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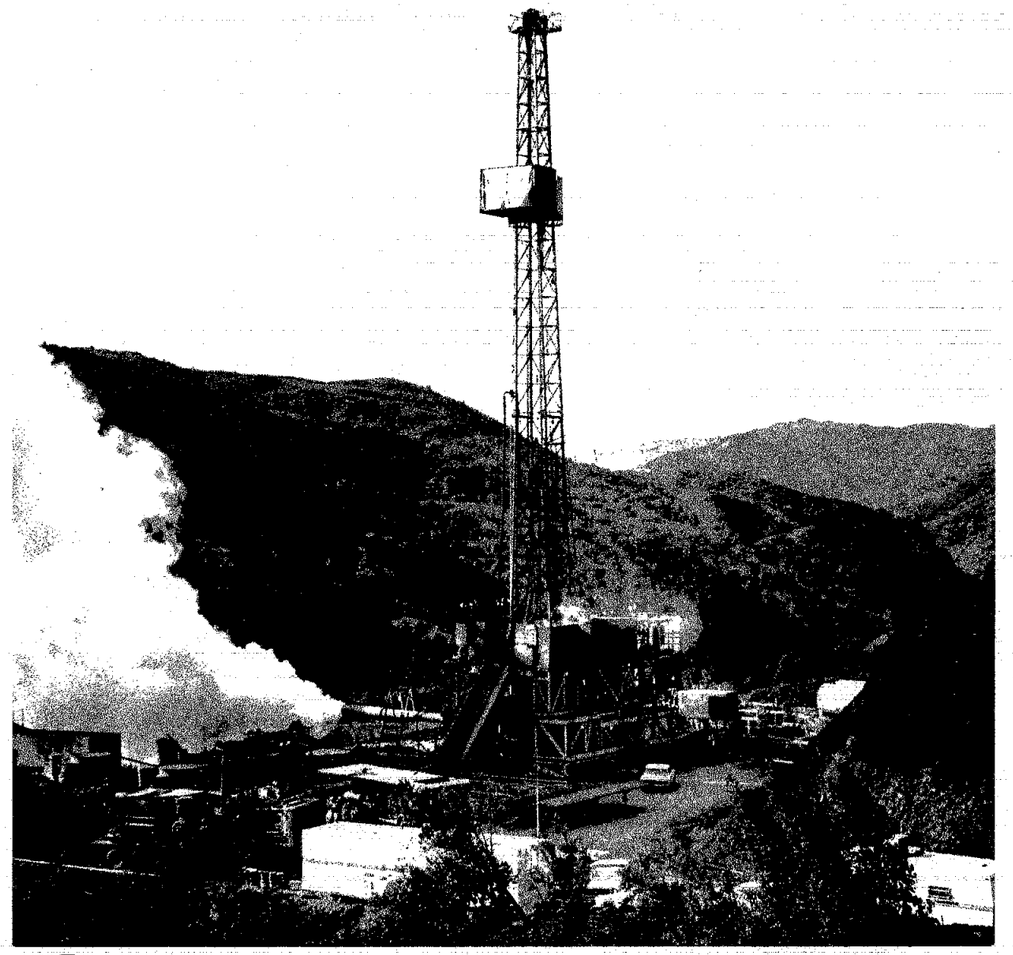
Cover photo: *Aerial view of The Geysers Geothermal field in 1975. Such photographs are used to help select well sites at the field. Article on page 6.*

Photo courtesy of the U. S. Bureau of Land Management.

the GEOTHERMAL HOT·LINE



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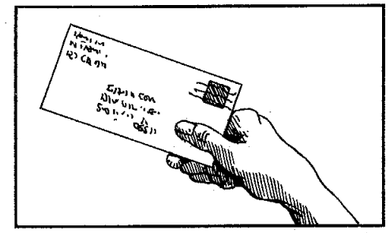

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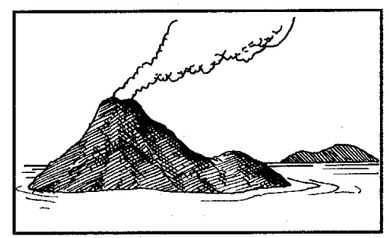

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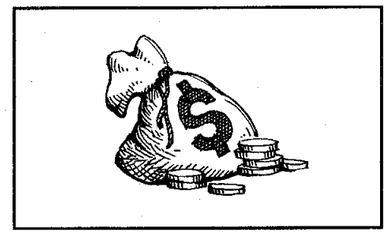

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CALIFORNIA

We Have Moved and Our Name Will Change

The Department of Conservation, Division of Oil and Gas has moved to a building a few blocks north of our old address. Our phone numbers are the same, and our new address is:

Department of Conservation
Division of Oil & Gas, MS 20
801 K Street, 20th Floor
Sacramento, CA 95814-3530

In January 1993, by statute, our name will change. We will become the Division of Oil, Gas, and Geothermal Resources.

California Activity in 1991

By law, the Department of Conservation, Division of Oil and Gas publishes annual geothermal statistics for the State of California. The following material describes 1991 activities.

During 1991, the Geothermal Section of the California Department of Conservation, Division of Oil and Gas, received and permitted 19 proposals to drill, 53 to rework, and 17 to plug and abandon geothermal wells on state and private lands, the same total number of notices as in 1990. Eight geothermal production wells were completed on nonfederal lands in 1991, compared with 10 wells in 1990. The number of well- and lease-inspections increased from 2,543 in 1990 to 2,826 in 1991.

New-well drilling continued to be slow at The Geysers Geothermal field, as new wells have failed to increase significantly the field's overall production. Moderate activity occurred during the year at the Salton Sea Geothermal field in the Imperial Valley.

Low-temperature geothermal exploration and development were also slow in 1991. Once again, Geothermal Grant and Loan Program managed by the California Energy Commission provided most state-financed expenditures earmarked for such activities.

In 1991, the Geothermal Section's CEQA Unit received three applications for exploratory projects: one in the City of Twentynine Palms, one in the City of Loma Linda, and one in Mammoth Lakes. Notices of Exemption were granted for all three projects, which will be undertaken to evaluate geothermal reservoirs in these respective areas. Two such applications were received in 1990.

Additional information is in the *77th Annual Report of the State Oil and Gas Supervisor*, available free of charge from the Division of Oil and Gas in Sacramento.

BLM Geothermal Summary

In 1991, about 949 megawatts of electricity equaled the installed capacity of geothermal electrical production from lands leased from the U. S. Bureau of Land Management (BLM) in California. The amount was about 91 percent of the installed capacity of the nation's federal geothermal production, and earned $15.4 million in federal rents and royalties. Fifty percent of the amount is paid to the treasury of the State of California.

At the East Mesa geothermal area in the Imperial Valley, six power plants produced 123 megawatts of electricity. To the north near Mammoth Lakes, Pacific Energy's PLES I Power Plant, a 15-megawatt facility, began commercial operation in December 1990. The BLM is monitoring the well field and springs surrounding the power plant to ensure plant operation won't affect other area water users.

At The Geysers Geothermal field in Northern California, the BLM works with federal and state agencies and private companies to extend the life of the reservoir. Both the selective injection study initiated on federal leases last year, and the operation of power plants at varying power levels continue to show promise in reducing the overall pressure decline in portions of the reservoir.

Interest continues to be expressed by the geothermal industry to explore federal lands within the Randsburg Known Geothermal Resource Area in the California desert. As with Glass Mountain, sensitive wildlife issues, in this case involving the threatened desert tortoise, must be resolved before the BLM will be able to offer any lands under a competitive sale.

Reprinted from *Public Lands in California*, the 1991 Annual Report of the Bureau of Land Management.

New Reservoir Assessment

A new assessment of long-term electrical generating capacity for liquid-dominated geothermal reservoirs in most California Known Geothermal Resource Areas (KGRA's) was published in 1991. (The Lassen KGRA was not included because much of it is in a national park.) The study was carried out by Ebasco Services under a contract with the California Energy Commission. The study is especially interesting because the most recently published data of this nature were calculated in the mid-1970s by the U. S. Geological Survey. These were printed in USGS Circular 790.

Ebasco conducted no field investigations for the study. The limit on the amount of proprietary data made available to the company affected, writes Ebasco, the "accuracy and reliability" of the report. With these caveats in mind, Ebasco found that since the USGS study, "...about 13 years of exploration and production data have been acquired." From the updated data, the company estimated a 59 percent drop from USGS estimates in the potential electrical-generation capacity of liquid-dominated geothermal reservoirs in and adjacent to California. In potential megawatts, the fall is from 11,084 to 4,563.

The Ebasco findings are summarized in this table. All information is reprinted with permission of Ebasco and the California Energy Commission.

Summary of selected liquid-dominated geothermal reservoirs associated with KGRA's in California. (ND = no data)

No.	KGRA	TEMPERATURE min (deg C)	TEMPERATURE mean (deg C)	TEMPERATURE max (deg C)	Volume mean (km^3)	Thermal Energy (10^18 J)	Wa/qr, Fig 1	Work Available (10^18 J)	Proven Capacity (MWe30yr)	Probable Capacity (MWe30yr)	Calculated Potential Capacity (MWe30yr)	Estimated Potential Capacity (MWe30yr)	USGS estimate (MWe30yr)	% Change
1	Bodie	87	87	139	18	3.50	0.031	0.11	0	0	46	0		
2	Brawley	230	246	280	27	16.84	0.065	1.09	10	250	463	463	640	-28%
3	Calistoga	137	140	153	2	0.68	0.044	0.03	0	0	13	0		
4	Coso Hot Springs	156	230	341	28	16.25	0.06267	1.02	240	390	431	431	650	-34%
5	Dunes	105	121	170	6	1.72	0.0385	0.07	0	0	28	0		
6	East Brawley	200	204	280	5	2.55	0.0533	0.14	0	10	57	57		
7	East Mesa	138	170	182	30	12.56	0.04783	0.60	101	200	254	254	360	-29%
8	Glamis	105	121	170	2.8	0.80	0.038	0.03	0	0	13	0		
9	Glass Mt./Medicine Lake	ND	250	ND	150	95.18	0.065	6.19	ND	350	2816	750		
10	Heber	160	181	191	15	6.72	0.05083	0.34	47	75	144	144	650	-78%
11	Lake City/Surprise Valley	121	160	185	70	27.41	0.04333	1.19	10	100	502	502	1490	-66%
12	Mono–Long Valley	140	196	280	25	12.22	0.057	0.70	30	200	294	294	2100	-86%
13	Randsburg	115	125	250	2	0.59	0.04167	0.02	0	0	10	0	84	-100%
14	Saline Valley	ND	110	ND	1	0.26	0.0373	0.01	0	0	4	0		
15	Salton Sea	232	265	340	64	43.20	0.068	2.94	192	298.5	1242	1242	3400	-63%
16	Sespe Hot Springs	109	131	148	2	0.63	0.04233	0.03	0	0	11	0		
17	South Brawley (Mesquite)	230	260	280	15	9.92	0.066	0.65	0	50	277	277		
18	Wendel–Amedee	107	117	143	3	0.83	0.0373	0.03	0.6	10	13	13		
19	Westmorland	200	217	235	10	5.45	0.0585	0.32		15	135	135	1710	-92%
	TOTAL/MEAN	135	175	198	25	13.54			630.6	1948.5	6553	4563	11084	-59%

Unocal Reorganizes

On July 8, 1992, Unocal Corporation announced a major reorganization of its operating business units as part of the company-wide restructuring program announced in April. The company also announced other steps it proposes to take to accelerate its program of reducing debt by $1.5 billion over the next 5 years and increasing cash flow.

The reorganization consolidates the company's operating divisions into two main units, the Energy Resources Division, which encompasses Unocal's upstream activities, and the Petroleum Products & Chemicals Division, which consolidates the refining, marketing, and chemicals business segments.

With this restructuring, the company will eliminate about 1,100 positions and implement other significant expense reductions in 1992. Earlier, Unocal projected that employee reductions would range between 800 and 1,200. The company anticipates the expense and work force reductions will increase after-tax cash flow by $200 million a year, beginning in 1993.

With the reorganization of its operating units, the company will eliminate 450 positions in petroleum and geothermal energy exploration and production, 400 in downstream operations, and another 250 in corporate staff and research groups.

The new Energy Resources Division will combine three existing divisions -- International Oil and Gas, North American Oil and Gas, and Geothermal -- and eliminate or downsize the seven regional structures in North America.

Staff functions from the three existing divisions and some of the former regions will be consolidated. The total employee reduction for Energy Resources is more than 16 percent of the salaried work force. Executive level positions and total salaries will be reduced by more than 20 percent.

The Energy Resources Division will be divided into four line groups, one of which will be geothermal resource and development and power generation. U. S. geothermal operations will be consolidated, with most personnel based in Santa Rosa, California.

The company has identified and started the sales process of additional nonstrategic assets, which could generate at least $700 million in after-tax proceeds over the next 2 years.

Sale Considered of Imperial Valley Geothermal Operations

On August 19, 1992, Unocal Corporation announced it is considering the sale of its Imperial Valley, California, geothermal energy assets as part of a company-wide restructuring program announced earlier in the year.

Unocal has significant geothermal interests in the Brawley, Holtville, Salton Sea, Truckhaven, and Wister areas. The company currently has geothermal operations at the southern tip of the Salton Sea, including geothermal resource production facilities and three electrical generating plants with a nominal capacity of 80 megawatts.

"Geothermal is a profitable business for us, and we expect to obtain a premium price for these assets," said Richard J. Stegemeier, Unocal chairman and chief executive officer. "We intend to use some of the proceeds from this sale to help accelerate the development of undeveloped reserves in our core crude oil and natural gas businesses."

During the course of any sale activities, Unocal will continue to seek new power contracts with investor-owned utilities through the upcoming Biennial Resource Plan Update (BRPU) bidding process. As part of the BRPU, about 250 megawatts of needed power in Southern California have been set aside for supply from renewable energies, including geothermal.

"Unocal is in a strong position to compete for that portion of the new power generation contracts set aside for renewable energies," said Darcel Hulse, vice president, Geothermal Resources and Power Generation. Hulse noted that development of Unocal's acreage in the Salton Sea area could more than meet these power needs, using the company's proprietary technology for processing the highly saline geothermal brines in the area.

In recent months, the company has sold its polymers and chemicals distribution businesses, its product terminals network in the Southeastern U. S., and other assets. So far this year, asset sales have generated after-tax proceeds of nearly $330 million.

The company expects to generate another $700 million in after-tax proceeds over the next two years from the sale of additional assets. The contemplated sale of the Imperial Valley geothermal operations is one of the assets to be offered under this program.

NORTHERN CALIFORNIA

The Geysers Production

As of mid-October 1991, 1,326 megawatts of electricity were being produced from The Geysers Geothermal field. Almost a year later, in mid-August 1992, 1,221 megawatts were being produced.

A table in the *77th Annual Report of the State Oil & Gas Supervisor, 1991*, shows the amounts of gross steam produced from geothermal wells at The Geysers Geothermal field from 1968 to the present. Steam production at The Geysers has declined from a high of 111,821,897,000 kilograms in 1987 to 89,668,858,000 kilograms in 1991. With the decline in steam production, several older, less efficient power plants in the field have been retired, others have been closed or placed on standby, and most are operating at a reduced capacity.

The following table indicates the current output/status of the power plants as of mid-August 1992, along with their rated gross capacities.

by Kenneth F. Stelling
Geothermal District Engineer

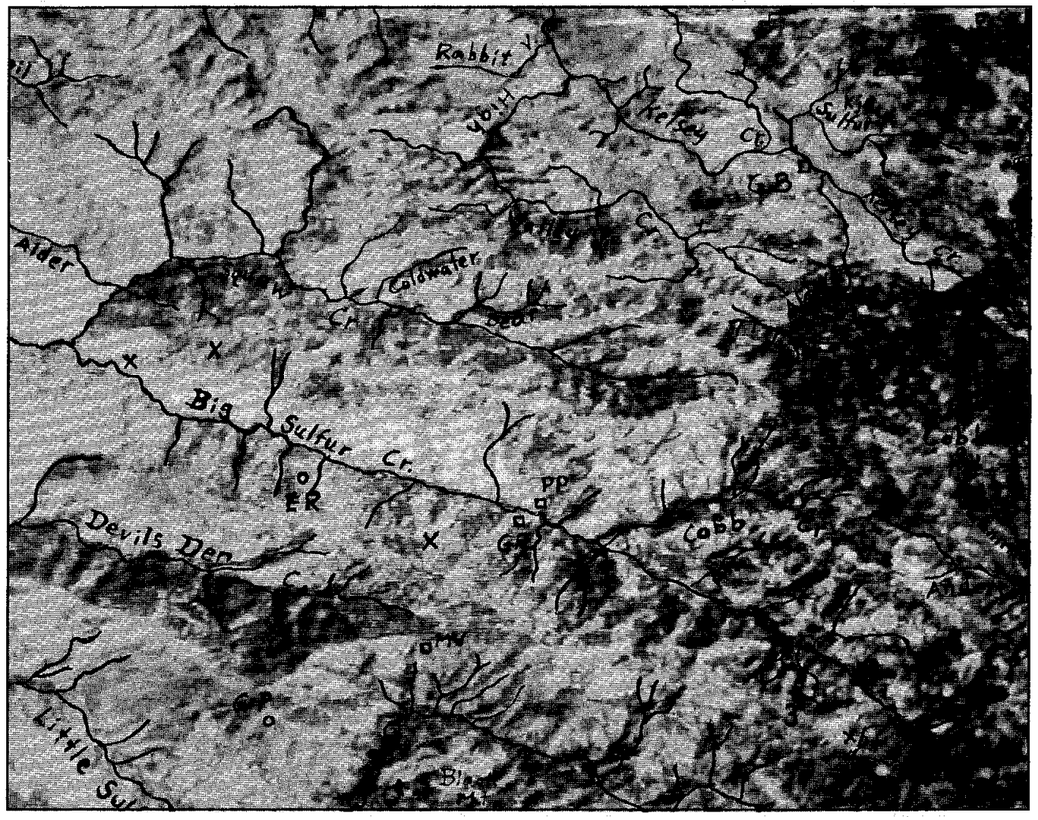
Steam Supplier	Power Plant Owner [1]	Power Plant Unit	Date On Line	Gross Capacity (Megawatts)	Output, Aug. 1992 (Megawatts)
UNION OIL CO. OF CA.	PG&E	Unit 1	9/60	12	Retired
		Unit 2	3/63	14	Retired
UNION OIL CO. OF CA.	PG&E	Unit 3	4/67	28	Retired
		Unit 4	11/68	28	Retired
UNION OIL CO. OF CA.	PG&E	Unit 5	12/71	55	50
		Unit 6	12/71	55	49
UNION OIL CO. OF CA.	PG&E	Unit 7	11/72	55	down
		Unit 8	11/72	55	49
UNION OIL CO. OF CA.	PG&E	Unit 9	11/73	55	38
		Unit 10	11/73	55	39
UNION OIL CO. OF CA.	PG&E	Unit 11	5/75	110	75
UNION OIL CO. OF CA.	PG&E	Unit 12	3/79	110	43
GEO OPERATOR CORP.	PG&E	Unit 15*	6/79	62	Retired
SANTA ROSA GEOTHERMAL	PG&E	Unit 13	5/80	138	99
UNION OIL CO. OF CA.	PG&E	Unit 14	9/80	114	61
UNION OIL CO. OF CA.	PG&E	Unit 17	12/82	119	49
NORTHERN CA. POWER AUTHORITY	NCPA	NCPA 1	1/83	122	75
UNION OIL CO. OF CA.	PG&E	Unit 18	2/83	119	71
SANTA ROSA GEOTHERMAL	SMUD	SMUDGEO 1	10/83	78	78
SANTA FE GEOTHERMAL	SANTA FE GEOTH.	Santa Fe 1	4/84	85	80
DEPT. OF WATER RESOURCES	DWR	Bottlerock**	3/85	55	Suspended
UNION OIL CO. OF CA.	PG&E	Unit 20	10/85	119	76
SANTA ROSA GEOTHERMAL	PG&E	Unit 16	10/85	119	89
NORTHERN CA. POWER AUTHORITY	NCPA	NCPA 2	11/85	124	75
COLDWATER CREEK OPER. CORP.	CCPA	Unit 1	5/88	65	55
SANTA ROSA GEOTHERMAL	SANTA ROSA GEOTHERMAL	Bear Canyon Creek	9/88	22	22
COLDWATER CREEK OPER. CORP.	CCPA	Unit 2	10/88	65	Standby
SANTA ROSA GEOTHERMAL	SANTA ROSA GEOTHERMAL	West Ford Flat	12/88	30	30
GEOTHERMAL ENERGY PARTNERS	GEOTHERMAL ENERGY PARTNERS	Aidlin 1	6/89	25	18
		Totals		**2,093**	**1,221**

[1]CCPA = Central California Power Agency
DWR = Calif. Dept. of Water Resources
NCPA = Northern California Power Agency
PG&E = Pacific Gas and Electric Company
SMUD = Sacramento Municipal Utilities District

*Sale of PG&E's Unit 15 is in negotiations with a new corporation, Geysers Power, Incorporated.

**The Department of Water Resources' Bottlerock Power Plant has all of its production wells suspended, with cement plugs placed in the well bores. Currently, the power plant is not scheduled to resume operation.

Geysers Aerial Photo



The image of The Geysers Geothermal field was sensed May 17, 1984, by an U-2 aircraft operated out of Ames Laboratory (NASA contractor), using the Daedalus Thematic Mapper Simulator. The system records solar reflectance in 12 spectral channels or bands ranging from Ultraviolet through visible, and near Infrared to Thermal Infrared (heat, bands 11 and 12). As bands 11 and 12 cover the same wavelength and differ only in amplification, the lower-gain band 11 was eliminated. The field was sensed from 65,000 feet altitude at about 9:00 a.m.

We analyzed the resulting Ames data in the Digital Image Analysis Laboratory of the Kodak Remote Sensing Company (formerly of General Electric Space Division) in Landover, Maryland, using the Interactive Multispectral Analyzer (IMAGE-100) developed by General Electric Co. We produced 157 spectrally different enhancements by combining the 11 bands in different ways.

This enhancement combines bands 10, 9, and 8, assigned to blue, green, and red, respectively. (The original photo is in color.) Band 10 covers 2.08 - 2.35 microns wavelength in the near Infrared and favors ultramafic rocks such as serpentinite, and less so some mafic rocks such as basalt or diabase. Band 9 covers the spectrum from 1.55 - 1.75 microns and modestly favors hydrothermally altered rocks. Band 8 covers 0.91 - 1.05 microns and does not portray any common rock or vegetation. However, it favors hydrated evaporite salts and highlights fairly faithfully the area of the steam field.

Caption and photo are courtesy of John W. Gabelman & Associates, Inc., 23 Portland Court, Danville, CA 94526. Phone (415) 837-5989.

Selecting, Engineering, and Constructing Drilling Sites at The Geysers Geothermal Field

Care must be taken in selecting, engineering, and constructing drilling sites for wells at The Geysers Geothermal field in Northern California. The steep terrain, thin soils, and heavy annual rainfall make for unstable conditions, resulting in many landslides in the area.

Aerial Photographs

To choose a drilling site, an operator's engineering staff often begins by reviewing aerial photographs. Next, the staff geologist may contact the Division of Oil and Gas in the Santa Rosa district office to discuss potential sites. The division staff uses similar photographs to study the site.

Engineering

Initial Studies

After a potential site is chosen, the operator's geologist may ask to look at it in the field with division representatives. Such meetings are helpful to pinpoint problems and resolve differences of opinion before formal geological reports and site plans are made. If no joint field study is made, division engineers will undertake their own study after receiving the geologist's report from the operator.

Test Borings

The operator submits results of all test borings to the division for review. The operator is notified if questions occur or if more borings are required.

Soil Tests

Soil samples from the drill site are sent by the operator to a soils laboratory for analysis. The samples are tested under the procedures of the American Society for Testing Materials. The tests might include Atterberg limit tests for the water content of soil; permeability tests for the flow of water through soil; optimum moisture content tests, measuring to what water content and maximum density a soil can be compacted; unconfined-compression tests, measuring the stress deformation as the load on a sample is increased; consolidation tests, measuring the total-volume decrease with load over time; and shear tests, measuring soil resistance to sliding. Test results are sent to the division. The operator is notified when further tests are needed.

The operator's engineering staff ensures that the soils meet earthquake standards, county construction standards, and general engineering standards. Although the division does not set standards for civil construction of drilling pads, it reviews the projects for compliance with local and industry standards.

Engineering Drawings

A civil engineer, hired by the operator, prepares plans of the proposed work at the well site. The plans are submitted to the division. They include maps to show the access road to the pad, any spoil areas for excess material, and complete plan and cross-sectional drawings of the site.

The plans are reviewed by the division engineer, who notifies the operator if changes or clarifications are needed. Once the site plans are approved and all permits received, an engineering contractor may begin site construction.

Construction

Land Survey

The operator hires surveyors to stake the well site. The site survey shows the extent of the proposed construction and the locations of the cut- and fill-areas. Division engineers verify that the staked and surveyed site corresponds with the site plan, and that the contours on the plan match those of the actual area. They locate the geological features in the construction area mentioned in the original site report.

Clearing

The well site is cleared of all vegetation. Cleared trees, brush, and other debris are stored or buried off site. Division engineers check to see that none of the vegetation is incorporated into the fill material used to construct the well pad. The vegetation would decompose, which could cause the fill material to subside and an important trench, called a keyway, to fail.

by Kenneth F. Stelling
Geothermal District Engineer

Keyways

A keyway is a large trench cut into the toe or bottom of the well site. An operator must excavate the keyway until bedrock is found, removing all loose material. Division engineers inspect the open trench. They check to see that the operator has found bedrock in the keyway at the location noted in the geological report. The keyway excavation must be deep enough to offer proper support for the toe of the fill material that will press against it.

The keyway excavation should verify the findings of any test borings. When this does not occur, this means the interpretations made from the test boring do not represent existing geological conditions. If the actual geology in the field is found to vary greatly from that which was theorized from the borings, the operator's engineers and geologists will be consulted. Modifications or a complete redesign of the site may be necessary.

> "The State Oil and Gas Supervisor shall so supervise the drilling, operation, maintenance, and abandonment of geothermal resources wells as to encourage the greatest ultimate economic recovery of geothermal resources, to prevent damage to life, health, property, and natural resources..." *Chapter 4, Division 3, Public Resources Code.*

Drainage

If any water is found in the key area, drainage measures are begun. Drainage of the keyway area is most important. When water is allowed to stand in the keyway or even to pass through it, the keyway cannot support the well-site fill above it, and the well pad could fail.

Dewatering the keyway is done by inserting a perforated pipe in a gravel or sand bed at the back of the trench. The keyway is excavated more deeply in this area, ensuring that water is trapped in the drainage area and directed away from the site.

Backfill and Compaction

After the empty keyway has been inspected and all necessary drainage plans are completed, backfill operations begin. Lifts of soil, freed of vegetation, are placed in the keyway. (A lift is defined as a specified amount of soil, usually 3- to 5-feet deep.) Each lift is compacted with portable rollers. Tests are made to determine the moisture content and compaction density of the soil. If the test results are satisfactory, lifts of material are continued until the keyway is filled to ground level.

Final Pad Elevation

After the final lift of material is compacted and tested, the top of the well site is graded to control rainfall and other surface runoff that might occur during drilling operations. Rainfall from the area around the pad will not be allowed to flow into the drilling sump. This is because rainfall at The Geysers can exceed 130 inches per year, and the rain water, when combined with fluids from drilling operations, soon could exceed the sump's capacity. The sump must hold only rain falling directly upon the pad and any fluid taken from normal drilling operations.

All-Weather Surface

When the well site has been graded and final elevations approved, a crushed rock, all-weather surface is added. The crushed rock will help control erosion during heavy rains, control dust during dry months, and create a solid working surface for drilling equipment.

Conductor Casing

Inserting and cementing conductor casing is the final construction activity at the well pad. Usually, the hole for the conductor casing, about 30 feet deep, is drilled with a bucket auger. Readymix is used to cement the conductor casing in the well bore. A drilling log kept during the operation is reviewed by division engineers. They check to ensure that geological conditions encountered in the first few feet of the well bore are those described in the geological studies.

Conclusion

Proper well-site construction at The Geysers Geothermal field is undertaken to provide safety and protect life, health, property, and natural resources. The division's geothermal staff in Santa Rosa inspects and approves well site-construction on private and state leases. Every effort is made to construct a stable well site before the drilling begins.

A videotape, titled *Before the Drilling Begins* and produced by the division, is available from the Division of Oil and Gas. It illustrates in more detail the procedures described in this article.

"A Trip to the California Geysers"

The Geysers are situated at the foot of the ridge. When about two-thirds of the way down the hill, the rushing noise of the escaping steam of the Great Geyser can be heard; but, unless the stranger's attention was called to it, he would mistake the sound for the roaring of the river. About this time, too, is recognized the sulphurous smell with which the air is impregnated.

Just as the traveler begins seriously to think that the hill has no bottom, the white gable end of the hotel, looking strangely out of place among its wild surroundings, comes unexpectedly into sight, and his trip is ended.

Upon awakening, on the following morning, it was a difficult matter to convince myself that I had not been transported, while asleep, to the close vicinity of some of the wharves in San Francisco--there was such a powerful smell of what seemed to be ancient dock mud. It was the sulphur. The smell is a trifle unpleasant at first, but one soon becomes accustomed to it, and rather likes it than otherwise.

