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Dating the timescales of closed-system crystallization of the Skaergaard intrusion with implications for magmatism in the North Atlantic Igneous Province and global climatic impacts

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Magmatism in the North Atlantic Igneous Province during the late-Paleocene and Eocene generated over 5,000,000 km^3 of mafic rocks (intrusions, lava sequences, offshore plateaus) from West Greenland to the United Kingdom and coincides with the Paleocene-Eocene thermal maximum (PETM), the most significant non-anthropogenic climatic excursion to have occurred on Earth during the Cenozoic. On the East Greenland margin, the Skaergaard intrusion represents an ideal location to test the timescales of crystallization of a single batch (280 km^3) of shallowly emplaced (~2 km depth) Fe-rich tholeiitic magma that underwent closed-system crystallization from the floor upwards (Lower Zone through to Sandwich Horizon), roof downwards, and walls inwards. Skaergaard cumulates contain interstitial zircon, displaying remarkable morphological diversity (e.g., skeletal, acicular, euhedral to subhedral), that crystallized from fractionated melts at near-solidus conditions (~750°C). A detailed high-precision CA-ID-TIMS U-Pb zircon geochronologic study established a framework for crystallization of the Skaergaard intrusion and a suite of post-Skaergaard intrusives (Transgressive granophyre, peralkaline dike, Sydtoppen and Tinden sills). Based on the results from 10 gabbroic to melanogranophyric samples, magmatic differentiation in the Skaergaard intrusion occurred over ~160,000 years at ca. 55.9 Ma, with a rapid increase in crystallization rate during late-stage crystallization. Regional extension and coastal flexure are temporally correlated to flood basalt volcanism that occurred during crystallization of the Skaergaard intrusion. The maximum timing of coastal flexure is constrained by the date of a peralkaline rhyolite dike that overlaps within uncertainty with the crystallization age of the Sandwich Horizon. Astronomically calibrated absolute ages for the onset of the PETM, which generated extremely wet climatic conditions in the North Atlantic, either shortly precede or overlap with emplacement and crystallization of the Skaergaard intrusion. Topography driven fluid flow facilitated by coastal flexure and an increase in regional precipitation may have contributed to the rapid late-stage crystallization rate of remaining Skaergaard magma. New geochronologic constraints on the Skaergaard intrusion and post-Skaergaard intrusives indicate that the magmatic trigger for PETM was correlated temporally with flood basalt volcanism and associated sub-volcanic intrusive activity on the East Greenland margin.