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Project Title: The Silicification of Soft-Bodied Biotas: A Model for Exceptional ‘Ediacara-Style’ Preservation

Project Report
I spent one month conducting a field investigation of the taphonomy and paleoenvironment of the Ediacara Biota—Earth’s earliest multicellular communities—in the Ediacara Member of the Rawnsley Quartzite, at Nilpena in the Flinders Ranges of South Australia. My field efforts were focused on the collection of preservational, sedimentological, geochemical and paleoecological data, in order to elucidate the biogeochemical conditions that prevailed during the development and preservation of early complex life. In particular, I sought to test the model that early-stage silicification, coupled with the unique nature of the Ediacara ‘microbial’ substrate were essential aspects in the exceptional preservation of the soft-bodied Ediacara Biota.

My fieldwork was demarcated into three areas of focus: 1) evaluation of the silicification hypothesis, including collection of specimens for post-field petrographic and geochemical analyses; 2) assessment of the nature and heterogeneity of the Ediacara ‘microbial’ substrate, and the manner in which substrate interacted with physical environmental conditions to mediate the taphonomy and distribution of Ediacara macroorganisms; and 3) reconstruction of the paleoenvironmental conditions under which the Ediacara Member was deposited, including the timing of ‘ferruginization’ of fossiliferous horizons.

For objective #1 (evaluation of the silicification hypothesis), the preservation of specific Ediacara fossil taxa was studied across several marine facies, in order to compare the relative influence of biological properties (e.g. tissue complexity), environmental or facies parameters and localized diagenetic processes. The holdfast form genus *Aspidella* received particular attention, due to its occurrence across all fossiliferous facies of the Ediacara Biota and wide range of preservational morphs. Field observations of *Aspidella* were coupled with collection of individual specimens, which were brought back from the field to facilitate micro-petrographic and in situ geochemical analyses to reconstruct the diagenetic history of these specimens and, in particular, to search for early-stage (seawater-sourced) silica cements. Specimens of other taxa, such as *Dickinsonia* and the tubular taxon *Funisia*, were also collected, as well as a suite of ‘matground’ textures, in order to test whether preservational patterns observed in *Aspidella* occur in other taxa and whether the Ediacara macrofossils and the Ediacara matground substrate were subject to the same diagenetic processes. These petrographic and geochemical analyses are ongoing.

For objective #2 (nature and heterogeneity of the Ediacara microbially-bound substrate), I focused upon two of the most distinctive matground textures or “textured organic surfaces” (TOS), informally known as “weave” and “micropucker.” Previous work (e.g. Gehling and Droser, 2013, *Geology*) has indicated that the distribution of Ediacara macrofossils is strongly facies-correlated (specific taxa occur in certain individual facies of the Ediacara Member; other taxa occur solely in other facies); my findings suggest that the same pattern holds true for TOS (distribution of individual TOS types is also facies specific). Moreover, TOS exhibit variable relationships with spatially associated macrofossils—for instance, weave appears to have colonized broad areas of the seafloor prior to macroorganism colonization, whereas micropucker occurs as spatially confined patches, superimposed upon taphonomically degraded macrofossils, suggesting post-mortem overgrowth of death assemblages. These data were collected through in-field mapping of discrete TOS patches, measurement of TOS dimensions and orientation, notation of TOS morphology, photography, and latex casting. Initial results of this work have been presented at the 2014 annual meeting of the Palaeontological Association (Leeds University, Leeds, UK) and the 2015 Northeastern Geobiology Symposium (Princeton University, NJ, USA).

For objective #3 (reconstruction of Ediacara paleoenvironments), I used a combination of field-, hand sample- and petrographic-scale sedimentological techniques to study the physical and chemical environmental conditions under which Ediacara organisms lived, died and were fossilized. A particular focus of this work was assessment of the timing of 'ferruginization' of fossiliferous horizons, given recent debate concerning whether the Ediacara paleoenvironment was marine or terrestrial (a debate that hinged in large part upon field observations of iron-rich vs. iron-poor horizons in the Ediacara Member). My work suggests that ferruginization was largely a post-depositional, late-stage diagenetic phenomenon and that the presence of iron-rich staining along fossiliferous horizons cannot be used to construe a terrestrial habitat for the Ediacara Biota. Initial findings, derived from in-field analysis, concerning the Ediacara paleoenvironment in general and the timing of ferruginization in particular have recently been published in *Palaeogeography, Palaeoclimatology, Palaeoecology* (attached to this email).

This work will hopefully do much to clarify the taphonomic pathways responsible for the exceptional preservation of the Ediacara Biota, as well as paving the way for reconstruction of seminal steps in evolutionary diversification, and elucidating the biogeochemical conditions that prevailed during the development and preservation of early complex life.

