Significance of the longevity of the marine rare earth pattern

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The modern, shale-normalised seawater rare earth element and yttrium (REY) pattern is characterised by distinct anomalies. We demonstrate that, with the exception of the cerium anomaly, these features develop in the estuary. The discovery [1,2] that hydrogenous sediments preserve a modern-type marine REY pattern in the Palaeoarchaean has implications for the distribution of Archaean land masses.

The presence of a marine REY pattern in Palaeoarchaean hydrogenous sediments indicates a significant non-hydrothermal flux of REY to the ocean, requiring a substantial exposed landmass as far back as 3.7 Ga. Yet, there is wide agreement from Pb- and Nd-isotope systematics of the depleted mantle [3,4], that the volume of continental crust was very limited from 3.7 to 2.9 Ga. Mass balance calculations show that the small continental mass is inadequate to balance even a modest hydrothermal REY flux at 3.7 Ga.

The most plausible solution to this dilemma is that the Archaean landmass was largely composed of exposed oceanic lithosphere and that arc generated continental crust [4] only contributed marginally to the riverine and atmospheric fluxes. This hypothesis also offers elegant solutions for two further dilemmas of the continental crust volume record.

First, the small continental crust volume appears to provide insufficient weathering potential to draw down atmospheric CO_2 [5] to the levels required by the Huronian glaciation at 2.3 Ga [6]. Second, it resolves the difficulties [7] in obtaining a combined mass balance for both Sr isotopes and the REY in Archaean BIF.

Hence, marine REY systematics challenge the view, based on modern plate tectonics, that exposed crust was only continental lithosphere. It is likely that the much thicker Archaean oceanic lithosphere was also partly exposed.

References

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