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A DATABASE FOR THE GEYSERS GEOTHERMAL FIELD

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Abstract

A general menu driven software package has been developed that stores and retrieves geothermal field data and produces a large variety of graphic displays. These include, for example, production plots, cross-sections, contour plots, base maps and Horner plots. This has been applied to The Geysers geothermal field which has open file data for over 200 wells. The data include production histories, directional surveys, lithology logs, wellhead temperatures and pressures, digitized base maps, steam entry locations, casing diagrams, pressure transient tests, heat flow measurements and noncondensible gas concentrations. Although the database software was developed using data from The Geysers, it can be used for any geothermal reservoir.

Introduction

The Earth Sciences Division of Lawrence Berkeley Laboratory (LBL) is conducting a research project on The Geysers geothermal field for the California State Lands Commision (CSLS). The main objective of this project is to develop a field-wide model of the heat and mass transport in this large, vapor-dominated system. Another important objective is to understand the complex fracture characteristics of the field and fracture/matrix interactions. The Geysers field presents an excellent opportunity for research into the behavior of goethermal systems because of the large amounts of data that have been collected since drilling began in the 1920's. Several hundred wells have been drilled since the 1960's, when large-scale power production of the field started. Data from these wells include temperature/pressure surveys, rig test data, wellhead pressures and temperatures, production/injection histories, pressure transient tests, lithology logs and directional surveys. These data are invaluable in developing a thorough understanding of the geologic and reservoir processes.

In the first two years of the project, a major effort was devoted to assembling the data and organizing it in an easily accessible form. This was accomplished by compiling a computerized data base and developing a menu driven software package that allows the data to be easily retrieved and exhibited in a variety of plots and maps. Various types of data for individual wells, leases, or arbitrary groups of wells can be retrieved and integrated to produce displays such as cross-sections, production graphs, or contour plots. A flow chart of the system capabilities is shown in Figure 1. This paper provides a brief overview of the database; a complete description may be found in Bodvarsson, et al. (1986).

Data Acquisition and Organization

The data are stored on a MicroVax workstation, using an INGRES database management system. The bulk of the data consists of production and injection histories for 280 wells, obtained on computer tape from the California Division of Oil and Gas (CDOG). The production histories consist of flow rates, wellhead pressures and temperatures, and shut-in pressures. Of the 280 wells, 200 are publicly available "open file" wells and the rest are proprietary wells located on State leases. Nearly all of the data from a well is considered proprietary during at least the first five years of its production life. After that period, the well is usually put on open file, which means that the production histories and much of the drilling data become public domain. Drilling reports and additional data such as well locations, casing diagrams, directional surveys, lithologic logs and steam entry depths were obtained from well files at the DOG offices, USGS and GRC reports and the open literure. These data were manually entered into the database.

Data Presentation and Analysis

Directional surveys typically have 50 to 60 data points consisting of measured depth, true depth, and east-west and north-south horizontal deviation. Depths range from less than 1000 feet in some wells near the Thermal shallow anomaly to greater than 10,000 feet in the northwest Geysers. Well courses at The Geysers range from nearly vertical to having horizontal displacements greater than 2000 feet. Several wells are usually directionally drilled from one drilling pad to minimize drilling costs, because of the rough terrain at The Geysers field.

The lithology data were taken from detailed mudlogs. Each rock unit was assigned a numerical code which the computer draws as an unique symbol. A sample computer generated cross-section incorporating directional surveys, lithology data, casing shoe depths and steam entry locations is shown in Figure 2. Cross-sections can be drawn for any number of wells and the wells can be projected onto any specified plane, or onto planes connecting the wells. The steam entries shown in Figure 2 all occur within the graywacke, which is true throughout most of The Geysers reservoir. Figure 3 shows a histogram of the total number of steam entries in each lithologic unit, for the wells in the database. The number of steam entries per well at The Geysers ranges from 1 to about 20, with 3 to 6 being the most common.

The database contains production histories from wells dating back to the 1960's, yielding flowrates and shut-in pressures that reflect changes in reservoir conditions caused by exploitation. A sample flowrate plot from the database is shown in Figure 4. The wellhead pressures may be plotted versus time for individual wells or computer generated contours of shut-in pressures may be drawn for a group of wells, as shown in Figure 5. The large amount of flowrate and pressure decline information contained in the database provides excellent history matching control for calibrating computer models. It is also very useful for performing material balance calculations and decline curve analysis. The database software has the capability to carry out decline curve analysis of flow rates by performing a least squares fit of the data to the hyperbolic, harmonic and exponential decline equations. An interactive type-curve matching procedure may also be performed, by matching the flowrate data to theoretical curves developed by Fetcovich (1980).

Base maps of The Geysers have been digitized to include power plants, wellhead locations, topographic data, and section, county and lease lines. Surface traces of the directional surveys may also be included on the map. Maps may be generated for the entire field or for any lease. Contours of data such as shut-in pressures, degree of superheat at the wellhead, heatflow and depth to first steam entries may also be drawn on the base map.

