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GEOTHERMAL WELL STIMULATION PROGRAM - - OPENING REMARKS

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For over thirty years, well stimulation techniques of one form or another have been employed to enhance production from marginal or sub-marginal oil and gas wells. The formal introduction of well stimulation as a pseudo-science can probably best be tied to the introduction of hydraulic fracturing as an effective method for providing better communication between the producing reservoir horizon and the wellbore. Prior to this, independent operators were sometimes known to drop sticks of dynamite into unproductive wells initiating the era of "homegrown" stimulation techniques. What they lacked in sophistication, they sometimes made up for in increased production as these attempts were apparently more than casually successful.

Technical developments during the last decade on the application of well stimulation methods to oil and gas wells have been particularly significant. During this same time interval, the number of available geothermal wells that could benefit from effective stimulation treatments has become quite large. In response to this situation, the Department of Energy/Division of Geothermal Energy (DOE/DGE) elected to fund an extensive program in geothermal well stimulation technology. The basis for the program was the hardware, experience, and technology developed from the stimulation of hydrocarbon wells. The objective was clear - - extend this hardware and technology to the very specific requirements associated with the stimulation of geothermal wells.

The stimulation of geothermal wells presents some new and challenging problems in addition to the ones currently being faced in oil and gas well stimulation treatments. Formation temperatures will be in the 150-300C range and the behavior of frac fluids and proppants at these temperatures in a hostile brine environment will have to be carefully evaluated before

performance expectations can be determined. In order to avoid possible damage to the producing horizon of the formation, the high-temperature chemical compatibility between the in situ materials and the frac fluids, fluid additives, and proppants must be verified. In trying to assess the probability for a successful stimulation treatment, the response of formation rocks with entirely different physical characteristics must be predicted. Perhaps most significant of all, in geothermal wells the required techniques must be capable of bringing about the production of very large amounts of fluid. This necessity for high flow rates represents a significant departure from conventional oil field stimulation and demands the creation of fractures with very high flow conductivity or very large fracture surface areas in the case of matrix permeability dominated formations.

My involvement in the formulation of this program began with visits to a large number of industrial organizations with a firm commitment or vested interest in the development of geothermal energy. The technical discussions during these visits centered on the question - - - in what areas could the injection of Federal dollars be most productive in developing commercial geothermal well stimulation techniques applicable to the growing number of unproductive or marginal geothermal wells. Many of the people attending this first symposium on Geothermal Well Stimulation are people I contacted during those formative stages of this program. The end result of this effort was a document called a Request for Proposal (RFP) in which the DOE solicited proposals for formulating, managing, and implementing an extensive geothermal well stimulation program designed to assess, develop, and field test methods for increasing and prolonging the productivity of geothermal wells. This document was published by the Los Alamos Area Office of the DOE and was mailed to prospective industrial participants. Additional publicity for the program was sought by advertising in such prominent journals as The Oil and Gas Journal.

After publication of the Request for Proposal, a pre-proposal conference was held in Denver to answer questions related to the proposed program, DOE's ultimate intentions in this area, and the desired magnitude and scope of the program. By the required deadline date, five significant proposals were received from industrial organizations. It is interesting to

note that each proposal represented a consortium of organizations, apparently in response to the large magnitude and scope of the desired program. While a large segment of the geothermal community was enjoying the scenic wonders of Hilo at the Geothermal Resources Council annual meeting, another small group was tolerating the delights of downtown Washington in August while these proposals were being thoughtfully reviewed. This process was concluded with the announcement that the proposal submitted by Republic Geothermal had been selected as the winner.

The organizational structure under Republic Geothermal will be presented in detail by Don Campbell. I would like to point out that this program is under the technical cognizance of Cliff McFarland within the Division of Geothermal Energy at DOE. My capacity within this program is to serve as a technical advisor to the DOE.

Numerous geothermal wells have been drilled on the more obvious thermal anomalies with respectable success ratios. Dry holes or marginal producers, however, do occur in the development of every field. While some of these unproductive wells are on or outside the boundaries of the established reservoir, others are within the reservoir boundaries but have just not intersected a good portion of the producing horizon. These are the wells that become prime candidates for stimulation treatments. The goal of this program is to identify specific geothermal wells of marginal or submarginal value and to develop and test the necessary hardware and techniques to perform successful stimulation treatments on these wells. The ultimate goal of the program is to ensure that these products and techniques become available in the commercial marketplace for use by all well owners and operators.

The Statement of Work contained in the RFP set out very specific emphasis areas that were to be followed throughout the conduct of this program. The geothermal well stimulation program is limited to hydrothermal convective systems with a strong emphasis on hot water dominated reservoirs in the 150-300C range. The RFP was worded in such a way that nothing has been absolutely excluded but strong attention is directed toward the use of hydraulic fracturing and/or chemical treatments in hot water wells in developed reservoirs. High drilling costs associated with drilling in hot, fractured, and unpredictable geothermal formations provides the major

economic incentive for this program. The cost of drilling and completing a geothermal well can frequently be higher by a factor of 2 or 3 over the cost of a conventional oil or gas well to the same depth.

Stimulation treatments will be conducted in formations which produce hot water as a result of both matrix permeability and from natural existing fracture systems. The following targets of opportunity are of particular interest to this program:

- ° Wells that require additional drainage area because of insufficient formation permeability.
- ° Wells that did not intersect major fracture systems that are presumed to exist nearby.
- ° Wells that suffered man made damage during drilling or completion operations including mud or cement invasion.
- ° Wells that require periodic remedial treatment as a result of fluid production related damage.

Although numerous criteria have been established for the selection of candidate wells, perhaps the most significant is definite proof of a good producing reservoir. This data will normally be obtained from offset well production.

I would like everyone in the geothermal community to be aware of the existence of this program and the fact that we are continually reviewing well data as part of the selection process in picking our next candidate wells for stimulation treatments. Invitations to the stimulation team to review data for a potential candidate well are always in order.