OVERVIEW OF RECLAMATION'S GEOTHERMAL PROGRAM IN IMPERIAL VALLEY, CALIFORNIA

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The Bureau of Reclamation is presently involved in a unique Geothermal Resource Development Program in Imperial Valley, California. The main purpose of the investigations is to determine the feasibility of providing a source of fresh water through desalting geothermal fluids stored in the aquifers underlying the valley. Significant progress in this research and development stage to date includes extensive geophysical investigations and the drilling of five geothermal wells on the Mesa anomaly. Four of the wells are for production and monitoring the anomaly, and one will be used for reinjection of waste brines from the desalting units. Two desalting units, a multistage flash unit and a vertical tube evaporator unit, have been erected at the East Mesa test site. The units have been operated on shakedown and continuous runs and have produced substantial quantities of high-quality water. Bechtel Corporation of San Francisco, California, is assisting Reclamation in the evaluation of geothermal desalting. Later program stages will evaluate the feasibility of producing large quantities of product water along with the generation of electric energy and investigation of mineral recovery. Reclamation has a unique test facility on the East Mesa of Imperial Valley that is available as a field laboratory for selected scientists for testing and research under actual field conditions with producing geothermal wells.

I. INTRODUCTION

The Bureau of Reclamation is presently involved in a unique Geothermal Resource Development Program in Imperial Valley, California. The main purpose of the investigations is to determine the feasibility of providing a source of fresh water for augmentation of the Lower Colorado River system through desalting geothermal fluids stored in the aquifers underlying the valley. Water shortages in the foreseeable future are very probable, unless some form of river augmentation is accomplished.

The Bureau's research and development program is investigating the feasibility of desalting mineralized geothermal fluids and delivering the fresh water to the Colorado River system to help meet the future needs of the arid Southwest. The addition of large amounts of high-quality water would also counteract the serious problem of increasing salinity of the river.

The advantage of obtaining fresh water from geothermal sources by desalting is that the application of heat, so essential for distillation processes, is not required from external sources. The earth yields this required component naturally in the form of hot fluids under pressure.

Geothermal deposits are one of the nation's relatively untapped resources. They could provide electric energy, fresh water, and possibly mineral byproducts without the associated air pollution so prevalent with other methods of energy, water, and mineral production.

II. GEOLOGICAL HISTORY

The Colorado River for millions of years has gouged the landscape of the Southwest, leaving scenic canyons such as the Grand Canyon, carrying trillions of tons of sediment to the Gulf of California. Through the centuries, the river has spilled sporadically into the Imperial Valley, building a delta thousands of feet deep. The periodic floods have saturated the delta with water, estimated at several billion acre-feet. This water is stored in the subterranean strata of Imperial Valley as a latent resource awaiting man to release part of it to serve the Southwest. This structural feature filled with saturated sediments is called the "Salton Trough."

The Salton Trough lies astride the East Pacific Rise, a primal fault from which molten rock from the earth's mantle provides a mechanism whereby the sediments in the trough are heated to high temperatures by abnormal heat flow.

III. GEOTHERMAL RESOURCES

It is possible to tap the heat in saturated rocks by drilling geothermal wells. Geothermal wells are drilled routinely by qualified drillers in areas of high heat flow in many parts of the world. Geothermal reservoir engineering technology is presently in its infancy, but techniques for the exploration of geothermal resources are being improved constantly.

Remarkable developments in the use of geothermal resources are to be expected worldwide in years to come. Countries in which geothermal developments are underway include the United States, Japan, Russia, Iceland, New Zealand, Italy, and Mexico. The Imperial Valley area of southern California has one of the greatest known potentials for a successful geothermal development in this country.

The Bureau of Reclamation began long-range planning in 1968 on Reclamation withdrawn lands in Imperial Valley by providing financial aid to the University of California at Riverside, which had been studying the Geothermal resource in Imperial Valley since 1964. Reclamation became physically involved in 1971 by drilling on several geothermal anomalies, which substantiated earlier studies and provided the information needed to proceed with further research.

