

GEOTHERMAL DRILLING AND COMPLETION TECHNOLOGY DEVELOPMENT PROGRAM
ANNUAL PROGRESS REPORT

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1. INTRODUCTION

The high cost of drilling and completing geothermal wells is an impediment to the timely development of geothermal resources in the U.S. The Division of Geothermal Energy (DGE) of the Department of Energy (DOE) has initiated a development program aimed at reducing well costs through improvements in the technology used to drill and complete geothermal wells. Sandia National Laboratories (SNL) has been selected to manage this program for DOE/DGE. Based on analyses of existing well costs, cost reduction goals have been set for the program. These are to develop the technology required to reduce well costs by 25% by 1983 and by 50% by 1987.

To meet these goals, technology development in a wide range of areas is required. The near-term goal will be approached by improvements in conventional, rotary drilling technology. The long-term goal will require the development of an advanced drilling and completion system. Currently, the program is emphasizing activities directed at the near-term cost reduction goal, but increased emphasis on advanced system development is anticipated as time progresses.

The program is structured into six sub-elements: Drilling Hardware, Drilling Fluids, Completion Technology, Lost Circulation Control Methods, Advanced Drilling Systems, and Supporting Technology. Technology development in each of these areas is conducted primarily through contracts with private industries and universities. Some projects are conducted internally by Sandia.

This report describes the program, status, and results of ongoing R&D within the program for the 1980 fiscal year.

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2. HIGHLIGHTS

The following highlights set forth the major accomplishments achieved under the Geothermal Drilling and Completion Technology Development Program during the 1980 fiscal year.

Drilling Hardware

- Conducted the third field test of the downhole replaceable chain drill

The third field test of the chain drill confirmed the reliability of downhole cycling of the chain links. In comparison to the success achieved in the first field test, drilling performance was not as good. Investigation of the causes of the degraded drilling performance is underway, including theoretical analyses and controlled laboratory drilling tests.

- Identified seal designs and lubricants for use in sealed geothermal roller-cone bits

Elastomeric and all-metal seals were designed, and lubricants were formulated for use in sealed roller-cone bits under geothermal drilling conditions. The seals, soaked at 288°C (550°F) and tested at 125°C (257°F), and lubricants were successfully laboratory tested and are considered ready for full-scale drilling tests.

- Conducted two field tests with full-scale drag bits, modified to use PDC cutters

The first test of full-scale drag bits using PDC cutters was conducted in the Baca field early in FY80 and demonstrated penetration rates up to 4 times greater than a conventional bit. A second field test with a redesigned bit was attempted late in FY80, but a manufacturing error led to an unsuccessful test. The error has been corrected and more bit tests are planned to establish bit life.

Drilling Fluids

- Completed preliminary screening of surfactants for development of aqueous foam drilling fluids

Surfactant screening at high temperature and in various chemical environments has identified several surfactants that are promising for geothermal applications. Evaluation of selected surfactants is continuing at high temperatures and high pressures.

- Demonstrated a technique of nitrogen generation from diesel engine exhaust using a catalyst

Catalytically supported thermal combustion as a means of generating nitrogen from the exhaust of a diesel engine was successfully demonstrated in laboratory testing. The durability of the catalyst was shown in two 100-hour tests; one at a full engine load and one at a part load. The results indicate an ultimate catalyst life in excess of 1000 hours. Development of a scaled-up, field-size system is under consideration.

- Conducted a successful field test of a high-temperature drilling mud

A field test of the HTM-1 mud system was successfully conducted during the drilling of the McCulloch Mercer 2-28 well in Imperial County, California. No mud solidification, no serious lost circulation, and no corrosion problems were encountered during drilling with the HTM-1 mud. A detailed analysis of the test data is being conducted. The formulation used for HTM-1 mud is now commercially available from a leading mud company.

Completion Technology

- Designed and fabricated a system utilizing cavitation techniques for downhole geothermal well cleaning and scale removal

The motor and cavitating nozzle mechanisms for a downhole descaling unit were fabricated and laboratory tested. Experiments to determine the threshold intensity of erosion of calcium-based scale found in East Mesa wells were completed. A value of 650 W/m^2 (0.42 W/in.^2) was established. A field demonstration of the device is scheduled early in FY81.

