The Imperial Valley, California, photographed on the Apollo 9 Earth-orbital mission in 1969 at an altitude of 120 miles. Apollo photographs predated Landsat images, and were the beginning of repetitive photographic coverage of the earth from space.

Freshwater lakes intermittently occupied the Salton Trough from the Pleistocene Epoch to a few hundred years ago, according to Gordon Oakeshott in *California's Changing Landscapes*. The largest of the Ice-Age lakes, whose level was slightly above present-day sea level, was Lake Coahuila. Shorelines of this lake are readily apparent along the eastern side of the sea.

In 1901, an irrigation canal was dug from the Colorado River to the Imperial Valley. During the flood season in 1905, the canal was breached near its mouth at the Colorado River. The water eventually spilled northward through two dry washes into the Salton sink, forming the Salton Sea, photo upper left. The deltas of both flood courses form the concave area curving into the Salton Sea on the southeastern shoreline. Today, the shore of the Salton Sea is about 200 feet below sea level.

The checked patterns around the sea represent irrigated agricultural fields. Irrigation water is supplied by the All American Canal, the long narrow line intersecting the Colorado River, bottom photo right.

Because of different land-use practices, the U.S.-Mexican border is defined in the photo. Information on current Imperial Valley geothermal activity is in this Hot Line issue.
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- Malaysian prawns raised in geothermal water, page 53.
- Power plant near Mammoth Lakes underway, page 55.
- DOE geothermal programs, page 62.
- CDOG geothermal regulatory program funded, page 72.
These statements summarize the optimistic approach Imperial County takes to geothermal development. Shafer temporizes his views, however, by mentioning a possible "industrial feeling" resulting from power plant facilities. This could bring a certain loss of the agricultural and desert ambiance - which he terms "...an important consideration...."

Mitchell said that the Geothermal Element of the Imperial County Plan will be rewritten, and that the 18-month project will begin in January 1984. The county received a grant from the California Energy Commission to undertake the work, which includes preparing the transmission and water regulation (injection) elements, as well.

Contractor Awarded Binary Power Plant Project

A $4.2 million contract has been awarded to R. G. Fisher Constructors, Fresno, for foundation and structural work on the San Diego Gas & Electric Company Heber binary geothermal power plant in the Imperial Valley.

The Fisher company will install foundations for all the equipment required for the 45-megawatt plant. In addition, the contract is for the installation of large concrete pipe supports and structural concrete supports and the underground electrical work, to be encased in concrete.

The contract also calls for Fisher to build steel platforms near certain plant facilities.

Dravo Constructors Inc. is the construction manager for the Heber project and will administer the R. G. Fisher contract.

Rate Increase for S.D.G.&E. for Heber Binary Plant

The California Public Utilities Commission has granted San Diego Gas & Electric Company (S.D.G.&E.) authority to increase electricity rates one-half of one percent (or $2,572,000 a year), to pay for its portion of projected expenditures at the geothermal binary power plant project at Heber.

The Heber plant is a demonstration project that will be the nation's first plant of its size to use binary-cycle geothermal technology. Because of the importance of the project nationwide, the United States Department of Energy is contributing to the cost, along with the Electric Power Research Institute, Southern California Edison, the State of California, the Imperial Irrigation District, and the California Department of Water Resources. Although its share of the cost is 50 percent, S.D.G.&E. will own 81.2 percent of the facility.

Heber Geothermal field is about 7 miles south of El Centro. The geothermal brine will be extracted from strata at depths of between 2,000 and 10,000 feet.

Sites exist to drill 50-to 60-wells for the two power plants. Initially, 9 production wells and 8 injection wells are proposed for the dual-flash plant and 13 production wells and 9 injection wells for the binary plant.

Both projects have a production island area and an injection island area. Three wells were drilled by Chevron between July and November 1982 for the dual-flash plant. Drilling should resume by the end of December 1983. Chevron began drilling wells for the binary plant on December 1, 1983.

Both projects are scheduled to be completed by mid-1985. At that time, the binary plant will undergo a two-year demonstration period. Then, long-term operating plans for the plant will be made. The dual-flash plant will be considered a commercial producer once it begins operation.

Geology and Mineral Resources of Imperial County, California, (County Report 7, 1977), describes the Salton Trough geology. The publication is available for $8.50 from the California Division of Mines and Geology, P.O. Box 2980, Sacramento, California 95812.
Developing High-Temperature Geothermal Energy

"Anyone who wants to be in the geothermal business has to learn the utility business," said Al Cooper, Vice President of Chevron Geothermal Company of California. Cooper, addressing a North Workshop on Geothermal Reservoir Engineering sponsored by the Stanford Geothermal Program, spoke on constraints facing developers of high-temperature geothermal resources.

"Some constraints are technical," he said. "These include learning how to manage fractured or controlled reservoirs, gathering resource assessment data, and understanding brine characteristics.

Some constraints are economic. As energy prices fall in general, so do the prices of geothermal energy. "Under present economic conditions," said Cooper, "the utility doesn't need many more power plants and their customers continue to conserve energy."

"If utilities feel geothermal energy can't compete with other energy sources, we won't be able to develop it," he added.

"Any contracts negotiated to sell geothermal energy must include an adequate return for the utility and the producer. In California, the Public Utilities Commission (PUC) looks at these contracts and acts as an advocate for the rate payers," Cooper continued.

"We have to interface more with the PUC. We need its help. We need a more certain market to move this thing forward. We'll have to learn to work with the utility people, as well, so geothermal energy will be ready when the market is," he concluded.

Resouring Project Underway

A new resurvey of the Imperial Valley Geothermal Subsidence Detection Network is underway. The level net, consisting of about 200 miles of first order level lines and 270 miles of second order level lines, was last surveyed in 1980-81. This net was first run in 1971 and 1973, and extended in a 1975-1976 resurvey. In 1978, a resurvey program by the National Geodetic Survey was tied to the survey net.

Due to the high cost of completing a total resurvey in one winter, Imperial County is using a four-phased approach. According to Bob Estes, Assistant County Surveyor, the north-south axis of the first order lines was run in 1983-84, and the east-west axis of these lines will be run in 1983-84. (Both are financed by the California Energy Commission grant and by Imperial County.) The next priority of the county will be to resurvey some of the second order lines, which extend to the borders of the cultivated areas.

The purpose of the network and periodic resurveys is to collect baseline data on the pattern of natural vertical changes, so that any impacts of geothermal production on surface elevation can be quickly noted and addressed.

During 1984 and 1985, the National Geodetic Survey will adjust and analyze data and prepare a report on the findings.

Concerning the network, Estes said, "I feel comfortable with our data. We have technically qualified people making the survey and adjusting the data. We have a firm network upon which we can depend."

Calipatria Industrial Parks

"We're making progress," said William Sorensen, City Planner for the City of Calipatria. "Things can go very rapidly once we know the magnitude of the resource we have."

Sorensen was describing Calipatria's projected establishment of two geothermally heated industrial parks. The first would be built within a 100-square-mile area encompassing the city's school district.

Both parks will be established as public utilities, under state charter. The city will maintain shares in the ventures, which will be handled as common stock operations. Heat extracted from the binary system will be passed through a heat exchanger and sold to private enterprise. "We hope the users will become investors and thus care for the system," said Sorensen.

Many local industries are interested in the project, which will provide energy contractable over time for stable rates. Potential users include greenhouse operators and algae growers.

To date, a temperature probe hole has been drilled north of the city's airport. One will be drilled a few miles northwest of the airport, as well. The temperature probe holes are funded by grants from the Department of Housing and Urban Development ($25,000) and the California Energy Commission and the City of Calipatria ($104,000).