The results of the shallow drilling program, along with seismic ground-noise studies, gravity studies, and lithologic studies of other deep wells in the area, indicated that the first deep geothermal test well should be located near the center of the "Mesa anomaly." The well designated Mesa 6-1 was begun in June 1972 and completed in August 1972 to a depth of 8030 feet. Figure 1 shows the location of the Bureau facilities in southern Imperial Valley and the location of the East Mesa anomaly. Also shown is the Cerro Prieto steam field in the Mexicali Valley in Mexico.

Mesa 6-1 has a bottom hole temperature of 400°F. Under throttled flow conditions, fluid emerges at the surface at about 300°F.

After the fluid is forced to the surface by the temperatures and pressures from within the earth, it is directed to the cyclone separator, where the steam and liquid are separated and passed into the desalting units. Automatic pressure and level controllers at the separator allow the operator to retain complete and precise control of the steam and liquid as they pass into the desalting plants.

Cooperative studies with the Geological Survey and the University of California at Riverside have determined seismic activity and characteristics of the geothermal fluids. Instruments for measuring subsidence have been installed in selected areas. A subsidence level network has been established over the valley, and a seismic network covers a large part of the valley. The Bureau of Mines is actively involved by conducting research on the mineral content of the geothermal fluids. The Bureau of Land Management and State agencies of California are also involved with our program. The Department of Agriculture Research Service has established a test irrigation development at the East Mesa test site to investigate the use of desalted geothermal water for irrigation.

A major environmental safeguard is the 38-acre-foot capacity brine holding pond. The pond is lined with a 10-mil polyvinyl chloride plastic sheeting to prevent waste saline water produced by the well from infiltrating the local shallow ground-water table.

IV. DESALTING PLANTS

Testing is presently underway on the desalting plants. Installed at the test site is an experimental multistage flash (MSF) desalting unit and a vertical tube evaporator (VTE) unit. These units were built under contract with the Office of Saline Water specifically for research on developing fresh water from geothermal resources.

Both units rely on the effect of condensing steam from a hot, boiling fluid to produce distilled or product water. The major expense in producing product water from brine by distillation is in the heating of the salty water by external means in other types of distillation desalting processes. In the desalting of geothermal fluids, this major expense is unnecessary because the fluid is already heated from deep within the earth, where nature has provided an almost unlimited source of heat energy.

The desalting process is explained in more detail elsewhere in this proceedings (Suemoto and Mathias).

This "first-ever" project is planned to determine economical methods of desalting geothermal fluids and to provide data for the design of larger desalting plants. In the chemical laboratory at the test site, many of the problems associated with geothermal desalting are being analyzed. Although there is much experience in desalting seawater, geothermal water has unique characteristics. Because of the differences, significant research must be accomplished to determine exactly how geothermal fluids react to desalting equipment. The corrosion and scaling tendencies on vessels and heat exchanger surfaces must be determined. Problems with equipment, which in many cases cannot be anticipated in advance, must be solved. A contract is presently underway with a consulting firm to independently analyze the desalting process and make recommendations on improving the system.

V. ADDITIONAL DEVELOPMENT

A second deep test well, designated as Mesa 6-2, was drilled during the summer of 1973 to a depth of 6005 feet on the Mesa anomaly. It is located 1475 feet west of Mesa 6-1. Mesa 6-2 is cased to a depth of 5951 feet with the bottom 500 feet slotted. Temperature surveys show the bottom hole temperature to be 369°F, and the wellhead temperature of the flowing fluid is about 300°F.

To maintain continuity of operation, the brine produced during the desalting process will be reinjected into the producing geological formations. While the disposal capability of the lined pond will permit limited testing, an injection well will be essential for continual operation of the desalting units.

Three additional geothermal wells have been recently completed. One will be used for reinjection of waste brines from the desalting units, and the other two will be used to obtain additional data to further define the Mesa anomaly.

