

DOE/ID/13532--T3

Quarterly Progress Report

DOE Instrument DE-FG07-97ID13532

Determination of Silica Scale Deposition Rates and Thresholds Applied Toward
Protection of Injection Reservoirs

Reporting Period: April 1, 1998 through June 30, 1998

Synopsis

The program objective aims to identify the highest temperature at which silica scale will develop from partially evaporated and significantly cooled geothermal liquid. The approach involves tracking deposition of silica scale by monitoring the apparent electrical conductivity of the geothermal liquid in an isolation chamber. A decrease in apparent conductivity occurs because silica deposited on electrode surfaces is less conductive than the geothermal liquid.

The major technical hurdle is building a conductivity monitoring system that is sensitive enough to distinguish between no silica deposition and almost no silica deposition, while accounting for other factors which also affect conductivity, such as temperature and varying fluid composition.

Activities This Period

Late in the last quarter, improvements were made in the equipment by adding a programmable logic controller (PLC) to linearize the signals from both the conductivity and temperature sensors to the strip chart recorders. The J-type thermocouple temperature sensors were replaced with 100 Ω platinum RTD's, and two conductivity signal conditioner/transmitter modules were added. In early April, GDA staff finalized the installation of the PLC and tested the equipment in the lab.

Dr. Michels traveled to Reno on April 12 to participate in the lab testing. Although the intent was for Dr. Michels to field test the improved set-up, he had to travel back to Montana before lab testing and refinement reached a point which warranted field testing. GDA staff field-tested the equipment in late April.

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Testing revealed a significant improvement in signal quality. However, the effect of temperature on the apparent conductivity of liquid in the pipeline and in the test chamber is very large compared to the signal changes expected from silica scale effects. Furthermore, small changes in composition of pipeline liquid during experimental intervals also yield conductivity increments that are larger than the effects of silica scale. Thus, it became necessary to follow temperature and conductivity of liquid simultaneously in pipeline and test chamber during an experimental run. A run involves multiple re-fillings of the test chamber with fresh pipeline liquid so contrasts in basic conductivity must be accounted for in the final interpretation.

The original design for temperature measurement in the jacket of the test chamber was unsatisfactory due to lag time for temperature equilibration inside the chamber where conductivity was being monitored. Accordingly, in May a test chamber that contained conductivity and temperature probes inside was designed and assembled. Although not fully Teflon lined, this test chamber was built to investigate the benefits of directly measuring the temperature of the reactor fluid at a point very near the reactor fluid conductivity probe. In mid-June, GDA personnel field-tested the new chamber at the Caithness Power Plant at Steamboat Springs.

Findings and Improvements

Proof of the viability of the concept is illustrated in the attached Figure 1. The data in Figures 1A and 1B show negligible time lag exists between changes of temperature and conductivity. Figure 1C shows the temperature and conductivity correlations for successive fillings of the test chamber with fresh pipeline water. The progressive shifts in position of the T-C plots is taken to indicate successive increments of silica deposited on the conductivity electrode.

The success of this testing indicates that modification of the original Teflon-lined chamber is worth pursuing. A design for a conductivity electrode has been developed wherein the center electrode is also the RDT (temperature) probe. Materials are expected to be available for assembly and testing in the third quarter of 1998.

Additionally, we will attempt to calibrate conductivity probes in the test chamber and the pipeline, as a means to better characterize the liquid in successive fillings of the chamber.

A data logger will be used to obtain digital data required for making interpretive plots as in Figure 1 (which was derived from the strip chart).

The strip charts remain necessary as a means to track progress during field activity and to determine which segments of digital data are to be used for interpretation.

Schedule

It was originally expected that the project would be in its third month at this point. Due to the complexity of the required signal conditioning and the need to conduct additional field testing, the tasks of finalizing the configuration of the equipment and obtaining successful field testing have added at least eight months to the schedule.

Budget

As of June 30, 1998, Don Michels Associates invoiced the project \$33,950 for labor. Dr. Michels has \$24,250 left in the budget to complete the experiments in Nevada and Costa Rica, and to co-author the final report.

As of June 30, 1998, Geothermal Development Associates invoiced the project \$26,965. The unexpected difficulties with signal conditioning have required a substantial number of hours from our electrical engineer and technician. GDA has \$21,560 left in the budget to complete the equipment assembly, provide project management, and co-author the final report.

The original budget for equipment, materials, chemical analyses, and outside services was \$25,180. At the end of the second quarter of 1998, \$6,837 had been expended in these categories. DMA and GDA have confidence that the existing equipment will prove suitable, and that the only other major purchase would be some type of data logger to complement the strip chart recorders.

In summary, \$70,475 has been spent, representing about 52% of the total funded by the DOE. Table 1 has been included detailing expenditures and budget amounts for the various categories.

Anticipated Work in Third Quarter of 1998

The experimental methodology and equipment, although greatly improved, has not yet been finalized. Prior to Dr. Michels' trip to Costa Rica, GDA and Dr. Michels will conduct additional field trials of the equipment in Nevada.

It is anticipated that upon successful completion of system development in early August, Dr. Michels will travel to Costa Rica in the last part of August. This would allow data reduction and production of a draft report before the end of the third quarter of 1998. The final report and dissemination of the results will likely occur in the fourth quarter of 1998.

Summary

In this period, the benefits of sampling both conductivity and temperature within the chamber were determined. Good correlation between conductivity and temperature was achieved for both the chamber and pipeline fluids.

In the next period, the temperature and conductivity probes for the chamber fluid will be combined into a single probe. A data logger will be added to facilitate statistical analysis of the data. After final field testing in Nevada, the system will be transported to the Miravalles geothermal field in Costa Rica to determine the lowest practical temperature to which separated brine can be cooled without forming detrimental silica scale.

