MODELING OF DEEP TEMPERATURES AND HEAT FLOW IN CENTRAL HONSHU, JAPAN

BODRI, B., Department of Geophysics, Eötvös Univ., Budapest, Hungary
IIZUKA, S., Faculty of Marine Science and Technology, Tokai Univ., Shimizu, Japan
HAYAKAWA, M., Faculty of Marine Science and Technology, Tokai Univ., Shimizu, Japan

In this work, the results of a numerical study of the distribution of deep temperatures and of the heat flow at depth over an area of some 100,000 km^2 in Central Honshu, Japan, are presented. Due to complicated geological-structural characteristics of the crust and specific plate tectonic features of the lithosphere, this area has extensively been investigated by different geophysical methods for decades. Of the quite abundant number of seismic-refraction profiles available in the region, we have carried out temperature calculations along six transects with a total length of some 2000 km. The profiles were selected so as to consider possibly different geological environments and structural units and also to achieve a relatively uniform coverage of the area of interest. To complete information on crustal structure, the results of certain three-dimensional crustal models in the Kanto-Tokai District (Ishida,1984; Ashiya et al.,1987) have also been used in a limited amount.

The calculation of deep temperatures and the extrapolation of heat flow to depth were carried out on the base of a numerical solution of the two-dimensional steady-state equation of heat conduction in a heterogeneous medium. The finite difference analogue of this equation was solved on a rectangular grid with uniform zones of 10 km•2.5 km, applying a successive over-relaxation technique. To assess the distribution of radiogenic heat production ($\underline{A}$) along a profile with a specified seismic velocity ($\underline{v}_p$) pattern, an empirical $\underline{A}$ - $\underline{v}_p$ relationship (Rybach and Buntebarth, 1984) was used. Seismic velocities were converted to crustal heat production according to an algorithm given by Cermak and Bodri(1988). Since the entire region is characterized by a highly heterogeneous uppermost part of the crust and deep groundwater circulation might have led to considerable redistribution of radioelements, the distribution of heat sources in the upper crustal section was defined with the use of the surface heat flow - surface heat production relationship combined with Pollack and Chapman's(1977) empirical relationship between reduced heat flow and the mean surface heat flow. Heat production was taken as decreasing exponentially with depth within each crustal block and thermal conductivity was assumed to be dependent on temperature.

Because of the lack of appropriate boundary conditions at the bottom of the calculational area the problem of calculation of deep temperatures in present case is ill-posed. Therefore certain additional information is to be used for the solution. As such additional information, we took data on the distribution of surface heat flow in Central Japan (Li, 1988).

The investigated region, representing a boundary zone of three lithospheric plates: Pacific, Philippine Sea and Eurasia, appears to have extremely complicated tectonic features. The presence of many active volcanoes associated with the subduction of the Pacific plate and the collision of the Philippine Sea plate, and also the occurrence of a series of major faults and areas of local thermal activity like geothermal fields and hot springs are characteristic of the area. The thickness of the crust on land varies from 25-30 km to some 40 km and decreases to about 15 km at the oceanic sections of some of the considered profiles. Surface heat flow shows even stronger variations. Even in the smoothed heat flow map by Li(1988) it may change within distances of 150-200 km from 120 to 40 mWm^{-2}. Heat flow at depth exhibits also large variations. In zones of low surface heat flow temperature at the Moho amounts to 350-500 °C, whereas it may reach some 800-1000 °C in areas of pronouncedly high heat flow anomalies. Regional variations of the Moho heat flow range from 15-20 to 40-50 mWm^{-2}. The results definitely suggest the possible existence of the asthenoshpere at depths as shallow as 50 km in zones of very high heat flow.

A comparison between the features of distribution of deep temperatures and those of the variations of certain other geophysical characteristics (Curie-point depths, electrical conductivity, seismicity, seismic velocity perturbations, seismic attenuation) has also been made. In some cases fairly good correlations were found.

REFERENCES

Ashiya, K., Asano,. Sh., Yoshii, T., Ishida, M. and Nishiki, Ts., 1987. Simultaneous determination of the three-dimensional crustal structure and hypocenters beneath the Kanto-Tokai District, Japan. Tectonophysics, 140: 13-27.

Cermak, V. and Bodri, L., 1988. On the vertical distribution of radiogenic heat production in the continental crust and the estimated Moho heat flow. J. Geophys. Res., (in the press).

Ishida, M., 1984. The spatial distribution of earthquake hypocenters and the three-dimensional velocity structure in the Kanto-Tokai District, Japan. J. Phys. Earth,32: 399-422.

Li, X., 1988. Heat flow and its relations to geological and geophysical features in the Central Japan. M. Sci. Thesis, University of Tokyo, 87 pp.
Pollack, H. N. and Chapman, D. S., 1977. On the regional variation of heat flow, geotherms and lithospheric thickness. Tectonophysics, 38: 279-296.
Rybach, L. and Buntebarth, G., 1984. The variation of heat generation, density and seismic velosity with rock type in the continental lithosphere. In: V. Cermak, L. Rybach and D. S. Chapman (Eds.), Terrestrial Heat Flow Studies and the Structure of the Lithosphere. Tectonophysics, 103: 335-344.