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Fluid flow in a partially-thickening aquifer: A model for km-scale high heat flow on the outer rise of the Japan Trench

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Anomalous high heat flow is observed broadly on the seaward side of the Japan Trench offshore of Sanriku (*Yamano et al.*, 2008, 2014). Average heat flow within 150 km seaward of the trench axis is ca. 70 mW/m^2, which is substantially higher than that predicted by thermal models with the plate age 135 Ma, 50 mW/m^2. Individual heat flow values scatter between 50 and 120 mW/m^2. Dense measurements (at intervals of several 100 meters) conducted along 39^{o}N have revealed that the scatter has a spatial scale of 3-5 km (*Yamano et al.*, JPGU2015). The origin of such fine scale anomaly must be just below the seafloor; however, seismic surveys cannot detect any structure within the sediment below the heat flow anomaly.

A high V_p/V_s layer is imaged at the uppermost part of the subducting oceanic plate where the heat flow anomaly is observed (*Fujie et al.*, 2013a, 2013b). The layer is imaged to be thickened toward the trench axis. The uppermost part of the oceanic plate is porous and works as an aquifer, and the observation could be interpreted as thickening of the aquifer toward the trench axis.

Previously, we constructed a model to explain the high average heat flow (*Kawada et al.*, 2014). Being inspired from the observation of the high V_p/V_s layer, we modeled a 500-m-thick aquifer 150 km seaward the trench axis that is linearly thickened to 3000 m toward the trench axis. Numerical modeling of heat and fluid transport results in anomalous high heat flow that is comparable to the observation, +20 mW/m^2. According to this model, the origin of the observed anomalous high heat flow is vertical heat mining from the underlying plate below the thickening aquifer.

In this presentation, we investigate the role of partial thickening of the aquifer on the resulting heat flow anomaly, in order to explain the observed fine-scale heat flow anomaly. Although *Kawada et al.* (2014) assumed that the aquifer is thickened smoothly, thickening of the aquifer should occur as discrete events because it is physically propagation of fissures. We consider two situations:

1. A part (1-2 km width) of an aquifer is abruptly thickened to 3000 m. In this case, we conducted numerical calculations of heat and fluid transport across the trench axis.
2. A permeable fault of $\sim$100 m width, 3000 m deep, and infinite length along the strike is abruptly formed. In this case, we conducted calculations of conductive heat transport with enhanced thermal conductivity that mimics hydrothermal circulation.

In both cases, high heat flow peaks are formed above the permeable zone (thickened aquifer or fault) immediately after the calculation begins. High heat flow anomaly that is comparable to the observation $\sim$100 mW/m^2 persists over several hundreds of thousand years. Heat is transported from the surrounding areas of the permeable zone, where no hydrothermal convection occurs. That is, heat in the surrounding area is mainly transported horizontally toward the permeable zone by thermal conduction and then is transported vertically due to hydrothermal circulation within the permeable zone. Because the area of the surrounding area is larger than the permeable zone, high heat flow anomaly can continue for a long time.

Keywords: heat flow, hydrothermal circulation, Japan Trench, subduction zone