Understanding Circum-Antarctic Ridges: Hydrothermal alteration of oceanic mantle exposed on seafloor fractures

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The Circum-Antarctic Ridges (CARs) encircling the Antarctica constitute one third of the global mid-ocean ridge systems. The CARs have unique characteristics of shallow water depths, ultra-slow to intermediate spreading rates, and complex series of transform offsets. In addition, since the CARs cover all major oceans with no continental barriers, we can trace mantle flow between different oceanic domains, as well as the migration of hydrothermal vent fluids and animals.

In this study, we focus on hydrothermal alteration of oceanic mantle exposed on seafloor fractures developed at magma-poor settings. Exposures of ultramafic mantle rocks are extensively distributed within slow spreading environments, where alteration processes significantly influence submarine ecosystems and result in high concentrations of metals. The location and spatial extent of hydrothermal activity are difficult to constrain; however, studies of near-seafloor magnetic field can highlight these features because crustal magnetic minerals can be destroyed or created by hydrothermal processes. Therefore, investigating magnetic signatures in these ultramafic-hosted hydrothermal systems is important for detecting active and inactive hydrothermal sites and their mineralization states.

High-resolution vector magnetic measurements were performed on an inactive ultramafic-hosted hydrothermal vent field, called Yokoniwa Hydrothermal Field (YHF), using a deep-sea manned submersible *SHINKAI 6500* and an autonomous underwater vehicle (AUV) *r2D4*. The YHF has developed at a non-transform offset massif near the Rodrigues Triple Junction of the Southeast Indian Ridge, Southwest Indian Ridge, and Central Indian Ridge. Dead chimneys were widely observed around the YHF along with a very weak venting of low-temperature fluids so that hydrothermal activity of the YHF was almost finished.

The distribution of crustal magnetization from the magnetic anomaly revealed that the YHF is associated with enhanced magnetization, as seen at the ultramafic-hosted Rainbow and Ashadze-1 hydrothermal sites of the Mid-Atlantic Ridge. The results of rock magnetic analysis on seafloor rock samples (including basalt, dolerite, gabbro, serpentinized peridotite, and hydrothermal sulfide) showed that only highly serpentinized peridotite carries high magnetic susceptibility and that the natural remanent magnetization intensity can explain the high magnetization of Yokoniwa. These observations reflect abundant and strongly magnetized magnetite grains within the highly serpentinized peridotite. Comparisons with the Rainbow and Ashadze-1 suggest that in ultramafic-hosted hydrothermal systems, strongly magnetized magnetite and pyrrhotite form during the progression of hydrothermal alteration of peridotite. After the completion of serpentinization and production of hydrogen, pyrrhotites convert into pyrite or nonmagnetic iron sulfides, which considerably reduces their levels of magnetization. Our results revealed origins of the magnetic high and the development of subsurface chemical processes in ultramafic-hosted hydrothermal systems. Furthermore, the results highlight the use of near-seafloor magnetic field measurements as a powerful tool for detecting and characterizing seafloor hydrothermal system

References

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