

Lawrence Berkeley National Laboratory

LBL Publications

Title

Geothermal Reservoir Engineering Management Program Vol 2 No 3

Permalink

<https://escholarship.org/uc/item/5dt481gx>

Author

Lawrence Berkeley National Laboratory

Publication Date

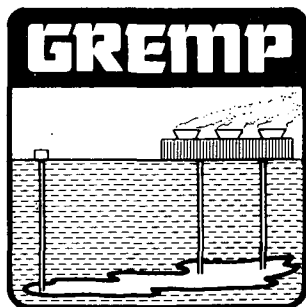
1979-08-01

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.



NEWS from

Geothermal Reservoir Engineering Management Program

Sponsored by

U.S. DEPARTMENT OF ENERGY - DIVISION OF GEOTHERMAL ENERGY

RECEIVED

NOV 12 1979

L.B.L. LIBRARY

Vol. II, No. 3
August 31, 1979

This is the fifth edition of *News from GREMP*. This edition is an update and features the specific achievements of five contracts now in progress. Copies of the *News from GREMP* are being sent to individuals who requested the publication by returning the coupon, attached to Vol. I, No. 1 and 2, and Vol. II, No. 1 and 2. For your convenience the coupon is being repeated again in this edition.

PROJECT HIGHLIGHTS

1. MODELING OF GEOTHERMAL RESERVOIRS TO MATCH PRESSURE PRODUCTION PERFORMANCE AND FACILITATE WELL TESTING ANALYSES

Principal Investigators: Frank G. Miller and William E. Brigham (Stanford University)

Objective: Improve methods of well test analysis for fractured reservoirs, forecast producing rates, and estimate reserves.

Progress: Preliminary research has been completed in recent months on three different projects:

1. Studies have been made of a parallelepiped reservoir model designed to analyze the pressure behavior of geothermal steam wells penetrating vertical fractures. Partially penetrating fractures common to many geothermal well systems were considered in the development of this model. Significantly, it is not limited to analyses of predesigned buildup and interference tests, but can also be used to analyze long-term pressure-production well data. Results will be presented publicly later in the year.

2. A reservoir engineering study was made of the Gabbro field, in Italy. Material balances coupled with pressure losses caused by fluid flow were developed. Depletion of a deep boiling zone was assumed to result from production at Gabbro plus losses to Larderello. Past production history has been matched. Application of the

PUB 285

model represents a new approach to geothermal reservoir problems. The model has been used to forecast future rates and reserves. Early publication of results is planned.

3. A study of geothermal well testing involving the application of "influence functions" has been made. The influence function is defined as the relationship between pressure and time for a well producing at a constant unit flow rate. Defined in this manner this function can be utilized in the common techniques of well test analysis. For geothermal wells, however, the pressure requirements of turbine inlet streams and unavoidable well shut-ins invariably lead to fluctuations in the flow rate. Thus, it is necessary to find influence functions that will alleviate the shortcomings of available data. Four different versions of such an influence function applicable to gas and geothermal wells have been developed. Results of this research will be presented publicly in September 1979 (Economides et al.).

Reference

Economides, M., Brigham, W. E., Cinco-Ley, H., Miller, F. G., Ramey, H. J., Jr., Barelli, A., and Manetti, G., 1979. Influence functions and their application to geothermal well testing. To be presented at the 1969 Annual Meeting of the Geothermal Resources Council, Reno, Nevada, Sept. 24-27, 1979.

2. DEPOSITION OF CaCO_3 SCALE IN POROUS MATERIALS DUE TO FLASHING GEOTHERMAL FLUID

Principal Investigator: Donald E. Michels (Republic Geothermal, Inc.)

