Melt-rock interaction processes inferred from spinel-bearing layered gabbros in the Hess deep rift, East Pacific Rise

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IODP Exp.345 had drilled three main holes (U1415 I, J and P) at the Hess Deep rift, East Pacific Rise and recovered layered gabbroic rocks formed at the fast-spreading mid-ocean ridge [1]. One of the enigmas of the gabbroic rocks is that orthopyroxene occurs like an early-formed mineral (Mg# = 85~88, subhedral) in layered gabbros, even though it has been considered to appear in the late stage of crystallization of MORB melt. However, the formation mechanism of orthopyroxene is still unrevealed. Previous researches about the U1415 have clarified various occurrences of orthopyroxene; as a cumulus mineral [1], as the reaction rim around olivines, in veinlets, in the concave of anhedral olivine or as a constituent mineral in the multiphase solid inclusion in chromian-spinel [2]. The inclusions hosted by chromian-spinels had not been studied in detail. Here, we report the petrological and chemical characters of spinel-bearing layered gabbros including orthopyroxene at Hole U1415P and discuss the magma processes associated with the formation of the layered gabbros.

Hole U1415P is about 100m in length and divided into two main units based on lithology. The upper unit is called the Multi-textured Layered Gabbro Series that is composed of mainly orthopyroxene-bearing olivine gabbro or olivine gabbro and has inhomogeneous structures which exhibit the centimeter-scale variations in modal composition or grain size. In contrast, the Troctolite Series of the lower unit shows almost no lithological change and is relatively homogeneous.

Spinel-bearing olivine gabbros (U1415P 6R-1 to 6R-2) are locally distributed in the Multi-textured Layered Gabbro Series. Spinels occur in the troctolitic part of the olivine gabbro and are not included in olivine and the core of plagioclase. They are associated with orthopyroxene which occurs as the reaction rim on olivine. The occurrence and distribution of spinels are well similar to the texture reported in a troctolite sample from the ODP Site 895 (the mantle-crust transition-zone[3]), which has been interpreted as a product of an interaction between depleted peridotite and primitive MORB melt [4].

In addition, Cr_2O_3 (wt%) and Mg# in clinopyroxene do not change so much with the variation of TiO_2 (wt%) in clinopyroxene. The trend is similar to that related to the formation of the podiform chromitite [4] (Constant Cr_2O_3 regardless of TiO_2 variation) than that in layered mafic intrusions like the Bushveld complex [5] (Cr_2O_3 decrease with increasing TiO_2). The similarity in the Ti-Cr relationship for clinopyroxene suggests that the spinel-bearing layered gabbros may have been formed by some kind of interaction process.

Spinel-hosted multiphase solid inclusions consist of some of four main silicates (clinopyroxene, orthopyroxene, plagioclase, and K-phlogopite) with minor accessory minerals (chlorite, talc, titanite, Fe-Ti oxides, spinel, apatite, Fe-Ni-Cu sulfides, and zircon). On the basis of the mineral assemblage, the spinel-hosted multiphase inclusions can be divided into the following four types(Fig.1),

(1) “Cpx + Pl type” mainly composed mainly of clinopyroxene, plagioclase, and chlorite,

(2) “Opx-dominant type” consisting mainly of a large amount of orthopyroxene (up to 80 vol%) and

minor phlogopite,

(3) “Intermediate type” including all main silicates which constitute “Cpx + Pl type” and “Opx-dominant type”,

(4) “Void type” is the tiny composite inclusion (up to 5 μm in size) which is composed of phlogopite, apatite, sulfides, and voids.

We analyzed the bulk chemical compositions of inclusions using a rastering technique on SEM-EDS. The bulk compositions of the “Cpx + Pl type” are mainly basaltic (partly picritic), ranging in SiO_2 from 45 to 48 wt% and in MgO from 7 to 23 wt%. In contrast, the “Opx-dominant type” inclusions have high-Mg basaltic andesitic to high-Mg andesitic compositions, with SiO_2 between 52 and 63 wt% and MgO between 20 and 34 wt%. Therefore, we conclude that a basaltic and a high-Mg andesitic melt may have been related to the melt-rock interaction process to form the Hess Deep spinel-bearing layered gabbro.

