

Spatial scale and dynamics of sub-seafloor hydrothermal systems inferred from detailed heat flow measurements

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Hydrothermal activity within the caldera of Suiyo Seamount in the Izu-Boni Arc was investigated in detail using manned or remotely-operated submersibles, and by deep-tow imagery and seismic surveys. Hydrothermal regime in the Suiyo Seamount was characterized by a geochemically uniform fluid, shallow reservoir depth, very permeable seafloor, and venting without creating big chimneys. Detailed heat flow surveys, as well as fluid flux measurements through the seafloor, were carried out during 5 research cruises in 2001-2003.

Heat flow is highest (higher than 10 W/m²) within the active area. These values were obtained generally close venting areas, thus are affected by venting or very shallow reservoirs. To the east, heat flow is uniform around 4 W/m². Since no indications of discharge have been found in the eastern area, it should be dominated by thermal conduction and the heat source would possibly be a hydrothermal reservoir sealed by the cap rock at depth. To the west, we detected very low heat flow values (lower than 0.3 W/m²) only several tens of meters away from the venting area. This localized strong contrast in heat flow is also observed in the TAG hydrothermal field of Mid-Atlantic Ridge, and in the Iheya-North and Izena hydrothermal field of the Okinawa Trough. These suggest that a localized circulation with its spatial scale 10-20m can be naturally realized in sub-seafloor hydrothermal systems.

We detected strange temperature profiles at 1-2m away from isolated sulfide mounds within active area of the Suiyo Seamount; subbottom temperatures were about 40degC at 10-20cm depth, then they decrease to about 20degC at 30-40cm depth. These temperature reversals suggest a meter-scale hydrothermal circulation, where a hot fluid discharges as a branch flow from the main vent to the isolated mound. An impermeable structure of the mound and a permeable sediment surrounding the mound would make this very local circulation possible.

Heat output rate in the Suiyo Seamount caldera is estimated as about 200 MW, from the heat flow data and distribution of the vents and diffuse flow sites. Out of 200 MW, heat output through thermal conduction makes only 0.2% contribution. This is in contrast with hydrothermal systems in mid-oceanic ridges or sediment-hosted environments. As mentioned already, the overall permeability structure is one of the dominant factors to control the size and lifetime of hydrothermal circulation.