Geophysical Research Abstracts
Vol. 14, EGU2012-2276, 2012
EGU General Assembly 2012

Spinel inclusion in olivine and plagioclase crystals: a marker for primary crystals and a tracer for crystal migration in a differentiating magma reservoir

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Crystal accumulation is an important process in magmatic differentiation. Although whether cumulus crystals were intratelluric phenocrysts or newly-formed crystals after magma emplacement is an important issue concerning mechanisms of magmatic differentiation, there has been no effective criteria for the judgement (e.g., Simkin, 1967; Gibb & Henderson, 2006; Latypov & Chisvakova). We demonstrate, from a study of the Murotomisaki Gabbroic Intrusion, that Cr-spinel inclusions in silicates may be used as a useful marker to identify the intratelluric phenocrysts and also as a tracer for studying crystal redistribution in a differentiating magma body.

The Murotomisaki Gabbroic Intrusion is a 210-m-thick sill-like magma body emplaced in Tertiary sediments in Shikoku, Japan. Several olivine-rich zones have been identified in a lower 100-m zone of the intrusion. Olivine and plagioclase phenocrysts in the chilled margin commonly contain tiny Cr-spinel inclusions, which have uniform composition regardless of the host phases. Cr-spinel inclusions also occur in olivine and plagioclase in the lower 40-m cumulates (AC subzone), whereas no Cr-spinel inclusions occur in the silicates from the upper 40-100 m zone (GR subzone).

For samples from the AC subzone, olivine-hosted spinel inclusions show increases in TiO_2, FeO and Fe_2O_3 contents and decreases in Cr_2O_3, Al_2O_3 and MgO as compared with those from the chilled margin. Al_2O_3 and Fe_2O_3 contents of spinel inclusions in olivine do not show clear correlations with depth, but spinel inclusions located near the edge of the host olivine have more TiO_2 and less Cr_2O_3 than those located in more central part of the olivine. It is noteworthy that TiO_2 contents of the spinel inclusions gradually decrease, with increasing distance from the edge of host olivine, and approach the chilled marginal value.

From the above observations, we infer that the olivine-hosted Cr-spinel inclusions from the AC subzone originally had the same compositions as those from the chilled margin and that their compositions have been modified by diffusional exchange between the spinel and the residual melt through the host minerals. We conclude that Cr-spinel inclusion bearing olivine crystals from the AC subzone represent intratelluric phenocrysts and Cr-spinel inclusions can be used to tell the intratelluric phenocrysts from those newly grown after the magma emplacement.