UTILISATION OF PTS SURVEYS FOR WELL STUDIES IN THE HATCHOBARU GEOTHERMAL FIELD

M. Koga, Y. Tsuru, H. Tokita, T. Yahara and E. Lima

West Japan Engineering Consultants, INC. Fukuoka Japan

Abstract

PTS (pressure, temperature, and spinner) surveys under static, injection and flowing conditions were started in 1993 in the Hatchobaru geothermal field. Trough the results of these surveys, the massflow rates at each feed point or at each injection point was estimated Also, the behaviour of the reservoir fluids close to the wellbore was studied. Utilising the location of feed points detected by the PTS surveys the assumed position of faults in this area were updated or confirmed. Using a wellbore simulator, the enthalpy of fluids at the feedpoints was also estimated and the behaviour of the fluids within the wellbore was better understood. In summary, the results of these studies have been very useful for the reservoir management operations.

1.0 INTRODUCTION

The Kyushu Electric Power Company (KEPCO) is operating the Hatchobaru Geothermal Power Plant located in central Kyushu Japan. The first unit (55 MW) started commercial operations in 1977 and some years later, in 1990, the second unit (55MW) was commissioned. Since then, the Hatchobaru Geothermal Power Plant remains the largest geothermal power station in Japan with a total installed capacity of 310MW. In order to supply the required 800t/h steam to drive the turbines and in order to dispose the 1300t/h separated water, KEPCO operates about 20 production wells, and about 15 injection wells. Fig. 1 shows that the

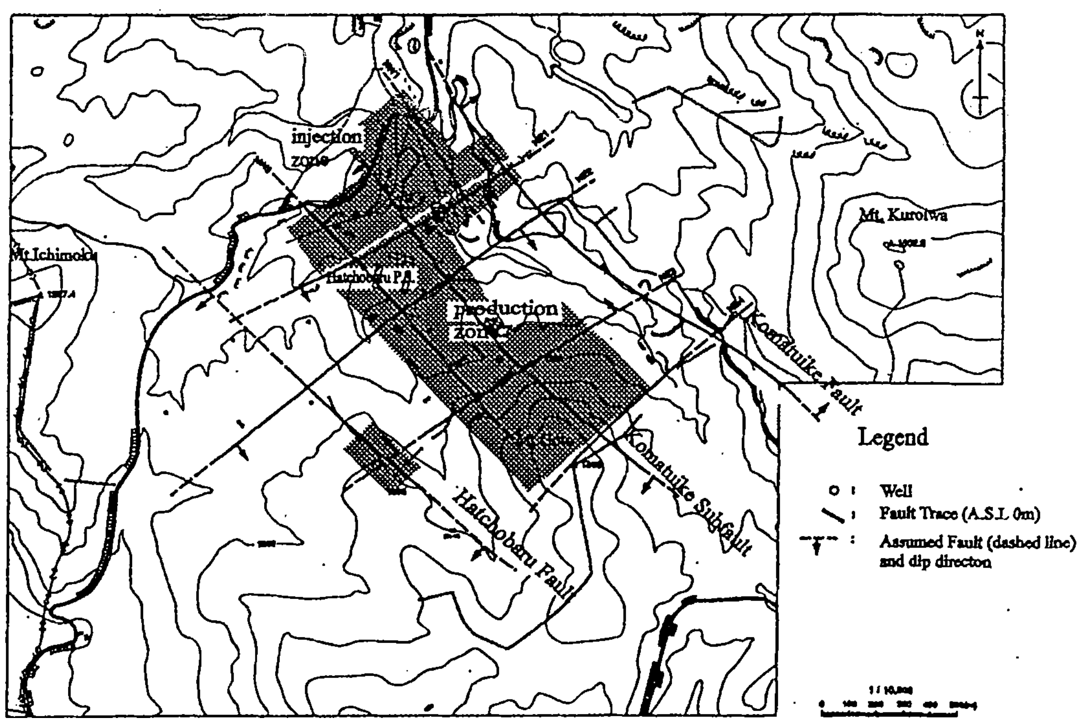


Fig.1 Hatchobaru location map

production wells are mainly drilled towards the *NW-SE* trending Komatsuike sub-fault and towards the NE-SW trending faults. The production zone is located at underground elevations ranging from -800 to 100m above sea level (1000m~2000m below the surface) while the location of the injection zone ,drilled to the north of production area, is found underground at elevations ranging from -400m to 300m above sea levcl (800~1500m below the surface).

