

A late diagenesis origin for the highly ^{13}C -depleted calcite nodules in the Ediacaran Doushantuo Formation of South China and its relationship with Shuram excursion

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The Shuram excursion in the Ediacaran Period represents the largest negative carbon isotope excursion in Earth's history. Despite of numerous studies, the origin of Shuram excursion remains highly debated. The occurrence of highly ^{13}C -depleted calcite nodules and cements in the upper Doushantuo and lower Dengying formations in the shelf-margin facies of South China was thought to be direct evidence for authigenic carbonate origin of the Shuram excursion. The pronounced ^{13}C -depletion has been interpreted as a product of anaerobic oxidation of methane (AOM) associated with microbial sulfate reduction (MSR) below sediment-water interface during early diagenesis stage. To test this interpretation, we carried out detailed petrographic and geochemical analysis on these calcite nodules and cements, as well as their host rocks from the Ediacaran Doushantuo and Dengying formations. Calcite nodules and cements mainly consist of calcite and quartz, and show remarkable differences from matrix dolomite in geochemical proxies including $\delta^{13}\text{C}_{\text{carb}}$, $\delta^{26}\text{Mg}$, Δ_{47} , and the distribution pattern of rare earth elements, indicating their precipitations in different fluids. The newly reported trapping temperatures of H_2S -rich fluid inclusions in calcite and quartz range from 134°C to 158°C, higher than that of matrix dolomite (generally lower than 60°C) and MSR process (generally lower than 80°C). Calcite in nodules yields a laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) U-Pb age of 428 ± 22 Ma, suggesting that the highly ^{13}C -depleted calcite was probably precipitated during the late Silurian period. The precipitation of highly ^{13}C -depleted calcite nodules and cements are likely related to the methane oxidation associated with thermogenic sulfate reduction (TSR) that occurred in late burial diagenesis or during late Silurian hydrothermal event, implying that methane oxidation associated authigenic calcite precipitation is not genetically related to the Shuram excursion.