PHILLIP M. WRIGHT

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PROCEEDINGS OF SPECIAL PANEL ON GEOTHERMAL MODEL INTERCOMPARISON STUDY

Sixth Annual Workshop on Geothermal Reservoir Engineering

December 16-18, 1980

Work Performed Under Contract No. AT03-80SF11459

Stanford University
Stanford, California

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STANFORD GEOTHERMAL PROGRAM
STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305

PROCEEDINGS
SPECIAL PANEL ON GEOTHERMAL MODEL INTERCOMPARISON STUDY

held in conjunction with
The Code Comparison Contracts
issued by
Department of Energy
Division of Geothermal Energy
San Francisco Operations Office

at the
Sixth Annual Workshop on
Geothermal Reservoir Engineering
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Conducted under Contract No. DE-AT03-80SF11459
Department of Energy
Division of Geothermal Energy

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PREFACE

The Stanford Geothermal Program hosts an annual workshop as part of its contract with the Department of Energy to develop reservoir engineering practices for accelerating the commercial development of geothermal resources. The annual workshop has two major objectives: (1) to bring together researchers active in the various scientific and engineering disciplines involved in the study of geothermal reservoirs to review progress and exchange ideas in this rapidly developing field, and (2) to summarize the effective state of the art of geothermal reservoir engineering in a form readily useful to the many government and private agencies involved in the development of geothermal resources. Each annual workshop features a panel analysis of a problem of major interest to the geothermal energy community.

The topic for panel analysis for the Sixth Annual Workshop in Geothermal Reservoir Engineering was selected in conjunction with the Department of Energy to assess the state of development and the appropriate role of geothermal reservoir simulator models in predicting geothermal reservoir performance as it affects investment decisions. The panel analysis was planned as a cohesive session with (1) an introduction on the background of the DOE decision to issue a number of contracts to determine how well existing simulator models can evaluate problems of varying complexity; (2) a report by the authors of the respective problems on how well the existing codes appear to evaluate the problems; (3) a discussion by invited panelists representing various sectors of the geothermal community to respond on how the state of art of the several simulators might meet industry needs; and (4) a general discussion by all of the participants with summary reports by three selected rapporteurs.

The Stanford Geothermal Program is making the results of this panel session available as a separate report since the potential role of simulators in geothermal reservoir engineering is large, and the need to encourage further development of simulator models is apparent. The Stanford Geothermal Program hopes that these proceedings will assist in furthering the successful development of these simulator models.

Paul Kruger
Stanford Geothermal Program
March 31, 1981

GEOTHERMAL RESERVOIR ENGINEERING CODE COMPARISON PROJECT

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Review of the need for geothermal reservoir simulators, begun at the 1978 Stanford Workshop, continues with the results of U.S. Department of Energy (DOE) contracts on comparison of computer codes. The fundamental issue is the appropriate role of simulators in major investment decisions on geothermal projects, such as the construction of a power plant at a specific reservoir.

WHAT

With this session at the 1980 Stanford Workshop, the Department of Energy responds to the geothermal industry's recommendation that reservoir simulators be evaluated and compared. Last year, DOE Headquarters' Division of Geothermal Energy budgeted for a code comparison project. In February 1980, a group of code developers met at DOE's San Francisco Operations Office to design a set of test problems. In the following papers, the designers of these problems will present the results of this Code Comparison Project.

In June, DOE requested proposals to run the problem set on commercially available geothermal reservoir simulators. In September, multiple awards were made to four offerors: Intercomp; Systems, Science and Software; GeoTrans; and Stanford Univ. Negotiations on a fifth contract were unsuccessful. Lawrence Berkeley Laboratory and the University of Auckland have also prepared solutions to the problem set. Final reports containing solutions, descriptions of the simulators, and approaches were delivered to my office in mid-November. Copies can be obtained from USDOE Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830 (Final Report DOE/SF/11451-1).

DOE has not undertaken to evaluate these results, or to certify any of the reservoir simulators. Rather, the final reports were delivered to the problem designers to summarize and comment on the results. The Department supports the Stanford Workshop as the medium for the geothermal reservoir engineering community to become familiar with these results, and to determine their meaning and value.

WHY

Public funds were expended on this project for two reasons: the recommendation of geothermal industry advisors, and the mandate in the geothermal public law.

In May, 1979, the Technical Review Committee on Reservoir Engineering (Nielson, 1979) recommended to DOE that "Model comparison and validation should be a new initiative in the (Geothermal) Reservoir Engineering Program.

