

RESERVOIR MANAGEMENT OF THE HATCHOBARU GEOTHERMAL FIELD

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SUMMARY— Reservoir pressures and temperatures in the Hatchobaru Geothermal field has been monitored since 1988, using several observation wells. These observed values are remarkably changed after 1990, starting the commercial operation of the second unit (No.2 unit) with power output of 55MWe. A numerical model for reservoir simulation was refined from the original one, using of these observed data. On the basis of the new reservoir simulation model, a behavior of generating capacity was recomputed, and changes of reservoir condition were visualized by the computer graphics tool named **GRAVIS**.

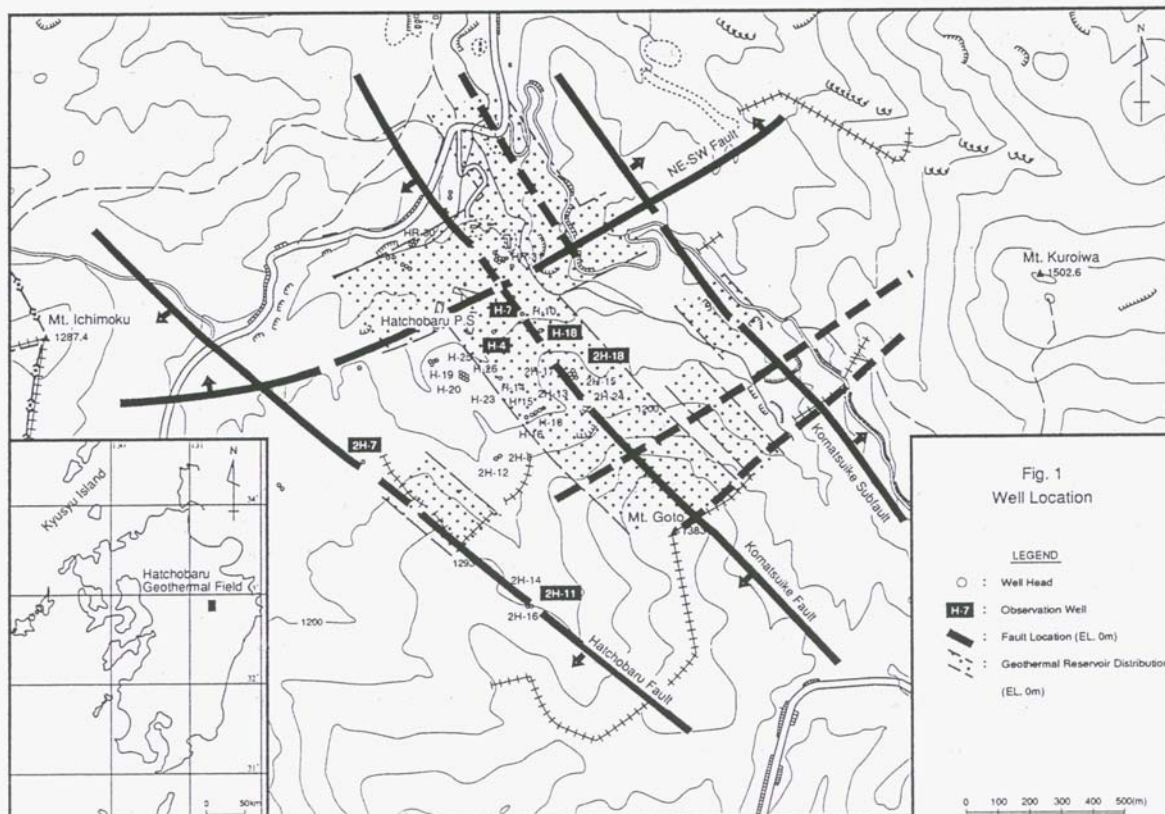
1. INTRODUCTION

In the Hatchobaru Geothermal field, central Kyushu, Japan, the first unit (No.1 unit; 55MWe) has been operated with stable generating conditions since 1977, by KEPCO (Kyushu Electric Power Company Co.). Temperatures and pressures have been monitored since 1988.

In 1990, the construction of Hatchobaru No.2 unit was finally completed. For No.2 unit, geothermal resources was developed mainly in the southeastern margin of known extent reservoir utilized for No.1 unit. The total generating capacity at that time reached to 110MWe which is the biggest generating

capacity in Japan. However, the power output has dropped gradually to about 90MWe (82% of capacity) for two years since 1990.

