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Mechanisms of differentiation in the Skaergaard magma chamber

C. Tegner (1), C. E. Lesher (2), M. B. Holness (3), J. K. Jakobsen (4), L. P. Salmonsen (1), M. C. S. Humphreys (5), and P. Thy (2)

(1) Aarhus University, Denmark (christian.tegner@geo.au.dk), (2) University of California, Davis, USA, (3) University of Cambridge, UK, (4) GeoForschungsZentrum Potsdam, Germany, (5) University of Oxford, UK

The Skaergaard intrusion is a superb natural laboratory for studying mechanisms of magma chamber differentiation. The magnificent exposures and new systematic sample sets of rocks that solidified inwards from the roof, walls and floor of the chamber provide means to test the relative roles of crystal settling, diffusion, convection, liquid immiscibility and compaction in different regions of the chamber and in opposite positions relative to gravity. Examination of the melt inclusions and interstitial pockets has demonstrated that a large portion of intrusion crystallized from an emulsified magma chamber composed of immiscible silica- and iron-rich melts. The similarity of ratios of elements with opposite partitioning between the immiscible melts (e.g. P and Rb) in wall, floor and roof rocks, however, indicate that large-scale separation did not occur. Yet, on a smaller scale of metres to hundred of metres and close to the interface between the roof and floor rocks (the Sandwich Horizon), irregular layers and pods of granophyre hosted by extremely iron-rich cumulates point to some separation of the two liquid phases. Similar proportions of the primocryst (cumulus) minerals in roof, wall and floor rocks indicate that crystal settling was not an important mechanism. Likewise, the lack of fractionation of elements with different behavior indicate that diffusion and fluid-driven metasomatism played relatively minor roles. Compositional convection and/or compaction within the solidifying crystal mush boundary layer are likely the most important mechanisms. A correlation of low trapped liquid fractions (calculated from strongly incompatible elements) in floor rocks with high fractionation density (the density difference between the crystal framework and the liquid) indicate that compaction is the dominating process in expelling evolved liquid from the crystal mush layer. This is supported by high and variable trapped liquid contents in the roof rocks, where gravity-driven compaction will not work.