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PRESENT STATUS OF THE OTAKE AND HATCHOBARU GEOTHERMAL POWER PLANTS(II)

——ON THE EXPLORATION AND RESEARCH ——

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ABSTRACT

The Otake and Hatchobaru geothermal fields are situated in northern side of the Oita-Kumamoto line, southern margin of the Beppu-Shimabara graben. From Miocene to Pleistocene, a large scale volcanic activity occurred in the graben, has resulted in the active geothermal fields such as Beppu, Yufuin, Otake, Hatchobaru, Aso, Unzen, etc, widely distributes and reserves an abundance of the geothermal energy.

This paper introduces the reservoir models and developing situations of Otake and Hatchobaru geothermal fields.

I. Reservoir models of Otake and Hatchobaru geothermal fields.

Otake and Hatchobaru geothermal fields are closely related to the Quaternary volcano Kujyu as shown in Fig. 1 Quaternary volcanoes in Kyushu. Distance from Otake geothermal field to Hatchobaru geothermal field is about 2km, however these fields have different characteristics such as the reservoir depth, chemical composition of geothermal fluid, reservoir capacity and etc, and then are interpreted as independent system each other.

Surface surveys and explorations were conducted around the Otake and Hatchobaru fields, such as aerophoto analysis, regional and detailed geological survey, gravity survey, magnetic survey, radioactivity survery, geochemical survey, isotope analysis, resistivity exploration, mise-a-la-masse, seismic exploration, and etc. These surveys and explorations data and well drilling data were compiled to modify the reservoir models, and are summarized as follow.

(1) These geothermal fields are mainly developed along the NW-SE trending faults and/or fractured zones of Quaternary volcanic rocks.

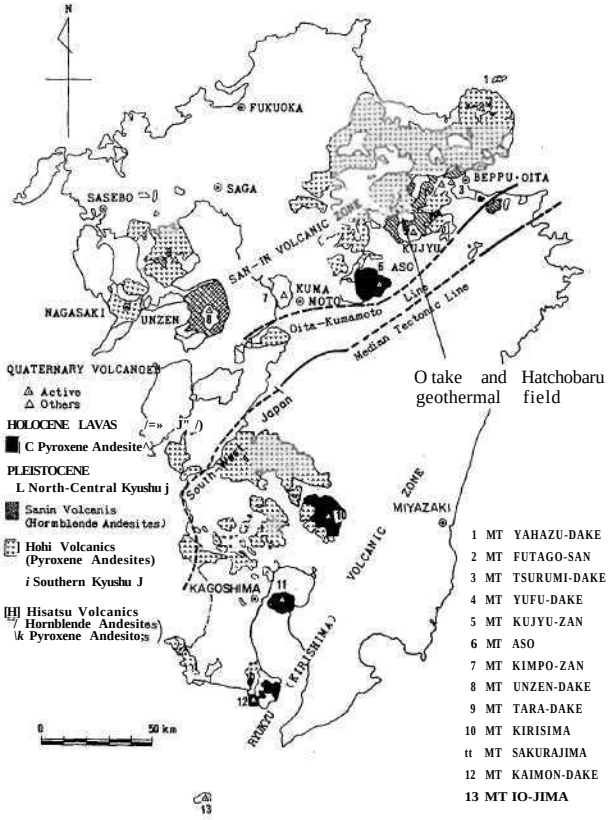

Fig- 1 . Quarternary volcanoes in kyushu. (Yamasaki. 1960)

(2) These geothermal fields are located at uplight structure of Pre-Tertiary basement, which is supposed by Bouguer gravity map in general and is comfirmed by deep exploratory well at Hatchobaru field.

(3) Origin of geothermal fluid is supposed as meteoric water which is permeated to the deep at southeast of Otake and Hatchobaru respectively, according to tritium and isotope analysis of surface water and discharging geothermal fluid samples.

(4) Heat source is assumed as heat conduction at deep rocks, because the chemical compositions of discharging geothermal fluid do not contain eruptions directly out of the magma, and indicate higher temperature at the southeast in where the youngest volcanic domes are outcroped.

