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Incipient island arc magmatism: petrogeneisis of boninitic dike swarms and related cumulates in the Oman ophiolite

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In the northern part of Fizh block in the northern Oman ophiolite, the crustal sequence contains large amount of late intrusive plutonics and dikes. The late intrusive plutonics formed ”late intrusive complex” in the early crystalized MORB-type gabbroic crust. The complex is consisting of ultramafic cumulates of dunite to clinopyroxenite, gabbronorites of ol-gabbro to oxide gabbronorite and plagiogranites of diorite to trondhjemite. Their parental melts show hydrated and depleted characteristics than those of MORBs (e.g. early crystallization of cpx than pl and lower Ti contents in pyroxenes). In this area, the large amount of the late intrusion thickened the crust to ˜8-9 km thick. As the latest intrusions in the lower crust, hundreds of parallel boninitic dikes are intruding into the early gabbros and the late plutonics and form four bands of dike swarm with 2-5 km width. The lava sequence of the northern area represents transition of magmatism from MORB (V1 or Geotimes unit) to IAT (V2 or Lasail & Alley unit) and contains boninite lavas within the Alley unit (Ishikawa et al., 2002). The boninitic dike swarms are considered to be feeders of the Alley boninites.

The boninitic dikes are pyroxene and olivine phenocryst phyric and classified into komatiite, high-Ca boninite, high-Mg basalt to andesite based on whole rock composition. This wide range of composition is explained by phenocryst accumulation and fractionation from primitive boninite melts with MgO 12-14 wt% in the lower crustal level. The zoning patterns of clinopyroxene phenocrysts represents that the parental melts experienced magma mixing with different boninite melts, which were fractionated various degree and some have slightly different trace element characteristics.

On the other hand, we found boninitic clinopyroxenite to dunite with depleted chrome spinels (Cr# $>$70) in the late intrusive ultramafic cumulates, which distribute around the root zone of the dike swarms. We concluded that these cumulates formed by mineral accumulation from less evolved boninite melts because the clinopyroxenes of the boninitic ultramafic cumulates have consistent trace element concentrations and patterns with the phenocrysts of the dikes. In addition, the estimated primitive boninite melts compositions from the dikes represents Th and LREE enrichment relative to M- to HREE in chondrite normalized pattern, which is interpreted as the result of slab derived sediment melt influx into depleted source mantle of boninite melts.

The magmatic history in the crustal section is summarized as follows. After the accretion of early crustal gabbros from MORB, the crustal thickening occurred by hydrated and depleted magmatism. Boninite magmatism subsequently occurred by partial melting of highly depleted mantle with influx of sediment melts and formed dike swarms. This crustal evolution is comparable to the nascent stage of crustal formation of oceanic island arc such as Izu-Mariana fore arc region, which contains depleted and hydrated magmatism as pre-boninite magmatism (fore arc basalts; Ishizuka et al., 2011). Thus, the northern part of Fizh block of the Oman ophiolite is a good example for oceanic island arc crustal section, which rapidly developed to ˜10 km thick immediately after subduction initiation event.

Reference:
Ishikawa et al. (2003) Geology, vol. 30, no. 10, p. 899-902.
Ishizuka et al. (2011) Earth and Planetary Science Letters, 306, 229-240.

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