Proceedings Ninth Workshop Geothermal Reservoir Engineering
Stanford University, Stanford, California, December 1983
SGP-TR-74

DOE's CURRENT GEOTHERMAL RESERVOIR PROGRAMS AND COMMENTS ON INTERNATIONAL COOPERATION IN HYDROTHERMAL RESEARCH

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ABSTRACT

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

CURRENT RESERVOIR-RELATED PROGRAMS

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

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

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

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

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

Under our State assistance programs we will continue programs in resource assessment, resource development, technical assistance and technology transfer. There will be an emphasis on high temperature resources, especially the Cascades and other prospects associated with shallow magma bodies.

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

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

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

sciences.

Finally, we are this year taking an engineering look at the potential for magma energy extraction. The scientific feasibility for this was established by the "magma tap" experiments at Kilauea Iki in Hawaii. We will review the candidate shallow magma bodies in the continental U.S. to evaluate their characteristics and location. We will estimate the cost of drilling and extracting energy from selected prospects, and consider their potential economics with regard to potential users and transmission lines. If the estimates are sufficiently promising we will then plan a definitive experiment for the future.

INTERNATIONAL COOPERATION

In view of the international theme of this meeting and the presence of so many distinguished geothermal experts from around the world, I will now give a short review of DOE's cooperation in international research. A meeting such as this one is an ideal forum for experts to exchange information. The world's geothermal community has a good record of informally sharing its research results, but as you know there are other, more formal ties between nations through which even closer interactions among researchers are fostered. Specifically it is DOE's cooperative agreements in geothermal energy and the outlook for the future that I will now discuss.

Since the days of its predecessor agencies, the Atomic Energy Commission and the Energy Research and Development Administration, DOE has actively pursued international cooperation in geothermal research. Ten years ago, in 1973, we joined with Iceland in a program of information exchange on direct heat applications and advanced energy conversion systems. Also in that year the United States was a party, along with fourteen other countries, in a geothermal pilot study sponsored by NATO's Committee on the Challenges of Modern Society (CCMS). This study examined a broad spectrum of geothermal topics including reservoir assessment, direct heat applications, small power plants, and hot dry rock.

The NATO-CCMS pilot study was a benchmark for future international cooperation in geothermal research. During the past decade nearly every international agreement concerning geothermal energy came about, either directly or indirectly, as a result of this pioneering effort. Not only was international cooperation stimulated, but the study spawned a renewed awareness in many countries of geothermal energy's potential. While perhaps not contributing directly to power on line, the NATO-CCMS work highlighted the many benefits of joint research among nations while also promoting geothermal energy as a real alternative in a petroleum-based world economy.

DOE perceives at least four principal values or benefits from its international cooperative agreements. First of all, such agreements enhance our domestic research programs by bringing a larger pool of talent and data to bear on technical problems. For instance, the knowledge we have gained about production from a liquid-dominated field through our bilateral agreement with Mexico will serve as a model for production in the Imperial Valley.

Secondly, we realize substantial cost savings through task sharing. The outstanding example of this benefit is our IEA Cooperative Agreement with Germany and Japan in hot dry rock technology. Under that agreement Germany and Japan each contribute up to 25 percent of the budget to operate the Fenton Hill Project in New Mexico. In return, both countries receive all project findings and may assign scientific and technical personnel to work with LANL Fenton Hill for extended periods.

The remaining benefits of our cooperative agreements are less tangible but no less important. We believe that cooperative R&D in alternative energy sources will encourage and accelerate a transition from dependency on imported oil and gas, thereby increasing this nation's and other nations' energy security. Lastly, but an important benefit, we regard our cooperative projects as a most positive step to improved relations between the U.S. and other nations.

Since the NATO-CCMS study, DOE has participated in ten other international cooperative arrangements. Of these, six were direct, bilateral agreements; the remainder were agreements involving three or more countries conducted under the auspices of an umbrella organization such as the IEA. The eleven agreements involved a total of 23 other countries. Italy has participated with us in four of those agreements, while Mexico, Japan, and Germany each have been party to three.

Whereas the legacy of international cooperation over the past decade has been rich, we have apparently reached a low point in that cooperation. Of the eleven agreements mentioned before, only two are actually active at present: (i) the IEA Agreement on Hot Dry Rock Technology and (ii) the bilateral arrangement between DOE and ENEL (Italy). Even the DOE-ENEL agreement, probably the one having the most interest to reservoir engineers, has been largely inactive of late while new tasks are being negotiated.

A number of reasons can be cited for the slackened interest in cooperation on geothermal research. The recent worldwide oil surplus coupled with a pervasive recession caused many nations to reevaluate their energy research programs. With fewer incentives and less funds for research, many countries chose to deemphasize their international programs; greater emphasis was

placed on purely domestic R&D activities. During this period DOE strived to fulfill its international commitments. The Department was reluctant, for budgetary reasons, to assume new obligations.

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

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

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