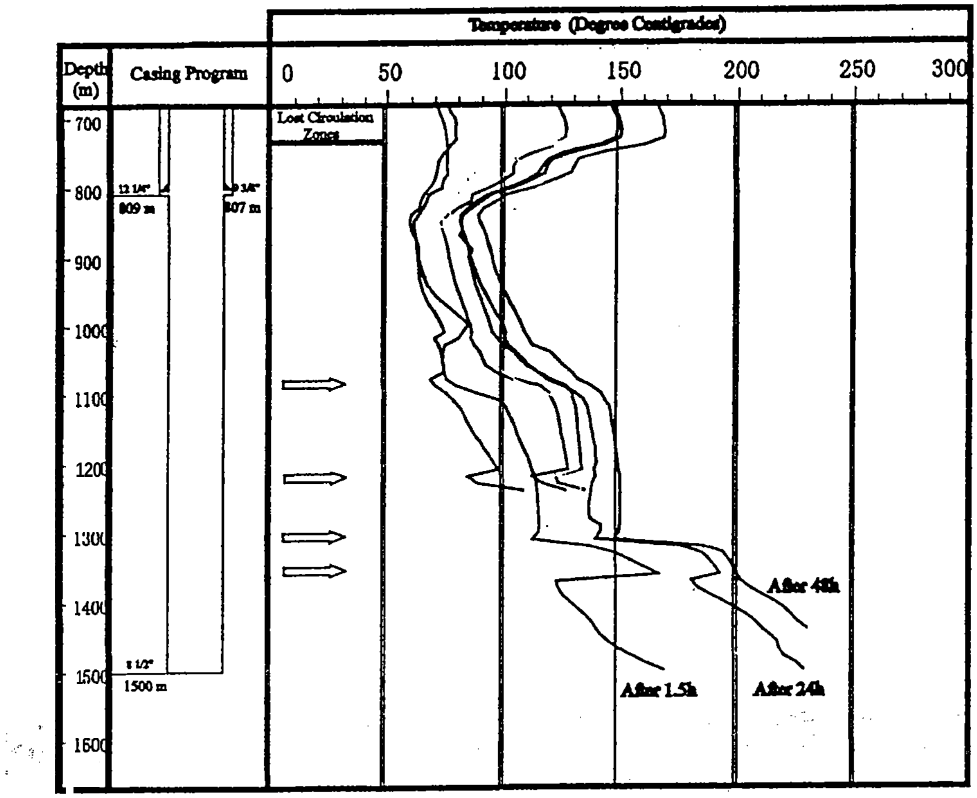
Many methods and procedures have been investigated for well and reservoir management at the Hatchobaru Geothermal Field. PTS surveys, which are reported in this paper, are one of them. Before the PTS survey were introduced, wells were evaluated using PT surveys only. However, since the number of production wells discharging geothermal fluid in two phase condition from the feed points increased, the introduction of spinner surveys was obviously necessary. These surveys started in 1993 and since then, using PTS surveys, wells have been evaluated.