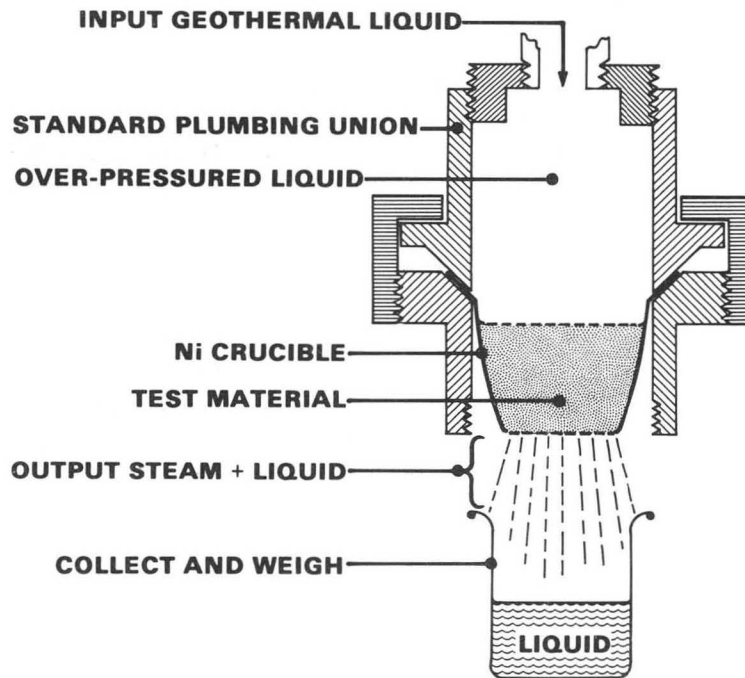
Objective: Obtain empirical data and make correlations among the features of deposition and the chemical and hydrodynamic conditions.

Progress: Field studies and most lab studies are completed. One-phase geothermal fluid from a pumped well at East Mesa was flashed inside cartridges of granular materials (Fig. 1). The resultant two-phase fluid transmissibilities were monitored during the field runs and compared with one-phase transmissibilities measured in the lab. Weight changes for the cartridges were used to estimate the amount of CaCO_3 deposited. Those results were compared with a chemical method based on the Ca losses from the fluid.

Distribution of the scale in the porous materials was determined by infusing the granular porosity with epoxy so that thin sections could be cut and examined with a petrographic microscope (Fig. 2). An assortment of nine granular materials and two rocks were used to obtain a range of pore structures, anticipating that the nature of fluid expansion and their chemical effects are partly dependent on the nature of the "chambers" in which flashing takes place.

Deposition occurred in most of the cartridges, but the efficiencies were not uniform. From 5% to 95% of the available Ca was retained in the substrate. Correlations of this variability with other features of the pore structures and fluid flow are still under study.

The samples were nominally 40 mm along the flow axis and in most the deposition occurred in the lowermost 10 mm, except that little or no deposition occurred within 1 mm of the downstream face of the granular material. In some substrates the zone of deposition was as little as 1 mm wide. Two exceptions involved glass beads, which retained CaCO_3 throughout the entire length of the substrate. These



XBL 799-11360

Fig. 1.

Setup for flashing
liquid in porous media.

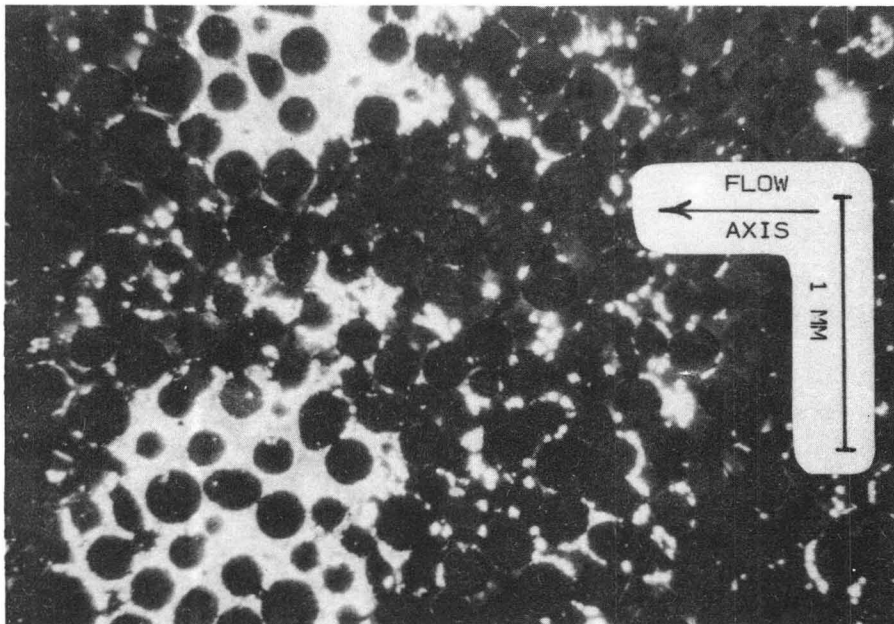


Fig. 2

Light-colored areas are CaCO_3 deposits among glass spheres. Photo is of a thin section and was taken through crossed nicols. An alternation of CaCO_3 -rich areas of apparent low permeability with CaCO_3 -poor areas characterized a zone at the downstream portion of a test cartridge used in this study.

two also had high chemical efficiencies for Ca depletion of the fluid. They also had exceptionally small values for the ratio of two-phase/one-phase fluid transmissibility.

