Synchrotron-based XRF mapping of Neoarchean stromatolites: trace element distribution in microbialites

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Stromatolites record ancient microbial metabolisms and potentially past environmental conditions on Earth, where their depositional geochemistry has been preserved through diagenesis. Here we test the innovative use of Synchrotron Rapid Scanning X-Ray Fluorescence (SRS-XRF) combined with conventional methods (optical petrography, XRD, ICP-MS/AES, EMPA) to determine whether trace element distributions: (i) can be distinguished in ancient stromatolites on cm to dm scales, (ii) show variation between biogenic textures/structures and abiogenic mineral precipitates, and (iii) are primary or secondary in nature.

Neoarchean fenestrate stromatolites from the ~2520 Ma Klein Naute Formation (Transvaal Supergroup, South Africa) in Agouron drill core GKF01 preserve cuspate morphologies within clearly delineated microbial mats. The biogenic structures are composed of xenotopic ferroan dolomite, encased in syndepositional to very early burial ferroan calcite, including herringbone calcite. Wholesale platform dolomitization likely occurred from seawater, but the sample might preserve an early dolomitization stage. Dolomite formation was likely facilitated by bacterial sulphate reduction during mat decay and occurred either as a primary precipitate, or using Mg^{2+} ions sourced from the degrading mat. Petrographic evidence precludes interaction with basin-derived fluids as a cause of dolomitization.

Several elements (Ca, Fe, Mn, Cu, Pb, As, Cl, Si, P, S) show distinct spatial variations that correspond to specific biogenic and abiogenic textures. Trace element distributions likely reflect differing element partioning behaviour between calcite and dolomite. SRS-XRF mapped distributions may also indicate primary element distributions within the mat and may possibly trace constituent microbial populations and their associated metabolic processes.