A simulation of reservoir characteristics was carried out, to know the reason for the steam capacity dropping and countermeasures for recovering the power output to 110MWe. This paper describes the simulation results based on monitored data, also shows some examples of computer graphics which present the distribution of pressures and temperatures obtained from the simulation.



2. MONITORING

In Hatchobaru, the monitoring of reservoir pressure and temperature was started with capillary-type equipment since 1988, before the commercial operation of N0.2 unit in 1990. Well location and monitored pressures and temperatures are shown in Fig.1 and Fig.2, respectively. The monitoring results can be summarized as follows.

①For both wells of H-4 and H-7 in the northern part, the pressure changes are in the same tendency each other. These changes are thought to be resulted from the combined interfered pressures among twenty-six active wells located in the present production zone, mainly along the Komatsuike subfault. From pressure interference analysis, the transmissivity (Kh) of this part is estimated to be around 80 to 100 darcy-m.

②Pressure and temperature of H-7 decrease about 8kg/cm^2 and 30°C , respectively. The decreasings of pressure and temperature are considered to be resulted from steam production for N0.2 unit and from inflow of reinjected water.

③The pressure history of 2H-7 observation well, which is situated at the western far from the Komatsuike subfault, is different from those of H-4 and H-7. This phenomenon show that the Komatsuike subfault plays a role of hydraulic boundary.

④The pressures and temperatures of 2H-18 situated at eastern side of the Komatsuike subfault, have not changed. However, the pressures of 2H-11 at the southern part of the Komatsuike subfault have decreased after the commercial operation of N0.2 unit. From these facts, main and deep origin of geothermal reservoir in the Hatchobaru geothermal field is situated around the eastern part of present reservoir. This coincides with the idea of the first reservoir model.

3. SIMULATION

3.1 Numerical Model

A three-dimensional numerical reservoir model was refined from original one, to change the boundary conditions, permeabilities and other necessary conditions by means of history matching to the monitored pressures and temperatures. Fig.3 shows the final model.

3.2 History matching

The results of history matching give good matchings, as a whole (as shown in Fig.4). The behavior of reservoir pressures and temperatures in past five years (1988-1993) was simulated. The results are shown in Fig.5.