The witches' cauldron.

The view of the Geysers, from the hotel, is a very striking one, more especially in the morning, when the steam can be plainly seen, issuing from the earth in a hundred different places; the numerous columns uniting at some distance above the earth, and forming an immense cloud, which overhangs the whole canyon.

As the sun advances above the hills, this cloud is speedily "eaten up," and the different columns of steam, with the exception of those from the "Steamboat Geyser", the "Witches' Cauldron", and a few others, become invisible, being evaporated as fast as they issue from the ground.

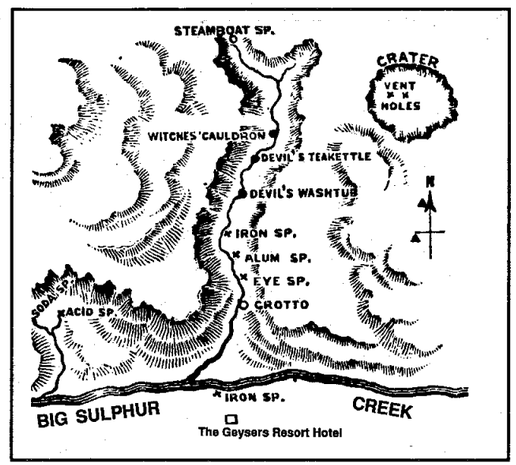
Breakfast disposed of, Mr. G. kindly offered to conduct me to the different springs. The trail descends abruptly from the house, among the tangled undergrowth of the steep mountain side, to the river, some ninety feet below. We passed on the way the long row of bathing-houses, the water for which is conveyed across the river in a lead pipe, from a hot sulphur-spring on the opposite side.

The unearthly looking canyon, in which most of the springs are situated, makes up into the mountains directly from the river. A small stream of water, which rises at the head of the canyon, flows through its whole length. The stream is pure and cold at its source, but gradually becomes heated, and its purity sadly sullied, as it receives the waters of the numerous springs along its banks.

Hot springs and cold springs; white, red, and black sulphur springs; iron, soda, and boiling alum springs; and the deuce only knows what other kind of springs, all pour their medicated waters into the little stream, until its once pure and limpid water,--like a human patient, made sick by over-doctoring,--becomes pale, and has a wheyish, sickly, unnatural look, as it feverishly tosses and tumbles over its rocky bed.

A short distance up the canyon, there is a deep, shady pool, which receives the united waters of all the springs above it. By the time the stream reaches here, its medicated waters become cooled to the temperature of a warm summer day, and the basin forms, perhaps, the most luxurious bath to be opened in the world. A few feet from this, there is a warm alum and iron spring, whose water is more thoroughly impregnated than any of the others.

By Panoramics
Reprinted from Hutchings' California Magazine, *January 1860, Vol. IV, No. 7.*



Map of Geyser Canyon, published in 1892 by Dr. Winslow Anderson.

A little way farther up, is "Proserpine's Grotto," an enchanting retreat among the wild rocks, completely surrounded and enclosed by the fantastic roots and twisted branches of the bay trees, and roofed over by their widespreading foliage. Glimpses of the narrow gorge above, with its numerous cascades, can be obtained through the openings of the trees; the whole forming one of the finest "little bits," as an artist would call it, to be found in the country.

As we proceeded up the canyon, the springs became more numerous. They were bubbling and boiling in every direction. I hardly dared to move, for fear of putting my foot into a spring of boiling alum, or red sulphur, or some other infernal concoction. The water of the stream, too, was now scalding hot, and the rocks, and the crumbling, porous earth, were nearly as hot as the water. I took good care to literally "follow in the footsteps of my illustrious predecessor," as he hopped about from boulder to boulder, or rambled along in (as I thought) dangerous proximity to the boiling waters. Every moment he would pick up a handful of magnesia, or alum, or sulphur, or tartartic acid, or Epsom salts, or some other nasty stuff, plenty of which encrusted all the rocks and earth in the vicinity, and invite me to taste them. From frequent nibblings at the different deposits, my mouth became so puckered up, that all taste was lost for anything.

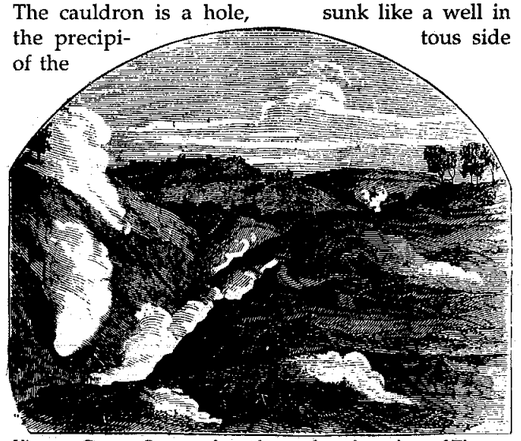
In addition to these strange and unnatural sights, the ear was saluted by a great variety of startling sounds. Every spring had a voice. Some hissed and sputtered like water poured upon red hot iron; others reminded one of the singing of a tea-kettle, or the purring of a cat; and others seethed and bubbled like so many cauldrons of boiling oil. One sounded precisely like the machinery of a grist mill in motion, (it is called "The Devil's Grist Mill,") and another, like the propeller of a steamer.

High above all these sounds, was the loud roaring of the great "Steamboat Geyser." The steam of this Geyser issues with great force from a hole about two feet in diameter, and it is so heated as to be invisible until it has risen to some height from the ground. It is highly dangerous to approach very close to it unless there is sufficient wind to blow the steam aside.

But the most startling of all the various sounds was a continuous subterranean roar, similar to that which precedes an earthquake.

I must confess, that when in the midst of all these horrible sights and sounds, I felt very much like suggesting to G_____ the propriety of returning, but a fresh handful of Epsom salts and alum, mixed, stopped my mouth, and by the time I had ceased sputtering over the puckerish compound, the "Witches' Cauldron," was reached. This is a horrible place. "Mind how you step here," said G_____, as we approached it; and with the utmost caution, I placed my feet in his tracks, that is, as much of them as I could get in.

The cauldron is a hole, sunk like a well in the precipitous side of the



View up Geyser Canyon, from the southern boundary of The Geysers Geothermal field. "Steamboat Geyser" is the large column of steam on the high, left-hand side of the canyon. The large column just below it, nearer the reader, is the famous "Witches' Cauldron." In the foreground is the "Mountain of Fire," from which steam issued through 100 different apertures.

mountain, and is of unknown depth. It is filled to the brim with something that looks very much like burnt cork and water. (I believe the principal ingredient is black sulphur.) This liquid blackness is in constant motion, bubbling and surging from side to side, and throwing up its boiling spray to the height of three or four feet. Its vapor deposits a black sediment on all the rocks in its vicinity.

There are a great many other springs--some two hundred in number, I believe--of every gradation of temperature, from boiling hot to icy cold, and impregnated with all sorts of mineral and chemical compounds; frequently the two extremes of heat and cold are found within a few inches of each other. But as all the other springs present nearly the same characteristics as most of those already referred to, it would be but a tedious repetition to attempt to describe more. They are all wonderful. The ordinary observer can only look at them, and wonder that such things exist; but to the scientific man, one capable of divining the mysterious cause of their action, the study of them must be an exquisite delight.

It is worth the traveler's while to climb the mountains on the north side of the Pluton, for the fine view which their summits afford on every hand; towards the north, a part of Clear Lake can be seen, some fifteen miles distant. But perhaps the scene which would delight a lover of nature most, can be obtained by rising early and walking back half a mile upon the trail which descends to the hotel. It is to see the gorgeous tints of the eastern sky as the sun comes climbing up behind the distant mountains, and afterwards to watch his long slanting rays in the illuminated mist, as they come streaming down the Canyon of the Pluton, flashing on the water in dots and splashes of dazzling light, and tipping the rich shadows of the closely woven foliage with a fringe of gold.

Biphase and Calpine Sign Agreement

On September 28, 1992, Biphase Energy Company and Calpine Corporation announced they have entered into a Project Development Agreement for the use of the Biphase turbine to improve performance of geothermal power plants. When added to currently operating power plants, the Biphase turbine can add up to 30 percent more power using existing well flow; and for new geothermal plants, the best use of geothermal resources is ensured.

The agreement gives Calpine the exclusive rights to use or install the Biphase turbine in the Western Hemisphere. In a typical project, Biphase will perform the engineering and supply the turbine, while Calpine will provide construction management and plant operation. The companies will offer third party projects as well as turnkey installations.

"The Biphase turbine is another element in Calpine's approach to maximize the value derived from geothermal resources," stated Peter Cartwright, president of Calpine. "Our goal is to maximize the amount and reliability of power production from this environmentally clean natural resource. The Biphase turbine converts previously wasted high-pressure, two-phase flow to useful power. In addition to operating conventional geothermal steam plants, we are developing technology to extract power from the previously wasted low-temperature brine. With the addition of the Biphase technology, Calpine now offers the world's highest efficiency utilization of geothermal resources."

Lance Hays, president of Biphase, stated, "We are particularly pleased that the Biphase turbine will now be integrated into the environmentally responsible power generating facilities. The Biphase turbine was invented in 1975, followed by development by the U.S. Department of Energy and the Electric Power Research Institute, and commercialization by Transamerica Delaval and Phillips Petroleum. Working together with Calpine, we are confident of wide application of this technology."

Calpine owns an interest in and operates in excess of 400 megawatts of geothermal facilities and 150 megawatts of gas-fired cogeneration facilities. Biphase is a subsidiary of Douglas Energy Company, which is active in gas turbine and steam turbine power plants and in environmental engineering.

Geo-Ag Heat Center, Lake County

The Geothermal-Agricultural Heat Center in Lake County, California, is a facility developed by the county to promote greenhouse agriculture using geothermal energy.

Phase I of the project was a joint venture between Lake County and the Mendocino/Lake Community College District to demonstrate technical feasibility. The college developed a greenhouse to be used as a teaching facility. The county developed the geothermal and irrigation systems.

Funding was supplied by the California Energy Commission (CEC), the County of Lake, and the Mendocino/Lake Community College District. Contributions were also made by the Geysers Geothermal Company and Pacific Gas & Electric Company.

Phase II is a plan to expand the Geo-Ag Heat Center to demonstrate the project's commercial feasibility. Phase II is funded by the CEC (85 percent) and the County of Lake (15 percent). The irrigation system for the greenhouse will be expanded and the amount of water increased. Geothermal well "Ag Park" No. 2 will be brought into production. About 80,000 square feet of greenhouse capacity will be available for commercial use.

A marketing program is underway to attract greenhouse operators. Brochures describing the facility are distributed at horticultural trade shows, advertising is placed in trade journals, and personal calls are made to prospective clients. Once Phase II is concluded, the county has plans for a Phase III expansion, which includes the acquisition of lands adjacent to the Ag Park.

For additional information, contact Richard Kishi, CEC, Geothermal Grant and Loan Program for Local Jurisdictions, 1516 Ninth Street, Sacramento, CA 95814. Phone (916) 654-4620.

Update: CEC-City of Clearlake HDR

The basic hot dry rock scientific evaluation (Phase II) of the geological subsurface regime in and near the City of Clearlake, California, is closer to completion by Los Alamos National Laboratories, project consultant. The consultant is under a contract to the City of Clearlake; cofunding is provided by the city and the California Energy Commission (CEC). The study will determine the hot dry rock potential of the area.

The six major factors being evaluated include the:

(1) Thermal gradients;

(2) Geological structure, including lithology, permeability, and thermal conductivity;

(3) Subsurface geohydrology, including fluid phases and flow boundaries;

(4) Seismicity, including interaction of fluids with rock, an evaluation of seismic data, and an analysis of spatial seismicity patterns;

(5) Geothermal regimes, including the synthesis of items 1-4 in this list; and

(6) Surface water, including a qualitative review of water needs and sources available.

The Los Alamos report on the CEC-City of Clearlake Hot Dry Rock Project will be available in the spring of 1993. For further information, contact Roger Peake, Geothermal Project Manager, California Energy Commission, at (916) 654-4609.

Geothermal Impact Mitigation Grants, Lake and Sonoma Counties

The California Energy Commission funds local county agency projects through its Geothermal Grant and Loan Program for Local Jurisdictions. Under the program, the following projects either are completed or will be by 1994.

Projects completed in Lake County:

- Butts Canyon groundwater monitoring program, undertaken by the county Department of Health Services as a geothermal development waste-facility impact-mitigation project. Mitigation measures will be monitored.
- Purchase and installation by the county Air Quality Management District of a personal computer hardware/software system to record aerometric data transmitted from three, existing data-gathering stations. The data will be entered in a "Micrometerological Air Dispersion Assessment Methodology" base. Pollutant concentration for selected receptors will be estimated.
- Development of a seed mix of grasses that either have evolved on serpentinite soils or have adapted to growing on them. The grasses will be used to mitigate environmental impacts in The Geysers area from soil disturbances during construction of geothermal projects.
- Upgrade the capability of emergency response and rescue services of the South Lake County Fire Protection District. Train the district staff and purchase equipment.
- Study geothermal noise sources, mitigation measures, and the constraints of specific mitigation measures.

Projects to be completed in Lake County by 1994:

- Upgrade capability for emergency response services of the South Lake County Fire Protection District for hazardous material spills. Train the district staff and purchase equipment.
- Continue The Geysers air-resources monitoring program by establishing a network to monitor PM-10 and toxics at the Anderson Springs and Glenbrook monitoring sites. Combine the data with existing data in a computerized, data-base management system.
- Expand the Geo-Ag Heat Center geothermal- and irrigation-water delivery systems to demonstrate commercial feasibility. Market the facility to commercial growers.
- Secure training for a hazardous-material spill technician and purchase equipment for a new, hazardous material incident vehicle for the Kelseyville Fire Protection District.

Projects completed in Sonoma County:

- A two-year study of the metal burdens in fish from 28 stations located on nine streams in The Geysers region. Additional or alternative mitigation measures are suggested.
- Improvement of a section of the Healdsburg-The Geysers Road, a program of the county Planning Department and co-funded by the geothermal industry. Construction is completed, and traffic monitoring is underway.

Projects scheduled to be completed in Sonoma County by the summer of 1993.

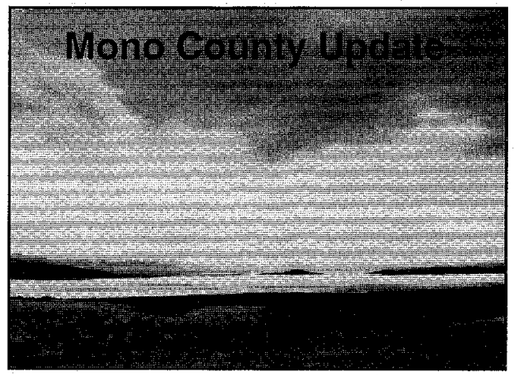
- Acquisition of a permanent site for the air-quality monitoring station, now located at a leased site.

Update: Geothermal Wells at Alturas

Two geothermal wells have been drilled in Alturas, California, for the Modoc Joint Unified School District. Well "AL" 1, drilled in 1988, now is used to heat most of the high school campus. The well was deepened recently by about 500 feet, and production increased by 50- to 80-gallons per minute. The additional production is expected to provide heat for classrooms and the agricultural shop area.

Well "AL" 2, drilled in October 1991, is used to heat the elementary and middle schools. The initial test for "AL" 2 produced 300 to 400 gallons per minute, with geothermal water temperatures at 170° to 180° F.

Plumas Geohydrology, Inc., the project consultant, will conduct interference tests on the two wells. Conventional electrical-use tests will be metered at the high school and elementary and middle schools for one year to compare and calculate the repayment schedule based on savings between the systems. Final design work on the space-heating system will complete the project.



Mammoth-Pacific, LP

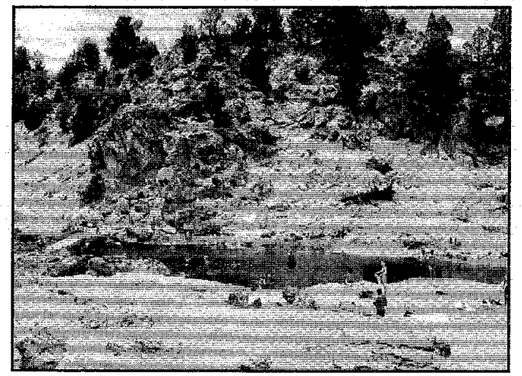
With the startup of the MP-II and PLES I geothermal power plants, each rated at 15 megawatts, gross, the total power production from Casa Diablo Geothermal field near Mammoth Lakes, California, is about 40 megawatts, gross. This includes electrical generation from the MP-I plant, on line since 1985. The three power plants have produced near capacity, relatively free from any operational problems.

A substantial increase in surface manifestations, such as fumaroles and steam vents, has occurred in the area around Casa Diablo Geothermal field. It is unclear how much the extraction and injection of geothermal fluids for power production is responsible for the activity. Some of the increased surficial activity began in September 1990, three months before MP-II and PLES-I plants went on line. Boiling in the upper portion of the production aquifer could be a contributing factor.

by Dan Lyster, Director
Mono County Energy Management Department

The Long Valley Hydrologic Advisory Committee (LVHAC) continues to monitor geothermal and hydrologic features located in the area around the Casa Diablo Geothermal field power plants and in the Hot Creek Gorge area. Data provided by Mammoth-Pacific, LP, from production, injection, and monitoring wells are reviewed by the LVHAC to determine the occurrence and extent of significant hydrologic impacts created by the operation of the three power plants.

In March 1992, the Mono County Energy Management Department required Mammoth-Pacific, LP, to drill a second monitoring well outside of its production field. In June 1992, an interference test was conducted by Mammoth-Pacific, LP, to ascertain the possibility for and/or the degree of communication between Casa Diablo Geothermal field and the monitoring well, about 2 miles away. Unfortunately, the occurrence of the Landers earthquake during the interference test has cast some uncertainty on the conclusiveness of the data. However, the data do have some value and will be incorporated into conceptual and numerical modeling efforts to be conducted over the next several months.

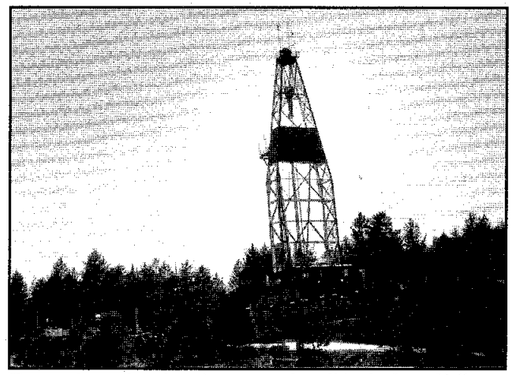


Hot Creek, August 1992. Photo by E. Johnson.

Regarding future development at Casa Diablo field, Mammoth-Pacific, LP, has applied to the Mono County Energy Management Department for a use permit for a fourth power plant, MP-III. The Mono County Energy Management Department informed Mammoth-Pacific, LP, that it would be necessary first to collect more monitoring and well-field data and to model the geothermal reservoir more accurately before proceeding with the use permit application review and environmental documentation.

Bonneville Pacific (Mammoth/Chance) Project

Due to financial constraints, Bonneville Pacific will not be revising the Environmental Impact Report (EIR) pursuant to the order of the Mono County Superior Court in the Writ of Mandamus decision of 1988. By virtue of the decision to leave the EIR as is, Bonneville Pacific has dropped the project. The company is in the process of turning over at least one of the exploratory wells to either the California Department of Fish and Game, Mammoth-Pacific, LP, or another geothermal company to be used as a monitoring/observation well.



The geothermal exploration-research well in the Long Valley caldera.

DOE/CEC Long Valley Deep Exploration Well

Phase II of the deep geothermal exploration-research well being drilled in the Long Valley caldera (LVF 51-20) has been completed to a depth of 7,588 feet.

There were two, distinct subphases of drilling activity in 1991. The first was drilling a 17 1/2-inch hole from the Phase I casing shoe at 2,558 feet to a depth of 7,130 feet, and then plugging back to 6,826 feet. The second subphase was drilling a 3.85-inch core hole from 6,826 feet to a total depth of 7,588 feet. A kick-out wedge was used to deviate the core hole from the previous wellbore at a depth of 6,868 feet. The total cost of drilling Phase II was about $2.3 million, and funding was shared almost equally between the California Energy Commission and the U. S. Department of Energy.

During the summer of 1992, scientific research activities were conducted at the well. These include using inflatable packers to hydrofrac isolated sections of the core hole to determine the in situ stress on the rock, using a borehole televiewer and impression packer to determine azimuthal orientation of fractures produced by hydrofracs; permeability tests; open hole slimhole logs (resistivity, magnetic susceptibility, magnetic field, neutron, gamma-ray, density, sonic, caliper, and temperature); vertical seismic profile; downhole gravity survey; and the downhole emplacement of seismic and water-level monitoring equipment.

SOUTHERN CALIFORNIA

Update: San Bernardino Reservoir Study

The California Energy Commission has approved funds to evaluate the geothermal reservoir underlying the adjacent Cities of San Bernardino and Colton in San Bernardino County. The assessment would define the extent of the resource.

Currently, the City of San Bernardino uses the underlying geothermal resource for space- and domestic-water heating in about 27 downtown buildings. The geothermal heat provides an alternative to burning fossil fuels for these purposes.

Funding for drilling in the City of San Bernardino has been delayed pending state budgetary deliberations. Two geothermal exploratory wells may be drilled in Colton in the near future to help delineate geothermal resources. Currently, geotechnical investigations underway will help determine the need for and siting of the two wells.

The wells may tap part of the same geothermal reservoir that underlies the City of San Bernardino. Further drilling would determine the extent of the geothermal reservoir and its capacity to sustain geothermal development for the San Bernardino-Colton areas.

If the geothermal reservoir is large, it could become a regional resource, usable by other cities in the area to develop geothermal heating districts.

Twentynine Palms Geothermal Resources

A geothermal resources assessment for the City of Twentynine Palms, California, is underway, funded by California's Geothermal Grant and Loan Program. Twentynine Palms is in the Mojave Desert, south of the Marine Corps Training Center and north of Joshua Tree National Monument. Low-temperature geothermal resources have been found in the area.

A test well, TNP-1, was drilled to a depth of 416 feet at the intersection of Two-Mile Road and Mesquite Springs Road. Preliminary testing showed the wellbore fluids reached temperatures of 123°F, hot enough to be used in a district heating/cooling system or in other direct-use applications. The TNP-1 site was selected for the test because it was closest to the developed areas of the city.

In Phase II of the assessment, further drilling will be undertaken based on the geological and geophysical characteristics of the area, and on geochemical parameters. Among other factors, a survey of potential users and retrofit requirements will be made.

For further information, contact Valentino M. Tiangco, Geothermal Project Manager, California Energy Commission, at (916) 654-4664.

Los Angeles DWP and Calpine at Coso

In January 1992, Calpine Corporation was selected by the Los Angeles Department of Water and Power (DWP) to enter into negotiation on contracts to develop a 150-megawatt geothermal facility at DWP's leases at the Coso Known Geothermal Resource Area in Southern California.

"Calpine was selected from the three short-listed respondents to our Request For Proposal for development of the Coso geothermal leases. Selection criteria included economic, financial, and technical considerations of each proposal, in addition to experience in operations and development resources," said Kellie Peterson, DWP's power contract supervisor.

Calpine proposes to develop, operate, and maintain the 150-megawatt geothermal facility, with the first two 30-megawatt units operational by January 1996. Total power production of 150 megawatts would be on line by January 1999. Power generated from the facility will be sold to DWP.

The power plant facilities will be financed by tax-exempt bonds with credit enhancements, if needed, from commercial banks or insurers. The resource development will be financed with private equity and commercial debt. Maurice Richard joined Calpine as program manager for the Coso project.

Ron Walter, Calpine's vice-president of geothermal development, said "Geothermal energy is a renewable and nonpolluting resource for the L.A. Basin. We are pleased to be working with DWP to develop the Coso resource.

"Since Calpine helped to develop the first power plant at Coso, we look forward to building upon our earlier experiences and relationships," he added.

In 1986 and 1987 at Coso, Calpine participated in the development of power plant Navy 1, Unit 1. This was the first power plant installed on U. S. Navy land, and was part of the Navy's program to develop alternative energy sources. Calpine coordinated engineering efforts during construction, supported start up, and was responsible for plant operations and maintenance.

On April 29, 1992, Calpine announced it had acquired developmental rights to 9,128 acres of geothermal properties from Sterling Grace Capital Management, Inc. The four leases are in Southern California and are contiguous to and south of the DWP geothermal leases in the Coso Known Geothermal Resource Area. The Grace properties will provide additional resource area to fulfill DWP's plan for generating up to 150 megawatts of geothermal power. "It was a good opportunity for us to have leases contiguous to DWP's" said Katherine Potter of Calpine's Public Relations Office.

Fort Irwin Receives Sierra Club Award

In May 1992, the Los Serranos Group of the Sierra Club presented its 1992 Conservation Award to Fort Irwin and the National Training Center (NTC), located in Southern California. The NTC earned the award for its geothermal research and development program.

Ms. Billie Schwarz, the conservation chairperson of Los Serranos Group, presented the conservation award to Brig. Gen. William G. Carter III, commander of the NTC. The award was presented during the San Gorgonio Chapter's centennial dinner celebrating the 100th year since the Sierra Club was founded by John Muir.

Ms. Schwarz said, "We are really excited about the work Fort Irwin is doing in geothermal energy. Military installations are not famous for their environmental work. What Fort Irwin is doing is so exciting because Fort Irwin can be a shining example for the rest of the military to follow for an environmental appreciation of the planet."

The Conservation Award is presented. Pictured, from left to right, are Lt. Col. David Schnabel, Ms. Billie Schwarz, Col. Hal Fuller, Brig. Gen. William Carter III, Lt. Col. Steve Haney, and Mr. Bill Gaskill. Photo courtesy of the Sierra Club and U. S. Army.

In accepting the award, Brig. Gen. Carter said, "We live on the planet and we're working very hard to protect the environment and to come up with nonpollutant means of energy. It's important to future generations of this great United States."

Geothermal research and development began at Fort Irwin several years ago. Fort Irwin is an ideal location for tapping into geothermal energy because of the many secondary geological faults located on the post.

"These faults are conduits for underground water, as well as natural seams where heat from the center of the earth can escape to the surface," said Rene Quinones, Fort Irwin's project manager for the geothermal program.

Working with NASA, Fort Irwin used satellite photography to identify these faults and the most likely spots to harness geothermal energy, according to Quinones.

Lt. Col. David Schnabel, Fort Irwin's chief engineer said the conservation award was significant because it recognizes many years of effort by Fort Irwin. "It's finally a recognition of where we're headed and that what we are doing at the National Training Center is full of visions and future oriented thought." Schnabel added that Fort Irwin should be using geothermal energy by the fall of 1994.

Bill Gaskill, the chairperson of the Los Serranos group, felt it was very appropriate for Fort Irwin to receive the award. "Geothermal production is a valid, nonpollutant source of energy and, as such, is in keeping with the Sierra Club doctrine of nonpollution," he said.

OESI Sells Power Plant Expansion 1E

In September 1992, OESI Power Corporation (OESI) announced it had sold its Ormesa 1E Expansion project, valued at $5 million and located in East Mesa Geothermal field, to the lessor of the Ormesa 1E facility. OESI received $2.5 million in cash at the closing and expects to receive the remainder over the term of the lease. The proceeds from this sale, together with corporate borrowings, were used to repay, in full, OESI's $4.1 million construction loan from Bank Hapoalim and nearly $700,000 in corporate payables.

Heber Geothermal Field

Heber Dual-Flash Plant

Heber Geothermal Company operates a 47-megawatt, net, dual-flash power plant at Heber Geothermal field in California's Imperial Valley. Heber Field Company operates the well field, which it acquired from Chevron Geothermal Company and Unocal Corporation.

Heber Binary Plant

A second power plant in Heber field, called the Heber Geothermal Binary Demonstration Project, will be dismantled and sold. The binary plant was operated by San Diego Gas and Electric Company (SDG&E) from 1985 to 1987. The power plant was a 45-megawatt, net, unit with isobutane and pentane used as working fluids.

Second Imperial Geothermal Project

In May 1992, the Second Imperial Geothermal Company (SIGC) applied for a conditional use permit from Imperial County to construct the Second Imperial Geothermal Project in Heber Geothermal field. The project includes a 33-megawatt, net, binary geothermal-electrical generation facility and associated well-field development.

SIGC is a California General Partnership, whose partners consist of AMOR 14 Corporation (a Delaware corporation), Second Imperial Continental Inc. (a Delaware corporation), and Geothermal Inc. (a Vermont corporation).

The proposed SIGC project consists of drilling, testing, and operating geothermal production and injection wells; constructing and operating production and injection pipeline systems related to the geothermal well field; constructing and operating a 33-megawatt, net, binary electrical-generation facility; and constructing about 1 mile of a 92-kV transmission line between the power plant and the Imperial Irrigation District transmission line, which is east of the proposed power-plant site. The location of the new power plant will be one mile west of the Heber Dual-Flash Power Plant. The city limits of Heber, California, are about 1/2 mile north of the proposed power-plant site.