The city is looking for investors to fund the geothermal wells. The wells will not extend below 2,000 feet and the temperatures are not expected to be above 300°F. The optimum wellhead temperature for the project is between 175°F to 230°F.

The industrial parks will produce growth, job opportunities, and economic stability," said Sorensen. "We need an alternate economic base. Many other areas can do the same thing."

For further information, write Mr. Sorensen at 131 West Main Street, Calipatria, California 92233.

Geothermal Agriculture in Coachella Valley

"We established Aquafarms Internationally in the Coachella Valley," said

Dov Grajcer, project manager, "because it offered the best chances for success on the hardest terms. Some difficulties come from desert conditions" Grajcer continued. "Little is known of how water and deserts interact. A 60°F temperature differential can occur in a day. Also, the water here is high in calcium. However, either near a market, labor is available, and land was relatively cheap. But, geothermal water is a key factor in our success, giving us great energy savings."

Malaysian prawns, bass, catfish, Japanese koi, and grass-eating carp are raised in the ponds at Aquafarms. Water from 3 geothermal wells and 5 irrigation wells is mixed in the farm's 61 ponds, with a combined water surface of 50 acres. Pond sizes vary from 1/10 acre to 2 acres. The water flows first to the prawn ponds, then cascades through irrigation pipes to ponds with the other fish.

The warmest geothermal well produces water at a temperature of 106°F with a TDS of 1,100 ppm. The second-warmest geothermal well -- perforated in a nongeothermal zone and a deeper, geothermal zone -- has geothermal water with a temperature of 93°F. The third has a temperature of 86°F. All 8 wells have a combined flow of 2,500 gallons per minute.

Aquafarms raises the prawns and fish to various stages of maturity depending on a customer's order. Most mature prawns are sold to gourmet restaurants in Los Angeles and Palm Springs. The company eventually hopes to supply young prawns and fish to other hatcheries.

Aquafarms was established in 1975. In 1979, it received a U.S. Department of Energy (DOE) grant to demonstrate the feasibility of using geothermal water for raising prawns. Eventually, the DOE will print a manual on the topic, written by Aquafarms.
The Navy wishes to learn what the direct heat potential is beneath its properties. Once this is determined, decisions for utilizing the energy will be made.

For further information, contact Chris Higgins at (916) 322-9997.

**Northern California**

**Binary Project at Mammoth Lakes**

A 7 megawatt geothermal power plant is under construction near Mammoth Lakes, California, at Casa Diablo Hot Springs by the Ben Holt Company, on property owned by Magma Energy, Inc. Construction is by Kennebec Construction Company, a Holt subsidiary.

The facilities are owned by Mammoth-Pacific, a joint venture of Pacific Energy Resources Company and Mammoth Binary Power Company. Pacific Energy Resources Company is a subsidiary of Pacific Lighting Corporation. The general partner of Mammoth Binary Power Company is Holt Geothermal Co., an affiliate of The Ben Holt Co. Mammoth Binary Power Company is managing the project.

The design of the plant is based on Magma’s patented Magmamax process, which has been demonstrated at Magma's 10 megawatt plant in the Imperial Valley. Under the Magmamax process, isobutane is heated under pressure by hot water in a tubular heat exchanger. The vapors are expanded in a turbine, condensed by cooling with air, and pumped back to the heat exchangers in a closed circuit.

Site preparation and grading began in August 1983 and the project is scheduled for completion in August 1984. The electricity produced at the power plant will be sold to Southern California Edison Company. The electricity generated at the plant will supply about one-third of the summer load of the Mammoth Lakes area and one-sixth of the winter load. The geothermal hot water used in the process will be supplied from wells drilled by Mammoth-Pacific.

**Binary Geothermal Power Plant Near Mammoth Lakes, California.**

**District Heating Project for San Bernardino**

The City of San Bernardino, California, received a $2,750,000 grant from the California Energy Commission to finance a geothermal district heating system. Six city and county buildings will be heated with the geothermal water. Nine public buildings and complexes along with 18 private facilities are potential users of geothermal heat.

The granted amount converts to a loan in 1985, with a 10.8 percent interest charge. The loan is to be repaid to the state over a 10-year period.

**Naval Geothermal Studies Undertaken**

The geothermal potential of land beneath several Southern California U.S. Naval facilities is being evaluated by geologists from the California Division of Mines and Geology.

Under an $80,000 grant from the U.S. Department of Energy, on behalf of the Navy, the geologists are measuring temperatures of hot oilfield brines beneath the Long Beach Naval Shipyard and the Seal Beach Naval Weapons Station. A brief reconnaissance of geothermal potential beneath Naval facilities in the San Diego area is also being undertaken.
Five wells have been drilled at the site: 4 production wells and 1 injection well. A second injection well may be drilled in 1984.

Features of the power plant include:

- Geothermal fluid produced as a liquid with 100 percent injected back into the reservoir. No steam is produced.
- Isobutane in a closed circuit never exposed to the atmosphere.
- Atmospheric air, not water, used for cooling. The process uses no water and expels no vapors to the atmosphere from a cooling tower.

The plant will occupy fewer than 3 acres of ground and will have a maximum height above grade of about 25 feet.

The cost of the project is estimated at $12,500,000.

"The Mammoth project is an excellent example of meeting expanding power needs of a community by generating that power from local geothermal resources," said Ben Holt. "This project is a world's first in its use of modular construction on a completed by Aminoil USA, Inc. wells, which are connected by about 12,000 feet of flow lines.

The power plant includes a Stratford H₂S abatement system. A secondary treatment system using hydrogen peroxide is used to remove hydrogen sulfide from the condensate.

According to Energy Watch, published by the California Energy Commission, 3.7 percent of the electricity (1,157,745 megawatt-hours) sold by California Public Utilities for the months of April, May, and June 1983 was generated from geothermal resources.

Most of this electricity was generated in The Geysers Geothermal field.

**Reservoir Definition Study of The Geysers**

"With this project, the northern, northeastern, and southeastern limits of the field may be defined," said Dick Thomas, California Division of Oil and Gas (CDOG) engineer. "The other boundaries are known with more certainty," he added.

Thomas referred to a CDOG heat-flow and reservoir definition study of The Geysers Geothermal field.

"A heat-flow map may be used as a planning tool in deciding where geothermal wells can be drilled, power plants sited, and power lines located," Thomas added.

One part of the study will be to correct well temperature data for topographical conditions. Measured temperature gradients for wells...
drilled near mountain tops or valley bottoms cannot be correctly extrapolated to the depth of the reservoir, since the well temperatures show the effects of heat losses or gains due to the uneven topography. Heat originating at great depths preferentially flows through the valley bottoms rather than at the mountain tops.

Also, thermal conductivity values for 180 well cutting samples from the Geysers will be determined in the study.

The CDOG study is partially funded with a $14,000 grant from the U.S. Department of Energy.

Nevada

Reno Subdivision Geothermally Heated

by David Carlson
William B. Nork, Inc.

Two wells were drilled and completed in southwestern Reno, Nevada, near Warren Estates, another geothermally heated subdivision (see July 1982 Hot Line). The wells are part of a system that will supply geothermal water to as many as 400 homes in that area. Pipes to distribute geothermal water will be laid throughout the subdivision. Homeowners may choose to retrofit home heating systems with heat exchangers to take advantage of the geothermal energy. A production well and an injection well have been drilled. As need arises, additional production and injection wells will be drilled and tied into the system.

Both wells are owned by Sierra Geothermal Inc. They were designed by William B. Nork, Inc. and drilled within the Naona KGDA. The 653-foot deep production well had a bottom hole temperature of 207°F when it was drilled in November 1980. During a pumping test undertaken in September 1983, the well yielded over 150 gal./min. of 178°F water. Calculations show that this well can accept at least 120 gal./min. of spent geothermal fluid.

