Hydrothermal activity and sub-seafloor serpentinization on the Yokoniwa Rise developed in the Central Indian Ridge: Constraints from AUV mapping and rock magnetisms

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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, known as 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 rock samples collected around the YHF and in the slope of the Yokoniwa Rise were utilized for measurements of physical and rock magnetic properties, and petlogical ivestigation.

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. The detailed magnetic hysteresis measurements demonstrated that single-domain (SD) magnetite was formed during the later stage of serpentinization, and it is assembled inside of mesh structures with strong magnetostatic interactions. 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 hydrogen production, 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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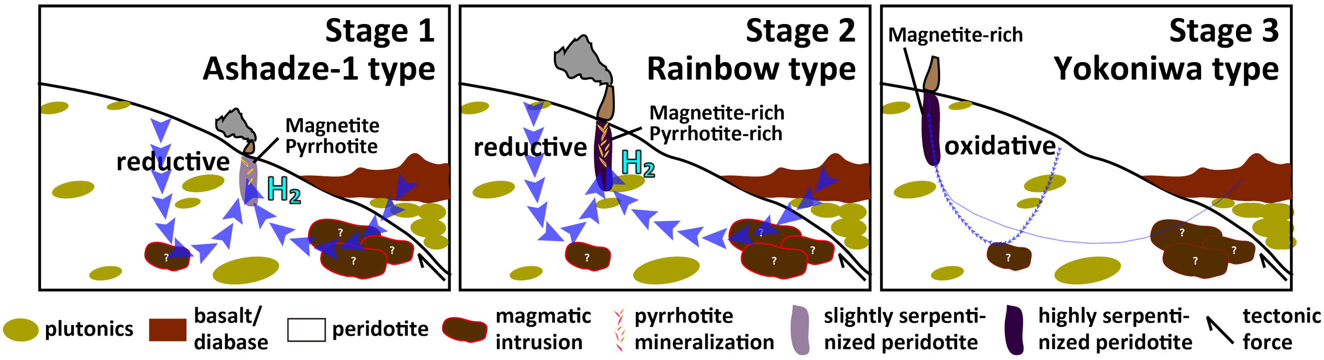

Figure. Model of magnetic mineral formation. Model showing the 3-stage formation history of magnetic minerals in ultramafic-hosted hydrothermal systems.
Stage 1: some magnetized magnetite and pyrrhotite form thorough serpentinization and sulfide mineralization under reductive conditions,
Stage 2: large quantity of magnetized magnetite and pyrrhotite are accumulated thorough serpentinization and sulfide mineralization under reductive conditions,
Stage 3: only magnetized magnetite remains as main magnetic source under oxidative condition after serpentinization of host rock.

