Effect of pressure on the crystallization differentiation of hydrous undifferentiated island arc basalt

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Dissolution of H_2O characterizes the island arc magmatism and plays a mojor role in producing diversity in phase relations and differentiation trends. The pressure at which crystallization takes place is another major intensive variable which affects the phase relations and/or phase proportions of island arc basalts.

We investigated phase relations of undifferentiated (Mg#˜60) hydrous island arc basalt experimentally to clarify the effect of crustal pressure (2 to 7 kb) on the crystallization differentiation in the island arc. The obtained degree of crystallization is as much as ˜50 wt.%. Composition of the starting material is enriched in normative orthopyroxene content compared with previous experiments. Experiments were originally designed to conduct under NNO buffer, but experiments under QFM (˜NNO-1) buffer were also added to discuss the effect of f_{O2} on phase relations.

With H_2O less than 1 (+/-1) wt.% corresponding to primary magma, tholeiitic differentiation trends were obtained, although they differs according to pressure. At 2 kb, crystallization differentiation is controlled by olivine + plagioclase. At higher pressure, increasing pressure higher than 4 kb induces early crystallization of orthopyroxene instead of olivine. As a result, enrichment of SiO_2 content in residual melt becomes suppressed. This is partly because normative orthopyroxene content of starting material is relatively higher.

With H_2O more than 3(+/-1) wt.% corresponding to primary magma, calc-alkaline differentiation trends were obtained due to early crystallization of magnetite and/or clinopyroxene. At 2 kb, crystallization differentiation is controlled by olivine + plagioclase + magnetite. At pressure higher than 4 kb, crystallization differentiation is controlled by olivine + clinopyroxene +/- plagioclase +/- orthopyroxene +/- magnetite. Contribution of clinopyroxene instead of orthopyroxene became significant as near liquidus phase, resulting in the enrichment of SiO_2 and depletion of FeO^t. Phase relations and proportions are sensitive to H_2O content and f_{O2}.

The contrasting differentiation trends between Izu-Oshima volcano and Fuji volcano, both of which are tholeiitic volcanoes located in the northern Izu arc, could be explained by crystallization differentiation with primary H_2O less than ˜1 wt.% under different pressure. Tholeiitic differentiation trend commonly observed at the volcanic front such as Izu-Oshima volcano is interpreted as a result of crystallization at pressure less than ˜2 kb. Crystallization at deeper level (more than 3-4 kb) results in the greater contribution of pyroxenes and suppressing enrichment of SiO_2 in the residual melt, such as observed in Fuji volcano.