Nevada Geothermal Industry Can Export Electricity

The 1983 session of the Nevada Legislature passed legislation allowing geothermal developers to export larger amounts of electrical energy from Nevada.

In the past, producers of electricity from geothermal resources were required to make:

-- 50 percent of their production capacity available to utilities located within the area and within the state; or

-- Permit those Nevada utilities to recapture up to 50 percent of production from out-of-state utilities that had contracted to purchase the electricity from the geothermal producers.

Geothermal developers and the Nevada Mining Association members testified the restriction has discouraged investment towards the huge capital outlays needed to establish a geothermal-electrical utility in Nevada. They said Nevada-based utilities may not be able to raise half of the shares. Moreover, prospective out-of-state purchasers of geothermally generated electricity may find it uneconomical to contract for the energy if they are not guaranteed 100 percent of production.

The legislation, A.B. 592, now reads:

"In case of geothermal projects, the construction permit (from the state) may be conditioned only on a prior offering of the capacity of the project to the public utility in this state which primarily serves retail customers in the service area nearest to the proposed project; and if the offer is declined, the applicant is free to export the capacity of the project without any obligation to re-offer that capacity to any public utility in this state."

The legislation was opposed by representatives of Nevada electrical utilities.

Utah

Utah Well a Surprise

A geothermal well drilled 20 miles north of Beaver, Utah, unexpectedly penetrated a steam pocket at a depth of less than 1,200 feet. Steam temperatures in the well were above 400°F. The discovery was quite unexpected, as the well was drilled less than 1,400 feet from 1 of 4 wells drilled by Union Oil Company, none of which penetrated steam reservoirs with temperatures above 350°F.

The well, which blew out on October 24, 1983, was drilled by Mother Earth Industries, a small, family-owned company. Wayne Portanova, company president, said that the volume of steam and its shallow depth were two surprises. He said steam from the well could produce 5 to 10 megawatts of electricity from a flash system or 15 to 20 megawatts from a binary system. The original plan of the company was to install a 1.8 megawatt generator on a well to supply electricity to the City of Provo.

According to an article in The Oil Daily, the coal was to be used to fire a new, proposed city power plant. The geothermal energy was to be a supplementary power source. Now, says Provo Mayor Jim Ferguson, the geothermal well will take care of the city's power needs well past 1990.
The well was capped in November 1983, and a new well planned for a location 250 feet east to determine the extent of the reservoir. Ray Gould, drilling engineer at the well site, said a power plant could be in operation by August 1984.

Alaska

Aleutian Archipelago, Alaska.

Unalaska Island Well Completed (Adapted from Alaska Mines and Geology)

The first Alaskan geothermal well to successfully produce steam was recently completed at the Makushin Geothermal field on Unalaska Island, 900 miles west of Anchorage.

The Makushin field, 12 miles west of Unalaska Village on Unalaska Island in the Aleutian Island chain, was studied by the Alaska Division of Geological and Geophysical Surveys (DGGS) in 1980 and 1981. The number and distribution of thermal areas east of Makushin volcano and the chemistry of thermal waters and gases emanating from the thermal field indicate that a significant and widespread geothermal resource may exist at Makushin. Subsequent studies show that temperatures in the geothermal reservoir exceed 375°F, and could reach 572°F.

On the basis of highly promising DGGS findings at the Makushin Geothermal field, the state funded a major geothermal drilling program in 1981. The program purpose is to confirm the existence of a geothermal resource suitable to produce electrical energy needed by the island, and to drill a production well.

The program is administered by the Alaska Power Authority. In consultation with DGGS, the Power Authority selected Republic Geothermal, Inc. (RGI) of Santa Fe Springs, California to drill and test the wells.

A preliminary model of the geothermal resource area developed by DGGS and RGI was used to help site three thermal-gradient holes that were drilled in 1982. One of these holes, drilled to a depth of 1,500 ft., confirmed that resource temperatures exceeded 385°F.

Funding limitations precluded drilling a major production well, but a 3-in. diameter exploratory well was drilled to confirm reservoir fluid productivity. Drilling began on the well in June 1983 near the head of Makushin Valley, at an elevation of 1,200 ft. The well site was chosen on the basis of exploratory work by DGGS and RGI, and on the accessibility of the site to Unalaska Village.

Artesian well

In late August 1983, the well penetrated a fracture in the plutonic reservoir rock at a depth of 1,950 ft. (nearly 750 ft. below sea level). The fracture contained 375°F hot water.

Water and steam flowed from the well at a rate of 50,000 lb/hr. The temperature and flow from the 3-in. diameter pipe are estimated to be sufficient to produce 0.5 megawatts of electricity. Two standard production wells of 9½ in. diameter could generate up to 10 megawatts of electricity.

The Makushin field, 12 miles west of Unalaska, has been identified by DGGS and the Washington State as having geothermal resource potential. In September 1983, John Spellman, Governor of the State of Washington, and Peter Johnson, Administrator for the Bonneville Power Administration (BPA), announced signing a $500,000 agreement for the Washington State Energy Office (WSEO) to lead a study aimed at the identification and analysis of the region's geothermal energy potential.

WSEO will provide the technical and administrative coordination of the 18-month project, which will be conducted cooperatively with the other states in the BPA area. Agreements will be completed with Oregon, Idaho, and Montana to carry out much of the work.
According to Richard Watson, Director of WSEO, "This is the first in-depth analysis of the region's geothermal energy resources. It is important not only to the long range planning efforts of BPA, but also to the implementation of the Northwest Regional Power Plan." (See Hot Line, July 1983.)

The program will provide information on the availability, timing, and costs of geothermal energy for electrical generation, and identify how much future electrical generation may be offset through direct utilization of the region's geothermal resources. BPA will also be provided with information on institutional factors and legal restrictions that may affect the development of the resources.

For more information, contact Dr. R. Gordon Bloomquist, Project Coordinator, WSEO, 400 East Union, Olympia, Washington 98504, (206) 754-6774.

Federal Programs

DOE's Current Geothermal Reservoir Programs and Comments on International Cooperation in Hydrothermal Research

Ronald S. H. Toms
United States Department of Energy (DOE)
Washington, D.C., 20585

Presented on December 13, 1983 at the Ninth Workshop on Geothermal Reservoir Engineering, at Stanford University.

ABSTRACT

DOE's geothermal program continues to emphasize a range of reservoir-related programs in reservoir definition, brine injection, stimulation, hot dry rock, and associated research resources and, now, magma resources. These programs are described briefly. Programs in international cooperation between the U.S. and 23 other countries on hydrothermal research have produced important gains in knowledge over the past ten years. Although the activity has diminished, a resurgent interest is evident.

CURRENT RESERVOR-RELATED PROGRAMS

DOE's interest in geopressured resources is to determine the economics and to provide a technology base that industry will exploit. The three existing deep wells that were drilled in the Gulf Coast geopressured reservoirs will be continuously flow-tested this year to determine the drawdown and changes in fluid composition. ERI is planning a total energy extraction experiment that will give further impetus to industry involvement.

In hot dry rock we plan this year to complete the Phase II thermal loop at Fenton Hill, New Mexico, to the originally planned size, and to begin extended operation of the loop to assess reservoir longevity, operating performance, and environmental effects. We also plan to model the reservoir that we will have created.

Our experimental work in well stimulation was completed last year, and this year we will study the lessons learned and conduct additional analyses of new techniques before embarking on more experimental work. However, through our hard rock penetration research studies we have identified the use of a tailored-pulse loading, by a lime-burning propellant, as a promising technique, and work on this will proceed.

