TWO-DIMENSIONAL INTERPRETATION OF A HIGH ACCURACY MT DATA AT IWAMA, IBARAKI PREFECTURE

MIURA, Y., TAKASUGI, S., KAWAKAMI, N. and MURAMATSU, S., Geothermal Energy Research & Development Co., Ltd., Kyodo Bldg., 11-7, Kabuto-cho, Nihonbashi, Chuo-ku, Tokyo 103, Japan

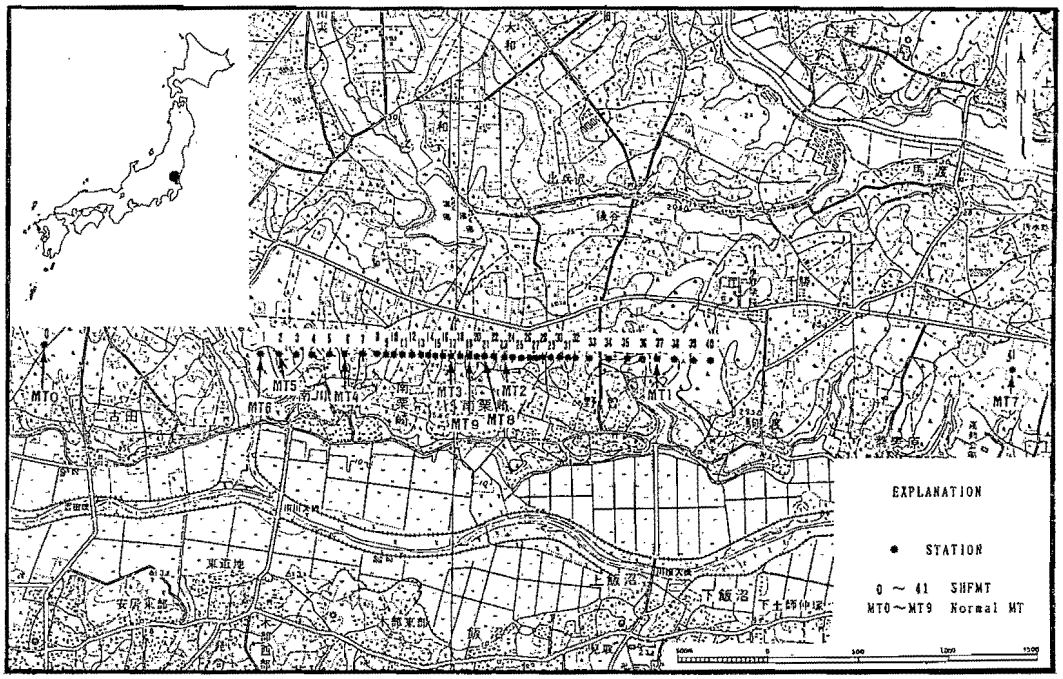

Fig. 1 Station location map

1. Introduction

Commissioned by the New Energy Development Organization (NEDO), we have been engaged under a 5-year plan since FY 1984 in the MT R & D project of the "Development of A High Accuracy Magnetotelluric (MT) Method Exploration Technology" as part of the "Confirmation study of the effectiveness of prospecting techniques for deep geothermal resources," a MITI Sunshine project.

This time, using the one-dimensional and two-dimensional model analysis programs developed up to fiscal 1987, we have analyzed the data that were obtained from a field test (Iwama Town, Ibaraki Prefecture). Our report follows.

2. Outline of field test

In the field test conducted in Iwama Town, Nishi-ibaraki County, Ibaraki Prefecture, with the layout of stations shown in Fig. 1, data by the Super High Frequency MT (SHFMT) soundings and by the conventional MT soundings with MT system developed through the MT R & D project were acquired at 42 points and 10 points, respectively. In this area, the structure of earth's interior was estimated by other surveys to have a trend of south-to-north strike (for example, Uchida et al., 1986; Komazawa, 1985; see Fig. 2), hence care was taken so that the traverse direction might be east to west.