Geothermal well Mesa 5-1, located about one and one-half miles northeast of Mesa 6-1, was drilled to a depth of 6000 feet. Downhole temperature surveys indicate a bottom hole temperature of 319°F. The fluid reaches the ground surface at a temperature of about 268°F at a flow rate of 360 gallons per minute. Since this well has slightly lower downhole temperatures than the other wells, it is scheduled for use as an injection well. It is expected that the colder and heavier injection water will flow down the well by gravity and may not require pumping.

Well Mesa 8-1 is located about one-half mile southeast of the facilities at Mesa 6-1. The bottom temperature was measured at 356°F. Preliminary tests indicate a maximum flow of about 1 cubic feet per second. Figure 2 shows the well blowing soon after drilling.

Well Mesa 31-1 is located near the north edge of the Mesa anomaly about two miles north of Mesa 6-1. It was completed on June 24, 1974. Temperature, pressure, and flow testing is now underway.

Twenty-four shallow temperature test holes 300 to 1000 feet deep were drilled during the winter of 1973-1974 to obtain heat flow data and monitor the anomaly.

Although the environmental impact is expected to be minimal with geothermal development, all environmental aspects will be thoroughly analyzed. Satisfactory methods of controlling gas emissions and disposal of waste materials will be studied. Environmental impact statements have been filed on the research and development activities.

Subsidence could become a serious problem when large quantities of ground water are extracted unless the producing aquifers are repressurized. Salton Sea water and ocean water are possible sources of replacement fluids. Investigations are continuing in this regard. Delivery points for product water are being analyzed to determine the most practical location.

The drilling and testing that have been done in the Mesa anomaly are the beginning of the research and development or first stage. This seven-year program will include field surveys and drilling and production testing, including the development of new technology from the first desalting test units. This stage will culminate in the construction of a larger prototype desalting plant with a capacity of 2 to 5 million gallons per day.

VI. FUTURE INVESTIGATIONS

Later program stages will progressively evaluate the feasibility of producing large quantities of high-quality water along with the generation of electric energy. Investigation of mineral recovery will be an important part of the program. It is anticipated that a multipurpose development will result in lower-cost products than single-purpose development. Reclamation is working with the Department of Agriculture on the experimental irrigation of crops common to Imperial Valley with high-quality desalted water. Use of this water will require a highly efficient irrigation system such as trickle deliveries.

Under a large-scale development, the desalted water could be delivered to several points along the Colorado River such as Imperial Reservoir or Lake Mead behind Hoover Dam. Lake Mead is the highest and most costly point of delivery in the Lower Basin, but would assure the greatest benefits for storage and regulation.

VII. CONCLUSIONS

Research to date clearly indicates that the geothermal resources underlying Imperial Valley offer considerable promise that someday more and better water can be developed within the Colorado River Basin for use in the Colorado River system. The geothermal program, not only in southern California, but possibly in other western states as well, could provide a solution to present-day water problems in both quantitative and qualitative terms.

In view of the present energy shortages, it is becoming increasingly important that the necessary steps be taken to begin capturing the energy from the latent geothermal resource. A multipurpose project could maximize the geothermal development by supplementing the production of high-quality water with the generation of electrical energy and mineral recovery. It is estimated that geothermal steam in Imperial Valley could produce several times the electric power capacity of Hoover Dam's generators.

Several private companies have proposed to install test units at the site, such as heat exchangers, downhole pumps, unique desalting devices, scale testing units, and various types of power generators. Recently, a private research and development company set up a scaling test unit at Mesa 6-1 to obtain data under actual geothermal field conditions. Others have also requested permission to set up test units.

Reclamation has a unique test facility on the East Mesa of Imperial Valley that is available as a field laboratory to selected scientists for testing and research under actual field conditions with producing geothermal wells.

As shortages continue to mount, it is becoming increasingly important to proceed on an orderly plan of development to help meet the water needs of the Lower Colorado River Basin, now and in the future. Input from this spectrum will help to assure that all the potential uses of the geothermal resource are fully evaluated and can be put to their maximum beneficial use for the good of mankind.

