INTERPRETATION OF SCHLUMBERGER SOUNDING DATA IN GEOTHERMAL AREAS

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Various authors have studied the methods of automatic interpretation known as the resistivity inversion, in which the adjustments of layer parameters are made by the computer based on the least squares method, starting from the initial guess parameters. The method is at present the most excellent tool for the interpretation of Vertical Electric Sounding (VES) curves.

In the present paper, the method of interpretation of VES curves is developed by the use of the linear filter method for the forward problem and the nonlinear least squares method for the inverse problem. The method is applied to the VES data over the present production area and to the data of the survey line D in a new area of Hatchobaru geothermal field, Ohita, Japan.

The section of resistivity layers derived from the inversion were compared with the drilling data from the production wells. As a result of this comparison, an acceptable geoelectric model was obtained for the fractured type of geothermal reservoir. Judging from the type of VES curve, it was found that the most of production wells are located on and near the VES stations where apparent resistivity curves show less than 10 ohm-m values against the moderate electrode separation.

CASE HISTORY

A series of resistivity sounding measurements has been carried out for the investigation of geothermal resources in Hatchobaru geothermal field. In this survey, the interval of VES station is taken as 200 m grid, with the maximum electrode separations to 2000 m.

We shall firstly consider the interpretation of VES curves at three stations B-12, C-15 and D-15 along the line S1, going from northeast to southwest as shown in Figure 1. Line S1 crosses the central part of the present production zone in Hatchobaru geothermal power station (55 MW).

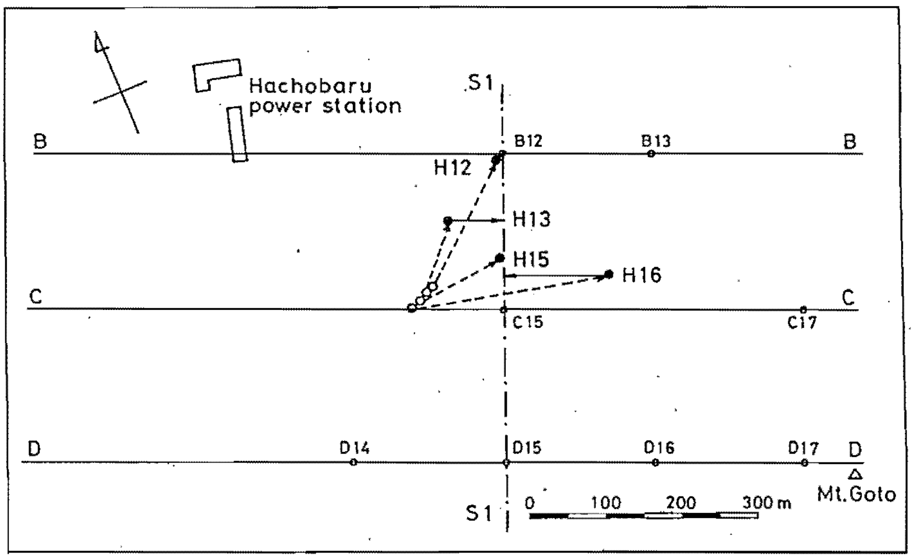

Figure 1. VES stations (B12, C15, D15) and location of production wells (H12, H13, H15, H16) in Hatchobaru geothermal field, Japan.

The observed VES curves with their interpretation are shown in Figures 2a and 2b. In this Figures, circles show the observed apparent resistivity values and a solid curve represents the theoretical VES curve computed by the use of the final solution in the resistivity inversion.