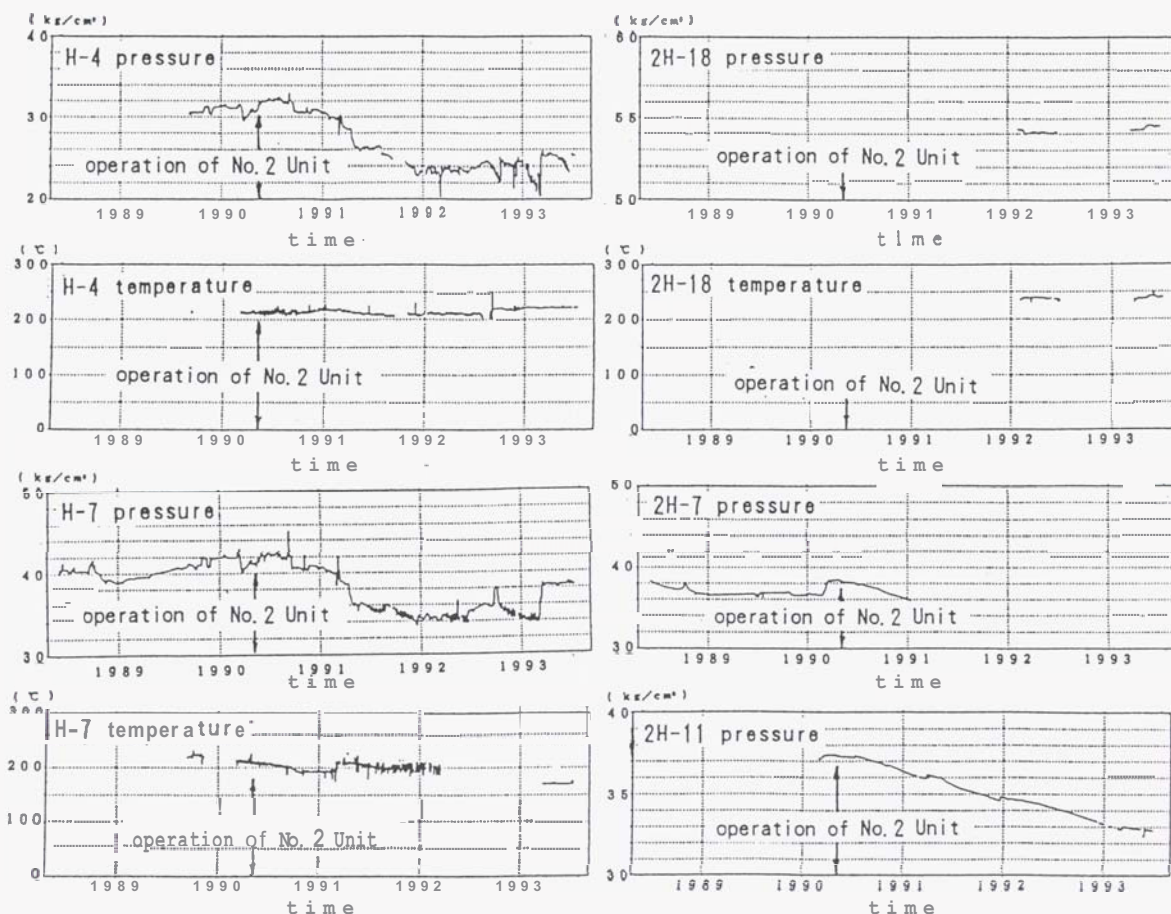


Fig.2 The result of reservoir monitoring

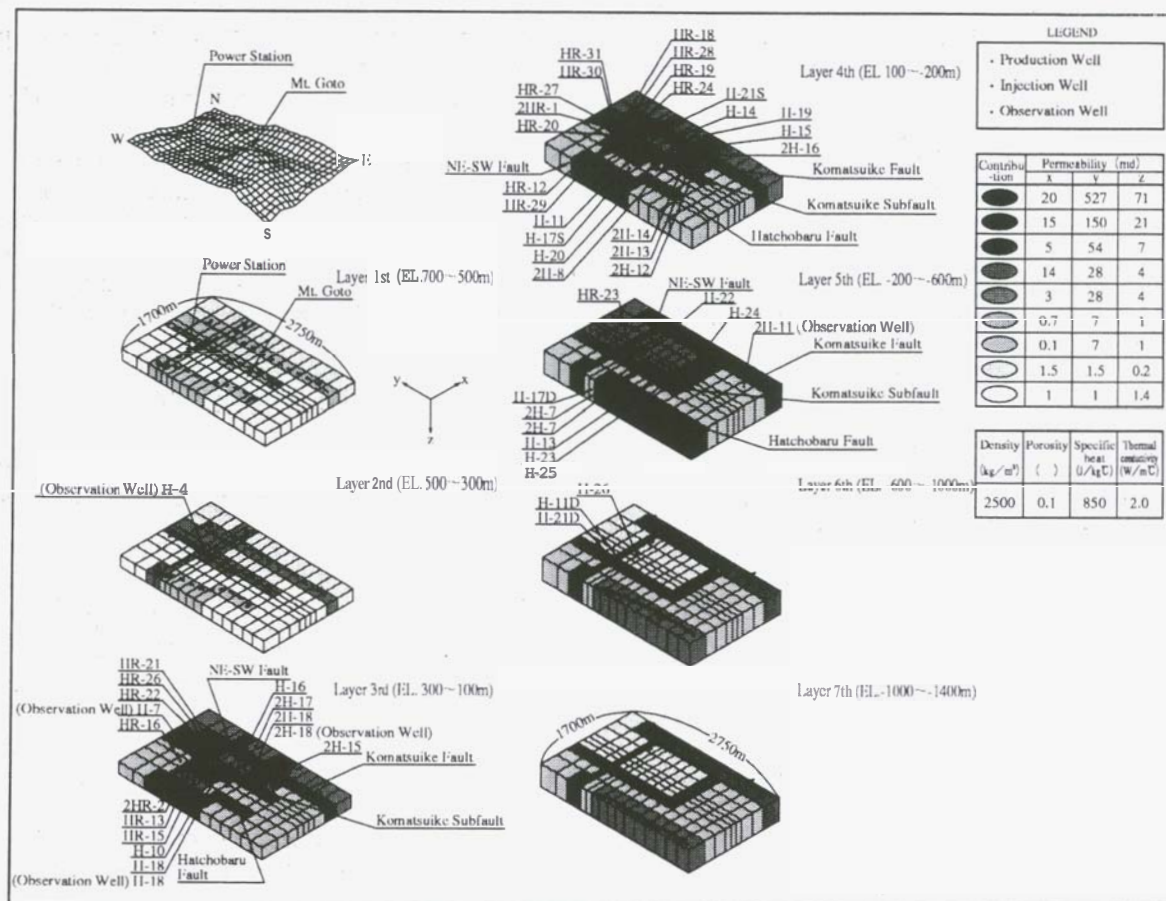


Fig.3 3D Numerical Model of Geothermal Reservoir in Hatchobaru

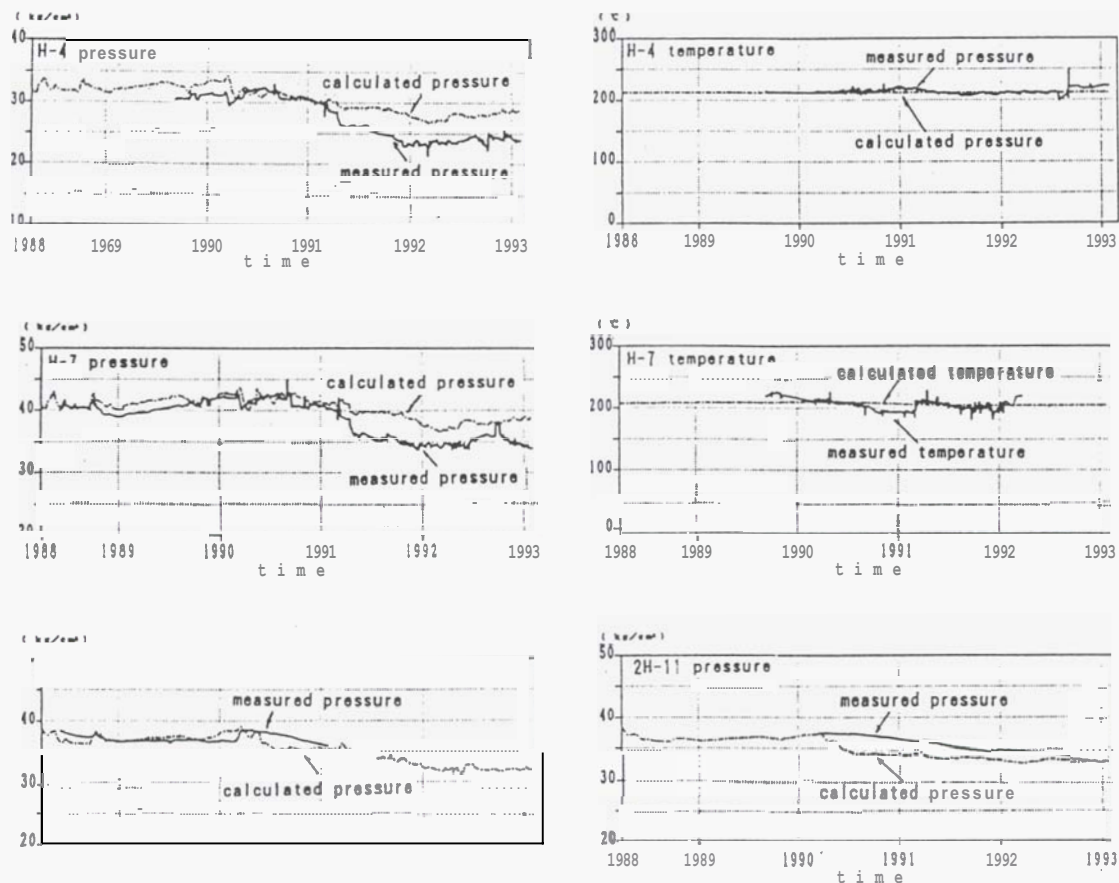


Fig.4 The result of history matching

①The average pressure decline in the production area of No.2 unit is about 9kg/cm^2 and the average temperature drop is about 1.5°C . However, both pressure and temperature seem to be stable.

