Climatic extremes at the dawn of animal life

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Paleo-temperature estimates utilizing clumped isotopic (Δ_{47}) analyses of ancient rocks and fossils generally depend on evaluation of diagenetic effects, including the following strategies; comparisons between two or more co-existing minerals (i.e. calcite, dolomite and apatite), comparisons between co-existing fabrics (i.e. late-stage cements vs. primary shells), and screening based on textural and chemical indicators of recrystallization. And, interpretations should take advantage of independent constraints on burial and thermal history. Creating a robust record of climate will require multi-section high-resolution comparisons through $\delta^{18}O$ excursions, and comparing similar materials globally across space and time. We will present results that utilize all of these strategies to assess the climate variability and evidence for substantially warmer periods in the Neoproterozoic, Cambrian and Ordovician. Diagenesis dominates the highest amplitude stable isotope variations in these materials. After controlling for these processes, we find no evidence for long-term evolution of the $\delta^{18}O$ of seawater from its ice-free Cenozoic mean of -1.4‰. Within this period of eukaryotic and early animal evolution and innovation, we find evidence for multiple cold and warm climatic events using clumped isotope thermometry.