Thin sections show that deposition of CaCO_3 generally occurs uniformly around individual grains of substrate. This implies that differences in fluid speeds at various places on a grain are not significant on a micro scale. Thus, the movement of Ca ions in fluid boundary layers is a major component of the reaction mechanism that forms CaCO_3 .

Analysis of the flashed fluids showed that the amounts of CO_3^{2-} , which develops from HCO_3^- during passage of fluid through the pore structures, were different among the several materials used. This buildup of CO_3^{2-} is a principal cause of the deposition of CaCO_3 . Finding that the amount of CO_3^{2-} which develops is partly dependent on the flashing event constitutes an important discovery in geochemistry and in geothermal development. Specifically, it demonstrates a hitherto unappreciated connection between the macroscopic events in fluid dynamics and the sub-microscopic events in aqueous chemistry.

A full technical report on this research is planned for December 1979.

3. GEOTHERMAL DECLINE CURVE ANALYSIS

Principal Investigator: Elliot J. Zais (Elliot Zais & Assoc.)

Objective: Analyze geothermal production data to develop standard operating procedures for using decline curves.

Progress: Data from Wairakei, New Zealand; Larderello, Italy; Cerro Prieto, Mexico; and Olkaria have been prepared for analysis. Arps's decline curve equations have been programmed into a least-squares statistical package. The 34 best producers at Wairakei have been analyzed using the exponential equation and 18 of the regressions show very good fits. All the data sets will be processed using Arps's (1945) equations. In addition the Larderello set is being analyzed following the work of Brigham and Morrow (1974) and Pruess, Zerzan, Schroeder, and Witherspoon (1979). Other analysis techniques being looked at include Fetkovich's (1973) type curve approach.

References:

- Arps, J. J., 1945. Analysis of decline curves. Trans. AIME.
- Brigham, W. E. and Morrow, W. B., 1974. P/z behavior for geothermal steam reservoirs. Dallas, SPE 4899.
- Fetkovich, M. J., 1973. Decline curve analysis using type curves. Dallas, SPE 4629.
- Pruess, K., Zerzan, J. M., Schroeder, R. C., and Witherspoon, P. A., 1979. Description of the three-dimensional two-phase simulator for SHAFT78 for use in geothermal reservoir studies. Berkeley, Lawrence Berkeley Laboratory, LBL-8802.

4. INSTRUMENT TO MEASURE THE CONCENTRATION OF NONCONDENSABLE GASES IN GEOTHERMAL DISCHARGES

Principal Investigator: Roger F. Harrison (Terra Tek)

Objective: To design, construct, and test an instrument that can continuously measure the concentration of noncondensable gases in saturated steam/water geothermal discharges. A device having this capability would be valuable in many aspects of geothermal resource utilization (such as reservoir definition and management, power plant design and operation).

Progress: The design of the measurement instrument has been completed. The unit can continuously monitor gas concentrations of up to 21 wt% in saturated steam/water geothermal discharges at pressures of up to 290 psi.

Two units have been fabricated to date. One unit has been shipped to New Zealand and will be field tested at the Wairakei, Broadlands, and Kawerau geothermal sites. The other unit has undergone a series of laboratory startup and calibration tests. These laboratory tests have demonstrated the operability of the instrument.

In addition to the New Zealand field testing, preparations are currently being finalized for conducting field testing of the second unit at several geothermal areas in the United States. During all field testing, device performance will be verified by making concentration measurements using an alternate measurement technique.

5. EVALUATION OF JAMES METHOD FOR DETERMINING GEOTHERMAL WELLBORE DISCHARGE CHARACTERISTICS

Principal Investigator: Ping Cheng (University of Hawaii at Moana)

Objective: Evaluate the sensitivity of James tube measurements to such parameters as pipe diameter, tapping position, noncondensable gases, and dissolved solids in two-phase fluids using current two-phase critical flow models.

Progress: A computer program based on Levy's critical two-phase flow theory has been written to generate a set of curves for values of slip pressure as a function of the flow rate and enthalpy. The program has been debugged and the generated values were compared with those predicted by James' experimental correlation. Good agreement was found. Using the developed computer program, the results have been plotted in an easy-to-use form for values of 14.7 to 200 psia and for saturation values of 0 to 0.99 for different flow rates. Calculations were carried out for the prediction of wellbore discharge characteristics based on Levy's critical two-phase flow theory. A comparison of results based on Fauske's model, Levy's model, and those based on James' method is presented, which shows that theoretical predictions are in good agreement with James' empirical method. Work on the application of Moody's model has been initiated.