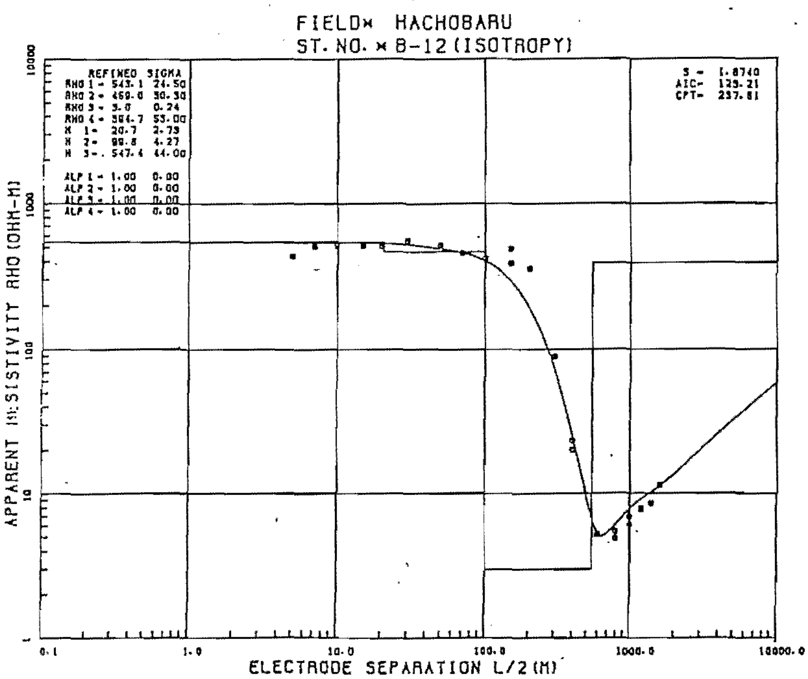

Figure 2a. VES curve with the interpretation at B-12.
B-12 locates in the north part of production zones.

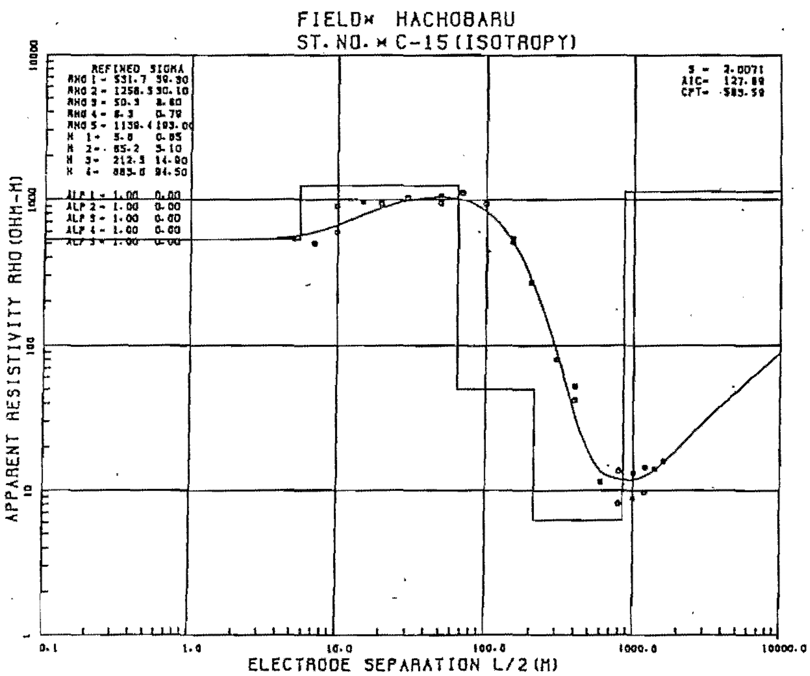

Figure 2b. VES curve with the interpretation at C-15.
C-15 locates 200 m south from B-12.

Figure 3 shows the section of resistivity layer obtained by the resistivity inversion based on the anisotropic (right) and isotropic (left) layered earth model(Ushijima, 1984).

