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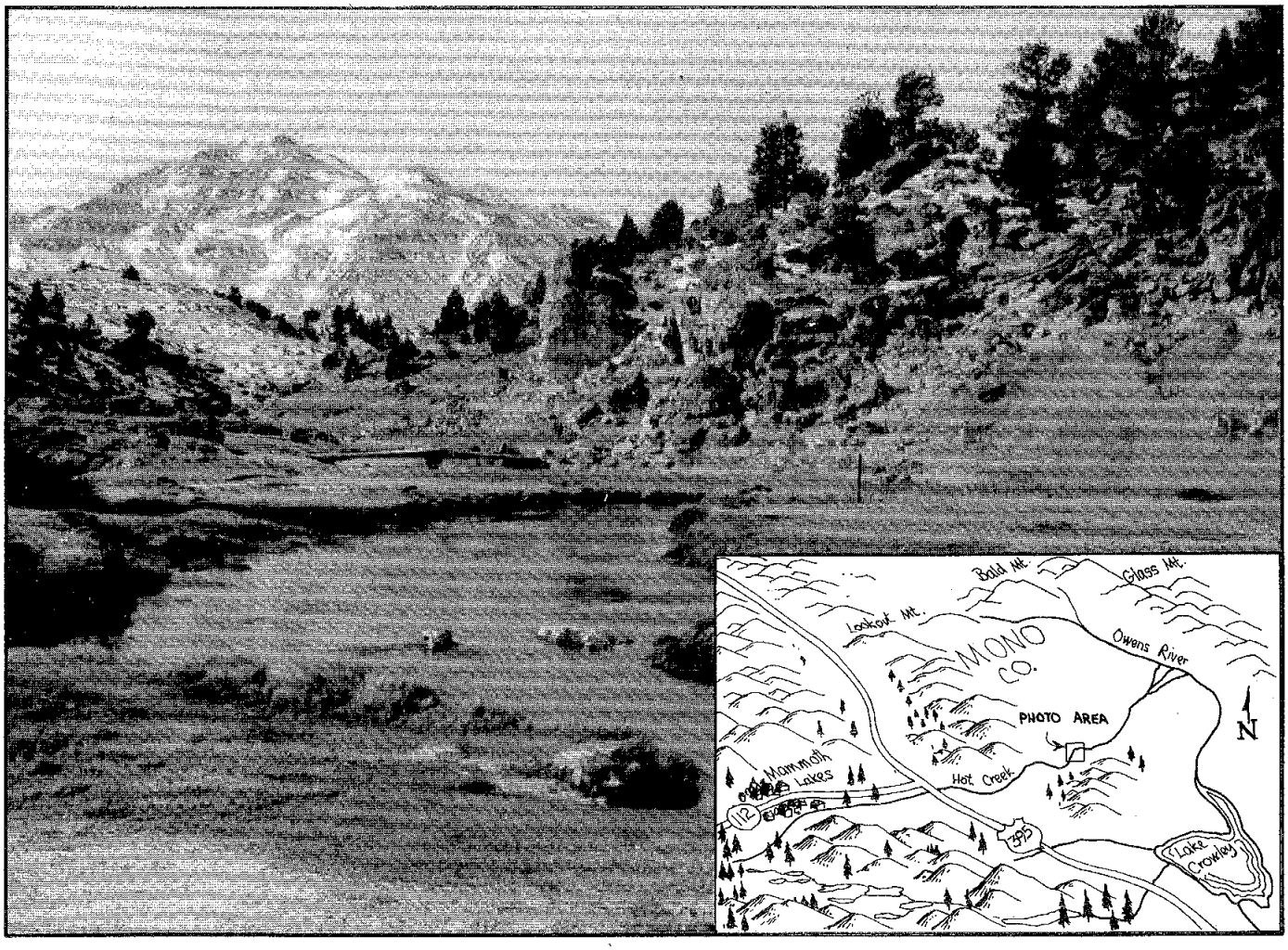

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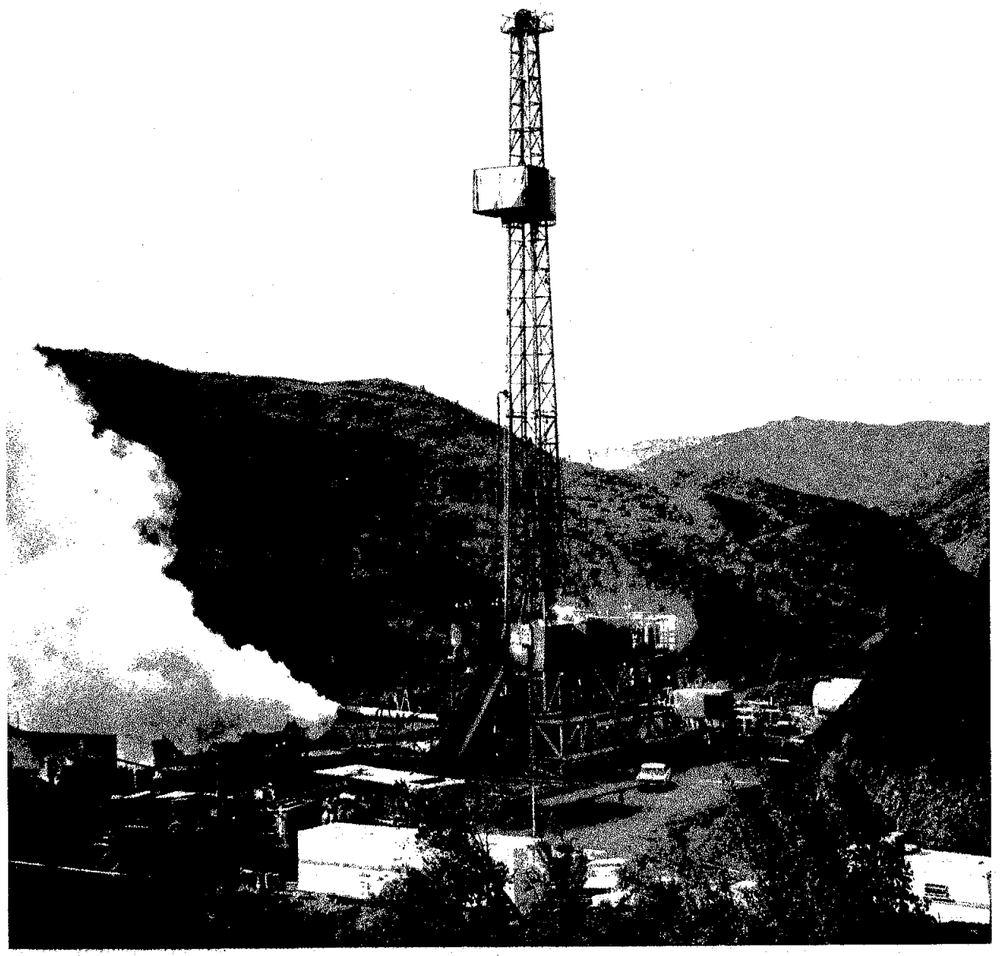

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Send Us Your News.....

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

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

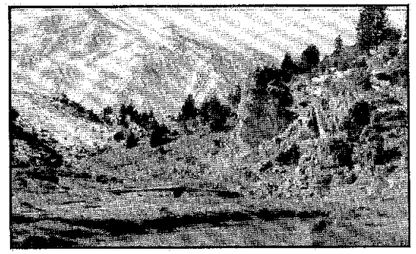
You can call me with a story or send in an article.

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

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

Susan Hodgson
Editor

COVER PLATE



Hot Creek Gorge, at the Hot Creek bathing area. Photo by Robert Habel. For Mono County geothermal activity, see page 12.

THE GEYSERS YESTERDAY

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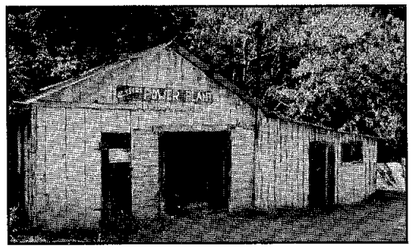
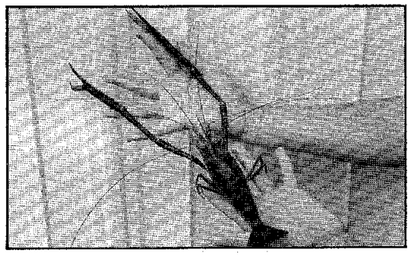


Some early views of The Geysers Geothermal field prove perceptive. Photo is of the first power plant.

GEOTHERMAL AQUACULTURE & AGRICULTURE

20



This approach spells research and commercial activities.

GEOTHERMAL ENERGY CONTROL ACT OF 1987

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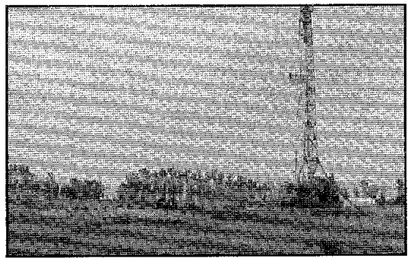


Exclusive franchises would be granted to explore for, develop, and market geothermal energy.

CALIFORNIA

NORTHERN CALIFORNIA

In Memoriam

Brian Maassen died in Santa Rosa, California, on March 10, 1988. He was thirty-four years old. Mr. Maassen was Systems Engineering Supervisor for Unocal Geothermal Division in Santa Rosa.

Brian received his Bachelor of Science degree in Petroleum Engineering from Louisiana State University in 1976. Following graduation, he began his career with Unocal. Brian was a registered Professional Engineer in Petroleum Engineering.

Brian gained the respect of all who were associated with him. He will be missed by his many friends and co-workers. Brian is survived by his wife, Alison, and his daughters, Amanda and Lisa.

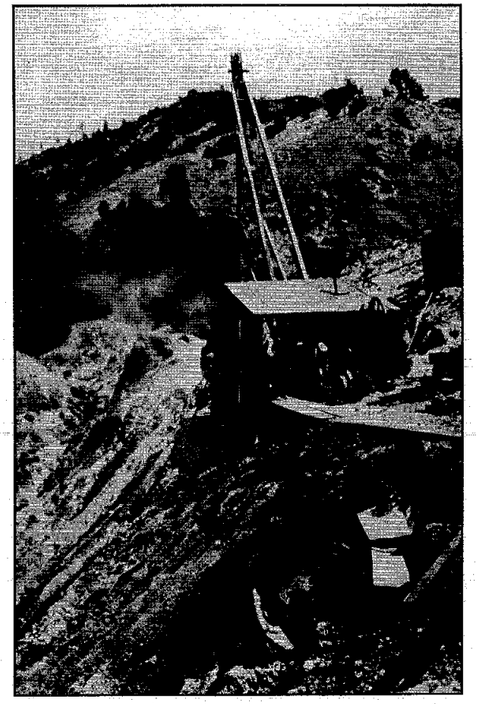
Terry W. Kelley
Mechanical Engineering Supervisor
Unocal Geothermal Division

1927 and 1988: Views of The Geysers Geothermal Field

The first comprehensive, scientific report on The Geysers Geothermal field was published in 1927 by the Carnegie Institution of Washington. The report, titled *Steam Wells and Other Thermal Activity at "The Geysers" California*, was written by E.T. Allen and Arthur L. Day. Excerpts from the report are reprinted in the following article, with permission of the Carnegie Institution. Included with these excerpts are comments written in 1988 by a geologist who has worked extensively in The Geysers Geothermal field.

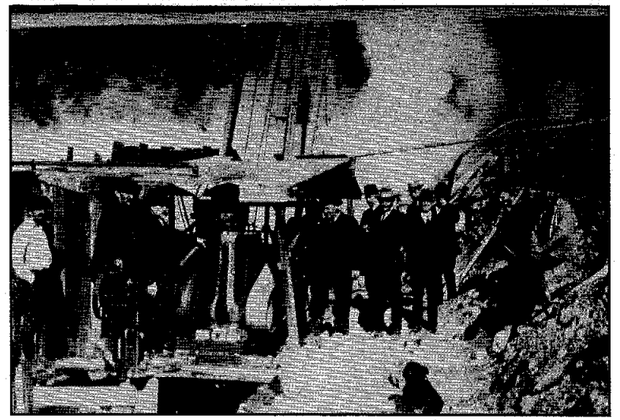
Drilling and Testing the Steam-Wells

In the summer of 1921, J.D. Grant of Healdsburg, California, began drilling on the hillside to the east of Geyser Creek with the hope of utilizing the steam for power. At that time, he was unaware of the fact that a similar project had already been successfully attempted at Larderello in Tuscany, but he had become impressed with the constant escape of steam at The Geysers and its relatively high temperature at the surface, and believed that both would increase with depth. The results confirmed his conclusion, though the first shallow bore-hole, when closed, blew out the casing and was abandoned. In the following summer the well, now designated No. 1, was drilled on the east bank of Geyser Creek and reached its present depth (203 feet) in September 1922. For the first 80 feet, only



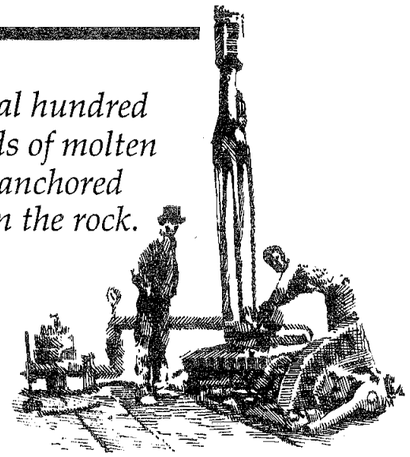
Drilling first well. The Geysers, 1922. All photos and captions in this article are reprinted, with permission, from the cited publication by Allen and Day.

A plank across mouth of casing, weighted with drill rod weighing about a ton, fails to "hold down" steam, 1922.



Drilling second well with steam power from first. Photo obtained from J.D. Grant.

Several hundred pounds of molten zinc anchored casing in the rock.

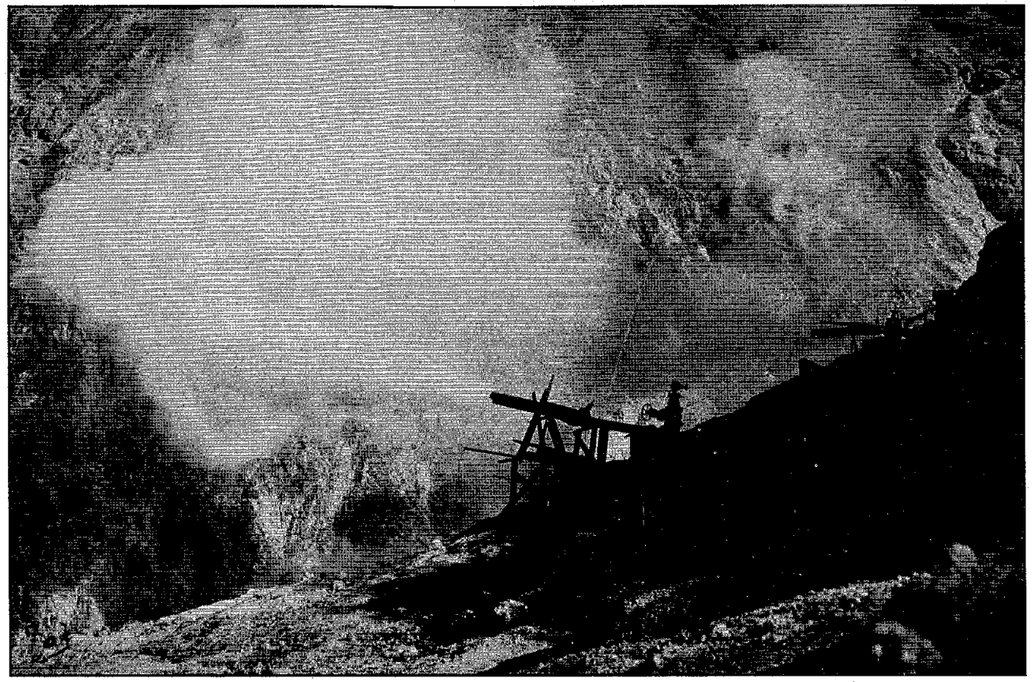


soft material was encountered, but the steam-flow increased rapidly with depth. The soft surface layer consisted of thoroughly decomposed rock and was probably similar to the surface mud well exemplified at the Smokestack Fumarole just opposite on the other side of Geyser Creek. At a depth of 80 feet, the sandstone cap was struck, and the drilling was continued through it, after which an 8-inch steel casing was lowered and "anchored" in the rock by pouring around the pipe several hundred pounds of molten zinc, which congealed and furnished a firm and tight joint.

Comment from 1988: We know now that the first 80 feet was drilled into a landslide called the Thermal Landslide. The sandstone cap referred to is the underlying Franciscan Formation graywacke.

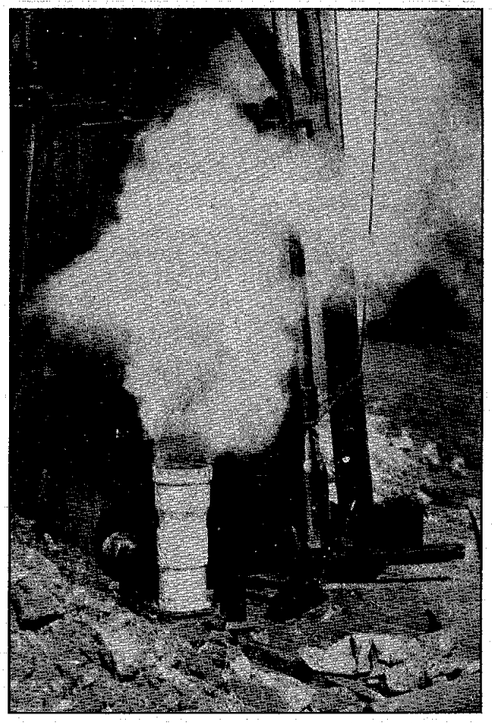
Boring continued to a total depth of 203 feet as an open hole, after which the well was closed by a heavy gate valve attached to the top of the casing. The drilling was done with a churn drill without special equipment, the steam in the drill-hole being controlled by admitting a stream of cold water to condense it. At the end of each half hour or so, the well was allowed to "blow." Considering that the workmen had had no previous experience of the kind, it speaks well for their skill, initiative and perhaps their good fortune, that the work was completed without serious accident. A steam gauge attached to the outlet pipe registered a pressure of 62 pounds to the square inch when the well was closed.

Encouraged by the success of the first venture to continue the undertaking, on October 18, 1922, the promoter began a second well within 50 feet of the first, carried it down to a depth of 318 feet, and closed it by the same methods. Steam from the first well was used without filtering or other treatment to furnish power for drilling the second, which was completed July 20, 1923. The gauge pressure in this well when closed showed 61 pounds. Notwithstanding that the wells were so close together, the pressure of neither seemed to be affected by the



Wells No. 1 and No. 2 discharging into atmosphere, 1924. Excellent view of Smokestack Fumarole, right.

Well No. 3 as it appeared in 1925. Casing is coated with opal formed by evaporation of small amount of water constantly thrown out with steam.



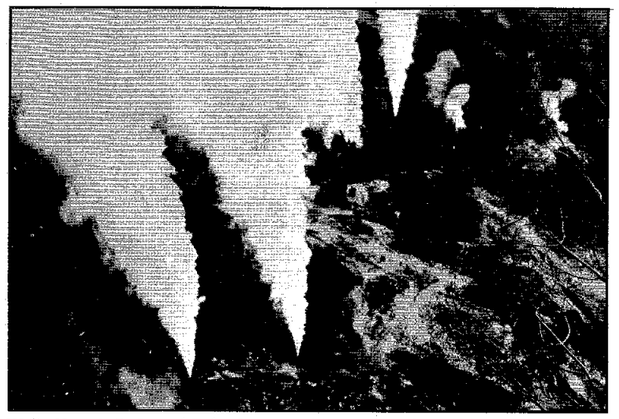
discharge of the other. Also, when either well was allowed to discharge continuously for months and then closed again, the pressure soon attained the same value as before.

Beginning in the summer of 1924, a third well was sunk on the extreme border of the hot ground, but the boring was discontinued at a depth of 154 feet.

During the first two years a local stock company, "The Geysers Development Company," was organized to carry on the work and Kingsley G. Dunn of San Francisco was the engineer in charge. After some vicissitudes, this pioneer group gave way to a new organization with stronger financial backing, and in January 1925, drilling was resumed by the Diamond Drill Contracting Company of Los Angeles, under the direction of J.D. Galloway, engineer, of San Francisco. This company, using rotary equipment, has already drilled five holes, numbered successively from No. 4 to No. 8, of which Mr. Galloway recently presented to the Engineering Societies of New York the following account:

"During the first seven months of 1925, four wells, No. 4, No. 5, No. 6, and No. 7 were drilled. These

four wells are of the same size and type and are distributed over an area about 550 feet long. An open hole is first drilled through the overburden and into rock as far as possible. Into this hole a 10-inch wrought steel casing is set and the space between casing and the walls of the hole filled with Portland cement grout. After the cement is set, the hole is then drilled deeper into the rock until the flow of steam is good and then an inside 8-inch wrought steel casing inserted and the space between the two casings is filled with cement grout, which is allowed to set. After this, the well is drilled as an open hole, deeper into the ground.



Wells Nos. 4, 5, 6, and 7 discharging, 1925. Photo by Kidd.

Comment: This is somewhat similar to what is done today. Typical casing programs now are a 30-inch surface casing down to a few tens of feet, 20-inch casing down a few hundred feet, 13 3/8-inch casing down to 2,000 feet, and 9 5/8-inch casing down to several thousand feet. A difference is that, today, mud is used to drill through the first several thousand feet in the nonproductive zone. Then, air is used to drill through the productive zone below.

"In drilling the wells, the incoming steam is condensed by the stream of cold water pumped down to the bottom of the well through the interior hole of the drill stem. The water is sent down under pressures up to 250 pounds per square inch, and under the pressure, rises to the top of the well outside the drill stem and flows off through a side vent. A point is reached when the cold water sent down comes back heated to near the boiling point, and this indicates about the depth required. All openings on the well are then closed and the drill removed. When all is clear, a valve at the top is opened and the hot water is blown from the well by the geyser effect. Rocks and dust are also blown out and it takes a week or so before the well clears the passages.

"In drilling through the rock, the hardness varies greatly. The drill often encounters fissures or fumaroles in its passage downward, and these underground fumaroles indicate the presence of steam."

