# Reconstructing environmental conditions in a c. 2.4 Ga microbialite reef using Si isotope and trace element analyses

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Approximately 2.4 billion years ago during the Great Oxidation Event (GOE), following a series of glaciations, a microbialite reef complex was deposited within the Turee Creek Group (TCG) in Western Australia. This reef is unique because it is well-preserved and contains an abundance of diverse types of both microbial and more cryptic life. The world's oldest known phosphorite made up of microbial mats, the first appearance of thrombolites and a complex deep water microfossil assemblage containing novel forms of life are a few examples of the diverse array of life within the reef [1,2,3]. This diversity has been linked to the influx of oxygen and nutrients in the oceans during the GOE. However, it is difficult to establish whether oxygenated, nutrient-rich conditions actually prevailed within the reef at the time of deposition. Sedimentary cherts are good preservers of geochemical signals that are related to primary environmental conditions because they form rapidly and often early, before burial. Silica is present throughout the carbonate-dominated microbialite reef complex in many forms including, as euhedral quartz crystals within phosphorous-rich peloids; microcrystalline quartz in thrombolites; and black chert lenses preserving deep water microfossils [1, 2, 3]. Known examples of primary and secondary cherts were compared using silicon isotope analysis, as well as major and trace element analysis to reconstruct the environment during the deposition of the reef from shallow to deeper waters. Isotopic data spanned a wide range, with $\delta^{30}$Si from -2.8 to 4.1‰, which is typical of Precambrian cherts [4, 5, 6]. The isotopic data was correlated with major element data to show that the primary quartz textures were seawater precipitates (e.g., $Al_2O_3 < 0.5$ wt% and $\delta^{30}$Si > 0‰) and that the secondary precipitates had a greater hydrothermal influence (e.g., $Al_2O_3 < 0.5$ wt% and $\delta^{30}$Si < -0.5‰). Rare earth element data showed that the more primary quartz textures had patterns typical of riverine (shallow water precipitates) to oceanic sources (deep water precipitates) (i.e., La/La* = 0.81- 3.78, Gd/Gd* = 0.48-2.42, Y/Ho = 14.37-50.18). This data also showed that there is evidence of oxygen in the shallow waters of the reef (i.e., Ce/Ce* = 0.4-1.1) and that there are relatively high levels of nutrient elements (e.g., P up to 7000 ppm) in shallow water precipitates. By linking isotopic data to trace and rare earth element data, as well as petrography, it has been established that: the shallow waters of the reef had a greater continental/ riverine influence and were oxygenated with an increase of nutrients (P); and that the deeper waters had a greater oceanic influence and were anoxic. The presence of oxygen and nutrients within the microbialite reef complex may provide a reason for the abundance and diversity of life preserved.

[1] Soares et al. (2019) *Precambrian Res.* **320**, 193-212. [2] Nomchong and Van Kranendonk (2020) *Precambrian Res.* **338**. [3] Barlow and Van Kranendonk (2018) *Geobiology* **16**, 449-475. [4] Zheng et al. (2019) *Geochim. Cosmochim. Acta* **253**, 267-289. [5] Stamm et al. (2019) *Geochim. Cosmochim. Acta* **255**, 49-68. [6] Heck et al. (2011) *Geochim. Cosmochim. Acta* **75**, 5879-5891.