

REVISITING THE PROTEROZOIC MOLAR TOOTH STRUCTURES IN LIGHT OF EMERGING MODELS FOR PROTEROZOIC OCEAN CHEMISTRY: A POSSIBLE METHANE DRIVER IN A LOW SULFATE AND OXYGEN OCEAN. L. G. Hancock¹ and T. W. Lyons², ¹University of California Riverside, Department of Earth Sciences, 900 University Ave. Riverside, CA 92521, lhanc001@ucr.edu, ²University of California Riverside, Department of Earth Sciences, 900 University Ave. Riverside, CA 92521, timothy.lyons@ucr.edu

Molar tooth structures have remained enigmatic carbonate features for many decades, in part because they are largely restricted to Mesoproterozoic and Neoproterozoic shallow-water marine successions. The term “molar tooth” encompasses a wide range of sheet- and bleb-like microcrystalline calcite structures that are hosted in fine-grained, shallow-water shelf carbonates. Their temporal restriction suggests an intimate relationship to seawater evolution during the Proterozoic. For example, their last appearance prior to the Sturtian Glaciation in the late Neoproterozoic, as constrained by ⁸⁷Sr/⁸⁶Sr, is consistent with a coeval shift in ocean chemistry prior to the onset of global-scale glaciations. Several mechanisms of formation have been proposed, including seismic shaking, calcite replacement of algal structures, CO₂ clathrate destabilization, biogenic precipitation, and rapid filling of gas-formed fractures. The general consensus is that both the dolomitization of the host rocks and the precipitation of the infilling calcite occurred very early in diagenesis, due to the presence of lag deposits that contain rip-up clasts of both the dolomite and calcite directly above molar tooth horizons. The most widely accepted mechanism is gas expansion cracking, though the exact mechanism for expansion and, most importantly, the responsible gas are still debated but carry implications for the global state of the ocean. The lack of isotopically light carbonate carbon in the molar tooth calcite has steered the argument away from methane as a driving gas in molar tooth formation, suggesting that the calcite precipitated from the same DIC pool as the host rock. This study revisits the potential influence of methane on these structures in light of emerging models of the Proterozoic oceans that suggest low sulfate and oxygen that might have favored broadly methanic conditions. Low sulfate is further indicated by the paucity of pyrite in molar tooth associated deposits despite the presence of elevated levels of iron. Capturing the isotopic signature of crack-forming methane would prove difficult if oxygen and sulfate were not present in concentrations that were sufficient to support appreciable aerobic and anaerobic 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 of Proterozoic ocean-atmosphere chemistry, and our favored model now

requires high carbonate saturation within methanic pore-water beneath an oxygen- and sulfate-poor surface ocean. Replace these instructions with the text of your abstract.