The opening of a well after the tools are removed presents an imposing spectacle. As the valve is opened, steam and hot water rush violently out with a great roar, rising in successive leaps like a geyser and carrying a shower of sand and loose rocks, which bombard the steel frame of the derrick with a rattle like a fire of musketry. The column quickly reaches its maximum height of 200 to 300 feet and in a few moments, much of the excess water and loose debris are cleared out, leaving a huge jet of intensely hot, roaring steam rushing from the well at high velocity, the noise of which can be heard for several miles and which at close range is absolutely deafening.

While the method employed in drilling the later wells is obviously unsuited to the determination of the nature of the rock below ground and the rise in temperature with depth, the log of the earlier wells yields considerable information of value.

In depth, the wells vary from about 200 feet to nearly 650 feet. The pressure is greater in the deeper wells, but it is not proportional to depth; it does not even follow the same order. When closed and capped, the pressure in different wells varies from 60 pounds to 275 pounds to the square inch. Mr. Galloway's paper, already referred to, contains interesting information upon this point also. With his permission, we quote once more:

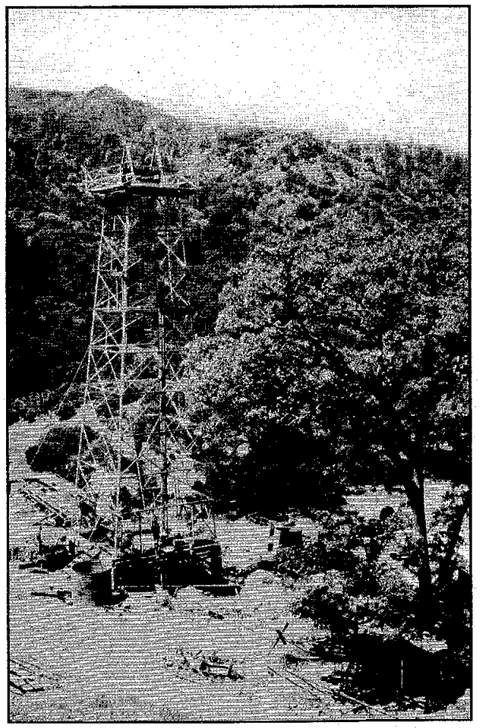
"Characteristics of the Steam—The steam pressure, wells closed, varies and the same is true of the quantity of steam discharged under different pressures. In the case of Wells N. 6 and No. 7, the wells have not been closed long enough to indicate the maximum pressure but it is believed that it will reach 300 pounds to the square inch. Since Well No 6 was brought in with an initial closed pressure of about 250 pounds, the static pressure in other wells has become greater."

Up to the present time, the opening of the wells has had no visible effect on the natural fumaroles; apparently, they keep on steaming at the same rate as ever. Neither has the discharge of any of the wells had the effect of diminishing the pressure in any other, although two of the wells are within 50 feet of each other. On the contrary, Mr. Galloway's record reveals the fact that after the opening of No. 6, the pressure in the neighboring wells No. 4 and No. 5 increased somewhat, but the individual pressures are still far apart.

Comment: The shallow thermal reservoir, where the wells were drilled, was later found to be connected at depth to the much larger main reservoir. Steam discharged from the wells was rapidly replaced by steam from the main reservoir, resulting in negligible interference between wells.

Up to the present time, the maximum pressure of none of the wells is appreciably affected by long-continued discharge; when closed again the pressure gradually regains its former value.

In the summer of 1925, with the kind cooperation of Mr. Galloway, a series of temperature measurements with corresponding pressures was made in the wells.



Well No. 6 just completed and shut off, 1925.

An 8-inch outlet pipe (horizontal), which was screwed into each valve body, was tapped to admit a threaded 3/8-inch pipe closed at the inner end while the outer end also could be closed by a removable plug. The small chamber thus formed admitted a maximum mercurial thermometer about 6 inches in length, graduated in single degrees from 100 degrees to 200 degrees. When a test was to be made, the thermometer was carefully slipped into the small pipe, which was then closed by a screw-cap. Valves were so arranged that the thermometer pipe could be surrounded by steam under full pressure, or steam discharging at any lower pressure down to that of the atmosphere. Three thermometers, made by the Taylor Instrument Companies of Rochester, were used in the measurements and there was no systematic difference in their reading. One of them, No. 1, was afterward carefully

Well No. 6. Steamboat Fumarole in foreground.

calibrated, and the errors in reading were found not to be greater than + 0.1 degree. In making a measurement, the thermometer was left in the pipe usually for 15 minutes, then withdrawn and read as quickly as possible with a reading glass.

The accidental temperature errors from all sources may be judged by comparing the measurements made in the same well on the same date, as the latter represent duplicate determinations made within an hour. That the differences are not entirely due to

errors of measurement is obvious from the results in Well No. 1, which remain unaccounted for, but they are probably due chiefly to delays in withdrawing the thermometer and a consequent shortening of the mercury column to which a 200 degree-maximum thermometer is prone. Except for the duplicates in Well No. 1, the differences average about 0.7 degrees C.

Pressures were measured with a Bourdon gauge, which from time to time was compared with a standard. The gauges were temporarily screwed on to a 3/8-inch pipe attached to the large valve body and controlled by a small needle-valve. The gauge was never left attached to the pipe and was connected to it only after cold water had been poured in. The pressures in all the closed wells were taken each morning by R.B. Kidd, usually about the same time the temperatures were read, but occasionally 12 hours earlier if the pressure had been found to be virtually constant for some time.

The first fact of interest which arrests the attention is that in all but Well No. 6, the pressures and temperatures eventually approximate to those of saturated steam. Since the pressure of saturated steam within the temperature range of these wells (154 degrees to 190 degrees C) varies from 2 to 4 pounds per square inch for every degree Centigrade, the final agreement appears satisfactory. Well No. 6 developed a pressure of 240 pounds not long after it was first closed. Fearing that steam under pressures of this magnitude would force its way outside the casing and ruin the well, the engineer gave orders to keep it open, and during the several weeks of our stay at The Geysers, it was discharging almost constantly through a 4-inch outlet pipe. Probably it is this circumstance that is responsible for the wider variations between p' (the total pressure in the well) and p" (the pressure of saturated steam at the temperature read) throughout the time of the tests than we find in the other wells.

In Well 2, pressures and temperatures corresponded pretty closely from the first with those of saturated steam, the average deviation in pressure amounting to 1.6 percent of the latter. All but one of the differences—the last—are negative.

In Well 1, the pressure remained nearly constant while the temperature slowly rose, finally reaching a point where the pressure approximated to that of saturated steam within 1.7 percent.

After Well 4 was closed, the pressure lagged for several days, but during the last three, the pressure deviated from that of saturated steam by an average difference of 1.2 percent only.

Similar to Well 4 was the behavior of Well 5; there was a high negative difference in pressure at first, falling after one day to an average of 3.8 percent for a period of ten days and reaching on June 21 a limit of 0.6 percent. On the following recorded date, June 26, the well being partially open, both temperature and pressure had fallen markedly. Most of the differences here are positive.

The history of No. 6 differs from that of all the other wells, in that it was discharging throughout the time of the tests, and here the pressure was below that of saturated steam in every test, much lower during the first seven days and on the average 5.5 percent lower during the last three. All the differences are negative. As the negative differences signify that the pressure read was lower than that of saturated steam for the recorded temperature, the steam must be superheated wherever such differences are found. Immediately after the wells are closed, the deviations are always in this direction. Wells 1 and 2 were generally kept closed during the summer of 1925, and they probably had not been recently opened. This seems to mean that the steam as it rises from the depths is superheated and becomes saturated only after it has stood under pressure in the wells—probably because of the condensation of a portion of the steam. Other observations confirm the truth of this hypothesis. In the record of a day's visit to The Geysers in 1922 when the first well (No. 1) had reached a depth of 150 feet, we find that the temperature 3 feet down was 109 degrees C; the true temperature was probably higher, for the thermometer, graduated to only 110 degrees C, was left in but a moment. This was not a sporadic instance; a similar observation was made in 1924 at the top of Well 3, then 100 feet in depth, when the temperature 9 inches below the top of the casing read 111 degrees C.[1] When the evidence is taken in its entirety, the steam of Well 1, like all the rest, appears also to be originally superheated.

The final differences in pressure in the closed wells, as previously remarked, are invariably positive. Though too small to be stressed, they are reasonably accounted for both by the fact that the temperature readings are probably all a trifle low and by the fact that the steam is accompanied by small amounts of gas, which would naturally raise the pressure above that of saturated steam.

Some details of the tests are still puzzling; the behavior of Well 4 when discharging at atmospheric pressure and the behavior of Well 1 in the beginning are anomalous. A system of piping with less metal exposed at the surface, less horizontal pipe especially, would no

[1] *Later temperature measurements at the top of the deeper wells, when the valves were wide open, gave much higher readings.*

doubt have been an advantage, and more tests in more wells and under a wider range of conditions would certainly have been helpful. Still, the facts as they stand show clearly that if the wells are kept closed, the steam finally reaches a pressure which corresponds to that of saturated steam at the temperature read at the top of the well, and, what is of greater interest to the geologist, they show that the steam is originally superheated. Mr. Galloway says (personal letter of March 6, 1926) of some later temperature measurements of his own:

> *"The temperatures, which I took of the steam-wells at The Geysers, were taken when the wells were discharging. At that time the temperatures seemed to correspond closely to that of saturated steam. Some later tests made this year indicate from 15 degrees to 25 degrees of superheat."*

Transmission of Steam from Its Source to the Surface

The principal facts about the steam flow, that it may be developed by boring anywhere within the hot area, that it increases with depth but not regularly, that boring gives rise to steam wells which when closed, stand at widely different pressures, and that each well after a period of discharge, returns when closed again to its former pressure—all have been stated in the foregoing. Determinations of maximum pressure indicate that it is constant or nearly so in the same well. A long record for the oldest wells and the investigations previously described support this statement. The facts show clearly that the rock is not equally pervious to steam in all directions; indeed, they indicate that it is not permeable in any direction to an appreciable degree, for there is nothing in the overlying sediments except stratification that could transmit steam in one direction more readily than another. While it is conceivable that stratified rocks suitably tilted might transmit steam vertically with special facility, they must inevitably transmit it more readily in one horizontal direction, which is not the case here. The ordinary view that the steam reaches the surface through cracks explains the facts in a measure. That the cracks cannot be open to any appreciable width, at least throughout their whole depth, must be obvious. The fault, if it exists as we assume, instead of being an unimpeded passage to the depths is probably a zone or band of rock shattered by an irregular system of seams long enough and narrow enough to interpose a high resistance to the passage of gases.

Comment: All of the wells were drilled in the shallow thermal reservoir, which has a circular-to-oval shaped expression at the surface. Outside this area, steam is encountered at much greater depths. The steam only increased when open fractures were encountered. Their conclusion that the rock between fractures is essentially impermeable is correct. Their conclusion regarding stratification having an influence on steam flow is wrong.

Such an hypothesis would explain the difference in activity which is found in different fumarole regions. Thus, the greater steam flow and much higher temperatures in the natural fumaroles of Tuscany than in those at The Geysers should be due to the slighter impediment which the steam in the former locality encounters in its ascent to the surface. It may possibly be affected also by a higher steam pressure at the source, but a variation in this factor alone could not explain the facts, since drilling at The Geysers makes apparently a far greater difference than it does in Tuscany. The irregularities in thermal activity in different parts of the same area may be accounted for in the same way.

On the other hand, while the hypothesis serves well in explaining the increase of steam flow with depth, it does not satisfactorily explain the increase of pressure. The figures prove that wells that emit the greatest quantities of steam do not necessarily possess the highest pressure.

The increase of pressure everywhere with depth shows clearly that at the source, whatever and wherever that may be, the pressure must be much higher than it is in any of the wells. Within the realm of laboratory experience, to be sure, two gas reservoirs connected by even the finest capillaries cannot remain for any length of time at very different pressures, but where gases are forced to traverse fine tortuous seams for perhaps thousands of feet, the conditions obviously transcend any with which we are familiar.

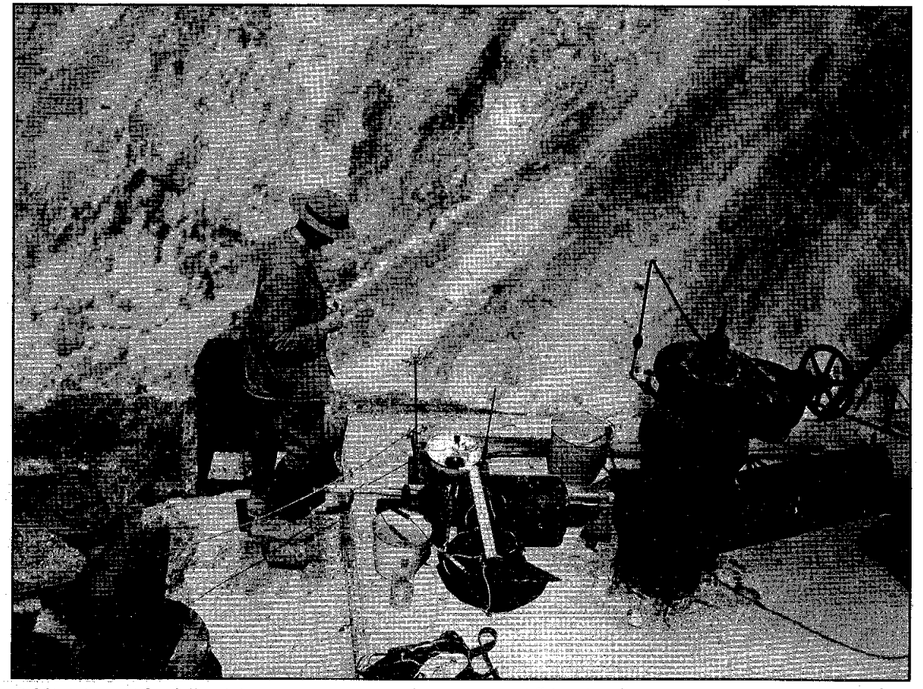
Origin of Steam at The Geysers

The hypothesis that hot springs are fed by ground water heated and augmented by magmatic steam that is condensed in the heating process was deduced in large measure from general considerations—the composition of rocks and their behavior on heating; rock decomposition with chemical reagents; and general physical relations of hot springs and fumaroles. A detailed field application of the idea had been possible only in the Lassen National Park, where superheated steam had been actually found in only one place. When, therefore, the hot springs at The Geysers were found to be associated with a supply of hot steam generally distributed not far below ground, the discov-

ery was naturally hailed as a confirmation of previous views. But of course it is realized that the magmatic origin of this steam cannot command the assent of geologists until the new knowledge that has come to light in the development of the wells, and the tests made on them, has been carefully considered from this viewpoint.

Any satisfactory theory of its origin must take full account of the huge volume of the steam, its high temperature and pressure, and its superheated condition. When the mild character of the original surface activity at The Geysers is compared with the immense steam-flow of today, the contrast is truly amazing—doubly so it must be to one who holds that the steam is derived entirely from ground water. Whatever previous views one may have had concerning hydrothermal activity, the facts brought to light in this field should convince him that the immediate origin of the steam lies at a very considerable depth. The steam-wells of California have been carried down to depths of nearly 650 feet, those of Tuscany to about the same depth, and while it cannot be said that temperature is proportional to depth, the deeper a well is drilled in either locality, the greater the steam-flow and the hotter the steam.

As to the situation in California, the more one ponders the question, the more difficult it is to conceive that a body of ground water of any great magnitude can penetrate even to such depths as a few hundred feet. Where cracks or seams exist, water will doubtless penetrate if the steam pressure it encounters is not prohibitive, but the water must be much more copious than it is here to penetrate far in such seams without being again vaporized. It is conceded that the ground temperature at any point and level is not so great before drilling as afterwards, but it must be well above boiling at depths say of 100 feet, except in places where no perceptible amount of steam is rising; where steam cannot find its way up, surely water cannot find its way down! It is conceivable that ground water under sufficient head might penetrate to a considerable depth about the periphery of a body of hot rock and that a vaporized portion of it might be fed into the cracks of the rock, under pressure, but admitting that possibility the facts point to a surface configuration in no way adapted to such water storage and a body of ground water wholly inadequate to supply continuously such volumes of steam.



Field equipment for determining gases accompanying steam at Well No. 2.

Duration of the Wells

Very interesting scientifically, and obviously important from the industrial viewpoint, is the question how long these wells will continue to flow, and whether they will maintain their pressure unabated for any considerable time. The data on this point are confessedly inadequate to constitute a safe basis for prophecy. Ginori Conti says of the Tuscan fumaroles that "as far as it has been possible to trace, they appear to have been known since the thirteenth century." The great geyser regions are doubtless losing a prodigious amount of heat. Iceland is the only one of these which has been long known to the white man. Records of the Iceland geysers are said to extend back about seven hundred years, but naturally they are not of such a character as to prove or disprove a decline. The Yellowstone Park has been the most studied. Hague says of it that "new springs are constantly breaking out and old ones are disappearing," but, in his opinion, there is nothing to indicate that any general decline has occurred within the forty years during which the Park had then been under observation. Frank J. Haynes and his son, J.E. Haynes, who have observed the geysers constantly during the summer season from 1881 to the present time, confirm this view.

On the other hand, the Katmai fumaroles have undergone a very perceptible decline in temperature inside of five years. The first temperature measurements were made there in 1918 by Savre and Hagelbarger. Another series of temperatures taken the following year indicated a decline. In 1923, Fenner made a second survey of the region and, being provided with a map locating the hottest fumaroles found by his predecessors, tested the temperatures of the same fumaroles with small disks of lead, tin, and zinc. All these hot fumaroles had declined in temperature, while the general aspect of the region, which Fenner had seen in 1919, as well as the appearance of numerous hot springs since the earlier date, constituted unquestionable proof of a general fall in temperature. The Katmai temperatures, however, were measured only a few years after the original eruption of igneous matter in which they are found, and being exceptionally high may very well decline at a diminishing rate as time goes on, and the store of heat there may still be very large. On the other hand, it may be that effective steam flow there will be of short duration because the source of heat seems to be unusually near the surface.

In any attempt to forecast the future of the steam output at The Geysers, one factor obviously must not be lost sight of: whatever the supply of heat and steam and whatever the source of it, the output of the steam-wells as compared to the natural fumaroles is enormous and it is not therefore to be expected that the life of the wells could be comparable to that of the natural fumaroles. On the other hand, the great industrial drafts upon the steam supply at Larderello, which extend back apparently to 1906, and the five years of observation at The Geysers both attest a very great store of energy. It is also a fact worthy of some emphasis that the extremely dry winter and spring of 1923-4, which was responsible for the cutting down of the output of the water-power development of California from 25 to 50 percent during the summer of 1924, exercised no measurable influence upon the steam flow at The Geysers.

A Geysers Memoir

If the story had anything to do with The Geysers, Glen Truitt probably had heard it.

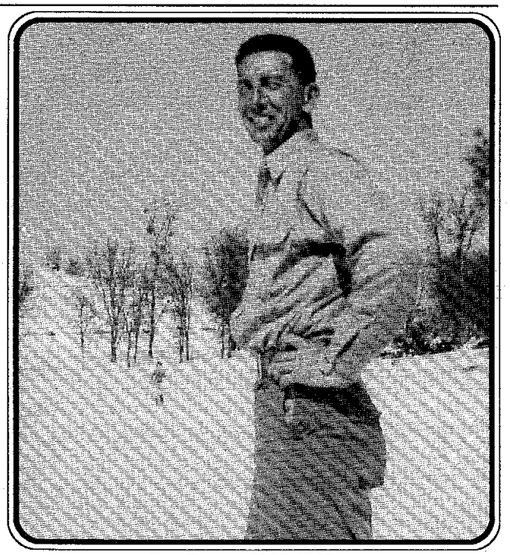
He knew as much as anyone about that rugged region in the Mayacmas Mountains of Lake and Sonoma Counties.

Glen's grandfather settled there in 1860, and the family homestead eventually grew to about 2,500 acres.

Glen grew up fascinated with the boom towns that sprang up around the early mercury mines in the area.

He hiked and fished along Squaw and Big Sulphur Creeks near the Big Geysers Resort and Spun Yarns with Charlie Foss, son of Clark Foss, the famous hell-for-leather stagecoach driver.

At age 17, tall and slender with a thick shock of dark



Glen Truitt 1905-1985

hair, Glen Truitt went to work for a Healdsburg visionary named John D. Grant.

Grant was doing something that had never been done before in California or the United States, or for that matter, in the Western Hemisphere.

Grant, who owned a gravel pit in Healdsburg, was drilling geothermal steam wells. At The Geysers. With the idea of making electricity and selling it in Healdsburg and Cloverdale.

"John Grant was 40 years ahead of his time," Glen Truitt recalled in a 1982 interview (he died three years later). "I've often wondered what the people who laughed at him would say if they could see The Geysers today."

Glen worked as a driller on the homemade cable rig (it was put together in Healdsburg) that was used to drill well G-1, generally credited as the world's first geothermal well outside the Larderello, Italy, project.

"G-1 was really Grant's second steam well," Glen remembered with a grin. "The first one blew up like a volcano."

If that misadventure unnerved Grant or his crew, including Truitt, they didn't show it. They set up their rig east of Big Geysers Resort on the other side of Big Sulphur Creek and spudded G-1.

Near the surface, they drilled through what Glen remembered as "soft stuff," probably debris from a large landslide. At just over 200 feet, they encountered steam.

"Everything came flying up," Glen recounted. "Mud, tools, rocks, and steam. After things settled down, there was just clean steam. But the noise was loud enough to hear all over the valley."

The job on G-1 was Glen's first and last as a rig hand. His first love was always mining, and he went on to work at some of the richest mercury mines in Lake and Sonoma Counties. Old-timers say he became one of the most knowledgeable people in the business.

Through his mining years, which included a tour at a mercury mine in Mexico, Glen stayed in touch with The Geysers and geothermal development there.

"Grant found an old steam engine at the Foppiano Winery in Healdsburg, and that engine let them use steam from the G-1 well to drill G-2," Glen recalled. G-2 was John Grant's last drilling project. He stepped aside in favor of a Los Angeles group.

But he continued to pursue his dream of bringing cheap geothermal electricity to Healdsburg and Cloverdale. In 1933, at the depth of the Great Depression, Grant was unable to meet contract deadlines, and the dream died.

"He proved it could be done by lighting up the (Big) Geysers hotel and the streets," Glen Truitt reminisced. "It looked like a Christmas postcard.

"He believed in it enough to put up a lot of his own money," Glen said of John Grant's faith in geothermal. "The country just wasn't ready for it then."