2.0 INJECTION SURVEY

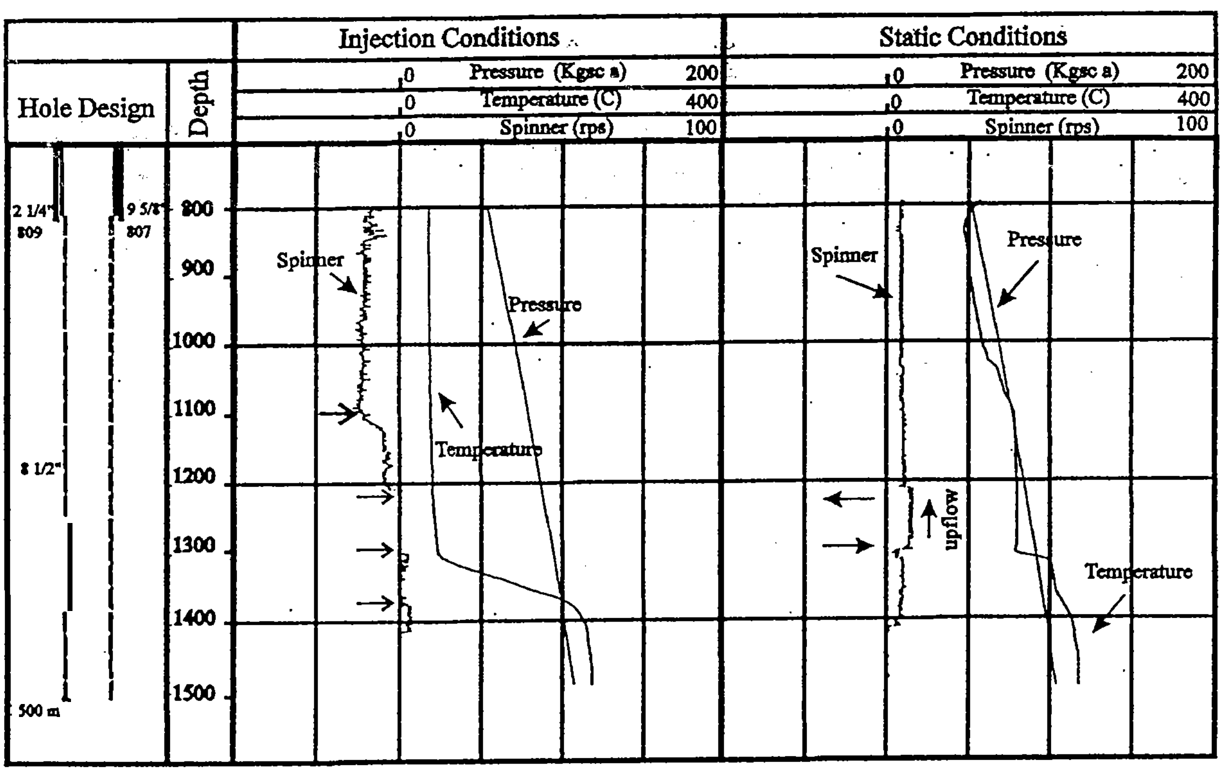
It is very important to know exactly the depth of the lost circulation zones. This depth has been estimated from the lost circulation records taken during drilling and from the temperature anomalies recorded during the warming up periods. Fig. 2 shows, for comparison, the results of temperature profiling during warming up and the results of PTS surveys run under injection condition. From the temperature curves, four lost circulation zones were detected at different depths. At these same depths, changes of rotational speed of the spinner were recorded confirming the position of the lost circulation zones. Moreover Fig. 2 also shows that from 1210m io 1300m depth, temperature values were almost the same. This is because fluids are flowing from the lost circulation zone at 1300m to the other one at 1210m. and thus reflecting only the temperature of the deep feed point. From this example, it is possible to say that the spinner records taken during injection tests, can be used to confirm the position of the lost circulation zones and that from the temperature surveys at static conditions valuable information on the well internal flow (under static condition). which is very important for the interpretation of the temperature profiles, can be obtained.

3.0 PRODUCTION SURVEY

To assess a production wells and to plan additional drilling it is also very important to know the depth at which the geothermal fluid is flashing and the pressure and temperature of fluids at the feed points. For this purpose PTS surveys are run with the well at flowing conditions. For the Hatchobaru wells, this kind of assessment is being done since 1993 when PTS survey were introduced. hi this geothermal field, many of the production wells have multiple feed points making it difficult to obtain the required wellbore information from pressure and temperature surveys only. In order to overcome this problem, flowing PTS survey were introduced. Since then, 15 wells have been surveyed. The depths of each feed points (in these wells) were confirmed, and in addition, it was understood that most of these feed points contribute fluids already in two phase conditions. Fig. 3 shows an example of these pressure, temperature, and spinner (number of rotations) profiles. From this figure it is possible to say (only from the pressure and temperature profiles), that no flash point exists along the wellbore and that the geothemal fluid seems to be flowing into well from near the 1650m depth. Other feed points were difficult to detect. Nevertheless, as shown in Fig. 3, from the change in the number of spinner rotations, three more feed points can be detected. Furthermore the result of the spinner survey indicated that most of the geothermal fluids (already in two phase condition) is flowing into the wellbore at depths close to 1450m and 1570m. By means of the spinner surveys it is possible to know exactly the depth of each feed point and its contribution to the total mass flow rate. This information is a very useful for detecting promising reservoirs, and for interpreting the analysis of discharged fluids. For wells with multiple feed points it is important to estimate the enthalpy of the fluids contributed by each feed point. However, this is not possible from the PTS information only and the use of a wellbore simulator is necessary. The estimation of these values is done by means of a trial and error procedure where by varying the enthalpy of the fluid incoming from each feed point a good match between calculated and measured pressure and temperature values is pursued. Fig. 4 shows the result of a matching procedure for one of the Hatchobaru wells. In this case, the enthalpy of the fluid contributed by the shallower feed point resulted little bit higher than that of the fluids contriiuted by the other feed points.