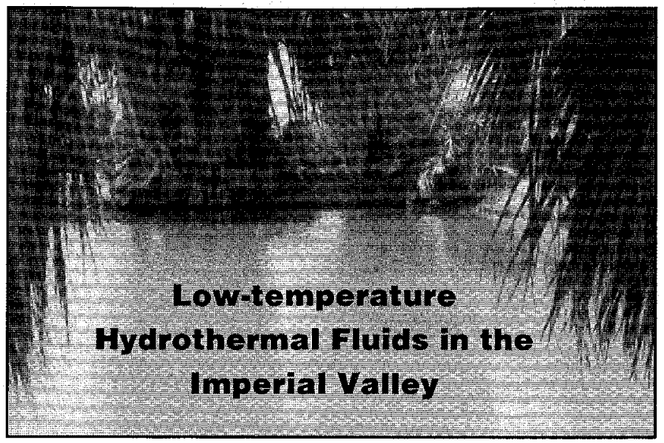
by Timothy S. Boardman
Geothermal District Engineer

Although the SIGC project will use some existing geothermal wells and gathering systems associated with the binary SDG&E power plant, SIGC plans to drill 11 new production wells and 3 new injection wells. The new wells will be drilled west of the current production area, with about 1,200-foot spacing in a 1-square mile area. The wells will be completed at depths between 2,500 feet and 6,000 feet and have down-hole pumps. All the produced fluids will be injected after they are cycled through the power plant. Additional wells would be permitted and drilled, as needed, to maintain the level of output stipulated in the Power Purchase Agreement for the life of the project.

The project will use 12 interconnected, dual-turbine, binary-cycle Ormat Energy Converter units (OEC's). The OEC's are operated on a subcritical, organic Rankine cycle, which results in lower parasitic losses and reduced internal pressures within the power plant. There is higher equipment reliability due to the lower stress on the components.

About 6 million pounds per hour of geothermal fluid at temperatures of about 330°F will be delivered to the power plant. The fluid will be distributed evenly to the 12 OEC units, where it will be used to evaporate the isopentane working fluid in the vaporizing heat exchangers. The isopentane vapor will power the turbine generators and be cooled in two cooling towers.

The net, electrical output will be sold to Southern California Edison, under a long-term Power Purchase Agreement.



Low-temperature Hydrothermal Fluids in the Imperial Valley

One of the world's hottest, water-dominated geothermal systems is in California's Imperial Valley, near the southern end of the Salton Sea. The system is one of several deep, high-temperature geothermal systems being developed for electrical generation throughout the Imperial and Mexicali Valleys. Because of their sizes and uses in generating electricity, these high-temperature resources receive a large amount of attention from governmental, commercial, and academic groups. However, potentially commercial, low-temperature geothermal areas along the margins of the region deserve attention, as well.

The study area for this report encompasses 200 square kilometers and measures about 16 kilometers from the Dos Palmas Spring Area in the north to the Hot Mineral Spa Area in the south (*see* Figs. 1 and 2). The report summarizes the chemical analyses and origins of hydrothermal waters in the study area.

The California Department of Conservation, Division of Oil and Gas collects geothermal reservoir and water quality data in geothermal areas. Some chemical analyses of the hydrothermal well fluids in the Hot Mineral Spa and Dos Palmas Spring Areas have been included in water chemistry studies of the Salton Trough (Coplen, 1972; Hardt and French, 1976). Also, Watt (1990) sampled hydrothermal waters from several sites in the project area. However, extensive samples of the waters were not taken, nor were the origins of the geothermal waters described adequately.

At the author's recommendation, a water-quality study was begun in 1991. It was undertaken by Curt Schneider, a student of Dr. Prem Saint, an instructor at California State University, Fullerton. The author helped gather the water samples, which were analyzed by the California Regional Water Quality Control Board in Palm Desert, California, and the U. S. Bureau of Reclamation in Yuma, Arizona. Isotopic analyses were made by T. Coplen, at the U. S. Geological Survey in Reston, Virginia.

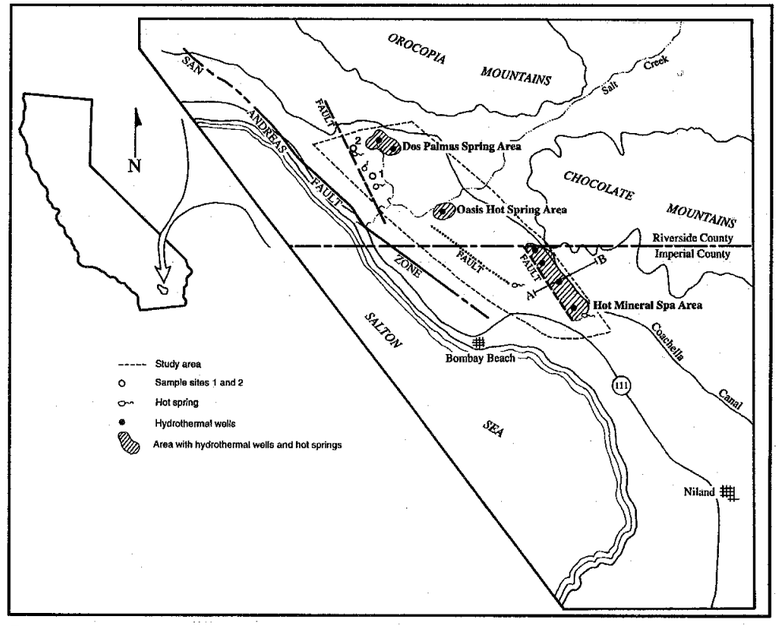


Figure 1. Location map.

By Christy Craig Hunter, Geothermal Engineer

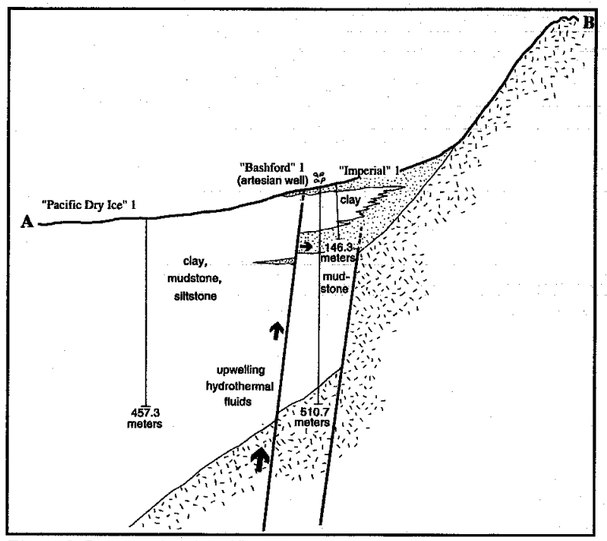


Figure 2. Cross section A-B, Hot Mineral Spa Area.

Occurrence of Hydrothermal Waters

The Hot Mineral Spa and Dos Palmas Spring Areas are at the base of the Chocolate and Orocopia Mountains, respectively. Salt Creek, the dominant drainage course, divides the two ranges and bisects the study area (*see* map). Most of the geothermal waters occur in the Dos Palmas Spring Area in the north and the Hot Mineral Spa Area in the south. Elsewhere, seeps and thermal springs emerge along the northwest-southeast trending faults south of Dos Palmas Spring. Additional springs, believed to be old, deserted wells, are located randomly in the central part of the study area.

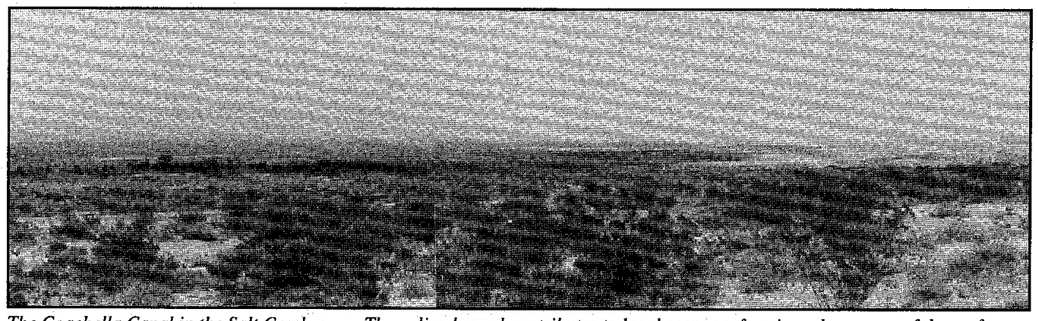
Accounts from the late 1800s refer to the original site of Dos Palmas Spring as a single spring, conspicuously marked by a lone pair of fan palms. Currently, Dos Palmas Spring consists of a 2 1/2-square kilometer area where at least a dozen artesian wells are flowing into several acres of large ponds. Water-well temperatures range between 24°C to 39°C. A large grove of fan palms is in the area.

Most low-temperature wells on privately owned lands in the Dos Palmas Spring Area are used for commercial aquiculture. A few wells on adjacent federal lands provide water to ponds, supporting a small wetlands environment that is part of conservation efforts of The Nature Conservancy, in cooperation with the U. S. Bureau of Land Management (BLM). Biologically diverse federal lands in the Dos Palmas/Salt Creek area include two endangered species. The lands are designated by the BLM as an Area of Critical Environmental Concern.

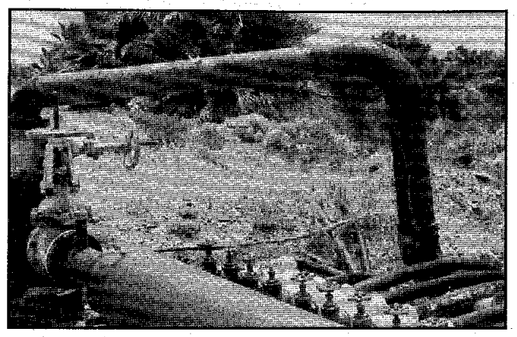
Southwest of the Dos Palmas Spring Area, seep mounds occur -- so named because springs are located here on broad, mound-shaped hills. Temperatures for two of the springs average 27°C. These are referred to as the San Andreas Springs, for they parallel the nearby San Andreas fault (Watt, 1990). The springs are probably fault controlled. Flow rates appear to vary seasonally.

Very few natural, hydrothermal springs occur in the study area. Most surface occurrences of water here are seeps from the nearby Coachella Canal. (The canal was built in the 1940s to import Colorado River water to the Imperial Valley.) Seepage from the canal is identified easily on aerial photos by locating the linear zone of thick vegetation paralleling the canal in down-slope areas.

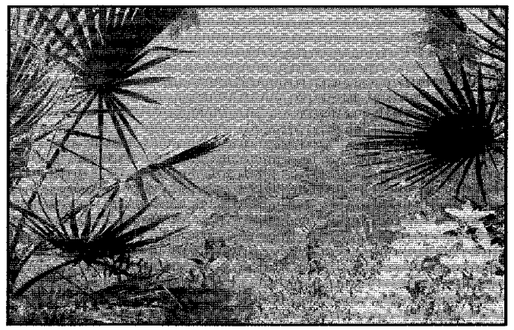
A number of isolated sites in the central part of the



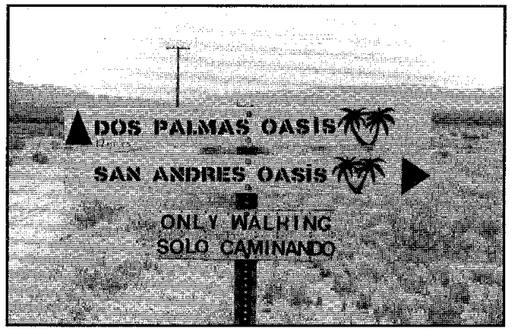
The Coachella Canal in the Salt Creek area. The unlined canal contributes to local seepage, forming a large part of the surface seeps in the study area. Photos by C. Craig Hunter.



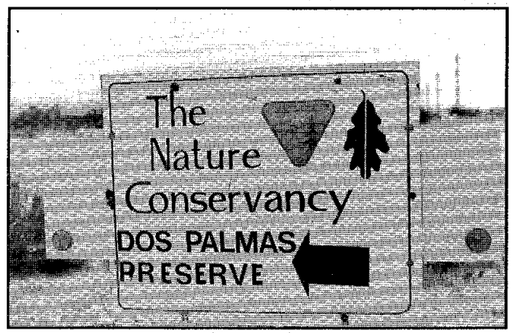
About eight, low-temperature wells are operated in the Dos Palmas Spring Area. Photo shows a well head and a manifold feed system.



Tilapia are raised commercially in low-temperature geothermal waters in the Dos Palmas Spring Area.

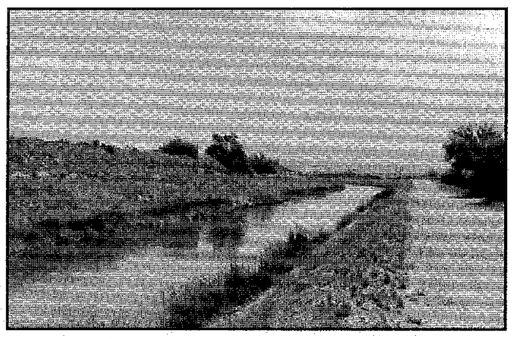


The entrance to the hot springs area, within the Dos Palmas Spring Area, owned and maintained by The Nature Conservancy.



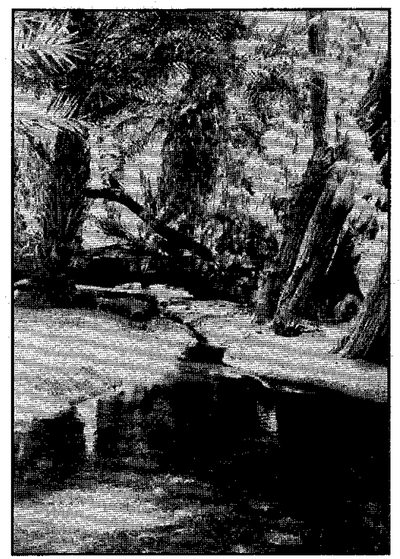
The Nature Conservancy owns and maintains the Dos Palmas Preserve, in cooperation with the U. S. Bureau of Land Management. The preserve is in the Dos Palmas Spring Area.

San Andreas Spring, in the Dos Palmas Spring Area.

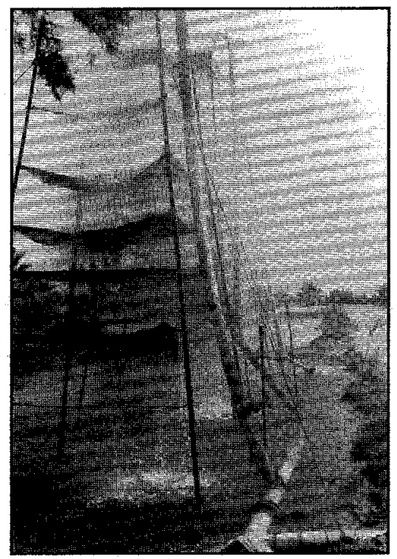


The Coachella Canal in the Salt Creek area. The unlined canal contributes to local seepage, forming a large part of the surface seeps in the study area.

study area are depicted on U. S. Geological Survey topographic maps as springs (perhaps more correctly as artesian wells). Water samples for this study were taken from only one of the sites, which is known informally as Oasis Spring. The site is actually two artesian wells, referred to by Watt as goat wells. They were drilled perhaps 40 to 50 years ago. Warm, 28°-32°C waters flow unchecked from the wells into small ponds, forming an oasis that supports wildlife such as Desert pupfish, deer, quail, date palms, cottonwoods, and lush stands of reeds. The area is managed as an ecological reserve by the California Department of Fish and Game.



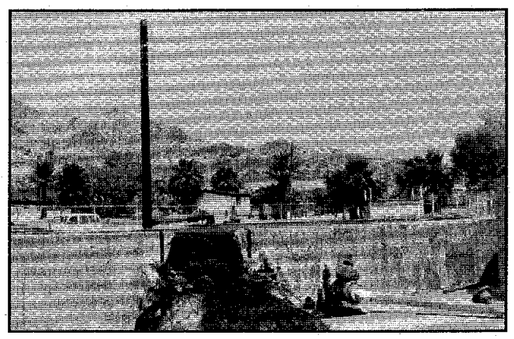
Oasis Spring, south of the Dos Palmas Spring Area. Oasis Spring is a state preserve, protected by the California Department of Fish and Game. The pools support a variety of desert oasis plants and animals, including the endangered Desert pupfish. Existence of the spring can be traced back to the turn of the century.



A fish farm in the Hot Mineral Spa Area. The hot water passes through cooling towers before entering the fish ponds.

The Hot Mineral Spa Area is in the southern portion of the study area, near Hot Mineral Spa Road. About 22 low-temperature geothermal wells have been drilled here, with temperatures ranging from 54°C to 78°C. Most of the wells are used for commercial fish farming operations. A few supply water to swimming pools and spas in privately-owned commercial trailer parks. The first well, "USBR", was a water-supply well, drilled in 1938 for canal-construction activities. Although the water was so hot it had to be cooled over palm fronds

The Hot Mineral Spa Area, with the fish farm in the background and the pond with cooled water in the foreground.



"USBR" is a flowing well in the Hot Mineral Spa Area. The water enters a large cement container and passes into public bathing pools. "USBR" is the first well drilled in the Hot Mineral Spa Area. The darkened area in front of the cement container is carbonate precipitate.

before being mixed with cement, at that time it was the closest source of water in a fairly desolate area. By the 1960s, the Hot Mineral Spa Area was well known, mostly for hot, mineralized baths enjoyed by the winter visitors. Today, the area holds a small business community, with both year-round and seasonal residents.

Hydrothermal Water Chemistry

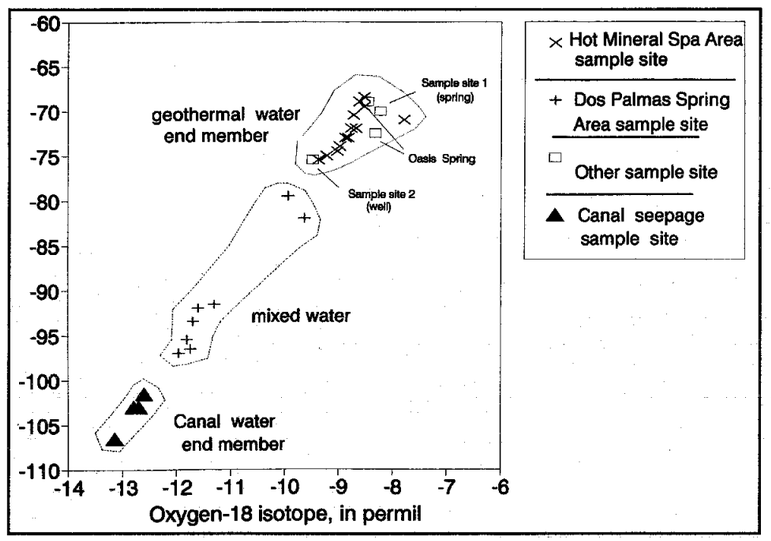
Chemical analyses of hydrothermal waters sampled in the study area have two general compositions: sodium-chloride, indicating geothermal waters, and sodium-sulfate-calcium, indicating canal water (Maloney et al., 1991). The hottest (54°C - 78°C) and most saline waters (2,100 ppm TDS - 3,800 ppm TDS) occur in the Hot Mineral Spa Area, where little if any canal water leakage exists (Watt 1990). Waters from the Dos Palmas Spring Area are cooler (27°C - 39°C), with fewer dissolved solids (900 ppm TDS - 2,300 ppm TDS), indicating a larger component of canal water. A study of the tritium content indicates that up to two-thirds of the Dos Palmas Spring water is derived from the Coachella Canal (Watt, 1990). Hydrogen-oxygen isotopic analyses substantiate the findings.

A graph of the isotopic data shows that a mixing line exists between these two water components, or end members. Waters in the Dos Palmas Spring Area vary in composition according to the ratio of canal to hydrothermal water; waters in the Oasis Spring and San Andreas Springs Area are comparable to those in the Hot Mineral Spa Area.

The chemical constituents of hydrothermal water can indicate the depths of reservoir fluids as they were heated. Estimates are that fluids in the study area ascended from depths of about 1.1 to 1.7 kilometers, probably along a system of steeply dipping faults (Hunter, 1992). The hydrothermal waters occur in shallow layers of gravel capped with a thick layer of lacustrine clay. Most wells penetrating the gravel have entered artesian regimes.

Origin of Hydrothermal Waters

The amount of hydrothermal water produced from the Hot Mineral Spa artesian aquifer is relatively substantial (4,000 acre-ft./yr.). Annual precipitation averages 6 inches or less in the surrounding mountain ranges, and 2- to 3-inches in the study area. This suggests that local precipitation is not a significant source of recharge to the hydrothermal reservoir. However, the stable hydrogen-oxygen-isotope data suggest that the hydrothermal waters originated as rainwater (Hunter, 1992). Tritium analyses indicate the waters are at least older than the 1952 tests of atomic bombs (Watt, 1990). Could the hydrothermal water be even older precipitation, from a time when the climate was colder and wetter? This would mean that finite quantities of the fossil hydrothermal waters exist.



Isotope composition of water samples from the Dos Palmas spring area, Hot Mineral Spa area, and various other sites located in the study area, northern Imperial Valley, California.

Conclusions

The sizes are still unknown of the low-temperature, geothermal reservoirs in the Imperial and Mexicali Valleys. They may be large enough to support additional commercial projects, since the area with low-temperature hydrothermal water manifestations is relatively extensive (200-square kilometers). However, data from several wells indicate that withdrawal rates depend more on the transmissive properties of the shallow aquifers than on deep reservoir capacities. Thus, both factors must be considered when low-temperature geothermal projects are planned.

Acknowledgements

I would like to thank the many landowners who made it possible to collect water samples. These include Dov Grajcer, Bill Engler, Fred Bartlett, Oscar Bashford, and Merl Leiss, with special thanks to Hazen Bair and all the folks at The Nature Conservancy, Dos Palmas Station.

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OTHER WESTERN STATES

NEVADA

BLM Holds Geothermal Lease Sale

A competitive geothermal sale of leases in Nevada netted nearly $149,000 at a Bureau of Land Management (BLM) sealed bid auction in March 1992. San Emidio Resources, Inc., a Nevada company, was the high bidder on the five parcels offered. All five parcels encompass nearly 7,000 acres and are in the Gerlach Known Geothermal Resource Area (KGRA).

Half of the monies from the sale will go to the state. Once production begins, the lessee will also pay a royalty rate of 10 percent of the value of the resource, minus production costs. Royalty rates are also shared with the state.

Leases are held for 10 years. During the first 5 years, a lease holder may simply pay the $2 per acre rental fee, but during the second 5 years, in addition to paying rental fees, the lessee must be involved actively in exploration work on the parcel.

The largest geothermal electrical-generation plant in Nevada is in Dixie Valley and is operated by Oxbow Geothermal. The plant generates about 70 megawatts of electricity, which is sold to Southern California Edison.

There is no statutory requirement for the BLM to schedule geothermal lease sales. A sale is usually held upon industry request, lease expiration, or a change in KGRA boundaries.

Brady Hot Springs Power Plant

Brady Hot Springs is about 45 miles northeast of Reno, Nevada. In 1978, Geothermal Food Processors, Inc. built a plant at the hot springs, the world's first geothermal food processing facility to use hot water for dehydrating onions. The plant is still in operation.

In 1991, ESI Energy and Nevada Geothermal Power Partners established Brady Power Partners. The company built a 26-megawatt, gross, geothermal power project at Brady Hot Springs. The power plant is on a 2.5-acre site, and the geothermal wells extend for over a mile.

The Industrial Company was the general contractor for the project; The Ben Holt Company provided detailed design, procurement, and start-up support services; and Oxbow Power Services, Inc. operates and maintains the plant and wells.

The dual-flash power plant has two, high-pressure turbines and one, low-pressure turbine. The plant produces 21 megawatts, net, of electricity from about 5.4 million lbs./hr. of brine. The electricity is delivered to the Sierra Pacific Power Company.

Brine from the reservoir is pumped from 6 of the 8 production wells and sent to the high-pressure, flash separators. The wells intersect the production zone from 1,000 to 1,400 feet deep. Bottom-hole temperatures range between 342°F and 360°F. The brine contains 2,090 ppm TDS and 0.018 percent noncondensables. The brine is injected into 3 of the 5 injection wells. The power plant was synchronized in June 1992 and became commercial in August 1992.

For further information, contact Larry Roesler at The Ben Holt Company. Phone (213) 684-2541.

Portions of the article were excerpted from "Brady Hot Springs Geothermal Power Plant" by Tom Ettinger and John Brugman, published in the August 1992 issue of the Geothermal Resources Council *Bulletin*.

30-Megawatt Power Plant Near Reno

A 30-megawatt geothermal power plant will be built 10 miles south of Reno, Nevada, at Steamboat Springs. The plant is scheduled to be on line in December 1992. The owner is Steamboat Development Corporation, an affiliate of Far West Capital of Salt Lake City.

The Ben Holt Company of Pasadena, California, provided engineering, procurement, startup, and other services for the air-cooled, binary-cycle power plant. The plant, essentially emissions free, will require no consumptive use of increasingly scarce fresh water. It will have a low profile and blend with the surrounding terrain. The power plant will be modeled after a similar plant built at Mammoth Lakes, California, owned by Pacific Energy.

The Ben Holt Company has designed power plants in California, Nevada, Utah, and Texas.

Well Drilled at Rye Patch, Nevada

In January 1992, OESI Power Corporation announced the successful completion of a geothermal production well at the company's Rye Patch "A" geothermal project near Imlay, Nevada, in Pershing County. The Rye Patch "A" geothermal power plant, a modular, binary facility, is expected to produce 13 megawatts of electricity. The electricity will be sold to Sierra Pacific Power Company under the terms of a 30-year power purchase agreement. Construction of the geothermal project is scheduled to begin in the spring of 1992. OESI anticipates that the geothermal power plant will be on line in early 1993.

The successful well, No. 44-28, was completed at a total depth of about 3,500 feet. Downhole temperatures have been measured at about 400° F, with a stabilized flow rate of about 500,000 pounds per hour.

On January 7, 1992, the company completed a 21-day flow test that confirmed stabilized downhole pressures. The company plans to drill an additional production well to confirm the extent of the reservoir. Communication testing with the existing Campbell E-1 production well has demonstrated that the production zone extends at least 3,000 feet along the Range Front fault zone.

The Rye Patch project will require 4 production wells (including a standby well), and 3 injection wells (including a standby well) to process over 1.5 million pounds of geothermal fluid an hour.

The project is owned and developed by Rye Patch Limited Partnership, a Nevada limited partnership consisting of AMOR 23 Corporation and AMOR 24 Corporation, both wholly owned subsidiaries of OESI.

OREGON

Oregon Geothermal Power Plant

An Oregon electrical utility company with an interest in renewable energy projects is developing the state's first, geothermal electrical-generation facility. The Eugene Water and Electric Board (EWEB), the state's largest municipal utility, has entered into a cooperative partnership with California Energy Company, proposing to build a 30-megawatt geothermal power plant near Bend and La Pine, Oregon. If the plant is built according to the current schedule, it will begin generating 30 megawatts of electricity between 1995 and 1997, and continue doing so for 30 years. If the project is successful, it can be expanded to 100 megawatts. The most geologically promising site for the power plant is in the Newberry Caldera area, near the Newberry Volcanoes National Monument.

"The project falls under the Bonneville Power Administration's solicitation of proposals to confirm geothermal resources in the Northwest," said Scott Spettel of EWEB.

EWEB received a mandate from its customers in 1974 to focus future power needs on environmentally benign, renewable-energy projects. The company believes that geothermal is a promising energy resource for the Northwest.

The EWEB and California Energy Company are working with a citizen committee from the Bend/La Pine area. The committee will offer advice to the utility and the company, plus study energy issues for the next 18 to 24 months. All groups see the interaction as a mutually beneficial, educational process.

WORLDWIDE

ITALY

Using Geothermal Energy for Protected Cultivation

Background

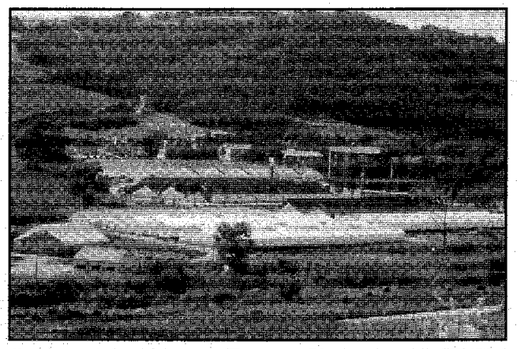
In Tuscany in Central Italy, the areas near natural geothermal manifestations were used long ago to grow farm produce early in the season. The high temperature of the ground favored the growth of vegetables out of season, and the steam and gas emissions around the plants formed a kind of protective covering against snow and frost.

In the second half of the 19th century, the natural geothermal fluids of the area, which since 1827 had been used as process fluids in the extraction of boron salts from the geothermal waters, began to be transported over distances through uninsulated, riveted tubes. These tubes were the first steam pipelines. Across these pipelines, the first protective structures (or greenhouses), made of masonry, wood, and glass, were built to grow crops for market gardening. Plants were cultivated inside the structures, warmed by the pipelines.

By Dr. P.D. Burgassi
ENEL-S.p.a.
Direzione della Produzione e Trasmissione
Vice Direzione Attivita Geotermiche-Centro Dimostrativo
Castelnuovo Val di Cecina, Italy

By 1890, the number of these family-run horticultural enterprises had increased. Now, natural steam began to be used to heat all the homes in Larderello and in the surrounding villages that sprang up near the various works created to extract boron salts from the geothermal waters.

