Sedimentological constraints on the Bitter Springs delta13C Anomaly

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Large magnitude (>10‰) carbon isotope ($\delta^{13}C$) excursions in carbonate-bearing sediments of Neoproterozoic age increasingly constrain the chronology of the Neoproterozoic stratigraphic record and have significant implications for our understanding of the evolution of the Precambrian biosphere. The ~825 Ma 'Bitter Springs Anomaly' (BSA) is an interval of $\delta^{13}C$ variability to depleted (-4‰) values from enriched (+5‰) values and is considered a robust stratigraphic marker and an indicator of carbon cycle perturbations that preceded the severe ice-ages of the Cryogenian. We present paired sedimentological and stable-isotopic ($\delta^{13}C$ and $\delta^{18}O$) data to show that the isotopic variability that defines the BSA is facies-dependent and its defining features rely on end-member paleoenvironments. The inflection points from enriched (+5‰) to depleted (-4‰) $\delta^{13}C$ values that define the excursion occur systematically with major facies changes between evaporative lacustrine environments and deeper-water microbial and grainstone carbonates respectively. A first-order relationship between $\delta^{13}C$ and $\delta^{18}O$ (R^2=0.75) across the facies changes indicates proportional end-member mixing along these changing environments. This coupling of isotopic values and sediment composition indicates that local modification of $\delta^{13}C$ in basin waters controls $\delta^{13}C$ variability and that these excursions are not representative of whole-ocean chemistry. This association would also satisfy $\delta^{13}C_{org}$ values shown to vary sympathetically with $\delta^{13}C$. Thus, our findings illustrate that some features of composite $\delta^{13}C$ records derived from Precambrian strata may be relics of isolated water-bodies as they respond to local hydrology and base-level. The anomalous $\delta^{13}C$ features in this part of the record may be analogous to similar excursions throughout the better-constrained Phanerzoic record that are evidently the function of local basinal conditions. This suggests that some Neoproterozoic excursions exhibit limited constraint on the function of Earth's biosphere through time.