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Progress on a record of Earth's atmospheric pCO_2 and pO_2 from samples of ancient air trapped in fluid inclusions

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Our current methods for reconstructing ancient atmospheric O_2 and CO_2 rely heavily on proxies for time periods prior to the ice-core record. Fluid inclusions in halite from surficial environments have gained attention for their ability to capture and preserve snapshots of ancient air, and by mechanical decrepitation these inclusion gases can be released and quantified via mass spectrometry. We have demonstrated that unaltered halite gases accurately represent the overlying atmosphere when they are partitioned to account for gas contributions from trapped air and brine[1]. Measurements of halite precipitated in a sealed pressure vessel reproduces the pCO_2 conditions under which they formed (450 ppm, 3000 ppm, and 5000 ppm)[2]. Similarly, results from modern and lab grown halite crystals faithfully record atmospheric O_2. A major concern with natural inclusions is their ability to trap organic matter and/or intact microbes, potentially leading to post-entrapment alteration of non-conservative species. Compositional variability imparted through phase chemistry and alteration is addressed by coupling partitioning techniques with a revised back calculation method. This includes using trends in gas ratios and mole fractions (particularly O_2, CO_2, and CH_4) to distinguish between multicomponent mixing and unique stoichiometric reactions where gases are consumed or produced[3]. We introduce stable carbon isotopes as a tool to assess alteration extent. Here we present progress on a direct record of atmospheric pCO_2 and O_2 from the Mesoproterozoic (1.4 Ga)[4] to the modern. Coupled with inclusion microthermometry, we provide insight into Earth's long term climatic evolution with implications for the drivers of long-term carbon cycling and diversification of complex life. Furthermore, these data provide crucial anchor points for the variety of O_2 and CO_2 proxies applied in deep-time where the absolute level of these atmospheric gases is unknown. Although pristine evaporite deposits are sparsely distributed through the geologic record, they are nonetheless one of the few archives that can extend our direct measurements of ancient atmospheric composition well beyond the ice core record.

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