Spatio-temporal scale of seafloor hydrothermal systems: Constraints from borehole and seafloor observations in the Mid-Okinawa Trough

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Drilling, submersible, and surface data suggest that an enormous hydrothermal reservoir with a horizontal extent of ~1500 m lies beneath the Iheya-North hydrothermal field. Heat flow exceeds 10 W/m2 within ~500 m of the Active Site, where active chimneys vent high-temperature fluid. At the Active Site, drilling encountered high-density (hard) layers 1–2 m thick and up to 90 m below seafloor (mbsf), and drilling through these layers led to hydrothermal fluid emission. Measurements of thermal and chemical discontinuities strongly suggest that a hydrological barrier confined the hydrothermal fluid below.
Eastward in the Western Basin, heat flow was up to 0.5–1 W/m2, substantially higher than the regional average (0.1 W/m2), although the surface morphology showed no sign of hydrothermal activity. Farther east, where the seafloor was flat but rough, surface heat flow values, including at IODP Site C0017, were much lower than in the surrounding area. Subbottom temperatures above 40 mbsf at Site C0017 indicated that the heat flow was consistently as low as the surface values (0.03 W/m2), but temperatures increased to 80 °C below 60 mbsf.
We used a 2-D time-dependent hydrothermal circulation model and performed simulations with and without the assumption of a hydrological barrier below the area from the Active Site to Site C0017. Simulations with a hydrological barrier with permeable windows below the Active Site and Site C0017 reproduced the observed hydrothermal conditions between 30 and 300 years after reservoir emplacement. Simulations assuming pure conduction or a continuous barrier could not reproduce the observed conditions.

Keywords: heat flow, Okinawa Trough, IODP, hydrothermal circulation

