Inter-related temporal shifts in the Paleoproterozoic biosphere, atmosphere, and lithosphere

SPENCER, C.J.[1], PARTIN, C.A.[2], KIRKLAND, C.L.[3], RAUB, T.D.[4], LIEBMANN, J.[1]

[1]School of Earth and Planetary Sciences, Curtin University, Perth, Australia; cspencer@curtin.edu.au
[2]Department of Geological Sciences, University of Saskatchewan, Saskatoon, Canada
[3]Centre for Exploration Targeting – Curtin Node, Curtin University, Perth, Australia
[4]Dept of Earth and Environmental Sciences, University of St Andrews, St Andrews, United Kingdom

The Paleoproterozoic Era records major geochemical changes. While the cause of isotopic shifts during this period have long been ascribed to atmospheric, biologic, and geologic processes, their overall significance remains unknown. An appraisal of the global geologic record from about 2.3 to 2.2 billion years ago demonstrates a tectono-magmatic lull when global-scale continental magmatism (plume and arc magmatism) decreased and relative plate motions were subdued. Additionally, the age of large igneous provinces reveals a step-change in the proportion of subaerial eruptions at ~2.3 Ga implying a rapid development of continental freeboard at this time. A precipitous rise in atmospheric oxygen at about 2.3 Ga has been implied to be driven by the evolution of photosynthesizing organisisms. While the geochemical proxies of atmospheric oxygenation is recorded at the atmosphere-lithosphere or atmosphere-ocean interface, how it may have affected the deeper lithosphere is more cryptic.

We address this cryptic interaction with oxygen isotopes of zircon from Paleoproterozoic sedimentary successions in Western Australia and Canada which chart a step-change increase in $\delta^{18}O$ at ~2.3 Ga.

Hence, we posit that atmospheric oxygenation, contential freeboard and magmatism are inter-related and likely driven by large-scale mantle processes in which continental rifting driven by a mantle upwelling created vast shallow seas that spurred the evolution of photosynthesis and resulted in the oxygenation of the atmosphere. This was accompanied by increasing continental freeboard and changes to the $\delta^{18}O$ of sediment flushed from the emmergent continents into subduction zones thus increasing the $\delta^{18}O$ of subduction related magmas.