Geophysical Research Abstracts
Vol. 13, EGU2011-5418, 2011
EGU General Assembly 2011

Marginal Reversal of the Imandra Layered Intrusion, Russia: Insights into Processes Operating During the Initial Stage of Magma Chamber Evolution

Vera Egorova (1,2) and Rais Latypov (1)

(1) Department of Geosciences, University Of Oulu, Oulu, Finland, (2) Institute of Geology and Mineralogy SB RAS, Novosibirsk, Russia (verae@uiggm.nsc.ru)

The initial stage in the development of magma chambers still remains one of the most unstudied areas in petrology of mafic-ultramafic layered intrusions. The $\sim$ 20 m thick marginal zone of the $\sim$ 3 km thick mafic Imandra Layered Intrusion (ILI), Russia provides several important constraints on the initial stage of basaltic magma chamber evolution. The zone consists of fine-grained pigeonite gabbros that are chilled against underlying host andesi-basalts but reveals a non-chilled upper contact with orthopyroxenites of the overlying Layered Series. The marginal zone shows pronounced reverse compositional trends from the bottom to the very top and can therefore be referred to as a marginal reversal. In particular, Mg# of pyroxenes, An content of plagioclase and whole-rock MgO and Cr2O3 show a systematic upward increase whereas whole-rock SiO2, TiO2, K2O, P2O5 and all incompatible trace elements (Rb, Ba, Zr, Y, REE) reveal an upward decrease. The marginal zone is abruptly terminated by the overlying coarse-grained orthopyroxenites interlayered with several massive chromititite layers of the Layered Series. The boundary between these two major units of the ILI represents a sharp break in terms of grain-size, chemical composition and crystallization sequences. It is noteworthy that, contrary to common expectations, the fine-grained pigeonite gabbros of the marginal zone are distinguished by much lower concentrations of all incompatible elements compared to the coarse-grained orthopyroxenite of the Layered Series. The data indicate that filling of the chamber started with evolved basaltic liquids that formed the marginal zone followed by more primitive and voluminous basaltic liquid that gave rise to the Layered Series. The origin of marginal reversal is best explained in the context of the "three-increase model" that implies that rocks becomes more primitive inwards in response to (1) an increase in the extent of primitivity of successively intruding magma pulses, (2) an increase in the extent of equilibrium crystallization of this magma and (3) an increase in the proportion of crystallizing cumulus minerals with distance from cold country rocks. These are the processes that appear to have been working most effectively along chamber margins during the initial stage.

The notable distinction in incompatible element abundances between marginal zone and Layered Series is attributed to fundamentally different regimes of magma flow during their formation. The crystallization of the marginal zone was dominated by fast-flowing (0.5-5 m/s) intruding magmas that favoured the effective removal of evolved liquids from in situ growing crystals and generation of incompatible element-depleted primary adcumulates (fine-grained pigeonite gabbro). In contrast, the formation of the Layered Series was prevailed by slow-flowing (0.5-5 m/year) thermally convecting magma that was much less effective in stripping of evolved liquid from crystallizing minerals and therefore gave rise to incompatible element-enriched orthocumulates (coarse-grained orthopyroxenites). The proposed sequence of magma replenishment events and rock-forming processes that have operated during the formation of the studied marginal zone may be common for the development of crustal basaltic magma chambers.