(5) Temperatures of geothermal fluid in the reservoir are about 220 - 260 C at Otake geothermal field and about 250 - 290 C at Hatchobaru geothermal field.

(6) Acidic hydrothermal alteration zone is distributed along the NW-SE trending fault at the surface. As shown in Fig.2. Reservoir model of Hatchobaru geothermal field, the acidic hydrothermal alteration zone is distributed at the shallow part and roles as the cap-rock, neutral-alkali hydrothermal alteration zones are distributed at the below of acidic hydrothermal alteration zone and forms the reservoir, and then silica minerals are dominant at production zone.

(7) From the viewpoints of resistivity structure, production zones are mostly detected at the discontinuity of electrical basement, and that the value of low resistivity layer of upper the electrical basement are 3-5 ohm-m.

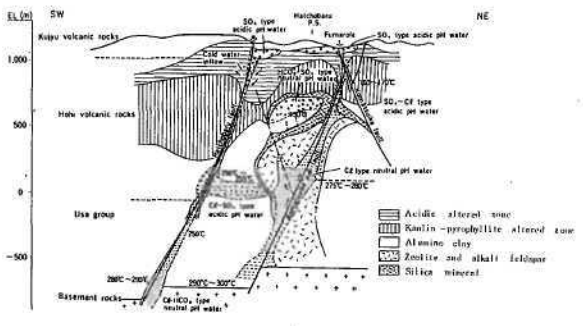

Fig. 2 Reservoir model of Hatchobaru geothermal field

Well evaluation methods (such as geological insepection, X-ray analysis, mercury analysis and fluid inclusion homogeneous temperature analysis of core / cuttings samples) during well drilling are recently very useful to decide the well completion and to decide to drill the well deeper than the planned depth.

Well characteristics of physical and chemical properties are very important not only at the beginning of production to utilize for power generating, but also after the production to carry out long periods reservoir simulation.

II. Recent data of Otake geothermal field

Otake geothermal field was developed around surface manifestations at the beginning of development, therefore the regional reservoir model such as heat source, fluid circulation system and etc was not clear. However, the reservoir model was prepared based on the review of existing data, new exploration data such as magnetotelluric survey (MT), controlled source audio magnetotelluric survey (CSAM) to drill replacing wells. The model shows that most production wells are related to Yokoo fault and most reinjection wells are related to Otake and Kawarayu faults. Replacing production and reinjection wells are planned based on the model, and most of them are drilled successfully. For an example, CSAMT data indicates that promising area is distributed at far from the surface manifestations and that at deeper than the developed production zone. The replacing production well 0-22 was planned based on this data to drill to 1200m depth in spite of the depths of production wells at Otake field are -400 - 500m as shown in Fig.3 Profile Otake geothermal field, was drilled to the depth of 154.0m, and was finally succeeded to produce steam which is equivalent to 6MW. It is very epochal that fluid inclusion homogeneous temperature analysis of cuttings shown in Fig.4 Temperature profile of well 0-22 was the only available data to decide to drill deeper than the planned drilling depth.

III. Development of Hatchobaru Unit II

Reservoir model of Hatchobaru geothermal field prepared from the drilling data of production and reinjection wells showed that the reservoir is formed in and around the NW-SE trending fractured zone and/or Komatsuike-subfault.

The development plan of Unit II was started based on the abovementioned model and to develop the southeastern extention of the same reservoir.

However, the new survey and exploration data (such as geological survey, isotope analysis of surface water and discharging geothermal fluid, MT and CSAMT and etc) indicate that NE-SW trending fault is crossed to Komatsuike subfault at around Mt.Goto and that promising geothermal reservoir is formed in and around the NE-SW trending fault as shown in Fig.5 Hatchobaru geothermal field. The development plan of Unit II was modified to develop the NE-SW trending reservoir which is formed in a different geological structure from the Komatsuike subfault and is far from the production wells of Unit I, by considering the capacity of reservoir developed for Unit I and the interferences among production wells.