Coldwater Creek Update

In 1988, one of the two, 65-megawatt units comprising the Coldwater Creek Geothermal Power Plant is scheduled to go into commercial operation at The Geysers Geothermal field in Northern California. The power plant, CCPA No. 1, is being built by the Central California Power Agency, composed of the Sacramento Municipal Utility District, the Modesto Irrigation District, and the City of Santa Clara.

Steam for the plant is produced from wells owned and operated by Geothermal Resources International, Inc. (GEO). GRI has drilled 17 wells, 15 of which will deliver abut 2.2 million pounds of steam per hour to the 130-megawatt power plant. The remaining 2 wells will serve as injection wells.

The power plant began accepting steam for testing on October 31, 1987. The main purpose of the activity was to pressure test the power plant's main steam pipeline.

The Aidlin Project Planned for The Geysers

A new geothermal project, called the Aidlin Project, is planned for The Geysers Geothermal field in Northern California by Geothermal Resources International, Inc. (GEO). GEO will drill the wells and construct the power plant.

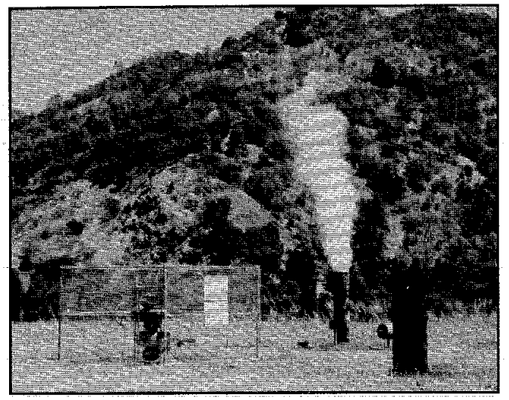
As part of the project, GEO has agreed to purchase from SAI Geothermal, Inc. (SAIG) two, 10-megawatt modified Standard Offer No. 4 electricity sales contracts to provide electricity to Pacific Gas and Electric Company (PG&E). According to GEO's Chief Executive Officer, Ronald P. Baldwin, GEO will pay SAIG a total of $4 million for the two PURPA contracts, which SAIG entered into in 1984 with PG&E.

The Aidlin Project will include a two-unit geothermal power plant constructed by GEO, with each unit producing 10 megawatts, net, of electricity. The project will be on about 700 acres in The Geysers, leased from private landowners Joseph W. and Mary Aidlin. Mr. Aidlin, through his association with Magma Energy Company, helped pioneer the initial geothermal development in The Geysers during the late 1950's and early 1960's. Total cost of the Aidlin Project is estimated to be about $50 million.

Mission Power Engineering, a subsidiary of Southern California Edison, has signed a Memorandum of Understanding with GEO to design, engineer, and construct the power plant, which must be in commercial operation by November 1989. GEO is working with a major Swiss financial institution to arrange the project financing.

Baldwin said, "The Aidlin Project can use existing access roads and field operation facilities because it's near to the Coldwater Creek Geothermal Project, GEO's other major development project in The Geysers.

"Also, the portion of the steam field where the geothermal wells for the Aidlin Project will be drilled by GEO is in the northwestern part of The Geysers, the section GEO is most likely to develop in the future. Therefore,



Well "Aidlin" 1 at The Geysers Geothermal field. The well will be among those used to power the new geothermal power plant planned by GEO. Photo by Ronald DiPippo.

the development drilling planned for the Aidlin Project will increase the company's geotechnical understanding of a reservoir GEO has a long-term interest in developing. One geothermal well, the Aidlin 1 well, which was drilled in the early 1970's by Aminoil USA, Inc., is on the Aidlin leasehold. GEO expects to begin drilling an additional development well in the area in February 1988," Baldwin said.

Thermal Power Company May Be Purchased

Geothermal Resources International, Inc. (GEO) announced that, although it missed the March 30, 1988, deadline to acquire Thermal Power Company from Maxus Energy Corporation, it remains interested in the purchase, and will make a new offer.

It's the first greenhouse in Lake County heated geothermally.

Geothermal Greenhouse Project Begun

On February 18, 1988, local officials broke ground near Kelseyville at the site of a greenhouse to be heated by geothermal energy. The greenhouse will provide vocational training and research opportunities for construction crews and interested students, and will offer a site for a geothermally-heated agricultural park—the Geo-Ag Heat Center — that could attract commercial growers in the future.

The California Energy Commission (CEC) provided nearly $500,000 in grant funds for the project. The CEC's Geothermal Grant and Loan Program offers financial assistance to cities, counties, and other local governmental agencies to develop low-temperature geothermal and geothermal electrical systems. Lake County contributed $126,675 and Mendocino-Lake Community College District $73,219 to the project.

Mark Dellinger, Lake County Geothermal Coordinator, said Lake County will be responsible for constructing and operating the geothermal system. "This is the first greenhouse in the county to be heated by geothermal energy," noted Dellinger. Using the heated groundwater instead of propane (currently the cheapest heat source available) can save thousands of gallons of fuel each year for commercial agricultural businesses. "Saving on heating costs is our primary objective. If it is successful, this project will encourage others in the area to take advantage of this clean, cost-effective natural resource," he added.

The college district will oversee construction of the 7,000 square foot agricultural greenhouse. Gib Cooper, an instructor at Mendocino College and manager of the greenhouse project, is responsible for developing curricula for his 'Greenhouse and Interiorscaping Practices' course. "I am excited about the hands-on experience students can gain from construction and operation of the greenhouse," Cooper said. Although designed to train the construction crew, the course is open to anyone interested in greenhouse operation.

The 3.5-acre agricultural park site is near the S-Bar-S Quarry on Highway 29 south of Kelseyville. Construction should be completed by June 30, 1988.

Bottled Water Company Sold

Sunny Farms Corporation, a Richmond, California, fruit-juice bottler, recently acquired Napa Valley Springs of Calistoga, a bottler of natural drinking water, according to an article in the February 19, 1988 edition of *The Calistogan.*

The article states that the purchase was spurred by 'the fact that the $1.5 billion a year, bottled-water industry is the fastest growing segment of the beverage market. California accounts for half of all bottled-water sales.

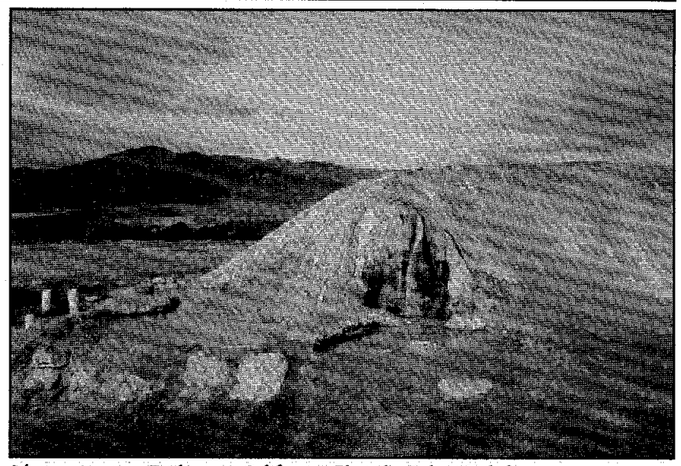
Mono County Update

Mammoth Chance Geothermal Project

On February 9, 1988, the Mono County Board of Supervisors voted 4 to 1 to approve Bonneville Pacific Corporation's Mammoth Chance Geothermal Project. The project is an air-cooled, binary, geothermal power plant, 10 megawatts, net.

The Mono County Board of Supervisors issued a project use-permit with vigorous and stringent conditions. Specific emphasis was placed on the establishment of a monitoring program designed to detect the effects of geothermal development on the springs at the Hot Creek Fish Hatchery and Hot Creek Gorge.

The developer must guarantee that the temperatures of the fish hatchery springs do not fluctuate outside of an agreed-upon temperature range. Whenever it becomes necessary, the developer must take remedial action to ensure the protection of hatchery springs, including supplemental heating of hatchery waters and, if necessary, curtailment or cessation of all project operations.



A hot spring near Bridgeport, California. Photo by Robert Habel.

by Daniel L. Lyster, Director
Energy Management Department
County of Mono
Mammoth Lakes, CA

Mammoth Pacific II Project

On October 5, 1987, the Mono County Planning Commission granted a use-permit to Mammoth Pacific for its Mammoth Pacific II Project, a binary, air-cooled, geothermal power plant, 10 megawatts, net.

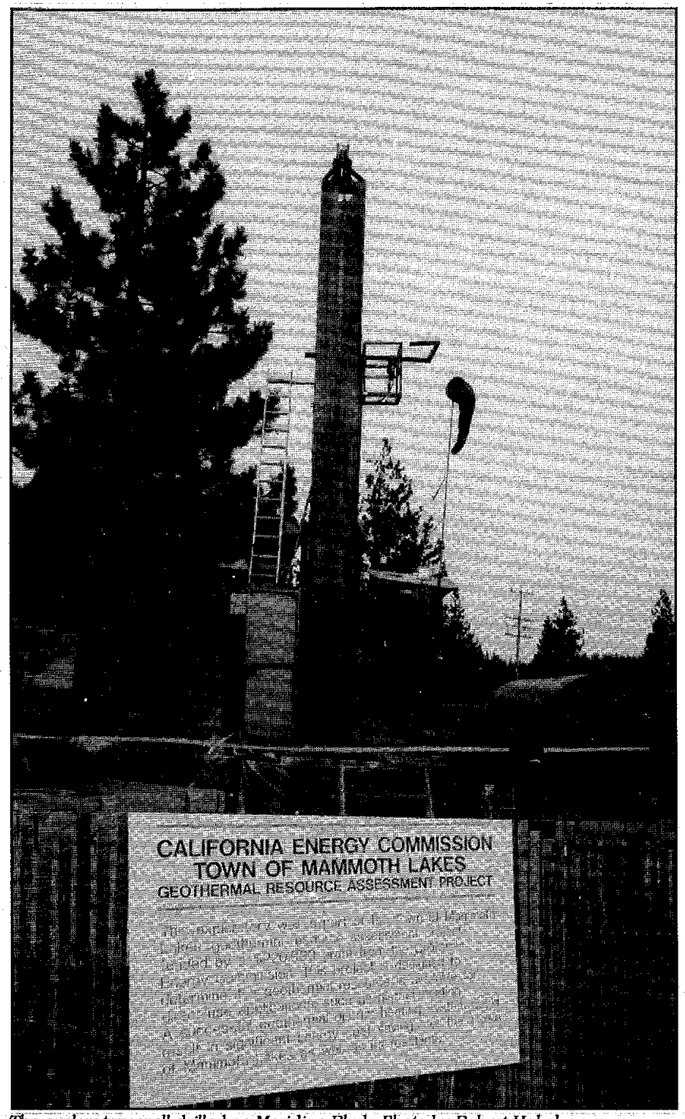
The issuance of the use-permit instigated an appeal by the Sierra Club. That appeal was heard on February 22, 1988, by the Mono County Board of Supervisors.

At the hearing, the Board received testimony from the Sierra Club and from Mammoth Pacific, who provided a rebuttal to Sierra Club statements. Members of special interest groups, regulatory agencies, and the general public spoke at the hearing both for and against the project. All the people who wished to speak in favor of the project were unable to be heard on February 22. So, the hearing was continued on March 1, 1988.

At the end of the testimony, the Sierra Club presented a final rebuttal. Then, the Board of Supervisors voted to uphold the appeal of the Sierra Club, thereby denying the project by a vote of 3 to 2.

The main areas of concern voiced by the majority of the Board included potential hydrologic impacts to Hot Creek Gorge and Hot Creek Fish Hatchery, visual impacts, and impacts to mule deer migration and survival.

One of the options now available to Mammoth Pacific is to request that the project be denied "without prejudice." This would allow Mammoth Pacific to return to the Board immediately with additional material regarding its concerns.



The exploratory well drilled on Meridian Blvd. Photo by Robert Habel.

Another Well Drilled in Mammoth Lakes

On January 31, 1988, the Town of Mammoth Lakes completed drilling its second geothermal exploratory well. According to Drilling Supervisor Doug Goodwin, the second well was drilled to a total depth of 1,536 feet, with tubing hung to a depth of 1,464 feet. The tubing is filled with clear water from which temperature measurements can be made. The well is on Berner Street, near Minaret Road. "The drill rig has been released, and the well is presently shut in and undergoing thermal rebound," said Goodwin. "Preliminary temperature indications and lithology are very encouraging for the well," he said, "but we'll know more after a few weeks of observation."

The town's first exploratory well, which is on private property behind the Luthern church on Meridian Blvd., was completed on December 11, 1987. Several temperature logs have been recorded at the well, with a maximum temperature of 165 degrees F observed to date. "This is not quite warm enough for our needs," said George Fetzer, town staffer in charge of the project. "Also, there doesn't appear to be any permeability at the depths where the warmest temperatures are found," he said.

The Mammoth Lakes Geothermal Resource Assessment Project is funded through the Geothermal Grant and Loan Program of the California Energy Commission. The purpose of the project is to locate and quantify the shallow geothermal resource underlying the Town of Mammoth Lakes. Mammoth Lakes is in the southwestern section of the Long Valley Caldera. There is extensive geothermal activity in the area, and the Mammoth Pacific Binary Power Plant at Casa Diablo Hot Springs is just a few miles outside of town. Positive results from the wells may lead to future utilization of the resource for the benefit of the town.

Mammoth Geothermal Power Plant: Operation Update

The Mammoth Geothermal Power Plant, the world's first modular, air-cooled binary plant, was designed to produce a year-round average of 7 megawatts of electrical power, net. Firm power was first produced in February 1985. The privately financed plant has met design objectives to the satisfaction of the Mammoth-Pacific Joint Venture.

Reservoir performance has been excellent. There is no evidence of a decline in productivity, and injection well pressures have been lower than anticipated. Downhole pumps have been in operation over one year, without servicing.

The equipment in the plant has been operating well. Early problems due to resonant frequencies in the turbine have been solved. Heat exchanger fouling has been as expected. The isobutane pumps and the air coolers have performed in accordance with expectations.

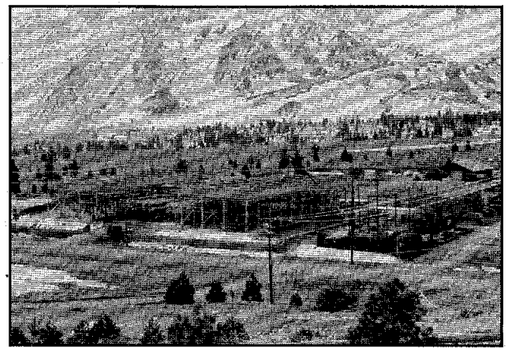
Plans are underway to expand the geothermal development at Mammoth, employing the Magmamax process and the same environmentally benign design concepts.

The plant is owned by Mammoth-Pacific (M-P), a wholly-owned subsidiary of Pacific Enterprises. Magma Energy, Inc. has leased the plant site to M-P and has licensed M-P to use its patented Magmamax process.

Design and construction was handled by the Ben Holt Co., who also operates the plant.

Design and operation of the plant takes advantage of the low ambient temperatures at the plant site. The plant is at an elevation of 7,300 feet, with an annual average dry-bulb temperature of about 40 degrees F. Condensation of the working fluid uses floating cooling. That is, the condensing temperature is allowed to vary with changes in the inlet air temperature. Power production during the summer is lower than average,

by Richard G. Campbell, Ben Holt, and Wilbert Asper
The Ben Holt Company
Pasadena, California 91101



The Mammoth Geothermal Power Plant, February 1988. Photo by Robert Habel.

but the high power production during the rest of the year makes up for the low summer production.

The geothermal fluid at Casa Diablo has a dissolved solids content of about 1,500 ppm and is noncorrosive. As a result, the piping and power plant have been built with carbon steel as the primary material of construction.

Eight geothermal wells were drilled on Magma's property and flow tested in the early sixties. This early work demonstrated the existence of a reservoir of hot water at shallow depths (400 to 800 ft.). Reservoir temperatures averaged about 330 degrees F.

Isobutane is the working fluid in a Rankine cycle. Vaporization is subcritical, though near the critical point. Condensation of the turbine exhaust is in air coolers.

The design basis of each module is as follows:

1. The Geothermal Fluid:

   a. Temperature in: 330 degrees F

   b. Temperature out: 150 to 190 degrees F, depending on ambient temperature

   c. Flow rate: 640,000 lbs./hr.

2. The Working Fluid:

   a. Composition: Isobutane

   b. Turbine inlet: 500 psia, 280 degrees F

   c. Condensing temperature: 70 to 120 degrees F, depending on ambient air temperature

   d. Cooling: 100 percent air

   e. Flow rate: 580,000 lbs./hr.

Operation using the floating mode concept results in varying power outputs throughout the year. Monthly average production exceeds 8 megawatts during the winter, with low air temperatures and low turbine back pressures. Power during the summer is about 6 megawatts, due to higher turbine back pressures and off design operation. The total annual power output is higher during this floating mode concept than if a single, high air temperature was chosen as the design point for year-round operation.

The nameplate generator capacity for each unit is 5 megawatts. Parasitic load for each unit is 1 megawatt. Thus, the design net power for sale is 4 megawatts. However, year-round output is about 3.5 megawatts.

Field pumping requires about 300 kW for each unit.

The geothermal brine is pumped from the production wells and through the heat exchangers with vertical, line-shaft turbine pumps. Cooled brine leaving the heat exchangers is pressurized for injection by centrifugal pumps at the plant site.

The power plants were constructed within the original budget estimate of $10,000,000.The field budget of $2,500,000 was exceeded by the need for remedial work and drilling additional wells.

New Power Plant Underway

Trans-Pacific Geothermal, Inc. of Oakland, California, and U.S. Energy Corp. of Reno, Nevada, are working to complete Phase 1 at Amedee Hot Springs in Lassen County, in Northern California.

Phase 1 consists of two 0.8 megawatt, net, Barber Nichols modular, binary power plants. The two units will operate on brine produced from two wells that have an average depth of 1,000 ft. The reservoir temperature ranges from 220 to 230 degrees F. Because waste-water quality is almost the same as that of the water produced by the hot spring, a temporary surface water disposal permit has been issued for the project by the State Water Quality Control Board.

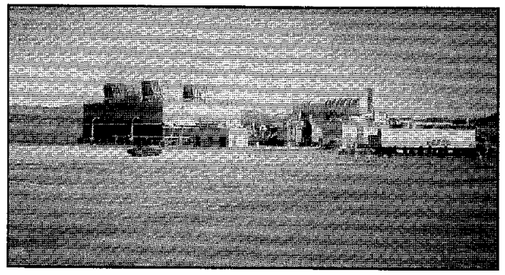
The operators are now in the process of drilling the second production well. Construction on the modular units has started and installation work in the field should start in the summer of 1988. Phase 1, with a total of 1.6 megawatts, is scheduled to go on line in November 1988. Power will be sold to Pacific Gas and Electric Co. under a 5 megawatt Standard Offer 4 contract. Power will be wheeled through a power line passing through the property.

Phase 2 will consist of a total of 3.4 megawatts, net, bringing the total for the project to 5 megawatts, net. Amedee Hot Springs is about 3 miles southeast of Wendel Hot Springs, and about 30 miles east of the City of Susanville, California.

NOTE: This article is reprinted from the Geothermal Resources Council Bulletin, vol. 17, no. 2.

Coso Geothermal Power Plant Dedicated

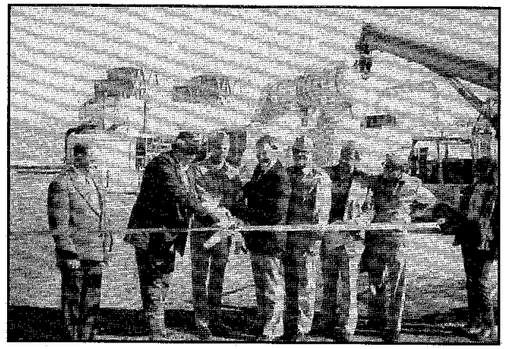
by Susan F. Hodgson



Coso Geothermal Power Plant No. 1, Unit No. 1, part of the Coso Geothermal Project, was dedicated on November 19, 1987. Units 2 and 3 of Plant No. 1 will be built in the photo foreground area.

The geothermal electrical generating plant is on the eastern edge of the Sierra Nevada, 23 miles north of Inyokern, California, in the China Lake Naval Weapons Center.

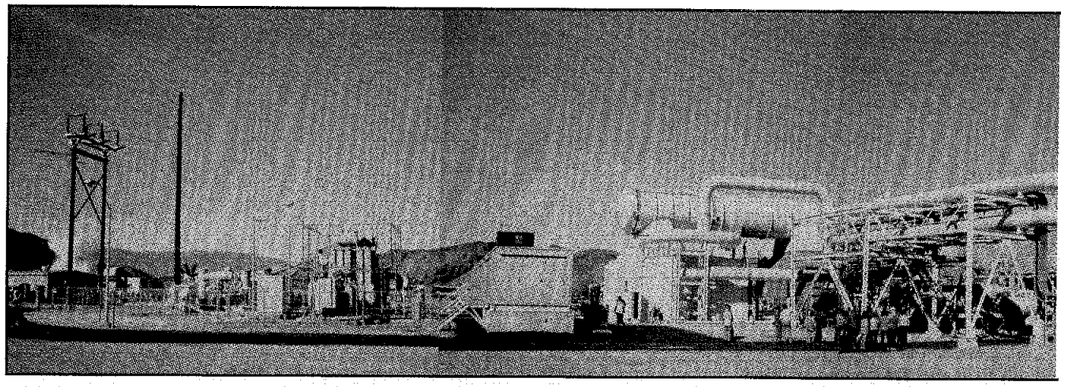
Development of the Coso Geothermal Project is the result of an association, begun in 1979, between the U.S. Navy and California Energy Company, Inc.



Among the speakers at the dedication ceremony was Charles Condy, Chairman of the Board and Chief Executive Officer of the California Energy Company. Condy said his company and the Navy must care for the environment at Coso as they develop the geothermal resources.

Keith Eastin, Principal Deputy Assistant Secretary of the Navy, also spoke. He said the Navy will use the geothermal development at Coso as an alternate energy source, to buffer itself from an energy shortage and to prevent dependence on foreign fuel.

A ceremonial ribbon was cut after the presentations. Dr. Carl Austin, second from left, is Head of the Geothermal Program Office, Naval Weapons Center, and has advocated the development of Coso's geothermal resources for many years. In 1964, he published the first Navy report on exploring for geothermal resources in the Coso area.



