984. $31.00, microfiche $4.50.

Use of geothermal energy for sugar refining in Imperial County. Pilot plant implementation. DOE/GO/10274-71. By Holly Sugar Corporation. 1984. $10.00, microfiche $4.50.

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 for $50.00 from the Division of Oil and Gas in Sacramento.

#### Drilling Permits for Geothermal Wells Approved Jan.-July 1985

<table>
<thead>
<tr>
<th>Date Notice Received</th>
<th>Operator &amp; Well No.</th>
<th>API No.</th>
<th>Sec. T.R.</th>
<th>Location &amp; Elevation</th>
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<td>025-90632</td>
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SONOMA COUNTY

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