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Sedimentology and stable isotope geochemistry of the Trezona Formation; A local or global biogeochemical event?

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ABSTRACT

High magnitude $\delta^{13}C$ shifts (>12‰) restricted to Neoproterozoic carbonate successions are widely interpreted to reflect a vastly different regime of carbon cycling that changed into the Phanerozoic. Despite isotopic values in the Neoproterozoic being anomalous, they are considered to reflect the $\delta^{13}C$ composition of sea water because the values appear to be reproducible, change systematically, and occur in a similar stratigraphic interval relative to overlying glacial intervals within successions in different basins. The relation to a primary marine origin of the isotopic values in carbonates is key to these isotopic excursions providing constraints on the global carbon mass balance during the Neoproterozoic, that are central to present models of the ancient carbon cycle. The Trezona Formation in the Central Flinders Ranges in South Australia records a large (~9‰) pre-Marinoan glacial $\delta^{13}C$ excursion widely correlated to basins globally and termed the 'Trezona Anomaly'. This study examines the depositional setting of the Trezona Formation using outcrop exposures, petrographic studies, and stable isotope geochemical data and investigates the origin of $\delta^{13}C$ values with respect to lithological and diagenetic controls. $\delta^{13}C$ and $\delta^{18}O$ data was collected using Isotope Ratio Mass Spectrometry. Field observations reported here are inconsistent with an open marine or tidal origin for the Trezona Formation. Sequence boundaries in the form of paleosols and fluvial deposits at the basal and upper contacts respectively indicate that it represents its own discrete depositional cycle. This is contrary to previous interpretations that the Trezona Formation records a broad shallowing upwards trend of widespread marine shales of the underlying Enorama Formation into the overlying glacial sediments of the Elatina Formation. Evidence of frequent desiccation throughout the basal half of the Formation and the limited spatial distribution of the Trezona Formation is suggestive of a consistently shallow, restricted marine or periodically lacustrine depositional setting.

Covariant and diverging relationships between $\delta^{13}C$ and $\delta^{18}O$ values in stratigraphic profiles suggest a lithological relation to isotope values. Furthermore, petrographic data suggests that intervals of the Trezona Formation housing strongly negative $\delta^{13}C$ values (<-5‰) may have undergone digenetic recrystalisation. A diagenetic origin for these values makes them typical of meteorically altered successions in the Phanerozoic, and removes the need for currently popular global biogeochemical models calling for dramatic differences in Precambrian carbon cycling. These observations also imply that the Trezona Formation is not a record homogeneous, open marine $\delta^{13}C$ values and is therefore inappropriate as a correlation of chemostratigraphic events. Rather, it likely records the common alteration of coastal or lacustrine carbonates responding to exposure and alteration during sea-level fall coinciding with the Marinoan glaciation.

Key Words: Trezona, Marinoan glaciation, Carbon Cycling, $\delta^{13}C$, $\delta^{18}O$