The section of resistivity layer consists of the three primary formations: first, the surface zone of high resistivity of 500 - 1300 ohm-m that were correlated with the Kujyu volcanic rocks; second, the intermediate layer with the low resistivity of 2.1 - 6.3 ohm-m that were correlated with a section consisting of Hohi volcanic groups and third, an electrical basement which has a high resistivity between 180 - 1200 ohm-m which appears to be correlated with the Usa formation.

Laterally, with regard to the low resistivity layer, the resistivity values increase from B-12 to D-15, that is from north to south. This trend coincides with the dip of faults and the lost circulation zones that may corresponds to the geothermal reservoir. In addition, it is also recognized that the clear discontinuity of the depth to the electrical basement exists between B-12 and C-15, thus such a large discontinuity must be considered to indicate the presence of fault denoted by F.

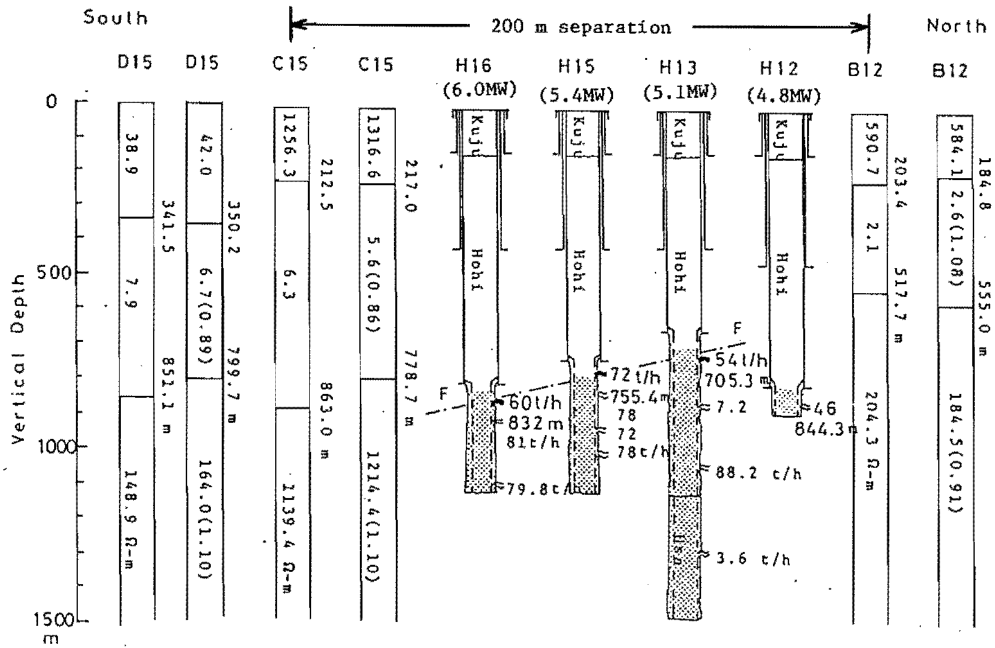

Figure 3. Comparison of the resistivity layer section (B12, C15, D15) along the line S1 with the drilling data from production wells (H12, H13, H15, H16).

Judging from these factors, that are the resistivity changes of vertical and lateral direction and the large discontinuity of the depth to the electrical basement, the location and dip of faults which regulate the upstream of the geothermal fluid could be determined. From these results, we may conclude that the geoelectric structure of fractured type geothermal reservoir can be explained by the model as shown in Figure 4.

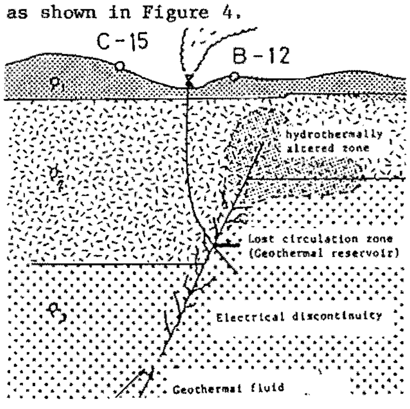

Figure 4. Geoelectric model for geothermal reservoirs.
VES curves show H-type ($\rho_1 > \rho_2 < \rho_3$).

