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Hydrothermal heat mining due to the aquifer thickening toward the trench axis: A model for the Japan Trench

KAWADA, Yoshifumi[1*] ; YAMANO, Makoto[1] ; SEAMA, Nobukazu[2]

[1]ERI, Univ of Tokyo, [2]Kobe University

Observation: At the Japan Trench, a 135-Myr-old Pacific plate is subducting beneath the Japan Island. Heat flow on such an old oceanic plate is expected to be 50m W/m^2 by a thermal model of the oceanic plate. However, observed heat flow values range from 50 to 120 mW/m^2 and the averaged value is 70 mW/m^2 (Yamano et al., 2008, Int. J. Earth Sci.). In the area of high heat-flow anomalies, a high V_p/V_s layer (highly porous, and probably highly permeable) is observed within the uppermost part of the oceanic plate (Fujie et al., 2013, JpGU Meeting). The layer thickness is observed to increase toward the trench axis.

Hypothesis: Permeability within the uppermost several hundred meters of oceanic plate is measured to be high for fluid to convect; this layer is called an aquifer. We assume that thickening of the observed high V_p/V_s layer is a consequence of thickening of this highly permeable layer. Accordingly, we construct a numerical model including hydrothermal circulation within an aquifer being thickened with time, and calculate the resulted heat flow anomalies.

Results: Calculations show that heat flow is increased as the aquifer thickness begins to increase. With typical parameter values for the Japan Trench, the result accounts for the observed high heat-flow anomaly of 20 mW/m^2. This high heat-flow arises due to the mining of heat from the base of the thickening aquifer. Downward thickening of the aquifer invades the high-temperature region, and incorporates the heat into convection. As a result, this heat is transported upwards through sediments above the aquifer, and heat flow is increased.

Keywords: hydrothermal circulation, heat flow, the Japan Trench, seismogenic zone