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Evaluation of the biogenicity of putative large (>10µm) spherical microfossils from the ~3.4 Ga Strelley Pool Formation

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Recent reviews on the oldest traces of life on Earth discuss the biotic and abiotic arguments proposed from isotopic, morphological, and geochemical features of possible microfossils[1,2]. Stromatolites from the ca. 3.4 Strelley Pool Formation (SPF), in Western Australia, remain the oldest undisputed biosignatures of microbial communities. However, the SPF also preserves carbonaceous microstructures that have been proposed as remains of biogenic organic matter or even microfossils[2,3]. The SPF is part of the greenstone belts of the Pilbara Craton, and includes diverse lithologies, usually metamorphosed in the greenschist facies. These comprise volcanoclastic materials, silicified sediments, dolomite (including stromatolites) and cherts, cut across by veins of siliceous and siliceous-carbonaceous materials[4]. Hydrothermal influences are observed through these multiples veins that transported additional and possibly abiotic carbonaceous matter. Moreover, abiotic microstructures in silicified volcanic clasts may exhibit morphologies[5] resembling those of the carbonaceous spheres and lenses observed in the cherts[3]. Here we report on five types of large (>10 µm) spherical microstructures, distinct from those previously reported[6]. These spheres are investigated with diverse petrographic techniques, including advanced transmitted-light microscopy (Z stacking images), Confocal Laser Scanning Microscopy (CLSM) for organic matter observation and 3D reconstruction, we are the first team to performed Electron Back-Scattered Diffraction (EBSD) for a unique petrographic analysis of quartz crystal arrangement, shapes and sizes; and Scanning Transmitted Electron Microscopy (STEM) on ultrathin Focus Ion Beam (FIB) sections. This methodology characterizes in depth the link between the textures of organic matter and its host quartz matrix. Among the five spheroid types studied, three may be explained at least partly by abiotic morphogenesis. In contrast, two types of spheres may be considered as possible cellular microfossils.

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