Temperature recovery during warming up



Results of the PTS surveys

Fig.2 Tempertaure profiles during warming up and results of PTS surveys

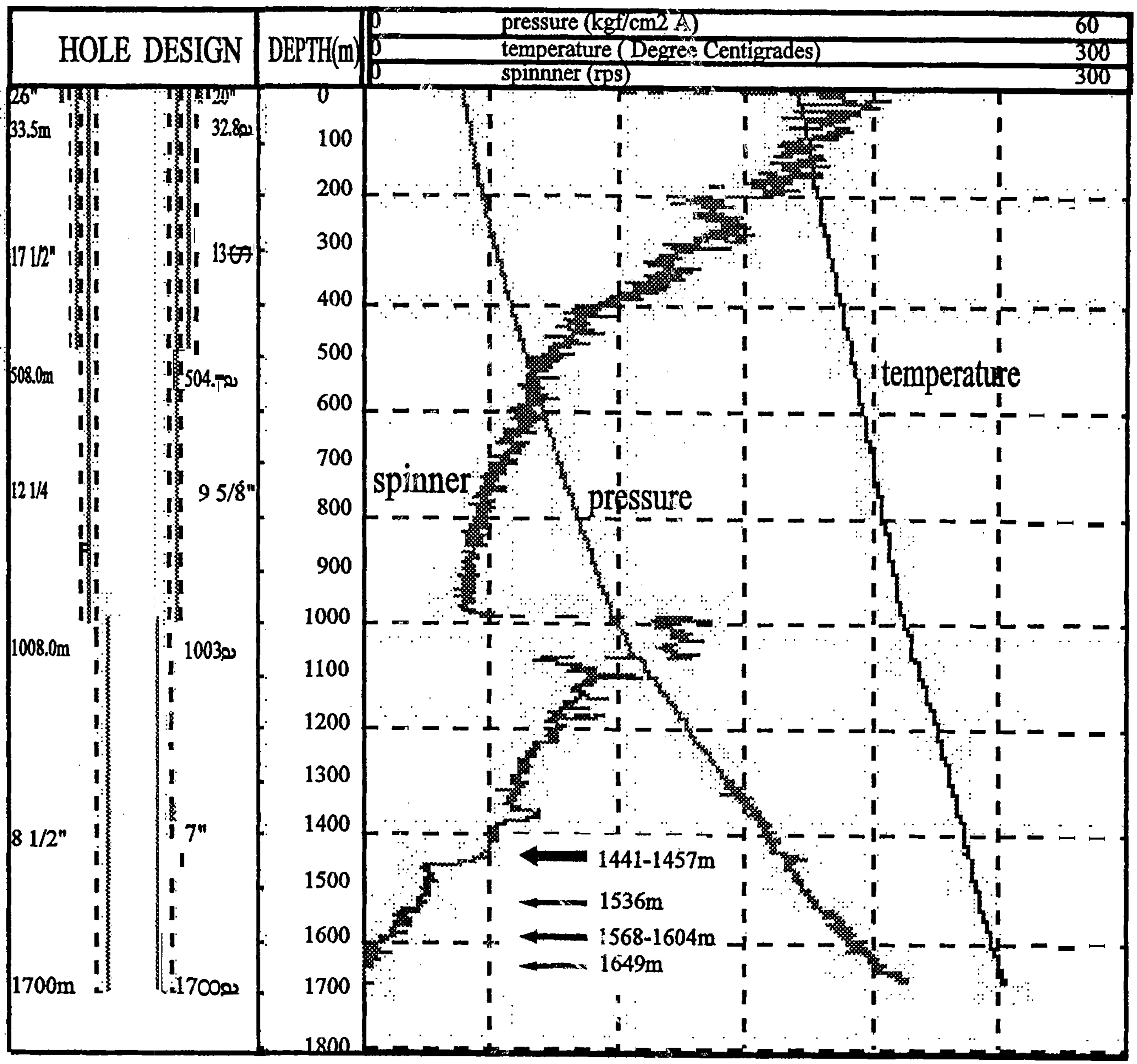


Fig.3 PTS profiles under flowing condition

Feed Point (m)	Mass **Flow Rate** (kg/s)	**Enthalpy** (kcal/kg)
1441-1457	19.12	308
1536	6.96	301
1568-1604	12.16	286
1649	1.76	274
Total	40	-

