# Iron isotope systematics of the Skaergaard intrusion

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The early Eocene Skaergaard intrusion, central east Greenland, is one of the most thoroughly studied layered mafic intrusions on Earth and an exceptional example of (*near)* closed-system magmatic differentiation. The Skaergaard intrusion is ideally suited to test models of closed-system fractional crystallization on non-traditional stable isotope systems, particularly iron. FeTi oxide minerals (titanomagnetite and ilmenite) appear after ~60% of the magma had solidified. This was a significant event affecting the liquid line of descent and potentially accompanied by iron isotope fractionation. Here we report the results of a broad study of the iron isotope compositions of gabbros within the layered and upper border series of the Skaergaard intrusion, pegmatite and granophyre associated with these gabbroic rocks, and the sandwich horizon thought to represent the product of extreme differentiation and/or liquid immiscibility. Forty-eight whole rock samples from well-constrained stratigraphic levels in the intrusion were crushed, powdered and dissolved, followed by iron separation by ion chromatography. Purified solutions were analyzed by MC-ICPMS in high-resolution mode using the sample-std bracket method. The $\delta^{56}$Fe values for Skaergaard gabbros range from a low of -0.019 per mil to a high of 0.253 per mil with an external precision of ±0.05 per mil (1σ) or better. This range in $\delta^{56}$Fe spans much of that reported for terrestrial igneous rocks. $\delta^{56}$Fe varies systematically with stratigraphic position. Forward modeling of closed system fractional crystallization constrained by cumulate volumes, whole rock and mineral compositions, mineral modes and independent constraints on Fe isotope fractionation factors account for the stratigraphic relations, except during the final stages of differentiation of iron-rich silicate magma where the largest variation in $\delta^{56}$Fe occurs. We assess and dismiss liquid immiscibility, Soret effects and hydrothermal alternation as responsible for the variations, and hypothesize that Fe isotope fractionation factors for silicate minerals decrease markedly due to a change in the structural role of $Fe^{+2}$ in very iron-rich silicate magmas characterizing the terminal stages of Skaergaard evolution.