In the 1930s, the first larger greenhouses were built. They were made of wood and glass and were heated with geothermal steam circulating through finned tubes.



Geothermal greenhouses in Tuscany. Photo courtesy of ENEL.

Eventually, they were used as guest quarters and company canteens for the various establishments of the Societá Boracifera of Larderello.

In 1950, when the big greenhouse installations of Castelnuovo and Lago Boracifero were built by the Larderello S.p.a., the company's agricultural branch was expanded. It changed from supplying vegetables for the company's needs to producing and selling vegetables to larger outside markets.

Today, treated water usually is used as a carrier fluid for the heat warming the greenhouses. The water temperatures depend on the characteristics of the geothermal fluid that is exploited. In a few old greenhouses, natural steam is still used as the heating fluid, circulating through in finned tubes used as heating bodies, like in the old days. Although this system saves the energy used for pumping treated water, it results in an incomplete exploitation of the fluid's energy potential.

Heating Systems

The type of heating system used in greenhouses depends on the temperature of the geothermal fluid and the crop that one intends to plant. In designing greenhouse installations fed from a geothermal source, it is first necessary to optimize the system by trying to integrate the characteristics of the source with the needs of the user. The utilization factor should also be increased to the maximum, while at the same time seeking to realize uses in cascade, thus achieving the lowest possible final temperature. Except for particularly favorable conditions, at the end of the cycle the geothermal fluid must be reinjected because it is rich in dissolved salts. This makes it necessary to use treated water in a closed cycle as a carrier fluid for the heat inside the greenhouse.

The heating systems vary. They include:

- *Forced circulation of hot air, by unit heaters.* Although developed to function with water at high temperatures, unit heaters are easily adaptable to low-temperature water, given the forced nature of the convective exchange.

- *Natural circulation of hot air, by means of tubes,* either smooth or finned, placed on the ground along the walls of the greenhouse. This system, suitable for the circulation of fluids at temperatures of around 90°C, normally presents small temperature differences between the water inlet and outlet. It, therefore, lends itself poorly to a rational, complete exploitation of the source.

- *Soil heating with buried plastic tubes* in which hot water is circulated. This system, although capable of maintaining a uniform temperature in the greenhouse, is closely tied to the type of cultivation and to plant-root optimum temperatures. Soil heating is always used in combination with another system.

The first use of geothermally heated soil was undertaken by the Italian Electricity Board (ENEL) in 1969, in collaboration with the National Research Council's International Institute for Geothermal Research. The project was carried out near the present-day Demonstration Center of Castelnuovo Val di Cecina, in a small pilot greenhouse of about 200 m², which could use water at temperatures between 30° and 70°C. The greenhouse had a dual heating system. Unit heaters were run with water at a temperature of 70°C and with polythene tubes buried at a depth of 25 cm, where water at 25° to 30°C was circulated.

- *Heating with tubes hung from the greenhouse frame.* The tubes could be set on the ground, suspended below the benches, or hung above the beds.

Present Situation in Italy

In some greenhouses (in Italy, about 5 hectares), steam at a temperature of about 120°C is used as a heat source. (Obviously, the fluid that circulates in the secondary circuit has a temperature of about 90°C.) For other greenhouses, waters from springs or wells are utilized, with temperatures ranging between 40°C and 97°C.

In this regard, the case of Piancastagnaio is very interesting. There, the geothermal fluid, which is superheated steam with a rather high gas content, is used to produce electricity in a discharging-to-atmosphere turbine. The discharged fluid goes into a direct-contact heat exchanger at atmospheric pressure, from which water exits at 97°C. The water is sent to plate-type exchangers, where it heats the treated water of the secondary circuit of a greenhouse installation to 90°C before it is sent for reinjection. Between the plate-type exchangers and the greenhouses, there is a considerable height difference. Thus, the water of the secondary circuit must pass through a shell-and-tube exchanger set at the same elevation as the greenhouses. The tertiary circuit leads off from here, where there are also large tanks for the heat accumulation. A closed cycle feeds the production installations.

Table 1. Greenhouses heated from geothermal sources.

Locality	Max. Capacity Gcal/h	Annual Gcal 10^3	Energy PET 10^3	Temperature Geoth. Source °C
Bulera (PI)	1.3	4.5	0.45	120
Canino (VT)	0.2	0.3	0.03	40
Castelnuovo V.C. (PI)	0.6	1.5	0.15	105
Civitavecchia (RM)	4.4	9.5	0.95	48
Galzignano (VI)	2.5	10	1	58
Lago Boracifero (GR)	1.4	5	0.5	125
Piancastagnaio (SI)	35	237	23.7	97
Radicondoli (SI)	7.5	4.9	0.49	120
Rodigo (MN)	1.6	7.9	0.79	60

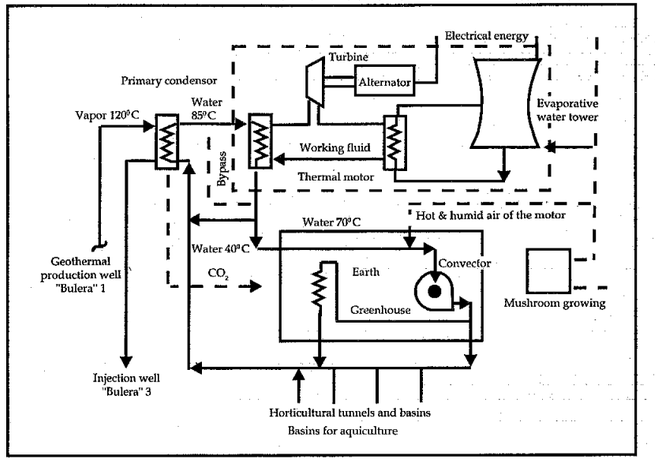


Figure 1. Simplified scheme of the Bulera Project.

With conventional fuels, heating expenses equal about 15 to 20 percent of the value of the sold product. Hence, it is possible to have competitive geothermal greenhouses in the hilly areas where geothermal resources are usually located, where the average outside temperature is lower because of the higher elevations. Sometimes, geothermal greenhouses are far from the product market. Then, transportation costs may account for a larger share of the final cost than in conventionally heated greenhouses.

Future Prospects

Italy has nine greenhouse installations that use geothermal energy. Some other initiatives of great interest are being implemented, due both to the dimensions of the new installations and the proposed technological innovations. For example, at Castelnuovo Val di Cecina, a greenhouse of about 2000 m² is being built for the production of basil. It will use a dual heating system with unit heaters (using water at 65°C) and soil heating by means of corrugated plastic tubes at a depth of 40 cm. Water of 35°C will be circulated from the unit heaters.

The geothermal source of this greenhouse is the district heating, system-outlet water from the nearby town. Once the district heating system has been activated and the greenhouse project is underway, this will exemplify the combined use of geothermal fluid with a high utilization factor, partly because greenhouses and district heating systems display about the same trend in a heating load diagram.

Technical and Economic Considerations

With respect to conventional energy sources, geothermal energy has a low environmental impact as long as a few basic rules are respected, such as the reinjection of spent waters.

Geothermal's main characteristic is high energy efficiency, particularly for low-temperature fluids. The ratio between heat produced and the thermal energy obtained from initial conditions to the ambient temperature, can reach 90 percent with geothermal fluids, as opposed to the 70 to 80 percent level found with fossil fuels.

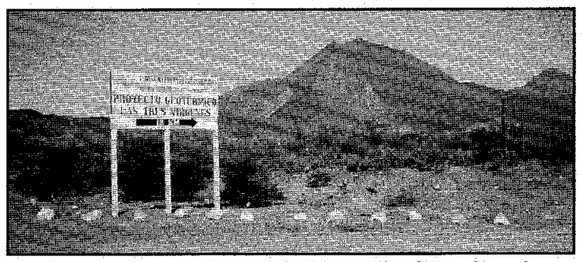
Because geothermal heat has a decidedly lower cost than coal, petroleum, and natural gas, it is advisable to choose high-energy consumption cultivations to use with geothermal. (By this, we mean plants that require high temperatures in order to grow, and thus a large amount of thermal energy.) Today, the Italian market seems to encourage especially floricultural production, such as flowers and ornamental plants. Among these are: *Aeschynanthus, cyclamen, Croton dieffenbachia, Euphorbia pulcherrima* (poinsettia), *Hydrangea scheffleria, Scindapsus, Spathiphyllum,* and *Syngonium philodendron,* even though specialized garden produce, such as basil, is also sold.

Other projects are being implemented at Castelgiorgio in the province of Terni and at Latera in the province of Viterbo. At Castelgiorgio, a 1000 kW binary-circuit unit will be powered with the 120°C fluid produced from one well drilled some time ago by ENEL. Downstream from the power plant, through plate-type exchangers, the now 90°C water will heat the fluid of a secondary circuit of an agro-industrial installation and 2 hectares of greenhouses before being reinjected in another well. At Latera, a two-phase fluid (water and steam at 200°C) will feed a double-flash power plant. Downstream, the discharged water will supply the heating plant of greenhouses covering 15 hectares.

MEXICO

Las Tres Vírgenes Geothermal Project, Baja California Sur, Mexico

The Las Tres Vírgenes Geothermal Project of Mexico's Comisión Federal de Electricidad (CFE) is about 30 kilometers northwest of Santa Rosalía (*see* map). The project is about 18 kilometers by secondary road from the main highway.

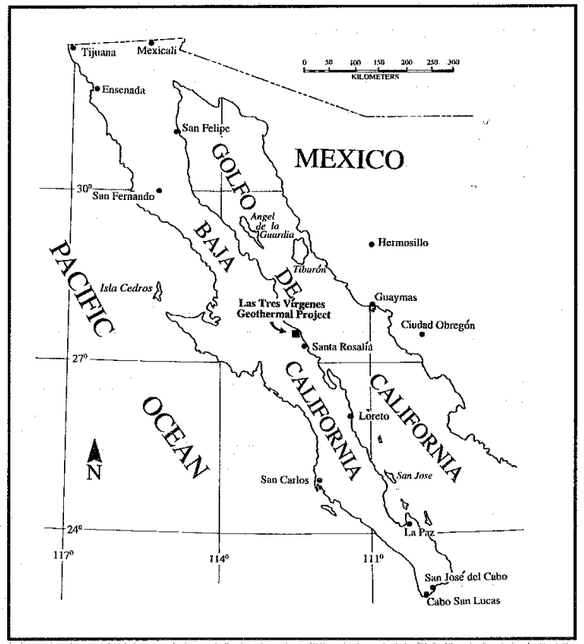


A sign along the main highway marks the turnoff to the geothermal project. The side road, lined with rocks painted white, winds through the volcanic cones of the Las Tres Vírgenes area. Photos by M. C. Woods, November 1991.

The area presents a fantastic scene of volcanic cones, calderas, lava flows, and varieties of native cacti. The volcanic activity is related to the Caldera de Reforma uplift to the east, along the coast of the Sea of Cortez. Thermal springs associated with hydrothermal alteration indicate potential for a geothermal zone at depth in the Las Tres Vírgenes area.

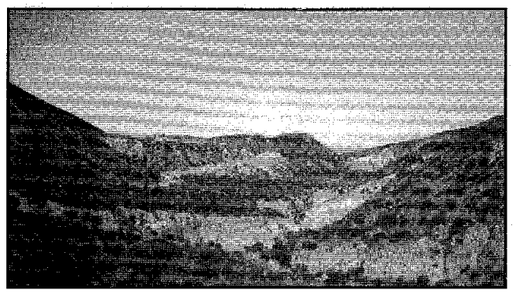
Wells were drilled here to find a reservoir suitable for use in a geothermal electrical-generation project. A vertical test well was drilled in 1985 to a depth of 1142 meters. The Quaternary sediments encountered are thin sandstone beds overlying andesite (to 196 meters) and ignimbrites (196 to 256 meters). Tertiary Pliocene sediments (256 to 376 meters) are sandstones with some fossils present. Miocene sediments include basalt (695 to 956 meters) interbedded with sandstone (956 to 1046 meters) and coarse sandstone (1046 to 1076 meters). A fault zone of transitional microbreccia, from 1076-1126 meters deep, is near the top of the Cretaceous at about 1046 meters. Below the microbreccia is granodiorite (1126 to 1142 meters). The reservoir fluid tested from below the fault zone is about 200° C, but the sediments were not permeable.

The second well, drilled in 1991, is a directional well off the first borehole at about 600 meters, drilled to a depth of about 1200 meters. Fluid in the directional well tested at a higher temperature and sediments were more permeable than

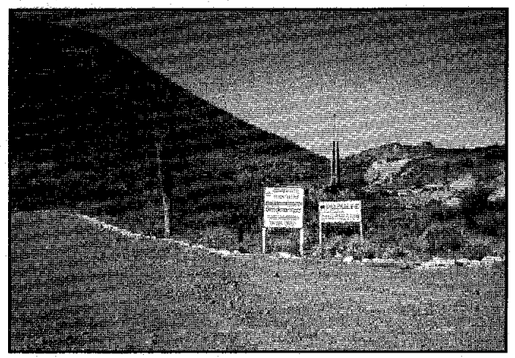


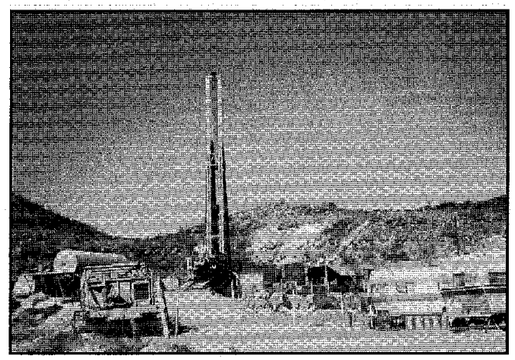
The location of the Las Tres Vírgenes Geothermal Project, Baja California Sur, Mexico.

by Mary C. Woods, Geologist



View of the calderas and lava flows surrounding the drilling area.





The drilling rig is near the base of Las Tres Vírgenes volcanic cones.

in the first well.

According to an article titled "Geothermal Exploration Activities in Baja California, Mexico" by Luis Quijano, published in the September/October 1992 issue of the Geothermal Resources Council *Bulletin*, "In the short-term, CFE plans to install 3 to 5 megawatts to meet the electrical demand of the local grid that includes the Cities of Múlege, Santa Rosalía, and San Ignacio. Larger generation capacity could be used to extend the grid to Vizcaino and Guerrero Negro to meet demand for ground water pumping and salt extraction. The availability of electricity can also help in developing the beautiful tourist resources of the area."

The author wishes to thank Mr. Martín Villavicencio, the project geologist, for his assistance.

CANADA

Meager Creek Update

Canadian Crew Energy Corporation, its wholly owned subsidiary Meager Creek Development Corporation, and Guy F. Atkinson Holdings Ltd. have established a joint venture to develop the Meager Creek Geothermal Project, located 100 miles north of Vancouver, British Columbia. Atkinson, or its affiliates, will earn a 57 percent interest in the Meager Creek Geothermal Energy Joint Venture in exchange for funding the initial, developmental phase of the project. Canadian Crew will maintain a 43 percent interest in the joint venture.

Canadian Crew Energy has contracted with GeothermEx, Inc. for a final evaluation of the geothermal resource at Meager Creek, near Pemberton, B.C. GeothermEx will analyze project data, update a conceptual model, develop a field program to complete the resource evaluation (including drilling up to 3 slim wells), interpret data, and design field development for commercial production.

In addition, the joint venture intends to undertake all aspects of the federal and provincial regulatory and permitting processes, negotiate the terms of an electricity sales agreement for the initial 60-megawatt plant, and negotiate transmission line easements and interconnection requirements.

Commonwealth Construction Company will design, obtain materials, construct, and operate the 60-megawatt geothermal power plant at Meager Creek. Commonwealth Construction is a division of the Guy F. Atkinson Company. The plant is scheduled to be completed by the end of 1995.

The Meager Creek project will be Canada's first geothermal electricity development. The project has an estimated electrical potential of 260 megawatts. Plans are to develop the project to full potential incrementally, following the construction and commissioning of the first plant.

RUSSIA

200 Geysers Counted in the Kronotsky Nature Preserve

The Kronotsky Nature Preserve is an area of beautiful, mountainous wilderness on the Kamchatka Peninsula. The preserve became the equivalent of a national park in 1934. The United Nations has designated the 2.5-million acre area a World Heritage Site in recognition of its great biodiversity. Two hundred geysers and 22 volcanoes have been counted there.

A geyser field, named Dolina Geizerov, was discovered in the preserve by Soviet expeditions in 1941, according to an interesting and well-illustrated article titled "The Valley of The Geysers" by T. Scott Bryan in the July 1992 issue of *Earth*. The geyser field is within a young, active, volcanic system and encompasses an area about 1-1/2 miles long, about the size of Yellowstone's Upper Geyser Basin, the site of Old Faithful.

The author writes that most of the geysers in Dolina Geizerov are small, and one is not over an inch high. But many of the geysers are large. The geyser called Grot Yubileinyi is presently one of the world's largest. Spray from this geyser has reached 230 feet.

Earth is published by the Kalmbach Publishing Company, 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187.

JAPAN

Chronological Table of Geothermal Energy Development

The following table offers a short timeline for the development of geothermal energy in Japan.

1925	November	Dr Heiji Tachikawa, Tokyo Electric Light Co., Ltd., was the first to successfully generate geothermal power in Japan (output: 1.12 kW).
1952	July	Promulgation of Electric Power Development Promotion Act.
1960	June	Establishment of Japan Geothermal Energy Association (Obtained sanction as a corporation on September 6, 1961).
1966	October	Initiation of the first operation of a modern geothermal power plant in Japan, by Japan Metals & Chemicals Co., Ltd. (Matsukawa Power Plant, output: 9,500 kW).
1967	August	Initiation of Japan's first operation of a water-dominated, geothermal power plant by Kyushu Electric Power Co., Inc. (Ohtake Power Plant, output: 11,000 kW).
1974	June	Start-up of Ohnuma Geothermal Power Plant (Mitsubishi Materials Corporation, output: 6,000 kW).
	July	Inauguration of Sunshine Project by Agency of Industrial Science and Technology.
1975	March	Start-up of Onikobe Geothermal Power Plant (Electric Power Development Co., Ltd., output: 11,000 kW).
1977	June	Start-up of Hatchobaru Geothermal Power Plant (Kyushu Electric Power Co., Inc., output: 23,000 kW).
	September	Start of fundamental investigation for geothermal energy development by the Agency of Natural Resources and Energy.
1978	May	Start-up of Kakkonda Geothermal Power Plant (Tohoku Electric Power Co., Inc.) (Steam supply by Japan Metals & Chemicals Co., Ltd., output: 50,000 kW).
1980	October	Establishment of the New Energy Development Organization (NEDO) (currently called the New Energy and Industrial Technology Development Organization).
	October	Initiation of investigation on geothermal energy development.
1981	August	Start-up of private geothermal power plant (Suginoi Hotel, output: 3,000 kW).
	November	Start-up of Mori Geothermal Power Plant (Hokkaido Electric Power Co., Inc.) (Steam supply by Donan Geothermal Energy Co., Ltd., output: 50,000 kW).
1984	February	Start-up of private geothermal power plant (Kirishima International Hotel, output: 100 kW).
	April	Initiation of elemental technology development for hot-dry-rock power-generation system by NEDO at the Hijiori district in Yamagata Prefecture.
1990	June	Start-up of Hatchobaru Geothermal Power Plant Unit 2 (Kyushu Electric Power Co., Inc., output: 55,000 kW).

Reprinted from the *Annual Report on Geothermal Energy Development in Japan, 1992*. A publication of the Japan Geothermal Energy Association, Yurakucho Denki Bldg., 1-7-1, Yurakucho, Chiyoda-ku, Tokyo 100 Japan.

1992 Report on Japanese Geothermal Development

There are four organizations promoting the development of geothermal energy in Japan.

1. Japan Geothermal Energy Association

Established in 1960, the association is the oldest among the geothermal organizations in Japan. The association surveys, researches, educates, publishes, and studies matters relating to geothermal energy. It has about 100 corporate members and 500 private members.

2. New Energy Development and Industrial Technology Development Organization

Established in 1980 as an implementing agency of the Japanese Government in fields related to technological development, the organization aims at reducing the Japanese economy's dependence on oil. It grants subsidies for the development of geothermal resources.

3. New Energy Foundation

Established in 1980, the foundation surveys and researches matters to promote the development of techniques related to new energy sources. It also surveys, researches, demonstrates, and distributes information concerning the development and use of small- and medium-sized hydraulic, geothermal, and other local energy sources.

4. Geothermal Research Society of Japan

The society was established in 1978 to promote the advancement of science and technology related to the exploration, development, power generation, and multiple uses of geothermal energy. Its general meeting is held every fall. Foreigners' attendance at the meeting and memberships are welcomed.

Three journals play a leading role among Japanese journals in the field of science on geothermal energy. These are *Chinetsu* (Japanese Geothermal Energy Association), *Geothermal Energy* (New Energy Foundation), and the *Bulletin of Geothermal Research Society of Japan*.

Table 1. Geothermal power plants operating in Japan, March 1991.

Name of Power Plant (Name of Enterprise)		Rated Output (MW)	Annual Energy Production (MWh)	Maximum Power (MW)	Operation Factor (%)	Load Factor (%)	Utilization Factor (%)	Auxiliary Power Ratio (%)
Matsukawa	(Japan Metals & Chemicals Co., Ltd.)	22.0	173,551	22.0	98.1	89.8	89.8	6.8
Otake	(Kyushu Electric Power Co., Inc.)	12.5	104,234	12.5	95.9	94.9	94.9	8.7
Ohnuma	(Mitsubishi Materials Corporation)	9.5	67,131	9.2	91.3	83.1	80.4	8.3
Hatchobaru I	(Kyushu Electric Power Co., Inc.)	55.0	384,152	54.9	100	79.6	79.5	7.9
Hatchobaru II	(ditto)	55.0	409,746	55.0	92.9	84.8	84.8	7.3
Onikobe	(Electric Power Development Co.)	12.5	87,430	12.5	86.0	80.0	79.6	10.7
Kakkonda	(Japan Metals & Chemicals Co., Ltd. and Tohoku Electric Power Co., Inc.)	50.0	363,121	50.0	94.8	82.7	82.7	5.0
Mori	(Donan Geothermal Energy Co., Ltd. and The Hokkaido Electric Power Co., Inc.)	50.0	172,210	30.0	87.4	65.4	39.2	14.2
Suginoi	(Suginoi Hotel)	3.0	2,811	1.75	100	76.1	10.7	23.2
Kirishima International Hotel	I							
	(Daiwabo Kanko Co., Ltd.) II	0.45	1,582	0.43	100	51.7	40.0	15.9
	III							
Takenoyu	(Hirose Trading Co., Ltd.)	0.105	—	—	—	—	—	—
	Total	270.055	1,765,968	248.28	—	81.0	74.5	—

Note: 1. "Annual Energy Production" covers energy production for one year from April 1, 1991 to March 31, 1992.

2. "Maximum Power" indicates the maximum power generated in one hour.

3. "Operation Factor" is equivalent to:
$$\left(\frac{\text{Number of Operating Days}}{\text{Number of Calendar Days}}\right) \times 100\%$$

4. "Load Factor" is equivalent to:
$$\left(\frac{\text{Average Power through the year}}{\text{Maximum Power}}\right) \times 100\%$$

5. "Utilization Factor" is equivalent to:
$$\left(\frac{\text{Average Power through the year}}{\text{Rated Output}}\right) \times 100\%$$

6. "Auxiliary Power Ratio" is equivalent to:
$$\left(\frac{\text{Auxiliary Power}}{\text{Annual Energy Production}}\right) \times 100\%$$

Table 2. Wells drilled for geothermal power plants in operation in Japan, March 1991.

Name of Power Plant	Rated Output	Steam Conditions (Turbine Inlet)			Production Well								Injection Well				
		Temp.	Press.	Flow Rate	In Use	Spent	Reserve	Total	Depth	Press.	Steam Flow Rate	Hot Water Flow	In Use	Spent	Reserve	Total	Depth
	(MW)	(°C)	(kg/cm²g)	(t/h)	(number)	(number)	(number)	(number)	(m)	(kg/cm²g)	(t/h)	(t/h)	(number)	(number)	(number)	(number)	(m-m)
Matsukawa	22.0	147	3.5	211.7	10	2	0	12	1,080-1,507	3.7-4.3	220	0	2(1)	0	0	2	1,000
Otake	12.5	127	1.5	135	4	6	2	12	350-1,561	3.3-6.6	135	604	15	11(2)	0	26(2)	360-701
Ohnuma	9.5	127	1.5	107	5	1	0	6	1,485-1,767	1.06-1.28	86.3	403.1	3	3(2)	0	6(2)	636-1,200
Onikobe	12.5	138.2	2.5	141.7	7	3	1	11	228-1,500	1.95-6.4	86	361	4	1	1	6	350-800
Hatchobaru I	55.0	164/109	6.0/0.43	345/124	14	7	1	22	552-1,971	5.8-7.5	348/124	576	13	13(3)	0	26(3)	703-1,500
Hatchobaru II	55.0	164/107	6.0/0.3	327/110	10	0	0	10	1,270-1,851	5.9-7.8	372/110	446	4	0	1	5	1,100-1,500
Kakkonda	50.0	147.4	3.5	478	19	3	0	22	887-2,000	4.8-20.2	435	2,300	16	3	0	19	521-1,600
Suginoi	3.0	142.9	3.0	40	3	7	0	10	150-400	2.5-3.5	25	3.0	0	0	0	0	–
Mori	50.0	162.4/119.6	6.0/1.0	356/137.8	8	0	3	11	736-3,000	7.9-15.0	229/102	1,118	8	0	5	13	998-2,383
Kirishima	0.45	142.9	3.0	6	3	0	0	3	70-400	1.8-2.2	5.5	0.2	0	0	0	0	–
Takenoyu	0.105	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	270.055	–	–	–	83	29	7	119	–	–	1,936.3/336	5,811.3	65(1)	31(5)	7	103(5)	–

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

Table 3. Installed thermal power for direct-use geothermal energy in Japan, April 1992.

Prefecture	Space Heating (MWt)	Agriculture (MWt)	Aquaculture (MWt)	Snow Melting (MWt)	Pools (MWt)	Industry (MWt)	Stock Breeding (MWt)	Total (MWt)
Hokkaido	9.47	23.09	0.92	3.81	0.65	0.45		38.39
Aomori	0.73	0.12	0.03	1.40				2.28
Iwate		3.22						3.22
Miyagi	0.19	1.65	0.03	0.74				2.61
Akita	0.92	0.72	1.21	1.18	1.50	0.99		6.52
Yamagata	0.08	0.00	3.29	1.81				5.18
Fukushima					1.95			1.95
Gunma	4.44			1.81	0.39			6.64
Tochigi	0.09	0.05		0.05				0.19
Nagano	1.85	0.40		1.14	0.01			3.40
Shizuoka	0.86	1.27	3.58				0.10	5.81
Gifu	16.37	0.05	1.41	0.95	0.21			18.99
Hyogo					0.09			0.09
Wakayama			0.17					0.17
Okayama	0.12	0.02						0.14
Shimane			0.01	0.35				0.36
Yamaguchi		0.20						0.20
Saga		0.01						0.01
Kumamoto	0.96	0.93	1.06					2.95
Oita	12.55	39.05	4.24					55.84
Kagoshima	3.45	8.24	12.92		0.08	0.02	0.10	24.81
Total	52.08	79.02	28.87	13.24	4.88	1.46	0.20	179.75

Table 4. Development status of geothermal power plants in Japan.

Name of Power Plant	Output MW	Electric Power Company	Development Company	Fiscal year* 1991	1992	1993	1994	1995	1996	1997
Uenotai	27.5	Tohoku Electric Power Co., Inc.	Akita Geothermal Energy Co., Ltd.		92/4 △	94/3 ▲				
Sumikawa	50	Tohoku Electric Power Co., Inc.	Mitsubishi Materials Corp.			93/4 △	95/3 ▲			
Yanaizu	65	Tohoku Electric Power Co., Inc.	Okuaizu Geothermal Co., Ltd.			93/6 △		95/5 ▲		
Kakkonda II	30	Tohoku Electric Power Co., Inc.	Tohoku Geothermal Energy Co., Ltd.				94/4 △	96/3 ▲		
Yamakawa	30	Kyushu Electric Power Co., Inc.	Japex Geothermal Kyushu Co., Ltd.			93/7 △	▲			
Ohgiri	30	Kyushu Electric Power Co., Inc.	Nittetsu Kagoshima Geothermal Co., Ltd.					▲		
Takigami	25	Kyushu Electric Power Co., Inc.	Idemitsu Geothermal Co., Ltd.						▲	
Oguni	25~30	Electric Power Development Co.,	Electric Power Development Co.,							

*Fiscal year in Japan is from April 1 to March 31 of the following year.
△Start of construction work
▲Start of operation

Indonesia: Archipelago on the Ring of Fire

Introduction

Indonesia, an area once called the East Indies Spice Islands, is a volcanic archipelago just below the equator between the Asian continent and the South Pacific Ocean and the Australian continent and the Indian Ocean (Fig. 1). The archipelgo is stretched out over 5150 kilometers, a distance equivalent to the width of the United States. There are more than 17,500 islands in this chain, but the Islands of Sumatra, Java, Kalimantan, Sulawesi, Bali, and Irian Jaya are concentration centers for population, industry, and cultural development.