Electrical yard.

Control trailer.

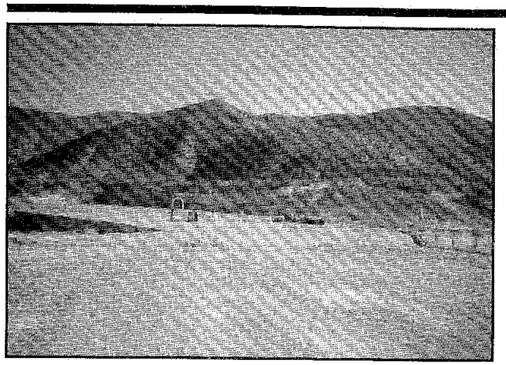
Turbine and generator.

Coso geothermal power-plant statistics

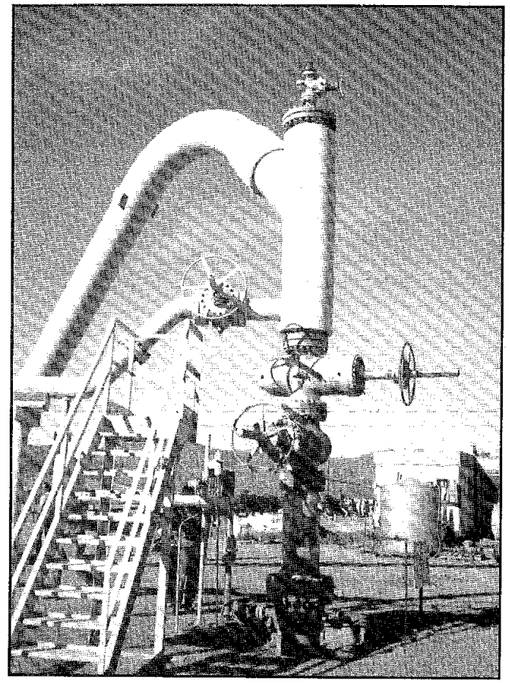
The turbine is a Mitsubishi outdoor, impulse-reaction, single-shaft condensing, double-flash system.

The average annual power production rate of this 25-megawatt plant will be 186,000,000 kilowatt-hours per year.

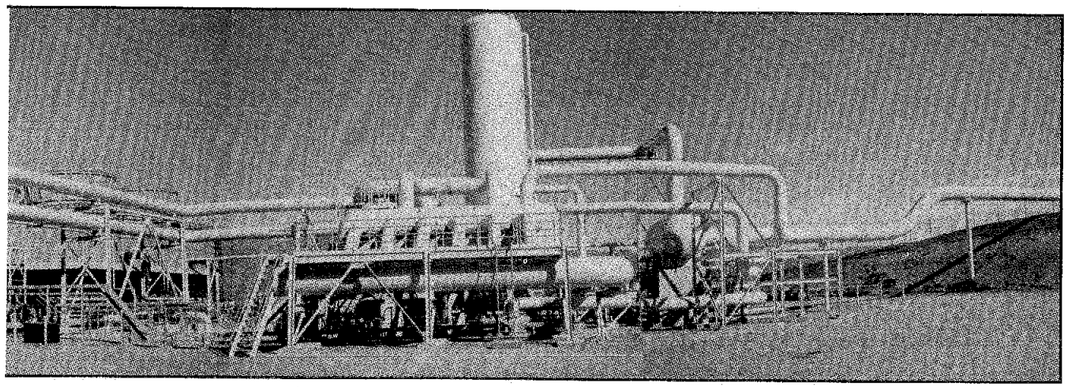
So far, no silica deposition problems have occurred. A limited amount of carbonate scaling has been noted.



An injection well near the power plant. Because of the Coso project, the Navy expects to spend $47 million less on electricity in the first 10 years of the operation of Unit No. 1.



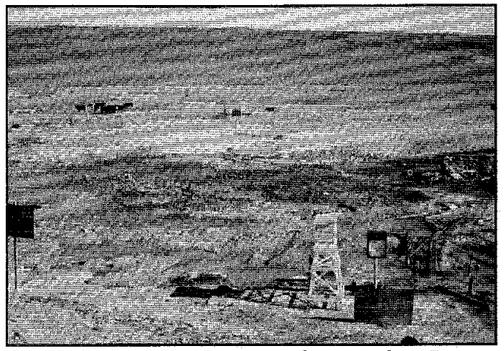
A production well. The wells at Coso are 2,500 feet to 4,500 feet deep.



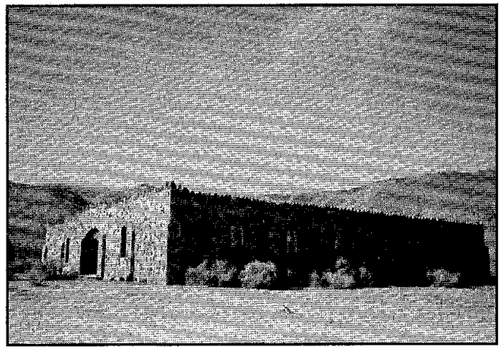
Cooling towers.

High-pressure separator (vertical vessel) and low-pressure separator (horizontal vessel).

Two-phase flow is delivered through pipelines to the geothermal plant from the production wells. The pipelines contain water suspended in steam.

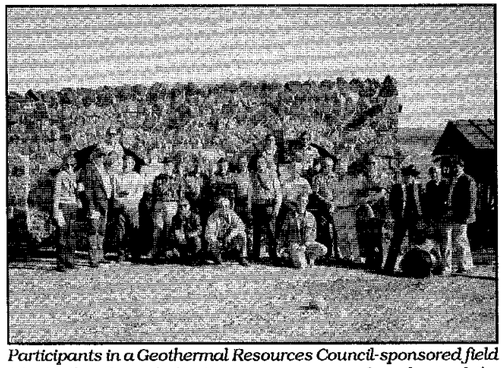


Coso Hot Springs Historic Area, near the power plant. Pioneers settled in this area in the 1860's, and the first land titles were registered in 1904. Today, hydrothermal activity at Coso Hot Springs is monitored carefully.

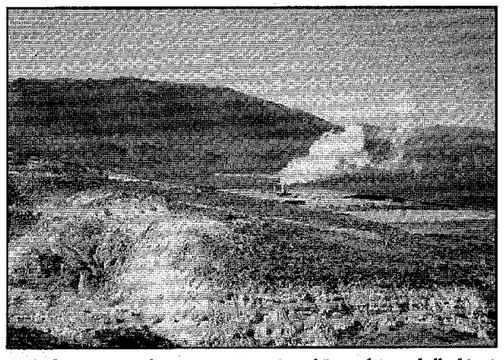


At one time, water, called Coso Magic Water, was collected from the springs, bottled, and sold.

In the 1920's, resorts catering to tourists from the Los Angeles area were developed at the hot springs. The Navy took control of the area in 1942, under Public Land Order 431.



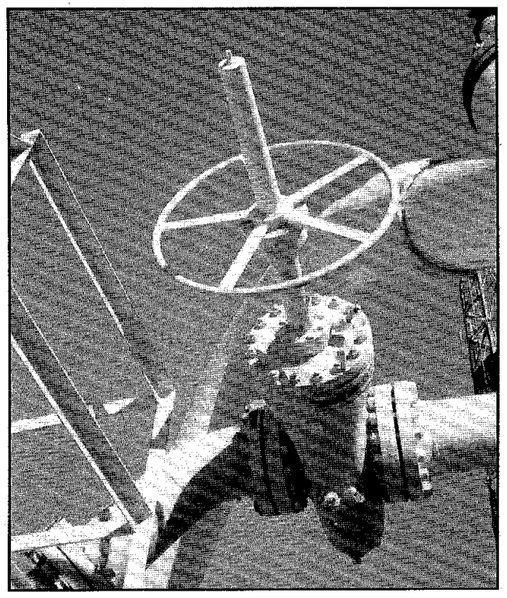
Participants in a Geothermal Resources Council-sponsored field trip to the Coso dedication ceremony stand in front of the remains of a beautiful, old fieldstone structure in the Coso Hot Springs Historic Area.



Wells from Power Plant No. 1, Units 2 and 3, are being drilled just beyond the Devil's Kitchen hydrothermal area (photo foreground). The photo was taken from the edge of the Coso Geothermal Power Plant site.

Not too far away, the Los Angeles Department of Water and Power (LADWP) has drilled a geothermal well on its own leases.

The LADWP is planning to build a 10-megawatt geothermal power-plant demonstration facility at Coso.



Geothermal resources at the Naval Weapons Center are being developed under a multiple, land-use program. Surface management is by the Navy, while subsurface management is by both the Bureau of Land Management (Steam Act leases) and the Navy (Navy development contract). Mutually separate geothermal development projects are by private venture capitalists, private industry, and public utilities.

Coso Development Continues

An agreement to engineer and construct additional geothermal power plants for the Coso Project has been reached with Mission Power Engineering Company (a wholly-owned subsidiary of Southern California Edison Company), according to Charles T. Condy, chairman and chief executive officer of California Energy Company, Inc.

Under the agreement, Mission Power will have two additional geothermal power plant units (Units 2 and 3) on line by the fourth quarter of 1988. Under separate agreements that are subject to standard conditions, Mission Power is also designing six additional power plant units that are expected to go on line after Units 2 and 3 at the Coso Project.

The first geothermal, 30-megawatt power plant unit at the Coso Project went on line in July 1987. By December 1989, a total of 240 megawatts is expected to be on line. Southern California Edison Company will purchase the electrical output of the plants under long-term contracts.

"The Coso Project's proven geothermal reserves at China Lake are currently estimated at about 171 billion kilowatt-hours," Mr. Condy said. He added that, "Continuing exploration and reservoir engineering work, as well as production experience since July, indicate that the China Lake geothermal field is capable of supporting 650 megawatts of capacity for at least 30 years."

Ormesa II Under Operation in East Mesa

In March 1988, Ormesa II, a 20-megawatt geothermal power plant, began generating electricity from moderate-temperature geothermal fluid.

Ormesa II is in the East Mesa Known Geothermal Resources Area, in California's Imperial Valley. The power plant is next to Ormesa I, a 30-megawatt sister plant, also developed and built by Ormat.

Ormesa II is the culmination of a development partnership between Ormat Energy Systems, Inc. and Harbert International, Inc. Construction of the $70 million project started in May 1987 and lasted seven months. Nine production and injection wells were drilled and tested. Preoperational tests of the power plant were successful, and the 20 Ormat Energy Converters were synchronized to the grid. Each of the modular Ormat Energy Converters is a self-contained power plant of 1.2 megawatts.

Ormesa II was financed by a construction loan from Bankers Trust Company (New York) and the Bank of Nova Scotia. In addition, Bankers Trust Company served as the financial advisor to the project, placing the long term debt and the equity. The project was structured as a 20 year leveraged lease, whereby two institutions act as the lessors with the long term debt being provided by a group of insurance companies. The development partnership serves as the lessee, and will operate and maintain the facility for the lease term.

GRI to Purchase B.C. McCabe Plant at East Mesa

Geothermal Resources International, Inc. (GEO), announced that it has signed a letter of intent to purchase from Magma Power Company for $12 million, all of the stock of Magma Electric Company. This Magma subsidiary operates the 12.5, net, megawatt B.C. McCabe power plant at East Mesa, which went into operation in 1979. This agreement, when finalized, would allow GEO to increase its access to the geothermal resources in the East Mesa area, and to assume operating control of the B.C. McCabe plant at East Mesa.

GRI Pushes Ahead with New East Mesa Plants

Geothermal Resources International, Inc. (GEO) has signed a contract with Mitsubishi International Corporation (MIC) for the engineering and construction of GEO's 37-megawatt geothermal East Mesa power plant with an option for a second 37-megawatt power plant, both of which will be about 30 miles east of El Centro in Southern California.

According to GEO's Chief Executive Officer Ronald P. Baldwin, the two-plant East Mesa Project is estimated to cost a total of about $200 million. The contract with Mitsubishi for the engineering and construction of the two plants, which will supply electricity to Southern California Edison Company, represents over 50 percent of the total project cost.

In April 1987, GEO acquired from Magma Power Company the rights to develop and utilize the geothermal resources from Magma's leaseholds at East Mesa. Electricity from the power plants, which must be in operation by November 1989, will be sold to SCE under 30-year contracts. Since April, GEO has drilled four wells at East Mesa and anticipates beginning further drilling in the near future.

According to Baldwin, MIC will engineer the plants in conjunction with Mitsubishi Heavy Industries Ltd. and Stone & Webster Engineering Corporation, and will employ Becon Construction Company (a Bechtel subsidiary) to construct the units. The East Mesa project utilizes the double-flash power cycle in which hot brine, collected from wells 4,000 to 8,000 feet deep, is piped to the power-generating facility and flashed to steam in a series of separators as the pressure drops. The steam drives a conventional steam turbine generator, and the condensed water is injected into the subsurface.

Baldwin said, "Geothermal power plant technology has matured to the point where MIC can guarantee project completion within 18 months."

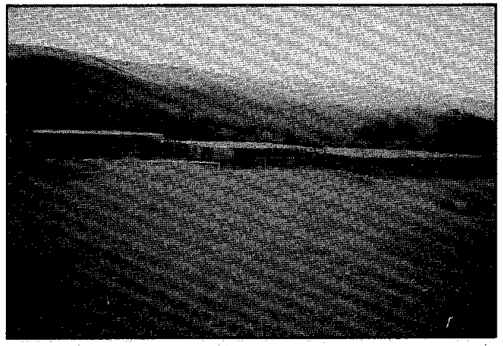
OTHER WESTERN STATES

NEVADA

Geothermal Aquaculture in Nevada

Work in geothermal aquaculture and vertically integrated agriculture is undertaken by Washoe Aquaculture Limited, Gourmet Prawnz Inc., General Managing Partners. This approach to agriculture is researched at the integrated Prototype Aquaculture Facility (IPAF) at Hobo Hot Springs, Nevada.

The principal objective at the IPAF is to use geothermal aquifers to commercially raise food, plants, and ornamental fish. At the IPAF, the feasibility of geothermal aquaculture has been demonstrated. The company has implemented many demonstration projects, including the cultivation of freshwater prawns, native baitfish, exotic tropical species, and commercially important aquatic plants.



Geothermal aquaculture ponds at Gourmet Prawnz Inc., Minden, Nevada. Photo by Susan Hodgson.

by Serge Birk, President
Gourmet Prawnz, Inc.

Although Hobo Hot Springs as a geothermal aquifer is marginal in geoheat generation and in volume recharge (110 degrees F and 100 GPM, respectively), the IPAF concept as it works there is an ideal example of vertical agriculture integration. As an example, nutrient-rich discharge waters are used to irrigate terrestial plants, such as Japanese cucumbers and commercially important aquatic plants for the aquaria market.

The company has recently demonstrated a method for intensive cultivation of freshwater prawns by individual segregation. This has increased our overall stocking density and reduced mortality associated with cannibalism. The concept is viable for commercial exploitation in areas with thermal discharge effluents, such as those with power plants, including geothermal power plants.

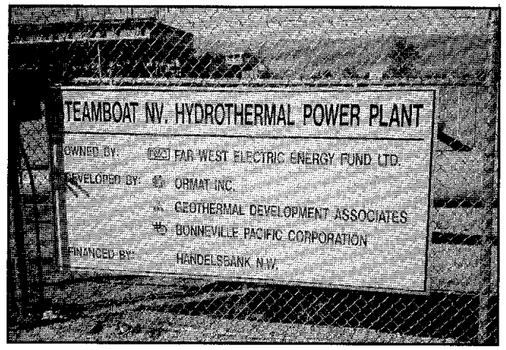
The IPAF uses both geothermal and passive solar (greenhousing) alternative energy sources. Our efforts to implement such concepts have made a significant impact on Nevada's economic diversification. Because our business is sited on Washoe Indian lands, the Tribe has received economic benefits, as well.

Operations at the IPAF are funded by revenues generated from contract research studies through academia and industry, and by commercial sales of fish and shellfish. The company's products are marketed in California, Nevada, Idaho, and Utah.

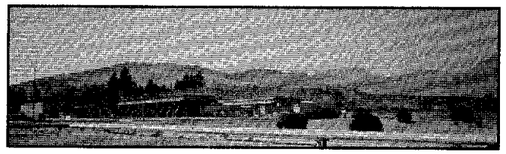
For further information, contact Serge Birk, Washoe Aquaculture Limited, Gourmet Prawnz Inc., Route 3, Box 1, Minden, NV 89423; telephone (702) 882-7670.

by Susan F. Hodgson

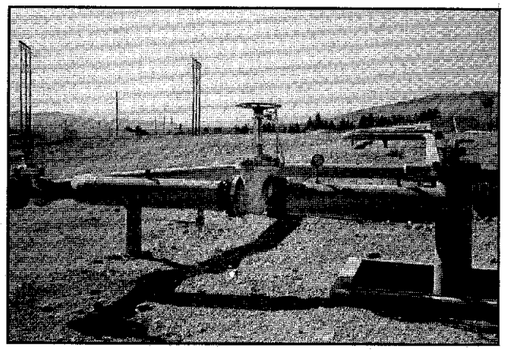
An 8.4 megawatt geothermal power plant is operating at Steamboat Springs, south of Reno, Nevada. The plant is composed of seven, 1.2 megawatt Ormat, binary units. Ormat Systems Inc. has contracted to maintain and operate the plant for the next 10 years.



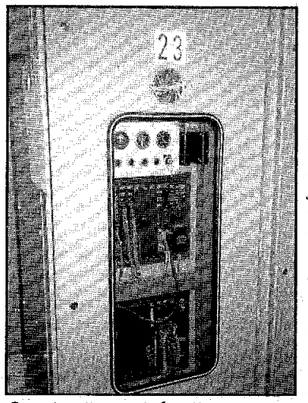
The project is owned by the Far West Electric Energy Fund Ltd. Bonneville Pacific Corporation financed project construction, but is no longer involved in the project.



The hydrothermal power plant. The project has 3 production wells and 1 injection well.



The injection well. Almost no drawdown has been measured in the reservoir.

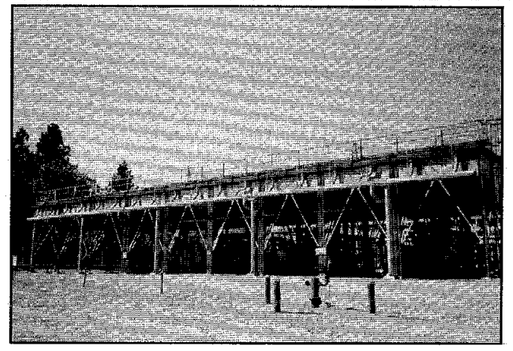


Control panel for 1 of the 7 Ormat units. Each unit is autonomous from the rest.

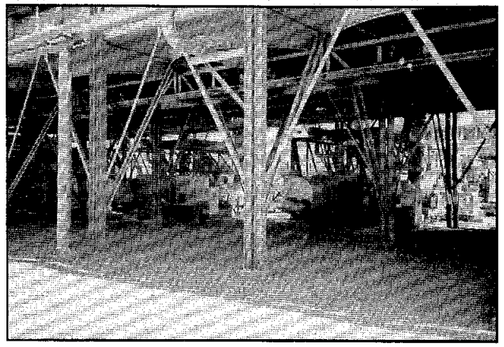
To operate the power plant, geothermal fluid between 275 degrees to 340 degrees F is mixed from 3 production wells and passed into the 4, high-level Ormat units. Here, the fluid heats a pentane working fluid to vapor. Next, the geothermal fluid, now between 240 degrees to 275 degrees F, is remixed and passed through the 3 additional Ormat units, again heating a pentane working fluid to vapor.

The working fluid vapor spins the turbine attached to each high-temperature and low-temperature Ormat unit, and electricity is generated.

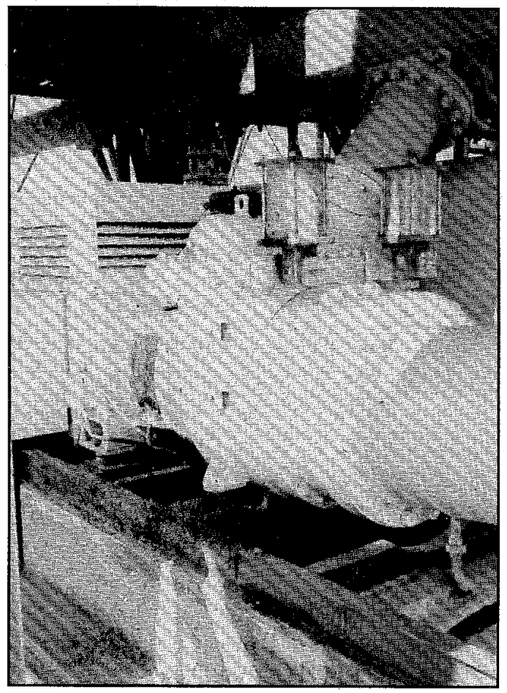
Two more Ormat units may be added to the project. In these units, 240-degree F water will heat the pentane working fluid. These additional units could increase the total output of the geothermal power plant by about 1.2 megawatts.



Closeup of the power plant. A production well is in the foreground. The TDS of the produced geothermal fluid is about 3,500 ppm.



A partial view of the 4, high-temperature Ormat units. Each high-temperature unit has 4 fans. Each of the 3 lower-temperature units has 6 fans. The fans are used to condense the vaporized pentane.



Where the electricity is generated.

The electrical substation.

NEW MEXICO

New Mexican Geothermal Development

New Mexico has many low-temperature geothermal resources. The state has more than 300 known thermal springs and wells, most located within the Rio Grande Rift, a north-south trending geological system that stretches south from central Colorado, through New Mexico, to northern Chihuahua, Mexico.

In the 1970's, state and federal governments took an active interest in geothermal energy in New Mexico. An extensive resource assessment of geothermal energy was conducted, funded through the U.S. Department of Energy, the New Mexico Energy Research and Development Institute (NMRDI), and the Energy and Minerals Department (EMD). The studies—consisting of geothermal exploration, demonstration, and technology transfer efforts—identified 21 low-temperature sites in the state with the highest potential for commercial development.

In 1980, the state initiated the Geothermal Commercialization Program with the support of NMRDI and EMD. The program's goal is to promote the use of geothermal energy for economic development. The primary target is the sector of the commercial greenhouse industry growing high-value horticultural and floricultural crops.

