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A multi-scale, spatially-resolved textural and geochemical approach to interpreting Paleoproterozoic biosignatures

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Identifying biosignatures in deep time, especially morphology-based biosignatures, can be challenging. A number of compounding factors, including variable preservation potential within the original depositional environment, subsequent alteration of material during diagenesis and metamorphism, and limited outcrop at the Earth's surface, make it difficult to quantify the interplay between biologic, paleoenvironmental, and geologic signals recorded in ancient rocks.

Here we investigate the relationship between life and non-life processes recorded in a suite of carbonate rocks from a Paleoproterozoic (c. 2.4 Ga) microbialite reef complex of the Turee Creek Group, Western Australia [1]. We combine data from field mapping, petrography, SEM-EDS, and LA-ICP-MS to characterise the textural, mineralogical, and elemental composition of samples of known fossiliferous and non-fossiliferous origin. By utilising *in situ*, spatially-resolved techniques to compare these samples, we aim to identify geochemical biosignatures (e.g., specific mineralogical distributions; trace element concentrations) that are tied to morphology-based biosignatures (i.e., microbialite laminae) in the fossiliferous samples, but that are absent, or diminished, in the non-fossiliferous samples.

Initial results show that differences in morphology and texture at field and hand sample scale are reflective of textural and grain size differences under the petrographic microscope. This is despite petrographic observations and SEM-EDS data that reveal the studied samples are compositionally identical, containing dolomite and quartz with minor clays. Variability in REE +Y patterns between samples appears to be reflective of individual sample location within the reef complex, consistent with previous field mapping and isotopic analysis that identified this reef complex fluctuated between a periodically restricted lagoon and a more open marine setting [2].

Results from this study will improve our ability to differentiate biologic from geologic signals, reducing ambiguity in deep time biosignature detection. This work also has implications for being able to distinguish potential agnostic biosignatures (universal signs of life) in rocks, contributing to the search for life 'as we don't know it' elsewhere.