S-CUBED

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WELL TEST ANALYSIS AND IMPROVED MODELS FOR GEOPRESSURED-GEOTHERMAL SYSTEMS

T. D. Riney

Final Report

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(Under DOE/UTA Cooperative Agreement,
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*P. O. Box 1620, La Jolla, California 92038-1620
(619) 453-0060*

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0.0 INTRODUCTION

In accordance with the S-CUBED Subcontract Work Statement, S-CUBED has concentrated on the synthesis, correlation and analysis of all pertinent data from the Department of Energy (DOE) geopressured-geothermal research wells undergoing testing during the contract period. This work has included the development of reservoir simulation models for the geopressured-geothermal resource in hydrological connection with each well. Existing S-CUBED simulation techniques have been applied to develop, update and improve the models for the reservoirs tested. During the contract period, data have been available from the Gladys McCall, Pleasant Bayou and Hulin test wells. S-CUBED has also contributed to the design of the well tests and participated in DOE's planning and review meetings in support of the geopressured-geothermal program. Detailed technical Topical Reports have been prepared and issued as appropriate during the contract period as referenced in the following summary of the work performed during the final year of the S-CUBED Subcontract to UTA.

1.0 ANALYSIS/SYNTHESIS OF TEST WELL DATA

1.1 Gladys McCall Well No. 1

Production from Sand Zone No. 8 by Gladys McCall Well No. 1 was initiated on October 7, 1983 and continued at an average rate of ~19,600 sep b/d until April 21, 1987 when the rate was decreased stepwise to ~9,800 sep b/d. The well was shut on October 29, 1987 in order to monitor the pressure recovery during a long-term buildup test which is still in progress. Except for relatively short time intervals (following decreases in the flow rate), the bottomhole pressure generally decreased from October 7, 1983–April 21, 1987. This period of over 3.5 years is called the "Depletion Phase". The bottomhole pressure since April 21, 1987 has increased and the period since that time (now also over 3.5 years) is called the "Recovery Phase" of the test history.

An earlier S-CUBED report (Riney, 1988) presented analysis of the Gladys McCall data available at the end of the Depletion Phase. During this final year of the S-CUBED Subcontract a Topical Report (Riney, 1990) documented the analysis of the more complete data available, i.e. the Depletion Phase and the Recovery Phase through May, 1990. In the absence of geological information, a simple reservoir configuration was used as a framework for integrating the data base available for the Gladys McCall geopressured system and a linear reservoir model was developed which simulated the production history of the test well.

The wellhead pressure data from the Gladys McCall well have been monitored by S-CUBED as the long-term test continues. During the coming year DOE plans to reenter the test well and perform tests to help resolve uncertainties in the reservoir model assumptions and to better understand the reservoir response. In particular, the tests will

investigate the possibility that the formation rock was irreversibly changed during the test history. An earlier S-CUBED Subcontract Topical Report (Riney, 1986) presented a series of parametric calculations which demonstrated the effects of nonlinear stress-deformation rock properties on the behavior of geopressured reservoirs. These calculations employed an existing S-CUBED simulator modified to approximate the irreversible compaction of formation rock using a bilinear model. Proposed subcontract tasks under which S-CUBED would have developed a specialized geopressured reservoir simulator (for treating a variety of possible nonlinear rock formation responses) were not funded.

1.2 Pleasant Bayou Well No. 2

Preliminary testing (Phase O) of Pleasant Bayou Well No. 2 took place in 1979, reservoir limits testing during 1980 (Phase I), and long-term testing (Phase II) was conducted during 1981–1983. Testing was suspended in May 1983 when the production tubing parted. The well was cleaned out and recompleted in 1987 and long-term production testing was resumed on May 27, 1988. In preparation for a new phase of long-term testing, UTA's Bureau of Economic Geology reviewed all the previous geological studies of the Pleasant Bayou area and constructed a simple configuration that approximates actual reservoir volume, dimensions and pore-space distribution of the C-zone reservoir in hydraulic connection with the test well. The geological based configuration (BEG1) does not provide information regarding formation compressibility and transmissivity, fluid properties, or the major hydrological pathways between regions of the reservoir. BEG1 does, however, provide a geologic framework within which S-CUBED has synthesized a reservoir simulation model using the diverse data sets available for the Pleasant Bayou fault block.