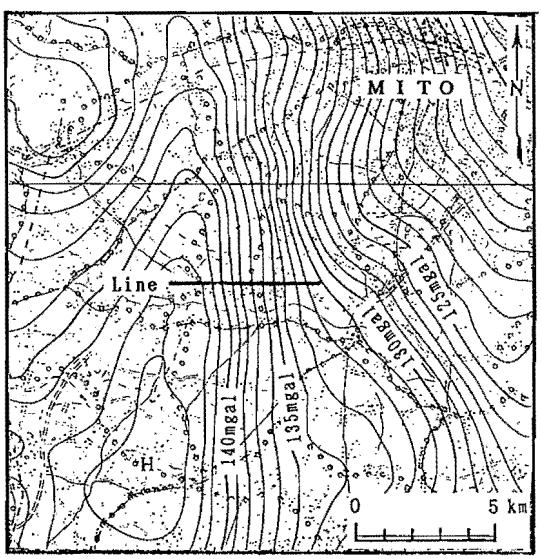

Fig. 2 Map of gravity anomalies around station (Kanto area gravity map, 1985, Geological Survey of Japan)

3. One-dimensional model analysis

3.1 One-dimensional model analysis procedure

In the analysis, the impedance tensor was so rotated that the TM mode might be in the east-to-west direction which is the traverse direction, and in order to study the effects of SHFMT and of station spacing density (distance between station to station), one-dimensional model analysis was applied for three cases as follows:

CASE A	10 stations for MT
CASE B	10 stations for SHFMT+MT
CASE C	10 stations for SHMT+MT, 14 stations for SHFMT

3.2 One-dimensional model analysis results

Fig. 3 and 4 show the resistivity

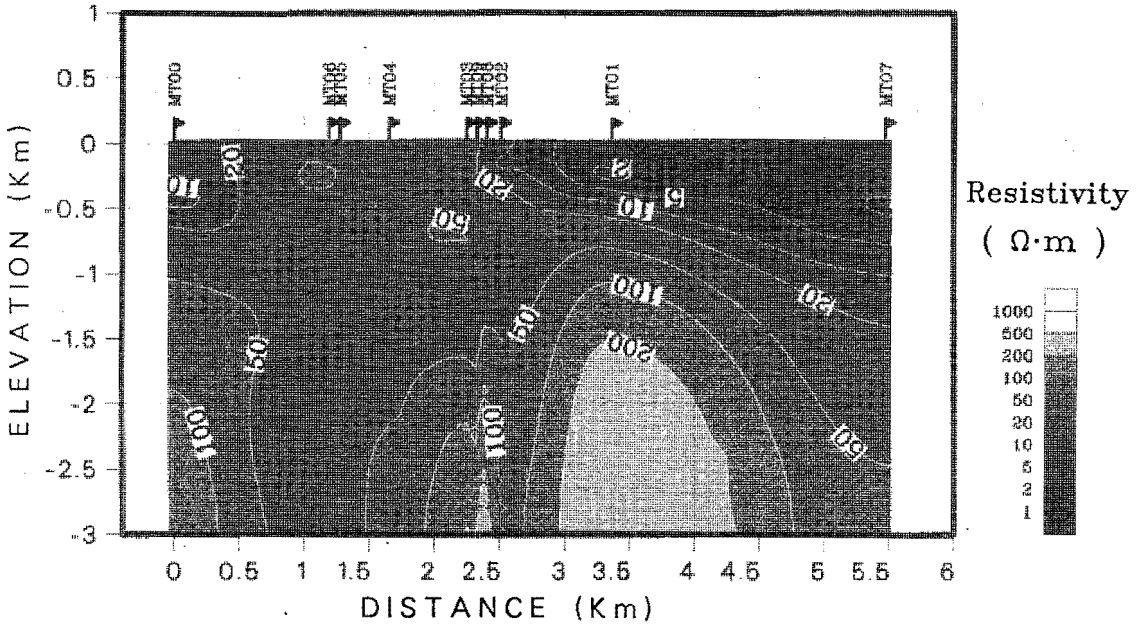

Fig. 3 Resistivity profile (CASE A)