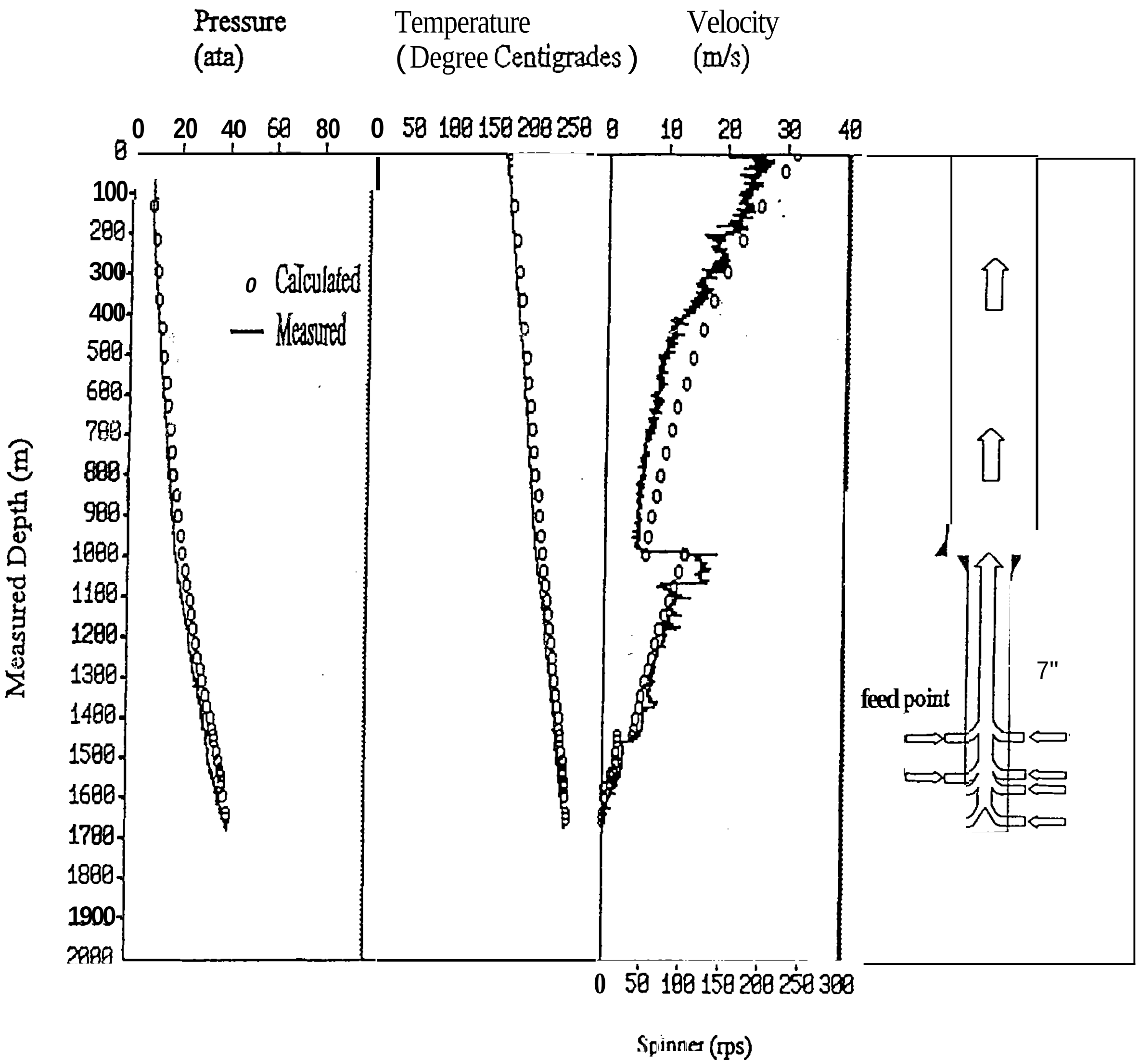