New Mexico State University (NMSU) has become the center of the state's geothermal research program, partly because of the abundant geothermal resources in Dona Ana County and partly because of a large thermal reservoir on the eastern side of the campus. The NMSU Geothermal Greenhouse Facility, constructed and operated by the New Mexico Solar Energy Institute, is a 12,000-square-foot, geothermally-heated greenhouse that provides a testing facility for commercial growers considering southern New Mexico for their operations. The research facility is built on Las Cruces' East Mesa Geothermal field, with water temperatures of 140 to 150 degrees F available from wells 600 to 1,000 feet deep.

by Valerie Gerard

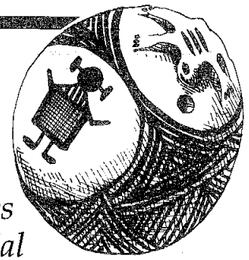
Excerpted from the New Mexico R&D Forum, Vol. 2, No. 2.

By 1985, the state's geothermal greenhouse industry covered 13 acres. Since the NMSU greenhouses were constructed in 1986, two large greenhouse companies have taken advantage of the facilities. Flores de New Mexico, of Las Cruces, and Masson Southwest, Inc. of Linwood, Kansas, used the facilities for pilot studies of the area. Both have stayed in the area and have expanded. Flores de New Mexico built 10 acres of greenhouses on the NMSU campus and is planning a five-acre expansion, and Masson, Inc. is building a four-acre greenhouse in Radium Springs, N.M.

Geothermal technology is also being used by three greenhouse businesses in Hidalgo County's Animas Valley, south of Lordsburg. Beall Company of New Mexico, Inc., Burgett Floral, Inc., and McCant's Greenhouse are tapping into the large thermal reservoir in the southwestern corner of the state. "By the end of 1987, 46 percent of the wholesale greenhouse acreage in southern New Mexico will be geothermally heated," says Rudi Schoenmackers, of the New Mexico Solar Energy Institute.

"Our scope of work for the current fiscal year will include not only the geothermal heating of greenhouses and the commercialization effort, but also the development of a computerized environmental control system," he stated.

Publications from New Mexico



New Mexican brochures tout heating commercial greenhouses with geothermal energy.

Advertising Brochures

Hidalgo County, New Mexico, the southwest gateway to the Land of Enchantment, featuring geothermal energy for your commercial greenhouse. Exceptionally well done brochure promoting geothermal energy. Free. A limited quantity is available. Write the New Mexico Energy Research and Development Institute, Communications Office, 457 Washington, SE, Suite M, Albuquerque, New Mexico 87108.

The brochure is part of an effort in New Mexico, undertaken in the last few years, to promote geothermal resources. The main thrust of the brochure is towards the development of geothermal greenhouses by the floral industry in.

To quote from the brochure:

The Below Market Rate Loan Program

Ninety million dollars has been earmarked for startup or expansion loans for those businesses that are established in or are new to New Mexico. Interest rates on Below Market Rate Loans are pegged to the interest rates of U.S. Treasury bonds of the same maturity plus one-eighth of a point. Qualifying criteria include a debt rating of Baa or better.

The State Guaranteed 90-10 Program for SBA Loans

The state has created a new secondary market for Small Business Administration (SBA) guaranteed loans. Eighty million dollars has been allocated for the state to purchase up to 90 percent of any SBA loan. The 90-10 program gives borrowers the opportunity to obtain a long-term loan at treasury bond rates plus 1 percent.

A second, similar brochure is available, titled *Geothermal Energy, Greenhouses, and Dona Ana County, New Mexico.*

Technical Publications

Fifty technical publications on geothermal development are available from the New Mexico Energy Research and Development Institute, at the same address. The publications list is free. The publications, themselves, are free for residents of New Mexico, and sold to others for a small fee.

General Information

Geothermal resources of New Mexico. Free. Available from the New Mexico Energy Research and Development Institute, at the same address.

The 17-page report is written for the general public as a summary of New Mexican geothermal resources and the way they are used.

Geothermal P.R. in New Mexico

"Three greenhouse businesses that are heated with geothermal energy have come to New Mexico in the last three years because of our public information campaign," said Rudi Schoenmackers, Project Director of the Geothermal Commercialization Program, New Mexico Solar Energy Institute.

Rudi was speaking about a public information campaign that included the advertising brochures just described.

"However," Rudi continued, "our P.R. emphasis has changed through the years. Eight or 9 years ago, when we began the campaign, energy was on everybody's mind. To get the greenhouse businesses to come here, we emphasized the advantages of geothermal energy."

"Today, we still want the greenhouses, but another approach is more successful. Now, we emphasize our climate—especially our winter sunlight. This fact is so important because all the big flower holidays are in winter months. We let growers know about using our geothermal resources for heating, as the icing on the cake."

Rudi uses a videotape to help promote New Mexico to the greenhouse industry. For information about the video or geothermal development in New Mexico, call Rudi at (505) 646-1846.

HAWAII

Hawaiian Update - 1988

Progress with geothermal development on the Island of Hawaii has been slow since my July 1987 report. Puna Geothermal Venture (PGV), which plans to have 25 megawatts on line by 1993, is in the midst of changing owners. The 75 percent owner of PGV, Thermal Power Company, may be acquired by Geothermal Resources International. Amfac Hawaii Inc., a unit of Amfac Corporation, has sold its 25 percent stake in PGV to Amor VI Corp., a subsidiary of Reno-based Ormat Energy Systems Inc.

Although PGV hasn't drilled additional wells since the successful Kapoho State-1A in late 1985, the venture has been moving ahead with planning and design for the 25 megawatt project. An Environmental Impact Statement for the project was accepted by the County of Hawaii in late 1987. Final touches are being put on the application for a Geothermal Resources Permit. The permit is the major land-use action required for PGV's *Agriculturally*--designated land near the state-owned 3 megawatt HGP-A geothermal power plant (see the July 1985 issue of the *Geothermal Hot Line*).

The other developer in Hawaii is True/Mid-Pacific Geothermal Venture. Principals of both True Geothermal and Mid-Pacific Geothermal are from Wyoming. This group has run into local opposition since late 1981. Originally, they planned to construct a 250 megawatt project in the upper end of the Kilauea East Rift Zone (KERZ) on the Island of Hawaii, near the Volcanoes National Park. Then, they changed to a 100 megawatt project in the middle of the KERZ. The EIS has been accepted and the group has received the necessary, state land-use permit. A state permit is needed because the project will be sited on land categorized as *Conservation*.

However, the permit action was appealed by a few Pele practitioners. This group claims that geothermal drilling will violate the volcano goddess Pele, and development will infringe on the worship of Pele. It was this group of Pele practitioners that sponsored full-page, anti-geothermal advertisements in several West Coast newspapers and two Hawaii newspapers on February 1, 1988.

In July 1987, the Hawaii Supreme Court ruled unanimously in favor of the development project. The U.S. Supreme Court is expected to take action soon on a further appeal to that Court.

In August 1987, Governor John Waihee established a blue-ribbon panel to study the feasibility of developing an inter-island cable system to transmit 500 megawatts of geothermally-produced electricity from the KERZ on the Island of Hawaii to the Islands of Maui and Oahu, where 80 percent of the state's population live. This system has a price tag of $475 million (1986). It will span a greater length of ocean and lie in deeper ocean depths than any other high-voltage submarine cable. There is no known U.S. manufacturer with the capability to build such a cable.

The Governor's Advisory Board on the Underwater Cable Transmission Project is chaired by former Governor William F. Quinn, and includes other well-known business, labor, and government leaders. In a January 15, 1988 preliminary report to the Governor, the Board concluded:

o Hawaii must rapidly reduce its extreme dependence upon imported petroleum as an energy source. (90 percent of the state's electrical-generating capacity is oil-fired.)

o Geothermal energy conversion is a mature technology. The KERZ contains sufficient heat to satisfy Oahu's electrical demand several times over, but considerably more exploration is needed to prove the availability of the resource for 500 megawatts of net power.

o Foreign cable manufacturers have said they could cope with the remaining technical uncertainties if a decision is made to proceed immediately, before an ongoing Government-funded Hawaii Deep Water Cable (feasibility) Program is completed in early 1990.

o The concept of a 500 megawatt geothermal/cable development to benefit Maui and Oahu appears technically feasible and economical, when compared with oil-fired generation under assumed future oil prices. The Board did say that more study is needed to determine if a geothermal/cable system is more economical than generation on Oahu using other alternative fuels. The Board had in mind coal, which is not presently a fuel in Hawaii.

o The geothermal development and cable development are so interdependent, that they should be undertaken as a single enterprise.

The Board's report went on to recommend strong state legislative actions. The Governor sent two bills to the Legislature, one to establish an Authority to expedite and facilitate the geothermal/cable development and the other to establish a consolidated (one-stop) permitting process for the geothermal/cable project. The consolidated permitting bill has made its way through the State Senate and will be considered by the House in March. Unfortunately, the Authority bill was held by the chairman of the Senate Committee that oversees energy. The bill has strong state administration, County of Hawaii administration, and developer support. The only significant testimony against the Authority was from those who claimed that it looked like public power, and that the bill would add another unnecessary layer of government that could impede the intended development.

The current legislative session (Hawaii's Legislature meets annually from the third week in January through the third week in April) is also considering matching funds for geothermal exploration, and for a County of Hawaii, geothermal-awareness program.

While progress has been slow in the past six months, there is considerable optimism that geothermal development in Hawaii will take some giant steps forward in 1988.

WORLDWIDE

Successful Well for St. Lucia

"A successful geothermal well has been drilled and flow tested south of the Sulphur Springs manifestation area on the island of St. Lucia," said Robert Hanold of Los Alamos National Laboratory. The well, almost 1-1/2 kilometers deep, appears to have a bottom-hole temperature of 300 degrees C. It initially was flow tested at 90 tons per hour of superheated steam.

Preliminary estimates indicate this geothermal well could supply one-half of the electrical generation needs of St. Lucia. Presently, all electricity on the island is produced by diesel engines using imported fuel.

The geothermal resource evaluation performed by Los Alamos on St. Lucia was funded by the Trade Development Program of the U.S. Department of State. This evaluation led to the selection of the site where the successful geothermal well was drilled.

The geothermal project is financed by the United States Agency for International Development, the United Nations Revolving Fund, and the government of St. Lucia.

The drilling contractor is Big Chief, Tulsa, Oklahoma, and the onsite manager is AQUATER, an Italian geothermal development company.

by Gerald Lesperance
Dept. of Business and Economic Development
Honolulu, Hawaii

CENTRAL AMERICA

Costa Rican Geothermal Development

In northwestern Costa Rica, Miravalles Geothermal field is being developed by the Instituto Costarricense de Electricidad (ICE). To date, 8 production and injection wells have been drilled in the field.

The drilling program at Miravalles is scheduled to resume in November 1988. Then, drilling will begin on 22 additional wells (12 for the first power plant and 10 for the second power plant). Both production and injection wells will be drilled. The 22-well program allows for a few nonproductive wells.

Both power plants will be single-flash units, 55 megawatts, gross, and 52 megawatts, net. They will be housed in the same power house.

The first power plant will be designed and supervised by West Japan Engineering Consultants, Inc. (WJEC). Then, a bidding process for facilities construction will be undertaken. Work by WJEC will begin immediately, and the first power plant is scheduled to come on line in January 1991.

The first power plant will be funded with a loan from the Japanese Overseas Economic Fund. The second power plant will be financed solely by a loan from the Interamerican Development Bank (IDB).

Concurrent with this activity, a feasibility study will be undertaken to see if the field can support a third and fourth power plant. The study will be made by Electroconsult of Italy and funded by the IDB.

by Susan F. Hodgson

Ahuachapan Update

Reservoir Models Prepared

In December 1987 and January 1988, dipole-dipole DC resistivity measurements were conducted in the Ahuachapan/Chipilapa Geothermal area of El Salvador. The work was conducted by the Comisión Ejecutiva Hidroeléctrica del Río Lempa (CEL), Los Alamos National Laboratory, and Geophynque International. The geophysical equipment was provided to Central America under the auspices of the Central American Energy Resources Project, funded by the United States Agency for International Development.

After completing training sessions, CEL personnel have continued to run additional DC survey lines throughout the area. Survey lines up to 13 kilometers long have been used in the field investigations. The measurements will provide more information on the structural setting for both geothermal fields. They'll serve to guide the CEL in future production-well drilling operations at Ahuachapan and Chipilapa.

During February 1988, a reservoir engineering team from Lawrence Berkeley Laboratory (LBL) visited Ahuachapan, presenting a conceptual model of the Ahuachapan reservoir, developed by LBL, to CEL reservoir engineers. Also, they discussed the development of a natural-state model that would reflect reservoir conditions before any exploitation occurred.

To date, Ahuachapan has not had a consistent fluid injection program. After 12 years of sustained production in the field, the reservoir pressures are declining and the overall output of the power plant is well below the installed electrical capacity.

The reservoir engineering models being developed by LBL will be used to develop a field management plan and brine-injection program to stabilize and, ultimately, increase the electrical power production from the Ahuachapan field.

Wells Logged

Four geothermal wells at Ahuachapan have been logged by Los Alamos with the high-temperature, 3-armed caliper tool provided to Central America by the Central American Energy Resources Project.

The logging results confirmed the declining reservoir pressures. The logs showed that scale accumulation is not a problem in the field's production wells.

The caliper tool was also used to confirm the integrity of production well casings at Ahuachapan. Data obtained with the spinner-temperature-pressure tool will be used in the reservoir engineering investigations. Brine samples were also collected with a downhole sampling tool. Hydrogeochemical analyses are in progress.

From an interview with Robert J. Hanold, Earth and Space Sciences Division, Los Alamos National Laboratory.

NEW ZEALAND

Small Geothermal Development Planned in New Zealand

Two small, geothermal-generation developments are currently planned in New Zealand. Both the projects will be undertaken at the Rotokawa Geothermal field, about 13 km northeast of Taupo.

One project is a 6.5-megawatt atmospheric-exhaust development that will use existing wells. Geothermal Developments and Investments (Rotokawa) Ltd., a nominee company of the Ministry of Energy Gas and Geothermal Trading Group, is planning to contract with the Rotokawa Geothermal Power Co. Ltd. for the supply of electrical generation services. The Rotokawa Geothermal Power Co. Ltd. will undertake the power development using steam from well RK5, owned by the Gas and Geothermal Trading Group, and generate electricity that will belong to the same group. The Gas and Geothermal Trading Group will sell the electricity to the New Zealand Electricity Corporation or to an alternative customer. Geothermal Energy New Zealand Ltd., which wholly owns the Rotokawa Geothermal Power Co. Ltd., will be the project consultant.

The second project discussed will be undertaken by Balcairn Mining and Investments Ltd., which is a wholly owned subsidiary of Fletcher Challenge Ltd. For this project, geothermal steam will be used to dry sulphur and to drive 2, four-megawatt condensing units to supply electricity for an associated sulphur-dredging operation.

by Roger B. Hudson
Geothermal Energy New Zealand
Box 8332
9 Madeira Lane
Grafton
Auckland 1, New Zealand

Excerpted from a paper presented in May 1987 at the Workshop on Small Geothermal Resources, UNDP, UN Institute for Training and Research.

DEVELOPMENT

GEOLOGY

A Vapor-Dominated Reservoir Exceeding 600 Degrees F at The Geysers, Sonoma County, California

A high-temperature, vapor-dominated reservoir underlies a portion of the northwest Geysers area, Sonoma County, California. The high-temperature reservoir (HTR) is defined by flowing fluid temperatures exceeding 500 degrees F, rock temperatures apparently exceeding 600 degrees F, and steam enthalpies of about 1,320 Btu/lb.

Steam from existing wells drilled in the northwest Geysers area is produced from both a "typical" Geysers reservoir and the HTR. In all cases, the HTR is in the lower portion of the wells and is overlain by a "typical" Geysers reservoir. Depth to the high-temperature reservoir is relatively uniform at about -5,900 feet subsea. There are no identified lithologic or mineralogic conditions that separate the HTR from the "typical" reservoir, although the two reservoirs are vertically distinct and can be located in most wells to within about 200 feet by the use of downhole temperature-depth measurements.

Gas concentrations in steam from the HTR are higher (6 to 9 wt.%) than from the "typical" Geysers reservoir (0.85 to 2.6 wt.%). Steam from the HTR is enriched in chloride and the heavy isotopes of water, relative to the "typical" reservoir. Available static and dynamic measurements show the pressures are subhydrostatic in both reservoirs, with no anomalous differences between the two—the HTR pressure being near 520 psia at sea level datum. The small observed differences in pressure between the reservoirs appear to vary along a steam-density gradient.

It is postulated that the northwest Geysers area evolved more slowly toward vapor-dominated conditions than other parts of The Geysers Geothermal field because of its poor connection with the surface.

The HTR in the northwest Geysers is probably a deep, evolving system in contrast to the shallower, leaky, and mature steam reservoir(s) in the central and southeastern portions of the field. Before natural venting and nearby production caused pressures to decline, the HTR was a liquid-dominated system with

by M.A. Walters, J.N. Sternfeld, J.R. Haizlip, A.F. Drenick, and Jim Combs

Excerpted from a paper presented at the Thirteenth Workshop on Geothermal Reservoir Engineering, Stanford University, January 1988.

some connate water—the connate water being the source of the high gas contents, chloride, and unique isotopic composition relative to steam from a "typical" Geysers reservoir. Therefore, the present boundary between the "typical" reservoir and HTR is a transient, thermodynamic condition due to the recent evolution of a vapor-dominated zone from a liquid-dominated zone that has yet to cool down. It also demarks a previous liquid-to-vapor interface. Pressure in the two reservoirs is essentially the same because they are in communication with each other. In other words, the temperature change in the HTR is lagging (behind) the pressure change.

TECHNOLOGY

Industry Review Panel Meets

The Lawrence Berkeley Laboratory Industry Review Panel on Geothermal Reservoir Technology helps inform the U.S. Department of Energy (DOE) about technical needs of the U.S. geothermal industry.

At the Sixth Meeting of the panel, in January 1988, DOE manager Marshall Reed said many of the current DOE geothermal research projects are nearing completion. He said industry input is needed now, to help choose new, DOE-sponsored projects for the FY 1989 budget. Ways were discussed to maximize this input.

Donald Shannon of Pacific Northwest Laboratory (PNL), presented a review of PNL's research activities in geothermal chemistry and in-line instrumentation. His presentation dealt with the importance of pH; pH sensor and particulate instruments; and technology transfer through Hypertext. The research using ion-sensitive, field-effect transistors to measure pH was terminated due to funding cuts. The method has promise for the 200 to 250 degrees C temperature range, but more funding is needed for basic research. The laser particle meter is able to detect and identify solid particles and steam bubbles in a liquid brine. This type of instrument may be of use for metering two-phase flow and measuring the fouling potential of suspended particles.

A new panel chairman was elected. Tom Box, Geysers Geothermal Company, will replace Mohinder Gulati of Unocal, who has served as chairman since the panel was created in 1984.

Excerpts from a summary of the minutes for the Sixth Meeting of the Lawrence Berkeley Laboratory Industry Review Panel on Geothermal Reservoir Technology, January 22, 1988.

New Rock Bits Tested at The Geysers

Promising results have been achieved through new developments in 3-cone tungsten carbide insert bits tested in The Geysers region of California. These new features included diamond-enhanced gauge inserts, diamond-enhanced integral bit stabilizer lugs, and bearing lubricator canisters.

Polycrystalline diamond has been manufactured on curved tungsten carbide surfaces using a proprietary process similar to that which produces flat PDC cutters for fixed head bits. Using this process, the gauge inserts of tungsten-carbide insert air bits have been enhanced with a polycrystalline diamond surface. The results are gauge inserts with greatly improved wear resistance, and bits that consistently drill full-gauge holes. The problems have been reduced associated with under-gauge holes, such as twist-offs, extensive reaming, and poor bit performance.

Two other features have also been tested: 1) diamond-enhanced integral bit-stabilizer lugs, and 2) bearing lubricator canisters. Bit-stabilizer lugs are steel pads pressed with inserts on each leg of the bit. The purpose of these lugs is to stabilize the bit and improve bit performance.

Stabilizer lugs are not new to The Geysers. Recently, however, diamond-enhanced inserts have been used in the lugs to improve wear resistance.

The bearings of these IADC type 622 and 732 bits are air cooled. A special lubricant canister has been installed in several of the new bits in an attempt to extend the life of the bearings. The canister is installed in the pin of the bit and allows a metered amount of grease to flow into the bearing with the cooling air.

By using the latest developments in diamond technology and novel bit design, drilling performance at The Geysers has been improved.

by Patrick Laursen, Unocal
Chris Reinsvold, Bill Salesky, and Stephen Steinke, Smith International
Bruce Campbell, Smith Megadiamond

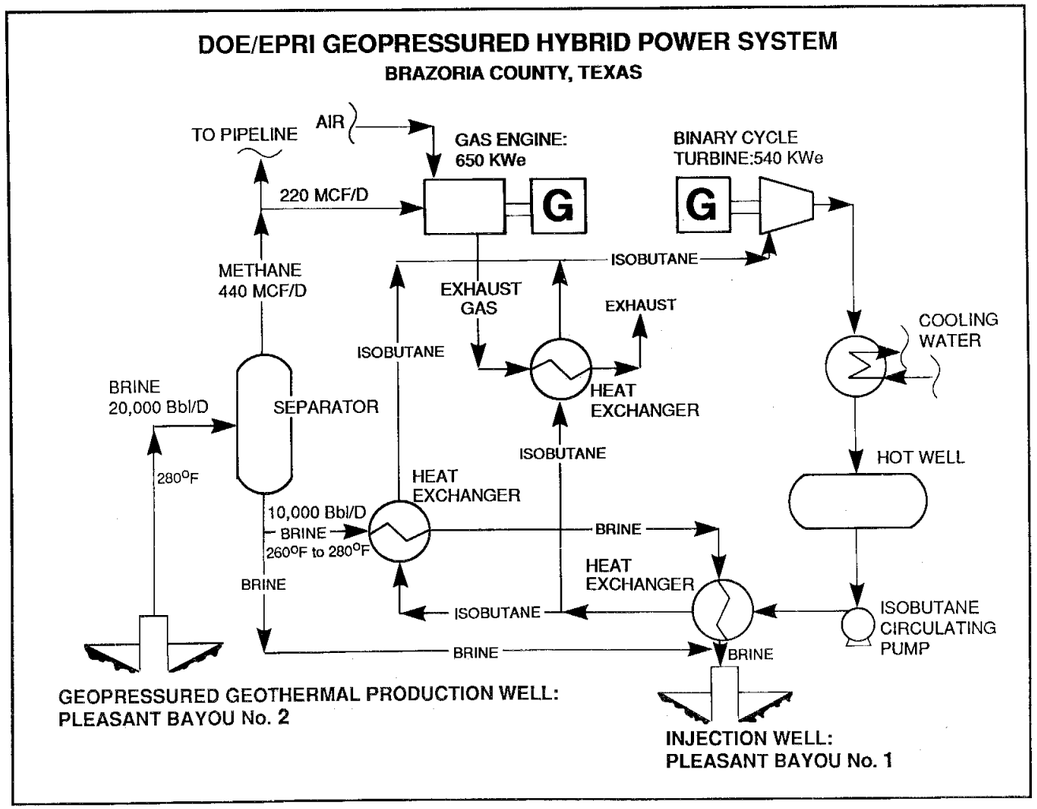
Exerpted from "New Rock Bit Developments Reduce Geysers Drilling Problems," presented at the Geothermal Energy Symposium, Eleventh Annual Energy Sources Technology Conference and Exhibit, New Orleans, January 1988.