General Applications of the Database Software

Although the system is currently being applied to data from The Geyers field, it can be used for any geothermal reservoir. New applications are easy to add because the menu driven package has been designed in a modular format. The database and plotting programs are general enough that the package can incorporate different types of data beyond what is used at The Geysers. One new application currently under development are cross-sections plotted on a 3-D projection. Another possible extension of the system is in the pressure transient analysis option. A variety of theoretical curves could be incorporated in the interactive type curve matching procedure.

Summary

A wide range of geologic, reservoir engineering, and production data from The Geysers geothermal field has been assembled and entered into a single computer database. Menu driven software has been developed that easily retrieves and plots the data in a wide variety of formats. Different data sets can be retrieved and integrated on a single plot. For example, directional surveys, lithology, and steam entry depths can be combined to produce detailed cross-sections. The database software can perform simple engineering analysis such as decline curve analysis, calculate and draw contours, and Horner plot pressure transient analysis. The database software is general enough to apply to any geothermal system.

References

Bodvarsson, G.S, Cox, B.L., Fuller,P., Ripperda, M., Stein, D., Tulinius, H., Witherspoon, P.A., Flexser, S., Goldstein, N., Pruess, K. and Truesdell, A., 1986, *A Database for The Geysers Geothermal Field., vols. 1, 2 and 3, LBID-1257.*

Fetcovich, M.J., 1980, Decline Curve Analysis using Type Curves, *J. of Pet. Tech.*, pp. 1065-1077

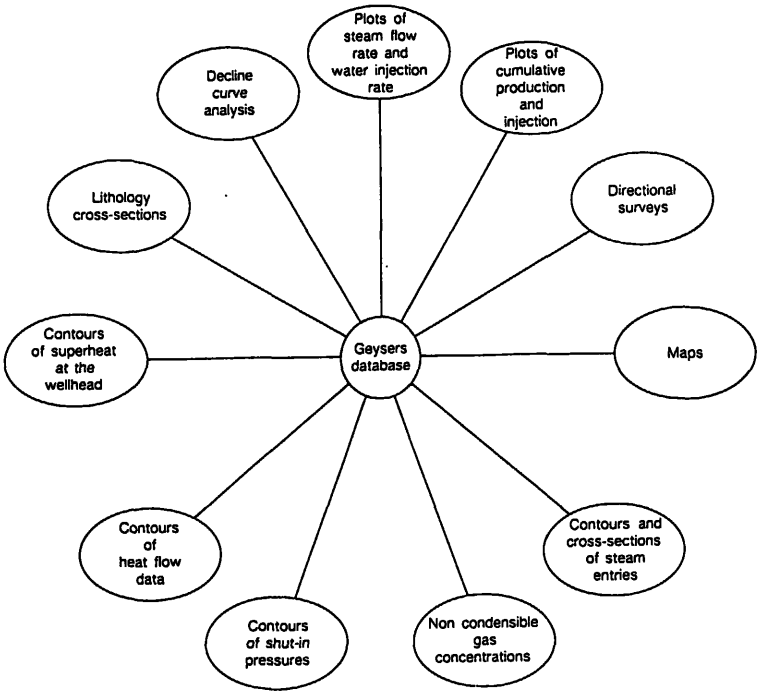

Figure 1. Capabilities of the database system.

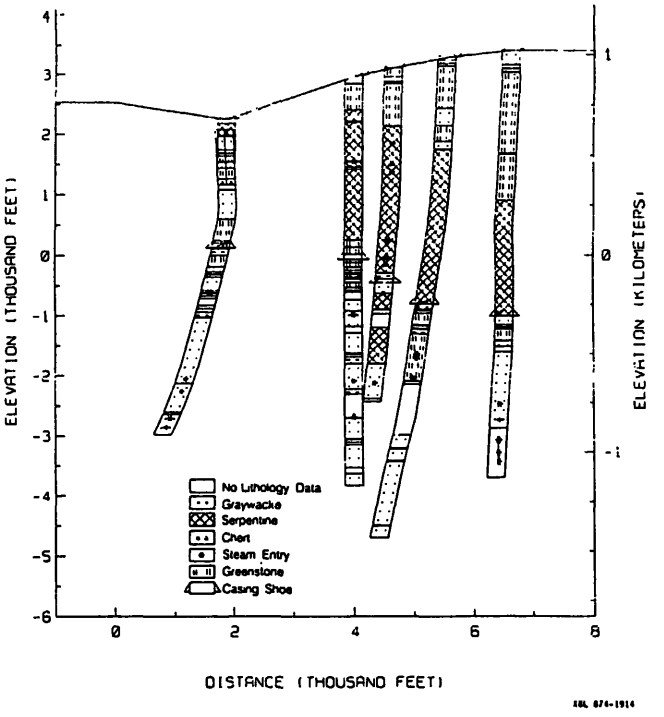

Figure 2. Sample cross-section of several wells from The Geysers geothermal field. The stars correspond to steam entries, the triangles are the casing shoes, and symbols represent lithologic units.

