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Morphological and geochemical biomarkers in ~3.5 Gyr. stromatolites of the Pilbara Block: possible evidence for biomineralization

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Preliminary data on a stromatolite-rich succession located in the eastern part of the Pilbara Block, NW Australia, 35 km south of Marble Bar and 8-10 km west of the Coongan River are presented. A 35 m-thick stratigraphic section was measured and sampled at various levels. Banded laminated oxide-rich grey cherts and dolomite-rich chert are the main lithofacies of stromatolites. The cherts fabric is composed of wavy and wrinkled laminae predominantly 50-150 micron thick, although many laminae are as thin as 20 micron. Oxide-rich layers are readily recognized macroscopically as red bands. Dolomitic laminae with similar fabric regularly alternate and interfinger with the chert, forming up to 50% of the rock volume. Quartz is the dominant mineral, occurring as cloudy and inclusion-rich microquartz (equant-anhedral crystals only a few microns across), megaquartz (crystals reaching 500 micron or more in size) and chalcedonic quartz, with radiating to form spherulitic growth structures. Microquartz or clay minerals mark micro-laminae surrounded by a drusy mosaic of mega-quartz. Spheroidal shaped large crystals of quartz indicate the presence of silicified grains, while isolated and aligned prismatic cavities represent ghosts of synsedimentary evaporites and carbonates. These cavities are now empty or partially filled with spheroidal and acicular Fe-oxides-hydroxides, such as foliated Fe-Mg-rich clay minerals. Dolomitic laminae are mainly composed of a mosaic of light-brown planar anhedral to subhedral ferroan dolomite crystals (Mg/Ca = 1 - 1.2 with Mn ~ 1.4 mole % and Fe ~ 4 mole %), tens to hundreds of microns in size. Thin layers of darker micritic dolomite are rarely

preserved. Dolomite is also present as patchily distributed irregular relicts within a mosaic of microquartz and as prismatic or spindle-shaped pseudomorphs after evaporites. Anhedral crystals of barite and F-apatite, forming sub-millimetric masses, frequently fill voids and mark both chert and dolomitic laminae. Sub-euhedral pyrite crystals are abundant in the chert-dolomitic lithofacies. Many micro- or sub-micron inclusions and polygonal voids are present inside and/or between the crystal of quartz and dolomite. Inclusions are spheroidal or dumbbell shaped particles with crystalline or amorphous structure of Fe, Ba, Si, P, S and Ti rich minerals. Several putative mineralized bacterial-like fossil remains were found within these mineral phases. They mainly consist of sub-spherical coccoid forms, 0.2-1.0 micron in diameter, preserved either as moulds and mineralised bodies, isolated or forming colonial-like clusters. Sub-microns-sized flat and filamentous carbonaceous (kerogen?) structures frequently occur between the silica crystals suggesting a very close association with this mineral phase. They comprise 0.5-1.0 microns thick gently folded sheets, which envelop the crystal aggregates extending for several tens of microns with a possible original viscous mucus-like behaviour. EDS analyses reveals their C-rich composition with traces of Cl, Na, K, P, S, Fe and Al. These organic structures frequently occur between the silica crystals or envelop the putative coccoid fossils, suggesting a very close association with this mineralized phase and a possible biogenic origin, such as fossilized (carbon-enriched) extracellular polymeric secretion. Although the chert has undergone diagenetic Si-enrichment, recrystallization and cementation, primary precipitation of biogenic silica is indicated by relicts of opal-like microstructures and confirmed by the inferred depositional context. Coeval primary microbial dolomite laminae formation probably occurred with subsequent recrystallization and partial silicification. The lamination morphologically resembles peritidal stromatolitic microbial mats forming in modern mud flats under arid climatic conditions, as indicated by the presence of evaporites and tepee structures. The studied 3.5 Gyr. chert-dolomitic stromatolite formation most likely occurred in a shallow, restricted evaporative basin adjacent to hydrothermal sources, characterized by rapid fluctuations in water depth and subject to burial by lava and low detrital sediment supply. Precipitates of evaporites (Ca-Mg-Ba sulphate) and primary dolomite were deposited inter-bedded with hydrothermal and/or evaporative silica. Modern microbial mats and biofilms form readily under such extreme conditions with microbes taking metabolic advantage from diverse mineral and organic substrate in a generally anoxic environment. The putative mineralized bacterial-like fossil remains found in the studied samples indicate syngenetic origin associated with microbial metabolisms.