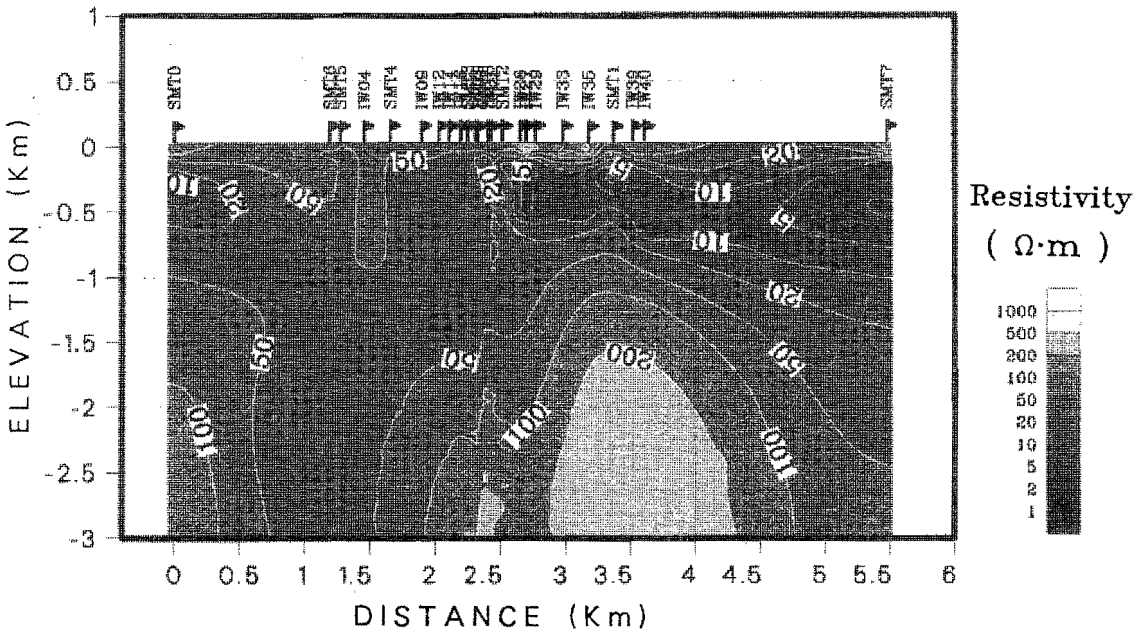

Fig. 4 Resistivity profile (CASE C)

profiles obtained by the Bostic inversion of the TE mode in cases A and C.

In CASE A, the low resistivity of east region spreads to the surface. In cases B and C, meanwhile, supplemented with SHFMT data, the low resistivity region is not recognized at the surface, spreading over 50 Ω.m resistivity layer in the top layer. In CASE C, moreover, it is more distinct. This brings out the effect of making the frequency range wider and of high station spacing density.

The resistivity structure in this area is thought to present a two-dimensional resistivity structure since generally it is small in skewness and large in tipper magnitude.

4. Tow-dimensional model analysis

4.1 Tow-dimensional model analysis procedure

Tow-dimensional model analysis was made of CASE C.

In the model used this time, the grid size at surface was made 10 m both horizontally and depthwise, a small enough amount to prevent losing the precision of calculation for the skin depth that will be about 35 m at 50 Ω.m and 10 kHz. The number of meshes was made 53 horizontal by 38 vertical, totaling 2,014. Based on the one-dimensional analysis results and other survey results, an initial model was constructed, calculations made for 10 frequencies at each station, and model changes attempted until good fitting with the observed data.