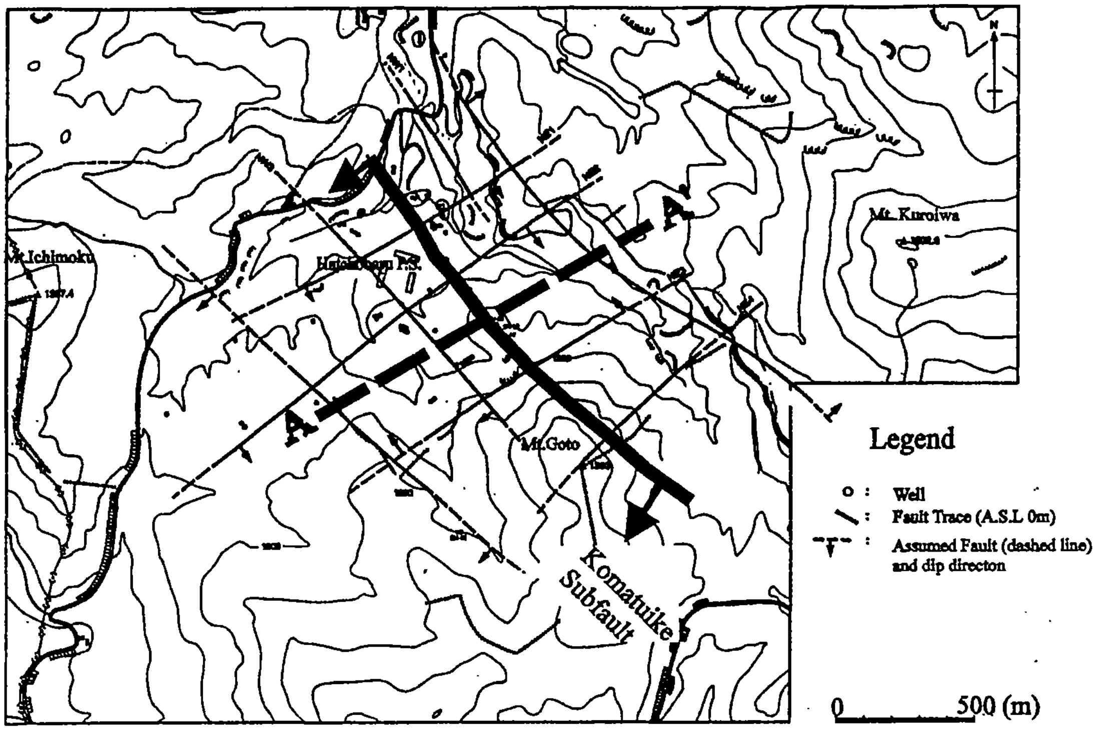