An attempt should be made to try all major codes on the same system and compare results with respect to output and efficiency of the code. It was suggested the codes should be run on an actual geothermal system where adequate data exists rather than a hypothetical situation. Suggested areas which could be used for code comparison include Cerro Prieto, Mexico; Wairakei, New Zealand; or Larderello, Italy. A workshop should then be held on the use and limitations of the various codes available..."

The mandate from Congress to the Department of Energy to support this effort is found in the Geothermal Research, Development and Demonstration Act of 1974 (Public Law 93-410, Sections 103(a) and 104(a)). "The specific goals shall include . . . the development of better methods for predicting the power potential and longevity of geothermal reservoirs; (and) . . . the development of reliable predictive methods and control techniques for the production of geothermal resources from reservoirs."

Don Campbell of Republic Geothermal, Inc. has stated the fundamental need as one of establishing the confidence of consultants to banks, utilities, etc. in computer simulation as a basis for investment decisions on major geothermal projects (e.g. power plants). As you know, computer simulation is an established technique in oil and gas investment decisions.

In summary, we seek to learn what the capabilities of geothermal reservoir simulators are, and if they are reliable bases for geothermal investment decisions.

HOW

In defining how to evaluate and compare simulators, DOE turned to code developers and industry users.

A position paper was prepared for DOE Headquarters by John Pritchett (1979) of Systems, Science and Software, to describe mathematical reservoir modeling and geothermal reservoir simulators. Pritchett pointed out that reservoir simulators are tools used in the overall reservoir modelling process whose application to real fields requires considerable engineering judgment and insight. He suggested, as a first step, testing the reservoir simulators alone by setting up a suite of idealized problems designed to fully exercise the codes, thus testing the "tools" rather than the "modellers."

A comprehensive review of geothermal reservoir simulators has been published by Pinder (1979) under the DOE-LBL subsidence research program.

At the December 1979 Stanford Workshop, differences between numerical simulations and observed data at geothermal fields were discussed by Donaldson and Sorey (1979), and several limited applications were proposed. Their paper responded to the questions posed at the 1978 Workshop: whether these simulators are of any real value, and, if so, what are their best uses.

DOE then requested code developers and industry users to validate the need for a Code Comparison Project. This they did, and recommended that a set of standard problems be defined for that purpose. And, in February, 1980, the code developers met and designed the problem set.

What Next?

In my understanding, the current situation is as follows (Fig. 1):

1) Specific Reservoir and Integrated Model

At operating and developing geothermal reservoirs, field and test data has been used to derive physical properties, their distribution and change over time. These same data form the basis for conceptual model(s) of the reservoir constructed by integrating structural geology, geochemistry and reservoir engineering analyses. Reservoir management strategies (flash, pump, inject, stimulate etc.), selected by the field operator(s), define production and injection operations used to produce the reservoir.

2) Computer Simulator

Fundamental physical processes in geothermal reservoirs have been represented by partial differential equations and assumptions. Several code developers have prepared reservoir simulators to solve these equations. A set of hypothetical reservoir problems has been designed to test the simulators.

3) Reservoir Model and Simulator

With the aid of simulator "tools", matches to actual production data may be achieved. Projections into the future, using possible reservoir management strategies, yield estimates of reserves, production/injection rates and reservoir lifetime. Together with extensive financial and other considerations, these results provide input to investment decisions on the reservoir.

Hopefully, the Code Comparison Project will establish that several reliable reservoir simulator "tools" are now available to the industry. The question remains of how best to engender industry and investment community confidence in the use of geothermal simulators. Perhaps acceptance of numerical simulation will evolve gradually, as more field studies are made which build a track record for the methodology.

Has DOE satisfied the concerns that led the geothermal industry to recommend that this effort be undertaken? Are consultants to major geothermal projects sufficiently confident to start using these "black boxes" for investment decisions?

If not, I invite you to define the tasks, the geothermal reservoir, and the sources of data that are needed. Will the next step be carried out by the industry, or do you recommend that DOE participate in a joint effort?

Acknowledgement

It is a pleasure to acknowledge the contributions of John Pritchett, Karsten Pruess, Michael Sorey, Michael O'Sullivan, Leland Mink and Marshall Reed in defining the code comparison project. Their concern with the relation between simulators and reservoir assessment has deepened my understanding, and increased the effectiveness of this effort.