DOE/EPRI Geopressured Hybrid Power System

The Department of Energy (DOE) and the Electric Power Research Institute (EPRI) are sponsoring a hybrid power system at the Pleasant Bayou geopressured well site in Brazoria County, Texas. The hybrid power system utilizes both natural gas (methane) and hot geothermal brine for power generation, and can produce over 15 percent more electricity than the same amount of fuel and geothermal fluid used in separate power plants. The hybrid concept can reduce the risk and cost of developing geopressured, geothermal resources for power generation.

The purpose of the DOE/EPRI geopressured, hybrid-power system experiment is to evaluate the gas/geothermal hybrid concept based on design, construction, and testing of a 1 megawatt power system. The system is designed for 10,000 barrels per day of geopressured brine containing 22 standard cubic feet of gas per barrel of brine. The working fluid in the binary cycle is isobutane. The power output is about 650 kilowatts from the gas engine/generator and 540 kilowatts from the binary turbine/generator, with auxiliary loads of 210 kilowatts. The power produced will feed into the local power grid.

The hybrid power system will be operated in conjunction with the planned reservoir testing program of the Pleasant Bayou No. 2 well.



LEGISLATION

Federal Legislation

The following material is a federal legislative report, with information on the status of geothermal legislation from the 100th Congress, current as of February 22, 1988. It was compiled by Senate LEGIS.

H.R. 235
DATE INTRODUCED: 01/06/87
SPONSOR: Quillen

SHORT TITLE AS INTRODUCED:
Geothermal Energy Control Act of 1987

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

DIGEST:
Requires the Commission to determine those areas in the United States that have a potential for the extraction of geothermal resources and to publish a list of such areas in the Federal Register.

Directs the Commission to grant exclusive 99-year licenses to persons capable of carrying out exploration and development of geothermal resources in such areas. Sets forth conditions for the granting of such licenses and for extensions of license terms. Authorizes the termination of a license for any violation of the terms of the license prescribed by the Commission.

Permits a licensee under this Act to apply for a license to market the geothermal resources from the licensee's area in their natural state. Requires the Commission to grant a marketing license for a geographic area that is the most reasonable area to market successfully the geothermal resources. Provides that a marketing license shall be valid for as long as the licensee holds the exploration and development license.

Permits the transfer of exploration and development licenses and marketing licenses with the Commission's approval.

Requires that a licensee under this Act be a U.S. citizen or person owned or controlled by a U.S. citizen.

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

H.R. 1662
DATE INTRODUCED: 03/17/87
SPONSOR: Shumway

SHORT TITLE AS INTRODUCED:
Federal Lands Receipts Clarification Act

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

H.R. 1421
DATE INTRODUCED: 06/25/87
SPONSOR: Wilson

SHORT TITLE AS INTRODUCED:
Federal Lands Receipts Clarification Act

LATEST OFFICIAL TITLE:
OFFICIAL TITLE AS INTRODUCED AS OF 06/25/87:
A bill to provide for a clarification of the receipt-sharing of amounts received from the National Forest System, geothermal leasing, mineral lands leasing, and oil- and gas-royalties.

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

S. 1006
DATE INTRODUCED: 04/09/87
SPONSOR: Hecht

and

H.R. 2794
DATE INTRODUCED: 06/25/87
SPONSOR: Matsui

SHORT TITLE AS INTRODUCED:
Geothermal Steam Act Amendments of 1987

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

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

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

S. 1889
DATE INTRODUCED: 11/20/87
SPONSOR: Melcher

SHORT TITLE AS INTRODUCED:
Geothermal Steam Act Amendments

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

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

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

States that the purposes of specified federal law, significant thermal features within the National Park System shall include features designated as significant in a certain Federal Register notice.

Amends federal law (Continuing Appropriations, Fiscal Year 1987), to direct the Secretary to include in geothermal drilling permits stipulations necessary to protect significant thermal features within specified units of the National Park System where use of permit lands is reasonably likely to adversely affect such features. (Current law restricts such stipulation to geothermal leases.)

Requires the Secretary, as part of a geothermal monitoring program, to establish a research program to collect and assess data on geothermal resources within units of the National Park System with significant thermal features.

Requires the United States Geological Survey to study and report to the Congress the impact of geothermal development in the vicinity of Yellowstone National Park upon thermal features within the Park. Prohibits geothermal well production or development in the Corwin Spring Known Geothermal Resource Area until 180 days after the Congress receives such study. Requires the Secretary to make recommendations to the Congress regarding the acquisition of geothermal rights necessary to protect Yellowstone National Park thermal resources if it is determined under the study that geothermal drilling may adversely affect such resources.

Prohibits the Secretary from issuing, extending, or modifying any geothermal lease or drilling permit in the Corwin Spring Known Geothermal Resource Area until 180 days after the Congress receives such study.

H.R. 3553
DATE INTRODUCED: 10/27/87
SPONSOR: Matsui

OFFICIAL TITLE AS INTRODUCED:
A bill to amend the Internal Revenue Code of 1986 to extend the energy investment credit for geothermal property.

DIGEST:
Amends the Internal Revenue Code to extend the ten percent energy investment tax credit for geothermal property from December 31, 1988, until July 31, 1991.

FINANCE

GEO Grants Options, Issues Stock

Geothermal Resources International, Inc. (GEO) announced that Lavino Investment Company, the owner of about 57 percent of GEO's common stock, has granted options to a group consisting of International Numatics, Inc., Alexander L. Cappello, Ronald P. Baldwin, Vice-Chairman and Chief Executive Officer of GEO, and Russell L. Pogue, to purchase all of Lavino's interest in 3,120,549 shares of common stock.

GEO has also reached a conditional agreement with an underwriter whereby the underwriter has agreed to use its best efforts to offer and place $14,850,000 of a newly issued class of Series B Convertible Preferred Stock in either a private placement or a limited public offering.

Nevada Public Service Commission Notice of Petition

Pursuant to NAC 704.760 et seq., Nevada Geothermal Utility, Inc. has filed with the Public Service Commission of Nevada ("Commission") Advice Letter No. 3, a petition, for approval of a form amended contract with rates for the sale of geothermal heat with its present and prospective customers in Reno, Nevada. This filing has been designated Docket No. 88-257.

The proposed amended contract will set rates at the same service charges that Sierra Pacific Power Company charges its residential natural gas customers and 70 percent of the energy charges for an equivalent amount of Btu's of natural gas. Some customers' bills will decrease and some will increase under the proposed amended contract rates and demand charges.

The petition and amended form contract are available for public inspection at the offices of the Commission, 727 Fairview Drive, Carson City, Nevada 89710.

High Court Upholds Steam Ruling

The state Supreme Court has allowed to stand a lower court's ruling that steam from The Geysers is not subject to the state's 6 percent sales tax, saving steam producers at The Geysers millions of dollars.

Late last year, the California Court of Appeals rejected Sonoma County's claim that geothermal steam is subject to sales tax. The county appealed the ruling to the Supreme Court, and the court refused to review the decision.

"This is an irrevocable decision," said Roger Fontes, assistant manager of the Northern California Power Agency.

Although exact figures are unavailable, one estimate is that a tax on geothermal steam would have entitled the county to about $22 million in back taxes.

The county first asked the state Board of Equalization to apply the tax to steam in 1981, but the state board refused and the county filed suit.

Two Sonoma County Superior Court judges ruled for the county but the appeals court ruled that steam is exempt from taxes. "The state Supreme Court's decision, handed down January 27, 1988, will save geothermal developers such as Union Oil millions of dollars," said Fontes.

Reprinted, with permisston, from the Santa Rosa Press Democrat, February 11, 1988 edition.

Proposals Accepted by the CEC

The following California Energy Commission (CEC) grant and/or loan proposals have been accepted by the CEC. They will be sent to the California Legislature with the request that the legislature approve them for inclusion in the 1988-89 state budget.

Sutter-Yuba Mosquito Abatement District $198,705

Construct an aquaculture facility at the Sierra County geothermal commercial park project. A series of experiments will be conducted to determine if mosquitofish can be grown year-round in a low-temperature geothermal medium. The mosquitofish will be used instead of toxic chemicals to combat disease-vectoring mosquitoes.

Lake County AQMD $18,650

Develop a computerized data base management system from the aerometric data acquired during the first phase of The Geysers Air Monitoring Program (GAMP I).

Lake County AQMD $45,410

Establish a limited program of PM-10 and toxics monitoring at the Anderson Springs and Glenbrook stations in The Geysers as part of the second phase of The Geysers Air Monitoring Program (GAMP II).

Sonoma County $739,843

In 1982, Sonoma County signed a matching fund agreement with Unocal, PG&E, and GEO Operator Corporation to reconstruct the Geysers-Healdsburg Road. This road is the main access to The Geysers Geothermal field, and is used almost exclusively by the geothermal operators. The substandard condition of the road has been the cause of numerous accidents and toxic-waste spills.

The original agreement between the county and the developers called for reconstruction of three sections of the road. Two of these three sections have been reconstructed. The remaining 1.25 miles will cost about $1.6 million to repair. The operators have committed $560,000, per the 1982 agreement, to complete this last section. Sonoma County has contributed $346,000.

The proposed award will allow the county to make up the deficit and complete the repairs to the road.

Mendocino County $84,062

Conduct a two-year study to establish baseline water-quality data for the Pieta Creek Basin in southeastern Mendocino County. The basin is within The Geysers Known Geothermal Resource Area (KGRA) and is likely to be subject to future geothermal exploration and development.

City of Susanville (Loan) $750,000

Since 1982, the CEC has made nine separate awards to both the City of Susanville and Lassen County to expand and improve the existing district heating system, presently owned and operated by the city. In the last 18 months, the CEC staff has had several discussions with the city staff to develop a more comprehensive approach to system planning and development.

This proposed award is a result of this planning effort. It will allow the city to undertake a significant expansion of the system by adding more than 2,000 feet of new geothermal transmission lines and retrofitting five, large, public-and private-buildings.

Mono County $100,000

Establish a monitoring system for the Long Valley KGRA to establish baseline hydrologic data. This will provide a way to determine the impact future geothermal development will have on the KGRA's hydrologic system, especially the state-owned Hot Creek Fish Hatchery.

Town of Mammoth Lakes (Loan) $1,222,500

In 1984, the CEC awarded Mono County a grant for $80,000 to conduct a feasibility assessment for building a district-heating system for the town of Mammoth Lakes. The study focused on the eastern part of the town. It identified numerous buildings as feasible retrofit candidates. However, the only existing geothermal resource at Casa Diablo was too far away from the study (4 to 5 miles) to be considered a likely source of heat for a heating system.

In 1986, the CEC and Mono County cost-shared expenses with the U.S. Dept. of Energy for drilling an exploratory well less than 1 mile north of the town's district-heating study area. This was the first moderately-deep geothermal well ever drilled this close to Mammoth Lakes. The results were very encouraging for the town's proposed heating system.

In 1986, the CEC awarded the town of Mammoth Lakes a grant for $220,000 to further determine the temperature, depth, and extent of the geothermal resource underlying the town. The town completed two exploratory core holes within the study area and will run further chemical and temperature analyses in the spring of 1988.

Preliminary results indicate the presence of a resource with a temperature of about 170 degrees F at about 1,500 feet.

This proposed award will allow the town to complete the exploration program, site and drill a production and an injection well, and design and install the first phase of a district-heating (and perhaps, cooling) system.

Santa Ysabel Band of Mission Indians $53,500

Conduct a resource assessment and exploratory drilling program on the Santa Ysabel Indian Reservation as a prelude to building a small district-heating/cooling system. The reservation is in Riverside County, about 15 miles southeast of Lake Elsinore.

Surprise Valley Hospital District $8,961

In 1985, the CEC awarded the Surprise Valley Hospital District a grant for $135,106 to retrofit the space- and water-heating systems in the main hospital building and clinic facility in Alturas.

This proposed award will allow the district to design and install a system to monitor the performance of the geothermal system after it becomes operational in about three months.

Indian Valley Hospital District (Loan) $259,000

Implement modifications to the hospital's geothermal space-and water-heating systems, as required by the State Fire Marshall's Office and the Office of Statewide Health Planning and Development.

San Bernardino County (Loan) $1,000,000

In 1986, the CEC awarded San Bernardino County three contingent awards totaling $811,245 to design and install space-heating systems in 20 county-owned buildings that would be hooked up to the City of San Bernardino's geothermal district-heating system. However, when the county solicited bids to do the retrofit work, the only proposal that was submitted was one for twice the approved budget.

At staff's urging, the county did a detailed review of its approved budget. It discovered that the original cost estimate in the final application was inadequate in the following areas:

o Estimates are three years old and based on 1985 prices - 10.7 percent of cost increase is inflation.

o Estimates were prepared for separate buildings and did not fully consider the costs of two, 10-building central control and distribution complexes - 21.7 percent of increase is for additional components for the two central systems.

o Estimates used state labor usage rates for 1985 - 47.6 percent of increase is due to current union scale rates.

o Estimates had inadequate construction management, engineering, and contingency fees - 20 percent of increase is due to additional reserves.

REGULATION

CEC Power-Plant Jurisdiction Clarified

"If a geothermal power plant is 50 megawatts or over, on federal, state, or private property, the California Energy Commission (CEC) has jurisdiction over the plant," said Stephen Rhoads, Executive Director of the CEC. "The question of CEC jurisdiction over power plants built on federal lands," Rhoads stated, "was the fundamental point at issue in recent discussions between the CEC and California Energy Company, Inc. (CECI)."

As a result of the discussions, the California Energy Company, Inc. (CECI) will file a Small Power Plant Exemption (SPPE) with the CEC for its Navy 2 Project on or about April 1, 1988. The Navy 2 Project is a 75 megawatt geothermal power plant located in Inyo County and within the China Lake Naval Weapons Center, about 30 miles north of Ridgecrest, California. The Navy 2 Project is one of four projects (Navy 1 & 2 and BLM 1 & 2), either built or in the planning stages at the Coso Known Geothermal Resources Area (KGRA). (Unit 1 of project Navy 1 began operations in July 1987.)

The application for the SPPE will be filed pursuant to Public Resources Code Section 25541 and California Administrative Code, Title 20, Section 1936 et seq. If the application is approved, the project would be exempt from the CEC power plant siting requirements, set forth in Title 20, Section 1701 et seq. of the California Administrative Code.

The California Energy Commission staff, CECI, the Bureau of Land Management (BLM), and the Navy will participate in two site visits to the Navy 2 Project location. The parties will also visit CECI's Navy 1 facility and their two BLM project sites. The site visits will include a trip along the existing 115 kV transmission line from the Navy 1 facility to Southern California Edison's Inyokern substation. A new 230 kV transmission line to transport power from the KGRA has been proposed and is being reviewed by the BLM. It will parallel most of the route of 115 kV line.

The CEC staff is interested in obtaining first-hand information on the Navy 2 Project because of the SPPE that will be filed by CECI. In addition, staff will visit the other project sites because of the issue of cumulative impacts and the need to determine what effects the currently proposed development in the Coso KGRA will have upon the environment. As part of staff's cumulative impacts analysis, and as part of staff's review of the Environmental Assessment on the 230 kV transmission line that has been prepared by the BLM, staff will visit the proposed corridor for the new transmission line.

Evolution of the FY 1988 U.S. Department of Energy Geothermal Budget

	FY 1987 (Final)	FY 1988 Request	House Bill	Senate Recomm.	FY 1988 (Final)
Hydrothermal Industrialization	1,980K	0 K	0 K	1,000K	500K
Geopressured Resources	3,970	2,700	5,000	5,000	5,000
Geothermal Technology*	14,100	12,400	18,800	14,600	14,600
Program Direction	780	835	835	835	835
Total	20,830K	15,935K	24,635K	21,435K	20,935K
* (Includes for Hot Dry Rock)	(8,000K)	(3,600K)	(10,000K)	(5,800K)	(5,800K)

Final
U.S. Department of Energy
FY 1988 Geothermal Budget

Program	Budget	Program Integration	Funding
Hydrothermal Industrialization	$ 500K	$ 45K	$ 455K
Geopressured	5,000	470	4,530
Hot Dry Rock	5,800	550	5,250
Reservoir Technology	3,500	175	3,325
Salton Sea Scientific Project	500	0	500
Hard Rock Penetration	1,800	160	1,640
Magma Energy	1,400	135	1,265
Heat Cycle Research	800	75	725
Materials	400	25	375
Advanced Brine Chemistry	400	25	375
Program Direction	835	0	835
Total	$20,935K	$1,660K	$19,275K

U.S. Department of Energy
FY 1989 Geothermal Budget

The President's budget for fiscal year 1989 was submitted to Congress on February 18, 1988.

Program	Congress's FY 1988 Budget	President's FY1989 Request
Hydrothermal Industrialization	$ 500K	$ 0K
Geopressured Research	5,000	2,900
Hot Dry Rock Research	5,800	3,600
Reservoir Technology	4,000	2,900
Hard Rock Penetration	1,800	2,400
Magma Energy	1,400	1,800
Heat Cycle Research	800	1,000
Materials Research	400	560
Advanced Brine Chemistry	400	470
Program Direction	835	835
Total	$20,935K	$16,465K

NPS Position on Crater Lake

On February 27, 1988, I taped the remarks of William Penn Mott, Director, National Park Service, at a conference titled Parks and Wildlife: Preserving and Enriching our Inheritance. The conference was sponsored by the Environmental Law Society, School of Law, University of California, Davis.

In his remarks, Mr. Mott commented on the problems faced by the National Park Service (NPS) from all types of development in areas around NPS lands. He went on to discuss geothermal development around Crater Lake National Park. Realizing his comments would interest *Hot Line* readers, I have included them in this issue. They are as follows:

"We have a similar problem up in Crater Lake about drilling for energy up there using the geysers and the hot-water areas. We've taken a very aggressive stand in connection with this. We want to know before they start the drilling that they're not going to disrupt the thermal activities that we suspected were taking place in the lake, and that, that thermal activity had something to do with the clarity of the water. We now know for sure that there is thermal activity in the bottom of Crater Lake. This summer, we will have a submersible working the bottom of the lake to get the exact information and also to understand why that thermal energy down at the bottom of the lake has something to do with the clarity of Crater Lake. And because of that information, now Crater Lake is put in with other areas where we have thermal activity, that those who drill for thermal activity have to prove conclusively that what they're doing isn't going to have a detrimental effect to the resources within the park. So we've been making some progress in that direction."

After Mr. Mott's talk, I had the opportunity to speak with him, personally. He commented on the general problem faced by the NPS in evaluating all types of development occurring-in or planned-for areas surrounding NPS lands. The NPS must decide what harm, if any, each activity would present or lead to. Mr. Mott said, "Today, the burden of proof is on the developers. They have to prove to us (the NPS) that their projects planned for areas outside national park boundaries will not harm the parks.

I asked, "I've heard that sewage from facilities around Crater Lake has been entering the lake and affecting water chemistry and color. Would you like to comment on this?"

We know for sure that there is thermal activity in the bottom of Crater Lake.

He said, "The research that's been done indicates no evidence that sewage has been going into the lake. However, we are going to put in a new sewage line and move all facilities except the hotel back away from the rim. This includes the parking lots.

"We've found that water in Crater Lake has a minimum of nitrogen. This may have something to do with the thermal action. We'll know for sure this summer," Mr. Mott concluded.

by Susan F. Hodgson

Significant Thermal Features IA Signed

The National Park Service, U.S. Forest Service, U.S. Geological Survey, and the Bureau of Land Management have signed an Interagency Agreement (IA). The IA sets forth guidelines for implementing requirements to protect significant thermal features within listed national parks from geothermal development outside of park boundaries. These requirements are in Section 115 of the FY 1987 appropriations act.

Starting with the Glass Mountain geothermal lease sale, scheduled by the BLM for April 6, 1988, all geothermal leases issued by the BLM will include stipulations ensuring that the BLM is in compliance with Section 115. A 30-day review period for the Glass Mountain sale has been completed, as required, and no public comments were received.

For a copy of the IA or of Section 115, contact Sean Hagerty, Geologist, BLM, Federal Bldg., 2800 Cottage Way, Sacramento, CA 95825; phone (916) 978-4735.

BLM Approves Environmental Plan

The Bureau of Land Management (BLM) has approved a Plan of Baseline Data Collection submitted by Pacific Lighting Energy Systems for the PLES I, 10 megawatt, net, geothermal power-plant project in Mono County, California.

The plan will report on environmental conditions in the project area. The BLM will require at least one year of data collection before power-plant production can begin.

The report will be the yardstick against which future environmental conditions will be compared. Periodic monitoring of sensitive environmental concerns will be made throughout the life of the project and after the plant shuts down.

Data will be collected on air quality/meteorology; water quality/hydrology; biological resources; noise; seismicity; and subsidence.

The plan may be reviewed at the BLM California State Office, Sacramento, and at several other BLM offices.

BLM Geothermal Energy Summary

California's dominance of world geothermal energy production increased in 1987, and most of that expansion came from federal lands.

Federal leases administered by BLM currently produce enough energy to supply 754,000 people (754 megawatts). These leases paid $13.13 million in rents and royalties in FY 1987; half of this money went directly to the State of California.

Most of the production occurs at The Geysers Geothermal field in northeastern Sonoma County, the most productive geothermal field in the world. Expansion in this area continued in 1987, with 25 new wells drilled on 12 public-land leases, bringing the total federal wells to 145.