Brine injection technology has become an important program in hydrothermal research. We will continue the monitoring and modeling techniques to monitor and predict migration of spent brines injected into reservoirs. We will also continue the development of chemical conditioning methods to prevent unwanted chemical reactions in the well and in the adjacent injection zone. We plan to develop well completion technology to enhance the acceptance of injected brine by the well and thus extend its useful life.

Our efforts on reservoir definition will continue on many fronts. We will continue the development and validation of reservoir models capable of predicting production depletion rates. We will evaluate surface and subsurface geophysical techniques capable of mapping natural fracture systems within reservoirs. Specific study areas will include Carls Prieto and Los Amoros, Klamath Falls, the Newberry Caldera and others to be determined.

Under our State assistance programs we will continue programs in resource assessment, resource development, technical assistance and technology transfer. There will be an emphasis on high temparature resources, especially the Cascades and other prospects around the world.

In conjunction with reservoir productivity we are continuing the work in two-phase flow through our hard rock experiments. This includes studies into the fundamental phenomena in facilities using fresh and air-to-water to simulate well-bore conditions.

As part of our effort in hard rock penetration research we are developing techniques for precise well location. We have already adapted an inertial navigation system to map a relatively cold well-bore, and temperature hardening in the next step.

The proposal last year to provide a hole-of-opportunity in the Salton Sea for scientific research, under the Continental Scientific Drilling Program, has resulted in funding that will be for competitive solicitation for deepening or drilling a well to 18,000 feet in the Salton Sea. It is anticipated that this effort will provide valuable geothermal research into the understanding of the formation of the Salton Sea geothermal anomaly, the nature of any underlying reservoirs, and new estimates of geothermal potential, as well as a variety of important answers in the earth sciences.

Finally, we are this year taking an engineering- oriented study of the Fenton Hill Plan to serve as a model for operation in the Imperial Valley.

INTERNATIONAL COOPERATION

In view of the international theme of this meeting and the presence of so many distinguished geothermal researchers from around the world, I will now give a short review of DOE's cooperative research program. The feasibility for this was established by the "geyser tap" experiments at Kilauea Iki in Hawaii. We will review the candidate shallow magma bodies in the continental U.S. to evaluate their character and location. We will estimate the cost of drilling and extracting energy from selected prospects, and consider their potential economic viability with regard to potential users and transportation lines. If the estimated viability of the project is positive we will then plan a definitive experiment for the future.

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of these agreements, while Mexico, Japan, and Germany each have been party to three.

Whereas the legacy of international cooperation over the past decade has been rich, we must address the current point in the cooperation. Of the eleven agreements mentioned before, only two are actually active at present: (1) the IEA Agreement on Hot Dry Rock Technology and (2) Mineral Arrangement between DOE and ENEL (Italy). Even these two agreements are meeting with difficulties. In particular, the IEA agreement is due to expire this year.

A number of reasons can be cited for the lackluster interest in cooperation on geothermal research. The recent worldwide oil surplus coupled with a pervasive recession caused many nations to reevaluate their energy research programs. With fewer incentives and less funds for research, many countries chose to de-emphasize their international programs; greater emphasis was placed on purely domestic R&D activities. During this period DOE strived to fulfill its international commitments. The Department was reluctant, for budgetary reasons, to assume new obligations.

Although, today, budget constraints are still very much present, DOE understands the usefulness and importance of cooperative research and development. Some of geothermal's remaining problems can best be solved through the combined efforts of experts from many countries. Accordingly, we are negotiating a new U.S.-Mexico Agreement covering both the Cerro Prieto project and Eldorado.

We particularly endorse arrangements which maximize information exchange among countries working on similar problems. In this regard DOE has begun negotiations with the United Kingdom's Department of Energy on a comprehensive program of exchange in hot dry rock technology.

The benefits of international cooperation and technology exchange among nations are again being evaluated. We predict that this decade will witness a reevaluation of many past ties in cooperative research and the forging of new ones. Certainly experience has taught that no country can solve all technical problems confronting us, and that by working together we will reach solutions a great deal faster.

BLM Geothermal Activities

In Executive Order 3087, the Minerals Management Service (MMS) was combined with the Bureau of Land Management (BLM) for onshore geothermal production management. Three BLM offices address the exploration and development of geothermal steam in California. The offices are in Sacramento, Riverside, and El Centro.

Some of the activities are identical to the activities of the old Minerals Management Service. The office of the Associate State Director of Minerals, Fluid Minerals Branch, will handle geothermal engineering, and the California Desert District at Riverside will have an Assistant Director (National) Resources to handle all of the actions formerly done by MMS within the Southern California Region. The Resource Area Office in El Centro will have a geologist and a staff to process any actions that are proposed in the field with reference to prior lease and post-lease activities. The merger was completed by June 9, 1983, with the geothermal staff essentially the same staff once with MMS.

The BLM has worked towards making Imperial County federal land resources available for lease. These lands include the Clamis and Dunes KGRA's, most offshore resources in the Salton Sea KGRA, some scattered tracts within the Brawley KGRA, a few acres in the Heber area, and a significant block of lands in the East Mesa KGRA. There are some noncompetitive areas in addition to the KGRA's. The Desert Plan is the master plan for resource allocation and leasing of geothermal steam. Many of the non-competitive areas are in the Yuha area, near Kane Springs, and in the Chocolate Mountains area according to Roger Zortman, BLM, who presented these data at the Imperial County Geothermal Development meeting in May 1983.

BLM geothermal regulatory operations in Imperial County are headed by Peter Ertean, Branch Chief for Resource Program Operations, who has reduced geothermal preleasing, drilling, production, abandonment, and post-lease activities on federal lands in the valley.

To date, about 20 geothermal wells (not all active and some abandoned) fall under BLM purview in the valley.

Ertean says there are two types of geothermal leases managed by his office. Leases that are issued through a competitive bidding process. The fee is $2.00 a year per acre, plus royalty percentage, plus a bonus bid. Noncompetitive leases are issued for lands outside of KGRA's. Applications for non-competitive leases are submitted over-the-counter, and a BLM decision on the proposals is released in 90 days. The leasing fee is $1.00 per acre per year.

According to Bruce Hellier, BLM Fluids Branch Chief, Minerals Resources Division, the BLM receives more revenue from California geothermal leases than from onshore oil and gas leases in the state. About $6 million is expected by the BLM in 1984 in royalty income from California geothermal leases.

BLM Areas of Mineral Potential

The U.S. Bureau of Land Management (BLM) is inviting recommendations from both the public and industry nominating "Areas of Critical Mineral Potential" (ACMP). Geothermal resources are considered "minerals."

The move stems from President Reagan's April 5, 1982, report to the Congress on his National Materials and Minerals Management Program Plan calling for an invitation to the public to nominate areas of high mineral interest. Nominations will be used to identify areas of critical potential for priority withdrawal review. There is no time limit for such recommendations.

Robert F. Burford, director of the BLM, said that information gathered in the competitive process will help to stimulate review of areas presently withdrawn or "off-limits" to energy and mineral entry or development. The nominations will also provide a basis for negotiating access to minerals on public lands withdrawn by other agencies.

Withdrawn areas in Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming can be nominated for Indian reservations and other Indian holdings; lands in the National Wildlife Refuge System; other lands administered by the U.S. Fish and Wildlife Service, National Park System, Wild and Scenic Rivers System, National System of Trails, and designated wilderness areas.

Areas within BLM or Forest Service Wilderness Study Areas may be nominated and will be treated as part of the wilderness study program.

Nominations should be in the form of a letter written as specifically as possible and including the following information:

1. Minerals of interest.  
2. A map or land description showing the area nominated.  
3. A brief statement of the rationale for the nomination, i.e., mineral occurrence or exploration potential.  
4. A brief description of the nature and the effect of the withdrawal of the area nominated, if known.  
5. The name, address, and telephone number of a person who may be contacted by BLM to review the nomination.  

