CARBONACEOUS MICROSTRUCTURES OF THE 3.46 GA STRATIFORM 'APEX CHERT': A NEW SUITE OF MICROSCOPIC MISS? Keyron Hickman-Lewis[1,2,3], R.J. Garwood[4,5], M.D. Brasier[1,2], N. McLoughlin[6], T. Góral[5], H. Jiang[7], D. Wacey[8,9]. [1]St Edmund Hall, University of Oxford, UK, [2]Dept. Earth Sciences, Univ. Oxford, UK, [3]Present address: CNRS Centre de Biophysique Moléculaire, Orléans, France (keyron.hickman-lewis@cnrs-orleans.fr), [4]School of Earth and Environmental Sciences, Univ. Manchester, UK, [5]NHM, London, UK [6]Univ. Bergen, Norway, [7]Dept. Materials, Univ. Oxford, UK, [8]School of Earth Sciences, Univ. Bristol, UK, [9]CMCA, Univ. W. Australia, Perth, Australia.

Introduction: Black chert veins of hydrothermal origin, intruding the 3.46 Ga Apex Basalt, contain some of Earth's oldest putative microfossils[1], whose biogenicity has been extensively questioned, and recently comprehensively disproved[2-3]. Comparatively little, however, is known about the stratiform sedimentary cherts (the stratiform 'Apex chert') that are conformably interbedded with volcanic rocks of the Apex Basalt at Chinaman Creek.

Within this stratiform unit, carbonaceous material occurs mostly within highly silicified clotted carbonaceous chert and microgranular chert. Microgranular cherts preserve a suite of carbonaceous microstructures constituting probable microbially induced sedimentary structures (MISS): i) laminated clasts, ii) roll-ups, iii) flaky grains, iv) persistent, wrinkled, filament-like laminae occurring over decimetres[4].

Putative Biosignatures: Laminated clasts of up to 300μm size comprise multiple, non-isopachous, undulose laminae, which thicken towards some ridge crests, and contain roll-up structures. This was determined by a novel confocal laser scanning microscopy (CLSM) approach. Raman spectroscopy proves the antiquity of the carbon (it has a thermal maturity concurrent with syngenicity) and, coupled with NanoSIMS ion mapping, denotes the co-occurrence of carbon, nitrogen and often sulphur in dark brown-black bands within laminated clasts. Roll-up structures either occurring as part of, or independent to, these laminated clasts indicate their initial plasticity; these are reminiscent of EPS-bound biogenic roll-ups in the 3.42 Ga Buck Reef Chert of South Africa[5]. Persistent, wrinkled, filament-like laminae are perhaps the most promising microbial indicator. Conformable with bedding surfaces, these also entrain relict sediment grains, thus are directly comparable to biofilm-type MISS in the 3.33 Ga Josefsdal Chert and c. 3.2 Ga Moodies Group of South Africa. Micro-scale computed tomography (μCT) conducted by us has further demonstrated the filamentous nature of these laminations[6]. Finally, individual flaky grains bear some morphological resemblance to ripped up fragments of microbial mats, though a sedimentary formation mechanism cannot yet be disproved[7].

Archaean comparisons: The carbonaceous microstructures of the stratiform Apex chert pass multiple criteria for biogenicity: they are syngenetic with the deposition of the Apex chert at 3.46 Ga and possess a range of morphological characteristics in both two and three dimensions which both allow direct comparison to known biosignatures while refuting an abiogenic origin. These encouraging morphologies are intimately linked to promising geochemistries[4-5]. Until the discovery of either macroscopic MISS or bona fide microfossils at this site, and since high-temperature hydrothermal activity was proximal throughout deposition, we continue to urge caution. Nonetheless, there may yet be evidence for life in the 'Apex chert'; the microgranular horizons of stratiform cherts of similar ages from both the Pilbara (Australia) and Barberton (South Africa) regions should prove promising targets for future biosignature research. Diverse life can flourish in hydrothermal environments, as recorded in the Josefsdal Chert, Barberton[8]. In those similarly hydrothermally influenced rocks, phototrophic mats (comparable to laminated clasts, roll-ups and flakes) and chemotrophic clots (comparable to the clotted carbonaceous cherts, which are not herein assessed) are ecologically interlinked.

Astrobiological significance: If the Apex microstructures are indeed biogenic, they represent vestiges of a very primitive biosphere, thus a good analogue for the proposed Noachian biosphere on Mars. Palaeoenvironmentally, the Apex chert is resemblant of the 3.45 Ga Kitty's Gap and 3.33 Ga Josefsdal cherts, all three portraying deposition in a shallow marine, anaerobic depositional environment, with a significant volcanogenic input which may have provided important nutrients to primitive life. Such silica-producing hydrothermal environments are considered probable on the early Mars. Proximity to hydrothermal effusion in the stratiform Apex chert hints at ecological domination by chemotrophs, the most relevant metabolism for Mars[9].

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