Promising expansion also occurred on three other active public-land geothermal sites in 1987. In BLM's El Centro Resource Area, the East Mesa Known Geothermal Resource Area (KGRA) continued to expand rapidly. One, 35 megawatt power plant came on-line in 1987, a permit was issued for the construction of another plant, and plans are being reviewed for two more power plants. The total current production in this area supplies the needs of 45,000 people, with more than double that potential in various stages of development.

At the Coso KGRA near China Lake in BLM's Ridgecrest Resource Area, exploration and expansion were finally underway in 1987, after two years of hiatus because of a pending lawsuit concerning land withdrawals. In 1987, five production wells were completed on public lands. Permits were being reviewed for construction of two, 48-megawatt power plants.

Near Mammoth Lakes in Mono County, the BLM is reviewing a permit for a 10-megawatt power plant, and construction is expected to begin in 1988.

The BLM's geothermal program is conducted under the Geothermal Steam Act of 1970. At the end of 1987, there were 293 federal leases covering 443,000 acres. Lands within the 21 KGRA's in California, covering 1,617,910 acres, are leased competitively. Lands not within KGRA's are leased on a first-come, first-served basis.

Excerpted from the Annual Report, Bureau of Land Management, FY 1987.

BLM GEOTHERMAL LEASING AND OPERATIONS, FY 1987

	1985	1986	1987
Total number of leases	310	365	293
Competitive leases issued	1	2	0*
Noncompetitive leases issued	33	39	0*
Federal production (megawatts)	430	735	754
Producing leases	13	14	15
Producing wells	69	132	167
Plans of operation approved	17	11	14
Drilling permits issued	59	50	64

* No leases issued due to Congressional moratorium

New USGS Mineral-Resource Office in Reno

A U.S. Geological Survey (USGS) field office will be placed at the University of Nevada-Reno (UNR) to coordinate USGS mineral-resource research and assessment activities in Nevada and adjacent states.

The Reno office will be staffed by nine, full-time USGS geoscientists with broad expertise in geology, geochemistry, geophysics, and resource assessment. The chief of the new field office will be Gary Raines, currently deputy chief for geophysics and international activities in the Office of Mineral Resources at the USGS National Center in Reston, Virginia.

The new Reno field office will emphasize:

o assessing the mineral resources of Nevada;

o producing fundamental data needed by industry to effectively explore, define, and understand mineral deposits; and by government agencies and Congress to make informed, land-management decisions;

o providing information, advice, and recommendations to federal, state, and local governmental agencies on mineral resources and mineral-resource issues by area and by commodity;

o developing concepts, technologies, and methodologies that are useful for identifying new mineral resources.

Among the organizations in and around Nevada with which the new USGS office is expected to cooperate are the U.S. Bureau of Mines research center in Reno; the Cooperative Institute for Aerospace Science and Technology, a cooperative project between UNR and the National Oceanic and Atmospheric Administration, with major emphasis on aerospace technology related to strategic materials; the Desert Research Institute of the University of Nevada; and the USGS Water Resources Division office in Carson City.

TECHNOLOGY TRANSFER

ORGANIZATIONS

What Is ENEL?

ENEL (The Italian Electricity Board) is a public statutory body established by law in December 1962, to generate, transmit, transform, and distribute electrical power produced from any source, to ensure the supply of electricity throughout Italy at a minimum cost.

ENEL also carries out important research and development programs in the fields of renewable and geothermal energy sources. The programs are oriented towards solving problems connected with the economical utilization of energy resources, environmental conservation, improving electrical service, and operating these programs economically.

Furthermore, ENEL attaches great importance to the exchange of experience and to international cooperation. Several general cooperation agreements have been signed by ENEL in recent years with foreign electrical power companies in over 40 countries for the supply of technical assistance and consulting services. Within this framework, specific contracts can be drawn up in particular areas of interest.

Reprinted from the UNITAR/UNDP Centre on Small Energy Resources Newsletter.

Activities of the UNITAR/UNDP Centre on Small Energy Resources for 1988

The UNITAR/UNDP Centre on Small Energy Resources (Centre) was established in Rome in 1984, with the aim of collecting and disseminating information on Small Energy Resources (SER), especially for the benefit of developing countries, and to promote contacts between developing countries and international and national organizations, or centres and companies involved in the field of SER. Until now, the Centre has worked basically on transferring information.

The activities of the Centre include basic information transfer activities performed through the support of its Reference Unit, through which the Centre plays the role of a clearing house; and the development of five major programs, which are described briefly.

The first program concerns the publication of the Newsletter, which is distributed worldwide (5,000 copies in English and 2,000 copies in French).

In 1987, the Centre prepared five issues of its Newsletter. Issues No. 6, 7, and 8 have been published, while Issue No. 9 focusing on Biomass, and Issue No. 10 focusing on Photovoltaic Energy are being printed.

Topics foreseen for the 1988 issues are:

- small oil and gas
- small energy resources in rural Africa
- energy saving processes with small-scale plants
- mini-hydropower
- thermal solar power

The second program includes a set of activities aimed at the diffusion and development of geothermal resources, with particular reference to small-scale installations (up to 4 to 5 megawatts or up to 50 megawatts).

The following activities, started in 1987, are foreseen for 1988:

- Publication of the proceedings of the First International Workshop on Small Geothermal Resources, (organized in May 1987 by the UNITAR/UNDP Centre on Small Energy Resources), including the technical and scientific papers submitted during the workshop. These proceedings will be published by Pergamon Press in Vol. 17 No. 1 of the periodical "Geothermics".

- Review, integration, and editing of a complete set of the country papers presented by the participants from the 29 developing countries at the First International Workshop on Small Geothermal Resources. The material will be published in the periodical "Geothermics", Vol. 17, Issues No. 2 and No. 3 (summer 1988).

- Publication of a report on Geothermal Energy in Developing Countries that will include, for each country, a summary of past and current geothermal developments and an indication of possible small-scale geothermal applications and prospects for future developments of geothermal energy. The report will be completed before the end of March 1988, and published as a Technical Report of the UNITAR/UNDP Centre on SER. It will be distributed widely.

- Publication of a Guidebook on geothermal energy exploitation, addressed to policy-makers and decision-makers. The Guidebook includes a description of the most salient technical and economic aspects of the use of geothermal resources for small-scale installations, and aims at providing decision-makers of developing countries with the most relevant information required. It will assist them in taking the most appropriate decisions on geothermal exploration and/or exploitation. The guidebook will be published by July 1988.

- Start of a program of publication of a series of Technical Guides on the selection and design of schemes and components for geothermal exploration and exploitation (addressed to technicians).

The third program, called "Promotional Program on SER for Rural Areas of Africa", is aimed at facilitating the most proper use of small energy resources in Africa, mainly to contribute to the solution of the problems of deforestation and desertification in African countries. As anticipated in Newsletter No. 8, the Centre is currently working on the identification of the main bottlenecks and constraints to the use of the most proper energy technologies and resources in rural areas of Africa; the prospects of a wider use of the most suitable SER techniques; the characteristics of projects to be financed on a bilateral or multilateral basis that will facilitate the development of local SER markets; and development of local manufacturing skills and saleable equipment in the field of SER. An Experts' Meeting is planned to be held in Rome from March 15th to 17th, 1988, to identify key points of the topics, and to define the main issues to be addressed in a promotional conference, presently planned for the end of 1988.

The Centre is preparing some appropriate documentation to provide the participants of the Experts' Meeting on Energy for Rural Areas of Africa with relevant information useful for their judgments and proposals, and thus provide a direct, original, contribution to the Experts' Meeting itself. In this context, a Compendium on the African Country Profiles in the field of Small Energy Resources is being finalized. This documentation will be distributed during the Experts' Group Meeting, and will be published with the results of the Experts' Meeting, itself.

The fourth program is the "Technological Program". Its aim is the diffusion of information on the most suitable technical solutions for energy supplies, and on the most appropriate technologies able to provide specific goods and services, using energy saving processes and components in small-scale plants and suitable for exploitation and development in developing countries.

In this overall framework, which includes a number of complex aspects, the Centre has started working in two specific fields: water pumping systems, and technolo-

gies for the production of detergent powders and soap bars. The publication by the Centre of technical reports on these subjects is planned before the end of the year. A subsequent distribution to potential users is also foreseen.

The fifth program concerns the organization of training courses. These courses aim to provide high-level and efficient training services to young technicians aspiring to work in the world of production of components and systems for energy and ecology, with an immediate, active, and productive role.

The Centre is organizing, together with the Association of Industrialists of Terni, Italy, a first course, which will take place in May/June 1988, on designing, manufacturing, and assembling criteria of components in the energy and ecology fields. Technicians from developing countries are expected to attend this course.

Among other activities of the UNITAR/UNDP Centre on Small Energy Resources planned for 1988, there are:

- Collaboration in the organization of the International Conference on Energy Options and the Rural Sector in Developing Countries (LDC), to be held in Bologna, Italy, on 28th and 29th June 1988.

- Collaboration in the organization of the Seminar on Energy Saving to be held at the University of Rome, Italy, "La Sapienza" in September 1988.

COURSES

GRC Courses

The following courses are offered by the Geothermal Resources Council for 1988.

May 12-13, 1988
"Geothermal Energy for Support Staff" Radisson Inn,
San Francisco Int'l. Airport
South San Francisco, CA.

June 6-8, 1988
"Introduction to Geothermal Power Plant Operation and Maintenance"
John Ascuaga's Nugget Hotel
in Sparks, NV.

October 7-8, 1988
"Drilling, Sampling, and Logging in Hot and Hostile Environments"
Town and Country Hotel
in San Diego,CA.

For further information, contact the GRC, P.O. Box 1350, Davis, CA. 95617-1350; phone (916) 758-2360.

CONFERENCES

Deposition of Solids in Geothermal Systems, sponsored by Orkustofnun, the National Energy Authority of Iceland and co-sponsored by the Hawaii Institute of Geophysics, United States, in Reykjavik, Iceland, August 16-19, 1988.

The workshop will address the scientific and technical aspects of solids deposition in geothermal systems, including the reservoir, wellbore, pipelines, equipment, direct use, and electric power plants. The workshop program will consist of three days of technical sessions and discussions.

The workshop will be held at the University of Iceland in Reykjavik. Field trips will be arranged to local geothermal fields and power plants, as an afternoon trip during the workshop and as a one-day trip the last day. The registration fee will be set to cover direct expenses. No funds are available to aid participants.

Further information on the workshop will be sent upon request. Hotel and other arrangements are being made for the participants.

Organizers (Technical Program)

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Phone: +354-1-83600/82857
Telex: 2339 ORKUST IS EARN/BITNET: jsg@isearn

Dr. D.M. Thomas
Institute of Geophysics
University of Hawaii
2525 Correa Road
Hawaii 96822
United States
Phone: 1-808-946-6482
Cable Address: UNIHAW

Secretariat (Hotel, Travel, and Registration)

Ferdaskrifstofa rikisins

(Iceland Tourist Bureau)
Attn: Ms. Asborg Arnthorsdottir
Skogarhlid 6
101 Reykjavik
Iceland
Phone: 354-1-25855
Telex: 2049 turist is

JIGASTOCK, 1988, Journées Internationales sur le Stockage de l'énergie Thermique et la Géothermie Appliquée, Palais des Congrès, Versailles, France, October 17-20, 1988. Official languages: English and French.

The meeting of scientists, engineers, and industrialists will focus on the exploitation of low-temperature geothermal resources, and heat storage or energy-products storage, mainly underground.

The conference is organized by the French Agency for Energy Management, together with the Bureau de Recherches Géologiques et Minières and the French Ministry of Housing and Equipment. It is sponsored by the European Community Commission and the International Council for Thermal Energy Storage.

For further information, contact: JIGASTOCK 88 Office, c/o Agence Française pour la Maitrise de l'énergie, Madame M. Leblanc, 27 rue Louis-Vicat, 75737 Paris Cedex 15-France.

Geothermal Resources Council Annual Meeting, 1988, Town & Country Hotel, San Diego, California, October 9-12, 1988.

The meeting will include a technical program, panel discussions, pre-meeting short courses, post-meeting field trips, and a photo contest.

The **1989** Annual Meeting will be at the El Rancho Tropicana in Santa Rosa, California.

The **1990** International Symposium on Geothermal Energy will be in Hawaii.

For further information, contact the GRC, P.O. Box 1350, Davis, CA 95617-1350.

International Symposium on Geothermal Energy. Kumamoto and Beppu, Japan, November 10-14, 1988.

The theme of the symposium is the exploration and development of geothermal resources. The symposium is organized by the Geothermal Research Society of Japan. The program will include invited lectures, oral and poster presentations, and excursions.

For further information, contact Prof. Kozo Yuhara, Dept. of Mining, Faculty of Engineering, Kyushu Univ., Hakozaki 6-10-1, Higashi-ku, Fukuoka 812, Japan.

Symposium on Energy and Mineral Potential of the Central America-Caribbean Region, presented by the Circum-Pacific Council for Energy and Mineral Resources in cooperation with the Costa Rican Ministry of Natural Resources, Energy, and Mines; and the Refinadora Costarricense de Petroleo, Conference Center at the Hotel Cariari, San Jose, Costa Rica, March 5-9, 1989.

The symposium is intended to focus attention on the possibilities for discovery and development of resources in the Central American-Caribbean Region, and to encourage efforts to identify, explore, and utilize those resources for the benefit of the Central American and Caribbean countries.

Geoscientists, engineers, and others concerned with investigation, assessment, and production of onshore and offshore resources will be given an opportunity to present information, exchange ideas, and coordinate planning during four days of formal presentations, poster sessions, and informal discussions.

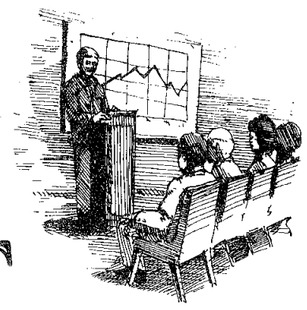
For further information, contact Ms. Mary Stewart, Executive Secretary, Circum-Pacific Council for Energy and Mineral Resources, c/o Michel T. Halbouty Energy Company, 5100 Westheimer, Houston, Texas 77056.

State if you are interested in attending the symposium, presenting a paper, or participating in field trips, local sightseeing and shopping, or in receiving further information.

A Symposium Review

The International Symposium on the Development and Exploitation of Geothermal Resources was organized by the Instituto de Investigaciones Eléctricas (IIE) of Mexico, with sponsorship of the Commission of European Communities.

The event took place in IIE's headquarters, at Cuernavaca, Morelos, October 5-9, 1987. It was attended by 89 participants from 18 countries (Argentina, Belgium, Colombia, Costa Rica, Ecuador, El Salvador, Federal Republic of Germany, France, Great Britain, Guatemala, Honduras, Italy, Mexico, Nicaragua, Panamá, Perú, República Dominicana, and the United States of America).



The symposium should be repeated every 1 to 2 years.

The participants represented 31 institutions, including 3 international organizations [European Economic Community, Organización Latinoamericana de Energía (OLADE), and Banco Interamericano de Desarrollo (BID)]; 9 utilities from Latin American countries with geothermal projects [Central Hidroeléctrica de Caldas (Colombia), Instituto Costarricense de Electricidad (Costa Rica), Comisión Ejecutiva Hidroeléctrica del Río Lempa (El Salvador), Instituto Nacional de Electrificación (Guatemala), Empresa Nacional de Energía (Honduras), Comisión Federal de Electricidad (Mexico), Instituto Nicarageuense de Energía (Nicaragua), Instituto de Recursos Hidráulicos y Electrificación (Panamá), and Electroperú S.A. (Perú)]; 7 R&D institutes [Centro Regional de Energía Geotérmica del Neuquén (Argentina), Institute Mixte des Recherches Geothermiques (France), Instituto Internazionale per le Ricerche Geotermiche (Italy), Instituto de Investigaciones Eléctricas (México), Instituto Mexicano Petróleo (México), Lawrence Berkeley Laboratory (USA), and United States Geological Survey (USA)]; 6 universities [Universidad Nacional de Tucumán (Argentina), Universitat Tubingen (Federal Republic of Germany), Camborne School of Mines (Great Britain), Universitá di Palermo (Italy), Universidad Nacional Autónoma de México (México), and Stanford University (USA)]; 2 governmental agencies [Secretaría de Energía (Argentina), and Dirección General de Minería e Hidrocarburos (República Dominicana)]; and 3 international private companies [ACEC (Belgium), Constructora y Perforadora Latina S.A. (México), and Desarrollo de Recursos Naturales S.A. (México)].

A meeting was held to assess the results of the Symposium. The main conclusions and recommendations of the participants were as follows: (a) the symposium provided a much needed, and very adequate, environment for interchanging information on the current status of, and relevant technology for, development and exploitation of geothermal resources in Latin American and European countries; (b) the symposium should be repeated, with the same host, every 1 to 2 years; (c) a key issue for the success of this symposium was the attendance of representatives of most Latin American countries with geothermal projects, which was made possible only by the generous financial support of the Commission of European Communities; (d) the IIE should seek the sponsorship of the Commission of European Communities for the next symposium to make possible the attendance of representatives from Latin American countries, thus maximizing the probability of success; (e) a bulletin, coordinated by IIE, reporting the advances of Latin American countries on development and exploitation of their geothermal resources was proposed, and a list of voluntary correspondents from Argentina, Costa Rica, Colombia, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Peru was compiled; and (f) it was proposed that the Abstracts of the papers presented at the symposium be published in "Geotermia, Revista Mexicana Geoenergía" (see publications section, this *Hot Line* issue).

by Dr. Eduardo R. Iglesias
Chairman, Technical Programs

The Abstracts of the papers presented at this symposium were published in Geotermia, Revista Mexicana de Geoenergía, vol. 3, no. 3, pp. 285-312, 1987.

Free copies of the Symposium Proceedings may be obtained from Dr. Eduardo Iglesias, Departamento de Geotermia, Instituto de Investigaciones Eléctricas, Apdo. Postal 475, Cuernavaca 62000, Mor., Mexico.

PUBLICATIONS

Publications, maps, and data services, December 1987. GPO 853-392. Free. Published by and available from the National Geophysical Data Center, NOAA, Code E/GC4, Dept. ORD, 325 Broadway, Boulder, Colorado 80303.

Many geothermal maps and publications are listed in the brochure. The following free leaflets describing products and data sets are also available from the same address: KGRD-22 Solid Earth Geophysics Data Services (1987); 82-TGB-14 Geothermal Resource Maps; 82-TGB-16 Geothermal Gradient Data and Map for the United States; 83-TGB-06 Thermal Springs for the United States; and 84-TGB-05 Scientific Map Series for New Mexico.

EPRI geothermal reports, 1987. Free. Published by and available from the Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, CA 84304. Phone (415) 965-4081.

The reports are free to EPRI utilities. Cost to all others varies, based on report length.

***Newsletter*, UNITAR/UNDP Centre on Small Energy Resources.** Free. In English or French. Published by and available from the United Nations Institute for Training and Research, and the United Nations Development Programme. Write the UNDP Energy Office, One United Nations Plaza, New York, NY 10017.

The September 1987 issue of this informative newsletter deals almost exclusively with geothermal energy. It mentions that the proceedings of the First International Workshop on Small Geothermal Resources, held in Pisa in May 1987, will be published in two special issues of *Geothermics*.

Geotermia, revista Mexicana de geoenergía. ISSN 0186-5897. Three issues a year. Free. Available from Geotermia, Revista Mexicana de Geoenergía, Apartado Postal 31-C, 58290 Morelia, Mich., Mexico.

This new, very interesting geothermal magazine, was founded 2 years ago 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, with pleasure, written in English, French, or Italian. All articles published are introduced with an abstract in English.

The editor-in-chief is Sr. Mario Cesar Suarez Arriaga.

Géothermie actualites. Revue internationale de la géothermie et des réseaux de chaleur. Subscription rates for 1 year: 260 FF in France; 320 FF in other countries. Published by and available from the Service d'Information sur l'Énergie, B.P. 6009-45060, Orléans Cedex 2, FRANCE.

The publication contains information on geothermal energy, heat pumps, and heat networks. It also has a summary of theses and reports published in France during the last trimester.

Bulletin des Centres de Recherches, Exploration-Production Elf-Aquitaine. Vol. 11, No. 2, 1987. One year subscription (2 volumes), 140 FRF, or equivalent in foreign currency. Available from Elf Aquitaine Edition, 64018 Pau CEDEX (France).

The volume cited has an interesting article titled, "Geothermal Gradient Map of Tunisia; Use of the Petroleum Temperature Values." It is the first such map devised for Tunisia, and was made with temperature values taken from 217 petroleum exploration wells. The geothermal gradients found range from 21 to 49 degrees C/km. The general trend of the geothermal gradient curves reflects the main structural direction of the country. The article is in French.

Geothermal energy symposium. The papers comprising this volume were presented in January 1988 at the Eleventh Annual Energy-Sources Technology Conference and Exhibit sponsored by the ASME Petroleum and Advanced Energy Systems Division and the Geothermal Resources Council in New Orleans. $50.00 plus $8.00

mailing. Published by and available from the Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617.

State of the world. 1988. $9.95 paperback; $18.95 hardcover. Discounts for multiple paperback orders. Published by and available from Worldwatch Institute, 1776 Massachusetts Avenue, N.W., Washington, D.C. 20036.

The publication is a complete, up-to-date reference to the world's resources, and to the way they are managed. Many energy-related topics are included.

Preliminary forecast of self-generation installations in California. 300-87-017. 1987. One copy free. Published by and available from the California Energy Commission, Publications Unit, 1516 Ninth Street, MS-13, Sacramento, California 95814.

The forecast provides information enabling readers to assess utility self-generation forecasts.

Energy Profiles II: A guide to the California energy market. 500 pages. $195 plus 6 percent sales tax. Published by and available from Barakat, Howard & Chamberlin, Inc., 180 Grand Avenue, Suite 1090, Oakland, CA 94612. For further information, contact Nancy Licht at (415) 893-7800.

Geothermal explorers, developers, and producers are among the more than 400 companies included in this new reference guide to the California energy market. The publication features management, operating, and financial data on the state's major energy players—oil and gas suppliers, pipeline and marketing companies, alternative energy developers, utilities, and regulators.

Energy Profiles provides key market intelligence on ownership structures, methods of financing, subsidiaries, project partnerships, and utility contract arrangements for geothermal, wind, cogeneration, biomass, and other energy projects. It was prepared for suppliers, investors, large energy users, and anyone involved in the California energy marketplace.

BPE and BPD, BASIC programs for microcomputers to calculate the local boiling point and the boiling point depth curve for "pure" water, OF 87-0017. By T.C. Urban, Manuel Nathenson, and W.H. Diment. 58 pages. Microfiche $4; paper copy $9.00. Available from the USGS Books and Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225.

