STUDY OF WATER INFLUX AND FLUID COMPOSITION IN THE BAGNORE FIELD

(Progress report and plan of future action for Task 3/15)

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Abstract

The purpose of Project 3/15 is to study water influx and variations of fluid composition in the Bagnore field. As this field contains large amounts of noncondensable gases it is an ideal candidate for studying the relationship of these gases with the flow performance of geothermal wells. An additional asset is that a posteriori models can be deduced because the field is depleted. The ultimate goal, of course, is to extract technology applicable to other reservoirs at an early stage in their development.

Introduction

Short-term as well as long-term models are to be considered.

1. Pressure transient analyses can be utilized to estimate reservoir variables such as permeability, porosity, and extent of drainage areas. Thermal effects are usually ignored in such analyses if isothermal operation is assumed, but this can affect the reliability of estimates. Other factors complicating geothermal rock formations are boiling interfaces, fractures in otherwise impermeable matrices, and nonhomogeneities. For the Bagnore field, large quantities of noncondensable gases also complicate analyses.

   From preliminary work it appears that pressure analyses can be facilitated by use of the "real gas pseudopressure," m(p), defined by:

$$m(p) = \int_{p_o}^{p} \frac{p}{\mu Z}\, dp$$

   in which p is the pressure of interest, p_o a base pressure, μ absolute viscosity, and Z the gas deviation factor. A calculation of the real gas pseudopressure or potential for the Bagnore field is now under way. Additionally, a more general form of this function is currently being generated for various noncondensable gas compositions. However, one must consider also that classic techniques of pressure transient analysis presume single-phase fluid reservoirs.

An approximation of what is believed to be a typical geothermal-reservoir configuration is the recently published "parallelepiped model." Even this configuration with its assumption of vapor- and liquid-dominated zones, may yield only gross-approximation results. Laboratory research just completed at Stanford University indicates that significant amounts of fluid can be adsorbed on the surfaces of geothermal rocks. Boiling off of this adsorbed fluid can account for as much as ten times the amount of steam that would otherwise be present in the pore space.

A solution of applicable partial differential equations using the adsorbed water mathematically as a source function is planned for early attention.

2. A more sophisticated approach to the Bagnore reservoir study and for an extension to other geothermal reservoirs, is to use M. O'Sullivan's two-phase model, recently discussed in the <u>Society of Petroleum Engineers Journal</u>.

   The O'Sullivan model has already been modified in the present research to include the effect of carbon dioxide. This modification can be extended easily to include other gases, methane for example. The model consists of a numerical simulator which is designed to interpret the long-term behavior of the Bagnore field. This simulator includes both dynamic and thermal effects; with the introduction of the gas factor, Z, it can also account for thermodynamic vapor-liquid equilibria. Further, the recent Stanford findings on water adsorption can easily be incorporated. An effort toward this goal is now under way.

3. While pressure transient analysis may provide values for reservoir parameters such as permeability, porosity, and length and height of fractures, it fails to yield estimates of the liquid reserves of geothermal reservoirs. Whether fluid is adsorbed or whether it exists as "subformation brine" it is often the major source for steam production at the surface.

   A guide method utilizing a "black box" Rayleigh distillation also has been developed in the present work. The distribution coefficients necessary for the distillation calculation can be both functions of pressure and temperature. The method can give an approximation of the liquid reserves provided that no water influx or generation of CO_2 is evident.

4. An all encompassing verification of the above methods can be represented by the results of a geochemical study currently under development. A conceptual model able to explain initial distribution of CO_2, CH_4 and possibly H_3BO_3 and NH_3, utilizing equilibrium calculations, will be investigated.

   Temperature of the depleting reservoir can be calculated using appropriate H_2 and H_2S geothermometers currently under development.

   The geochemical study could confirm the decreasing height of the vapor-dominated zone, the lowering of temperature by water-table influx, and possibly could reveal coning phenomena as well as determine whether appreciable amounts of carbon dioxide are entering the brine either by lateral influx or by generation in place. Answers to these questions will aid evaluation of the other models mentioned earlier in this report.

Future work

The continuation of Task 3/15 will be accomplished partly in Italy and partly at Stanford.

In Italy the model developed under Task 3/15 will be further improved and applied to the Bagnore field.

Gas behavior will be investigated applying the already modified model of O'Sullivan.

At Stanford the major effort will be devoted to developing simple techniques for analyzing pressure transients, taking into account the real gas potential for the Bagnore field, while long-term gas behavior will be studied by means of the Rayleigh distillation calculation.

Acknowledgments

This work was carried out as a part of Project 3 of the DOE-ENEL Agreement on Cooperative Research and Development in Geothermal Energy. The authors thank their sponsoring agencies for the opportunity to participate in this binational cooperative effort.