Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23633

A robust protocol for evaluating ancient carbonates and halites

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We propose a revision to the screening protocol presented by Blamey & Brand (2019) [1]. This new protocol signifies the importance of the order in which physico-chemical analyses are completed and sub-sampling consistency. As well, it provides a comprehensive diagenetic assessment across several methodologies to ensure diagenetic products are not mistaken for ideal, primary material. We illustrate this through the paleoreconstruction of a low-latitude locality of Neoproterozoic age (Tonian, ~ 1000 - 720 Ma), using marine carbonate and evaporite samples of the GSWA Empress-1A drill core from Western Australia [2][3].

Following lithological selection, a thorough petrographic assessment of sample's microstructures must be completed. In evaporites especially, overlain layers of fluid inclusion growth trails/chevrons may prove challenging to ensure sample sub-sets contain strictly unaltered material. Microthermometry targets two-phase, primary fluid inclusions to determine temperatures of formation. Using the cooling nucleation method [4], we derived homogenization temperatures averaging to 35.9 ± 0.5 °C, which are assumed to be paleotemperatures representative of local, tropical environment during a Tonian Earth.

Analysis of the gases within fluid inclusions was conducted following the completion of all petrographic analyses that require intact microstructures. All gas chemistry data was normalized to a water-free basis and back-calculated for organic matter gases from microbial activity. Analyzation and interpretation of Neoproterozoic halite fluid inclusion gas chemistry reveals ancient atmosphere O_2 concentrations of approximately 12% (Figure 1).

Leftover crushed material following gas analysis was homogenized and used for further chemical interpretations of liquids and/or solid material, including strontium isotopes, stable isotopes, trace elements and REE's. Plotted data on the strontium seawater curve fall within the ± 0.6 ‰ natural variation of $^{87}Sr/^{86}Sr$ in modern marine environments, verifying the age of the Browne sample suite to approximately 830 Ma and providing additional diagenetic assessments (Figure 1).

References:

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