Trench-parallel variation in high heat flow anomaly on the Japan Trench outer rise

*Makoto Yamano[1], Masataka Kinoshita[1], Kouta Sasaki[2], Yoshifumi Kawada[3]

1. Earthquake Research Institute, the University of Tokyo, 2. Kozo Keikaku Engineering Inc., 3. Japan Agency for Marine-Earth Science and Technology

Anomalous heat flow values, higher than that expected for the seafloor age of the incoming Pacific plate, are pervasively observed on the outer rise of the Japan Trench. The broad high heat flow zone can be attributed to efficient heat transport by pore fluid circulation in a permeable layer developed through fracturing of the oceanic crust due to plate bending. Overlapping the broad anomaly, local variations at a scale of several kilometers were detected through concentrated measurements along lines perpendicular to the trench. The local anomalies may reflect heterogeneity in fracture development: fractures with higher permeability and/or deeper extent would pump up more heat.
The most detailed heat flow distribution was obtained on the outer rise around 39°N along a line normal to the trench, at around 60 to 80 km from the trench axis. It shows a prominent sawtooth-like variation at a scale of 3 to 5 km, suggesting that fractured zones with higher permeability have developed in the oceanic crust at intervals of several km. The inferred fractured zones are supposed to extend in the direction parallel to the trench. We conducted two-dimensional numerical modeling of pore fluid circulation in the oceanic crust in which high-permeability fractured zones abruptly developed and found that the calculated heat flow distribution is similar to the observed one.
The actual structure of the oceanic crust off the Japan Trench is more complicated and probably three-dimensional as indicated by the distributions and strikes of fault escarpments on the seaward trench slope. We made closely-spaced heat flow measurements along two N-S lines to examine local variations in the direction parallel to the trench axis. The both lines intersect the trench-normal (E-W) survey line around 39°N mentioned above: one at local high heat flow on the E-W line and the other at local low heat flow. The obtained heat flow profiles along the two N-S lines both show significant variation at a scale of several km, similar to the variation along the E-W line. The amplitude of variation is larger along the line through the local high on the E-W line than that along the line through the local low. These features indicate that the permeability structure and pore fluid circulation in the oceanic crust on the outer rise are highly heterogeneous, including substantial trench-parallel variation.

Keywords: heat flow, Japan Trench, outer rise, fluid circulation, heat transport, heterogeneity

