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Magmatic Enrichment of REE-HFSE in Alkaline Igneous Complexes: Insights from the Illerfissalik Complex, Greenland

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Rare earth elements (REEs) and high-field-strength elements (HFSEs) are essential to modern technologies. Alkaline igneous complexes are one of the primary hosts for REE-HFSE mineralization, yet the processes driving their mineralization remain poorly understood. South Greenland's Gardar Province presents an ideal case study as parts of the province contain world-class REE-HFSE deposits (e.g. the Ilimmaasaq complex) whereas other parts are relatively barren, but exhibit fenitised haloes indicative of having dispersed substantial amounts of these elements into surrounding country rocks by fenitisation (e.g. the Illerfissalik complex; [1]). This study aims to identify both the magmatic processes responsible for REE-HFSE enrichment of Gardar plutonic centres, and the controls on variable fenitisation across the province, by integrating field observations, geochemical analyses, and thermodynamic models.

Initially we focus on eight samples collected from the composite Illerfissalik complex (consisting of augite and nepheline syenite units [2]). Textural relationships and mineral modes are quantified using Scanning Electron Microscopy (SEM), while phase compositions are analysed using Electron Probe Microanalysis (EPMA) and Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS), with a particular focus on decoding the record of zoned mineral grains. These observations are then integrated with thermodynamic modelling using a newly available model for alkaline systems [3], conducted via MAGEMin software [4], to simulate fractional crystallization under varying pressure, temperature, melt composition, and oxidation conditions. Finally, trace element partitioning models are used to quantify REE-HFSE distribution between mineral phases and residual melt and form predictive models of the optimal conditions for REE-HFSE enrichment. Future work will extend the workflow to other Gardar centres.

References

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