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Lu-Hf evolution patterns and implications for palaeotectonic settings

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Lutetium-Hafnium (Lu–Hf) isotopes provide information on the timing of addition of new mantle-derived material into the crust and recycling of ancient crust. Unique Hf isotopic evolution patterns would be expected for specific tectonic environments, reflecting either juvenile input or reworking or a combination of these. In an effort to distinguish between different palaeotectonic settings, Lu-Hf data in zircons from the North Atlantic Region (NAR) are compared with those from parts of the West Australian Craton that underwent distinct craton margin processes during the Proterozoic.

The Proterozoic Hf evolution of the West Australian Craton defines trends that reflect the original geometry of the craton margin. The closure of a large oceanic tract between the Pilbara Craton–Glenburgh Terrane and the Yilgarn Craton to form the West Australian Craton is recorded in the Capricorn Orogen of Western Australia (Johnson et al., 2010). First, leading up to the collision, major juvenile additions of intermediate to felsic magmas into the Pilbara Craton–Glenburgh Terrane margin was accompanied by Hf isotopic homogenisation. Subsequent crustal reworking events were dominated by the recycling of this older crust with the addition of only minor juvenile components.

Rifting of the West Australian Craton margin, possibly as a result of back-arc formation, is exemplified in the Albany-Fraser Orogen along the southeastern margin of the Yilgarn Craton. The oldest magmatic rocks (c. 1700 Ma) have initial Hf isotope values similar to those of the Yilgarn Craton. However, younger magmatic rocks become increasingly dominated by more radiogenic (juvenile) compositions, consistent with continued subduction, slab roll back and asthenospheric upwelling (Kirkland et al., 2010).

Thick latest Mesoproterozoic to Neoproterozoic siliciclastic sedimentary strata around the North Atlantic Region (NAR) include deposits in East Greenland, Scotland, Ireland, Norway, Sweden, the North Sea and Svalbard, which are mainly hosted in Caledonian structures. These deposits define two first order cycles of sedimentation and orogenesis which are distinct from earlier Grenvillian and later Caledonian events. Recent plate reconstructions for the Neoproterozoic place Baltica in a comparatively southerly position relative to Laurentia (Li et al., 2008), in which case many of the Neoproterozoic basins are located on the active continental margin of Rodinia facing the Panthallassan Ocean.

Detrital and magmatic zircons from the NAR show Hf evolution patterns that are intermediate between the two Australian craton margin scenarios described above. The Hf isotopic signatures indicate a prolonged period of mixing between juvenile sources and reworked unradiogenic crust (1800–1200 Ma), followed by the addition of juvenile material at 1200 Ma, after which major crustal reworking occurred between 1200 and 800 Ma without the addition of significant juvenile material. During the period 1000-850 Ma, sediments derived from the denudation of the Grenville-Sveconorwegian Orogen appear to have flooded an episodically active subduction zone system. The resulting Hf isotopic pattern best fits a cordilleran-type orogen with minimal juvenile input. This configuration provides a reasonable geotectonic context for the convergent deformation events and metamorphism affecting these sequences during the Neoproterozoic.

References

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