
Crystallization and Differentiation Processes in the Thin Layered
Alkali Gabbroic Intrusions of the Ulvö Gabbro Complex,
Central Sweden
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ABSTRACT

Fractional crystallization of magma is a commonly invoked mechanism for chemical differentiation in systems that range from volcanoes to entire planets. However, the processes that control separation of crystals and liquids in natural systems remain controversial, since the dynamics of crystallizing magma chambers cannot be studied directly. Currently popular models involve strictly mechanical separation processes e.g., crystal settling and compositional convection. In this thesis, however, it is demonstrated that a disequilibrium process can result in very effective fractional crystallization.

The ~1265 Ma Norra Ulvön Gabbro (NUG) is a ~300 m thick alkali gabbroic saucer-shaped sill in central Sweden that belongs to the Ulvö Gabbro Complex. The NUG is strongly differentiated, displays well developed modal layering, and has not experienced metamorphic alteration. A stratigraphic section through this intrusion has been studied in detail, including major and trace-element whole-rock analysis and *in situ* mineral analysis. Laser-ablation inductively coupled plasma mass spectrometry (LA ICP-MS) has been used to study a wide range of magmatic processes in this intrusion.

Strong stratigraphic variations in major and compatible trace-elements in the NUG were reproduced by a thermodynamically constrained fractional crystallization model. However, in contrast to the predictions of this model, little or no stratigraphic variations of incompatible elements in minerals or whole-rock can be demonstrated. This cannot be explained by any fractional crystallization model that occurs under equilibrium conditions. A trace-element model for diffusive mass transfer between well mixed supernatant liquid and a partially crystallized boundary layer was therefore developed. This model demonstrates that diffusive exchange of compatible elements can be effective, while incompatible elements are decoupled, since the diffusive flux of these elements move in the same direction as the solidification front. *In situ* crystallization on the floor of the intrusion in combination with thermal convection of the supernatant liquid is likely to have resulted in large scale differentiation of this intrusion. Modal layering and erosion-related layering features indicate that convection was an important factor governing the diffusive exchange during the crystallization. The modal layering developed due to fluctuations in the vigor of thermal convection that in turn affected the cooling rate and the nucleation rate of plagioclase relative to olivine and Fe-Ti oxides.

Key words: layered intrusion, fractional crystallization, modal layering, *in situ* crystallization, Ulvö, saucer-shaped sill, post-cumulus, LA ICP-MS.

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