Re-evaluation of thermal data in the Japanese Islands for better estimation of the temperature structure in the crust

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For investigation of the structure and composition of crust, we need to combine various geophysical data with estimated subsurface temperature stricture as well as geological and petrological information, since physical properties of rocks depend on temperature. Surface heat flow is the most fundamental data for estimation of subsurface temperature structure. However, published heat flow data on land in the Japan have been rather sparse and not evenly distributed owing to the limitation of boreholes available for temperature measurement.

Borehole temperature profiles have been measured in observation wells for the Hi-net seismograph network, which are densely and evenly distributed over the Japanese Islands. Temperature measurements have been conducted in groundwater monitoring wells located in and around large cities as well. Although these data can be valuable sources of new heat flow data, the most of the wells are shallow, 50 to 150 m, and subject to influence of ground surface temperature (GST) variation. We selected temperature profile data in relatively deep wells, over 150 m, in the central part of Honshu and attempted to evaluate the influence of GST variation on subsurface temperature structure.

After eliminating data apparently affected by groundwater flow, we reconstructed GST history in the past at each well through inversion analysis of the temperature profile data, taking account of the layered subsurface structure based on borehole lithological column information. GST histories for the last 300 years were successfully reconstructed at several sites in Kanto and Tokai regions and the obtained GST variations are similar to each other. It suggests that we may be able to determine an average GST history for each region in Japan, which can be used for analysis of shallow well temperature data in the region.

For determination of heat flow values, we need to know thermal conductivity of formations through which temperature gradient is measured. At many stations, however, it is difficult to obtain rock/sediment samples for thermal conductivity measurement. Aiming for better evaluation of surface heat flow, we have been conducting measurement of thermal conductivity of core samples collected from Hi-net wells and boreholes drilled for volcano observation. We used an optical scanning instrument, TCS (Thermal Conductivity Scanner), which enables nearly continuous measurement along the core, as well as a conventional box-type probe, QTM (Quick Thermal Conductivity Meter). High-density data with TCS provide valuable information on small-scale heterogeneity in thermal conductivity. For most of the samples we measured, the average of values obtained with TCS is consistent with the value with QTM.

A new version of database "Thermal Data Collection in and around Japan" was released by Geological Survey of Japan in March 2019. It contains updated compilations of heat flow data in the northwest Pacific area (0 to 60 ˚N, 120 to 160 ˚E) and geothermal gradient data in and around Japan, and a new collection of thermal conductivity values measured on rock samples from boreholes in Japan. These datasets, in combination with data from Hi-net boreholes and groundwater monitoring wells, would serve as a basis for modeling thermal structure of subduction zones around the Japanese Islands.

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Keywords: temperature structure, heat flow, thermal conductivity, borehole temperature, ground surface temperature, database

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