Exploratory wells for Unit II were drilled based on the modified reservoir model of Hatchobaru geothermal field, and were succeeded to produce steam which is equivalent to 38MW.

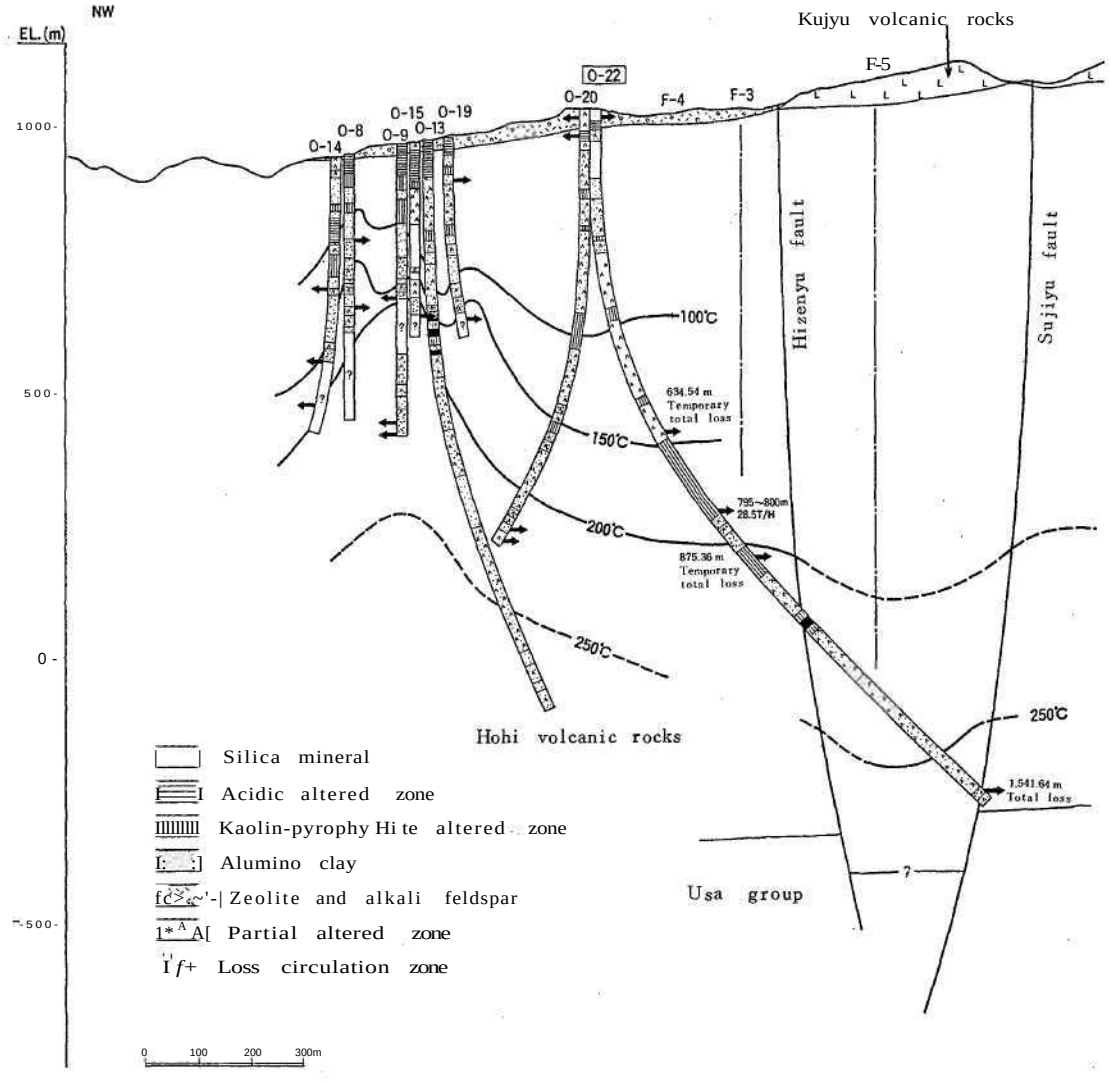

Fig. 3 Profile of Otake geothermal field

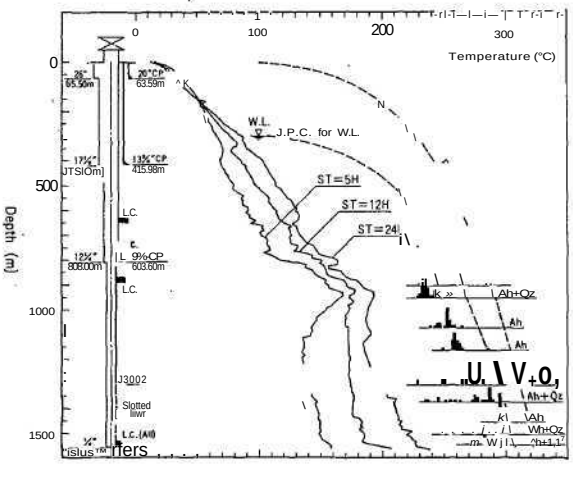

Fig. 4 Temperature profile of well 0—22

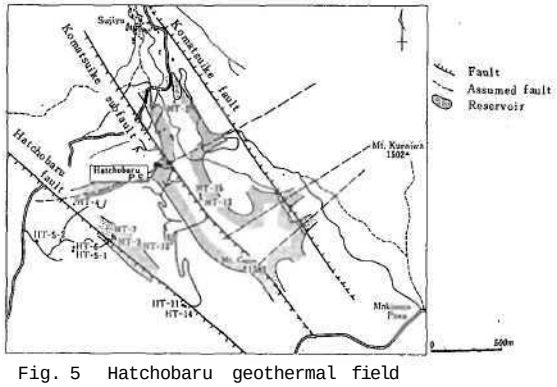

Fig. 5 Hatchobaru geothermal field

Reservoir evaluation for the modified reservoir model and interference test between the production zones for Unit I and Unit II were conducted simultaneously.

Construction of Unit II started in 1987 based on the results of abovementioned studies.

IV. Others

Capacities of Otake power station (12.5MW) and Hatchobaru power station Unit I (55MW) were decided by the developed steam flow rate and by considering the extention of promising area. Otake power station