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Reliability of phosphorites as a deep-time environmental indicator: apatite petrochronology of the 2.4 Ga Turee Creek Group in Western Australia

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Glimpses into life and its environment during the Great Oxidation Event (GOE) are rare due to the lack of well-preserved fossiliferous strata. Here we present new data from a microbialite reef complex in the c. 2.4 Ga Turee Creek Group, Western Australia, that contains a peritidal phosphorite potentially indicative of shallow-water oxygenation[1]. The phosphorite is composed of ripped-up microbial sediment and mat fragments, as well as peloids with variably preserved matrices[1]. The matrices range from organic and dispersed carbonate-fluorapatite-rich, to clay-rich matrices with euhedral apatite grains and organic matter (OM) lining the rim (Fig. 1)[1]. Previous analysis of the euhedral apatite from the more weathered textures (Fig. 1) showed these grains were altered by diagenetic processes[1], i.e., unrepresentative of the depositional environment. We expand on this work by analyzing a range of textures that span well-preserved to altered microbial rip-up fragments and peloids (Fig. 1). *In situ* Laser Ablation Split Stream (LASS) was performed on five samples across the breadth of the reef complex (*n*=186). U-Pb isotopic and trace-element data were collected simultaneously on each spot. Preliminary data shows a range of rare earth elements (REE) + Y patterns from arched, concave-down patterns of euhedral apatite to flatter, HREE depleted patterns of the dispersed apatite. Though its expression differs between samples, some grains show evidence of REE addition correlated with common Pb addition resulting in unrealistically old U-Pb dates (~3.5 Ga; Fig. 2). Within samples, mat fragments and peloids that have more OM and apatite recorded older dates (~2.1-2.3 Ga), with younger dates correlated to samples with more clay and chert (~1.7-1.9 Ga). Redox sensitive trace metal abundances (V, Mn, U and Mo) also differ within and between samples, as well as textures.

A clear interpretation of the U-Pb isotopic and trace-element differences within this phosphorite is complicated by sample heterogeneity. We surmise that each of the observed textures reflect remnants of initial formation, deposition and diagenetic environment, such that our work will help clarify which environmental proxies are resistant to diagenesis and useful in studies of ancient sedimentary deposits.

[1] Soares G.G., et al. (2019), *Precambrian Research* 320, 193-212.

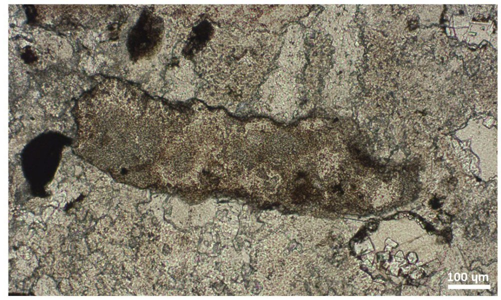

Figure 1. Plane Polarised photomicrograph of a variety of peloidal and rip-up fragment textures, including a dark black OM and apatite-rich peloid (left-hand side), dispersed apatite-rich microbial sediment rip-up fragment with dark brown OM-rich rim (middle), and a clay-rich peloid with euhedral apatite grains and OM around the rim (lower right-hand side).

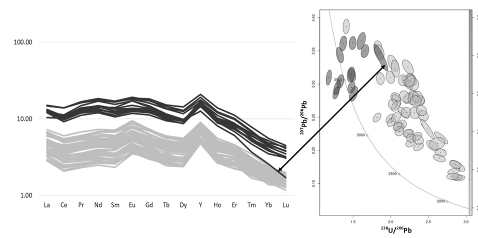

Figure 2. REE + Y and U/Pb isotopic data of dispersed apatite within microbial sediment fragments from two separate samples. Sample A is represented by the darker grey-black and has unrealistically old ages (~3.5 Ga) and enriched REE. Sample B is represented by the lighter grey and consists of younger ages and lower REE (the isotopic spread is due to multiple textures giving different ages within a heterogenous sample).