

Fluid circulation through petit-spot volcanic knolls inferred from surface heat flow distribution

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The uppermost part of oceanic crust, several hundred meters thick, has a high permeability. Detailed heat flow measurements in ocean basins indicate that active pore fluid circulation exists in this permeable layer even at very old ages over 100 Ma. Fluid circulation beneath old seafloor is generally not connected to the ocean because it is covered by thick, less permeable sediments. If there are outcrops of permeable basement, however, ventilated circulation connected with seawater can take place and may discharge heat efficiently.

On the incoming Pacific plate off the Japan Trench, petit-spot volcanism on and around the outer rise may have provided pathways for such ventilated fluid circulation. Closely-spaced heat flow measurements conducted around a young petit-spot volcanic knoll, located seaward of the outer rise, showed that heat flow is anomalously low within 2 km of the knoll. It strongly indicates that fluid circulation through the inside of the knoll discharges heat advectively, resulting in low conductive heat flow in the close vicinity of the knoll. Although the extent and pattern of circulation cannot be constrained by the present heat flow data, it is possible that fluid flow through the knoll is connected with circulation in the permeable layer in the oceanic crust through subsurface volcanic edifice, which may be highly permeable.

Recent seismic surveys on the outer rise of the Japan Trench around 38°N revealed that the sediment layer above the acoustic basement is anomalously thin in the area where numerous petit-spot volcanoes have been found. The thin sediment cover may have arisen from pervasive intrusion of petit-spot magma forming wide-spread sills within pelagic sediments. In this petit-spot area, many small volcanic knolls, which extruded out from the sediment, might be acting as fluid conduits penetrating through sediment layers. It is therefore possible that there exist large fluid circulation systems consisting of volcanic knolls, sills and the permeable layer in oceanic crust. Detailed heat flow survey and geochemical analyses of pore fluid and bottom water would allow us to examine the existence and the nature of such circulation systems. Fluid flow through petit-spot knolls and sills can also be important as pathways for water infiltration into deeper part of oceanic crust which was fractured due to bending of the incoming plate associated with subduction.

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