- Investigated formation permeability impairment due to drilling mud invasion as a function of varying stagnation times, mud types, temperature, and backflow durations

The evaluation of the laboratory test results for two mud systems indicated that (1) permeability impairment due to formation/drilling fluid interaction is time dependent, with significant impairment occurring within 48 hours residence time, (2) permeability impairment is temperature dependent, with lower temperature, i.e., 100°C (212°F), exposures resulting in greater impairment than higher temperature, i.e., 200°C (392°F), exposures, and (3) both temperature and time dependence vary with drilling fluid chemistry.

Lost Circulation Control Methods

- Completed a study to determine the geological characteristics of lost circulation zones in volcanic sequences

A study of the geological characteristics of lost circulation zones was conducted in an attempt to define one or more parameters that could be utilized to predict with a high degree of accuracy those zones where

circulation might be lost. The study found that detailed quantitative data on the geological characteristics of lost circulation zones do not exist and concluded that experiments should be conducted in drill holes to determine the physical parameters of those zones.

- Acquired an extensive data base concerning rock properties, temperature histories, and lost circulation experience in geothermal wells

A data collection effort was completed to acquire and collate information on rock properties, well temperature histories, and lost circulation experience in geothermal wells. The data will be used for thermal simulation of wells during drilling, production, and injection, using the GEOTEMP code.

- Completed an assessment of lost circulation mapping tools and techniques

Tools and techniques were identified, described, and evaluated concerning their capabilities to map lost circulation zones in geothermal wells. Twenty five tools were examined and ranked on the basis of performance, risk, availability, and cost. The Sound-Temperature Survey received top ranking although the study concluded that multiple tools, usually two, are required to obtain sufficient information in order to map lost circulation zones.

- Initiated a project to design and fabricate a facility for testing lost circulation materials and cementing techniques at simulated geothermal well conditions

The number, availability, and capabilities of existing lost circulation/cementing testing facilities indicate an urgent need for a facility to support development of materials and procedures for lost circulation control and cementing. Design of the facility has been initiated and construction is expected to be completed during FY81.

Supporting Technology

- Fabricated a facility for conducting studies of drill bit hydraulics

Fabrication and assembly of a test facility that will be used in optimizing the design of bit hydraulics for geothermal drill bits were completed. The facility provides the capability to visualize the flow field along the bit face and to measure bottomhole pressure gradients, cutter heat transfer coefficients, and chip removal. Experiments will begin in early FY81.

- Produced an H₂S resistant, silicon-based, dual-phase steel sample for possible drill pipe applications

An experimental quantity of a silicon-based, dual-phase steel was produced and processed for use in corrosion-fatigue tests. Fabrication of

specimens from the steel for heat treatment experiments is underway. A corrosion resistant drill stem material with suitable mechanical properties is expected to result from this effort.

- Expanded the capability of the GEOTEMP code for predicting transient wellbore temperatures during drilling, circulation, injection, and production in geothermal wells

Modifications to the GEOTEMP code were completed to handle deviated holes, variable tubing areas, and multiple fluids separated by interfaces in the wellbore. Work is continuing to develop compressible flow capabilities in the code.

Advanced Drilling Systems

- Identified new seal designs and lubricants for use in downhole motors

A facility for testing a downhole motor bearing and seal package under simulated downhole conditions has been completed. This facility has been used to screen seal designs and lubricants. The Variseal® high-temperature seal achieved a lifetime of 165 hours at temperatures ranging from 82° to 177°C (180° to 350°F) and a pressure drop of 10.3 MPa (1500 psi).

- Demonstrated the feasibility of a downhole pressure-pulsing device for use with cavitating jets in high-pressure, jet drilling systems

Laboratory tests of a tandem-orifice "Pulser" concept indicated the feasibility of developing a downhole pressure-pulsing device for creating cavitation at lower nozzle pressure drop. This development may lead to high cutting rates with reduced surface pressure. Work on optimizing the configuration of the device will be continued in a follow-on program.

- Evaluated percussion drilling devices for use under geothermal conditions

Laboratory tests of conventional percussion drilling equipment were conducted at high temperatures. The percussion equipment drilled up to three times faster than conventional rotary drilling, but high-temperature failure of plastic parts in the air valving mechanisms of the percussion hammers was encountered. Work is continuing to determine modifications required to correct the failures encountered and to compile additional data for an economic analysis of the potential benefits of percussion drilling.