Heat flow observation around a young petit spot volcano on the old Pacific Plate subducting into the Japan Trench

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Estimating the temperature structure and fluid circulation inside the subduction zone is important for quantifying the behavior of the mega-thrust zone faults because the upper and lower ends of these faults are somehow affected by the temperature and the water content. In the Japan Trench, there are at least two factors potentially controlling the subduction zone temperature and water circulation before subduction: faults and fractures, and young volcanoes, both of which are due to plate bending near the trench. This presentation focuses on the latter, volcanoes, but aiming the transfer of heat and fluid through seafloor rather than the volcanic heat input. On some seafloor of the Japan Trench seaward of the trench axis, young petit-spot volcanoes (~1 Ma) exist on the very old Pacific Plate (>100Ma) subducting into the Japan Trench. Even for this young seamount age, heat input itself does not dominate. To date, there are few observations for the seamount of this type to asses their ability to transfer heat and fluid through the seafloor.

During the Shinsei-Maru cruise KS-19-13, we conducted heat flow observation around one of these petit-spot volcanoes. The targeted seamount has a diameter of ~2000 m above the seafloor. The seafloor southwest of the seamount is deeper than that of the northeastern side, indicating that a fault running NW-SE exists near or beneath the seamount. This direction may reflect the regional tectonics because many lineation structures of this direction are found in the bathymetric map of the target area. We used a 3-m-long Ewing-type heat flow probe with seven miniaturized temperature loggers equipped equally spaced at 40 cm, performing the pogo style operation from the mother ship. For each site, the temperature gradient estimated from at least four temperature time series during 15-minute-long penetration is multiplied by a common typical thermal conductivity for this site, 0.9 W/m/K, to calculate the heat flow. The tilt is corrected but little is changed.

The resulted heat flow values range between 20 and 300 mW/m^2, suggesting the existence of hydrothermal heat transport. The heat flows more than 3 km away from the summit of the seamount is 50 mW/m^2, a typical heat flow value predicted from the plate-cooling model with the corresponding plate age. The low heat flows are recorded on the northern to eastern foot areas of the seamount. The high heat flows are on the western foot areas as well as the mountain surface of this side. Along an ENE-WSW transect, the heat flow changed from the lowest to the highest values within two kilometers. From the observation, we may presume the existence of a single convection cell within the seamount. Seawater recharges into the seafloor from the northeastern side of the seamount, and heated hydrothermal fluid discharges from the southwestern side. Our numerical modeling targeting a single permeable seamount protrude from the seafloor indicates that this type of fluid flow can be formed using a certain parameter set. A simple energy balance calculation, with the basal heat flow of 50 mW/m^2, can estimate the heat output using either the observed heat flow deficit and the excess heat flow multiplied by the area involved. The heat output from the targeted seamount is around 1 MW for each case. If the discharge temperature is assumed as 10 degrees Celsius, a typical sediment-basalt interface temperature for the target area, the fluid flux is estimated to be of the order of 10 kg/s. These are comparable with those associated with one of a well-known pair of seamounts, the Baby Bare on the Juan de Fuca Ridge.

Heterogeneous distribution of petit-spot seamount seaward of the Japan Trench causes heterogeneous fluid circulation along the Japan Trench subduction zone, which may affect the behavior of the thrust zone faults.

Keywords: crustal heat flow, temperature structure, seismogenic zone, hydrothermal circulation, seamount