Mantle Source Enrichment in the Evolution of One of Europe's Largest Rare Element Provinces - the Gardar Province, South Greenland

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One of the big questions in economic geology is why some regions and periods of Earth history gave rise to significant ore deposits and others did not. For mantle-derived magmatic ore deposits, such as the carbonatite or alkaline igneous rocks targeted for high-field strength elements (HFSEs) and rare earth elements (REEs), the composition and temperature of the mantle control the abundance of metals and ligands within resultant magmas, and thus the potential for the formation of the ore. Yet the processes that form enriched mantle sources are poorly constrained.

The mid-Proterozoic (1.32–1.14 Ga) Gardar Province in South Greenland contains several globally significant rare earth, niobium, vanadium, and titanium projects, formed during breakup of the Columbia/Nuna supercontinent. Gardar intrusions have multiple surface ($\delta^{34}S$, $\Delta^{33,36}S$) and Archaean ($\Delta^{33,36}S$, εHf, εNd) crustal signatures inherited from their mantle source. These enriched signatures vary across the province, showing temporal and spatial heterogeneity.

We interpret the metallogeny of the Gardar rift to be controlled by mantle source composition, which in turn reflects the geodynamic history and the recycling of continental sediments through subduction along the margin of the North Atlantic craton, presumably during the assembly of Columbia/Nuna. Our data provide evidence for fertilisation of the mantle by subduction as a precursor for these HFSE and REE deposits—such a model may be widely applicable for other Proterozoic critical metal deposits associated with the breakup of Columbia/Nuna.