4.2 Two-dimensional model analysis results

The final model obtained after the two-dimensional model analysis is shown in Fig. 5.

By and large, resistivity changes from high - low - high with increasing depth from the surface. Another feature found is a low resistivity region of 2 to 5 Ω.m spreading at about 100 m to 700 m below sea level to the east of the profile.

4.3 Results of fitting with actual measurement data

The MT parameters used in making calculations on the models were compared with the observed data to evaluate the resistivity model obtained as a result of the two-dimensional model analysis.

So far, the results of fitting with the observed data were evaluated by forming the pseudo section (vertical axis; frequency, horizontal axis; distance) of apparent resistivities and phases, but this time the pseudo section of residual errors in apparent resistivity between the model and observed data, as newly derived from equation (1), was added to evaluate the fitting of resistivity model in plane and quantitative terms (see Fig. 6).

$$R = \log(ac) - \log(ao) \qquad (1)$$

where R = absolute value of residual error
ac = apparent resistivity calculated from model
ao = apparent resistivity in actual measurements

Concerning the coincidence between two-dimensional model analysis results and observed data, good coincidence was found in both TE and TM modes except at the peripheral or low frequency parts.

5. Comparison of one-dimensional and two-dimensional model analysis results

Comparing the one-dimensional model analysis results and two-dimensional model analysis results, the depth section of one-dimensional TE mode analysis shows about the same image of underground resistivity structure as that given by two-dimensional

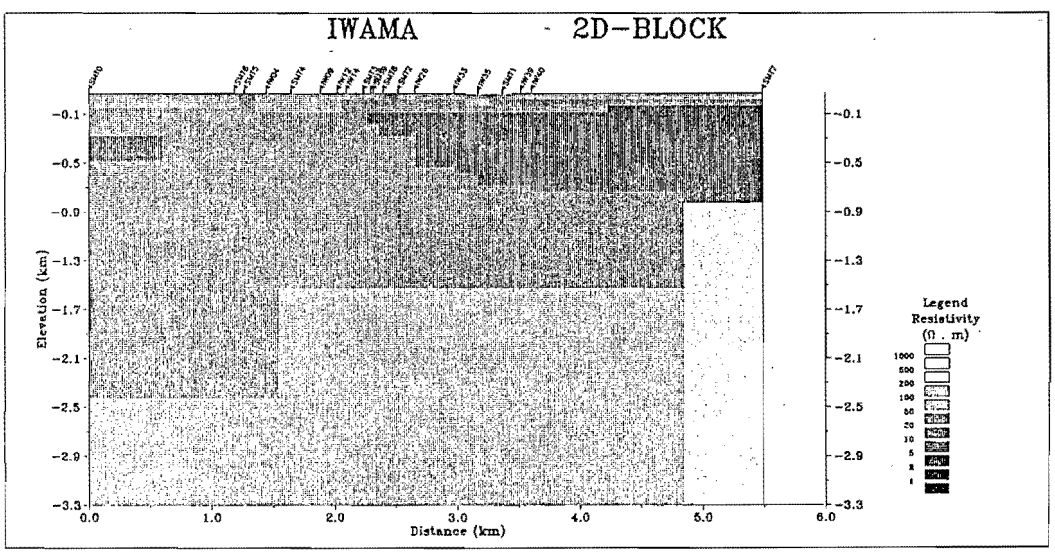

Fig. 5 Result of two-dimensional model analysis (CASE C)