FUTURE MEETINGS OF INTEREST TO RESERVOIR ENGINEERING

Title	Place	Date	Contact
Second Symposium on the Cerro Prieto Geothermal Field	Baja, California, Mexico	Oct. 17-19, 1979	Alfredo Mañon M. Coordinadora Ejecutiva de Cerro Prieto, Comisión Federal de Electricidad, P.O. Box 248 Calxico, CA 92231
Fifth Workshop, Geothermal Reservoir Engineering	Stanford University	Dec. 12-14, 1979	H. J. Ramey (415) 497-1774
Third Invitational Well Testing Symposium (Subject: Well testing of impermeable rocks)	Lawrence Berkeley Laboratory	March 26-28, 1980	W. J. Schwarz (415) 486-6756
Italian/American Meeting on Geothermal Resources Assessment and Reservoir Engineering (ENEL/ERDA)	Lawrence Berkeley Laboratory	March/April 1980 (tentative)	R. C. Schroeder W. J. Schwarz (415) 486-6756
Field trip to The Geysers, California	From LBL	March/April 1980 (tentative)	W. J. Schwarz (415) 486-6756

Note: *News from GREMP* will be sent to those who ask to be put on the mailing list. If you are not receiving *News from GREMP* or if you know of someone who would be interested, please fill out and return the coupon.

PUBLICATIONS AND DOCUMENTS

The following publications will be available upon request from the GREMP Program office at LBL.

- GREMP-1 (LBL-8664)
Annotated Research Bibliography for Geothermal Reservoir Engineering.
(R. Harrison and G. Randall, Terra Tek, Inc.), due August, 1979.
- GREMP-2 (LBL-8669)
Summary of Reservoir Engineering Data, Wairakei Geothermal Field, New Zealand.
(D. Riney, Systems, Science and Software)
- GREMP-3 (LBL-8784)
Modeling Heat and Mass Transfer at the Mesa Geothermal Anomaly, Imperial Valley, California
(K. Kassoy and K. P. Goyal, University of Colorado)
- GREMP-4 (LBL-9088)
Water/rock interactions in the Cerro Prieto geothermal field, Baja California, Mexico.
(W. A. Elders, J. R. Hoagland, E. R. Olson, S. D. McDowell, and P. Collier, UC-Riverside), due September/October 1979
- GREMP- (LBL-9089)
Scale Inhibitor Tests at East Mesa
(O. Vetter, Vetter Research)
- GREMP-6 (LBL-9090)
An Appraisal of Measurement Methods for Geothermal Well System Parameters
(M. Lamers, Measurement Analysis Corporation), due August, 1979
- GREMP-7 (LBL-9248)
Evaluation of Potential Geothermal Well Head Flow Sampling and Calorimetry Methods
Battelle Pacific Northwest Laboratory
- Proceedings, Invitational Well Testing Symposium (LBL-7027)
- Proceedings, 2nd Invitational Well Testing Symposium (LBL-8883)
- News from GREMP, Vol. I, No. 1 (Aug. 1, 1978), No. 2 (Nov. 3, 1978);
Vol. II, No. 1 (Feb. 1, 1979), No. 2, (May 1, 1979)
- Subsidence Series, #1 (GSRMP-1, LBL-8615)
Environmental Economic Effects of Subsidence (EDAW/ESA)
- Subsidence Series, #3 (GSRMP-3 LBL-8617)
Guidelines Manual for Surface Monitoring of Geothermal Areas
(Woodward Clyde Consultants), due September, 1979
- Subsidence Series, #4 (GSRMP-4 LBL-8618)
Areas of Ground Subsidence due to Geofluid Withdrawal
(Systems Control, Inc.)
- News from Subsidence, Vol. I, No. 1 (Feb. 1, 1979), No. 2, (June 1, 1979)

GREMP

☐ I wish to be on the mailing list.☐ I do not wish to be on the mailing list at this time.

Name: _____ Phone: () _____

Affiliation: _____

Address: _____

(city)_____
(state)_____
(zip)

Please clip and return to W. J. Schwarz, Bldg. 90, Room 1012F,
Lawrence Berkeley Laboratory, University of California, Berkeley CA 94720

For further information contact

Werner J. Schwarz
Lawrence Berkeley Laboratory
Building 90, Room 1012A
One Cyclotron Road
University of California
Berkeley, California 94720
(415) 486-6756
FTS 451-6756