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The Role of Substrate and Seawater Geochemistry in Shaping the Fossilization of Earth's Earliest Animal Communities

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Earth's earliest fossils of complex macroscopic life are recorded in Ediacaran-aged siliciclastic deposits as exceptionally well-preserved three-dimensional casts and molds, known as "Ediacara-style" preservation. Recent work on the Ediacara Member of South Australia [1] has indicated that elevated concentrations of dissolved silica (DSi) in Precambrian seawater —2mM, an order of magnitude higher than in today's oceans— may have driven the exceptional preservation of these soft-bodied organisms. Additionally, experimental work conducted under high DSi conditions has shown that silica readily precipitates onto the organic surfaces of a wide range of invertebrate animals and microbial organisms, forming silica cements that facilitate their moldic preservation in sandy sediments [2]. Instances of Ediacara-style fossilization are represented in a variety of sedimentary facies characterized by clean quartzose sandstones (as in the Ediacara Member) as well as less compositionally mature, iron- and clay-rich sandstones. Furthermore, Ediacaran marine DSi levels remain subjects of debate; recent work has suggested substantially lower DSi levels than previous estimates [3]. Here, we build upon previous experimental work to explore various sedimentary substrates bracketing those in which Ediacara Biota fossil assemblages are preserved (quartzose sands, iron oxides, and clays) and a wider range of initial DSi concentrations (0.5-2 mM). We observe the development of amorphous silica and authigenic clay coatings along the surfaces of various experimental organisms and in intergranular pore spaces. Our results provide evidence that soft tissues can be rapidly preserved by silicate minerals precipitated under a wide range of predicted scenarios for Ediacaran seawater DSi concentrations and variable substrate compositions. These observations suggest that interactions between sediments, organic substrates, and seawater DSi likely played a significant role in the exceptional fossilization of the first complex ecosystems on Earth

References

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