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SLIM-HOLE DRILLING FOR GEOTHERMAL EXPLORATION

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ABSTRACT: Drilling production-size holes for geothermal exploration puts a large expense at the beginning of the project, and thus requires a long period of debt service before those costs can be recaptured from power sales. If a reservoir can be adequately defined and proved by drilling smaller, cheaper slim-holes, production well drilling can be delayed until the power plant is under construction, saving years of interest payments. In the broadest terms this project's objective is to demonstrate that a geothermal resevoir can be identified and evaluated with data collected in slim holes.

We have assembled a coordinated working group, including personnel from Sandia, Lawrence Berkeley Lab, University of Utah Research Institute, US Geological Survey, independent consultants, and geothermal operators, to focus on the development of this project. This group is involved to a greater or lesser extent in all decisions affecting the direction of the research. Specific tasks being pursued include:

- Correlation of fluid flow and injection tests between slim-holes and production size wells.
- Transfer of slim-hole exploration drilling and reservoir assessment to industry so that slim-hole drilling becomes an accepted method for geothermal exploration.
- Development and validation of a coupled wellbore-reservoir flow simulator which can be used for reservoir evaluation from slim-hole flow data.
- Collection of applicable data from commercial wells in existing geothermal fields.
- Drilling of at least one new slim-hole and use it to evaluate a geothermal reservoir.

BACKGROUND: Although the vast majority of drilling technology used in the geothermal industry is derived from the oil and gas industry, geothermal requirements are qualitatively different. There are hard, abrasive, and fractured rocks; high temperatures; and underpressured formations, frequently containing corrosive fluids -- all these factors impose a more rigorous environment than normally found in oil and gas drilling. The service and drilling tool industries have little incentive to address these problems, since the number of geothermal wells drilled in a year is about 0.1% of the corresponding number for oil and gas. This lack of commercial research and development is the primary rationale for DOE's support of technology development.

A recent systems analysis (Pierce and Livesay) identified drilling costs associated with exploration and reservoir assessment as a major factor affecting future geothermal development. The geothermal industry (utilities and geothermal operators) needs to reduce exploration and reservoir assessment costs in order to be competive in meeting the expanding requirements in the

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West for environmentally benign, alternative energy sources. Slimhole drilling has been shown (Walker and Milheim) to reduce oil and gas exploration costs by 25 to 75%; however, the more hostile conditions for geothermal resources present technology challenges which must be solved before the cost impact can be thoroughly evaluated. Once demonstrated, slimhole drilling technology will have application to geothermal exploration and reservoir assessment in both the U. S. and international markets.

The principal reason for the lower cost of drilling slim-holes is the smaller size of crews and equipment. This reduction in drill-site size, road preparation, mobilization, and human traffic is also critical in minimizing environmental impact. If geothermal development follows its expected expansion into the Pacific Northwest, a relatively benign environmental presence will be critical to public acceptance and progress. Smaller equipment is also especially appropriate for geothermal exploration in Third World countries, or wherever financial and institutional support are minimal.

RESULTS TO DATE: Early activities in the project were concentrated on a survey of the geothermal industry to specify their exploration needs and to select areas of research where Sandia could provide effective help. There is considerable industry interest in slim-hole exploration, and it has been used in a few special cases (Combs and Dunn), but is not widely recognized as being informative enough to secure power plant financing. Results of the survey convinced us to begin a program of research into the validation of slim-hole drilling as an exploration tool.

Later, we addressed collection, evaluation, and combination of existing wellbore-flow computer codes, which will be used for the analysis of measurements made in the geothermal field at Steamboat Hills, near Reno, Nevada. Sandia has signed an agreement with Far West Capital, the company which owns and operates a 24MW power plant there, which allows testing of their existing core holes for comparison with existing production wells. Near the end of the Fiscal Year, we performed flow and injection tests with simultaneous pressure-temperature-spinner logs in three core holes at Steamboat Hills.

Specific results for the past fiscal year were:

- An industry survey indentified several sites (e.g., Steamboat Hills, Desert Peak, Coso, Roosevelt Hot Sprins; see Combs and Dunn) where reservoir parameters measured in slim-holes and production-size wells could be compared.

- Flow and injection tests, with accompanying pressure-temperature-spinner logs, on coreholes at Steamboat Hills yielded flow data which were in excellent agreement with results obtained by using measured downhole conditions as input for wellbore simulator codes. This is necessary for extension of specific results at a well-characterized reservoir like Steamboat Hills to a more general predictive capability.

- Investigation of existing wellbore and reservoir codes indicates that these can be combined and/or slightly modified to produce a useful tool for analysis of reservoir parameters from wellbore flow data.

PLANNED WORK: For slim-hole exploration to become widely useful, it must be accessible to the small, independent geothermal developer. Our ultimate product will be the tools to bring about that result. These include, but are not limited to, the following:

- Guidelines for drilling and completing exploration slim-holes.
- Recommended test procedures and strategies, including data requirements, for the slim-holes.
- Improved downhole instrumentation to collect needed data.
- Data interpretation techniques, possibly in the form of a PC-compatible flow simulator which could be distributed at a nominal expense to independent developers. Use of this software would allow basic reservoir evaluation from slim-hole data and, once accepted as an industry standard, would be considered sufficient support for development financing.
- Publication of the analysis and experimental procedures which have led to the above products.

Successful technology transfer will require broad dissemination of our test results and analysis. This can be done by sponsorship of industry workshops, publication in technical journals, appearances at professional meetings and reviews, and personal contact through the working group and industrial partners.

REFERENCES:

JBCombs, JCDunn; "Geothermal Exploration and Reservoir Assessment: The Need for a US Department of Energy Slim-Hole R&D Program in the 1990s"; Geothermal Resources Council BULLETIN, November 1992, pp 329-337

KGPierce, BJLivesay: "A Study of Geothermal Drilling and the Production of Electricity from Geothermal Energy"; Sandia National Laboratories, SAND92-1728, (in press)

SHWalker, KKMilheim; "An Innovative Approach to Exploration and Exploitation Drilling: The slim-hole, high-speed drilling system"; Journal of Petroleum Technology, v. 42, pp 1184-1191