Geologic maps, cross-sections, and sample analyses may be included. Published literature and reports may be cited in support of the nominations. Any data considered confidential should be appropriately marked. Nominations should be limited to no more than three typed pages excluding any maps or bibliographic materials. Send nomination to the Director (690), Bureau of Land Management, 1800 C Street, N.W., Washington, D.C. 20240.
After Washington Office review, nominations will be sent to BLM State and District offices for processing. Each party making a nomination will be notified of the action BLM plans to take regarding the nominated area.

Cerro Prieto Geothermal Field
by Susan F. Hodgeson

Cerro Prieto Geothermal field is in a flat, poorly drained area of the Mexicali Valley, about 35 km south of Mexicali, Baja California.
The photo was taken in the southern end of the field where there are mud volcanoes and hot springs.
There are over 110 wells in the field, which is being expanded to the east.

Cerro Prieto 1 is a 180 megawatt geothermal power plant. The two larger plant units produce 150 megawatts of electricity. They are operated with high-pressured steam, flashed at the wellhead and piped directly to them.

The smaller, 30 megawatt unit is operated with medium- and low-pressured steam. This steam is flashed from hot water collected from the wells and brought to this gathering station.

Cerro Prieto power plant Unit 2, under construction. The plant, with two 110 megawatt units, will cost about $118 million dollars. Toshiba turbines will be used.

The remaining brine is pumped from the gathering station into the large holding pond.
The pathway along which steam from 25 wells will be piped into Cerro Prieto 3. The plant is scheduled for completion in February 1984.

Cerro Prieto 3, an identical plant, will be built a few miles north of Cerro Prieto 2, and slightly north-east of Cerro Prieto 1. Cerro Prieto 3 is scheduled for completion in 1985, and will bring the field to a total generating capacity of 620 megawatts.

Little injection has occurred in the field. However, once Cerro Prieto 2 and 3 go on line, injection programs will begin. This is necessary because the power plants are next to farming areas.

The total dissolved solids in brines from the field are between 4,000 to 4,500 ppm.

Projects underway at Cerro Prieto to use the by-products of field geothermal activities include the extraction of potassium chloride from geothermal brines. In 1984, the government plans to begin full-scale operations to extract about 100,000 tons per year of KCl from the brines - about the total Mexican demand for the product. The KCl will be sent to fertilizer plants throughout the country.

In a hydroponics project at the field, squash, tomatoes, and other vegetables are grown in greenhouses that use geothermal water piped in from the cooling towers.

Also at the field, prawns, striped bass, and other fish are raised in a series of demonstration ponds. The pond water is heated by pipes filled with hot geothermal brines.

Canada

Canadian Geothermal Exploration Rights Awarded

A Canadian company, O'Brien Energy and Mines Limited, received the first geothermal exploration rights to be awarded in Canada.

The geothermal permit, advertised as Parcel No. 63 with 8286 hectares of Crown rights in the Mt. Cayley area, is about 100 kilometers north of Vancouver. The award was based on what was considered to be the best proposed geological or geophysical exploration and exploratory drilling program.

O'Brien will undertake yearly commitments over a five-year program that, if successfully completed, will require expenditures up to a maximum of $4,249,720.00. In the event that the company does not meet each of the yearly commitments, the geothermal permit will be cancelled.

O'Brien Energy and Mines Limited has extensive experience in geothermal operations, and, at present, is part of a group developing geothermal properties for power generation in the Roosevelt area near Milford, Utah.

At the end of each year, O'Brien has the option of continuing with the program for the subsequent year or surrendering the permit. At the end of the fifth year, no further commitments are required. For subsequent years until the permit is surrendered or converted to a geothermal lease, the statutory obligations of the Geothermal Resources Administrative Regulations will apply.

New Zealand

Ngawha Geothermal Field Update


The 1982 Energy Plan indicated that though Ngawha Geothermal field was scheduled for development primarily for electricity production, the "timing and mode of operation" had yet to be finalized. It was possible that commissioning could be deferred to beyond the end of the planning period (i.e. by 15 years). This hedge was a consequence of the uncertainty in the construction of the Aramoana Aluminium Smelter.

When the smaller development fell through, the forecasted electricity demand took a nose dive. Hence, the large scale (100 MW-size) Ngawha development was deferred until at least 1997. However, as also stated in the Energy Plan, the possibility of installing smaller scale, noncondensing sets was acknowledged. Presently, MOE, NZE and MWD are investigating the utilization of small (2-15MW) backpressure sets at Ngawha and at other fields.

Along with the Ngawha deferral, the need for drilling exploration wells was reassessed, reducing a two-rig operation to a one-rig operation. Because existing operations at Wairakei and Kawerau must be maintained and development at Broadlands is proceeding, the exploration drilling program had to be curtailed. Since there should be "plenty of time in the future" for pursuing exploration drilling at Ngawha, upon completion of NG 13, the GC - 350 rig was shifted to Mokai in the search for higher enthalpy fluid.

The G.C. 350 rig was set up at Ngawha well NG 13 on December 20, 1982.
Drilling began on January 23 and was completed during May after many difficulties. Maximum drilled depth was 2337.7m. During the completion tests, the maximum temperature was 287°C at 2300m (the highest temperature yet encountered at Ngawha). Overall permeability is excellent, and the well should prove to be the largest producer at Ngawha.

China

Chinese Looking at Geothermal Technology

The People's Republic of China wishes to establish contact with Western firms active in alternative energy fields, including the development of geothermal energy. Western companies are being asked to show products at a series of exhibitions scheduled for early 1984. Other activities are planned, as well, to acquaint Chinese officials with the Western technology. For further information, contact David Phillips, China Industrial Development, Inc., 447 W. Carvey Avenue, Suite 130, Monterey Park, California 91754, phone (213) 571-6401.

High-Temperature Reservoirs

High-Temperature Geothermal Reservoirs

"After the successful development of the vapor-dominated geothermal reservoir at Larderello, geologists and geochemists searched for other dry-steam systems," said Don White.

"Eventually many geothermal systems were found, but only about 5 percent are vapor-dominated," he added.

White has spent many years studying the evolution and nature of geothermal reservoirs. He feels all geothermal reservoirs pass through natural life cycles, and all begin as hot water systems. Only by changing in a special manner will a hot-water system ever become a vapor-dominated system.

White has published information on this topic. Abstracts follow from two of his papers: Vapor-Dominated Hydrothermal Systems Compared with Hot-Water Systems and Production of Superheated Steam from Vapor-Dominated Geothermal Reservoirs. Abstracts from other papers will appear in the next issue of the Geothermal Hot Line. These are: Active Geothermal Systems and Hydrothermal Ore Deposits and Geochemistry Applied to the Dis-

covery, Evaluation, and Exploitation of Geothermal Resources.


Vapor-dominated ("dry-steam") geothermal systems are uncommon and poorly understood compared with hot-water systems. Critical physical data on both types were obtained from U.S. Geological Survey research in Yellowstone Park. Vapor-dominated systems require relatively potent heat supplies and low initial permeability. After an early hot-water stage, a system becomes vapor-dominated when net discharge as steam starts to exceed water recharge. Steam then boils from a declining water table; some steam escapes to the atmosphere, but most condenses below the surface, where its heat of vaporization can be conducted upward. The main vapor-dominated reservoir actually is a two-phase heat-transfer system. Vapor boiled from the deep (brine?) water table flows upward; most liquid condensate on the reservoir borders flows down to the water table, but some may be swept out with steam in channels of principal upflow. Liquid water favors small pores and channels because of its high surface tension relative to that of steam.