Photographs

Figure 1. Field photograph of the holdfast form genus *Aspidella*, superimposed upon a matground comprised of the tubular fossil *Funisia* in the Ediacara Member of South Australia. Scale bar increments in centimeters.

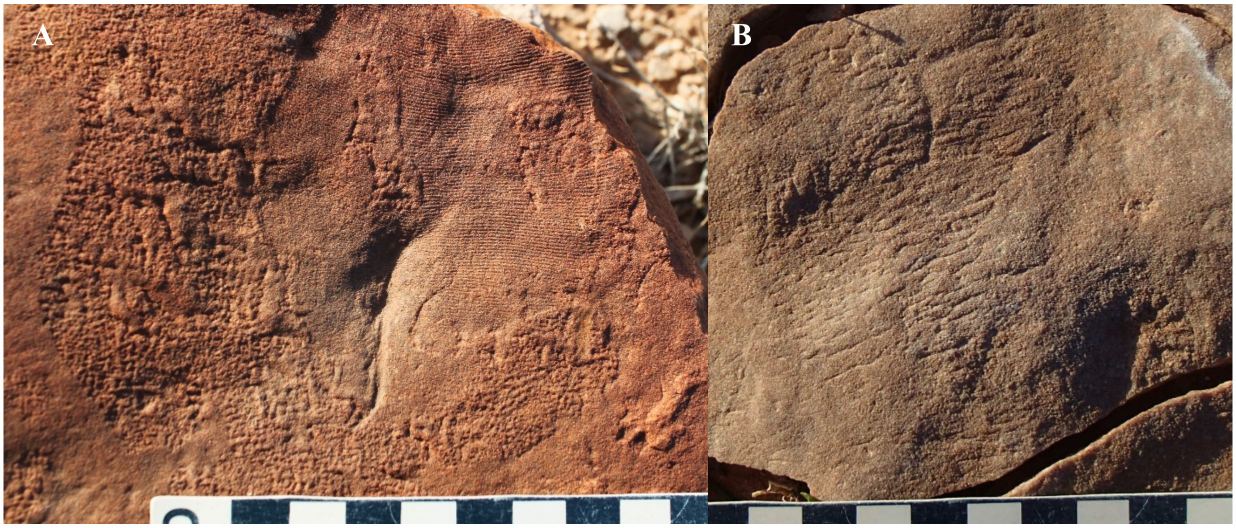

Figure 2. Field photographs of facies-specific textured organic surfaces (TOS) of the Ediacara Member. (**A**) The TOS "micropucker," overgrowing a taphonomically degraded, shrunken and folded *Dickinsonia*. (**B**) The TOS "weave," overprinted by the macrofossil *Rugoconites*. Scale bar increments in centimeters.

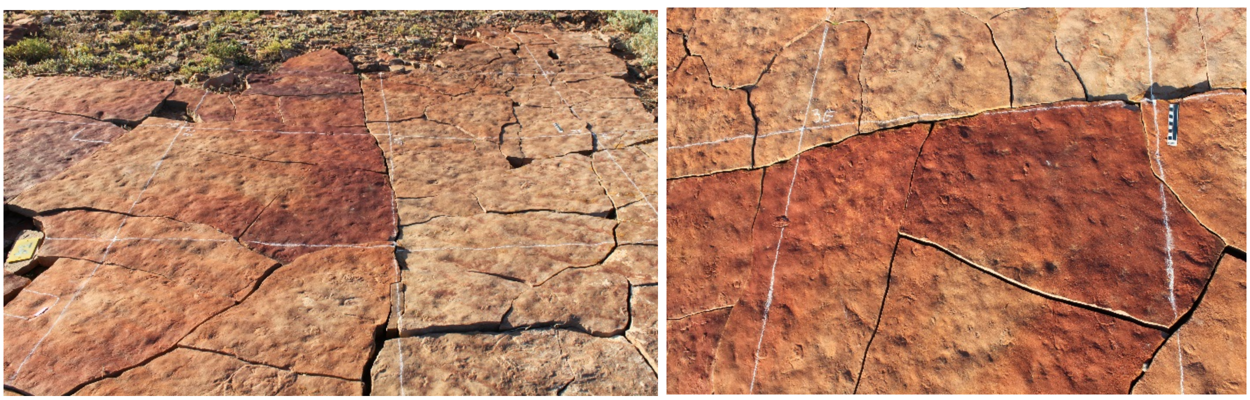

Figure 3. Field photographs of non-uniform distribution of ferric iron along a fossiliferous bedding plane of the Ediacara Member, indicating that 'ferruginization' occurred post-depositionally rather than synchronous with deposition. White chalk lines denote 1 m^2 increments; scale bar is 10 cm long. Modified from Tarhan et al., 2015, *Palaeogeography, Palaeoclimatology, Palaeoecology*.