At the end of this final year of the S-CUBED Subcontract, another Topical Report (Riney, 1991) was issued which documents the results of the synthesis/correlation/analysis of data from the Pleasant Bayou geopressured resource. This work includes the development of input parameters for the simulation model based on the BEG1 geologic framework, laboratory measurements performed by UTA, and data from the Pleasant Bayou test well during 1979–1983 and from May 27, 1988 through December 31, 1990. The model provides a good match to the test history to date. Since the data base is continuously being expanded and updated, the model development is a dynamic process and the reservoir simulation model will necessarily evolve as more complete information becomes available from the continuing testing of Pleasant Bayou No. 2.

1.3 Willis Hulin Well No. 1

Superior Oil Company turned the Willis Hulin Well No. 1 over to DOE during 1984 for evaluation under its Geopressured Geothermal Program. The well was recompleted in 1989 and preliminary flow testing of the reworked well were performed during November 1989–January 1990. S-CUBED performed pre-test calculations to estimate expected wellhead pressures and temperatures as a function of flow rates. S-CUBED collaborated with IGT in the design of the multi-rate drawdown/buildup tests of the deepest sand package (20,616–20,690) in the target sand/shale sequence (20,220–

20,690 feet) and analyzed the results of the two flow tests of this sand. Analysis of the data from these preliminary short-term tests indicates a permeability of about 15 to 20 md and the presence of a hydrological barrier in the deepest sand package at about 100 to 125 feet from the test well.

2.0 REPORTING AND DELIVERABLES

2.1 Project Review/Technical Liaison

Throughout the duration of the Subcontract, S-CUBED participated in DOE project reviews and test planning sessions. During the final year of the subcontract the following activities by Dr. T. D. Riney can be recorded.

On April 19 and 20, 1990: Participation in the DOE convened meeting on "Geopressured-Geothermal Long-Term Planning" held in San Francisco and, at the request of UTA's Dr. Myron Dorfman, participation in the subsequent meeting in Berkeley to acquaint LBL with the status of the S-CUBED reservoir modeling work.

On July 29, 1990: Participation in the DOE convened meeting held in Houston to discuss "A Three-Year Plan for Geopressured-Geothermal Research".

On October 23, 1990: Presentation of a summary of the reservoir engineering work performed under this contract to an external Program Review Panel convened by DOE in Idaho Falls, Idaho.

On December 6 and 7, 1990: Participation in the annual DOE convened Geopressured-Geothermal Program Review held in Washington, D.C.

2.2 Preparation of Formal Reports

As discussed above, S-CUBED completed the documentation of the results of its analysis of the Gladys McCall and Pleasant Bayou geopressured reservoirs in two separate formal Topical Reports issued during this final year of the subcontract. Those documents have been distributed to the geopressured geothermal program participants under separate covers and together with this report comprise S-CUBED's Final Report under this Subcontract to UTA.

2.3 Preparation of Open Literature Paper

A manuscript based on one of S-CUBED's Topical Reports ("Depletion and Recovery Behavior of the Gladys McCall Geopressured Reservoir") has been accepted for publication in an upcoming issue of the Energy Sources Journal.

3.0 REFERENCES

- Riney, T.D. (1986), "Simulation of Irreversible Rock Compaction Effects on Geopressured Reservoir Response", Topical Report under U.S. Department of Energy and The University of Texas at Austin Cooperative Agreement No. DE-FC07-85NV 10412, December.
- Riney, T. D. (1988), "Gladys McCall Geopressured Reservoir Analysis-June 1987", *Journal of Energy Technology, ASME, Vol. 110*, No. 4, pp. 262-268, December.
- Riney, T. D. (1990), "Depletion and Recovery Behavior of the Gladys McCall Geopressured-Geothermal Reservoir", Topical Report under U.S. Department of Energy and The University of Texas at Austin Cooperative Agreement No. DE-FC07-85NV 10412, June.
- Riney, T. D. (1991), "Pleasant Bayou Geopressured-Geothermal Reservoir Analysis—January 1991", Topical Report under U.S. Department of Energy and The University of Texas at Austin Cooperative Agreement No. DE-F07-85NV10412, January.