Fluid and carbon cycling in the shallow forearc mantle revealed by serpentinized peridotite from hadal seafloor

*Ryosuke Oyanagi[1,2], Atsushi Okamoto[3], Madhusoodhan Satish-Kumar[4], Masayo Minami[5], Yumiko Harigane[6], Katsuyoshi Michibayashi[2,5]

1. Kokushikan University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Tohoku University, 4. Niigata University, 5. Nagoya University, 6. AIST

Carbonate minerals provide a unique opportunity to investigate the mechanism of the carbon cycle in the subduction zone. Investigation of upwelling fluids and serpentinite from the Mariana forearc has revealed that carbon is released from the subducting slab at shallow forearc depths. However, in contrast to the deep carbon cycle, little is known about the timescale and rates of carbon and fluid cycling in shallower forearc regions. In this study, we investigated a peculiar occurrence of calcium carbonate (aragonite) in forearc mantle rocks recovered from ~6400 m water depth on the Umigame seamount, in the Izu–Ogasawara Trench. The recovered peridotites are strongly serpentinized (~80%) and contain extensive fractures infilled with carbonate and consist mainly of serpentine minerals (lizardite and chrysotile that are locally intermixed with talc, showing the mesh texture. The serpentine mesh texture is cut by aragonite veins, suggesting that aragonite precipitation postdated the serpentinization. Strontium–carbon–oxygen isotope geochemistry and rare earth elements pattern of aragonite suggest that the aragonite was formed at the ambient temperature of deep seafloor (~2 °C) and sourced from the dissolved inorganic carbon derived from seawater. Moreover, radiocarbon analysis of aragonite revealed that the aragonite samples are nearly ^{14}C dead, suggesting that the aragonite is sourced from seawater that accumulated for more than 42,000 years.

The serpentine clasts in the aragonite are interpreted to have formed by fluidization in a high fluid flux regime. The particle size of serpentine clasts in the aragonite suggests that the accumulated fluid was expelled with fluid velocity ranging 10^{-2}–10^{-1} m s^{-1}. Thermodynamic modeling on serpentine-seawater reaction revealed the aragonite would be formed under high seawater-to-rock mass ratio ($10^{2.5}$-$10^{3.5}$). These modeling results suggest that discharge of the accumulated fluid continued for a few decades at most. We suggest that the fluid discharge was driven by episodic rupture events, and the recycling of subducted seawater from the shallowest forearc mantle influences carbon transport from the surface to Earth’s interior.

References

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