Fig.4 Results of the matching procedure



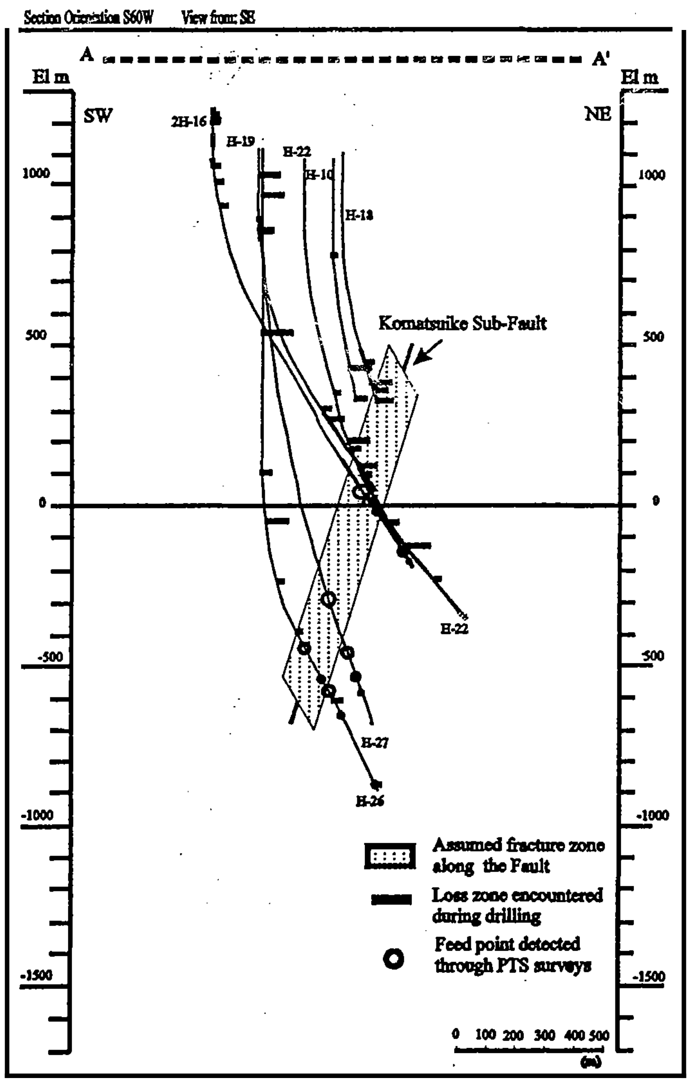


Fig. 5 Distribution of feed points and location of the Komatsuike Sub-Fault

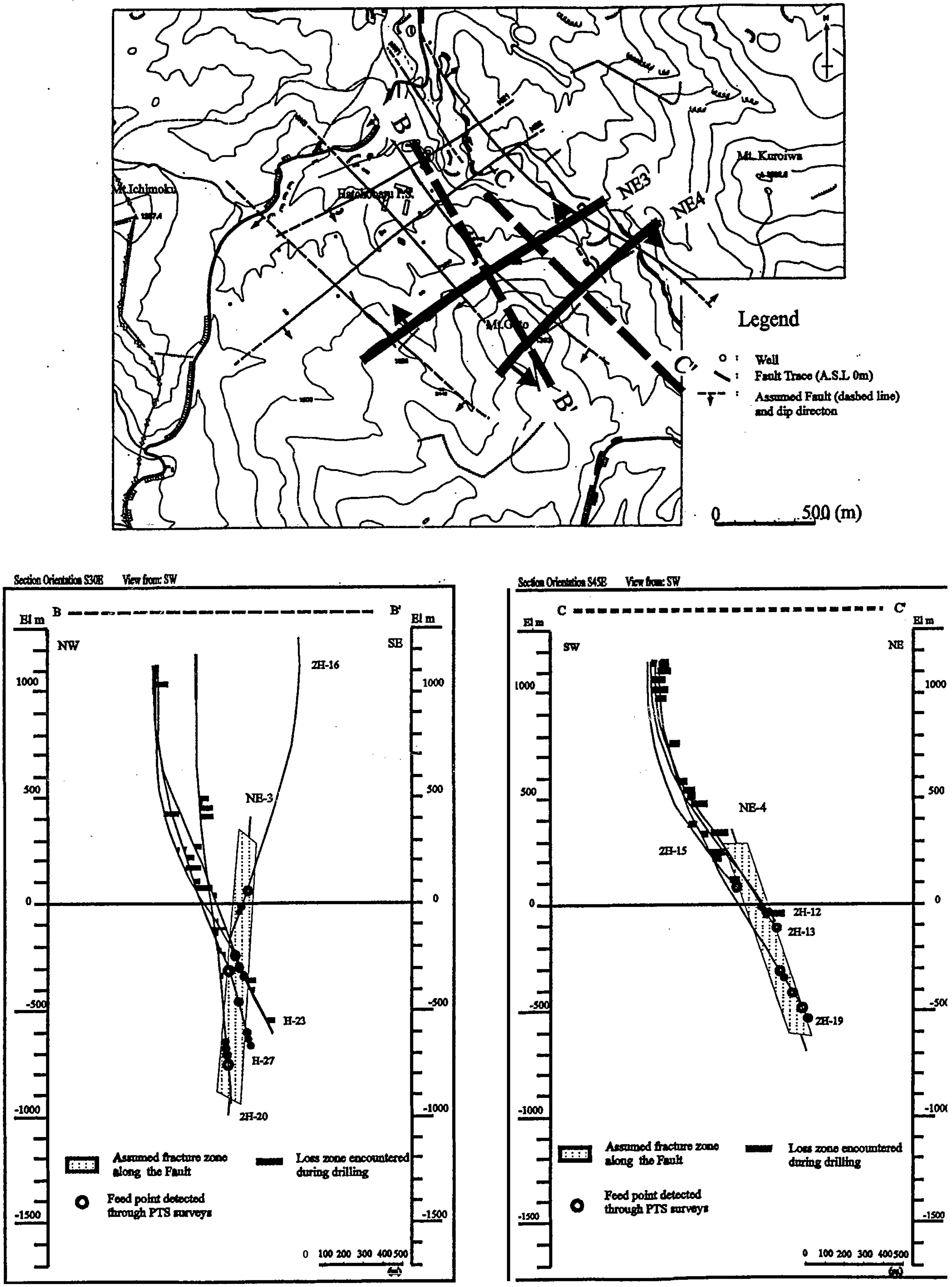


Fig. 6 Distrubution of feed points and NE-SW trending Faults

4.0 DISTRIBUTION OF FEED POINTS

In the Hatchobaru geothermal field, the faults systems formed by NW-SE trending and NE-SW trending faults were assumed from geophysical and geological surveys. Of all these faults, steam is mainly being discharged from a geothermal reservoir extending along the NW-SE trending Komatuike sub-fault and from its orthogonal system formed by the NE-SW trending NE3 and NE4 faults. Fig. 5 shows the vertical distribution of feed points in the section A-A' perpendicular to the Komatuike sub-fault. Fig. 6 shows the vertical distribution of feed points in the sections B-B' and C-C' perpendicular to the NE3 and NE4 fault. As shown in Fig. 5 and Fig. 6 it is clear that the distribution of feed points is concentrate along the Komatuike sub-fault and along the NE3 and NE4 faults. From this result, it is considered that the geothermal fluids are being discharged from a geothermal reservoir extending within fractures along these faults. The distribution of feed points is utilised for the planning of additional drilling targets and for refining the model used for reservoir simulation.