APPLICATION OF GEOELECTRIC MODEL TO A NEW AREA

The geoelectric model for the geothermal reservoir can be applied to the interpretation of VES data obtained in the measuring line D where there is no drilling data within the region until 1984. The result of resistivity inversion is expressed in a resistivity layer section as shown in Figure 5. The Figure suggested that the equivalent geoelectric structures to the present production zone exist on and near the VES station of D17 (Mt. Goto). It was concluded that the region around D17 is the most promising site for drilling in order to develop a further geothermal resources for the second geothermal power station in Hatchobaru geothermal field.

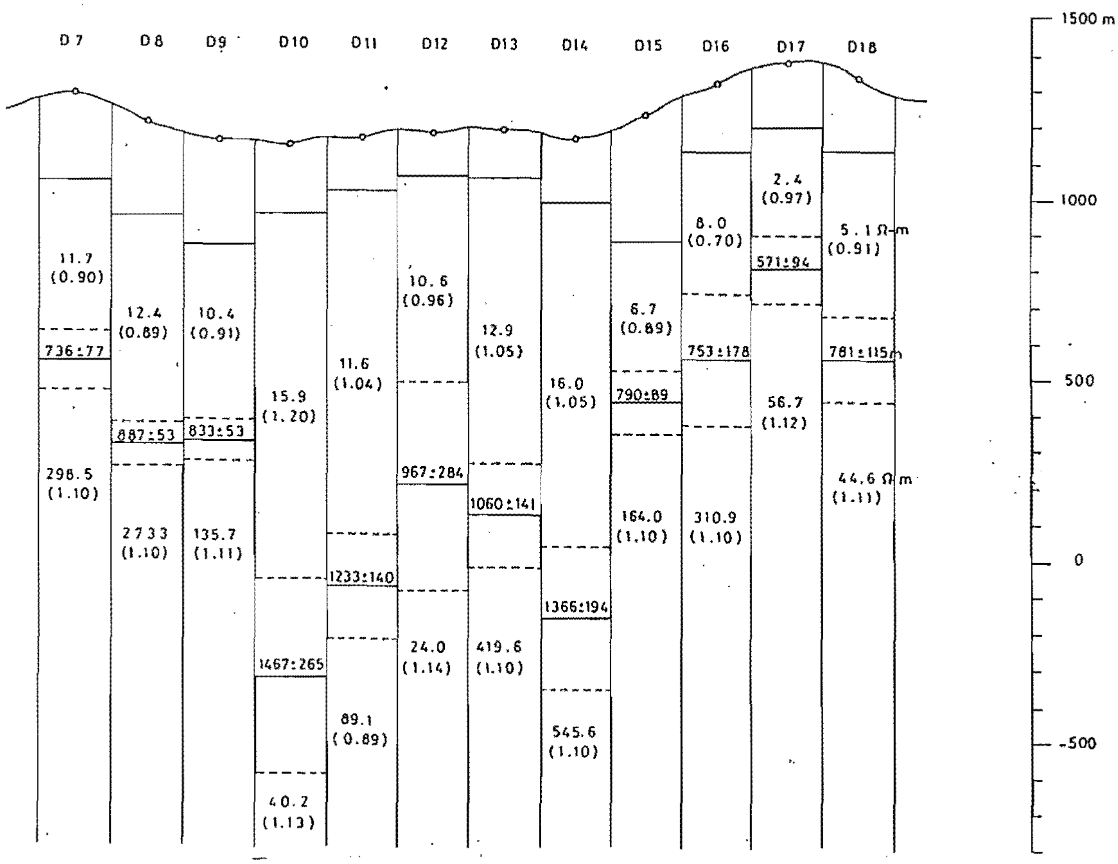

Figure 5. Section of resistivity layer of the measuring line D in a new area.

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