

## 論文要旨

区分	甲	氏名	Enrique Alberto Porras Mendieta
論文題名 DEVELOPMENT OF NUMERICAL MODEL OF THE MOMOTOMBO GEOHERMAL FIELD, NICARAGUA ニカラグア国モモトンボ地熱地域の数値モデルの開発に関する研究			

## 論文内容の要旨

The Momotombo geothermal field is the only field that has been developed in Nicaragua in spite of its large potential of geothermal resources. Momotombo has been exploited since 1983 with installed capacity of the power plant that was progressively increased to 77MWe by 2002 with two condensing type and one binary type. Actual power output, however, dropped down to only 9 MWe in 1999, but it recovered to 35 MWe in 2003 with a rehabilitation program. Main reasons for insufficient steam supply to the plant are because of well productivity decline probably due to reservoir temperature decrease and scaling in wellbore. Thus, quantitative evaluation of reservoir productivity is of importance for proper management of the reservoir as well as maintaining power output. This can be only realized through numerical simulations of reservoir by use of a numerical model.

Objectives of the study are to develop a reliable numerical reservoir model that can explain reservoir behaviors during the last twenty years exploitation, and also can predict future performances of reservoir and well upon various production and reinjection scenarios. Then, a plausible exploitation scenario can be proposed for future management of geothermal reservoir at Momotombo.

The dissertation consists of six chapters. Chapter 1 introduces the background of this study, literature review and objectives of the study.

Chapter 2 presents available field data from studies on geology, geophysics, geochemistry, and well measurements to extract features of the geothermal systems at Momotombo prior to any exploitation. In particular, repeated temperature measurements in wellbore were examined in detail to construct subsurface temperature structure. They were combined with fault distributions, and then a conceptual model of reservoir system was developed. The model indicated that high temperature fluid(>320°C) recharged at depth flows upward through fault systems in the northwest of the well

field, then flows laterally to the southeast in shallow zone. There present no flow boundary in the east of the field.

Chapter 3 is devoted for description and examination of production well histories for more than twenty years exploitation to understand changes in reservoir conditions, and for analysis of field data. Chloride concentration of produced fluid and discharge enthalpy explained that decreases in steam production of wells were caused by extensive boiling in the shallow reaservoir and low temperature shallow water intrusion. Interference test analysis provided values of transmissivity and storativity for  $1.27 \times 10^{-7} \text{ m}^3/\text{Pa}\cdot\text{s}$  and  $2.36 \times 10^{-6} \text{ m}/\text{Pa}$  in the presence of impermeable boundary. Grant's curves for steam-water relative permeability seem to be the most appropriate ones for the Momotombo reservoir where two-phase conditions were formed.

Chapter 4 is focused on development of a three dimensional numerical model of the Momotombo geothermal reservoir. The model of porous type included features described in the conceptual model of Chapter 2. Development of two-phase zone and its extension with time in the shallow reservoir was successfully simulated. The changes of phase condition from two-phase to liquid water single-phase induced by the halt of fluid production of wells in 1997-2000 were also reproduced. Pressure draw down history of four wells were satisfactory matched except for well MT11. Agreements on discharge enthalpy of shallow wells were relatively poor for wells of high enthalpy. Simulated temperature distribution during history matching indicated that cooling in the shallow reservoir occurs as a result of boiling.

Chapter 5 presents predictions of reservoir and well performances upon four different exploitation scenarios. The scinarios were examined by numerical simulations using the best model of Chapter 4 for the next fifteen years. Effects of reinjection water temperature on production wells and required number of makeup wells to maintain a specified steam production(400 t/h) were evaluated. Simulated results of a scenario that considered reinjecting at relatively shallow depth near the production zone affects on flow rates and enthalpies of produced fluid from most of the shallow production wells. The most suitable reinjection can be deep and farther away from the production area such as in the southeast of the current well field.

In Chapter 6 conclusions are drawn, and recommendations are made for future studies on numerical simulation of the Momotombo geothermal system.