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Testing the cellular nature of large (>10 µm) spheroids in the ~3.4 Ga Strelley Pool Formation

MR. MAXIME COUTANT, PHD[1,2], KEVIN LEPOT[1,3], ALEXANDRE FADEL[4], AHMED ADDAD[4], ELODIE RICHARD[5], DAVID TROADEC[6], SANDRA VENTALON[1], KENICHIRO SUGITANI[7] AND EMMANUELLE J. JAVAUX[2]

[1]Univ. Lille, CNRS, Univ. Littoral Côte d'Opale
[2]Université de Liège
[3]Institut Universitaire de France (IUF)
[4]Univ. Lille, CNRS
[5]Univ. Lille, CNRS, INSERM, CHU Lille, Institut Pasteur de Lille
[6]Univ. Lille, CNRS, Centrale Lille, Univ. Polytechnique Hauts-de-France
[7]Nagoya University

Presenting Author: maxime.coutant@uliege.be

The oldest traces of life on Earth are still highly debated and both biotic and abiotic arguments are proposed for isotopic, mineral and morphological biosignatures [1,2]. The ca. 3.4 billion year old Strelley Pool Formation (SPF), in Western Australia, is well-known for its stromatolites and for its diverse assemblages of carbonaceous microstructures [1-5]. Some of these microstructures have been claimed as the oldest microfossils [2,3]. The SPF lies in greenstone belts of the Pilbara craton, and comprises (volcano)clastic material, silicified sediments, dolomite (including stromatolites) and precipitated cherts (including stromatolites). The metamorphic grade of studied samples lies is the lower-greenschist facies. The SPF is cut across by siliceous and siliceous-carbonaceous veins [4]. Such veins may have transported carbonaceous matter into hydrothermally-influenced sediments [2,3,4]. For example, microstructures in silicified volcanic clasts of the SPF exhibit morphologies resembling mineral textures associated with organic matter [5], such as simple spheres or lenses. Here we rigorously describe unusual spherical microstructures which differ from the abundant, smaller (≤10 µm) spheres previously reported in cherts of the SPF [3]. These microstructures are imaged and analyzed through a combination of *in situ* techniques, including optical microscopy and confocal laser scanning microscopy (CLSM), electron backscattered diffraction (EBSD), and transmitted electron microscopy (TEM) on ultrathin (focused ion beam) sections (FIB). This approach yields an effective visualization of carbonaceous microstructures and their relationships with quartz crystal grains down to the nanoscale. It revealed a wealth of textural features that allow us to classify the spheroids into five types and to discuss possible cellular origin *versus* mineral morphogenesis in presence of organic compounds.

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