Magmatic differentiation processes in the Murotomisaki gabbroic complex : segregation of crystal mush from the boundary layer

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The Murotomisaki gabbroic complex is a sill-like layered igneous intrusion of up to 220m thickness, located in Cape Muroto, Kochi Prefecture, Japan. We investigated the layered structure in terms of modal composition, crystal size and crystal number density of olivine for the intrusion. We found out that the olivine-rich zones in the intrusion can be classified, according to the mode of its origin, into two kinds: 'the crystal accumulation zone (AC zone)' which was formed by the crystal settling of olivine comprised in the intrusive magma and 'the crystal growth zone (GR zone)' in which the increase of the olivine mode accompanied the crystal growth of olivine (Hoshide, Obata and Akatsuka, 2005; An annual meeting of GSJ).

The compositional trend of the AC zone (termed as 'A trend') is interpreted to be a mixing trend between the initial melt composition (Akatsuka, Obata and Yokose, 1999) and the olivine composition (Fo83), which is consistent with the crystal settling and accumulation hypothesis presented above. On the other hand, the whole rock compositions of the GR zone (40~100 m from the bottom) also define a linear trend (termed as 'B trend'), which as a different slope from the A trend but which goes through the same initial melt composition. Moreover, the whole rock compositions of the coarse gabbro, the upper olivine gabbro and the anorthosite veins in the GR zone roughly lie on the B trend, but on the opposite side of the GR zone compositions.

In the GR zone, numerous anorthosite veins occur, orientating nearly concordant to the compositional layering of the sill. The upper surfaces of the anorthositic veins typically show wavy or plume-like structures, while the lower surfaces are rather flat. Within these veins, plagioclase crystals are aligned parallel along the top wavy surfaces and the plume surfaces of the veins. The mode of occurrence and the whole rock composition of the veins indicate the possibility that these veins played a significant role in the formation of the GR zone. In order to examine whether the anorthosite veins may be generated by the crystallization differentiation within the crystal growth zone, the fractionation path of the melt that can develop in the boundary layer (after the crystal accumulation stage) was examined by the use of the phase equilibrium calculation program 'Pele' (Boudreau, 1999) assuming equilibrium crystallization. We found out that the composition of the observed anorthositic vein can be generated by a mixing of a fractionated melt and the precipitating plagioclase crystals within the boundary layer. If such mixtures (i.e., anorthositic crystal mush) are segregated out and float from the boundary layer, the composition of the residual boundary layer will shift to the opposite direction of that of the anorthosite vein, forming a residual trend. At the same time, since the undifferentiated magma (i.e., the initial melt) lying above the boundary layer is mixed with the anorthositic crystal mush that is transported from below, the composition of the magma will be shifted toward the direction of that of the anorthosite vein, forming another a mixing trend. The B trend is, therefore, considered to be a combination of such residual trend and the mixing trend.

Segregation vein is a common phenomenon in layered intrusions and sills from many other localities such as the Skaergaard intrusion. The segregation and floatation of the crystal mush may be an important differentiation process in the crystallizing magma.