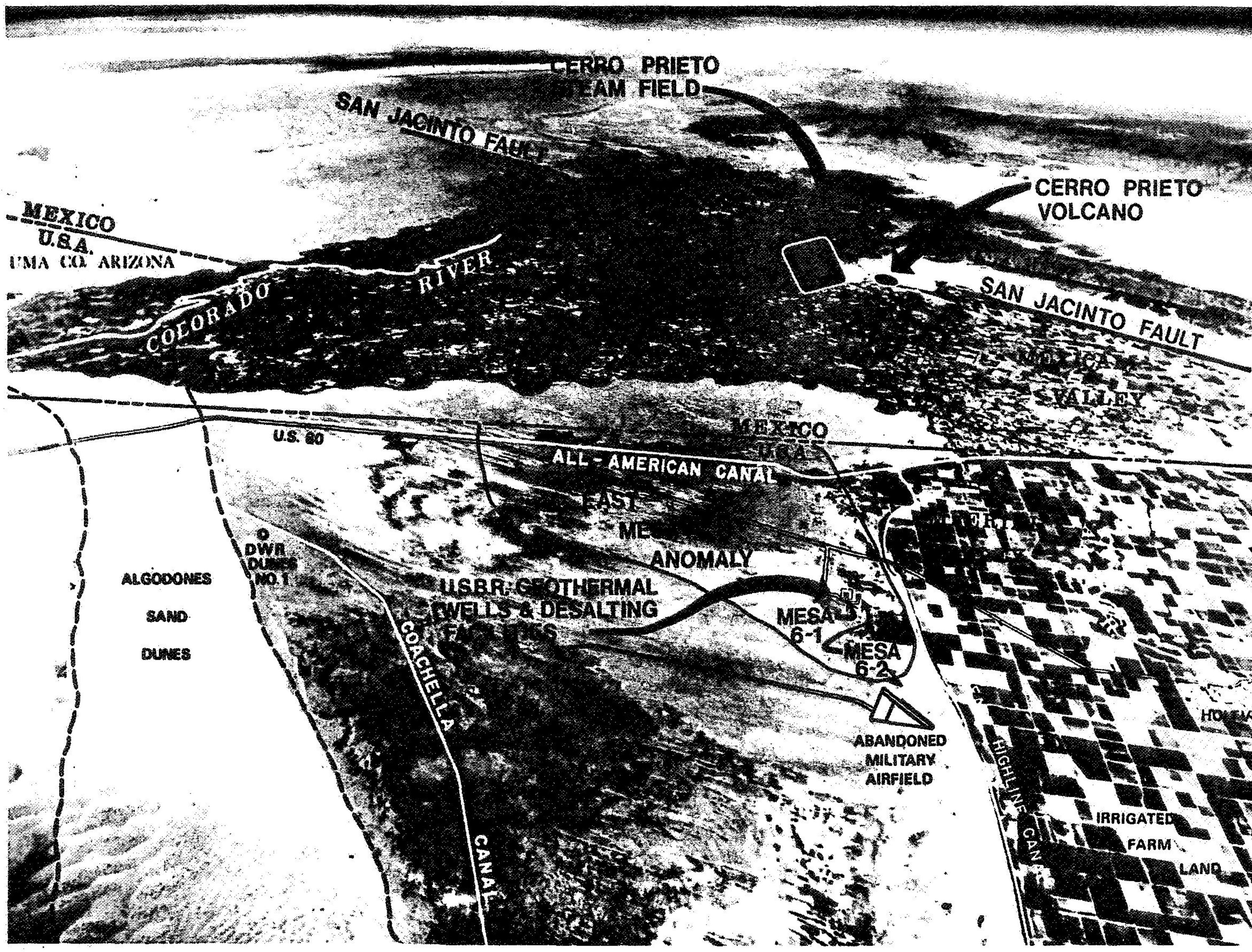

Fig. 1. Location of Bureau of Reclamation facilities, East Mesa anomaly, and Cerro Prieto steam field (photo by Bureau of Reclamation, U. S. Department of the Interior)