Cultural History

Indonesia has a population of about 180 million people, and 55 percent are children. There are about 17 major ethnic groups, each numbering in the millions, and more than 200 smaller ethnic groups. This great mix is due to migrations over the last 5,000 to 6,000 years.

Over the centuries, the archipelago has felt the influences of Mongols, Arabs, Indians, Asians, Native Australians, and Europeans; all have left cultural and religious impacts. The Dutch dominated Indonesia from about 1605 until late 1949.

Because of such ethnic diversity, about 50 languages and many dialects are spoken. The national language is Bahasa Indonesia, which is written in Roman script.

Geological Setting

The geology of the Indonesian archipelago is almost as diverse as the culture. Starting about 400 million years ago, the area has evolved through complex subduction and strike-slip faulting of megaplates (the Eurasian, Philippine, Indian-Australian, and Pacific plates) and of minor plates (Sunda and Caroline plates). Sediments (melange, continental, pelagic, and accretionary terrigenous deposits) have been rearranged and deposited in ever changing patterns of deformation.

For about 65 million years, volcanic activity has been prominent in Indonesia. The locations of volcanoes, the lava characteristics, and the geothermal activities vary from island to island, due to the complexities of tectonic plate motion and the magma source. Of more than 177 volcanic centers in the archipelago, 70 to 80 are active. About 10 major volcanic eruptions occur each year. Geothermal activity (fumaroles and solfataric vents) occurs in about 88 localities in the archipelago.

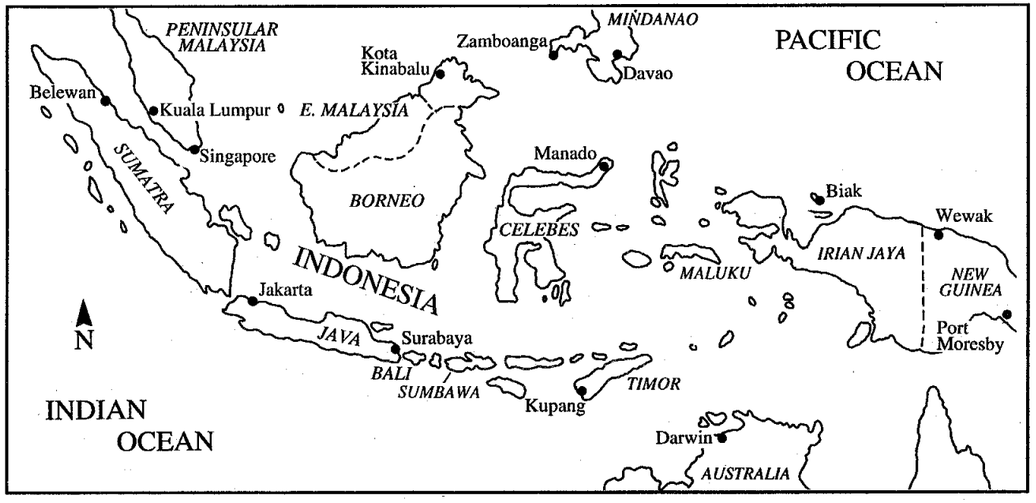


Figure 1. Indonesia, showing locations of major islands in the archipelago.

by Mary C. Woods
Geologist

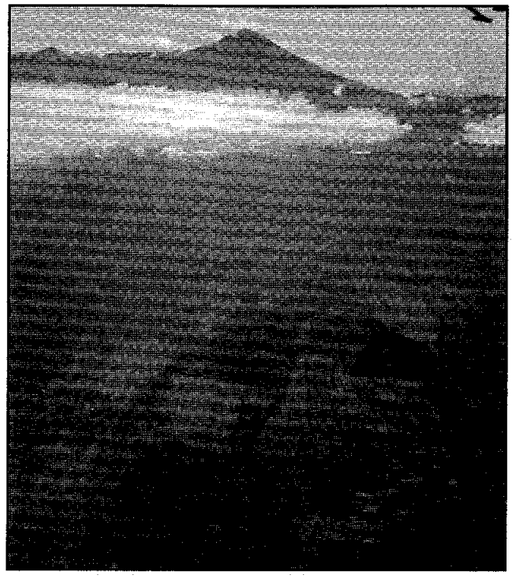


Photo 1. View of Tambora, Island of Sumbawa, Indonesia. In 1815, this volcano produced the earth's largest historic eruption. Photos by M. Woods, July 1992.

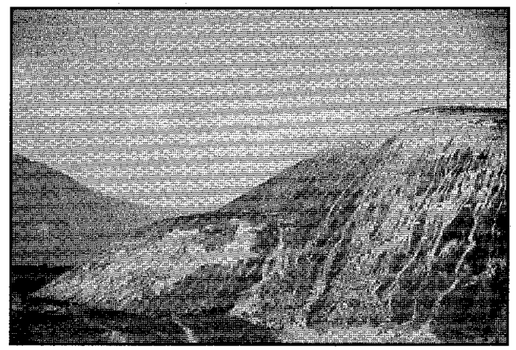


Photo 2. Krakatau volcano area, Java, Indonesia. Three small islands in the former crater are all that remained of the volcano after the 1883 eruption. Today, the volcano is made up of cinders and volcanic debris built up by eruptions in 1927 (lower left) and 1988 (larger cone on right). The light colored streaks on the 1988 cone are sulphur deposits.

Sumbawa Island

Tambora, a towering 2820-meter volcano, dominates the Island of Sumbawa. It is one of the largest volcanic cones in the world (Photo 1 and Fig. 2). The caldera is 6 kilometers wide and about 700 meters deep. Tambora produced the largest historic volcanic eruption when it erupted in April 1815. The eruption brought the immediate death of 12,000 people, with another 78,000 people dying of starvation and disease in the aftermath of the gigantic explosion of 100 cubic kilometers of volcanic ejecta. One-half meter of volcanic ash and mud covered the island, and no crops could be grown for several years. The climate was affected worldwide, and the year of 1816 became known as the year without a summer.

Java Island

The Island of Java is the site of the famous Krakatau volcano (Photo 2), which erupted in 1883, causing worldwide variation in climatic conditions. The volcano was 30 miles off the west coast of Java. The explosion of Krakatau created a collapsed submarine

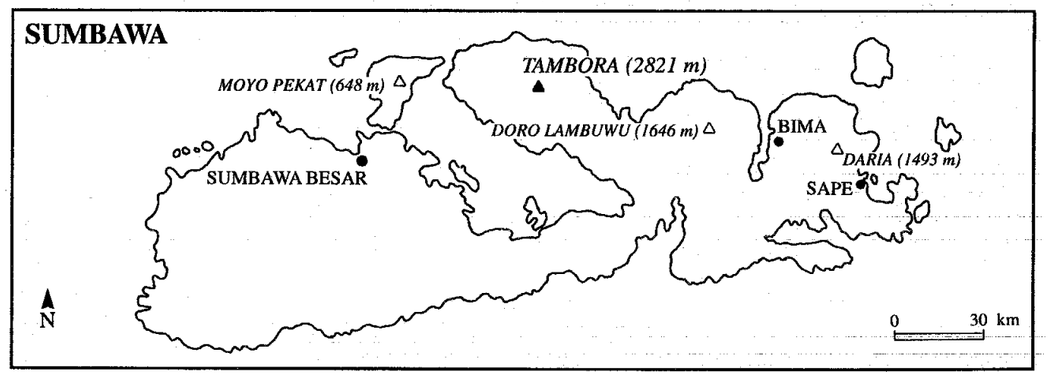


Figure 2. Sumbawa, Indonesia, showing the location of Tambora volcano.

caldera. Remnants of the cone formed an island one-fourth the size of the 1883 volcano. Submarine volcanic activity in the submerged crater formed a new cinder cone that emerged in 1928 and built up to 500 feet in elevation. The 1928 volcanic cone was called Anak Krakautau, or "Child of Krakatau." Other eruptions occurred from 1960 through 1979, and in 1981. In 1988, lava extrusions formed another cone (Photo 2).

Photo 3. Gunung Merapi (High Fire Mountain), Central Java, Indonesia. This is one of the most active and destructive volcanoes in the world.

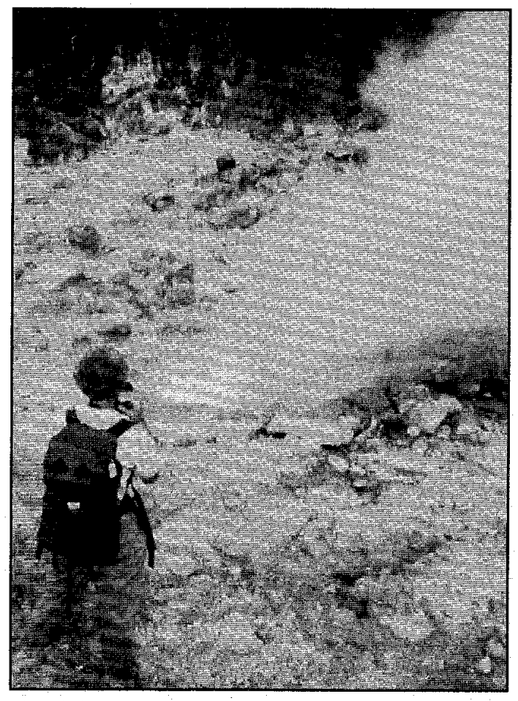


Photo 4. Sulphuric steam vents and mud pots, Gunung Papandayan, Garut Plateau area of Java.

Gunung Merapi, or High Fire Mountain, is in Central Java about 25 miles north of the city of Yogyakarta. It erupts often and is one of the world's most active and destructive volcanoes (Photo 3). Since 1930, Merapi has erupted 25 times, killing 1,500 people. The most recent major eruption was in 1969; volcanic activity occurs here at intervals of about 5 1/2 years.

Gunung Papandayan

The active crater of Gunung Papandayan is 2622 meters high, located in the Garut Plateau area of Java. Near the crater are geysers, fumaroles, sulphuric steam vents, and mud pots (Photo 4).

The volcano erupted in 1772, devastating 40 villages and killing 2,957 people. In the 1920s, earth tremors, explosions, and lahar flows occurred. Today, the volcano is monitored by seismologists.

Geothermal Power Plants

Kamojang geothermal area is on top of a volcanic mountain range, about 30 kilometers southeast of the City of Bandung, Java (Fig. 3). The area has many steam geysers, boiling mud pots, and sulphur springs. Dutch engineers first drilled wells in this area in the mid-1920s (Photos 5 and 6). Five wells were drilled to a

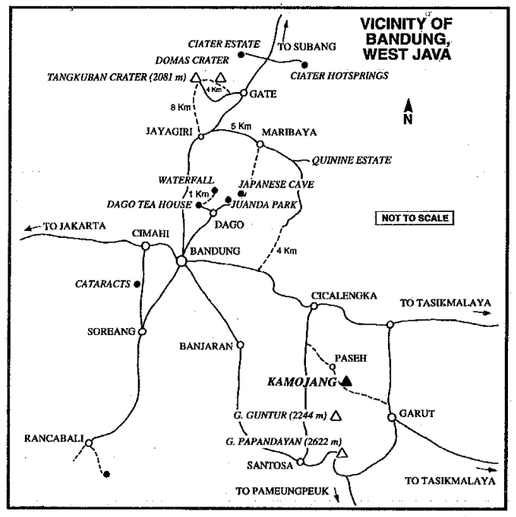


Figure 3. Vicinity of Bandung, West Java, showing location of Kamojang geothermal area.

Photo 5. Steam vents in the Kamojang geothermal area. Dutch engineers drilled 5 steam wells here in the mid-1920s.

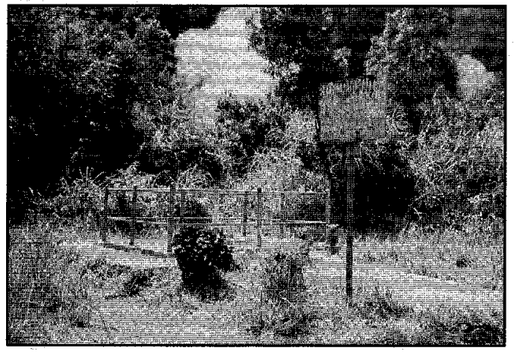


Photo 6. One of the 5, original steam wells in the Kamojang geothermal area, drilled by Dutch engineers in 1926. Well #2 is now sealed. The drill bits are displayed, embedded in cement, and information about the well is on the sign (right side of photo). Steam from vents can be seen in the background.

depth of about 18 to 20 meters; the steam temperature was about 110°C, with pressure measured at 0.5 kilograms per square centimeter (KSC). Steam was produced at a rate of 0.75 tons per month, according to a sign at one well.

Today, geothermal electrical-generation projects are being developed by Pertamina, the Indonesian national agency for oil and geothermal development. The Lanpangan Kamojang geothermal steam plant is operated with steam from 52 wells (Photos 7 to 9). Unit I generates 30 megawatts; Unit II, 55; and Unit III, 55. Total production is 140 megawatts of electricity, which is used in the Cities of Garut and Bandung on the Island of Java, and in cities on the Island of Bali.

The Kamojang geothermal reservoir is 1000 meters thick. Gravity survey techniques were used to site wells in the field. The wells are first drilled vertically, and then extended horizontally into the geothermal reservoir. Tungsten drill bits are used.

Well #51 was drilled in June 1992, to a depth of 1300 meters (Photo 10). The reservoir temperature is 240°C, and the production rate 120 tons per hour. The well is the third largest producer in the field. The wellbore was begun with a casing diameter of 40 inches, reduced eventually to 7 inches by the time the steam reservoir was penetrated. Waste water is reinjected. The new well will be tested for 3 months before being connected to the steam generating plant.

Dieng Geothermal Fields

On the Dieng Plateau of Central Java, the geothermal prospects of Sikidang (Photo 11), Sileri, Candradimuka, and Sroja are being developed. The Dieng Plateau is a collapsed caldera with an elevation of 2093 meters. Numerous steam vents and mud pots in the area are surface indications of deeper geothermal activity (Photo 12).

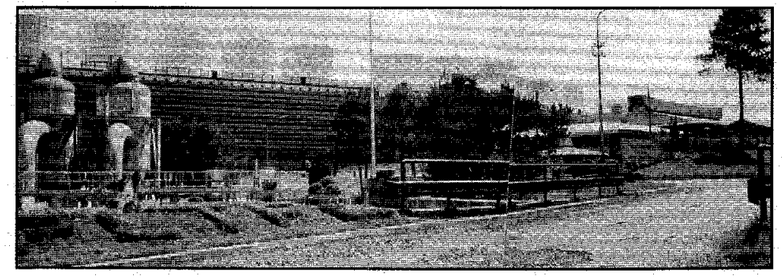


Photo 7. Lanpangan Kamojang Geothermal Plant, showing cooling towers and two, large steam-intake pipes. A vacuum pulls steam from the well units, through the pipelines and into the power plant. Three units in the field produce a total of 140 megawatts of electricity.

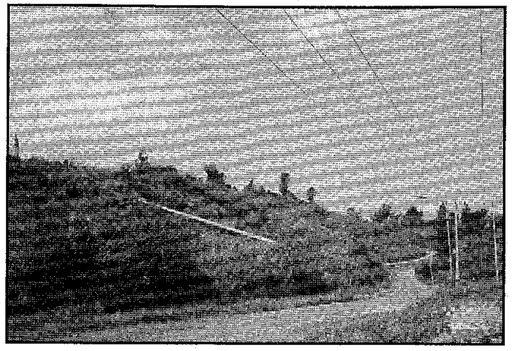


Photo 8. Steam at Kamojang Geothermal field is piped into the power plant.

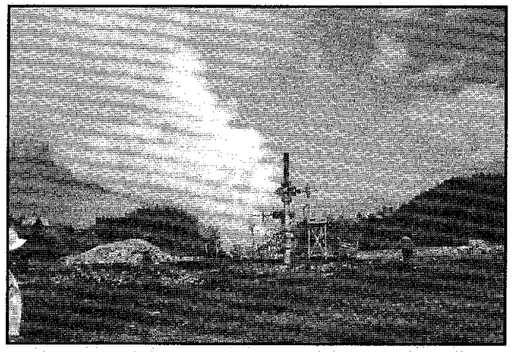


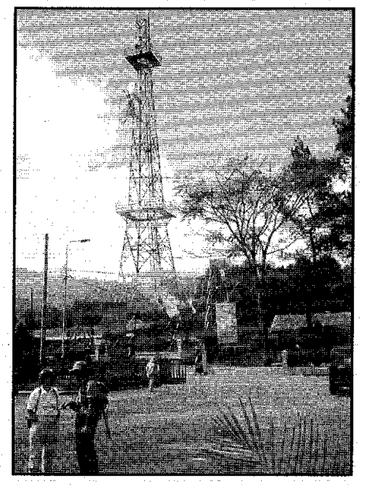
Photo 10. Kamojang Geothermal field. Well #51, drilled in June 1992, is the largest well in the field. After 3 months of testing, it will be connected to the steam plant.

Potential Geothermal Production of Indonesia

It is estimated that the potential geothermal production of Indonesia is 16,035 megawatts of electricity. There are about 80 medium-enthalpy potential geothermal sites. Five sites have been investigated and geothermal energy is being produced at Kamojang and Dieng (Sikidang).

Various factors in developing geothermal energy must be taken into consideration in some areas. In the case of the Island of Bali, geothermal development may impact the scenic environment, important to Indonesian tourism. However, it is this same tourism that could increase the electrical needs. In other areas, the transmission of geothermal energy would require costly submarine cable lines. In some areas, drilling is very difficult and expensive due to the types of rock overlying the reservoirs.

In summary, it is clear that geothermal resources will provide a significant amount of domestic energy in Indonesia.



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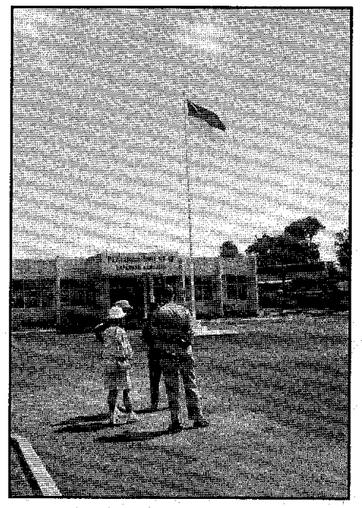

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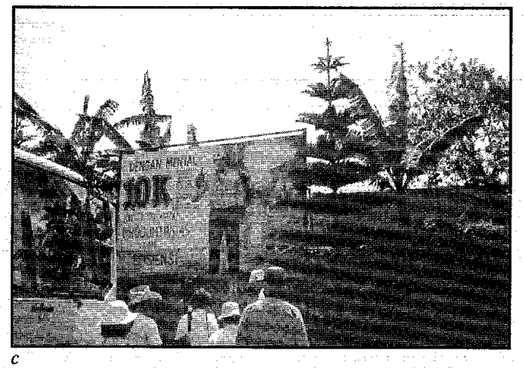

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Photo 9. Views of the Pertamina office compound, Kamojang Geothermal field. (a) The Indonesian flag flies in front of Pertamina field office headquarters. (b) Symbolic drilling rig and a loud speaker. (c) A billboard with a list of safety practices for workers.

Photo 11.Geothermal well, Sikidang prospect, Central Java. Pertamina, the Indonesian oil and geothermal agency, is extending production in this locality on the Dieng Plateau. Electricity for Dieng Village, on the northern side of the plateau, is produced from Sikidang Geothermal field.

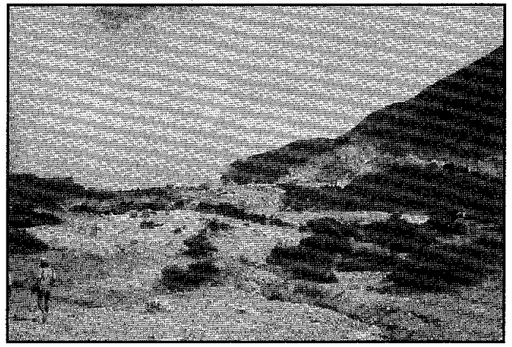

Photo 12. Steam vents and boiling mud pots in the vicinity of the Sikidang geothermal prospect, Dieng Plateau, Central Java. The geothermal activity is associated with the Dieng caldera.

Indonesian High Enthalpy-Geothermal Prospects

Abstract

Geothermal exploration in Indonesia officially started in 1972, although scientific drilling was recorded from 1926 to 1928 in Kamojang geothermal prospect, West Java. During the last 20 years, geoscientific field work has been carried out along the Indonesian volcanic belt, and many geothermal features have been discovered. The successful interpretation of the data obtained from these geoscientific surveys has resulted in a conceptual model. More than 55 high-enthalpy geothermal areas are found among the Islands of Sumatra, Java, Sulawesi, and East Indonesia. Some have been developed for electrical generation, such as Kamojang with 140 megawatts and Dieng with 2 megawatts. In the near future, the electrical production expected to be supplied by the year 1995 from geothermal energy will be increased by 437 megawatts.

Introduction

Indonesia lies on an active volcanic arc and is well endowed with high-enthalpy geothermal resources. Based on geoscientific investigations, the total estimated geothermal potential of the country is about 16,035 megawatts of electricity.

In Indonesia, modern geothermal investigations have been carried out since the 1970s. Later, detailed surveys have pointed out several promising, high-enthalpy geothermal areas. The exploration surveys were started on the Islands of Java and Bali. In 1982, surveys were extended to the Island of Sulawesi and, in 1988, to the Island of Sumatra. East Indonesia is scheduled to be investigated in 1993. Deep geothermal wells have been drilled since 1974 in Kamojang.

Sumatra Island

The geothermal prospects in Sumatra are along the great Sumatra graben neighboring the Bukit Barisan ridge. There are 15 prospects already investigated and 3 prospects ready to drill; reconnaissance is just finished for 1 prospect, and the rest are being surveyed. The total estimated resource potential is 4,885 megawatts. The first exploratory well is being drilled in the Sibayak prospect.

By S. Ganda, D. Sunaryo, D. Hantono, and T. Tampubalon. Reprinted, with permission, from a display prepared for the 20th Annual Meeting of the Geothermal Resources Council, San Diego, CA, October 1992.

Java Island

All active geothermal prospects are along the volcanic chain in the center of Java. Fifteen have been investigated in detail, with total estimated resources of 8,100 megawatts. Five prospects are being developed: Kamojang, Darajat, Dieng, Salak, and Wayang Windu, with 895 megawatts of proven potential. Seven prospects are being prepared for exploratory drilling and two have to be reevaluated.

Sulawesi Island

Exploratory investigations have occurred in North and South Sulawesi. In North Sulawesi, the Lahendong prospect will be developed for 20 megawatts, beginning in 1995/96. Two other prospects are being surveyed. The only prospect investigated in South Sulawesi is Bituang, where a reconnaissance was made. The total resource potential in Sulawesi is about 1,500 megawatts.

Bali and Flores Islands

In Bali, the Bratan geothermal prospect has been investigated in detail. The possible potential is about 215 megawatts. Some exploration methods have been applied, and they have defined the boundary of the prospect to support the status of ready-to-drill. Tourism facilities are the potential market in Bali.

Flores Island is included in the program of rural electrification, and geothermal energy is the potential energy resource in the area. Two hundred megawatts are suggested as the possible potential.

East Indonesia

East Indonesia will be considered for the next program on geothermal investigation. This activity will parallel the government program for developing East Indonesia in the next 5-year planning period. The estimated potential is about 1,500 megawatts--from Nusa Tenggara and Maluku to West Irian Jaya. The forestry and fishery industries are the potential markets.

DEVELOPMENT

POWER GENERATION

CPUC Hearing on Expanding Competition for Electrical Supply

On September 16, 1992, the California Public Utilities Commission (CPUC) announced it will hold an "en banc" hearing of the four-member commission to advance its implementation of competitive energy resource bidding by all sources of energy providers. The hearing is scheduled tentatively for October 21, 1992.

Such bidding would expand the types of energy resource providers allowed to bid for contracts to supply energy to electrical utilities. By obtaining energy from independent providers, electrical utilities can defer building plants.

Expanding the bidding to all-source providers will provide increased competitive pressures, encouraging low-priced electricity for California ratepayers. Also, it will further the CPUC's goal to ensure reliable, least cost, environmentally responsible energy in California.

CPUC Introduces DSM Pilot Program

On September 16, 1992, the California Public Utilities Commission (CPUC) approved pilot programs for demand side management (DSM) bids for Southern California Gas, Southern California Edison, and San Diego Gas and Electric.

The pilot programs, along with the program already approved for Pacific Gas & Electric Company, will test a variety of DSM bid programs through which independent companies that are not utility affiliates or subsidiaries will provide utility-funded, energy-conservation programs.

The CPUC will use the pilot programs to learn whether or not a DSM bidding program can be used to increase and improve energy conservation programs for utility customers at reduced utility costs.

Similar to other DSM programs, shareholders will earn profit incentives on the energy the program conserves. Utility customers will absorb the program costs because they benefit directly from the conservation activities.

To implement the program:
Southern California Edison will redirect $35.4 million from previously approved funding and customer rates will not be increased.

Southern California Gas is authorized to increase its DSM spending to $13.7 million beginning in 1994. This increases incrementally its DSM costs by $324,000 throughout the life of the program. Any necessary customer rate increase will be decided in the company's 1993 biennial, cost-allocation proceeding.

San Diego Gas and Electric Company is authorized to increase DSM spending to $19.2 million, beginning in 1993. This will increase its DSM expenses by about $4 million over current funding. The rate increase for its customers will be decided in the next appropriate rate case.

Today's order sets a consistent set of cost-effectiveness criteria for the bids and directs utilities to consider project comprehensiveness in the bid evaluation process.

The CPUC has set aside certain portions of each utility's service for the pilot as follows:
Southern California Edison bids will be for its small offices, industrial, and large commercial customers in the Southern and San Gabriel service areas.

Southern California Gas will solicit bids for energy efficiency improvements for retrofitting residential homes. However, residences that qualify for the utility's low-income weatherization program are excluded from the DSM bidding program.

San Diego Gas and Electric Company bids will replace the utility's residential Appliance Efficiency Incentive Program, provided the bids do not conflict with the utility's low-income direct assistance, energy audit, load management, and information programs.

CPUC Interim Transmission Access Established

The California Public Utilities Commission (CPUC) has established an interim transmission access program. The interim program establishes the terms and conditions by which nonutility suppliers, known as Qualifying Facilities (QF's), can deliver electricity to the wholesale market through utility transmission lines. The program will coincide with and be limited to the Final Standard Offer 4 auction to be held before the end of 1992.

The interim transmission access program is designed to facilitate participation and competition in the wholesale market by as many QF's as possible, both within California and out-of-state. Both for environmental and economic reasons, the CPUC wants to maximize use of the existing transmission system. If necessary transmission capacity is added in a timely manner, there will be better access to low-cost power, and this will produce savings for ratepayers because new power-plant construction will be avoided or deferred and resources conserved.

Improved transmission access also enables smaller sellers with diverse technologies and fuel types, which tend to be more geographically dispersed than utility plants, to compete in markets that otherwise would be closed to them for lack of access.

The program will allow the incorporation of transmission costs in the bid evaluation so that generating plants with the lowest total generation and transmission costs will be selected in the auction. Also, it will ensure that the transmission system is not overbuilt, by providing incentives for QF's to locate near existing, available transmission capacity.

The interim program is limited to the state's three major electrical utilities. Eventually, a permanent transmission access program will include municipal utilities and other suppliers, thus enabling other electricity suppliers besides QF's to bid in the auction. Involvement of municipal utilities that are not regulated by the CPUC is important in promoting competition and economic efficiency. These utilities serve a large portion of the state's population, and control substantial transmission and generation facilities.

The interim program will enable the CPUC to learn what areas need refinement for a permanent program, including comparing estimated costs with actual transmission costs. The second phase of the proceeding will focus on broader transmission-access issues, including

wheeling to and from in-state municipal utilities and out-of-state utilities, and cost allocation issues.

Now, the parties must conclude successfully the verification process for utility transmission cost tables. Transmission costs will then become part of the bid evaluation procedure, consistent with today's interim decision.

A prehearing conference to continue Phase II of this proceeding will be held after the auction, probably in December 1992.

Sierra Pacific Electric Resource Plan

On July 1, 1992, Sierra Pacific Power Company released its 20-year plan, developed to meet the growing electrical needs of Nevada. The plan projects energy supplies and demands from 1992 through 2011. Plan elements include adding new power generating facilities and reducing energy usage through conservation programs.

"Our intent is to develop a plan to meet our customers' growing energy needs with low-cost, environmentally acceptable supply-side resources and cost-effective demand-side reductions," said Tom Parker, Sierra's vice president of Electric System Planning and Engineering. "The planning was guided by the goals of meeting customer energy requirements in a least-cost fashion, while not exposing our customers and shareholders to unacceptable economic and technical risk."

The utility anticipates that between 1992 and 1997, customer demand for electricity will increase from 1,079 megawatts to 1,306 megawatts. The increase represents an average annual growth rate of 3.9 percent. Mining and manufacturing segments of the economy are predicted to be major contributors to the growth.

Mr. Parker stressed that all items proposed in Sierra Pacific's Electric Resource Plan are in compliance with Nevada State Senate Bill 497, which requires the Nevada Public Service Commission (PSC) to determine whether a utility's resource plan considers economic benefits and environmental impacts to the state and to utility customers.