An experimental investigation of the hydrodynamic and heat-transfer behavior of aqueous foam in laminar tube flow. SAND85-1922. By B.F. Blackwell and K.B. Sobolik. 1987. $9.95 paper, $5.95 microfiche.

Development of a method for predicting the performance and wear of PDC drill bits. SAND86-1745. By D.A. Glowka. 1987. $22.95 paper, $5.95 microfiche.

Geological structures from televiewer logs of GT-2, Fenton Hill, New Mexico, Part 3, quality control. LA-10619-HDR, Part 3. By Kerry L. Burns. 1987. $9.95 paper, $5.95 microfiche.

Newberry Crater Geothermal Resource Area, Deschutes County, Oregon. DOGAMI Open-File Report 0-88-3. By Dennis Olmstead and Don Wermiel. Blackline ozalid print 36" x 52". Scale 1:24,000. $5.00. Orders under $50.00 require prepayment. Published by and available from DOGAMI, 910 State Office Bldg., 1400 SW Fifth Avenue, Portland, Oregon 97201.

The map covers the area in and around Newberry Crater. It includes locations of past and future geothermal drilling activity. The map will be updated periodically to reflect new drilling activity or changes in area restrictions.

Physical geology, fourth edition. Charles C. Plummer and David McGeary. 1987. Paperback, 535 pages. Published by and available from Wm. C. Brown Publishers, P.O. Box 539, 2460 Kerper Blvd., Dubuque, Iowa 52004-0539. Phone (319) 589-2963.

This excellent book is written as a text for geology majors and nonmajors. For both groups—for all its readers—it offers a vivid, clear introduction to earth processes and features. The many color photographs and excellent color drawings help to bring them all to life.

New sections have been added to this edition on several topics, including landscape development, groundwater pollution, and the Mexico City earthquake. A lab manual, instructor's lab manual, student study guide, instructor's manual, 64 acetate transparencies, 120 slides, a computerized Testpak, and a computerized Quizpak are also available.

Heat mining. By H. Christopher H. Armstead and Jefferson W. Tester. 1987. 477 pages; $89.95 (New York and New Jersey residents, please add sales tax). Published by and available from Methuen, Inc., 29 West 35th Street, New York, NY 10001.

Heat mining technology is introduced and the framework is described for developing strategies to extract heat efficiently from hot rock. Both theory and field work are reviewed. Engineering analysis, modeling, and hardware development are discussed in relation to drilling, reservoir sizing, and simulation. System performance is considered in the context of development at the two major hot dry rock sites in the USA and UK. The overall economics are analyzed for energy recovery from the earth's crust.

Proceedings, geothermal program review V, April 14-15, 1987, Washington, D.C. CONF-8704110. By the U.S. Dept. of Energy. 1987. $22.95 paper, $5.95 microfiche.

Geothermics and geothermal energy, published as a special issue of Revista Brasileira de Geofísica, 5(2), 1987, scheduled for March 1988. Edited by V.M. Hamza, A. Frangipani, A.E. Beck, and F.B. Ribeiro. $20.00 surface mail, $25.00 air mail. Make order of payment to Sociedade Brasileira de Geofísica—Account No. 2274-8, Banco do Brasil S/A—Agency 0300X, São Paulo—Brasil.

Available from the Instituto Astronômico e Geofísico—USP, Caixa Postal 30627, 01051—São Paulo—Brasil.

The special issue will include around 30 selected papers presented at the International Meeting on Geothermics and Geothermal Energy, held at Guaruja, Brazil, in August 1986. Among the papers is one authored by F. Barberi et al., "Resources and Development Perspectives of Geothermal Energy in Central and South America."

The following publications are available from the National Technical Information Service, U.S. Dept. of Commerce, 5285 Port Royal Rd., Springfield, Virginia 22161.

Review of international geothermal activities and assessment of U.S. industry opportunities. LA-11066-MS, Vol. II. By Los Alamos National Laboratory. 1987. $9.95 paper, $5.95 microfiche.

Geothermal progress monitor. DOE/CE-0196. Prepared for the U.S. Dept. of Energy, Geothermal Technology Division, 1987. $11.95 paper, $5.95 microfiche.

Geothermal program review V, April 1987. Conf-8704110. Sponsored by the U.S. Dept. of Energy. $22.95 paper, $5.95 microfiche.

Geothermal injection technology program annual progress report: FY 1986. EGG-2511, July 1987. By the Idaho National Engineering Laboratory and the University of Utah Research Institute. 1987. Paper $9.95, microfiche $5.95.

Tapping the earth's geothermal resources—hydrothermal today, magma tomorrow. BNL 52054. By Lawrence E. Kukacka. Paper $9.95, microfiche $5.95..

A basic overview of geothermal energy.

Hot dry rock geothermal energy development program. Annual Report FY 1985. LA-11101-HDR. By D.W. Brown, P.R. Franke, M.C. Smith, and M.G. Wilson. 1987. $9.95 paper, $5.95 microfiche.

Water geochemistry and hydrology of the Shallow Aquifer at Roosevelt Hot Springs, Southern Utah, a hot dry rock prospect. LA-11160-HDR, 1987. By Vuataz and F. Goff. $11.95 paper, $5.95 microfiche.

Geological structures from televiewer logs of GT-2, Fenton Hill, New Mexico. LA-10619-HDR, Part 1, Feature Extraction, and Part 2, Rectification. Each part must be ordered separately at a cost of $9.95 paper and $5.95 microfiche.

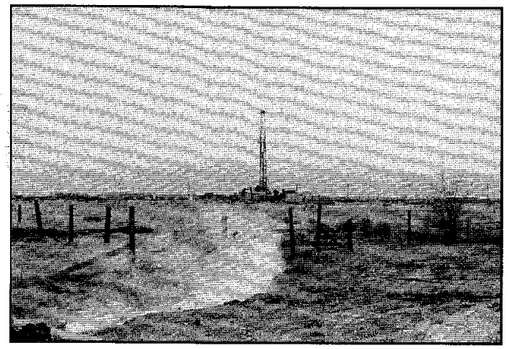
Chemical analysis and sampling techniques for geothermal fluids and gases at the Fenton Hill Laboratory. LA-11006-MS. By P.E. Trujillo et al. 1987. $11.95 paper, $5.95 microfiche.

Downhole fluid sampling at the SSSDP California State 2-14 Well, Salton Sea, California. LA-11052-OBES. Edited by Fraser Goff, Lisa Shevenell, C.O. Grigsby, and Bert Dennis. 1987. $9.95 paper, $5.95 microfiche.

Relief map of New Mexico. By Andrea Kron. $6.50 plus $1.50 postage and handling. Published by and available from the New Mexico Bureau of Mines and Mineral Resources, New Mexico Tech., Socorro, NM 87801.

The relief map, just published, uses Landsat imagery and unusual colors to present a highly detailed and accurate picture of the state's topography.

VIDEOS



Before the Drilling Begins

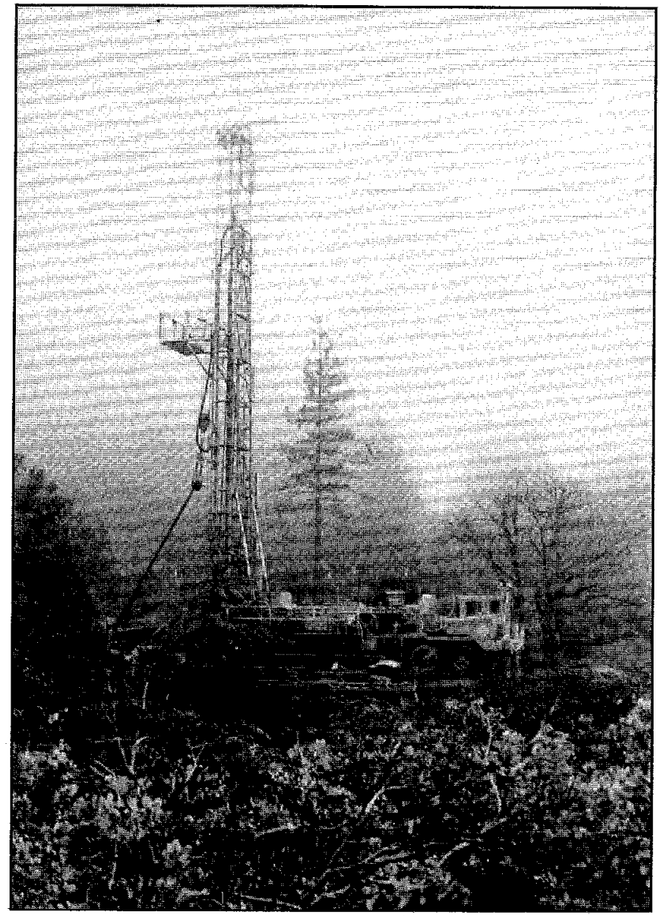
The environmental-documentation process and well-pad engineering practices used at The Geysers Geothermal field are the topics of a new videotape available from the Division of Oil and Gas. The videotape is about 13 minutes long and was taped on location at The Geysers Geothermal field.

The videotape, titled "Before the Drilling Begins," may be purchased for $25 in 1/2" (VHS or Beta) formats.

Contact Susan Hodgson for further details at (916) 323-2731.

Division Well Data Available

A computer-generated file of geothermal production and injection statistics for wells and records open to public inspection is available from the Division of Oil and Gas. All data are in metric units. The file may be purchased for $50.00 from the Division of Oil and Gas in Sacramento.



CALIFORNIA WELLS

Drilling Permits for Geothermal Wells Approved July 1987-March 1988 by the Division of Oil and Gas

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
	DISTRICT G1			
	Lassen County			
7/15/87	CITY OF SUSANVILLE "SGI" 1	035-90080	5 29N 12E	Fr NE cor 558m S, 678m W, El 1400m gr
	Modoc County			
12/2/87	MODOC JOINT UNIFIED SCHOOL DISTRICT "AL" 1	049-90034	12 42N 12E	Fr SW cor 480m N, 321m E, El 1335m gr
	Mono County			
11/4/87	TOWN OF MAMMOTH LAKES "MLGRAP" 1	051-90120	34 3S 27E	Fr NW cor 10m S, 652m E, El 2450m gr
	"MLGRAP" 2	051-90121	35 3S 27E	Fr SW cor 456m N, 722m E, El 2396m gr
	Shasta County			
2/5/88	YANKEE POWER, INC. "BBTG" 1	089-90019	36 37N 1W	Fr NW cor 610m S, 1097m E, El 518m gr
	"BBTG" 2	089-90020	36 37N 1W	Fr NW cor 305m S, 701m E, El 510m gr
	"BBTG" 3	089-90021	36 37N 1W	Fr NW cor 366m S, 366m E, El 510m gr
	"BBTG" 4	089-90022	36 37N 1W	Fr NW cor 640m S, 671m E, El 510m gr
	"BBTG" 5	089-90023	36 37N 1W	Fr NW cor 640m S, 823m E, El 510m gr
3/2/88	"BBTG" 6	089-90024	25 37N 1W	Fr SW cor 152m N, 472m E, El 609m gr
	"BBPW" 1	089-90025	25 37N 1W	Fr SW cor 140m N, 470m E, El 609m gr
	"BBPW" 2	089-90026	36 37N 1W	Fr NW cor 310m S, 701m E, El 512m gr
	"BBPW" 3	089-90027	36 37N 1W	Fr NW cor 605m S, 1110m E, El 514m gr

DISTRICT G2

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
	Imperial County			
8/17/87	GEO OPERATOR CORP. "EM" 42-16	025-90692	16 16S 17E	Fr NW cor 302m S, 701m E, El 23m kb
8/28/87	"EM" 11	025-90694	11 11S 17E	Fr NW cor 350m S, 717m E, El 23m kb
8/3/87	KENNECOTT EXPLORATIONS "Imperial" 1-13	025-90695	13 11S 13E	Fr SW cor 896m N, 152m E, El -65m gr
11/2/87	IMPERIAL MAGMA "J.J. Elmore" 5	025-90701	26 11S 13E	Fr SW cor 472m N, 855m E, El -68m gr
	"J.J. Elmore" 6	025-90702	26 11S 13E	Fr SW cor 411m N, 855m E, El -68m gr
	"J.J. Elmore" 10	025-90703	27 11S 13E	Fr SW cor 759m N, 329m E, El -68m gr
	"J.J. Elmore" 11	025-90704	27 11S 13E	Fr SW cor 759m N, 359m E, El -68m gr
	"J.J. Elmore" 12	025-90705	27 11S 13E	Fr SW cor 759m N, 835m E, El -68m gr
	"J.J. Elmore" 13	025-90706	27 11S 13E	Fr SW cor 759m N, 865m E, El -68m gr
	"J.J. Elmore" 15	025-90707	27 11S 13E	Fr SW cor 759m N, 1564m E, El -68m gr
	"J.J. Elmore IW" 3	025-90708	34 11S 13E	Fr SW cor 890m N, 1564m E, El -68m gr
	"J.J. Elmore IW" 4	025-90709	34 11S 13E	Fr SW cor 1469m N, 1564m E, El -68m gr
	"J.J. Elmore IW" 5	025-90710	34 11S 13E	Fr SW cor 1164m N, 1564m E, El -68m gr
	"J.J.Elmore IW" 6	025-90711	27 11S 13E	Fr SW cor 46m N, 1225m E, El -68m gr
11/13/87	UNION OIL CO. OF CALIF. "IID" 10	025-90726	5 12S 34E	Fr SW cor 861m N, 140m E, El -70m gr
12/15/87	IMPERIAL MAGMA "Del Ranch Inj" 4	025-90727	33 11S 13E	Fr SE cor 353m N, 347m W, El -60m gr
2/1/88	UNION OIL CO. OF CALIF. "Sinclair" 21	025-90846	5 12S 13E	Fr SW cor 53m N, 85m E, El -66m gr

DISTRICT G3

	Lake County			
8/11/87	FGRC "Davies Estate" 5	033-90678	36 11N 8W	Fr NW cor 824m S, 758m E, El 573m kb

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	FMRP "McKinley" 13	033-90679	35 11N 8W	Fr NW cor 286m S, 473m E, El 740m kb
8/12/87	UNION OIL CO. OF CALIF. "GD Horner State" 7	033-90680	5 11N 8W	Fr SW cor 83m N, 50m E, El 953m kb
9/21/87	"CM" 1	033-90681	16 11N 8W	Fr SW cor 670m N, 366m E, El 1293m gr
	"CM" 2	033-90682	9 11N 8W	Fr SW cor of Sec. 6, 1768m N, 945m E, El 1183m gr
	"CM" 3	033-90683	16 11N 8W	Fr SW cor 1052m N, 549m E, El 1244m gr
10/13/87	"GD Horner State" 8	033-90686	5 11N 8W	Fr SW cor 95m N, 63m E, El 952m kb
10/16/87	FMRP "Davies Estate" 6	033-90684	36 11N 8W	Fr NW cor 820m S, 765m E, El 537m kb
10/20/87	"Thorne" 10	033-90685	26 11N 8W	Fr SW cor 667m N, 632m E, El 670m kb
12/10/87	FGRC "Davies St 5206" 3	033-90688	36 11N 8W	Fr NW cor 816m S, 771m E, El 537m kb
	FMRP "MLM" 7	033-90689	26 11N 8W	Fr SW cor 671m N, 625m E, El 670m kb
2/8/88	UNION OIL CO. OF CALIF. "G" 28	033-90692	27 11N 8W	Fr NW cor 259m S, 320m E, El 963m gr
	"G" 30	033-90693	8 11N 8W	Fr NW cor 701m S, 412m E, El 1006m gr
	Napa County			
2/2/88	NAPA VALLEY SPRINGS MINERAL WATER CO. "Fox" 3	055-90120	36 9N 7W	Fr SE cor 561m N, 12m W, El 111m gr
	Sonoma County			
8/12/87	UNION OIL CO. OF CALIF. "D & V" 23	097-90760	34 11N 8W	Fr NW cor 595m S, 237m E, El 734m kb
8/13/87	GEO OPERATOR CORP. "Prati" 14	097-90761	36 11N 8W	Fr SW cor 292m N, 1114m E, El 937m kb
9/21/87	UNION OIL CO. OF CALIF. "ANG" 1	097-90764	16 11N 8W	Fr SW cor 335m N, 549m E, El 1293m gr

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	"LFGT" 9	097-90765	17 11N 8W	Fr NE cor of Sec. 20, 137m N, 1108m W, El 833m gr
	"G" 4	097-90766	29 11N 8W	Fr NE cor 564m S, 396m W, El 671m gr
	"G" 5	097-90767	19 11N 8W	Fr NE cor 701m S, 945m W, El 671m gr
	"G" 8	097-90768	8 11N 8W	Fr NW cor 686m S, 31m E, El 1006m gr
	"G" 12	097-90769	11 11N 8W	Fr SE cor 274m N, 694m W, El 561m gr
	"G" 13	097-90770	18 11N 8W	Fr NE cor 290m S, 753m W, El 1061m gr
	"G" 14	097-90771	2 11N 8W	Fr SW cor 152m N, 213m E, El 866m gr
10/2/87	"D & V" 24	097-90773	34 11N 8W	Fr NW cor 595m S, 245m E, El 934m kb
10/6/87	"G" 19	097-90776	34 11N 8W	Fr SE cor 229m N, 1921m W, El 625m gr
	"G" 20	097-90777	1 11N 9W	Fr SE cor 152m N, 305m W, El 750m gr
	"G" 21	097-90778	17 11N 8W	Fr SE cor 305m N, 915m W, El 970m gr
10/13/87	"D & V" 25	097-90774	34 11N 8W	Fr NW cor 594m S, 252m E, El 934m kb
11/20/87	"G" 23	097-90780	13 11N 9W	Fr SE cor 381m N, 99m W, El 598m gr
	"G" 24	097-90781	12 11N 9W	Fr SE cor 122m N, 107m W, El 787m gr
	"G" 25	097-90782	20 11N 8W	Fr NE cor 602m S, 229m W, El 1041m gr
	"G" 26	097-90783	34 11N 8W	Fr SW cor 320m N, 160m E, El 926m gr
1/20/88	"LF State 4597" 40	097-90787	20 11N 8W	Fr NW cor 242m S, 735m E, El 973m kb
2/8/88	"G" 29	097-90789	17 11N 8W	Fr SE cor 76m N, 259m W, El 1024m gr
3/3/88	"Abril" 1	097-90790	11 11N 9W	Fr NE cor 337m S, 690m W, El 866m kb

DIVISION OF OIL AND GAS
GEOTHERMAL OFFICES AND MAPS

OFFICES

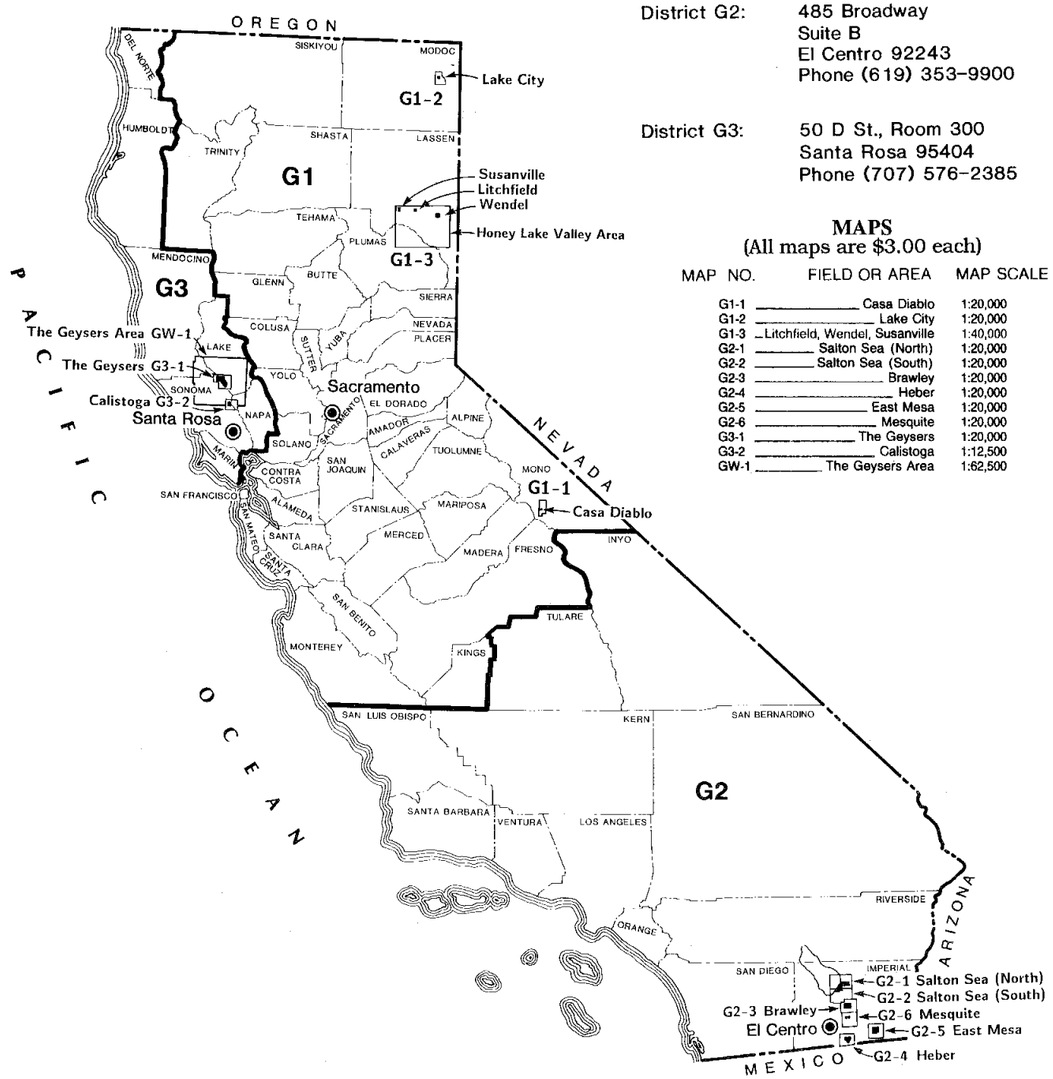
Headquarters & District G1: 1416 Ninth St., Room 1310, Sacramento 95814, Phone (916) 323-1788

District G2: 485 Broadway, Suite B, El Centro 92243, Phone (619) 353-9900

District G3: 50 D St., Room 300, Santa Rosa 95404, Phone (707) 576-2385

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



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