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中央インド洋熱水系総合探査報告 –水素の大河の全貌–

Hydrothermal exploration along the Central Indian Ridge - background and impacts of a hydrogen-rich hydrothermal system

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The Kairei Hydrothermal Field (KHF) is located at the southern end of the Central Indian Ridge (CIR), near the Rodriguez ridge triple junction. The KHF was discovered by ROV Kaiko in 2000, based on the preceding report of hydrothermal plume anomaly detected in Hakuho-maru KH-93-3 cruise in 1993. The fluids venting from the KHF are characterized by its high concentration of hydrogen, and a hydrogen-based hyperthermophilic subsurface lithoautotrophic microbial ecosystem was confirmed by Takai et al. [2004]. The hydrothermal vent lies on basaltic lava area on the shoulder of ridge axial wall, on the other hand, gabbro and ultramafic rocks are discovered around the KHF [e.g., Kumagai et al., 2008; Nakamura et al., 2009]. The recent submersible dive discovered a group of dead chimneys on the hill north of the KHF, where peridotite is widely exposed. Previous studies on other hydrogen-rich hydrothermal systems inferred that they may be related to the serpentinization of lower crust and/or mantle rocks and be controlled by detachment faulting, however the integrated study based on detailed field observations have not been done. The microbiological production and its impact on deep-sea ecosystem of hydrogen-rich hydrothermal plumes are unknown. The objectives of KH-10-6 cruise (23 Nov. 2010 - 13 Dec. 2010) are, 1) to verify the hypothesis that hydrogen-rich KHF is controlled by the ambient crustal structure and the chemical composition of lithosphere, 2) to estimate the chemical and microbiological fluxes from KHF to seawater through hydrothermal plumes, and 3) to quest an unknown hydrothermal field on the rise, tentatively called Yokoniwa Rise, north of the KHF. During 21 days operation, we conducted one successful AUV dive, 22 dredge hauls, 10 CTD tow-yo surveys, 3 CTD vertical casts, 4 VMPS and 1 MTD plankton net. Total 800 miles of surface geophysical mapping was also done and a 80 miles of deep-tow magnetic profile was obtained. The preliminary results are, 1) A r2D4 #68 dive was done successfully above the Yokoniwa Rise north of the KHF, where the dead chimneys on ultramafic exposure were discovered in 2009. High-resolution side scan image and interferometric bathymetry was obtained with data of chemical and physical sensors. The attached magnetometer could detect the positive anomaly on the dead chimney area. 2) Surface geophysical mapping revealed the detailed feature of CIR-4 segment, where no previous data existed. The result will improve our understanding of spreading history and structural segmentation of the CIR, and will provide a key to consider the tectonic setting of the EHF. 3) Total 80 mile of deep-tow magnetic profile was obtained across CIR-1 segment. The detailed spreading history since 2 Ma was revealed, that will constrain the evolution of detachment faults around the KHF. 4) A number of lower crust / mantle materials were collected around the KHF. Focused dredge hauls on the Yokoniwa Rise will lead us a reliable model of Yokoniwa formation. 5) Systematic sampling of mid-ocean ridge basalts with fresh glass along the ridge axis will provide a good opportunity to study the mantle heterogeneity beneath the southern CIR. 6) Total ten CTD tow-yo surveys and three vertical casts could reveal the spread of hydrothermal plumes and their chemical and physical properties around the Kairei and Edmond Hydrothermal Fields. The anomalies of pH, turbidity, alkalinity, Mn, CO₂ and DO were detected around the KHF. Very high concentration of hydrogen was also confirmed. 7) Newly developed pH sensor and turbidity meter were attached to the wire during most of dredge hauls and plankton net operations. Distinct turbidity anomalies were detected at some sites, that could prove the effectiveness of 'dredge-attached' sensors. 8) Approximately double-dense microbial cell density was detected within the hydrothermal plume above the KHF. The detailed distribution will provide a new insight into microbiological flux through the plume.

Keywords: hydrothermalism, Central Indian Ridge, tectonics, petrology, hydrothermal plume