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Closely-spaced heat flow measurements in the vicinity of the splay fault on the the Nankai accretionary prism

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Heat flow measurements have been conducted in the Nankai Trough area southeast of the Kii Peninsula (off Kumano) for investigating the thermal structure of the target area of IODP seismogenic zone drilling (NanTroSEIZE). Combining the data obtained with ordinary heat-flow probe and long-term monitoring instruments with those estimated from gas hydrate BSRs, the overall pattern of heat flow distribution was delineated. Heat flow is around 100 mW/m^2 on the floor of the Nankai Trough and decreases landward to 40 to 60 mW/m^2 in the forearc basin (Kumano Trough), which should reflect the thermal structure of the seismogenic zone and the overriding plate. On the slope of the accretionary prism, however, highly scattered values (60 to 100 mW/m^2) were obtained about 15 to 25 km landward of the deformation front, where the megasplay fault system approaches and intersects the surface. Possible causes of the scatter are: localized fluid flow along active faults, recent deformation near the surface including submarine landslides, bottom water temperature variation (BTV), and topographic disturbance.

To study the relation between the scattered heat flow and tectonic activities around the splay fault, we conducted closely-spaced heat flow measurements at two sites on the prism slope on KH-10-3 and KH-11-9 cruises of R/V Hakuho-maru in 2010 and 2011. One site is located around a prominent 400-m high scarp associated with a branch of the splay fault, At the foot of the scarp, biological communities have been found, indicating cold seepage activity along the fault. The observed heat flow is higher on the seaward side of the scarp and lower on the landward side. The highest values were measured at the foot of the scarp. The overall heat flow distribution across the scarp is attributable to the effect of bathymetric relief, whereas the local high at the foot of the scarp might arise from upward fluid flow along the fault. The other site is located around a U-shaped slump scar topography on the middle part of the prism slope and measurements were made along a line crossing the scar. The obtained data show no significant heat flow variation across the scar. It suggests that submarine landslide corresponding to the scar is not a very recent event.

We also conducted long-term temperature monitoring with pop-up type instruments and obtained bottom water temperature records for 15 months at two stations with water depths of 2550 and 3340 m. The record at the 2550-m station shows large BTV over 0.3 K, similar to the one previously obtained at about the same water depth. BTV with this amplitude has significant influence on temperature distribution in surface sediment. The BTV observed at the 3340-m station is much smaller, less than 0.1 K, and cannot cause appreciable variation in heat flow measured at the surface. Half of the existing scattered heat flow values were measured at sites shallower than 3000 m and may have been affected by BTV. We need to collect more long-term water temperature records at depths around 3000 m for evaluation of influence of BTV and for measurement of undisturbed heat flow.

Keywords: Nankai Trough, heat flow, accretionary prism, splay fault, cold seep, submarine landslide