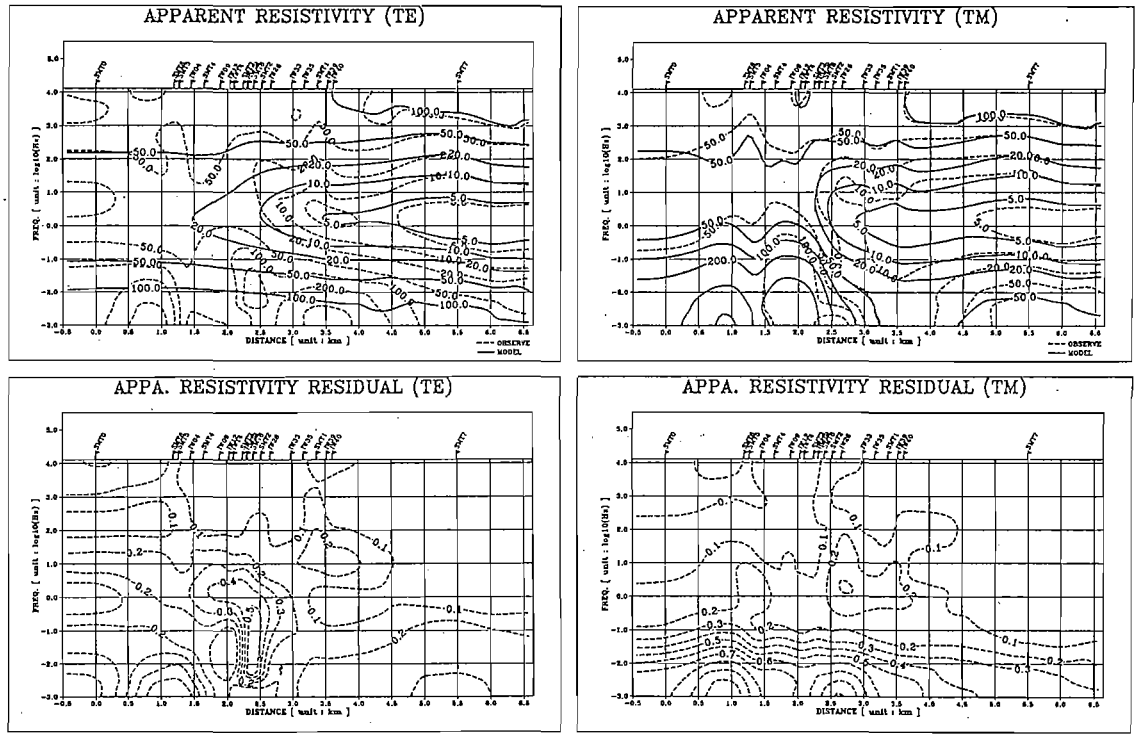

Fig. 6 Pseudo sections of apparent resistivities and residual apparent resistivities derived from observed data and model

model analysis. Thus, it could be ascertained that analyses by the TE mode are fully effective where the underground resistivity structure manifests itself to be two-dimensional.

6. Conclusion

One-dimensional and two-dimensional model analysis was carried out regarding the data that were acquired in the field test conducted last year.

For the evaluation of matching between calculated MT parameters and observed data in the two-dimensional model analysis, the way we tried was not only to ascertain pseudo section coincidence by mapping apparent resistivities and phases but also to grasp errors quantitatively by mapping the residual errors in apparent resistivities as derived from observed data and model and to modify the underground resistivity model. By using this way, we could modify the model efficiently. The analysis results were found in good agreement with the observed data.

We also could make sure that one-dimensional model analysis using data of the TE mode is effective enough in this area where the underground resistivity structure is found two-dimensional in general. Besides, there were no static effects in this area, so the effect (static correction) of using SHFMT data could not be confirmed; yet by using the SHFMT data the shallow resistivity structure could be analyzed in detail, thus indicating that SHFMT data are effective in improving the reliability of deep resistivity structure interpretation.

Reference:

Kato, N.; Buturi-Tansa (Geophysical Exploration), vol.38, No.5, p.267-277, 1985

Komazawa, M.; Gravity map (Bouguer anomaly map) in Kanto region, 1985

Uchida, T. et al.; Buturi-Tansa (Geophysical Exploration), vol.39, No.3, p.1-8, 1986