Acknowledgements

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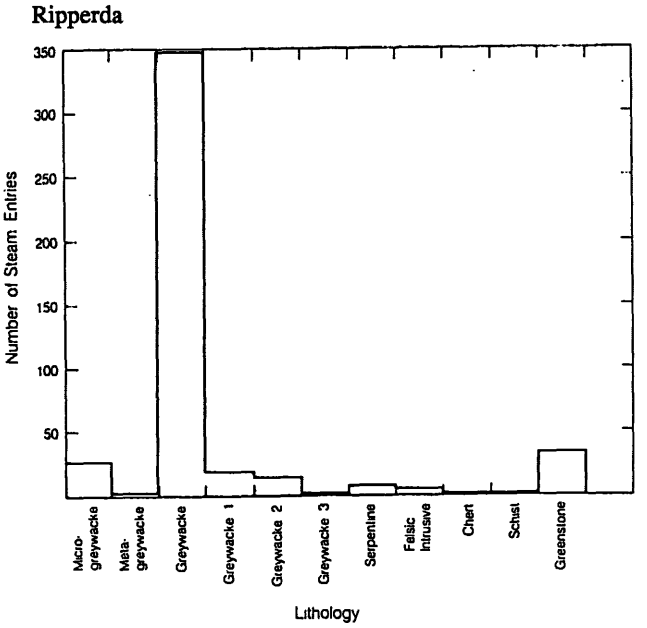

Figure 3. Number of steam entries reported for the various lithologic units in The Geysers reservoir.

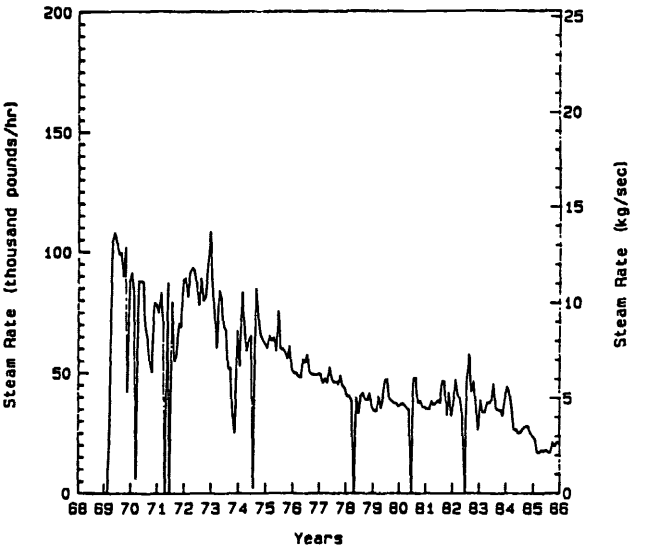

Figure 4. Steam flowrate curve for a well at The Geysers.

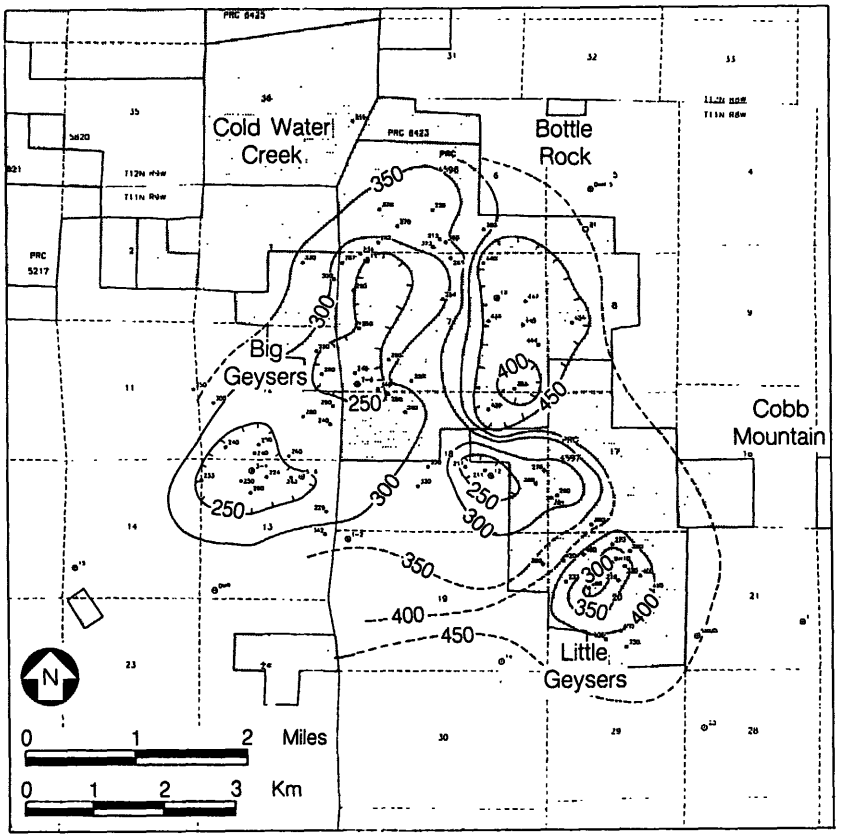

Figure 5. Contour plot of shut-in pressures at The Geysers for 1980.