5.0 CONCLUSION

1) Using PTS logging, it is possible to confirm the depth of lost circulation zones and feed points with a better precision than was done before.

2) Using PTS survey under flowing condition, it is possible to estimate the contribution to the total mass flow rate by each feed point and the enthalpy values of these fluid near wellbore.

3) The feed points detected by PTS surveys confirm its distribution within fractures along the faults assumed through geophysical and geological surveys. The information of feed point distribution is utilised for planning additional drilling targets and for refining the reservoir simulation model

REFERENCES

T.Manabe, I.Kumagai, S.Harada, T.Fujino, T.Yahara, and H.Takagi (1989). Operation Record and Management of the Otake Hatchobaru Geothermal Power Station. CHINETSU (Geothermal) Vol.26 No.4 (Ser.109).

Y.Baba, S.Kawazoe and Y.Sueyoshi (1991). Geothermal Well Drilling in the Otake-Hatchobaru Geothermal field. CHINETSU (Geothermal) Vol.28 No.4 (Ser.119).

K.Shimada, K.Tagomori, T.Fujino, and I.Kitakoga (1994). Deep Geothermal Structure and Targets of Future Development in the Hatchobaru Geothermal Field. CHINETSU (Geothermal) Vol.3 1 No.4 (Ser.134).

H.Yoshiyama, T.fujino and I. Kumagai (1996). A Reconstruction of the Geothermal Structure in the Hatchobaru geothermal area. 17th PNOC-EDC Geothermal Conference 69-76.