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Compositional differences between roof and floor rocks of the Skaergaard Intrusion

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The Skaergaard intrusion solidified inwards from the margins forming the Layered Series on the floor and the Marginal and Upper Border Series on the walls and roof, respectively. Comparison of the roof and floor rocks is the most straight-forward way to contrast differentiation processes controlled by gravity. Here, we present new bulk rock (major and trace elements, Sr and Nd isotopes), mineralogical and petrographic data for the Upper Border Series. The Upper Border Series mainly diverge from equivalent Layered Series rocks by relatively higher concentrations of incompatible elements, lack of igneous lamination and frequent development of interstitial granophyre, whereas the core compositions of minerals and isotopic signatures are similar in the two series. Here, we examine the main explanations for these differences.

Firstly, it has been suggested that the roof zone was enriched by assimilation of stoped gneissic blocks. Our new Sr and Nd data of the Upper Border Series exclude this as a first order process as has been shown before. Mixing models suggest that the Layered and Upper Border Series assimilated less than 3 percent Precambrian host gneiss. Furthermore, no correlation exists between incompatible elements and Sr-Nd isotopic ratios.

Secondly, magma stratification as a consequence of compositional convection has been invoked. However, by combining petrography and whole rock compositions we show that the crystallization sequence in the Upper Border Series is identical to the Layered Series. Moreover, the anorthite content of plagioclase cores is identical within error in the roof and floor at the cumulus phase boundaries. This is most easily explained by in situ crystallization inwards from the margins of a homogeneous magma.

Thirdly, the enrichment of incompatible elements in the Upper Border Series relative to the Layered Series has been explained by the trapping of a higher fraction of intercumulus liquid in the roof rocks relative to the compacted floor cumulates. Our data corroborates this interpretation. They also confirm that the concentrations of incompatible elements in certain levels of the roof rocks exceed what can be explained by trapped liquid contents. This is explained by instability of the upper solidification front and infiltration of evolved liquid into tension gashes.

Fourthly, recent melt inclusion and textural studies show that the magma exsolved into immiscible Fe- and Si-rich liquids. It has been suggested that the buoyant Si-rich end-member segregated and rose to the roof. Compared to the Layered Series, the Upper Border Series is enriched in all incompatible elements regardless of their affinity to the Fe- or Si-rich melt. Thus, the effect of high trapped-liquid fractions dominates over that of liquid separation due to immiscibility. During solidification of the last 10 percent of the magma (UZb, UZc and Sandwich Horizon), however, concentrations of Fe, Mn and Ca decrease in the roof rocks while they increase in the floor rocks. Simultaneously, Si, K and Na increase strongly in the roof relative to the floor rocks. We interpret this as a consequence of efficient segregation of immiscible silicate liquids at least during the late stages of differentiation.