Steam is largely excluded from smaller spaces but greatly dominates the larger channels and discharge from wells. With time, permeability of water-recharge channels, initially low, becomes still lower because of deposition of carbonates and CaCO3, which decrease in solubility with temperature. The "lid" on the system consists in part of argillized rocks and CO2-saturated condensate.

Our model of vapor-dominated systems and the thermodynamic properties of steam provide the keys for understanding why the major reservoirs of The Geysers, California, and Larderello, Italy, initially have rather uniform reservoir temperatures near 240°C and pressures near 34 kg/cm² (absolute) gas other than H2O increases the pressure). Low content of steam results in a liquid and great stored heat of solid phases account for the physical characteristics and the high productivity of steam wells.

We suggest that vapor-dominated systems provide a good mechanism for separating volatile mercury from all other metals of lower volatility. Mercury is likely to be enriched in the vapor of these systems; the zone of condensation that surrounds the uniform reservoir is attractive for precipitating HgS.

A more speculative suggestion is that porphyry copper deposits form below the deep water tables hypothesized for the vapor-dominated systems. Some enigmatic characteristics of these copper deposits are consistent with such a relationship, and warrant consideration and testing.


Vapor-dominated geothermal systems such as Larderello, Italy, The Geysers, California, and Matusaka, Japan yield dry or superheated steam when exploited. Models for these systems are examined along with production data and the thermodynamic properties of water, steam and rock. It is concluded that these systems initially consist of a water-saturated reservoir, a water-saturated cap rock, and a water or brine-rich deep reservoir below a water table. Most liquid water in all parts of the vapor-dominated part of the system is relatively immobilized in small pores and crevices; steam dominates the large fractures and voids of the reservoir and is the continuous, pressure-controlling phase. With production, the pressure is lowered and the liquid water boils, causing massive transfer of heat from the rock as it cools and eventually dries. Passage of steam through already dried rock produces superheating as pressure decreases toward a producing well. After an initial vaporization of liquid water in the reservoir, the decrease in pressure produces increased boiling below the deep water table. With heavy exploitation, boiling extends into hotter rock and the temperature of the steam increases.

This model explains most features of the published and unreported behavior of these systems and can be used to guide exploitation policies.

Legislation

California Legislative Update by Cheryl Menezes

The following is an update on the geothermal bills introduced in the State Legislature. All four bills will be effective on January 1, 1984. For a full description of the bills, see the July 1983 issue of the Hot Line.
This text contains a discussion on geothermal well fees in California, including a bill (AB 886) to require operators to pay for wells that produce oil and gas.

The text also mentions another bill (AB 1780) concerning geothermal grants and another bill (AB 1466) regarding the payment of fees for geothermal wells. The text further discusses the status of federal legislation affecting geothermal energy, as of December 1, 1983.

Federal Legislative Update

Status of federal legislation affecting geothermal energy, as of December 1, 1983.


4. H.R.2841: SPO:Lehman of CA, et al; LATEST TITLE=A bill to establish the Mono Lake National Monument in the State of California, and for other purposes. LATEST ACTION=Jul 27, 83 Referred to the Committee on Energy and Natural Resources.

5. H.R.1568: SPO:Cheney; STTL:Energy Tax Act of 1983 LATEST ACTION=May 4, 83 Executive Comment Requested from USDA.


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


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

13. H.R.2592: SPO:Hall, of OH, et al; LATEST TITLE=A bill to amend the Internal Revenue Code of 1954 to clarify the definition of geothermal energy, and for other purposes. LATEST ACTION=May 5, 83 Referred to House Committee on Ways and Means.


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


29. S.1237 : SPONSOR=Symms, et al; LATEST TITLE=A bill to amend the Internal Revenue Code of 1984 to clarify the definition of geothermal energy, and for other purposes. LATEST ACTION=Jun 13, 83 Committee on Finance requested executive comment from OMB, Treasury Department, Energy Department.


31. S.1331 : SPONSOR=Cranston; LATEST TITLE=A bill to establish the Mono Lake National Monument in the State of California, and for other purposes. LATEST ACTION=Jul 18, 83 Read twice and referred to the Committee on Agriculture Energy and Natural Resources.

32. S.1369 : SPONSOR=Durenberger, et al; LATEST TITLE=A bill to amend section 170 of the Internal Revenue Code of 1954 to increase the amounts that may be deducted for maintaining exchange students as members of the taxpayer's household. LATEST ACTION=May 31, 83 Committee on Finance requested executive comment from OMB, Treasury Department.


35. S.1470 : SPONSOR=Bingaman; LATEST TITLE=San Juan Basin Wilderness Protection Act of 1993 LATEST ACTION=Aug 3, 83 Read twice and referred to the Committee on Energy and Natural Resources.


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Grants

**Grants**

**CSC Geothermal Grant Program for Local Governments**

by Nancy Libonati

The following fourth round preliminary applications were received:

**NOTE:** S = grant monies requested

M = matched contributions

1. **Riverside Planning Dept.**
   - **Geothermal Energy Element**
     - $120,000 (S) $50,000 (M)

2. **City of Desert Hot Springs**
   - **Resource Assessment Well Drilling**
     - $182,000 (S) $6,500 (M)

3. **Kelseyville Unified School District**
   - **Purchase of a School Bus**
     - $71,998 (S) $1,112 (M)

4. **Siskiyou County**
   - **Groundwater Heat Pump for Co. Courthouse and Jail**
     - $289,000 (S) $739,444 (M)

5. **M-R Public Power Agency**
   - **Feasibility/Financial Study**
     - $65,000 (S) $70,200 (M)

6. **Surprise Valley Unified School District; Retrofit Elementary/High Schools**
   - $197,365 (S) $20,861 (M)
7. Modoc County
Resources Assessment and
Revolving Loan Program
$244,000(S) $206,398(M)

8. City of Calipatria
Resource Assessment Well
Drilling
$391,000(S) $412,980(M)

9. Bridgeport Public Utility
District; Drill and Test
Production Well
$1,052,583(S) $1,940,622(M)

10. Mono Co. Economic Development
Corp.; Feasibility Study
Mammoth Lakes
$143,437(S) $9,346(M)

11. City of San Bernardino
Geothermal Retrofit of
City Hall
$596,000(S) $35,750(M)

12. City of Santa Clarita
Resource Assessment
Community Center
$10,850(S) $4,500(M)

13. County of Inyo
Sierra Valley
$267,000(S) $6,000(M)

14. County of San Bernardino
High Temperature Exploration
$110,000(S) $6,000(M)

15. City of Rohnert Park
Resource Assessment and
Drill 2000' TG Hole
$154,009(S) $0(M)

16. Sonoma County
Survey and Aerial Mapping
of Cloverdale-Geyser Road
$85,000(S) $2,576(M)

17. Sonoma County
Revegetation of Heals-
bury-Geyser Road
$26,399(S) $0(M)

18. City of San Bernardino
Geothermal Retrofit of
City Hall
$15,050(S) $11,000(M)

19. City of San Bernardino
Geothermal Retrofit of
Community Center
$10,850(S) $4,500(M)

20. City of San Bernardino
Geothermal Retrofit of
Senior Citizens Center
$20,700(S) $6,000(M)

21. City of San Bernardino
Geothermal Retrofit Support Program
$625,000(S) $775,000(M)

22. City of Paso Robles
Geothermal Pool Heating
$101,900(S) $37,000(M)

23. 29 Palms Water District
Resource Assessment for
Space Heating
$74,000(S) $0(M)