Sierra Pacific's plan will now undergo review by the PSC, which will hold public hearings. On November 11, the PSC will decide whether or not to implement the measures outlined in the plan.

GROUND-SOURCE HEAT PUMPS

Teleconference on Ground-Source Heat Pumps

On July 21, 1992, a downlink of the Geothermal Heating and Cooling Teleconference was located in Sacramento, California. The downlink in Sacramento was sponsored by the Sacramento Municipal Utility District and the National Geothermal Association. Eight other agencies and associations, headed by the U. S. Department of Energy (DOE), sponsored the teleconference as a whole. The teleconference was viewed by about 3,500 people around the United States.

During the teleconference, William Rosenburg, Assistant Secretary, Air and Radiation, U. S. Environmental Protection Agency (EPA), said that the EPA is interested in geothermal heat pumps (interchangeably called "ground-source heat pumps" by the various speakers) because they reduce emissions 35 to 73 percent per household. "Recent developments make heat pumps real winners," he stated. "Customer satisfaction with installed heat pumps is high."

J. Michael Davis, Assistant Secretary, Conservation and Renewable Energy, DOE, said, "Many new technical opportunities exist in the utility sector to provide what consumers want. Ground-source heat pumps can be operated at a lower cost than the more traditional choices for heating and cooling. They allow utilities a way to manage loads and still meet the needs of the customer."

David Goldstein, of the Natural Resources Defense Council, said that "...ground-source heat pumps are crucial to a least-cost heating strategy. The largest three residential uses of energy are heating, cooling, and hot water. All can be handled by geothermal heat pumps."

William F. Hecht, president and chief executive officer, Pennsylvania Power & Light Company, commented that the utility hopes by 1996 to increase by 10 fold the installation of ground-source heat pumps. He expects one fourth of the new homes in the area to have them. "The heat pumps give $3.50 of heat for every $1.00 spent on electricity. They are cheaper than almost any other energy source, require lower peak demand, and allow the construction of new power-generation projects to be deferred," Mr. Hecht stated.

Mr. Hecht listed some problems. He said that too few people know about ground-source heat pumps, that lack of contractor infrastructure makes heat-pump installation difficult, and that he is looking for ways to decrease the initial capital expense for installation.

More geothermal heating and cooling teleconferences are planned for 1993. For information on the teleconferences or on ground-source heat pumps, contact Lew W. Pratsch, U. S. Dept. of Energy, 1000 Independence Avenue, S.W., Washington, D.C. 20585. Phone (202) 586-1512.

New Jersey College Chooses Geothermal

Stockton State College in Pomona, New Jersey, will receive about $5 million in funding from the New Jersey Energy Conservation Bond Act and other sources to install one of the nation's largest geothermal energy systems. The funding will make it possible for Stockton to replace its outdated heating and cooling units with a state-of-the-art, super-efficient system. The new geothermal unit is expected to be in operation before the fall term of September 1993. Part of the New Jersey College System since 1969, Stockton's 1,600-acre campus is in southeastern New Jersey at the tip of the Pine Barrens and within 12 miles of Atlantic City.

The Capital Renewal and Replacement Project will cost an estimated $5,022,000 and preserve, in a cost-effective and environmentally-sound manner, the State of New Jersey's substantial capital investment in the main campus facilities of Stockton. These consist of over 357,000 square feet of instructional and educationally-related space.

Approval of the project was made at an August 1992 meeting of the college Board of Trustees.

"The entire Stockton community is very excited about this innovative concept for conserving energy, and extremely pleased that the state Department of Environment Protection and Energy is a partner in this venture," said Stockton State College President Vera King Farris.

Dr. Farris added: "This outstanding project will enable Stockton to create a more efficient energy system with fewer pollutants and advance to the cutting edge of energy conservation. Through the installation of this system, Stockton will become a pioneer not only in New Jersey, but throughout the country with this revolutionary provision of an alternative source of energy. This is one of the rare times when a single creative decision benefits so many key aspects of our lives. The system will conserve energy, preserve the environment, and reduce the cost of higher education at Stockton State College."

Nancy Wittenberg, director of the New Jersey Department of Environment Protection and Energy agreed. "The Department of Environment Protection and Energy is particularly pleased to be involved in the Stockton project as it clearly represents energy planning of the future," she said. "The technology of geothermal systems utilizes the earth's natural heat, a remarkable energy source. This project decreases the state's overall energy consumption and meets the goals of the New Jersey Energy Master Plan of providing secure energy supplies, encouraging economic growth, and protecting the environment," she concluded.

According to Atlantic Electric Senior Vice President Henry K. Levari, "Atlantic Electric's participation in the Stockton project is a good example of our commitment to encouraging the use of high efficiency appliances and technologies. Geothermal heat pumps are the most efficient heating and cooling systems on the market today. Besides their environmental benefits, geothermal systems help us put off the construction of new generating units by controlling the demand for electricity during the crucial summer months."

The geothermal water heat-pump system will substantially reduce Stockton's operating budget, according to Dr. Charles Tantillo, Stockton's Senior Vice President for Administration and Finance. The net savings from energy cost savings, reduced maintenance costs, and the annualized cost of owning the equipment is about $455,000 per year. For example, the new geothermal system is expected to save Stockton State College an estimated $330,000 each year in energy costs alone. It will reduce the electrical consumption in the college's academic facilities by 25 percent and cut the gas consumption by over 70 percent.

"By reducing our energy consumption, Stockton will remove over 2,100 tons of environmental pollutants from the air -- that's the equivalent of removing over 400 automobiles each year from the roadways," said Dr. Tantillo.

The college's existing heating, ventilation, and air conditioning system will be replaced with a geothermal earth-coupled, water-source heat-pump system. Additionally, the college's new Arts and Sciences building, which is under design by architect Michael Graves, will be integrated with the geothermal water heat-pump system.

Geothermal heat pumps differ from conventional air-source heat pumps in that the geothermal heat-pump system uses the earth as a heat sink. This is accomplished by circulating water through an underground, high-density polyethylene, closed-loop piping system. Over three-hundred and ninety, 400-foot deep wells will be involved in the project, located in open spaces adjacent to college buildings. Because ground temperature is significantly higher than air temperature in winter and lower in summer, the ground-coupled or geothermal heat pump is capable of extraordinary efficiency.

The college has 72 existing heating, ventilation, and air conditioning systems, which are rooftop, gas-fired/DX multi-zone units. Replacement parts are scarce, costly, and in many cases, impossible to obtain. As a result, maintenance is expensive and time-consuming.

Although direct replacement with higher efficiency gas-fired/DX rooftops would result in energy savings, maximized savings can be achieved by replacing the existing system with geothermal system.

A major proponent of Stockton's geothermal project is Atlantic Electric. As part of its heat-pump rebate program, the South Jersey utility will pay Stockton $1.1 million for the installation of the system. Atlantic Electric's rebate incentive works out to $800 per ton of cooling for the college's nearly 1,400 tons of cooling, which amounts to a total of $1.1 million in rebate. Also, under the New Jersey Energy Conservation Board Act of 1980, the New Jersey Department of Environmental Protection and Energy approved a request for assistance of $2,373,000 to construct the geothermal groundwater system. The $50 million NJEC Bond Act provided for energy audits and energy conservation renovations at state-owned buildings.

The U. S. Department of Energy (DOE) has endorsed geothermal heat pumps as an energy-efficient option for consumers. In the National Energy Strategy, the DOE forecasts geothermal heat pumps can provide as much as 2.7 quads of renewable energy annually by the year 2030. Energy provided in this manner will result in less environmental impact than use of conventional combustion of heating and electric cooling.

Stockton State College is a college of liberal arts, sciences, and professional studies with an enrollment of 5,600 students. The college offers a full-range of environmentally related courses. Stockton's Governor's School on the Environment is the first of its kind in the country.

HOT DRY ROCK

Hot Dry Rock Update

The construction of the surface plant at the Fenton Hill Hot Dry Rock (HDR) site was almost completed during the 1990-91 fiscal year. A short flow test was undertaken to commission the plant and assess the state of the reservoir, which had gone for a long period without production. After several, additional short flow tests in February and March 1992, the continuous, steady-state long-term flow test was begun in early April.

The test has demonstrated that a HDR plant can be run in a highly automated mode. Of major significance from a power production standpoint is the fact that the injection side of the system can be shut in for several hours while the reservoir pressure serves as ballast, allowing the production of energy to continue. This implies that HDR power plants can be designed to operate with the same high level of availability that is characteristic of conventional hydrothermal installations.

Output from the pilot operation has been about 100 gallons of water per minute at a temperature above 180°C (360°F). Water consumption to date has been in the range of 10 to 12 percent. Previous static pressurization tests indicate that at constant pressure, reservoir water demand declines with time. Verifying this fact under flow conditions is a goal of the long-term flow test.

For further information, contact Dave Duchane, Program Manager: Hot Dry Rock, Los Alamos National Laboratory, MS-0443, Los Alamos, New Mexico 87545. Phone (505) 667-9893.

Copies of the *FY 1991 HDR Annual Report*, and a 4-page flyer, *Heat Mining to Tap Hot Dry Rock Energy*, are available from Dr. Duchane.

The Fenton Hill Hot Dry Rock Site

By Dave Duchane
Program Manager: Hot Dry Rock

The high-pressure injection pumps (1) at the center left of the photo, pressurize water to about 4,000 psi. They deliver water through a stainless steel line to the injection well (2). There are two injection pumps but only one is used in normal operations. The operating schedules of the two pumps are alternated. The water passes down the injection well to the reservoir, at a depth of about 12,000 feet, and migrates through the reservoir rock to the production well bore. The water returns to the surface through the production well (3) as superheated water. Next, it passes through a series of pressure-control valves (4) and on to the heat exchanger (5), where its useful energy is extracted as it is cooled back to the ambient temperature. Any makeup water required is added by pumps in the makeup water building (6) as the water is circulated back to the pump.

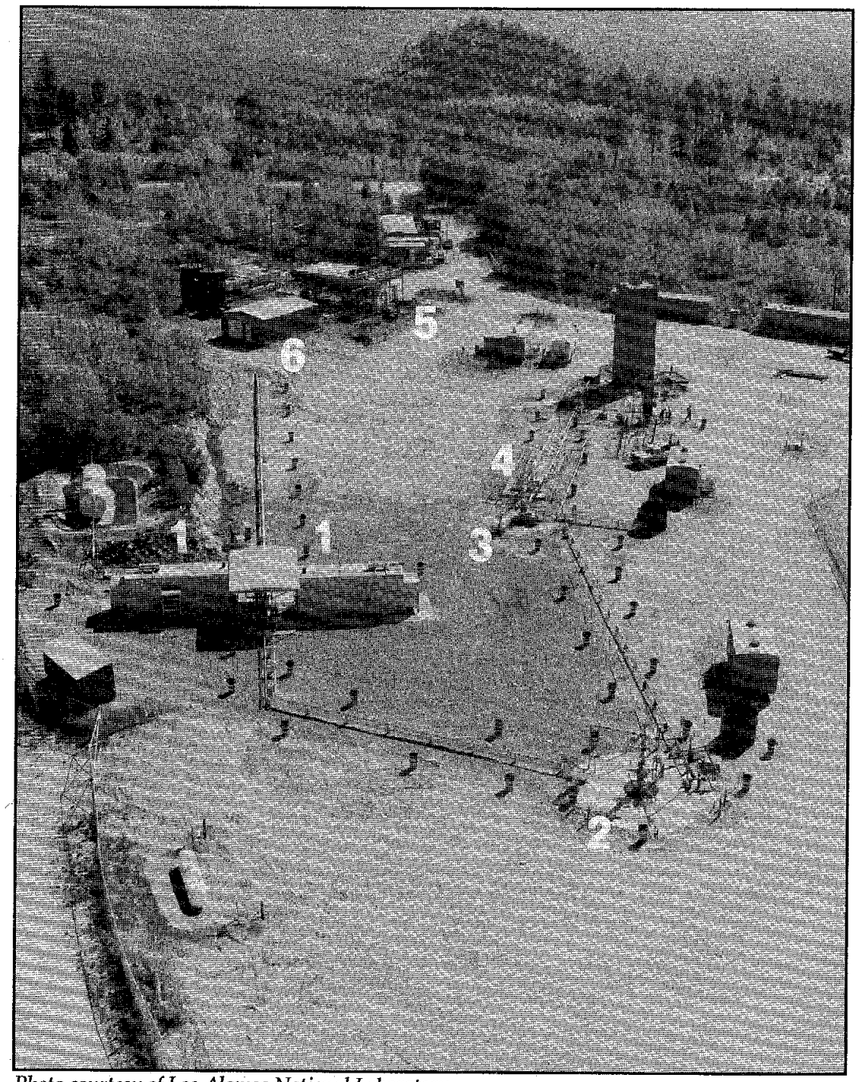

Photo courtesy of Los Alamos National Laboratory.

GEOLOGY

Mantle Research Underway

Dr. Louise H. Kellogg, a geophysicist at the University of California, Davis, studies how motion in the Earth's mantle affects surface geological processes such as volcanoes, earthquakes, and the formation of mountains. She has just received a Presidential Faculty Fellow Award to study these matters. The award carries a 5-year $500,000 grant from the National Science Foundation.

An assistant professor in the geology department at UC Davis, Dr. Kellogg uses high-powered supercomputers to model the motion of the Earth's mantle. The slow movement of material in the mantle is believed to be the driving force behind geological processes such as earthquakes, mountain building, and plate tectonics. Dr. Kellogg is especially interested in upwellings of hot mantle material called plumes, which form massive volcanic areas such as the Hawaiian Islands.

USGS Geothermal Volunteers

The U. S. Geological Survey (USGS) "Volunteer for Science Program" offers unique experiences in USGS laboratories, offices, and field sites to persons of all ages, backgrounds, and areas of interest.

One field research project, offered in 1992, is from the USGS Branch of Igneous and Geothermal Processes, Denver field office. The contact scientist is Thomas J. Casadevall, phone (303) 236-1028.

The USGS is the nation's largest earth science, civilian mapping, and water-information agency. For further information about all volunteer opportunities available, contact Ms. Susan Wells, USGS, 215 National Center, Reston, VA 22092. Phone (703) 648-7452.

REGULATIONS

New BLM Geothermal Regulations

New U. S. Bureau of Land Management (BLM) geothermal appeal regulations are listed in the *Federal Register*, vol. 57, no. 129, in the "Rules and Regulations" section for Monday, July 6, 1992.

The new regulations were effective August 5, 1992. They allow a decision to stand from an authorized, BLM officer on such matters as the approval of a drilling permit or a utilization plan after an appeal by an adverse party is filed, unless the decision is reversed by the Interior Board of Land Appeals (IBLA). Previously, an appeal by an adverse party would stay or stop the BLM's decision until it was affirmed by the IBLA.

For further information, contact Erik Kaarlela, at (202) 653-2127.

New Geothermal Regulatory Code in New Zealand

"The *Code of Practice, Deep Geothermal Wells* was developed with the assistance of the New Zealand geothermal fraternity," said Jonathan Leaver, Chief Geothermal Inspector of New Zealand's Mining Inspection Energy & Resources Division. "The code is designed to be relevant to the completion of geothermal wells to depths and temperatures in excess of 3000 meters and 350°C, respectively."

In a separate document, Mr. Leaver and others further describe the code.

"The (New Zealand) code covers all aspects of a geothermal well up to and including the master valve but does not cover any aspects of utilization of geothermal energy downstream of the master valve. Full use is made of both overseas and local material and equipment specifications, with oil industry specifications referred to, where applicable. The code integrates practices developed in New Zealand with those proven in many geothermal fields, worldwide. Care was taken not to inhibit the use of new or experimental techniques that may be developed in the future. It ensures that an adequate margin of safety could be achieved in all aspects of the drilling, operation, and maintenance of wells.

"The adoption in law of the code will be achieved by incorporating it as part of the geothermal Energy Regulations 1961 or the replacement regulations currently being drafted. It is probable that the code will attain legal status in New Zealand by December 1991."

Copies of the code are available for about US $281.30 for nonmembers and US $168.78 for members of the Standards Association of New Zealand. For more information, write to the association at its Sales Section, 6th Floor, Wellington Trade Centre, 181-187 Victoria Street, Wellington 1, New Zealand.

FINANCES

U. S. International Energy Trade and Development Program

The U. S. Agency for International Development (USAID), the Department of Energy (DOE), and the U. S. Trade and Development Program (USTDP) jointly support commercial development of international energy trade opportunities for U. S. industry by funding feasibility and planning studies. The collaborative program, "U. S. Federal International Energy Trade and Development Opportunities Program (FIETOP)," seeks proposals from U. S. industry that would result in a substantial increase in exports of U. S. goods and services, and support economic development in foreign countries.

Support from the participating agencies provides for a 50-50 cost-sharing arrangement and administrative-resources coordination with the applicant. The DOE is authorized to fund advanced coal technology projects only; USAID can fund any type of energy or power generation project, including coal; and USTDP can provide 50 percent of the cost of feasibility studies (repayable to USTDP over 4 years on a no-interest loan basis).

For further information, contact Peter Cover, U. S. Department of Energy, Office of Planning and Environment (FE-4), Washington, D.C. 20585. Phone (202) 586-7297.

USAID Energy Project Development Fund

The Office of Energy and Infrastructure in the U. S. Agency for International Development (USAID) has announced available funds for prefeasibility and feasibility studies related to energy. The funds may be applied towards both privately- and publicly-owned energy projects in USAID-assisted countries. The funds may be used for up to 50 percent of the cost of studies for a project.

Objectives for the Energy Project Development Fund include:

1. Providing financial assistance to evaluate private and public energy projects in the developing world. Priority is given to projects that involve proven, environmentally acceptable, and clean technologies; and

2. Assisting private companies from the United States and public-sector entities from USAID-assisted countries to identify and develop projects that support sustainable and environmentally acceptable economic development and promote U. S. trade and investment.

It is expected that the projects will employ commercially proven technologies.

Public-sector projects must be publicly-owned and operated. They must use commercially-proven innovative or advanced technology. Eligible projects may include clean coal technologies, energy conversion, advanced electric power generation, advanced energy transmission and distribution, and energy related environmental technologies.

Private-sector projects must be owned or operated by the private sector, and may include private power plants, private leasing and rehabilitation of energy facilities, contracting out energy-utility functions, and privatization.

Eligible applicants may include U. S. majority-owned, private-power developers; utilities and their subsidiaries; energy and environmental equipment suppliers; and engineering firms. Eligible applicants may also include developing country public utilities and other public-sector entities working with U. S. companies.

The fund will share with eligible applicants up to 50 percent of the cost of feasibility studies and other related project-development activities.

The purpose of cost sharing is to create incentives for energy-development activities. Projects are expected to exhibit a high potential for commercial implementation.

Threshold criteria for application to the fund include

the following. The applicant must be a U. S. company or a public agency from an USAID-assisted country that is working with a U. S. company. The project must meet World Bank environmental standards (*see* Publications Section, this issue). Technologies must be commercially proven. The project site must be identified. The applicant must provide at least 50 percent of the cost.

Applications for both public and private projects are available from the Energy Project Development Fund, R&D/E1, Room 508, SA-18, Agency for International Development, Washington, D.C. 20523-1810. Phone (703) 875-4052, Fax (703) 875-4053.

Geothermal Grant and Loan Program

Grants and loans through the California Energy Commission's (CEC) Geothermal Grant and Loan Program may be used to develop direct-use and small-scale electrical systems. Funding also may be used to lessen adverse effects of planned or existing large-scale geothermal power plants.

Funding is available for hardware research and development that will make geothermal energy technologies more efficient and cost effective, or resolve technical barriers to commercialization.

Private entities can also take advantage of the geothermal option with state funding available for geothermal resource development, such as:

- technology research and development;
- geothermal resource assessments;
- exploration, production, and injection wells;
- design, engineering, and construction; and
- economic and engineering feasibility studies.

Funding is also available for geothermal planning, such as:

- market studies, identifying potential users;
- preparing project planning documents; and
- collecting environmental data.

Geothermal impact mitigation studies to be funded include:

- identifying and controlling adverse impacts;
- air and water quality monitoring; and
- upgrading adversely affected public services.

Grants and loans will be awarded for geothermal research, resource development, planning, and mitigation projects. Loan terms are up to 20 years with a maximum interest rate of 8 percent. The loan ceiling is 80 percent of the total project cost.

For more information, contact Kelly Birkinshaw, Geothermal Grant and Loan Program, CEC, 1516 Ninth Street, MS-43, Sacramento, CA 95814. Phone (916) 654-4542.

INDUSTRIAL DEVELOPMENT

Diamond Film Technology

Du Pont and the U. S. Department of Energy have signed joint research agreements on diamond film technology, which could produce the world's strongest materials for commercial and defense applications. Sandia and Los Alamos National Laboratories will work with Du Pont to develop the technology and manufacturing capability for coating a variety of composite materials with diamond and diamond-like carbon to produce materials with improved mechanical, chemical, and thermal properties. The collaborative work is expected to generate a new class of composite materials with high strength and improved thermal conductivity.

The three-year, $6 million effort is expected to employ about 14 government and industry scientists at least part time. The cost will be split evenly between the government and the company.

ORGANIZATIONS

The Mexican Geothermal Association

The Mexican Geothermal Association (MGA) was founded on May 8, 1992, in Mexico City as a nonpolitical, nonprofit association. Its purposes are to encourage geothermal research, to promote the use of the earth's heat, and to disseminate national and international geothermal information in Mexico. Its statutes are similar in scope and purpose to those of the International Geothermal Association, and arrangements are underway to affiliate the MGA with the IGA.

On October 3, 1992, about 35 people attended the first annual general meeting of the MGA in Tijuana, Mexico. Organizational details were discussed at the meeting, a new slate of officers was elected, and technical papers were presented.

"I think the association started out on the right foot," said Dr. Eduardo Iglesias, the newly elected vice president. The other new officers include the president Ing. Héctor Campbell, the secretary Ing. Ranulfo Gutiérrez, the treasurer M. en C. César Suarez, the vice-secretary Ing. Nabor Rosas, and the vice-treasurer Ing. René Palacios.

The second annual general meeting will be in Mexicali in October 1993.

Those interested in joining the MGA should contact the secretary at the Instituto de Investigaciones Eléctricas, Dante 36 11590 Mexico, D.F.; Phone: (5) 5 117938; Fax: (5) 5 252172.

TECHNOLOGY TRANSFER

CONFERENCES & COURSES

Course on Exploration and Assessment of Geothermal Fields

The Government of Mexico, through the Program for Professional Development of the Banco Centroamericano de Integración Económica, has completed a course on geothermal energy for the second time. Called "Exploration and Assessment of Geothermal Fields," the course was directed toward professional geothermalists from Central American countries. Twenty professional geothermalists from Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua received fellowships covering their expenses. Two Mexican engineers who attended were sponsored jointly by the Comisión Federal de Electricidad and the Instituto de Investigaciones Eléctricas (IIE). The course included 20 hours of geology, 32 hours of vulcanology, 32 hours of geochemistry, 80 hours of reservoir engineering, and a 3-day field trip to Los Humeros Geothermal field.

The course was held at the IIE, in Cuernavaca, September 7 to October 7, 1992. The IIE provided the instructors, laboratories, computing facilities, and logistics.

For further information, contact Dr. Eduardo Iglesias, Leader Reservoir Engineering Group, Department of Geothermics, IIE, Apdo. Postal 475, Cuernavaca, Mor. Mexico. Fax: 52-73-18-2526.

By Dr. Eduardo Iglesias
IIE

Eighteenth Annual Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 26-28, 1993.

At the workshop, researchers, engineers, and managers involved in geothermal reservoir studies and developments will report on their progress and discuss geothermal matters.

For further information, contact Ms. Jean Cook, Program Manager, Petroleum Engineering Dept., 360 Mitchell Bldg., Stanford, California 94305-2220. Phone (415) 723-4745.

Geotechnica, "Protecting the Earth-Challenges to Science and Technology", Cologne, Germany, May 5-8, 1993.

The conference is sponsored by the Alfred Wegener Foundation. The topics to be covered are environmentally conscious utilization of resources, acquisition of information, sanitizing and landscaping, preventive action and environmental protection measures, and environmental politics and its acceptance.

For further information, contact KolnMesse, Messe- und Ausstellungs-Ges. m.b.H. Koln, Messeplatz 1, Postfach 21 07 60, W-5000 Koln 21 Germany. Professor Dr. F. Strauch is president of the executive committee.

International Symposium on Problems of Geothermal Energy, June 21-27, 1993, Saint Petersburg, Russia. Sponsored by the Saint Petersburg Mining Institute and the Russian Geothermal Association.

The goals of the symposium are to advance theoretical knowledge and practical application of the development of geothermics, geothermal resources evaluation, technology and utilization of energetics and balneology; to establish and develop scientific contacts among specialists from different countries; and to improve and expand on the contents of *Geothermal*

Energy, a three-volume collection of scientific papers to be published in 1994, in Russian and English.

The main topics to be discussed are geotemperature fields and geothermal resources; geothermal energy and fluids extraction; and using geothermal energy and thermal water.

Symposium sponsors and participants include the State Committee on Science, Higher Schools and Technique of Russia, the Russian Academy of Sciences, the Academy of Natural Sciences of Russia, the International Geothermal Association, and the International Bureau on Mining Thermophysics.

Papers are solicited in all aspects of theoretical and applied geothermics, geothermal technology, geothermal energetics, and balneology. Authors should submit brief summaries of papers (about 300 words) to the organizing committee before March 15, 1993.

The registration fee for symposium participants is $250 and for accompanying persons $125; for Russian Geothermal Association foreign members, the fee is $200. The registration fee covers organization, editing and sending a 3-volume monograph, Geothermal Energy; the Collection of Abstracts; the Cultural Program; supper on the first evening; and a farewell dinner.

For further information, contact the Saint Petersburg Mining Institute, Dom 2, 21st Linia, Saint Petersburg, Russia 199026. Phone 2136137, 2188605. Telex 121494 LGIP SU. Fax (812) 2132613. You may also contact the co-chairman of the program committee, Prof. Paul Kruger, Civil Engineering Dept., Stanford Univ., Stanford, CA 94305. Fax (415) 725-8662.

VII International Symposium on the Observation of the Continental Crust through Drilling. Santa Fe, New Mexico. April 25-30, 1994.

The symposium is sponsored by the organization for the Deep Observation and Sampling of the Earth's Continental Crust and the U. S. Department of Energy, Office of Basic Sciences.

For further information, contact: Dr. Earl Hoskins, DOSECC, College of Geosciences and Maritime Studies, Texas A&M University, College Station, TX 77843-3148. Phone (409) 845-3651.

VIDEOS

Before the Drilling Begins

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

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

A Geysers Album, the History of The Geysers Geothermal Field

Development of The Geysers Geothermal field began four times in Geyser Canyon, on the southeastern edge of the field. First, Native Americans found and enjoyed the thermal features on the steep hillsides. They showed them to early California settlers, who spread the word. By the 1850s, organized tourism was underway. The 1920s saw the first attempts to generate electricity from the field's dry steam. It was then that John D. Grant drilled the first well in the field, next to the Witches' Cauldron, a famous bubbling hot spring with pitch-black water. The project ended in the 1930s. In the 1950s, modern, electrical-generation projects began, next to John Grant's wells. This and recent developments at The Geysers are discussed in the video.

A Geysers Album, a history of The Geyers Geothermal field, was produced by the Division of Oil and Gas in 1992. Copies may be purchased for $25 in the VHS format.

MAPS

Geothermal map of North America, CSM006. By D. D. Blackwell and J. L. Steele. *With contributions from: D. S. Chapman, E. R. Decker, W. D. Gosnold, Jr., A. M. Jessop, T. Lewis, A. Prohl-Ledsma, P. Morgan, A. D. Duchov, M. Reiter, D. L. Smith, and J. Witcher.* 1992.

Four sheets, each about 42" x 55", scale 1:5,000,000, in an illustrated file envelope.

Folded $37.50; rolled $39.50. (Digital data included on this map are available separately from the National Geophysical Data Center (NGDC), NOA Mail Code E/GC1,325 Broadway, Boulder, CO 80303). Phone (303) 497-6478 or 6124.

Published by and available from the Geological Society of America, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301. Phone (800) 472-1988.

New Nevada Wilderness Status Map

The Bureau of Land Management (BLM) has published a new Wilderness Status Map for Nevada. The 1:1,000,000 map, dated May 1992, replaces the June 1986 map and features Nevada Wilderness Study Report recommendations as well as U. S. Forest Service Wilderness Areas designated under the Nevada Wilderness Protection Act of 1989.

The map, which is available through BLM offices statewide for $3, shows Wilderness Study Area (WSA) names, numbers and boundaries on the front of the map, and includes WSA descriptions, Final Environmental Impact Statement references, and Wilderness Study Report recommendations on the map's reverse side.

A Wilderness Study Area is a unit of land administered by the BLM whose characteristics meet criteria set forth by Congress for wilderness. The Federal Land Policy and Management Act of 1976 (FLPMA) required the BLM to review the lands it manages, determine which areas have potential as wilderness, and report to Congress. In Nevada, nearly 49 million acres were reviewed. Some 34 million acres were impacted by roads, mining, power lines, or were in pieces too small to effectively manage as wilderness; these were dropped from review in 1979.

