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Hydrogeological structure of a seafloor hydrothermal system related to backarc rifting in a continental margin setting

Jun-ichiro Ishibashi
Kyushu University, Dept. Earth & Planetary Sciences, Japan (ishibashi.junichiro.779@m.kyushu-u.ac.jp)

Seafloor hydrothermal systems in the Okinawa Trough backarc basin are considered as related to backarc rifting in a continental margin setting. Since the seafloor is dominantly covered with felsic volcaniclastic material and/or terrigenous sediment, hydrothermal circulation is expected to be distributed within sediment layers of significantly high porosity. Deep drilling through an active hydrothermal field at the Iheya North Knoll in the middle Okinawa Trough during IODP Expedition 331 provided a unique opportunity to directly access the subseafloor. While sedimentation along the slopes of the knoll was dominated by volcanic clasts of tubular pumice, intense hydrothermal alteration was recognized in the vicinity of the hydrothermal center even at very shallow depths. Detailed mineralogical and geochemical studies of hydrothermal clay minerals in the altered sediment suggest that the prevalent alteration is attributed to laterally extensive fluid intrusion and occupation within the sediment layer. Onboard measurements of physical properties of the obtained sediment revealed drastic changes of the porosity caused by hydrothermal interactions. While unaltered sediment showed porosity higher than 70%, the porosity drastically decreased in the layer of anhydrite formation. On the other hand, the porosity remained high ($\sim$50%) in the layer of only chlorite alteration. Cap rock formation caused by anhydrite precipitation would inhibit the ascent of high temperature fluids to the seafloor. Moreover, an interbedded nature of pelagic mud units and matrix-free pumice deposits may prompt formation of a tightly layered architecture of aquifers and aquicludes. This sediment architecture should be highly conducive to lateral flow pseudo-parallel to the surface topography. Occurrence of sphalerite-rich sulfides was recognized as associated with detrital and altered sediment, suggesting mineralization related to subsurface chemical processes. Moreover, the vertical profiles of mineral occurrence documented for the obtained cores could be directly compared to those found within economically important Kuroko-type volcanogenic massive sulfide deposits (VMSD). High porosity within volcaniclastic sediment led to the development of a laterally extensive hydrothermal reservoir, favorable for formation of these large polymetallic ore deposits.