Revisiting molar tooth structures in light of a low oxygen and sulfate Mid-Proterozoic ocean

HANCOCK, L.G.[1]*, LYONS, T.W.[1], REINHARD, C.T.[2], WEHRMANN, L.M.[1], BEKKER, A.[1], OLSON, S.L.[1] AND GOLDBAUM, E.F.[1]

[1]*Department of Earth Sciences, University of California Riverside, 900 University Ave., Riverside, CA 92521 (*correspondence: lhanc001@ucr.edu)

[2]California Institute of Technology, 1200 East California Boulevard, Pasadena, CA 91125

Molar tooth structures are globally distributed carbonate features that are largely restricted to Mesoproterozoic and Neoproterozoic shallow-water, marine successions. The term "molar tooth" encompasses a range of sheet- and bleb-like microcrystalline calcite structures hosted in fine-grained, shallow-water shelf carbonates. The temporal restriction of these enigmatic structures suggests a relationship to seawater evolution in the Proterozoic. Several mechanisms of formation have been proposed, including seismic shaking, calcite replacement of algal structures, CO_2 clathrate destabilization, and biogenic precipitation. Most researchers agree that both the dolomitization of the host rock and the precipitation of the infilling calcite occurred very early in diagenesis, based in part on the presence of lag deposits directly above molar tooth horizons that contain rip-up clasts of both the dolomite and calcite. The most widely inferred mechanism is gas expansion cracking, though the exact mechanism for expansion and type of gas responsible is still unresolved. The lack of isotopically light carbonate-carbon in the infilling calcite has steered the argument away from methane, suggesting that the calcite precipitated from the same DIC pool as the host rock. Our study aims to revisit the influence of methane on these structures in light of emerging models suggesting low sulfate and oxygen in the Proterozoic oceans that may have favored broadly methanic conditions. Low sulfate is further indicated by the general paucity of pyrite despite ample Fe. Capturing the isotopic signature of crack-forming methane would prove difficult if oxygen and sulfate were too low to support appreciable anaerobic and aeroboic oxidation, respectively, leading to rapid gas escape into the overlying water column. The overarching goal of this study is to bridge the debate about enigmatic molar tooth structures with the latest developments in understanding Proterozoic ocean-atmosphere chemistry.