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Heat flow distribution in the northern Japan Trench area and temperature anomaly in the upper part of the Pacific plate

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We conducted heat flow surveys in the northern Japan Trench area for investigation of the high heat flow anomaly on the seaward slope of the trench, which was recently found along a parallel of 38°45'N (Yamano et al., 2008). Measurements were made mainly along two E-W lines at around 40°15'N and 37°50'N, where multichannel seismic surveys had been conducted, on four cruises in 2008 and 2009 (KR08-10 and KR09-16 of R/V Kairei and KT-08-25 and KT-09-8 cruises of R/V Tansei-maru). We used ordinary deep-sea heat flow probes, a piston corer with temperature sensors mounted on its barrel, and short probes for submersibles (SAHF) for temperature profile measurements. Thermal conductivity was measured on core samples obtained with the piston corer.

We found that heat flow profiles along the two lines (40°15'N and 37°50'N) are very similar to that along 38°45'N. Heat flow on the seaward trench slope is highly variable: high (over 70 mW/m^2) at some locations and normal for the seafloor age (about 50 mW/m^2) at others, whereas no low values (lower than 40 mW/m^2) were measured. This result strongly suggests that the heat flow anomaly continuously extends along the Japan Trench. On the trench outer rise, high values have been obtained within 150 km of the trench axis. Additional measurements still need to be made to delineate the seaward limit of the anomaly. Closely-spaced measurements at some stations revealed that heat low may significantly vary in a short distance, e.g., by nearly 100 % in only about 2 km.

A possible cause of steep spatial variation of heat flow is fluid flow along normal faults developed due to bending of the plate, though no clear correlation between the heat flow distribution and the seafloor topography has been recognized. The high average heat flow further requires the existence of some heat source in the upper part of the plate. The heat source may have been provided by intra-plate 'petit spot' volcanism in the last several million years. We have been conducting numerical modeling of the thermal structure of this area taking account of advective heat transfer by pore fluid flow along normal faults and in a permeable layer in the upper crust, together with heating by magma intrusion in the crust and uppermost mantle. Preliminary results suggest that fractures with high permeability should reach the seafloor to reproduce the observed heat flow distribution.

Our final goal is estimation of the temperature distribution along the subduction plate interface including the seismogenic zone of large thrust earthquakes. Heat flow data on the landward side of the trench is also important as constraint on deep thermal structure. In a relatively shallow sea area with water depth shallower than 2000 m, we made long-term monitoring of temperature profile in sediment and/or water temperature in order to remove the influence of temporal variation of bottom water temperature. Temperature records of good quality were obtained for over one year at three stations. Analyzing these long-term records, we could successfully obtain the first reliable heat flow data in shallow sea areas landward of the Japan Trench.

Keywords: heat flow, Japan Trench, Pacific plate, thermal structure, subduction zone,

bottom water temperature