

247

5. Ground water of part of the Klamath River basin. Al Leonard, U.S. Geological Survey, Portland, Ore.
6. Flood mapping reports for Rogue River and Elk River in Jackson County. D. Harris, U.S. Geological Survey, Portland, Ore.
7. Flood mapping report for the Applegate River in Jackson County. D. Harris, U.S. Geological Survey, Portland, Ore.
8. Movement of radionuclides in the Columbia River estuary. D. Hubbell and Glenn, U.S. Geological Survey, Portland, Ore.

**UNIVERSITY OF UTAH  
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EARTH SCIENCE LAB.**

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### GEOHERMAL ACTIVITY IN 1970

By R. G. Bowen\*

Interest and activity in geothermal power production accelerated noticeably in 1970. The Larderello field in Italy, with a capacity of 400,000 kw continued to be the largest developed geothermal field in the world. Exploration activity has been directed to the south in the Naples area, and efforts are now under way to develop new resources in that region. New Zealand, where the Wairakei field with an installed capacity of 200,000 kw is the second largest, a new field, Brodlands, is currently being drilled. The first units are expected to be in production during the early 1970's. The Geysers field in northern California continues to be the world's third largest production facility, with an installed capacity of 83,000 kw. This is being expanded with two new plants of 110,000 kw each now under construction and expected to be on stream in 1971 and 1972. Japan, where installed capacity is a little more than 30,000 kw from two areas, expansion programs are under way.

Exploration programs sponsored by the United Nations are going on in El Salvador, Turkey, Chile, Kenya, and Ethiopia. During the year significant discoveries of dry steam were made in widely scattered parts of the world: Guadeloupe, West Indies; Los Alamos, New Mexico; and La Negritos, Mexico. In southern California a program is under way to evaluate the geothermal potential of the Imperial Valley, an area where preliminary drilling has found fluids with temperatures of nearly 700°F and geophysical studies indicate these may be widespread. Development there has stopped because of the high salinity of the geothermal fluid, but it is expected that lower salinity fluids amenable to development will be found in other parts of the valley. A few miles to the south in Cerro Prieta

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Mexico, low salinity fluids have been found, and development is under way on the first 75,000 kw unit of a planned 300,000 kw plant.

Probably the most important development in the United States during the year was President Nixon's signing of the Federal Geothermal Leasing Law on Christmas Eve. The passage of this act allows exploration and development on federal lands, withholding national parks, wildlife refuges, wilderness areas and Indian trust lands. This bill was of particular importance because it is believed that at least 75 per cent of the land with a potential for producing geothermal resources is owned by the Federal Government.

During the year numerous articles about geothermal power appeared in the newspapers and magazines, as the press and public became aware of the promise of geothermal energy and its capacity for producing electricity with minimal impact on the environment. The public's growing enthusiasm for this clean power source is well founded because the geothermal boiler is deep within the earth and requires no combustion with its attendant smoke, sulfur oxides, nitric oxides, and fly ash. Nor is there any radioactivity associated with either the generating plant or the supporting activities.

The public's attitude toward geothermal energy, along with its proven economic advantages, has caused the electric power utilities to show more interest in the possibilities of geothermal power generation. During the hearings in Washington, D. C. on the Federal Steam Leasing Law, other utility companies, besides Pacific Gas & Electric, testified that they supported the development of geothermal energy even though their funds for research activities are limited. Southern Edison is furnishing some of the funds for the Imperial Valley studies of Dr. Robert Rex and his group at the University of California, Riverside. Sierra Pacific Power is working with Magma Power Co. to develop a method for producing electrical power from hot water reservoirs. Both of these companies, along with the Northern California Power Agency, have expressed interest in purchasing natural steam.

World-wide interest in geothermal energy was demonstrated in 1970 by the Second International Symposium on Geothermal Resources, sponsored by Italy and the United Nations, held in Pisa, Italy, during September. (The first international meeting was in Rome in 1961.) Papers presented at Pisa summarized the developments of geothermal energy around the world since 1961, and presented new ideas for its exploration and utilization.

The exploration for geothermal resources is going through a transitional period as new ideas are being put forth, tested in the field, and in many cases rejected. Geologic thought is changing from: "Find a hot spring and drill it" to more basic theories developed from studies of volcanology, plate tectonics, and sea floor spreading. One of the tools being used most extensively is temperature gradient surveys. By this method areas of high heat flow can be located, the first requirement for a geothermal field, but

it does not necessarily indicate the presence of a reservoir containing geothermal fluids. The detection of characteristic seismic impulses radiating from the geothermal reservoir at depth is the principle of the geothermal ground noise and microseismic methods. These methods have apparently figured in the recent dry steam discoveries in Mexico and New Mexico.

Several factors combine to predict widespread utilization of geothermal resources in the western United States during the 1970's. First is the passage of the Federal Leasing Law thereby making large blocks of land available on which to explore. Next is the recognition that electricity can be produced by this method with a minimal effect on the environment. A third factor is new financing coming in from oil and mining companies that are beginning to explore for geothermal resources. This is occurring at a time when exploration philosophies are crystallizing and sophisticated geophysical tools are becoming available.

Within the Department of Geology and Mineral Industries, our main activity has been to act as a "clearing house" for information on geothermal resources. During the year we have been called on many times to provide information on this subject from groups as diverse as high school students and members of the Congress of the United States. One staff member, R. G. Bowen, attended the International Symposium for development and utilization of geothermal resources in Pisa, Italy. A map listing thermal springs and wells (Miscellaneous Paper 14) was published by the Department in December. Several geothermal gradients were measured in wells drilled for other purposes in eastern Oregon and "borrowed" for study by the Department. A published report will appear on these gradients later in 1972.

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#### FUTURE DEPARTMENT PROGRAMS

In the past, the State of Oregon Department of Geology and Mineral Industries has engaged in a wide variety of activities and short- and long-range programs without benefit of any formally published pronouncement, other than that appearing in the biennial reports. Starting with the next biennium, which begins July 1, 1971, the Department will use a fully detailed set of activities as a guide. A summary of the more important and interesting portions of these activities appears below. Although there are no plans for publication of the complete document, interested persons may examine an open-file copy at the Department's Portland office at any time.

Activity 1 Geologic Studies for Protection and Enhancement of the Environment. Geology is the study of the earth and man is steadily damaging the earth by dumping his waste materials without regard to the environment. The Department plans to continue its studies of suitable sites for disposal of