24. Lake Co-Mendocino/Lake
Community Coly Demo and
Educational Greenhouse
$175,600(S) $178,549(M)

25. Sierra County
Resource Confirmation in
Sierra Valley
$207,054(S) $7,750(M)

26. City of Susanville
Computer Monitoring of
District Heating System
$26,712(S) $12,439(M)

27. City of Susanville
Pipeline Extension
$143,437(S) $9,346(M)

28. City of Susanville
Installation of Variable
Speed Pump
$43,238(S) $5,072(M)

29. Konocti School District
Purchase of School Bus
$65,000(S) $923(M)

30. County of Lake
Land Use Mapping in The
Geyser
$21,277(S) $5,426(M)

31. County of Riverside
Geothermal Energy in
Riverside County
$33,300(S) $18,000(M)

32. City of Lake Elsinore
Geothermal Development
Program
$163,928(S) $55,200(M)

33. County of San Bernardino
Design and Retrofit of GSA
$25,740(S) $5,680(M)

34. County of San Bernardino
Design and Retrofit of the
Sheriff's Office
$15,000(S) $14,510(M)

35. County of San Bernardino
Design and Retrofit of EPWA
$50,540(S) $25,160(M)

36. County of San Bernardino
Design and Retrofit of the
Central Jail
$45,000(S) $27,260(M)

37. County of San Bernardino
Design and Retrofit of
County Center
$996,000(S) $35,750(M)

38. Surprise Valley Hospital
Space Heating for the Hospital
$180,000(S) $18,000(M)

39. Mendocino County RCD
Baseline Data Collection
for Pieta Creek
$33,930(S) $9,718(M)

40. County of San Bernardino
Resource Assessment in
29 Palms
$75,000(S) $3,717(M)

41. City of Lakeport
Analysis of Municipal
Small Scale Electric
$22,500(S) $7,000(M)

42. Lake County APOD
Continuous H,S Monitoring
and Process Control
$30,000(S) $7,150(M)

43. Calif. Pines Com. Service
Dist.; Geothermal Pool and
Space Heating
$30,000(S) $7,150(M)

44. County of Lassen
Feasibility Study of Geo-
thermal Space Heating
$35,000(S) $1,772(M)

45. Fort Bidwell Indian Com-
Community; Slim Bore Exploratory
Well
$19,800(S) $12,430(M)

46. Kern Council of Governments
High Temperature Exploration
Program
$61,309(S) $6,309(M)

**Seminars, Tours, and Conferences**

**Stanford Geothermal Program Seminars**

Under the aegis of the Stanford Geothermal Program, the following seminars are scheduled. All will be held in Room 867, Mitchell Building, Stanford University, from 1:15 to 2:30 p.m. The seminars are open to the public and are free of charge.

For further information, contact Jon S. Guddmundsson, Petroleum Engineering Department, Stanford University, at (415) 497-1218.
59th Annual Meeting, AAPG-SEPM-SEG, The meeting will include three days of technical sessions, a poster session, and special sessions, among other activities. For further information, contact the GRC Meetings Group, P.O. Box 1350, Davis, California 95617.


The international meeting will be an expansion to 4 days of the 1985 GRC annual meeting. Special international update sessions along with worldwide geothermal development will be discussed. Field trips, special courses, and seminars may be included.

For further information, contact the GRC Meetings Group, P.O. Box 1350, Davis, California 95617.

Maps

Geological world atlas. $190.00 plus $15.00 shipping and handling in North America and $35.00 elsewhere. The atlas, started in 1911, is co-published by the Commission for the Geologic Map of the World and UNESCO. The American Association of Petroleum Geologists is the North American distributor. Available from the AAPG Bookstore, P.O. Box 979, Tulsa, Oklahoma 74101.

The atlas contains valuable geologic data compiled by geologists and geophysicists around the world.

- Geologic map index of California, 1982. By W.L. McIntosh and M.P. Eister. Free. Published by and available from the U.S.G.S., Distribution Branch, Box 25286, Federal Center, Denver, Colorado 80225.

- Geologic map of the Santa Rosa Quadrangle, 1967, by D.L. Wagner and R.J. Boruguio. $15.00. Published by and available from the California Division of Mines and Geology, P.O. Box 2980, Sacramento, California 95814.

The map includes 5 sheets drawn at a scale of 1:250,000 and a list of thermal springs and wells, and the radiometric ages of rocks in the Santa Rosa Quadrangle.

- Geothermal Resources of Texas. 1982. Scale 1:1,000,000. Free. Available from the Bureau of Economic Geology, The University of Texas at Austin, University Station, Box X, Austin, Texas 78712.

The map includes a table with data on selected thermal wells and springs of Texas and a generalized map with Texas regional structural-tectonic features.

- Geologic map of Oregon west of the 121st Meridian (the western half of the state). Miscellaneous Geologic Investigations Map I-325, U.S.G.S. $5.00. Scale 1:1,500,000.

- Order from the Oregon Dept. of Geology and Mineral Industries, 1005 State Office Building, Portland, Oregon 97201.


- The publication contains an overview of energy data for the United States, by state.

- EIA publications directory, the Energy Information directory, and the directory of energy data collection forms. Free. Published by and available from the National Energy Information Center, DOE, 1000 Independence Avenue, S.W., Washington, D.C. 20585.

- 69th Annual Report of the State Oil and Gas Supervisor. 1983. 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 1982 California geothermal activities.

- Lassen Volcanic National Park

The following publications are available from the OFSS, Western Distribution Branch, USGS, Box 25425, Federal Center, Denver, Colorado 80225:

- Precision gravity network for monitoring the Lassen geothermal system, Northern California. OF 83-0193. By R.C. Jachens and R.W. Saltus. 1 over-sized sheet. $5.00, microfiche $4.00.

- Basic data for thermal springs and wells and records in the KGRA. By M.J. Reed, R.H. Mariner, C.A. Brook, and M.L. Sorey. $17.00; microfiche $3.50. Published by and available from OFSS, Western Distribution Branch, USGS, Box 25425, Federal Center, Denver, Colorado 80225.


- Chemical analyses of thermal and nonthermal springs in Lassen Volcanic National Park and vicinity. Open File Report 83-0311. $3.50; microfiche $3.50.


A workbook developed in conjunction with a course presented in June 1983. Contributing authors are from the California Energy Commission, the Public Utilities Commission, San Diego Gas and Electric Company, and other companies involved in cogeneration projects at California industrial, commercial, and institutional sites.

- The following publications are published by and available from the California Energy Commission, Publication Unit, 1316 Ninth Street, MS #13, Sacramento, California 95814.

- Project Status Report No. 5. $14.00. Identifies and describes over 1,800 potential future electric generation projects in which California investor-owned utilities, municipal utilities, local irrigation districts, and the California Department of Water Resources have an ownership interest or from which they expect to receive energy.

- Securing California's energy future: 1983 biennial report. $10.00.

In the report, emerging energy supply and demand trends are identified. The level of statewide and service area electrical energy demand for each year in the forthcoming 5, 12, and 20-year periods is included.


In the report, existing public services and fiscal resources in Sonoma, Lake, Mendocino, and Napa Counties (counties included in The Geysers KGRA) are described. Public services impacts...
and fiscal impacts of two geothermal development plans are analyzed. A method is provided for calculating mitigation fees for geothermally related impacts on local schools and roads.

Small-scale systems using geothermal energy: a guide to development. Publication number P500-83-011. $2.20.

An overview of small-scale (100 kilowatts to 10 megawatts) electrical systems that could be developed with geothermal hot water as the energy source. Resource considerations, small-scale technologies, and financial incentives are discussed.

Feasibility of geothermal direct use applications in San Bernardino, California. Publication number P500-83-013. $3.15.

A proposed geothermal district heating system is described in the report. An analysis of project and user costs and paybacks is included.

UPDATE


The results of magnetic, gravity, and electrical resistivity surveys conducted in the Ruhrt Park area are presented in this report. Subsurface volcanic rocks which possibly contain warm water aquifers were mapped.