②The average pressure decline in the production area of No.1 unit is $5-7\text{kg/cm}^2$ and the average temperature drop is 7°C . The pressure seems to be stable at present, but the temperature is still decreasing. The temperature drop is estimated to be about 3°C per year. The decreasing of the pressure and of the temperature are thought to be resulted from steam production for No.2 unit and from inflow of reinjected water, respectively.

③Recently, reinjection wells were located in the northern part of reinjection area, more than 500m far from production area. And the decreasing of reservoir temperature was moderated. Therefore, it is considered that the effect of reinjection on reservoir temperature can be removed by replacing the reinjection wells.

3.3 Prediction

The future behavior of power output was predicted by the well-flow simulation and the reservoir simulation. The result is shown in Fig.6, and suggested as follows.

①In case of no additional well in future, the total electric power will drop to 77.6 MWe in 1998. (No.1 unit; 34.5MWe, No.2 unit; 43.1MWe). The decline of power output per year is estimated to be 3%. (No.1 unit; 5%, No.2 unit; 1%)

The reservoir temperature of five production wells (H-10,14,18,19 and 2H-16) will drop $3-6^\circ\text{C}$ per year. The reservoir temperature of another five

production wells (H-15,16,26,2H-13 and 2H-17) will decrease and the power output of these wells will drop. The reliability of above-mentioned prediction results was confirmed sufficiently in comparison the with the observed power output during 1992-1993.

②In case of drilling six additional wells on the basis of the future development plan, the power output will recover to 110MWe in 1995, assuming the average power output of 5MWe per one production well. It will be possible to sustain 110MWe by drilling one additional production well every year after 1995.

4. COMPUTER GRAPHICS

The visualization-system of reservoir information by computer Graphics (CG) has been developed for the reservoir management.

The examples of CG are shown in Fig.7 and Fig.8. These were made by using SUN VISION, which is a graphic tool for SUN SPARC Work Station. Fig.7 represents the pressure and temperature distribution in reservoir at 200m above sea level, and Fig.8 represents the reservoir temperature distribution at sea level, which are obtained by reservoir simulation. It is possible to represent dynamically change of pressure and temperature distributions. And the CG of three dimensional geological structure and resistivity distribution helps us to realize the reservoir structure.

All data for is managed by the Data Base named GRAVIS (Geothermal Reservoir Analytical-information Visualization System), which was originally developed by KEPCO and WJEC. At present this system has been utilized to locate additional well and to study the reservoir behavior.