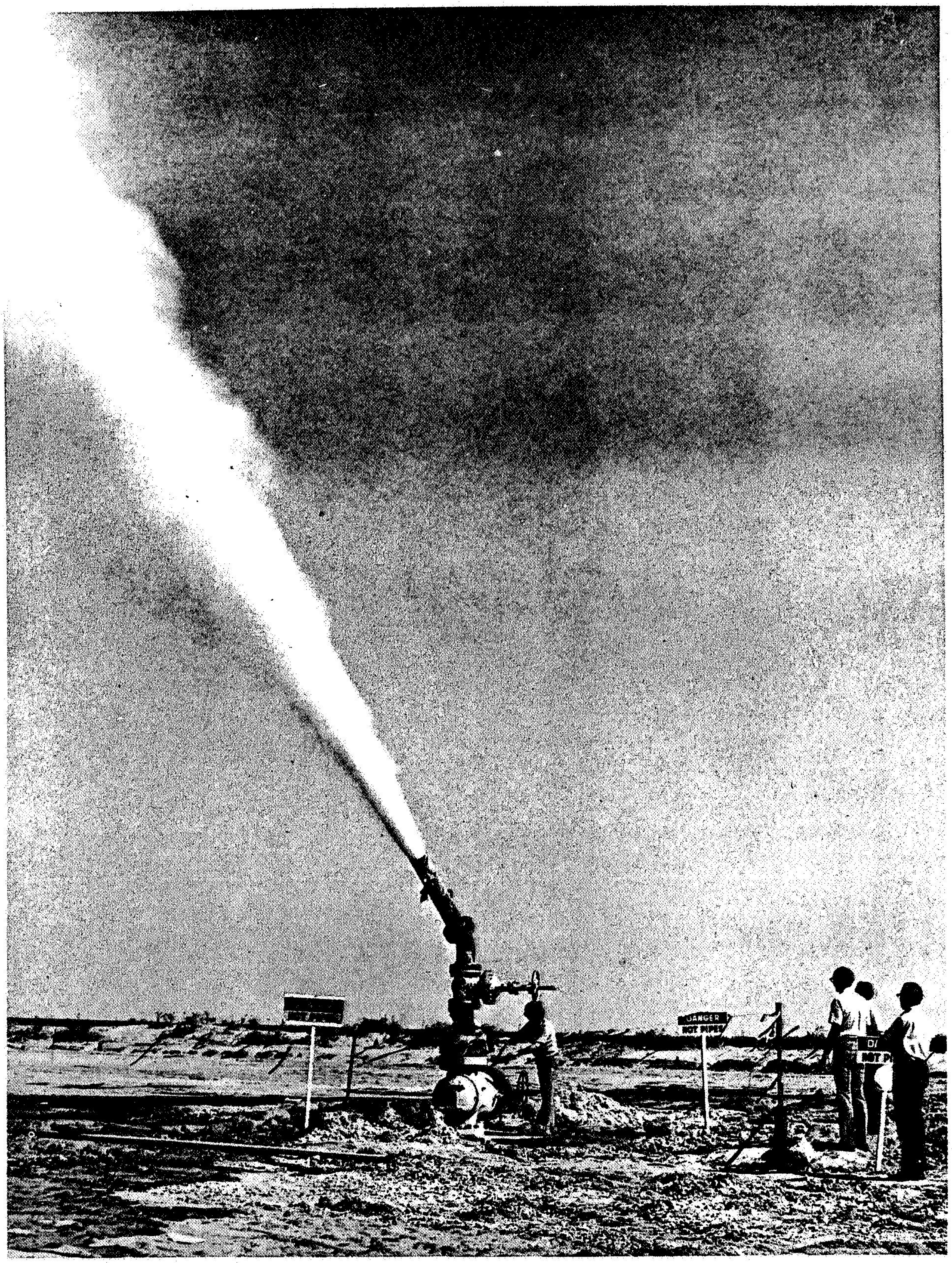

Fig. 2. Well at Mesa 8-1 blowing soon after drilling (photo by Bureau of U. S. Department of the Interior)