Petrological evidence supports the death mask model for the preservation of Ediacaran soft-bodied organisms in South Australia

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Liu et al. (2019) recently petrographically analyzed several samples of the fossiliferous Ediacara Member of South Australia and reported iron-oxide grain coatings, framoidal structures, and iron staining, which they interpret as the oxidized remnants of Ediacaran pyrite. They posit that precipitation of pyrite preceded that of the authigenic silica cements previously interpreted to have played a critical role in facilitating the moldic preservation of the soft-bodied Ediacara Biota (Tarhan et al., 2016). Liu et al. discount a role for silica cementation, arguing that the previously proposed ‘death mask’ model of fossilization mediated by pyrite veneers (Gehling, 1999) offers a more compelling explanation for the preservation of Ediacara Member fossils.

Liu et al. cite the presence of isolated spherical iron oxide phases, which they interpret as pseudomorphs after pyrite (Liu et al., 2019, their figures 2D, 3A–3D, DR2A, and DR2D), as evidence for death mask preservation. However, they do not demonstrate a systematic association between Ediacara Member fossils and laterally continuous pyrite crusts, as required by the death mask model. In fact, Ediacara fossils in the Ediacara Member (Tarhan et al., 2016) and the unweathered White Sea succession (Bobrovskiy et al., 2019) occur in the absence of pyrite. Nor do Liu et al. offer a mechanistic explanation for how isolated framoids could have promoted three-dimensional molderic preservation of Ediacara fossils. Pyrite and iron oxides are ubiquitous in marine sediments; their scattered presence does not indicate that pyrite was the primary agent of Ediacara-style fossilization, nor does this negate a role for authigenic silica cements.

Moreover, it is not clear that oxides on weathered Ediacara surfaces can be linked to seafloor processes. Spherulitic phases are not unique to pyrite; they merely reflect rapid, non-nucleation-limited precipitation (e.g., Golden et al., 2008). Individual grains within the spherules figured by Liu et al. lack the cubic or octahedral habit of pyrite, and instead appear tabular—a common hematite morphology. We observe similar spherulitic phases in mudstones and shales, which they interpret as pseudomorphs after pyrite (Liu et al., 2019, their figures 2D and 2E) are most parsimoniously interpreted as late-stage precipitates (e.g., fracture infill). Liu et al. concede that their scrutiny was confined to weathered surfaces, which are complicated by recent weathering processes and, moreover, are likely not relevant to intrastratal fossils characterized by petrographic evidence for early silica cementation (Tarhan et al., 2016).

Liu et al. suggest that authigenic silica cementation should have resulted in preservation of organic matter. However, the taphonomic mechanism proposed by Tarhan et al. (2016) is of early grain-boundary and then progressive silica cementation over the paragenetic history of the Ediacara Member, a process that would not capture organic materials and is not synonymous with Bitter Springs-type fossilization of organic microfossils in cherts. Liu et al. suggest that the elevated Ge values observed by Tarhan et al. (2016) in Ediacara quartz cements reflect later diagenetic silica precipitation in tandem with Al remobilization. However, the Ge and Al data reported by Tarhan et al. (2016), with a maximum R2 value of 0.1, do not, by standard practice, display a “weak positive correlation” (contra Liu et al., 2019).

High dissolved silica concentrations in the Precambrian and early Paleozoic oceans appear to have mediated several modes of fossilization, including Bitter Springs-type preservation, silica replacement, silica cementation, and precipitation of authigenic clay phases. These taphonomic processes, along with pyritization, phosphatization, carbonate-associated and carbonaceous preservation, have provided an exceptional window into Ediacaran ecosystems. There is no single mode of Ediacaran fossilization, but compelling evidence for the death mask model still awaits development.

REFERENCES CITED


