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Shale and carbonate geochemistry of the Proterozoic greater McArthur Basin, Australia.

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The greater McArthur Basin is a regionally extensive Palaeo-to-Mesoproterozic, intra-cratonic, super basin system overlying the North Australian craton. Deposition initiated after the Pine Creek Orogeny whereby the basin extends from Western Australia to northwestern Queensland. Lithostratigraphic units are divided into five coherent packages of similar age, stratigraphic position and facies association. Successions of the basin system are dominated by an assemblage of sedimentary siliciclastics, evaporitic carbonates and organic-rich mudstones with minor intersections of volcanic rocks and records nearly a billion years of Earth's history from ca. 1.82 Ga to the Tonian. This period has generally been considered a time of stability within the Earth system and is therefore unfortunately titled 'the boring billion'. However, compilation of new and existing water chemistry proxies shown in this study reflected the contrary. Notably, shales and carbonates from the greater McArthur Basin chronicled a critical time in Earth's history; where the oxygenation of the ocean and atmosphere began and multi-cellular eukaryotes started to thrive within the ecosystem, demonstrating that this interval in the geological record is anything but boring.

This study applied a multi-proxy approach based on observations of isotopic tracers and elemental variations from an extensive archive of carbonate-rich units throughout the greater McArthur Basin to reconstruct its palaeoenvironment, determine the tectonic setting and establish regional or global correlations. Elucidating the evolution of the basin is essential for understanding the controls of its petroleum and mineral resources as well as how Earth system processes developed during the Proterozoic. Radiogenic and stable isotopes are used to infer palaeo-depositional constraints such as biological productivity, weathering fluxes and provenance sources. Redox-sensitive elemental concentrations can also be used to reflect the changes in water-column chemistry between oxic, anoxic and euxinic conditions.

Consequently, results from this study illustrate the relationship between the precipitation of metal compounds, production of organic matter and preservation of both systems with large-scale

biogeochemical processes. Furthermore, this study also highlights the spatial and temporal variations of water chemistry within the basin. Enrichment in Mo concentrations in the Wollogorang Formation within the Tawallah Group indicated spells of widespread euxinia. Base metal concentrations within the unit showed lithogeochemical, halo-like distribution that is strongly correlated with changes in water column redox conditions. A shift to more radiogenic $^{87}Sr/^{86}Sr$ values up to 0.722 in the Fraynes Formation of the Limbunya Group reflected an increase in relative contribution of strontium from old continental crust in contrast to hydrothermal input which is consistent with a transient basin restriction from the open ocean. Rare earth and yttrium (REY) plots of the Dook Creek Formation inferred parts of the basin may have been lacustrine at ca. 1.5 Ga. Further up stratigraphy, the Middle Velkerri showed a shift towards more positive $\varepsilon_{Nd(t)}$ values, representing a change to more juvenile source regions. These mafic provenances are richer in essential nutrients for biological activity such as phosphorus. More juvenile $\varepsilon_{Nd(t)}$ data within the Velkerri Formation coincide with an increase in P concentrations and total organic carbon content (>8 wt. %).