Ogachi Project with Multi-layer Fracturing Method for HDR Geothermal Power - Outline and Future Plan -

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Abstract

A 22-day water circulation test, from a 1,000-m deep injection well to a production well through two hydraulically fractured zones at about 720 m and 1,000 m, was performed in the fall of 1993 at the Ogachi Hot Dry Rock (HDR) site, northern Japan. During the test, the injection flow rate increased from 400 to 1,200 liter /min at almost constant pressure of 20 MPa. Unfortunately the recovered water from the production well was as small as 4 % of the injected water. According to AE (microearthquake) observation results, the production well is not connected to an estimated main floe path. We sill conduct a fracturing test in the production well to get good watrr connection to the main flow path.

INTRODUCTION

The Central Research Institute of the Electric Power Industry (CRIEPI) has conducted a Hot Dry Rock (HDR) geothermal energy production project since 1986. The project is divided into five Phases (I – V) as shown in Figure 1. In the first Phase I, a new hydraulic fracturing method was developed. Three fractures were created at different depths by applying thn method tu a 400-m deep injection well drilled at Akinomiya, northern Japan (Kaieda et al., 1990). In Phases II and III, experiments have centered on the site at Ogachi, in northern Japan. We call these experiments 'Ogachi project'. The site is separated hy about 4 km from the previous Akinomiya site. We wished to confirm the practicability of the fracturing method by applying it to rock at a depth of 1,000 m and at a temperature of 200 ℃ at first. After creating two fractures at different depths hy the hydraulic fracturing method developed in Phase I, a production well was drilled in

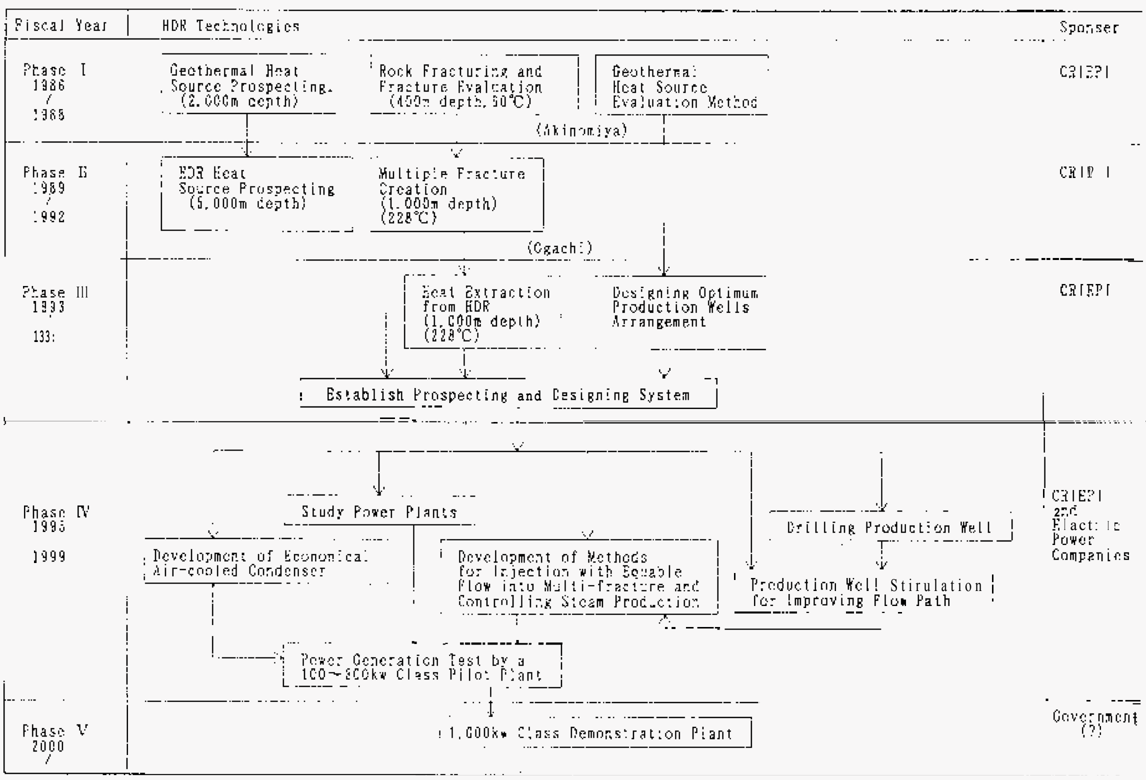

Figure 1. CRIEPI's Plan for the HDR development.

order to intersect both the fractures in 1992 (Hori et al., 1994). The following are results obtained in a 22-day water circulation test conducted through the fractures between the injection and the production wells in 1993.

