Protolith of metamorphic sole in the Oman ophiolite inferred from whole rock trace element abundances and Sr-Nd isotope ratios

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The Oman ophiolite represents a former oceanic lithosphere obducted due to intra-oceanic thrusting at mid-ocean ridge about 95 million years ago. During the thrusting the young hot oceanic lithosphere gave contact metamorphism to the upper surface of the subducting oceanic plate forming amphibolite and greenschist (Hacker and Mosenfelder, 1996). On the other hand, highly depleted peridotite is distributed over the mantle section of the northern Oman ophiolite as a results of flux melting assisted by the fluid from a metamorphic sole (e.g., Kanke and Takazawa, 2014). When considering the fluid that reacted to the mantle section, it is important to know the geochemical character of the metamorphic sole. In this study, we analyzed whole rock trace element compositions and Sr-Nd isotopic ratios of the samples collected from the metamorphic sole distributed over the Sumayni Window (Searle and Malpas, 1982) in the northern part of the Oman ophiolite. Our study aimed at clarifying the original protolith for the metamorphic sole.

The metamorphic sole is observed along three routes of Sumaini Window. The lithology changes from Gar-Cpx amphibolite to Cpx amphibolite to Ep amphibolite to greenschist (or quartzite) to chart with increasing the distance from the boundary to the mantle section. Marble is locally taken in as a block. In the Ta-Hf-Th discrimination diagram, amphibolites are plotted within the fields of N-MORB, E-MORB and oceanic island basalt to alkali basalt. There is a tendency that amphibolite near the boundary has N-MORB affinity. In the Nb-Zr-Y discrimination diagram, amphibolites are also plotted within the fields of N-MORB, E-MORB, and within plate tholeiite and volcanic arc basalt. The REE patterns of amphibolites normalized to C1 chondrite can be classified into three patterns. The amphibolites in Ash Shiyah show either N-MORB or E-MORB-like pattern. The amphibolites near the boundary to the mantle section tend to show N-MORB-like pattern, then change to E-MORB-like pattern with increasing distance from the boundary. In Wadi Sumayni, amphibolites show N-MORB-like pattern near the boundary, then become E-MORB like pattern with increasing distance from the boundary. Greenschists are strongly enriched in LREE similar to OIB.

The Sr-Nd isotopic compositions of amphibolite and a greenschist differ from the isotopic composition of crustal rocks in the Oman ophiolite. The ε_{Sr} in 96Ma is in a range from +10 to +30, and resembles the isotopic composition of the oceanic crust polluted by seawater. The ε_{Nd} ranges from +1 to +8 lower than the values for Oman ophioilte. The ε_{Nd} is considered to reflect the various origin (N-MORB, E-MORB, OIB) of protolith supported by a negative correlation with the La/Yb ratio.

It became clear that HFS elements and rare earth elements are resistant to and is kept considerably in spite of the contact metamorphism and dehydrating process during the formation of a metamorphic sole. Our results show the original protoliths of amphibolite and greenschist are variable with N-MORB, E-MORB, and OIB. E-MORB is dominant while N-MORB partly exists near the boundary to the mantle section. On the other hand, in Wadi Sumaini, greenschist and amphibolite in the lowermost horizon were originally OIB, and the upper horizon was E-MORB to N-MORB from the bottom to the boundary to the mantle section. Further examination is required to clarify whether such stratigraphy reflects the original profile beneath seafloor or it is an apparent stratigraphy obtained by thrusting and juxtaposition at the time of metamorphic sole formation.

References

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