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Spatial compositional variability and origin of incipient subarc mantle inferred from the northern Oman ophiolite

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The Oman ophiolite is a remnant of Neo-Tethyan oceanic lithosphere that has been modified by arc-related magmatism during oceanic thrusting prior to the obduction to the Arabian continent. To understand the formation of oceanic mantle lithosphere at spreading ridge and subsequent modification at incipient subduction zone we conducted a Km-scale mineral chemical mapping of the mantle section in the Fizh and Salahi blocks in the northern Oman ophiolite.

In the Fizh mantle section the range of spinel Cr# (=100xCr/[Cr+Al] molar%) in harzburgites becomes wider from the south (Cr# 43-67) toward the north (Cr# 22-78). In the south, where paleo-ridge segment center has been inferred, relatively homogeneous harzburgites with spinel Cr# around 60 are widely distributed indicating that the degree of melting was equivalent to the upper limit of abyssal peridotites (spinel Cr#~60). On the other hand, in the northern part, where a paleo-ridge segment end was inferred, refractory harzburgites with spinel Cr# greater than 70 are abundant and are linearly distributed from the basal thrust to the Moho. Such highly refractory harzburgites are associated with thick dunite bands in which spinel Cr# is also high (greater than 70). Such region with abundant refractory peridotites is called highly refractory zone (HRZ, hereafter). Away from the HRZ the harzburgites are less refractory and often contain spinels with low Cr# (smaller than 50). Thus, except for the peridotites in the HRZ the harzburgites in the northern Fizh mantle section is less refractory relative to those in the southern Fizh mantle section. Dunites in the Fizh mantle sections have spinel with Cr# ranging from 45 to 80 and tend to have higher spinel Cr# than the harzburgites. Moreover, the dunites with high Cr# spinel (greater than 70) are abundant in the HRZ and in the basal part of the Fizh mantle section.

In the Salahi mantle section the spinel Cr# of harzburgites ranges from 42 to 70 and is most frequent in the range of 55-60. The harzburgites in the southern Fizh mantle section also have similar variation. On the other hand, the Cr# of spinel in dunites in the Salahi mantle section shows a bimodal distribution: frequency peak occurs both at 55-60 and at 68-75. The peak in the 55-60 is also observed in the harzburgites while the peak in the 68-75 occurs only in the dunites. The dunites in the lower level of the Salahi mantle section above the basal thrust often contain high Cr# spinels greater than 70 while the dunites in the upper level of the Salahi mantle section have spinel with Cr# smaller than 65. We consider that the dunites with such low Cr# spinel were formed at MOR stage while those with the high Cr# spinel formed by a reaction with boninitic melt during oceanic thrusting stage.

The distribution of refractory harzburgite and dunite in the northern Oman ophiolite can be modeled as follows. During oceanic thrusting the Oman ophiolite was forced to be located above an incipient subduction zone. The fluid released from metamorphic sole due to thermal metamorphism of altered oceanic crust infiltrated into the mantle section. Dunite channels may have been responsible for fluid infiltration from the base of the ophiolite. The fluid infiltration through dunite channel caused the flux melting of wallrock harzburgite. The presence of the HRZ in the northern Fizh mantle section implies that the infiltration of fluid from the base of ophiolite was abundant in the ridge segment boundary region. The orientation of the HRZ may imply that shear deformation in the segment boundary region enhanced the fluid infiltration. Alternatively, flux melting of less-refractory harzburgites (spinel Cr# smaller than 50) in the ridge segment boundary region produced relatively large amount of boninitic melt. Large porosity may have enhanced further infiltration of fluid from the base resulted in the formation of the HRZ in the segment boundary region.

Keywords: Oman ophiolite, mantle, peridotite, spinel Cr#, flux melting, fluid migration