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Fluid migration and boninite formation in incipient subarc mantle inferred from dunites in the Oman ophiolite

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The Oman ophiolite has experienced a flux melting of residual peridotites during oceanic thrusting subsequent to the formation at Neo-Tethys mid-ocean ridge. We studied spatial variability of spinel Cr# (=Cr/[Cr+Al]x100 mol%) and REE abundances of clinopyroxene in dunites from the Fizh mantle section, the northern Oman ophiolite. These data are used to understand fluid infiltration from the base of ophiolite and flux melting of residual harzburgite during oceanic thrusting.

Rock texture of dunite in the Fizh block is classified into six subgroup such as very-coarse granular, coarse granular, fine granular, planer, porphyroclastic and mylonitic textures. Rock texture of dunite is similar to the wallrock harzburgite in the upper half of Fizh mantle section. However, in the lower half of Fizh mantle section dunite becomes very coarse granular with olivine grain size greater than 1 cm although porphyroclastic or mylonitic textures is common in wallrock harzburgite.

Spinel Cr# in dunites from the Fizh mantle section varies from 45 to 80 and is the most frequent in 65-70 while spinel Cr# in harzburgites is the most frequent in 55-60 that is lower than that for dunite. Moreover, harzburgites with spinel Cr# greater than 70 is limited in the highly refractory zone located in the nothern Fizh mantle section while dunites with Cr# greater than 70 distribute over much wider area. In the area where dunite has low Cr# spinel less than 60 wallrock harzburgite tends to have spinel Cr# lower than 40.

Chondrite-normalized REE patterns of clinopyroxene in dunites are variable especially in LREE. Chondrite-normalized patterns of hypothetical melts in equilibrium with clinopyroxenes in dunites from the basal part show spoon-like shape with depletion in MREE relative to HREE and enrichment in LREE relative to MREE. Chondrite-normalized patterns of such melts are similar to those of boninites from the Fizh crustal section although some melts are more depleted in LREE to MREE relative to the boninite.

Spinel Cr# within a thick dunite layer (5 m thick) is the highest in the center (Cr# 71). Fluid flow and reaction may have been enhanced in the center by higher porosity resulted in the high Cr# spinel and formation of thick dunite. Because abundance of REE in clinopyroxene is uniform over dunite and wallrock harzburgite the migration of fluid and melt was comprehensive along with focused flow in the center of dunite layer.

High Cr# spinel frequently occur in harzburgite and dunite in the northern Fizh mantle section indicating that large volume of fluid flew through dunite and caused flux melting of wallrock harzburgite. Dunites with low Cr# spinel also occur in the northern Fizh mantle section indicating that fluid flux was limited in this region. In the southern Fizh mantle section dunite tends to have high Cr# spinel while harzburgite has spinel Cr# around 60 indicating fluid flux was low so that the extent of flux melting of wallrock harzburgite was limited.

The basal part of the Fizh mantle section is characterized by high Cr# spinel greater than 60 that is similar to subarc mantle, by dunites with very coarse granular texture, by dunite clinopyroxenes enriched in LREE. We consider that the dunites in the Fizh mantle section was reacted with boninitic melt formed by flux melting of harzburgites with addition of fluid from the base due to thermal metamorphism of altered oceanic crust during oceanic thrusting of the ophiolite. Variability in REE patterns for dunite clinopyroxene requires addition of fluid as much as 8% and as low as 0.1% being variable depending on the region. These results indicate that the fluid infiltration from the base of ophiolite and migration of boninitic melt after flux melting of harzburgite was not uniform over the Fizh mantle section. Reactive infiltration instability may have developed regional variability in porosity in the Fizh mantle section forming finger-like shape of fluid and melt migration.

Keywords: Oman ophioilte, mantle section, dunite, mid-ocean ridge, subduction zone, spinel