Ogachi HDR project

As shown in Figure 2, an injection well was drilled at Ogachi in 1990. The well reached a depth of 1,000 m and a bottom-hole rock temperature of 228℃. The well penetrated granodiorite from a depth of around 300 m (*see* Figure 3). Two fracturings were conducted by the hydraulic fracturing method developed in Phase I. The first (lower) fracture was created by injecting a total of 10,169 m^3 of water at a bottom 10-m open-hole interval of the injection well. According to AE observation results, the fracture created extended in a direction of N20° E with a 1,000 m length (Kaieda et al., 1992). The second (upper) fracture was created by injecting a total of 5,400 m^3 of water at a interval from 711 m to 719 m in the injection well. The fracture created was estimated to extend in a direction N110 E with an 800 m length (Hori et al., 1994). A production well was drilled in 1992 in *order* to intersect both the fractures according to the AE location distributions.

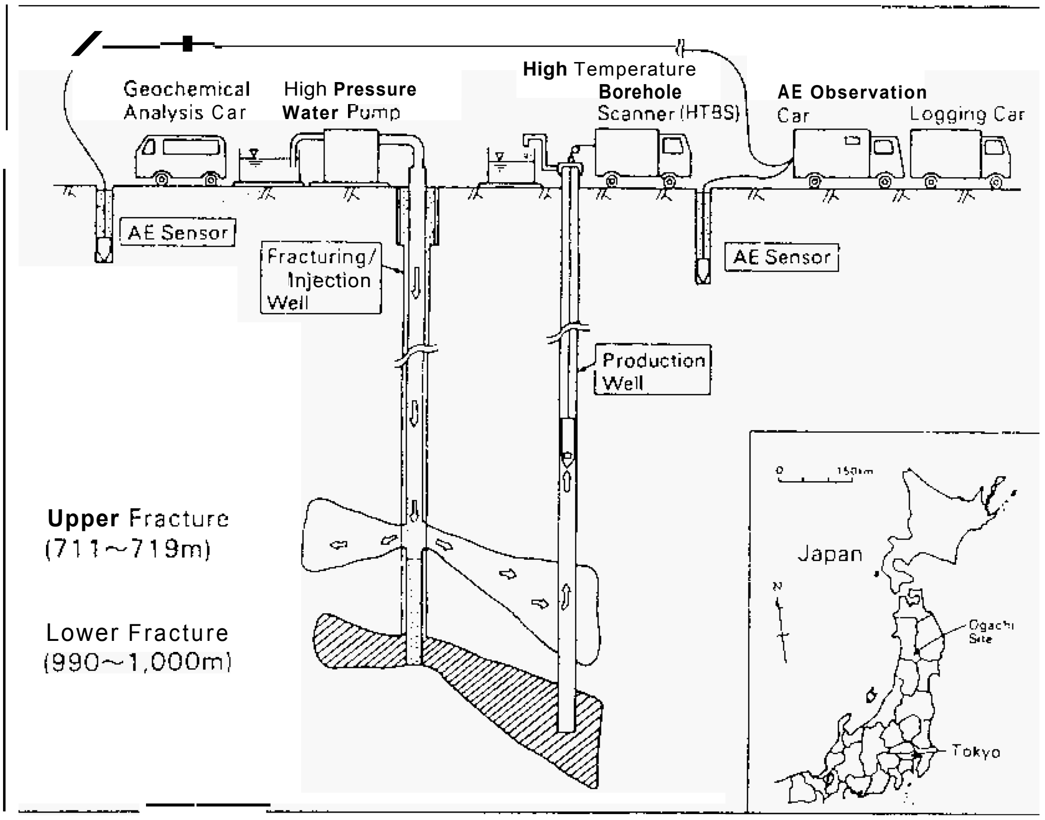

Figure 2. Concept of Ogachi HDR experiment

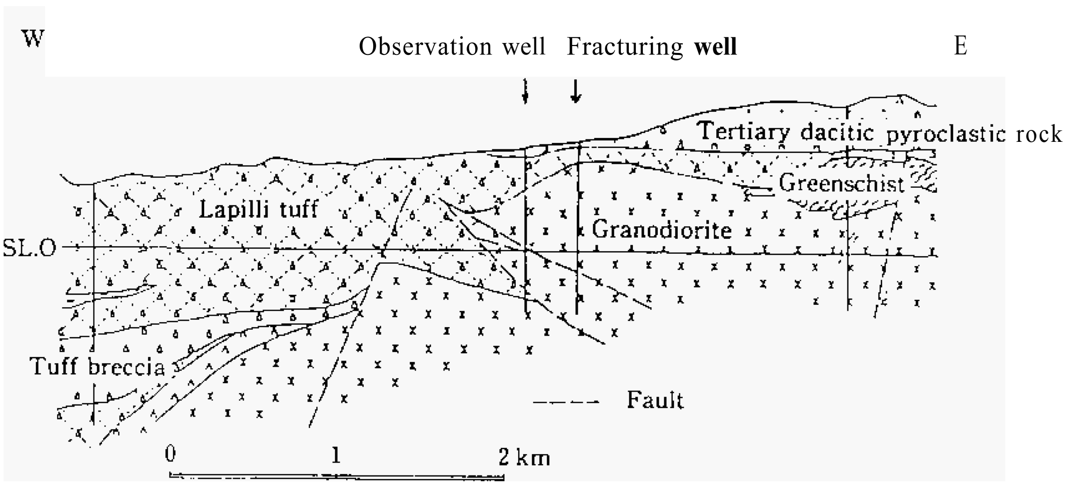

Figure 3. Geological cross section

Water circulation test

Water from a river near the test site was pumped up into a 400-m^3 pond then injected into the injection well. Because of the pump capacity, the maximum injection pressure was limited to 20 MPa. Recovered water from the production well was flowed into a production well pipeline. If the water temperature exceeded 100℃, the water could be separated into a steam line and a hot water line for measuring each flow rate, pressure and temperature. Then the steam and water flowed into a silencer in which the steam dispersed into the air and the water flowed into the pond.

Figure 4 shows the water injection results. Water injection for the circulation test started on Oct.17 and ended on November 8. Water was injected at a flow rate of 400 liter/min with a wellhead pressure of around 20 MPa at first. The wellhead pressure decreased gradually, while the injection flow rate increased to a maximum of 1,200 liter/min. Figure 5 shows the recovered water