Global tectonics and Late Archean to Early Paleoproterozoic environmental change

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The Late Archean to Early Paleoproterozoic (2.8 to 2.2 Ga) is a key period in Earth history. It records one of the most important episodes of growth of continental lithosphere followed by the change from oxygen poor to oxygenic conditions in biosphere. Links between the Phanerozoic tectonic cycle and environmental change are well documented, with greenhouse conditions and high sea-level accompanying periods of enhanced global magmatism (or superplume events) during the breakup and aggregation of supercontinents followed by periods of low sea-level and glaciation. Most biogeochemical and isotopic indicators of conditions in the biosphere, atmosphere and hydrosphere, including giant metal accumulations, closely reflect this tectonic cyclicity although there is a potentially confusing overlap of events caused by periodic global changes and those caused by secular change. The period from 2.8 to 2.2 Ga is generally viewed as a change from an active Late Archean tectonic regime dominated by mantle plume activity to a quiet Paleoproterozoic with little evidence of modern tectonic processes. A review of this period using new precise geochronology to establish chronostratigraphic correlation of key events indicates Phanerozioc-like global tectonic cyclicity that is linked to changing environmental conditions. It is clear from this preliminary analysis that distinguishing periodic, local and secular environmental changes through better chronostratigraphic resolution of the geological and biogeochemical records has the potential to result in the next major breakthrough in our understanding of coevolving Earth systems during the Archean and Early Paleoproterozoic.

Mantle gases in carbonatites

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Carbonatites contain trapped gases of mantle origin [1]. Based on the lower mantle He, Ne signatures in Kola carbonatites [2], the $\delta^{15}N$ signature in it (3±1‰) has been attributed to that of lower mantle[3]. We have undertaken a systematic investigation of carbonatites for nitrogen and noble gases, to delineate the trapped gas components of their source magma. Carbonatites from five different provinces of India, ranging in age from 65 Ma to 2.4 Ga have been investigated by vacuum crushing (VC) and pyrolysis (P) techniques for gas extraction from seperated carbonate and apatite minerals. Here, we focus on the N and Ar data.

While apatites are studied by both VC and P, carbonates have only been studied by VC. All carbonate analyses gave positive $\delta^{15}N$ values, falling within the range of 5 to 11‰ and accompanied by $^{40}Ar/^{36}Ar$ values of 3000 to 8000. Only ≤15% of N, but ≥40% of ^{36}Ar (in one case almost all ^{36}Ar) are released during VC of apatites. More importantly, the $\delta^{15}N$ (-11 to -22‰) is much lighter in VC, as compared to P (6 to 11‰) (except in the case of Sevattur, where both VC and P resulted in similar $\delta^{15}N$). Similarly, the $^{40}Ar/^{36}Ar$ values during VC reach upto 4700, while the corresponding values in P are low (again for Sevattur, VC and P gave similar values). These results indicate that both N and Ar in these carbonatites have more than one component. For apatites, almost all ^{36}Ar (the trapped component) is released in VC. This also indicates that dissolved N in the matrix is negligible and most of the N released in P is in a solid form and its $\delta^{15}N$ signature should correspond to pure recycled component. The $\delta^{15}N$ signature from VC, on the otherhand, is a mixture of recycled and source mantle components, implying that the mantle end member of the carbonatites is more likely to be ≤ -22‰, different from the Kola value, but similar to that of Reunion basalts [4]. The VC data in Fig. 1 indicate that a three component mixture (Lower Mantle, Air and Recyled Sediment) can better explain these results.

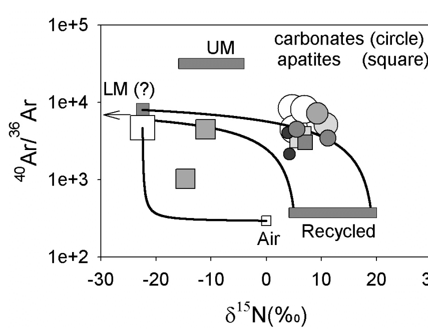

Fig. 1 $\delta^{15}N$ Vs. $^{36}Ar/^{14}N$ for the VC data. Symbol size indicates age of sample, but not to scale.

References

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