Resolving the Diagenetic and Marine Influences on the Carbon Isotopic Composition of the Ediacaran Wonoka Formation, South Australia

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TITLE

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RUNNING TITLE

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ABSTRACT

Variations in the carbon isotopic composition ($\delta^{13}C$) of carbonate rocks can reflect climatic and biological events throughout geologic time. However, a number of Neoproterozoic carbonate-bearing successions show spatially reproducible negative shifts in $\delta^{13}C$ which reach as low as -12 ‰, a magnitude incompatible with current carbon cycle models. The largest of these shifts is known as the 'Wonoka Anomaly' after the Ediacaran Wonoka Formation in South Australia. This anomaly closely precedes the widespread appearance of macroscopic multicellular life in the geologic record, suggesting a link between potential changes in carbon cycle dynamics and the widespread rise of complex life in the Ediacaran. Alternatively, spatially reproducible, negative $\delta^{13}C$ shifts in Quaternary carbonate platforms are known to result from diagenesis and can be demonstrated to be diachronous by biostratigraphic constraints unavailable in the Neoproterozoic. This study investigates the origin of the carbonate within the Wonoka Formation, to determine the marine and diagenetic influences on its carbon isotopic composition. Sedimentological, petrographic and isotopic analyses show the carbonate phase associated with anomalously negative $\delta^{13}C$ values is a carbonate cement of no obvious internal origin, while the return to typical marine $\delta^{13}C$ values is characterised by the appearance of identifiable marine carbonate grains. Isotopic analysis of this cement reveals a strong linear co-variation between $\delta^{13}C$ and $\delta^{18}O$, a characteristic associated with meteoric diagenesis. Thus the Wonoka Anomaly is interpreted here as the result of cementation by meteoric water in association with small-scale changes in sea level. Given that meteoric water is depleted in $\delta^{13}C$ by organic matter, the presence of meteoric carbonate cement in the Wonoka Formation implies significant terrestrial photosynthetic life in the late Neoproterozoic. Therefore the Wonoka Anomaly likely represents some of the earliest development of the terrestrial biosphere, rather than whole ocean secular change.

KEYWORDS

Wonoka Anomaly, Carbon, Carbon Isotopes, Wonoka Formation, Ediacaran, Neoproterozoic, Diagenesis, Adelaide Geosyncline, South Australia.

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