The 15 million acres that remained were divided into study areas and inventoried to assess wilderness characteristics. In November 1980, 102 WSA's were designated in Nevada, covering 5.1 million acres. Nine Natural Areas were reclassified as WSA's.

Between 1980 and 1991, an Environmental Impact Statement (EIS) was prepared for each WSA. The U. S. Geological Survey and U. S. Bureau of Mines conducted a mineral study in each WSA.

Early in 1991, the Nevada BLM completed a Wilderness Study Report, with boundary recommendations for wilderness and nonwilderness areas in each of the 52 WSA's. The Secretary of the Interior reviewed the report in October 1991 and recommended to the President the establishment of 1.9 million acres for wilderness designation, and the release of 3.2 million acres for uses other than wilderness.

Now, Presidential review has been completed, with recommendations forwarded to Congress on September 4, 1992. Congress is not expected to take any action on the recommendations until the next session, at the earliest. Congress has sole authority to designate WSA's as new additions to the National Wilderness Preservation System, or to release them for uses other than wilderness.

Until Congress decides on these recommendations, the BLM will continue to manage all WSA's under an interim management policy designed to not impair the suitability of these areas for preservation as wilderness.

For a copy of the map, send $3 to the Nevada State Office, 850 Harvard Way, P.O. Box 12000, Reno, Nevada 89520-0006. Phone (702) 785-6500.

PUBLICATIONS

Renewable energy excursion: supporting analysis for the National Energy Strategy, December 1990. Free. (Prepared by the Energy Information Administration.)

National Energy Strategy, 1991/1992. Free.

Both publications are available from Dr. Lew Pratsch, Conservation and Renewable Energy, Department of Energy, 1000 Independence Avenue, S.W., Washington, DC 20585. Phone (202) 586-1512.

The documents include ample discussions of geothermal energy and other types of energy used in the United States.

The National Energy Modeling System -- a preview. By the Energy Information Administration, Office of Integrated Analysis and Forecasting. Brochure. Free. Available from the National Energy Information Center, El-231, EIA, Room IF-048, Forrestal Bldg., Washington, D.C. 20585. Phone (202) 586-8800.

The National Energy Modeling System (NEMS) is a unified system of models built to produce mid- and long-term energy forecasts that evaluate the effects of alternative energy policies and assumptions. NEMS will forecast energy supply, conversion, demand, prices, trade, macroeconomic activity, and related environmental impacts.

The Office of Integrated Analyses and Forecasting invites user review and comments on NEMS.

State energy data report, consumption estimates, 1960-1990. DOE/EIA-0214(90). Stock No. 061-003-00756-2. May 1992. $26.00. Published by the Energy Information Administration. Available from New Orders, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954.

The report provides estimates of energy consumption by major end-use sectors developed in the State Energy Data System, prepared by the Energy Information Administration.

U. S. Department of Energy Publications

The following publications are available, free of charge, from the U. S. Department of Energy, Geothermal Division, Mail Code CE-122, 1000 Independence Avenue, SW, Washington, D.C. 20585.

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Geothermal energy R & D program, annual progress report for fiscal year 1991. 1992.

Three categories of geothermal resources are discussed. These are hydrothermal energy from liquid-dominated or vapor-dominated reservoirs with temperatures ranging from 150°-360°C (300°-680°F); geopressured-geothermal energy from moderately hot brines containing dissolved methane at high pressures; and hot dry rock.

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Geothermal program review X, geothermal energy and the utility market - the opportunities and challenges for expanding geothermal energy in a competitive supply market. Abstracts. 1992. Produced by the U. S. Department of Energy, Assistant Secretary, Conservation and Renewable Energy, Geothermal Division.

The publication contains abstracts on the geothermal research programs in universities and in U. S. governmental agencies and laboratories.

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Geothermal energy, multi-year program plan, FY 1993-1997, draft. 1992.

The publication summarizes the Geothermal Division's near-term efforts to expand the use of geothermal energy in the United States. The information is for internal planning and management purposes. Budget figures and projections are for planning and are not approved as U. S. Government budget figures or projections.

EIA publications directory 1991. By the Energy Information Administration. 1992. Free. Available from the National Energy Information Center, EI-231, EIA, Forrestal Building, Room 1F-048, Washington, DC, 205815.

The directory contains citations and abstracts arranged by subject categories, such as coal, petroleum, geothermal, and natural gas, with subcategories, such as reserves, products and by-products, and marketing and economics.

Geothermal energy, program overview, fiscal year 1991. 1991. $9.95, 15 p. Prepared for the U. S. Department of Energy. Available from the National Technology Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

The publication offers a concise, general description of geothermal energy, and goes on to explain the ways geothermal energy is used, where it is found, and U. S. Department of Energy research accomplishments for FY 1990-1991. The publication is an attractively presented overview of geothermal development.

Energy R & D: DOE's prioritization and budgeting process for renewable energy research. GAO/RCED-92-155, April 29, 1992. 22 p. One copy free. Available from the U. S. General Accounting Office, P.O. Box 6015, Gaithersburg, MD 20877. Phone (202) 275-6241. (For just a summary of the report, request publication number GAO/T-RCED-92-57, April 30, 1992. The title is the same.)

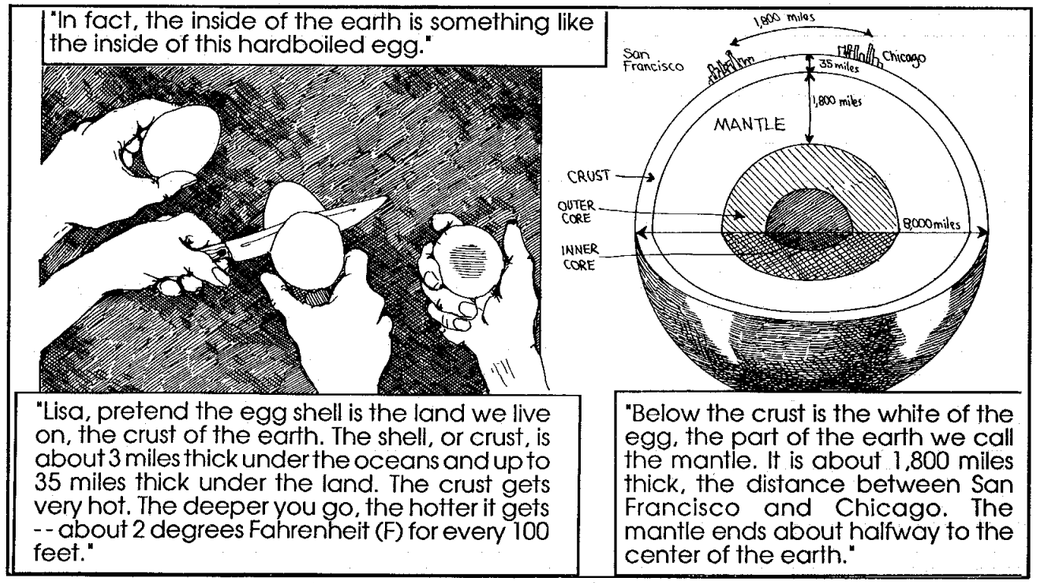
The GAO report discusses how the U. S. Department of Energy plans for and budgets research- and development-projects for renewable energy technologies, including geothermal.

Electrifying America, social meanings of a new technology. By Davis E. Nye. 1992. $15.95, paper; $32.50 hard cover. Published by and available from The MIT Press, 55 Hayward St., Cambridge, MA 02142.

"In a single lifetime between 1880 and 1940, the process of electrification transformed the landscapes of the city, factory, home, and farm. Americans built electrical devices into their lives and with the exception of a few isolated individuals and groups such as the Amish, social reality by definition became electrified." The interesting story of this change is described in the book.

Geothermal in California. By Susan F. Hodgson. 1988. Free. Free classroom sets available on request. Published by and available from the Division of Oil and Gas, MS-20, 801 K Street, 20th Floor, Sacramento, CA 95814-3530.

Over 200,000 copies have been distributed of this illustrated review of geothermal development. Although prepared for grades 4 through 9, the publication offers a quick, accurate overview for anyone interested in geothermal resources and projects.



From Geothermal in California.

Drilling Through Time, 75 Years with California's Division of Oil and Gas. By William Rintoul. Edited by Susan F. Hodgson. 1990. $10.00. Published by and available from the Division of Oil and Gas, MS-20, 801 K Street, 20th Floor, Sacramento, CA 95814-3530.

The history of California's geothermal and oilfield development and regulation includes 227 photographs and illustrations, many never before published. The unique volume goes to the beginnings of these important industries, describes turbulent changes they have undergone, and concludes with descriptions of modern-day development.

The 1992-1993 California energy plan, the biennial energy report of the California Energy Commission, Pub. 106-91-001. 1992. One copy free; additional copies $5.00. 63 p. Published by and available from the California Energy Commission, Publications Unit, 1516 9th Street, Sacramento, CA 95814-5512.

The publication is California's principal energy planning and policy document. It identifies emerging trends in energy supply and demand. After it is approved by the Governor, it becomes the state's official energy policy.

The plan is based on five technical reports that provide the analytical basis for the policies set forth in the plan. These are the *Energy Efficiency Report*, the *Fuels Report*, the *Energy Development Report*, the *Electricity Report*, and the *California Contingency Plan*.

California Indian energy news. Free. Published by and available from the California Energy Extension Service, 1400 Tenth St., Room 209, Sacramento, CA 95814.

Renewable energy: Native to California. Free. Published by and available from the California Energy Extension Service, 1400 Tenth Street, Room 209, Sacramento, CA, 95814. Phone (916) 323-4388.

The guidebook discusses renewable energy projects (including geothermal) undertaken by Native Americans in California. The 34 case studies are based on Tribal responses to a 1990 survey. An overview is included of renewable energy technologies, along with contacts for further information.

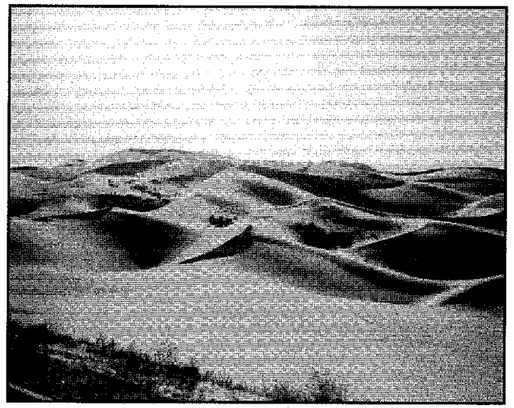
Directory of water resources expertise in California. Free. 1992. Published by and available from The Water Resources Center, U.C. Davis, Davis, CA 95616. Phone (916) 757-8901.

The directory lists more than 500 water experts in 300 technical and policy-oriented areas. It includes faculty and staff researchers from the University of California, California State University, and private institutions that investigate water resources issues.

Integrated exploration for low-temperature geothermal resources in the Honey Lake basin, California. By Ulrich Schimschol. In *Geophysical Prospecting*, v. 39, no. 2, February 1991. p. 279-291.

Geology of Imperial County: a bibliography. By Mary Elizabeth Harris. 1991. 10.00. Published by and available from the Friends of the Love Library, San Diego University, Library - Special Collections, San Diego, CA 92182-0511.

The bibliography includes over 1,300 entries, indexed by subject and place names. Over 200 entries are under "geothermal". A unique, interesting volume.



Algodones Dunes in the Imperial Valley. Photo by S. Hodgson.

Salton Sea Scientific Drilling Project, a summary of drilling and engineering activities and scientific results, final report, DOE/CE-12429-H1, April 1992. $30. Prepared by the University of Utah Research Institute for the U. S. Department of Energy. Available from the NTIS, U. S. Dept. of Commerce, 5285 Port Royal Rd., Springfield, VA 22161. Phone (703) 487-4650.

The publication is the final technical report for the Salton Sea Scientific Drilling Project (SSSDP). Most scientific results from the project are here, including 18 papers in a special 1988 issue of the *Journal of Geophysical Research.*

Also included are descriptions of project management, drilling, engineering, and site restoration activities. The report summarizes all major aspects of the SSSDP; briefly describes the technical and scientific results; and indicates the availability of technical publications, engineering studies, and other publications, reports, and open-file data. Much of the information is from two draft, final reports written by Bechtel National, Inc.

The publication describes Phase 1 and Phase 2 activities for the SSSDP in a single volume and identifies subcontractor reports, open-file data, and scientific publications available for more detailed study. The report emphasizes engineering, management, and project integration rather than scientific results, which are described in greater detail elsewhere.

Drilling began at well "State" 2-14 on October 23, 1985. In the following 160 days, the well was drilled to a depth of 10,564 feet. About 730 feet of core sample was recovered and flow tests were completed. Several hundred scientists and engineers from over 40 laboratories and organizations participated in the project.

While several of the major operational and scientific objectives of the SSSDP were achieved, budget limitations forced the project to forego others. However, preliminary and extended flow tests indicated a potential for the economic production of the well.

California environmental insider. Published twice monthly. $255 a year. Available from California Environmental Publications, P.O. Box 10106, San Rafael, CA 94912-0106. Phone (415) 647-8633.

The periodical covers environmental regulatory matters affecting California, including air and water quality; hazardous and solid waste; hazardous materials; toxics and Prop 65; CEQA; and various resource issues.

BNA California environment reporter. Published 25 times a year. Charter rate, $495; annual subscription rate, $595. Published by and available from The Bureau of National Affairs, Inc., BNA California, 770 L St., Suite 910, Sacramento, CA 95814. Phone (916) 552-6500.

All types of environmental news are included in the periodical. Among these are state actions, upcoming activities, enforcement, fees, hazardous waste, permitting, recycling, superfund, and a regional update.

Energy and the environment in the 21st century. Edited by Jefferson W. Tester, David O. Wood, and Nancy A. Ferrari. 1991. 1006 p. $60.00. Published by and available from the MIT Press, 55 Hayward Street, Cambridge, MA 02142-1399. Phone (800) 356-0343.

The comprehensive volume is well edited and organized. It includes over 100 papers from a conference held at MIT in 1990. Environmental aspects covered include air, water, thermal, and noise pollution; land and water usage; land subsidence, loss of natural beauty and scenic wonders; and catastrophic events.

Some of the articles cover geothermal matters, specifically. Included are "Geothermal Energy Opportunities for Developing Countries" by Carel Otte and "Geothermal Energy: Electricity Production and Environmental Impact, a Worldwide Perspective," by Ronald DiPippo.

Toxics A to Z: a guide to everyday pollution hazards. By John Harte, Cheryl Holdren, Richard Schneider, and Christine Shirley. 1991. Cloth, $75.00; paper, $20.00. Published by and available from the University of California Press, 2120 Berkeley Way, Berkeley, CA 94720. Phone (510) 642-1144.

Toxics A to Z is a well written and organized approach to the complex, often emotionally charged issues of toxics. It is a very useful desktop guide.

The book begins with an essay on the meaning of risk and with risk descriptions. It covers medical aspects of the toxics problem; the four major sources of toxics exposure (including groundwater); toxics and the environment; and managing toxics (legislation is discussed, such as the Safe Drinking Water Act).

A large portion of the book is a guide to commonly encountered toxics, including their physical and chemical properties, exposure and distribution, health effects, protection and prevention, environmental effects, and regulatory status. Sources are included for additional information.

Environmental assessment sourcebook, The World Bank. *Vol. I. Policies, procedures, and cross-sectoral issues.* 244 p. $13.95. *Vol. II. Sectoral guidelines.* 298 p. $17.95. *Vol. III. Guidelines for environmental assessment of energy and industrial projects.* 252 p. $13.95. $3.50 handling charge per order. Published by and available from World Bank Publications, P.O. Box 7247-8619, Philadelphia, PA 19170-8619.

The three volumes include World Bank environmental policies, procedures, guidelines, precedents, and "best practices." They are prepared for World Bank project designers and task managers, borrowing governments, and environmental assessment teams. Anyone interested in how The World Bank approaches environmental assessment will find the information useful.

Earth, air and water: resources and the environment in the late 20th century. By I.G. Simmons. 1991. $24.95, paper. Distributed by Routledge, Chapman and Hall, Inc., 29 West 35th Street, New York, NY 10001.

The volume is an up-to-date, comprehensive description of the discovery and use of natural resources, and the management of waste products. A philosophical thread is woven through the scientifically based, and fact-filled text. Geothermal energy is included in the description of alternative energy sources.

The author feels that governments and people must repair, reuse, recycle, and move increasingly towards consuming less energy.

Warner Valley, Northern CA. Photo by W. Winkler.

Endangered, threatened, and sensitive vascular plants of Nevada. Free. Available from the BLM Public Affairs Office, P.O. Box 12000, 850 Harvard Way, Reno, NV 89520-0006. Phone (702) 785-6586.

The publication identifies the vascular plants that are in greatest jeopardy of extinction in Nevada. Included are the eight vascular plants federally listed as threatened or endangered. Seven of these are endemic to Ash Meadows in southern Nye County. The eighth, the Steamboat buckwheat, is narrowly endemic to soils around hot springs south of Reno.

Besides the plants on the federal list, many more species are described as threatened or endangered or in categories of concern. Four ranks are in the publication: the federal categories, Nevada state categories, Northern Nevada Native Plant Society status, and Nevada Natural Heritage Program rankings.

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Three major texts were adopted by the United Nations Conference on Environment and Development, often called the Earth Summit, held in June 1992 in Rio de Janeiro, Brazil. These were the *Agenda 21* blueprint for global action in all areas of sustainable development, including energy; the *Rio Declaration on Environment and Development*; and a set of principles for the sustainable management of forests.

The conference documents are published in a 650-page document called ***Drafts Agenda 21, Rio Declaration, Forest Principles***. The publication costs $75.00 and may be ordered from United Nations Publications, Sales Section, Rm. DC2-0853, Dept. 218, New York, NY 10164-0512. Please add 5 percent ($3.50 minimum) for postage and handling.

Another publication available from the UN is **Energy Systems, Environment and Development: A Reader.** 1991. 496 p. $29.95 (plus 5 percent or $3.50).

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EPRINET, an environmental externalities clearinghouse. For information, contact the Electric Power Research Institute, Larry Williams, phone (415) 855-2695.

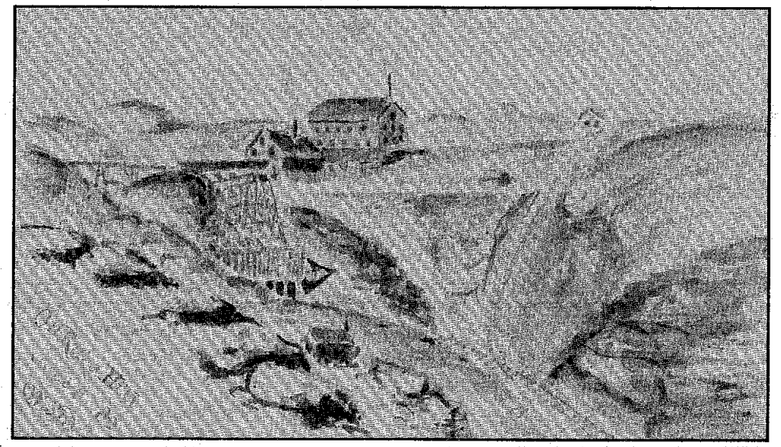
The database includes state-by-state regulatory activity related to externalities--the assignment of explicit economic value to certain environmental impacts from energy projects. It includes requirements, citations of important filings and orders, details of implementation issues, and a bibliography.

Off the Beaten Trail: How One Man Saw The Frontier Mining West In Colors

Nevada, Spanish for "snow covered," is the Silver State, the Sagebrush State, the Battleborn State (having entered into union with the United States in 1864 during the Civil War) and a state with a great deal of geothermal energy. At first, Nevada mined just silver. After a couple of decades, the silver was gone and people moved on. The mining towns became ghost towns and the boom-to-bust cycle was completed, although geothermal resources remained, and people returned 100 years later to develop them.

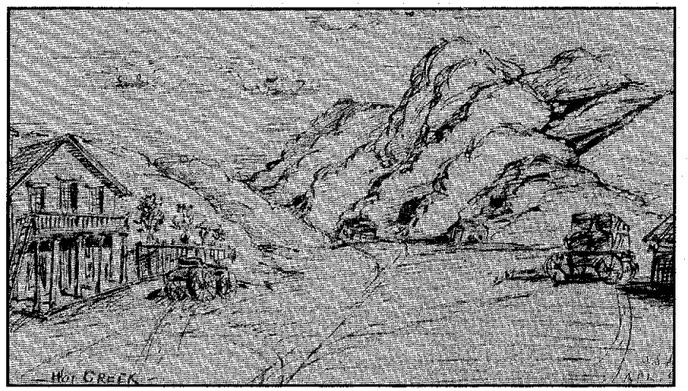
Native Americans in Nevada used geothermal energy. From 1844 on when John C. Fremont discovered Las Vegas hot springs, each year marked more hot springs discoveries and more uses found for geothermal energy.

Who captured for us future generations this bygone era in central Nevada's late nineteenth century frontier?



On Ruby Hill. June 8, 1880.

by Barbara A. Baylard
Geothermal Section, Santa Rosa



Hot Creek. April 4, 1879.

of Boston was Walter Long's Muse, his inspiration. He transformed his feelings and thoughts for her into the shape of an artistic endeavor. That was the Magic. He made three sketchbooks that contained these post-card watercolors: "Sketches in Silverland, (Nevada in November)"; "Tem Piute; Sketches of Mountain and Mine"; and "In and Around Eureka, Nevada." He places the name Elizabeth C. Parker on the title page of the first sketchbook; he dedicates the second sketchbook to "to ECP"; in the third sketchbook, he even composes a poem, offering the sketches to Miss Parker. Perhaps the paintings that depicted the austerity of his life style also reflected the bleakness of his personal life in a land full of hardships. All we are told about Elizabeth C. Parker is that "he never won her hand or heart." (We also have to keep in mind that the flurry of painting production was within a short time frame, from 1878 to 1880). So it is highly plausible that these pictures were some sort of visual diary, a journal intended to show her his daily life and surroundings. Whatever the reason, it is a timeless creation that found its niche in immortality.

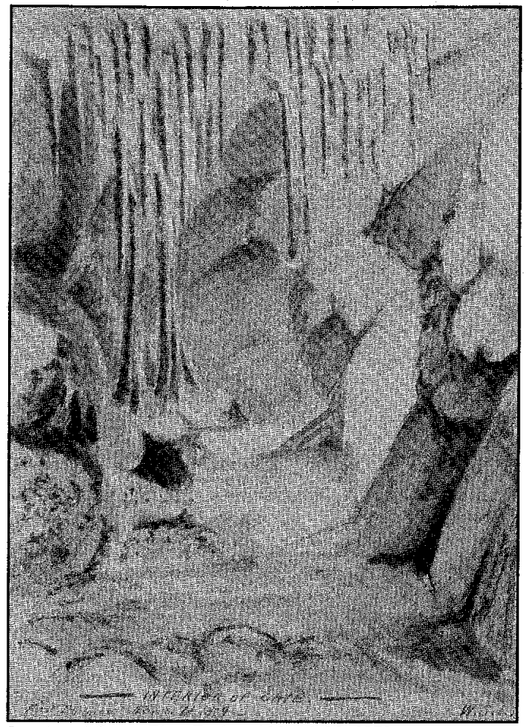
Not necessarily the photographers, they were too restricted by the rugged terrain--it was unrealistic to drag the cumbersome photographic equipment of that day to such remote areas. Not necessarily the professional painters--to be in fashion then, landscape scenery always had to include a body of water (an unspoken rule). Who caught that rugged conservative look of Nevada, crossed with the individualism of the Old West, for descendants to review as the "Bonanza" years? According to authors Michael J. Brodhead and James C. McCormick in their volume entitled *Brushwork Diary, Watercolors of Early Nevada*, it was a civil engineer of that time period named Walter S. Long.

With the meticulous eye of a draftsman, Walter Sully Long, "a genuine American primitive," captures Nevada in his 64 post-card sized watercolor paintings in color included in this book. Indeed, it is a most singular record of the Nevada mine sites, city streets, desert terrain, even of cabin interiors and of everyday mining life. The pictures can be important to any mining historian or art buff of that particular era, or to today's geothermal developer who appreciates Nevada's early mining history.

What is the romance behind these pictorial outputs? Elizabeth C. Parker

What is the mystery behind these pictorial outputs? The artist is obviously skilled, certainly not an amateur.

Our Present Habitation. Tempiute. November 14, 1878.



Interior of Cave. First Explored March 21, 1879.

set against a (strong) wash of blue sky instead of the hills." They go on to suggest that his attitude reflected "a heightened optimism about life." Then why does he abandon this style at the end--tapering off into monochrome? Another mystery. Four months after the last sketch was drawn, Long makes reference to this fact in one of the stanzas he writes to Elizabeth Parker, "Unfinished--all I have to give." Apparently, as his obsession with her faded, he surrendered his pencils and brushes, also.

Walter S. Long is buried on Angel Street in a cemetery located in Reno. His tombstone reads, "Major Long of the 96th Regiment of the U. S. Colored Infantry." During the Civil War, he had spent his time in the Union army using his engineering abilities "engaging in reconnaissances," and building and fortifying roads, primarily on the Gulf Coast.

After the Civil War, Long went to Eureka, Nevada, where at age 36 he began using his engineering skills as a mining and irrigation surveyor. He started with Wyandotte Silver Mining Company and ended up as county surveyor in Elko County. A letter was written to President William McKinley by Long's superior, Matthew Kyle, U. S. Surveyor General for Nevada, strongly urging the retention of Long in a politically appointed position as U. S. Deputy Surveyor General during the confusion caused by an incumbent's death. The matter was resolved by another official retaining Major Long. Major Long died shortly thereafter in Reno.

He had mastered shadows, textures, space, and lighting. His professional maps, drawn for the Union army during the Civil War, have been uncovered. Yet, any newspaper articles about him during his various campaigns and even his obituary notice fail to mention his painting. Thusly, the work of 11 pictures and three sketchbooks remains an isolated phenomenon in Walter Long's life.

Let's take a look at them. Mainly horizontal, the paintings were sketched initially with a graphite pencil and then filled in with colors that Long mixed from a palette of ten basic watercolors. In critique of his style, the authors note that the "application of color grew more adventuresome . . . painting in a relaxed and confident manner . . . his objects were

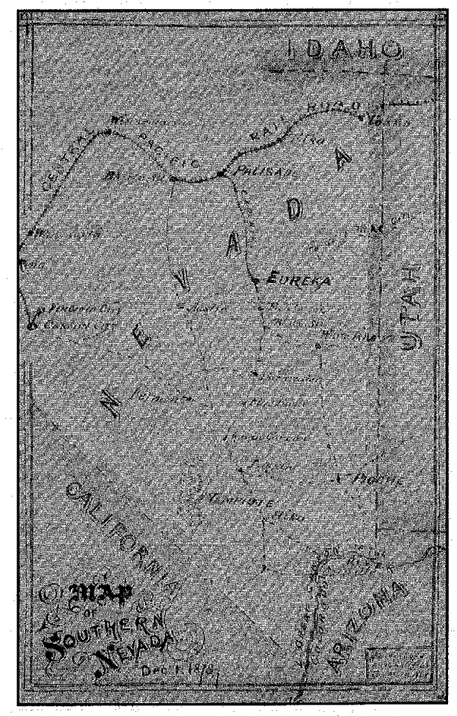
Entrance to Cave, South Side of Tem Piute Mountain. (Explored for the first time, March 21, 1879 by W.S. Long, W. McMurray & C.C. Bradley.) March 21, 1879.

Office in Eureka House. May 10, 1880.

Authors Michael J. Brodhead and James C. McCormick conclude that Walter Sully Long would have been very surprised at how he won his claim to fame's hand. Despite his long, productive, and adventurous years in civil engineering, whether in the military or as a civilian or even in the political limelight as an elected official or appointee, he labored to bring to himself achievement and respect. But it was from those few years that he spent "whiling away" and obsessed by his unrequited love for Miss Parker that he earned immortality in history.

Flip through these pages and you will be enchanted by the charm of the casual and unpretentious drawings of a man with a penchant for architecture. From studies of small operations that go on in a mining camp to the town's hose house and Chinese joss-house, to the domestic articles in his office and bedroom, you will glean from these engaging pictorials, a "faithful record of the typical." Even the minuscule lettering titling each sketch at the bottom sets a mood: "Beginnings of Comfort," "The March of Improvement," and "Luxury" are some examples. "Love and constancy must ever live," is a stanza from his poem addressed to Elizabeth Parker. And so it does, eternally, in his artistic endeavor.

Brushwork Diary, Watercolors of Early Nevada, is available from the University of Nevada Press, Reno, Nevada 89559-0076. Phone (702) 784-6573. 1991. $24.95 plus $2.50 postage.



Map of Southern Nevada. December 1, 1878.

Economic geology, Mexico, Volume P-3 of the Geology of North America. Edited by Guillermo P. Salas. 1991. $62.50. Published by and available from the Geological Society of America, Inc., P.O. Box 9140, Boulder, CO 80301.

The volume is a comprehensive reference for those interested in the geology of geothermal, coal, metallic and other nonmetallic resources in Mexico.