Respectfully submitted,
GEOTHERMAL DEVELOPMENT ASSOCIATES

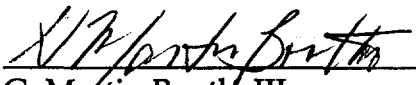
 July 23, 1998
G. Martin Booth, III Date
President

Figure 1.

TEMPERATURE-CONDUCTIVITY at CAITHNESS, 18Jun98 DATA FROM REACTOR CHAMBER

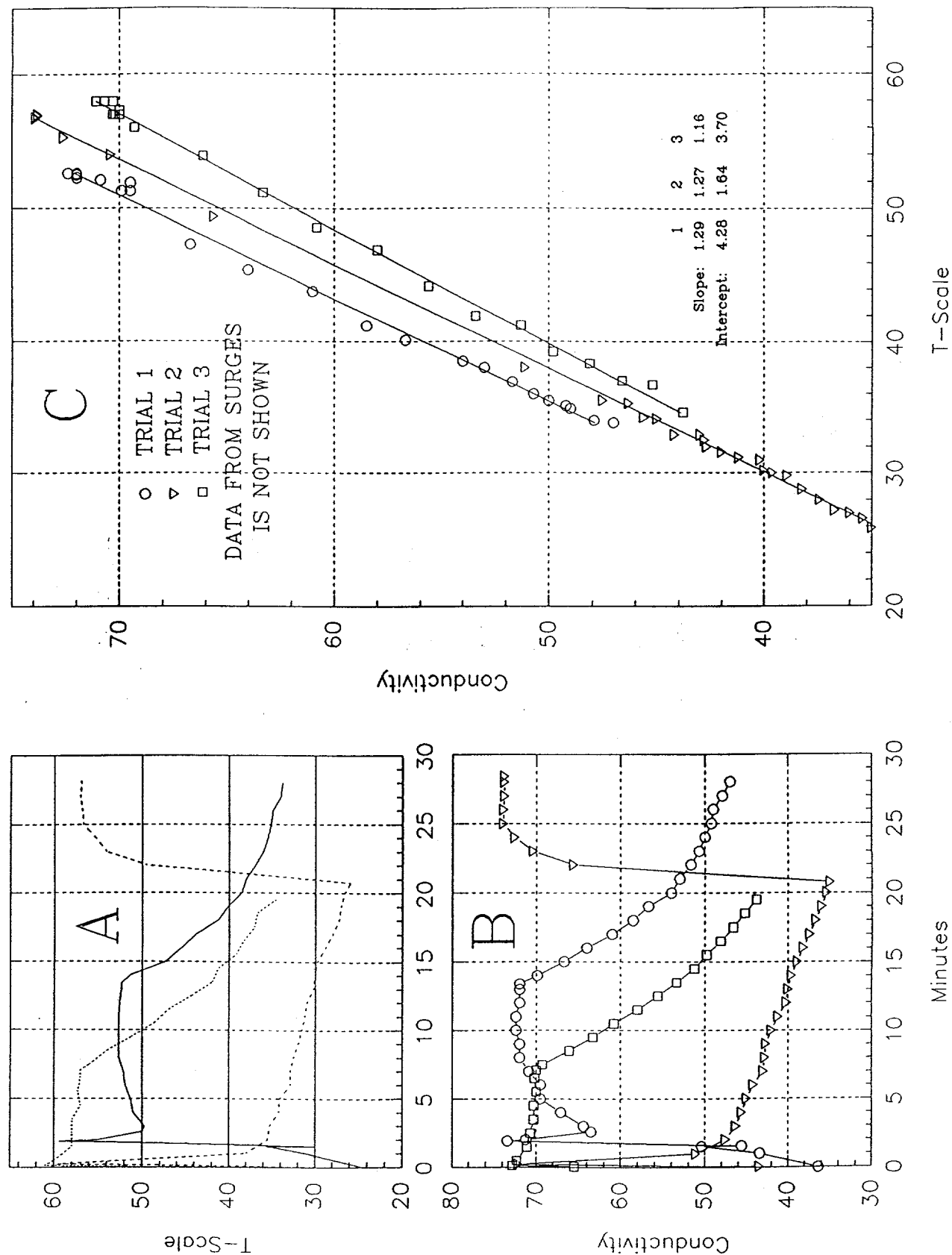


Table 1. Budget Summary by Task
Period Ending June 30, 1998

No.	Section of Form 424A Description	6a, 6b		6a, 6b		6f		6d, 6e		6f		6c		Total (Actual)
		Actual	Budget	Actual	Budget	Actual	Budget	Actual	Budget	Actual	Budget	Actual	Budget	
1	Project Management	23,465	32,400											\$ 23,465
2	Finalize Design & Procure Components			6,250	4,000			5,710	15,980					\$ 11,960
3	Build and Assemble Components			9,400	6,300						500			\$ 9,900
4	Field Test in Nevada	3,500	4,875	18,300	11,900	239	1,500	388	1,000			2,723	2,125	\$ 25,150
5	Field Experiments in Costa Rica				21,000		6,200						1,200	\$ 0
6	Data Reduction and Reporting		11,250		15,000								1,620	\$ 0
	Total	\$ 26,965	\$ 48,525	\$ 33,950	\$ 58,200	\$ 239	\$ 7,700	\$ 6,098	\$ 16,980	\$ 500	\$ 500	\$ 2,723	\$ 4,945	

Total DOE Funding (Budget) \$ 136,150

Total to date (Actual) \$ 70,475

Balance remaining \$ 65,675