measurement results. The flow rate of recovered water from the production well increased gradually up to 40 liter/min and the maximum water temperature reached 108℃. During the circulation test, a total of 30,000 m^3 of water was injected for 22 days and a total of 614 m^3 of water was recovered from the production well.

According to AE and mise-a-la-masse measurements, the injected water flowed into the lower fracture at first, but the production well did not reach to that fracture, which was estimated to be the main flow path (Kaieda et al., 1995). The injected water flowed into the lower fracture at first and dispersed in the opposite direction from the production well. Almost no AE and electrical anomalies were observed in the upper fracture progression area.

Future plan

Because water recovery from the production well was small, we must improve the connection between the expected main flow path in the fractures and the production well. We think that a stimulation (or fracturing) in the production well is the cheapest way to improve the water circulation system. Therefore, we will conduct a water injection test into the production well. If we succeed in improving water communication between the injection well and the production well, we will perform a 5-month water circulation test in 1994.

In Phase IV, which is scheduled to start in 1995, we will drill another production well at first to get more water recovery. New technologies will be needed for injecting water equably into a multiple fracture system. Now we are discussing construction of a 100 kW power plant with the electric power companies.

Conclusion

A 22-day water circulation test was conducted. Unfortunately, the amount of recovered water was very small at a maximum flow rate of 40 liter/min against the maximum injection flow rate of 1,200 liter/min. According to AE measurement results, the production well did not connect to the expected main flow path through the reservoir. Therefore, we will conduct a stimulation test of the production well to get a better connection, then perform a 5-month water circulation test in 1994.