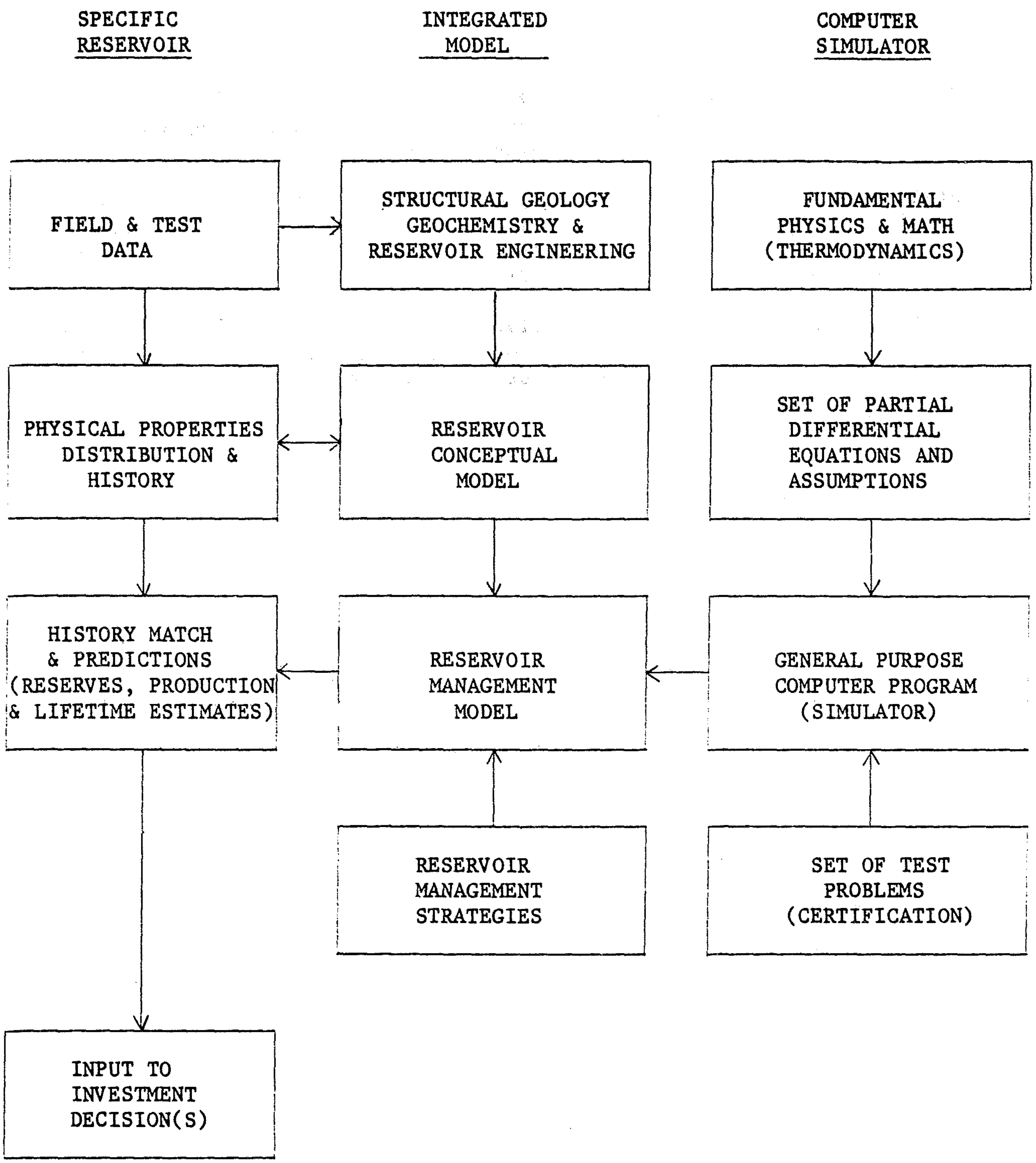

Figure 1. Design and Application of Reservoir Simulators.

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Nielson, D.L. ed., "Program Review, Geothermal Exploration and Assessment Technology Program, Including a Report of the Reservoir Engineering Technical Advisory Group", Earth Sciences Laboratory University of Utah Research Institute, Salt Lake City, Utah; Dec. 1979.

Pinder, George F. and Golder Associates, "State-of-the-Art Review of Geothermal Reservoir Modeling, Geothermal Subscience Research Management Program, Lawrence Berkeley Laboratory, LBL-9093, GSRMP-5, UC-66a, March 1979.

Pritchett, J.W., "Position Paper; Mathematical Reservoir Modeling Using Numerical Reservoir Simulators as Applied to Geothermal Systems", Aug. 1979 (unpublished).

EXHIBIT I

PROBLEM SET

The Contractor shall provide solutions to the problems included herein. Work shall be accomplished in accordance with the terms and conditions of this contract and with the Contractor's proposal submitted in response to Request for Proposal (RFP) No. DE-RP03-80SF10844.

If possible within the project budget, although not a requirement of this contract, problem set #6 will be addressed to illustrate the capabilities of the Contractor's code, but a complete solution will not be provided.