References:

[1] : Gillis et al. (2014), Nature 505, 204-207.
[2] : Hoshide et al. (2015), AGU Fall Meeting 2015, abstract id. V11E-05.
[3] : Arai and Matsukage (1996) Proceedings of the Ocean Drilling Program, Scientific Results 147.
[4] : Matsukage and Arai (1998), Contrib Mineral Petrol 131, 111-122.
[5] : Atkins et al. (1969), Journal of Petrology 10, 222-249.
[6] : Borisova et al. (2012), Journal of Petrology 53, 2411-2440.
[7] : Tamura et al. (2014), Contrib Mineral Petrol 167:974.

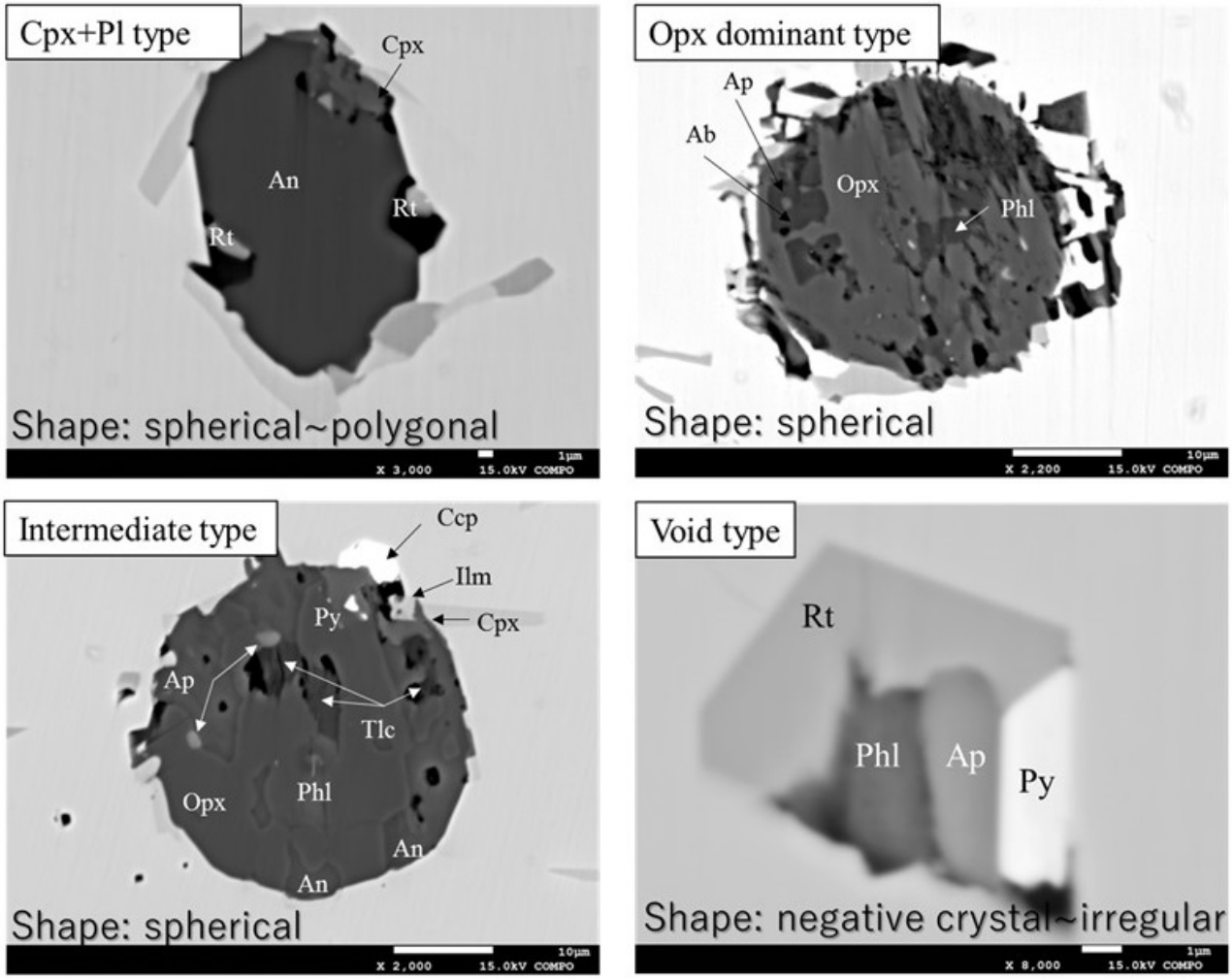

Figure 1: Backscatter-electron images of multiphase solid inclusions in spinels from the Hess Deep layered gabbros