and Hatchobaru power station Unit I have been operated continuously more than 22 years and 12 years respectively, and therefore the capacity factors of these power plant are extremly high.

Capacity of Hatchobaru power station Unit II(55MW) was carefully studied by reservoir simulation using two dimensional block model and history matching of enthalpy. Calculated enthalpy comparatively coincides with the observed enthalpy records as shown in Fig 6 Production history of H-4. and H-7.

It will be, however, necessary'to evaluate the reservoir capacity more accurately from the viewpoints of long period planning. For these purposes, it is planned to develop an accurate three dimensional simulator and to carry out interference test for long period.

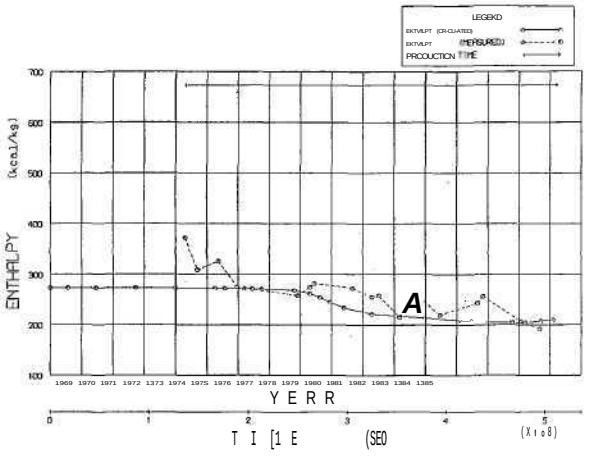

Fig. 6 Production history of H—4 and H—7

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