CARBONACEOUS MICROSTRUCTURES OF THE 3.46 GA STRATIFORM 'APEX CHERT', PILBARA, WESTERN AUSTRALIA: PRESENTING A NEW SUITE OF EARLY ARCHAEAN MICROBIALLY INDUCED SEDIMENTARY STRUCTURES. K. Hickman-Lewis[1,2], R.J. Garwood[3], M.D. Brasier[1]†, T. Goral[4], H. Jiang[5], N. McLoughlin[6], D. Wacey[7,8]. [1]Dept. Earth Sciences, Oxford, UK, [2]*Present Address*: CNRS-CBM, Orléans, France (keyron.hickman-lewis@cnrs-orleans.fr), [3]Univ. Manchester, UK, [4]Natural History Museum, London, UK, [5]Univ. Oxford, UK, [6]Univ. Bergen, Norway, [7]Univ. Bristol, UK, [8]Univ. Western Australia, Perth, Australia.

Introduction: Black chert veins of hydrothermal genesis, intruding the 3.46 Ga Apex Basalt, contain some of Earth's oldest putative microfossils[1], whose biogenicity has been extensively questioned[2-3]. Comparatively little 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 chert, we assign five lithological designations: silicified volcaniclastics, banded black-grey-white chert, metalliferous chert, clotted carbonaceous chert and microgranular chert. Carbonaceous material occurs mostly within the latter two lithologies, and is present in lobate grains throughout. Microgranular chert contains a suite of four carbonaceous microstructures possessing probable microbially induced sedimentary structures (MISS): i) laminated clasts and ii) roll-ups (both Fig. 1a), iii) flaky grains, iv) persistent, undulose, filament-like laminae (Fig 1d).

Methods: We used optical petrography and confocal laser scanning microscopy (CLSM) for morphology coupled with SEM, laser Raman microspectroscopy and NanoSIMS for geochemistry to assess the biogenicity against accepted criteria[4-5].

Biosignatures: Laminated clasts comprise multiple, non-isopachous, wrinkled laminae, with noted thickening towards some ridge crests[6], as determined by CLSM (Fig. 1c). Raman spectroscopy demonstrates the antiquity of the carbon, and, coupled with NanoSIMS, proves a close correlation between carbon, nitrogen, and often sulphur, in dark brown-black bands (Fig. 1b). The roll-up structures either occurring as part of, or independent to, these laminated clasts indicate an initial plasticity of the structures, possibly reflecting binding by extracellular polymeric substance (EPS).

Persistent, undulose, filament-like laminae are similarly non-isopachous and are seen to entrain relict sediment grains, similar to biofilm-type MISS cf. [7]. Flaky grains bear some morphological resemblance to ripped up fragments of microbial mats, though an abiogenic, purely sedimentary formation mechanism[8] could not be disproved by our study.

Edifices without architects: Morphologies and chemical compositions observed within this suite of structures are consistent with, and encouraging of, a biological interpretation, suggesting that microscopic MISS were present in the microgranular Apex chert. However, since neither macroscopic MISS nor *bona fide* microfossils have yet been recorded at this site, and since high-temperature hydrothermal activity was proximal throughout deposition, we urge a note of caution. Nonetheless, there may yet be evidence of life in the 'Apex chert', and the microgranular members of similar stratiform cherts could prove promising targets for future biosignature research.

Martian relevance: The suitability of the stratiform Apex chert in light of the search for biosignatures on Mars lies in its similarity to current Mars analogue rocks with sedimentary protoliths, particularly the Kitty's Gap chert [9]. Both of these units reflect a shallow marine, anaerobic depositional environment, with a significant volcaniclastic input which may be important to primitive life. It is also proximal to hydrothermal effusion, which is proposed as a nutrient source for chemotrophic life, the relavent metabolism for Mars, in the Josefsdal Chert, South Africa[10].

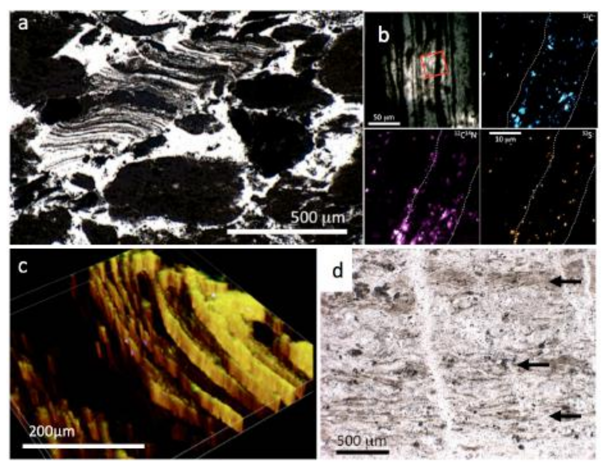

Fig 1. Candidate biosignatures of types i), ii) and iii).

References: [1] Schopf J.W. (1993) *Science*, 240, 640-646. [2] Brasier M.D. et al. (2002) *Nature*, 441, 714-718. [3] Brasier M.D. et al. (2015) *PNAS*, 112, 4859-4864. [4] Wacey D. (2009), *Springer*. [5] Noffke N. (2010) *Springer*. [6] Pope M.C. and Grotzinger J.P. (2000). [7] Noffke N. et al. (2006) *Geology*, 31, 673-676. [8] Schieber J. et al. (2012) *J.Sed.Res.*, 80, 119-128. [9] Westall F. et al. (2011) *Plan.SpaceSci.*, 59, 1093-1106. [10] Westall F. et al. (2015) *Geology*.