Estimation of subseafloor environment at active hydrothermal fields in Okinawa Trough based on mineralogical and geochemical analysis

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A series of drilling campaign was conducted in Okinawa Trough under the framework of the Next-generation Technology for Ocean Resources Exploration Project. I investigated hydrothermal alteration, sulfide and sulfate minerals in drill core samples. The study fields of this investigation are the Iheya-North hydrothermal field and Noho Site in mid-Okinawa Trough. Deep sea drilling was conducted in 2014 (CK14-04 Cruise) and 2016 (CK16-01 Cruise) using the drilling vessel *Chikyu*. In total, 7 holes in the Iheya-North hydrothermal field and 3 holes in Noho Site were drilled. The deepest hole reached 208.5 mbsf (meters below seafloor). X-Ray Diffraction analysis of the core samples was performed onboard for 199 samples to identify mineral species in the cores. 67 polished sections were prepared to determine rock texture and mineral assemblage. Electron Probe Micro Analysis was applied to determine chemical composition of the sulfide minerals. Pb isotope ratios were analyzed for 26 representative sulfide samples using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry.
Site C9021 is located midway between Natsu Site and Aki Site in the Iheya-North hydrothermal field. The core sample consisted of a 70 m thick layer of fresh pumice. Sites C9016 and C9023 were drilled in the vicinity of two active hydrothermal vents. The core samples consisted of abundant anhydrite with clay minerals associated with minor sulfides (pyrite, sphalerite, galena, and chalcopyrite). K-bearing minerals such as illite and K-feldspar were also observed. The abundant anhydrite indicates rigorous mixing between the seawater and hydrothermal fluids beneath the seafloor. Sphalerite was relatively low in Fe suggesting deposition under an oxidative condition. Pb isotope composition of the sulfide minerals shows a narrow range indicating deposition from a common hydrothermal fluid. Site C9017 is located in the Noho Site. The 120 m-long core sample consisted of alternations between basaltic lava and clay-rich layers. Hydrothermal alteration was not intense but observed over the entire core sample. Ca-bearing minerals, anorthite, wairakite, and dolomite occur in ascending order of core depth. Minor pyrite, pyrrhotite, cubanite, sphalerite, and anhydrite were identified. Sphalerite was relatively high in Fe indicating deposition under a reduced condition.
In the Iheya-North hydrothermal field, hydrothermal alteration and sulfide minerals occur under oxidative condition beneath the seafloor, in the vicinity of the active hydrothermal vents. Indicative of a high seawater flux entrained through the permeable pumice layer. In contrast, the Noho Site is under a reduced condition. This may have been generated by the lava layers which act as cap rocks and prevent seawater penetration. In both fields, a high temperature condition is estimated in the deeper portions, based on occurrence of alteration minerals. Alteration minerals in the Iheya-North hydrothermal field are rich in K, whereas those in the Noho Site are Ca-rich. This difference reflects different host rock, dacite pumice for the former and basaltic lava for the latter. In summary, degree of seawater entrainment, temperature of the hydrothermal fluid, and chemical composition of the host rock are important controlling factors that determine environment beneath the active hydrothermal fields in Okinawa Trough.

Keywords: Seafloor hydrothermal deposit, Iheya-North hydrothermal field, Noho Site, CK14-04 Cruise, CK16-01 Cruise, Hydrothermal alteration