REFERENCES

1) Kaieda, H., Hibino, S., and Hori, Y. 1990, HOT DRY ROCK EXPERIMENT IN TUFF AT AKINOMIYA, NORTHERN JAPAN, Geothermal Resources Council Transactions, Vol.14, Part 1, pp.561-565.

2) Kaieda, H., Sakunaga, S., Motojima, I., Kondo, H., Kiho, K.,Suzuki, K., Higashi, S., Sasaki, S. and Hori, Y. 1992, Ogachi project for HDR geothermal power in Japan, First hydraulic fracturing results. Geothermal Resources Council Transactions, Vol.16, pp.493-496.

3) Hori, Y., Kitano, K. and Kaieda, H. 1994, Outline of Ogachi project for HDR geothermal power in Japan, Geothermal Resources Council Transactions, Vol.18, pp.439-443.

4) Kaieda, H., Fujimitsu, Y., Yamamoto, T., Mizunaga, H., Ushijima, K. and Sasaki, S. 1995, AE and mise-a-la-masse measurements during a 22-day water circulation test at Ogachi HDR site, Japan. Submitted to this meeting.

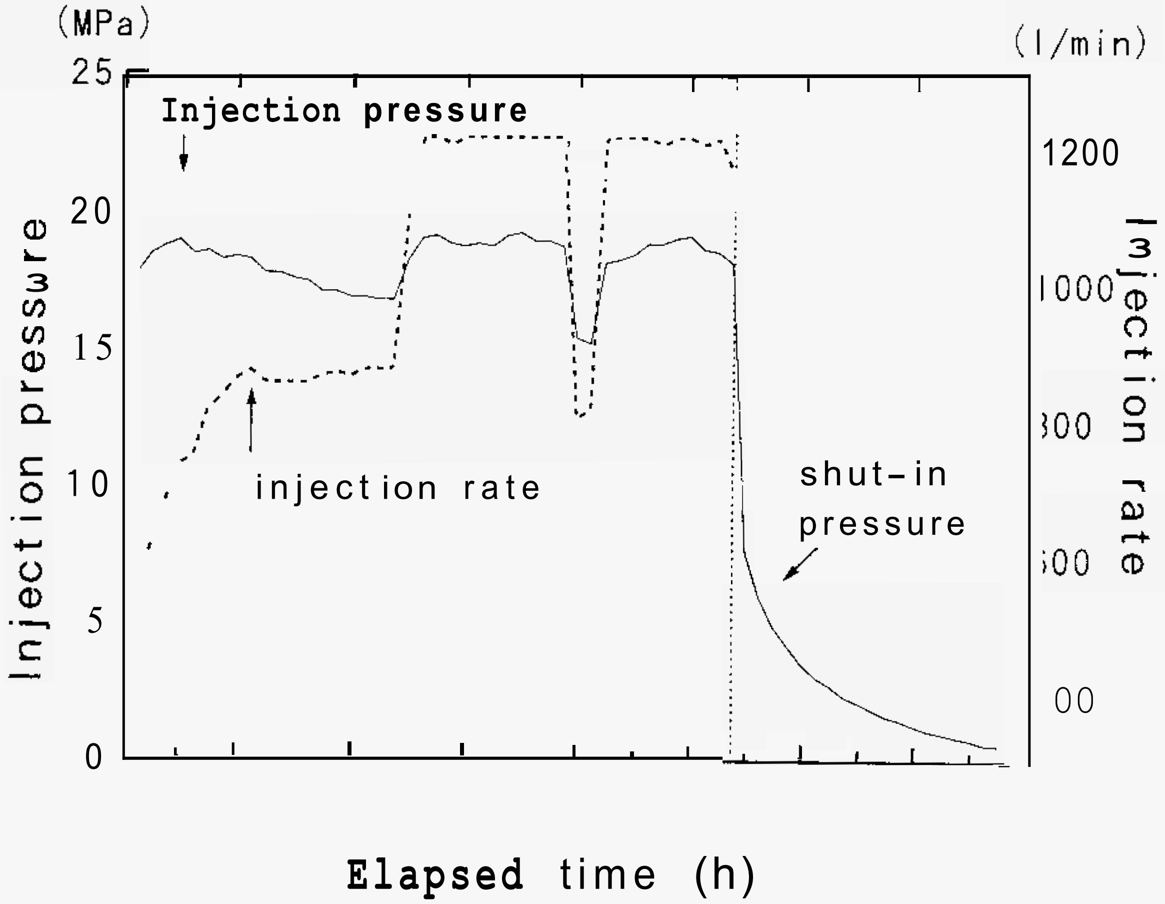

Figure 4. Injection flow rate and pressure during the 22-day water circulation test.

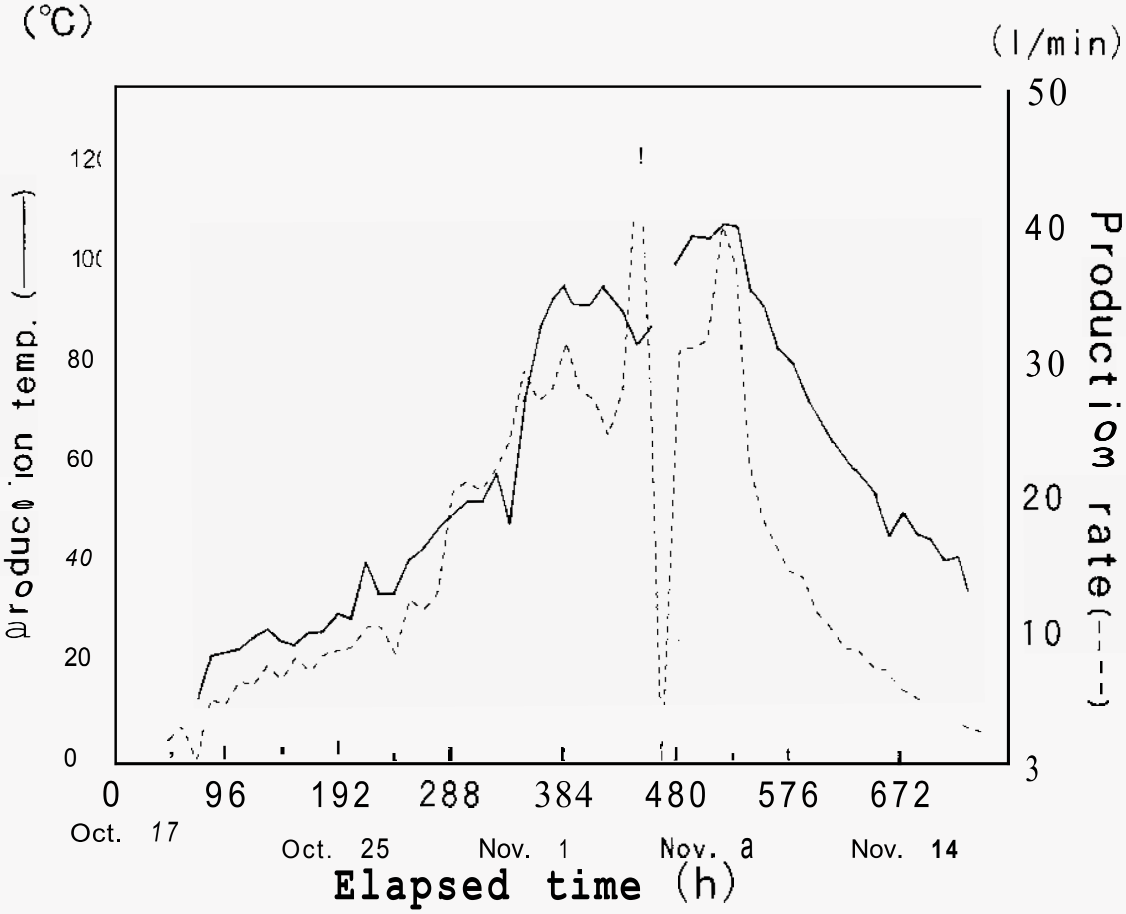

Figure 5. Production flow rate and temperature during the 22-day water circulation test.