Making and breaking Columbia (Nuna): formation of a critical metal province? A North Atlantic view

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The Palaeoproterozoic supercontinent of Columbia (Nuna), assembled at 2.1-1.8 Ga, included almost all of the Earth's cratonic blocks (Zhao et al. 2004). Following assembly of the cratons along collisional orogens, accretionary tectonomagmatic belts developed along the supercontinent margins. The margins of the Archaean craton in Greenland are marked by the Paleoproterozoic Nagssugtoqidian orogen to the north, and Ketilidian accretionary belt to the south. In Scandinavia, the Svecofennian orogen and the Lapland-Kola belt are of similar age. Between these two areas lies the Lewisian Complex of NW Scotland, comprising Archaean crust reworked in the Palaeoproterozoic.

In the context of Columbia assembly, the most important aspect of Lewisian history is a Palaeoproterozoic event known as the Laxfordian, which is characterised by development of shear zones, amphibolite-facies metamorphism, and localised crustal anatexis to form granite and pegmatite sheets. New U-Pb geochronological data show that initial Laxfordian magmatism (c. 1.9-1.88 Ga) was characterised by emplacement of alkaline to calc-alkaline granite sheets at most major terrane boundaries within the Lewisian. This timing correlates with the formation of continental arcs in Greenland and Scandinavia. Subsequent collision of arc terranes with the continental margin led to localised high-grade metamorphism and deformation. This was followed by crustal thickening, with associated metamorphism and partial melting peaking at c. 1.79-1.77 Ga, again correlating with events in Greenland and Scandinavia.

Through the Mesoproterozoic, a number of intra-continental rifts developed, which would eventually lead to the break-up of the Columbia supercontinent. In Southern Greenland, the Gardar Rift is characterised by two episodes of alkaline magmatism at c. 1.28 and 1.18-1.14 Ga (Upton et al. 2003). Igneous complexes associated with this rifting are now of significant importance for their resources of critical metals, particularly the Rare Earth Elements (REE), Nb and Ta. The ultimate source of these magmas, and of their critical metal enrichments, is considered to be in sub-continental lithospheric mantle (SCLM) that was enriched during Palaeoproterozoic subduction.

In Scotland, Mesoproterozoic rifting is chiefly represented by the sandstones and volcaniclastic rocks of the Stoer Rift. However, fault zones within the Lewisian Complex have been dated to this period by use of the Ar-Ar technique on pseudotachylites (e.g. Sherlock et al. 2008). Ongoing work suggests the prospect of critical metal enrichments being introduced by hydrothermal activity along the fault zones. This may potentially be related to deep-seated magmatism analogous to that in the Gardar Rift. The margins of the North Atlantic Craton are clearly a fruitful area for critical metal exploration, characterised by SCLM that was enriched by Palaeoproterozoic subduction, then melted during Mesoproterozoic (or potentially younger) rifting.

Sherlock et al. (2008) Journal of the Geological Society 165, 73-83
Upton et al. (2003) Lithos 68, 43-65
Zhao et al. (2004) Earth Science Reviews 67, 91-123