

## **Compositional Variation in Olivine in the Skaergaard Intrusion and Its Petrologic implications.**

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Olivine from the Layered Series (LS), Upper Border Series (UBS), and Marginal Border Series (MBS) of the Skaergaard intrusion was analyzed to examine major and trace element variations. In general, olivine from all three series shows similar trends in major elements with differentiation: FeO\* (total iron as FeO\*), TiO<sub>2</sub>, and MnO in the olivine, progressively increase, MgO and SiO<sub>2</sub> progressively decrease, and Na<sub>2</sub>O, K<sub>2</sub>O, Al<sub>2</sub>O<sub>3</sub>, CaO, and P<sub>2</sub>O<sub>5</sub> remain unchanged at low abundances. No abrupt changes in the trends of major components in Skaergaard olivine are observed, except for MnO, which decreases abruptly during the final stages of crystallization as a result of the crystallization of ferrobustamite rich in MnO.

Changes in trace element abundances in olivine reflect changes in the Skaergaard magma and changes in olivine partition coefficients with differentiation. In general, olivine from all three series has similar trends for trace element variation with differentiation. The Skaergaard magma appears to have been well mixed during differentiation of the intrusion. Ba, Cs, Rb, and Sr, acted as excluded trace elements in Skaergaard olivine, and remained at relatively low abundances in olivine during differentiation until the final stage, during which they all increase in abundance. The transition elements, Co, Cr, Cu, Ni, Sc, Zn, and V, are included in Skaergaard olivine. Owing to the high  $D_{Ni}$  in olivine, Ni decreases with differentiation in both olivine and the calculated Skaergaard magma. The low concentration of Cr in olivine during differentiation is attributable to early depletion of Cr by pyroxene crystallization. Decreases in the abundances of V and Co are related to the onset of magnetite crystallization and the separation of immiscible Co-rich sulphide. HFSE such as Hf, Nb, Ta, Th, U, and Zr, are strongly excluded elements in Skaergaard olivine, and as a result, all remain very low in olivine until the final stages of crystallization when their abundance in the magma increases exponentially. Similarly, the concentration of rare earth elements in Skaergaard olivine increases gradually with differentiation, until the final stages of differentiation, when REE abundances increase exponentially. In general, calculated partition coefficients ( $D_i$ ) for Skaergaard olivine show similar trends in the LS, UBS, and MBS. Calculated partition coefficients for the rare earth elements in Skaergaard olivine do not change significantly with differentiation. Partition coefficients for some trace elements, however, systematically change as the composition of olivine become more Fe-rich. Calculated  $D_i$ s for Sc, Cr, and Ga in olivine, progressively increase, and  $D_i$ s for Zr, Nb, Hf, Cs, Ta, Th, and U progressively decrease, with differentiation.

The systematic variation in major and trace element contents of Skaergaard olivine during differentiation would appear to preclude the possibility of any significant injection of new magma into the chamber during differentiation. Included trace elements are particularly sensitive to injections of more primitive magma. As a result of the high  $D_{Ni}^{ol/liq}$ , any injection of new, more-primitive magma into the Skaergaard chamber should have caused an abrupt increase in the

Ni content of olivine. The Ni content in Skaergaard olivine, however, systematically decreases with differentiation as would be expected if the intrusion remained a closed system. In fact, no abrupt increases are observed in the abundances of any of the transition metal in olivine during differentiation.

The high values for  $D^{ol/cpx}(Fe/Mg)$  in the Skaergaard intrusion indicate that olivine and Ca-rich pyroxene in these rocks probably do not preserve magmatic Fe/Mg distributions and that some process of post-crystallization reequilibration must have occurred. This process of re-equilibration was apparently more effective in the UBS than in the LS.