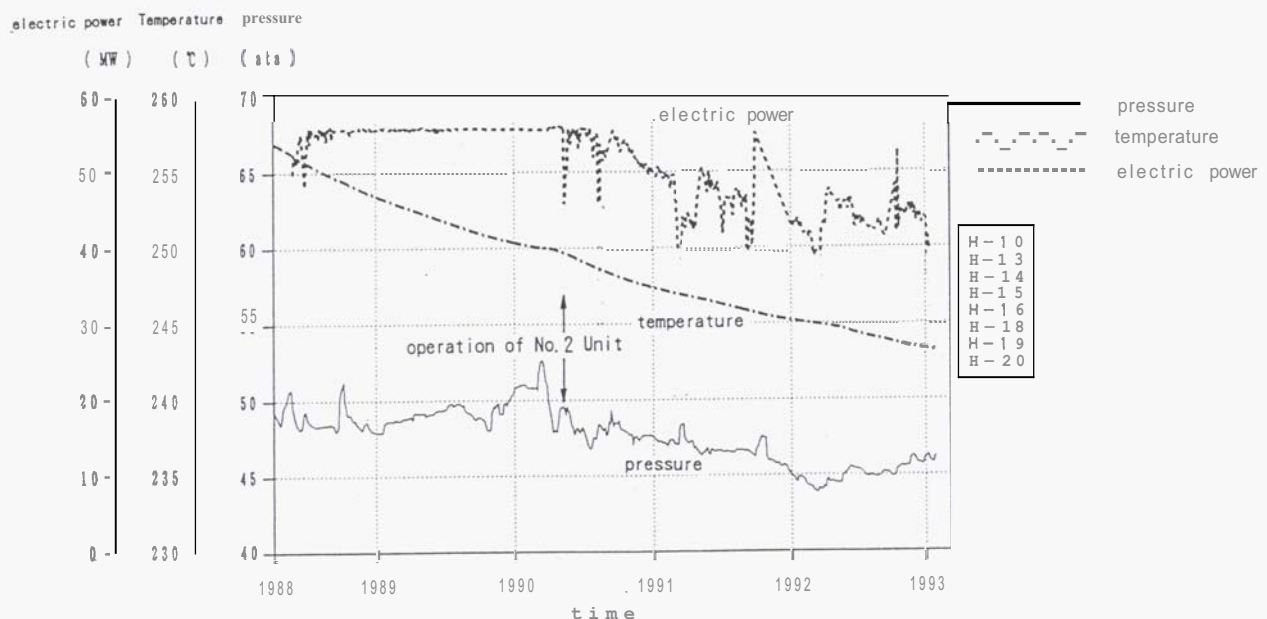


Fig. 5 The reservoir behavior in the production area of No. 1 Unit (1988-1993)

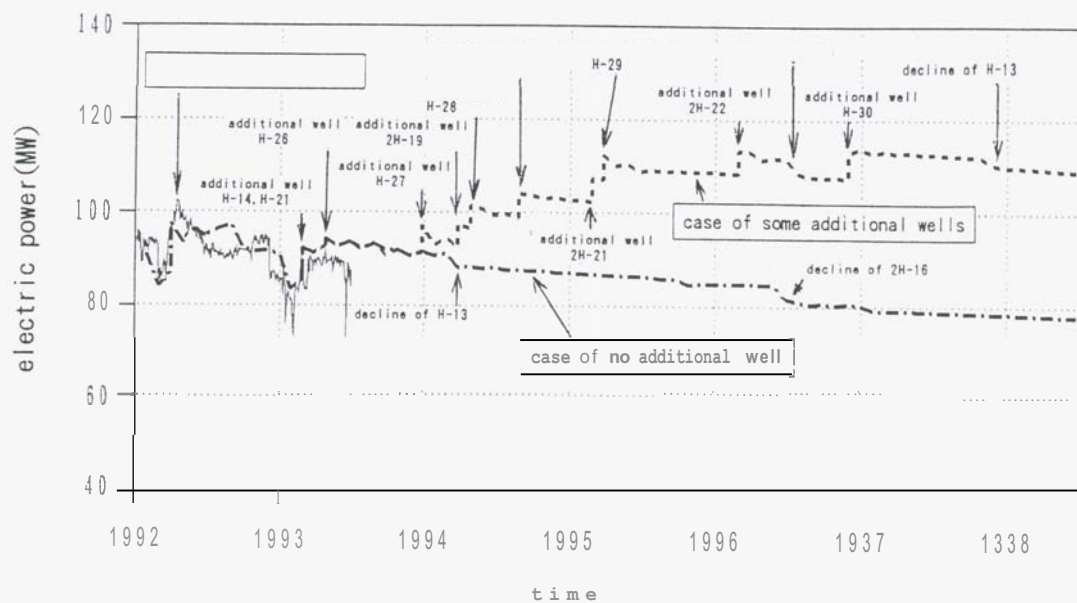


Fig. 6 The predicted behavior of electric power

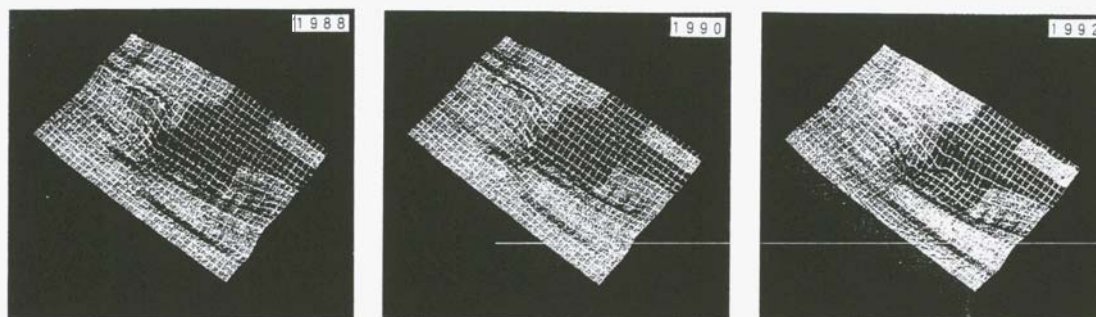


Fig. 7 The change of reservoir pressure and temperature distribution



Fig. 8 The change of reservoir temperature distribution