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Stable isotope data of modern and ancient microbialites

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When post-depositional alteration is carefully evaluated, then the stable isotope composition of organo-sedimentary carbonate structures (microbialites) can provide valuable information on early Earth environmental conditions. Carbonate-based reconstructions of environmental conditions in the Precambrian rely heavily on shallow-water and typically microbially-formed carbonates. Recently, also non-traditional stable isotope signatures of microbialites are used for paleo-environmental reconstructions. Constraining diagenetic alteration, however, is key for interpreting non-traditional isotope data and inferred paleo-environmental conditions. We present geochemical analyses focused on stable C and O isotope data and diagenetic alteration of modern and ancient microbialites. The aim is to build a framework for interpreting paleo-environmental reconstructions using non-traditional isotope systems. This is part of an ongoing study on the chromium isotope systematics of modern and fossil microbialites (1).

The samples are **(a)** fine-grained, thinly laminated microbialites (3,000-5,000 a) from the coastal Marion Lake (**MRN**; **Fig. 1**) that is on a regressive marginal flat with connection to open marine conditions, **(b)** dolomitized stromatolites formed on a carbonate ramp in the marine ~720 Ma Andrée Land Group (**ALG**), Greenland (2), and **(c)** cyclic stromatolitic carbonates from the non-marine ~800 Ma Bitter Springs Formation (**BSF**), Australia (3). We used bulk sample powders of ca. 1 cm^3 cubes cut along profiles perpendicular to the lamination or along a core to rim profile. Powdered aliquots of these samples were analyzed for their $\delta^{13}C$ and $\delta^{18}O$ values using a NuPerspective IRMS at AMGC, VUB, Belgium (reproducibility of the standard materials IAEA 603, IAEA CO-8 and the in-house MAR-2 were 0.12‰ and 0.21‰ for C- and O-isotope data, resp., n=48).

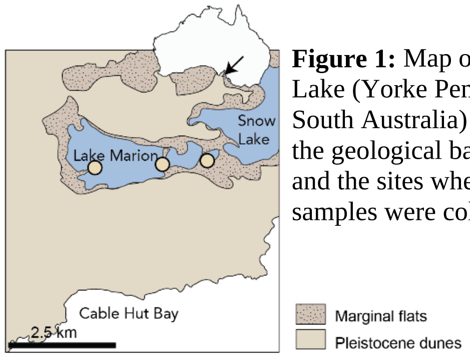

Figure 1: Map of Marion Lake (Yorke Peninsula in South Australia) indicating the geological background and the sites where MRN samples were collected (1).

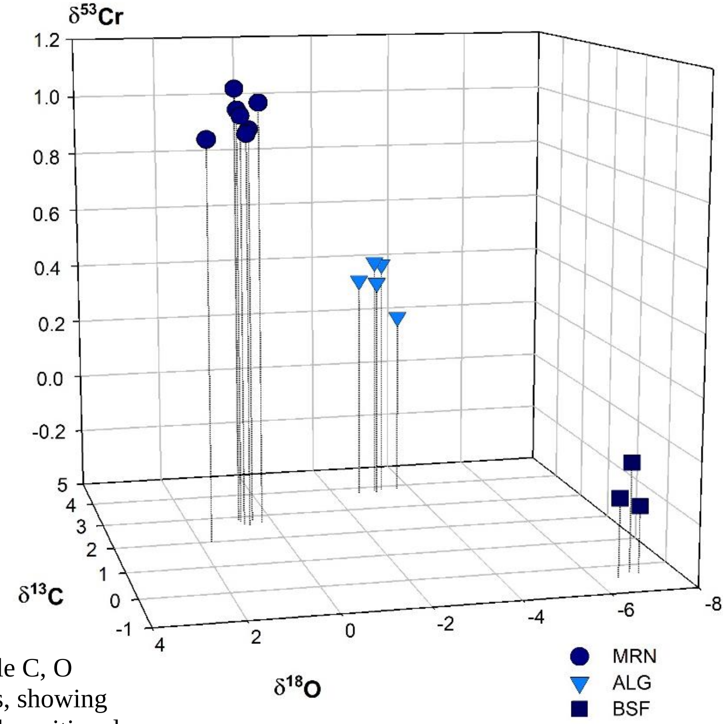

Figure 2: Stable C, O and Cr isotopes, showing differences in depositional environments and alteration.

The modern microbialites from Marion Lake have stable C- and O-isotope data (**Fig. 2**) that reliably reflect the environmental conditions of their depositional settings: high $\delta^{13}C$ values (+1.97 to +2.85‰) indicate extensive microbial activity and high $\delta^{18}O$ values (+0.27 to +1.73‰) point to evaporative settings.
The Precambrian samples from the ~720 Ma Andrée Land Group have slightly higher $\delta^{13}C$ values (+3.70 to +3.81‰), similar to modern microbialites, but low $\delta^{18}O$ values (-3.78 to -2.63‰) relative to modern samples.
However, the Precambrian microbialite samples from the ~800 Ma Bitter Springs Formation have low $\delta^{13}C$ (-0.48 to -0.31‰) and $\delta^{18}O$ values (-3 to -6‰).
The differences likely indicate a different depositional environment and a stronger degree of post-depositional diagenetic alteration. This might also explain the comparatively low $\delta^{53}Cr$ values of these samples (1).

References: (1) Bruggmann et al., in prep.; (2) Klaebe et al., 2018, *Precamb. Res.* 319:96-113; (3) Klaebe et al., 2016, *Geobiol.* 15:65-80;