The results of magnetic, gravity, and electrical resistivity surveys conducted in the central portion of the Sonoma State Hospital area are presented in this report. Subsurface volcanic rocks which possibly contain warm water aquifers were mapped.


The article contains a newly compiled gravity map of the Calistoga and St. Helena, California, U.S. Geological Survey 15-minute quadrangles. An interpretive model is presented showing the relationship of selected gravity anomalies to the geology and geothermal resources of the area.


The report presents geological, geothermal, and historical data for another 40 low-temperature geothermal sites located throughout California.

A brief summary of OFR 82-4 SAC appears with the announcement of availability in CALIFORNIA GEOL0gy (June 1983), v. 36, no. 6, p. 135-136.


The article presents the results and conclusions of a U.S. Geological Survey geothermal and geologic-investigation of the Newberry Volcano area of the Cascade Range in central Oregon. Included are geologic and temperature data from two exploratory holes drilled near the caldera.


The report presents the data and results of a detailed scientific geothermal resource inventory of the Pass ROohn geothermal area, San Luis Obispo County. The history of geothermal development, geology, geochemistry, hydrology, geophysical surveys, temperature measurements, and geothermal reservoir characteristics are described in the report.

A brief summary of OFR 83-11 SAC appears with the announcement of availability in CALIFORNIA GEOL0gy (October 1983), v. 36, no. 10, p. 229.


The results of magnetic, gravity, and electrical resistivity surveys conducted near the city of Santa Rosa, Sonoma County, are presented in the report. Interpretation of data suggests that the known low-temperature geothermal reservoirs in the area are within a dense mass of volcanic rocks underlying the eastern part of Santa Rosa and Bennett Valley.

A brief summary of OFR 83-9 SAC appears with the announcement of availability in CALIFORNIA GEOL0gy (May 1983), v. 36, no. 5, p. 116.


A section of this article describes the nature and potential of interstratified zones within volcanic rocks as geothermal reservoirs in an area near Copco Lake, Siskiyou County, California.


The report describes detailed geological, geophysical, and geothermal investigations of the area immediately southwest of Bridgport, Mono County, as well as a regional geothermal evaluation of the Bodie Hills. The results of the investigations are used to speculate on the source of the thermal water and the nature of the area's source of heat.

A brief summary of OFR 83-14 SAC appears with the announcement of availability in CALIFORNIA GEOL0gy (September 1983), v. 36, no. 9, p. 194.


A 4 by 5 foot, color map of California with more than 600 geothermal wells and springs annotated. In addition to temperature data, the map presents information on water chemistry including some mineral concentrations and water chemical type. An accompanying explanatory text contains tables and maps.


This report presents the data and results of a scientific geothermal resource inventory of the northern Sonoma Valley area, Sonoma County. History of known warm water springs in the area, geology, geothermal investigations, seismics, shallow and moderately deep hot subsurface temperatures, hydrology, geochemistry, and general geothermal reservoir characteristics are described in this report. Also included is an overall comparison of the geothermal resources of the northern Sonoma Valley area with the geothermal resources of the southern portions of the valley.

A brief summary of OFR 83-27 SAC appears with the announcement of availability in this issue of CALIFORNIA GEOL0gy, p. 251.


This report presents the data and results of a detailed scientific geothermal reservoir investigation of the Sonoma Valley area, Sonoma County. Historical geothermal development, geology, geothermal reservoir characteristics, and geothermal reservoir characteristics are discussed in the report.

A brief summary of OFR 83-13 SAC appears with the announcement of availability in CALIFORNIA GEOL0gy (June 1983), v. 36, no. 6, p. 134.


The report is a compilation of existing scientific data and newly acquired downhole temperature data, interpreted to evaluate the low-temperature geothermal resources of the Big Valley area, Lake County, California. History of the known warm springs in the area, geology, hydrology, downhole temperature measurements, geophysical results, and geological data are discussed in the report.

Publications may be ordered from the California Division of Mines and Geology, P.O. Box 2980, Sacramento, California 95812.

NMG Publications

The following publications are published and available from the Nevada Bureau of Mines and Geology, University of Nevada, Reno, Nevada 89557-0088.

The Nevada mineral industry, 1982. $5.50 by mail. Geothermal drilling and utilization are among the topics discussed in this overview of 1982 mineral industry activity.

A mineral inventory of the Elko Resource Area, Open-file report 83-9. $32.00.


Oregon Geothermal energy publications. Free. Published by and available from the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, Oregon 97201.

A wide variety of geothermal publications is available from the Oregon Department of Geology and Mineral Industries. A monthly publication, Oregon Geology, also published by this department, often contains geothermal information. Oregon Geology is published monthly, is available for $6.00 a year or $15.00 for 3 years.


The list includes many geothermal publications. Most of the new publications are assessments of geothermal areas in Colorado. One, on another topic, is titled Industrial Market Opportunities for Geothermal Energy in Colorado, and is available for $1.00 by mail.

Energy alternatives in Latin America. Edited by Francisco Szekely. $25.00 paper, $50.00 cloth. Available from UNIPUB, 1180 Avenue of the Americas, New York, N.Y. 10036.

In the United Nations publication, the potentials of new and renewable energy sources in Latin America are assessed.


Includes over 70 research and project assessment papers presented in technical sessions that include regional exploration and reservoir assessment and local exploration and drilling.

Geologic assessment of the fossil energy and geothermal potential of the Sudan. By L.W. Setlow. $7.75; microfiche $3.50. Published by and available from the OFS5, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225.

Geothermal resources: energy on tap. Transactions, Volume 7, for the 1963 Annual Meeting of the Geothermal Resources Council. $33.00. Compiled by and available from the GRC, P.O. Box 1350, Davis, California 95617.

The volume includes a special section on the Cascades and Unalaska Island, one of the Fox Islands in the central portion of the Aleutian Islands area. A list of the many GRC publications can be ordered from the address.

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California Wells

CDOG Collects Geothermal Well Data

Every month, the California Division of Oil and Gas collects geothermal production and injection data from the state's geothermal operators. A computer-generated file of these geothermal production and injection statistics for wells with records open to public inspection is available from the division for $50.00. Also available is an instruction booklet for operators submitting these data. The booklet is called Manually Prepared Geothermal Steam Production, Water Production, and Injection Reports.

Drilling Permits for Geothermal Wells Approved June 1983

Through December 1983 by the California Division of Oil and Gas

Date Notice Operator & Well No. API No. Sec. T. R. Location & Elevation

LAKE COUNTY

5/24/83 Union Oil Co. of Calif. 033-90465 8 11N 8W Fr. SE cor. 712m N, 853m W, 1026.5m KB.

6/20/83 Union Oil Co. of Calif. 033-90460 30 12N 8W Fr. SW cor. 17m N, 409m E, 889.7m KB.

High Valley St* 39A-30


The book contains recent advances in the application of isotopic and chemical techniques and recommendations to the IANA on future activities and developments.


The authors state that an understanding of rates of hydrothermal reactions would allow predictions to be made for reactions in geothermal and metamorphic systems. After undertaking a literature review, they discovered a general Arrhenius relation between reaction rate and temperature that appears to hold over temperatures from 25° to 710°C. It also holds for a large number of different silicate and related mineral species.
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<td>Fr. SE cor. 91.4m N, 213.4m E. -39.0m GR.</td>
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<td>Fr. SE cor. 518.2m N, 304.8m W. -45.7m GR.</td>
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<td>025-90573</td>
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<td>Board of Water Commissioners, Municipal Water Dept., City of San Bernardino</td>
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<td>Fr. centerline of intersection, Mill St. and Arrowhead Ave., 63m N, 236m W. 305m GR.</td>
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