Several papers discuss geothermal resources. They

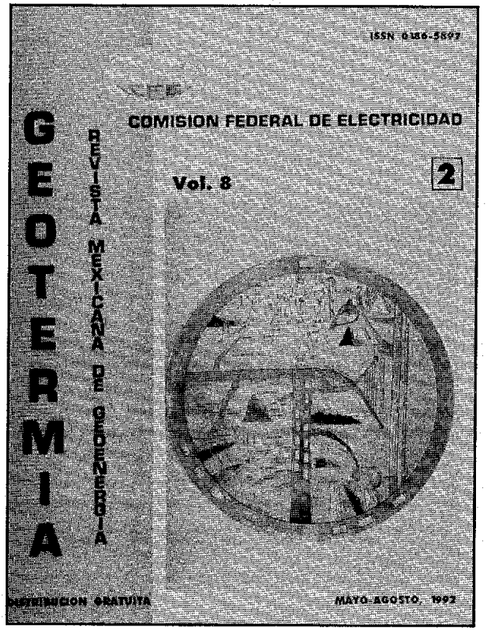
include "Economic geology of the geothermal deposits of Mexico;" "Geothermal resources and provinces in Mexico;" "Main geothermal fields of Mexico;" "Cerro Prieto Geothermal Field, Baja California;" "Los Azúfres Geothermal Field, Michoacán;" "Los Humeros Geothermal Field, Puebla;" and "La Primavera Geothermal Field, Jalisco."

Geotérmia, revista Mexicana de geoenergía. ISSN 0186-5897. Three issues a year. Most articles in Spanish. All have an English summary. Free. Available from *Geotérmia*, Revista Mexicana de Geoenergía. Apartado Postal 31-C, 58290 Morelia, Mich., Mexico.

This comprehensive geothermal magazine was founded in 1985 by members of the Geothermoelectrical Projects Division of the Comisión Federal de Electricidad, a semi-autonomous organization of the Mexican Federal Government.

The aim of the publishers is to distribute technical information to all people working in geothermal development, worldwide.

Spanish is the review's official language, but articles are accepted in English, French, or Italian. All articles are published with an abstract in English. The editor-in-chief is Ing. Mario César Suárez Arriaga.



Geology of Baja California: bibliography. By Mary Elizabeth Harris. 1991, revised edition. $10.00. Published by and available from the Friends of the Love Library, San Diego State University, Library - Special Collections, San Diego, CA 92182-0511.

Several geothermal listings are included among the 1,856 entries.

Moonlight on the Sea of Cortez, Baja California Sur. Photo by S. Hodgson.

Geothermal in Ancient Times: Three Publications

The Inca king bathes "in great tubs of gold and silver...where there are fountains of natural hot water." From one of the earliest accounts of the history of the Inca empire (Tahauntinsuyu), prepared by Garcilaso de la Vega, el Inca. He was born in Cuzco, Peru, in 1539 to a Spanish captain and an Inca noblewoman.

The quotation is from Libro Sesto de la primera parte de ***Los Commentarios Reales de los Incas***, published in Lisbon in 1609, and now part of the Library of Congress, Rare Book and Special Collections.

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Primera contribución al conocimiento historiográfico de la energía geotérmica en el Area Mediterranea y en la América Latina. By P.D. Burgassi, R. Cataldi, J.L. Hernández Galán, M. Moggi, R. Rubinovich, and J.J. Saldaña. 1992. About 700 p. Most entries in the volume are in Italian or Spanish, but several are in English, French, Latin, or Greek. Limited imprints. Several archival copies of the volume are in central locations.

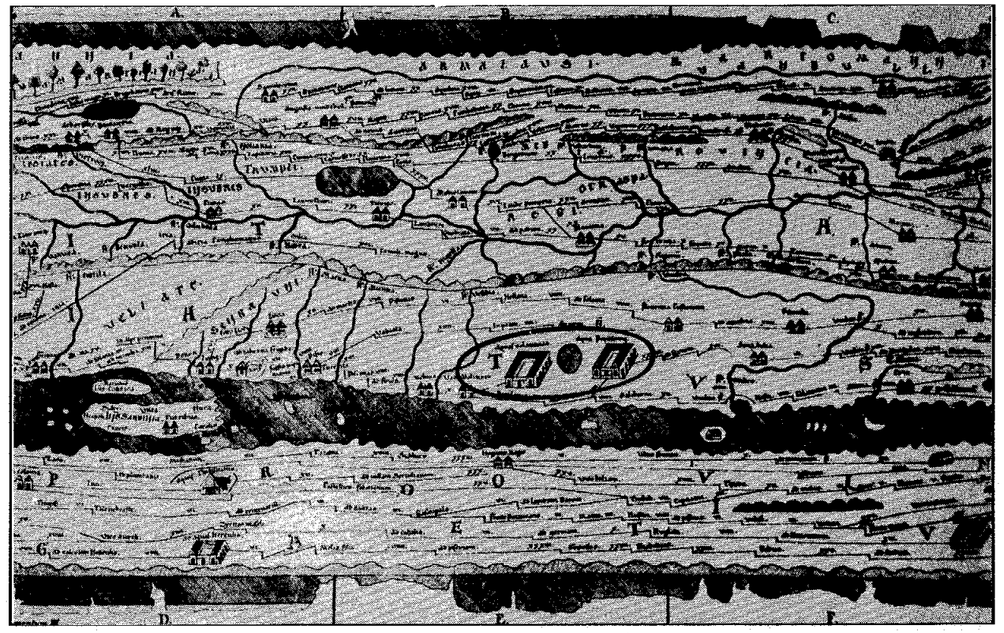
In Mexico, contact: Ing. José Luis Hernández Galán, Instituto de Investigaciones Eléctricas, Dante No. 36 - 6o. Piso, Col. Nueva Anzures - Deleg. Hidalgo, 11590 México, D.F. Phone: 511-79-38 or 511-42-11.

Biblioteca del Instituto de Investigaciones Eléctricas, Edificio 12 - 2o. Piso, Internado de Palmira, Municipio de Palmira, 62008 Cuernavaca, Mor. - Apartado Postal 475, Mexico. Phone: 18-38-11.

Dr. Juan José Saldaña, Sociedad Mexicana de Historia de la Ciencia Y la Tecnología, Av. México No. 145 - Desp. 202, C.P. 04100 Mexico, D.F.

Biblioteca - Universidad Nacional Autónoma de México; Biblioteca Nacional de Antropología e Historia-México; Revista "Geotérmia", Morelia; Centro de Información Técnica IIE - Cerro Prieto; Biblioteca - Universidad Autónoma de Baja California - Mexicali; or Biblioteca - Universidad Nicolaíta Morelia.

In Costa Rica, contact Dr. Alfredo Manieri, ICE, Apdo. 10032-1000, San Jose, Costa Rica.



Portion of the Tabula Itineraria Peutingeriana *with two spas circled, the* Aquas Volaternas *and the* Aque Populaniae. ***This is the first cartographical document recording the two spas, which are near Larderello, Italy. This document, dating back to the 3rd century A.D., is the map of the main routes and military roads of the Roman Empire. The fact that these two spas were chosen to be recorded among the many existing in central Italy, signifies that they had already attained an advanced state of development and fame.***

At the time of maximum expansion of the Imperial Roman Empire, Rome, alone, had over 1,000 public thermal baths, one for about every 1,000 people, without counting the numerous, private thermal baths. Thermal baths were part of everyday life for all classes of society in the whole of the Imperial territory. The baths were not only sites of recreation and hygiene, but centers where ideas were discussed, public opinions formed, and political movements begun.

Caption information is from "La Geotérmia en el Periodo Precolombino" by R. Cataldi, P.D. Burgassi, and S. Mercado, presented at the III Congreso Latino-Americano de Historia de la Ciencia y la Tecnología, January 1992.

In the United States, contact:

Susan F. Hodgson, Division of Oil and Gas, MS 20
801 K Street, 20th Floor, Sacramento, CA 95814-3530.

David N. Anderson, Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617.

In Italy, contact Dr. P.D. Burgassi, ENEL/VDAG, Piazza Matteotti, 11, Centro Dimostrativo, 56041 Castelnuovo di Val di Cecina (Pisa), Italy.

The human-geothermal relationship in the Mediterranean and in Latin America has developed over thousands of years. The publication covers the relationship from the dawn of pre-history to the voyage of Columbus, citing original documents in six languages. The ancient texts and maps offer fascinating glimpses into our geothermal past.

The juxtaposition of these original documents is unique, and bibliographical data for each entry are included in the volume. There is a brief description of the geothermal elements found in the work, such as references to thermal localities, descriptions or citations of volcanic and geodynamic events, practical uses of natural heat, popular customs or beliefs, divinity cults, magical or ritual aspects, scientific or mythological interpretations, and poetic images. The publication is a fascinating, amazing document.

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Baths and bathing in classical antiquity. By Fikret Yegül. 1992. $65.00. 499 pages, hardback. Extensively illustrated with photographs and drawings. Published by and available from The MIT Press, 55 Hayward Street, Cambridge, MA 02142.

The well written, very interesting, and thoroughly researched publication is an amazing review of the role of baths and bathing in classical antiquity. Many artificially heated baths were built, but "the original and overriding impetus for the artificial heating systems of the early Roman baths came from the thermomineral establishments of Baiae and the Phlegraean Fields, (meaning, fields devoured by fire) a volcanic region north of the bay of Naples." Such naturally heated establishments are well described. The thermal waters were used for medicinal purposes from the earliest days of the republic. Their popularity influenced public taste, promoted the practice and enjoyment of bathing, and provided excellent technical models eventually imitated in constructing artificially heated baths.

Nothing, says the author, can give a better indication of the popularity of the thermal baths in antiquity than the hundreds of modern spas located over the same thermal sources throughout the Mediterranean and Europe.

One especially memorable thermal bath was described by Pliny the Elder. Pliny wrote that M. Crassus Frugi (probably a consul under Nero) owned an offshore bathing facility near the Phlegraean Fields. It was built in the sea, perhaps like an offshore oil-production platform, around or over a natural hot spring. The spring was emitted from the seabed and forced itself up through the surface in spectacular clouds of steam.

The author, Dr. Yegül, is an architect, Professor of The History of Architecture, and Chair of the Art History Department at the University of California at Santa Barbara.

European directory of renewable energy suppliers and services 1992. 360 p., including 56 p. U. S. supplement. Free to buyers or servicers of renewable-energy equipment. Published by James & James (Science Publishers) Ltd. and the University of Wales College of Cardiff. Available from Edward Milford, European Directory of Renewable Energy Suppliers and Services, James & James (Science Publishers) Ltd., 5 Castle Road London NW1 8PR, England. Phone (+44) 071 284 3833.

The directory lists over 2,000 companies and organizations active in renewable energy. The directory also contains a wide range of articles about the renewable industry, a bibliography, data tables, energy distribution maps, and other information of interest to people in this area.

Geothermal energy in Europe, the Soultz Hot Dry Rock Project. Edited by J.C. Bresee. 1992. 309 p. $45.00. Published by and available from Gordon and Breach Science Publishers, PO Box 786 Cooper Station, NY, NY 10276.

The publication contains the results of scientific research on geothermal energy conducted in the Alsace region of Eastern France by a team of French and German scientists and engineers.

Polish Geothermal Periodical

Technika Poszukiwa Geologicznych, Geosynoptyka I Geotermia (Exploration Technology, Geosynoptics and Geothermal Energy). Published bimonthly. Subscription to English or Polish editions is U. S. $60.00 a year or $10.00 an issue plus $9.00 a year for postage and handling in Europe or $15.00 in overseas areas. Subscription requests should be accompanied by check or money transfer order to the Bank Przemyslowo-Handlowy, IV/O Kraków, Acc. No. 32345-2899. Published by and available from the Mineral and Energy Economy Research Center, Polish Academy of Sciences, J. Wybickiego 7, 31-261 Kraków, Poland.

The bulletin, published for 30 years, presents papers on prospecting and exploring for liquid and solid mineral deposits; forecasting and planning exploration; techniques and technology of exploration; technological and economic criteria for prospecting, exploring for, and recovering liquid minerals; mining operations and recovery of minerals; and progress in science and technology to hasten development in exploration and mining.

Geothermics, international journal of geothermal research and its applications. $409 a year. Free sample copies available. Published by and available from Pergamon Press, Headington Hill Hall, Oxford OX3 OBW, UK.

Private sector electricity in developing countries: supply and demand. By Jack D. Glen. 1992. $6.95. Published by the International Finance Corporation. Available from The World Bank, Room T-8048, Washington, D.C. 20433.

Small geothermal resources: a guide to development and utilization. Edited by Mary H. Dickson and Mario Fanelli. 1992. Published by the International Institute for Geothermal Research, International School of Geothermics, Pisa, Italy, in collaboration with The UNITAR/UNDP Centre on Small Energy Resources. $30.00. In English. Available from UNITAR/UNDP Centre on Small Energy Resources, Via del Corso, 303 Rome 00186, Italy.

The guidebook helps policy-makers to make the most appropriate choices at the various stages of a geothermal program and to avoid potential project pitfalls. It covers all aspects of geothermal energy exploration and development, and is addressed to a wide audience who may be involved directly in planning, assessing, financing, and/or developing geothermal projects.

The guidebook includes general information on geothermal resources and geothermal energy. It reviews the steps needed to assess geothermal potential and to plan a geothermal project. It illustrates the ways geothermal energy is cost-effective, and presents data and methodologies for evaluating its competitiveness with other energy sources. Particular attention is paid to the financial aspects and to data on the approximate cost of each phase of a geothermal project.

Cogeneration & resource recovery magazine. Bimonthly. $225 a year. Available from Cogeneration and Small Power Magazine, P.O. Box 26253, Crystal City, Arlington, VA 22215. Phone (703) 418-0286.

The magazine includes an array of issues related to energy production. The September/October 1991 edition featured geothermal energy and an article titled "FERC's Approach to Market-Based Pricing."

Heat pump manual. 1989 edition. By the National Rural Electric Cooperative Association. 116 p. $20; order item 81-9. Available from NRECA Energy Research Publications, 1800 Massachusetts Avenue, N.W., LL 102B, Washington, DC 20036. Phone (202) 857-4845.

The volume describes electric heat-pump equipment and systems, and identifies the range of available technology, including earth-coupled and water-source heat pumps. This is an excellent introductory text to the types of heat-pump systems, their energy-use characteristics, and to pump-installation maintenance practices.

Geothermal direct use engineering and design guidebook. Second edition. 1992. 445 p. $25 hard cover, $20 soft cover; foreign orders add $3.00 for surface mail or $15 for airmail. Published by and available from The Geo-Heat Center, Oregon Institute of Technology, Klamath Falls, Oregon 97601-8801.

The publication, prepared by OIT for the U. S. Dept. of Energy, includes technical information on low- and-moderate temperature (100°F to 300°F) geothermal development and equipment. Geothermal exploration, drilling, space heating and cooling, greenhouse heating, aquiculture, industrial processes, economics, regulations, and the environment are included.

Hot dry rock, proceedings of the International Hot Dry Rock Conference at the Camborne School of Mines in Redruth, Cornwall, United Kingdom, June 1989. Edited by Roy Baria. 1990. 613 p. $140 (US). Published by Robertson Scientific Publications. Distributed by James & James Science Publishers Ltd., 5 Castle Road, London NW1 8PR, England. Phone (+44) 071 284 3833. Also available in North America from Books International, P.O. Box 605, Herndon, Virginia 22070. Phone (703) 435-7064.

The proceedings contain 50 papers presented by experts from a wide range of countries on the subjects of hot dry rock environment, the current status of hot dry rock technology, resource economics, reservoir creation, and reservoir development.

New Geopressured Publications

Geopressured-geothermal energy, the untapped resource. JNDW-202-92. 1992. 11 p. Free.

Geopressured-geothermal habitat report. 1992. 200 p. Free.

The publications are available from Dr. Jane Negus-de Wys. INEL, P.O. Box 1625, MS 3526, Idaho Falls, ID 83415. Phone (208) 526-1744.

The publications are good sources for information on geopressured, geothermal resource development, including thermal-enhanced oil recovery and direct uses of geothermal energy. The information on geopressured habitat offers an interesting description of the nature of geopressured resources--the causes, the hydrocarbons involved, the pressures, the total energy and energy forms, the geographical locations, and seals.

Whistle, a nearly dormant geyser in Upper Geyser Basin, Yellowstone National Park, Wyoming: the first geyser to be studied by research drilling. USGS Bull. 1967. By Donald E. White. 1991. 13 pages. $3.50. Published by and available from the Books and Open-File Reports Section, USGS, Federal Center, Box 25425, Denver, CO 80225.

Whistle Geyser is the first geyser proven to depend on supplies of deep, overpressured water from a much more extensive system than can be demonstrated from surface measurements in the geyser tube; the dependence also proves the existence of a continuous, upward supply of water, though not at a constant rate.

"Deep-sea geysers of the Atlantic." By Peter A. Rona. October 1992 issue of *National Geographic.* Available from the National Geographic Society, 17th and M Streets, NW, Washington, D.C. 20036.

In the article, the author describes his dive in a submersible to a valley in the Mid-Atlantic Ridge, 1,800 miles east of Miami, Florida. While stopped here in the middle of a large geyser field, the craft was enveloped by 650°F water from an erupting geyser. Dr. Rona first discovered the geyser field, which he calls an "astrodome-sized mound with jetting geysers," in 1985.

Fire under the sea. By Joseph Cone. 228 p. $25.00 hard cover. Published by and available from William Morrow and Co., 1350 Avenue of the Americas, NY, NY 10019.

Seafloor hot springs, first discovered in 1977, are the focus of this book. The writer concentrates on work conducted at seafloor springs along the northwestern coast of the United States.

Hydrothermal systems of the Cascade Range, north-central Oregon, OF 91-0069. By S. E. Ingebritsen, R. H. Mariner, and D. R. Sherrod. 1991. 217 p., 2 over-sized sheets, scale 1:500,000. Microfiche $5.50; paper copy $37.25. Available from USGS Book and Open-File Report Sales, Box 25425, Denver, Colorado 80225. Phone (303) 236-7476.

Histoire géothermique et diagenèse organique. 1985. 345 p. 199 figures. Price: 370ff. English figure captions and chapter abstracts. A second edition, in English, was published in 1988. The price is 370ff paperback and 630ff hardback. It is distributed worldwide by Reidel, Dordrecht, and by Elf Aquitaine in French speaking countries. Both editions are published by and available from Elf Aquitaine Edition, F-31360 Boussens, France. Orders from individuals should be prepaid and can be paid by US bank check.

The book describes a microscopic study of organic matter, its thermal evolution, and its application to the knowledge of the geothermal history of sedimentary basins. The geothermal history is responsible for hydrocarbon genesis and migration, but has also become a key for geodynamic investigation.

Granitoid Rocks. 1992. By D. B. Clarke. $49.95. Published by and available from Routledge, Chapman & Hall, 29 West 35th Street, New York, New York 10001. Phone (212) 244-3336.

Granitoid Rocks presents to petrology students and earth scientists the principal tools for unravelling the petrogenetic history of a granitoid body -- field relations, mineralogy, petrology, geochemistry, geochronolgy, and experimental petrology. The book concludes with a chapter on future directions for research in the petrogenesis of granitoid rocks.

Volcanology and geothermal energy, Los Alamos Series in Basic Applied Sciences, Vol. 12. By Kenneth Wohletz and Grant Heiken. 1992. $65.00, hard cover. 450 p., 241 figures, and 43 tables. Published by and available from the University of California Press, 2120 Berkeley Way, Berkeley, CA 94720. Phone (510) 642-1144.

Advances in volcanology from several decades are reviewed by the authors, who believe that understanding volcanic systems helps to understand geothermal systems. Information from volcanological literature is combined in the book with the authors' research, which often has included geothermal exploration. The authors develop a quantitative approach towards studying volcanic fields. They believe the approach may be applied usefully to volcanic geothermal areas already studied.

Chapters 1 to 3 review general volcanological principles and geothermal reservoirs and manifestations. The authors cite recent volcanological findings that emphasize the importance of studying fragmental products of volcanoes (tephra). Chapters 4 to 7 discuss the main types of volcanic fields, including calderas, silicic domes, basaltic volcanoes, composite cones, geological structures, and models of origin. Very interesting case histories from geothermal fields throughout the world are included for each volcanic type.

Seven appendices offer practical background material, including volcanic field and laboratory study techniques; rock classification schemes and data; engineering units and conversions with abbreviated steam-table data; a two-dimensional heat flow code for personal computers; logging methods for cores and cuttings; and an extensive glossary of volcanological terms.

CALIFORNIA WELLS

Division Well Data Available

A computer-generated file of geothermal production and injection data for wells and records open to public inspection is available from the Division of Oil and Gas. All data are in metric units. The file may be purchased at cost from the Division of Oil and Gas in Sacramento. Be sure to use the new address, Division of Oil and Gas, MS 20, 801 K Street, 20th Floor, Sacramento, CA 95814-3530. The telephone number is unchanged: (916) 445-9686.

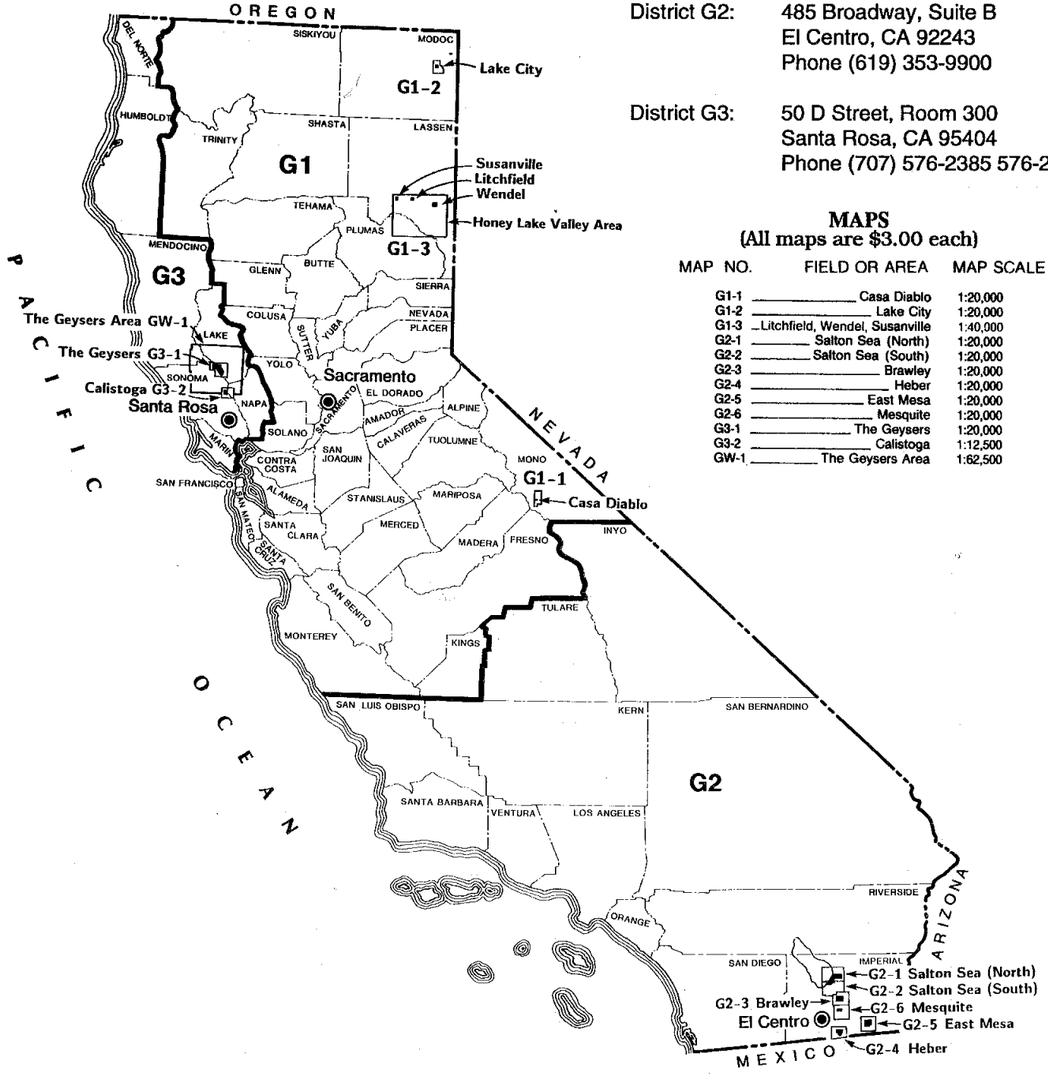
Drilling Permits for Geothermal Wells Approved January-September 1992 by the Division of Oil and Gas

Date Notice Received	Operator & Well Name & No.	API No.	Sec. T. R.	Location & Elevation
	DISTRICT G1			
	MONO COUNTY			
	MAMMOTH-PACIFIC, L.P.			
01/10/92	"Casa Diablo" 28-34	051-90156	34 3S 28E	Fr SW cor 46m N, 350m E, El 2179m GR
07/03/92	"MP" 24E-32	051-90157	32 3S 28E	Fr NW cor 823m S, 274m E, El 2228m GR

Date Notice Received	Operator & Well Name & No.	API No.	Sec. T. R.	Location & Elevation
	DISTRICT G2			
	IMPERIAL COUNTY			
	RED HILL GEOTHERMAL, INC.			
03/04/92	"Elmore" 15	025-91205	26 11S 13E	Fr SW cor 752m N, 88m E, El -69m GR
	FISH PRODUCERS			
04/16/92	"Ray" 1	025-91206	12 11S 14E	Fr NW cor 388m S, 649m E, El -12m GR
	RED HILL GEOTHERMAL, INC.			
05/15/92	"PR" 1	025-91207	4 12S 13E	Fr NE cor 704m S, 56m W, El -66m GR
	HEBER FIELD COMPANY			
06/10/92	"HGU" 201	025-91211	32 16S 14E	Fr NE cor 30m S, 366m W, El -3m GR
06/10/92	"HGU" 202	025-91212	33 16S 14E	Fr NW cor 30m S, 46m E, El -3m GR
06/10/92	"HGU" 203	025-91213	32 16S 14E	Fr NE cor 427m S, 975m W, El -3m GR
06/10/92	"HGU" 204	025-91214	32 16S 14E	Fr NE cor 366m S, 579m W, El -3m GR
06/10/92	"HGU" 205	025-91215	32 16S 14E	Fr NE cor 823m S, 975m W, El -3m GR
06/10/92	"HGU" 206	025-91216	32 16S 14E	Fr NE cor 914m S, 518m W, El -3m GR
06/10/92	"HGU" 207	025-91217	32 16S 14E	Fr NE cor 762m S, 152m W, El -3m GR
06/10/92	"HGU" 208	025-91218	32 16S 14E	Fr NE cor 1,250m S, 975m W, El -3m GR
06/10/92	"HGU" 209	025-91219	32 16S 14E	Fr SE cor 396m N, 488m W, El -3m GR
06/10/92	"HGU" 210	025-91220	32 16S 14E	Fr SE cor 30m N, 488m W, El -3m GR
06/10/92	"HGU" 211	025-91221	32 16S 14E	Fr SE cor 30m N, 30m W, El -3m GR
06/10/92	"HGU" 251	025-91222	33 16S 14E	Fr NW cor 91m S, 671m E, El -3m GR

Date Notice Received	Operator & Well Name & No.	API No.	Sec. T. R.	Location & Elevation
06/10/92	"HGU" 252	025-01223	33 16S 14E	Fr NW cor 518m S, 305m E, El -3m GR
06/10/92	"HGU" 253	025-91224	33 16S 14E	Fr SW cor 381m N, 260m E, El -3m GR
	VULCAN POWER COMPANY			
09/29/92	"IW" 8	025-91227	34 11S 13E	Fr NW cor 79m S, 762m E, El -68m GR
	RIVERSIDE COUNTY			
	ELMER, JOHN			
03/02/92	"Elmer" 1	065-90170	33 2S 5E	Fr SW cor 10m N, 5m E, El 366m GR
	DISTRICT G3			
	LAKE COUNTY			
	SANTA ROSA GEOTHERMAL CO.			
07/29/92	"Davies St 5206" 4	033-90734	36 11N 8W	Fr NW cor 1,062m S, 470m E, El 594m KB
	SONOMA COUNTY			
	GEOTHERMAL ENERGY PARTNERS, LTD.			
04/07/92	"Aidlin" 9	097-90825	4 11N 9W	Fr SE cor 1,114m N, 1,433m W, El 382m GR

DIVISION OF OIL AND GAS
GEOTHERMAL OFFICES AND MAPS



OFFICES

Headquarters & District G1:	801 K Street, 20th Floor Sacramento, CA 95814 Phone (916) 323-1788
District G2:	485 Broadway, Suite B El Centro, CA 92243 Phone (619) 353-9900
District G3:	50 D Street, Room 300 Santa Rosa, CA 95404 Phone (707) 576-2385 576-2386

MAPS
(All maps are $3.00 each)

MAP NO.	FIELD OR AREA	MAP SCALE
G1-1	Casa Diablo	1:20,000
G1-2	Lake City	1:20,000
G1-3	Litchfield, Wendel, Susanville	1:40,000
G2-1	Salton Sea (North)	1:20,000
G2-2	Salton Sea (South)	1:20,000
G2-3	Brawley	1:20,000
G2-4	Heber	1:20,000
G2-5	East Mesa	1:20,000
G2-6	Mesquite	1:20,000
G3-1	The Geysers	1:20,000
G3-2	Calistoga	1:12,500
GW-1	The Geysers Area	1:62,500

Division of Oil & Gas
801 K Street, 20th Floor, MS21
Sacramento, CA 95814-3530