METASTABLE MINERALS AS A BIOSIGNATURE. F. Westal1l, B. Cavalazzi1,2, C. Andreazza3, F. Foucher1, J-N. Rouzaud4, L. Lemelle5, A. Simionovici6, 1Centre de Biophysique moléculaire-CNRS-OSUC, Orléans, France (frances.westall@cnrs-orleans.fr), 2Univ. Johannesburg, South Africa, 3Centre de Recherche de la Matière Divisée-CNRS, Orléans, France ; 4ENS-Géologie, Paris, France, 5ENS-Géologie Lyon, France, 6ISTE-Grenoble, France

Introduction: Certain minerals and/or mineral features are considered to be biosignatures. Minerals directly or indirectly precipitated through microbial activity, such as carbonate, Fe oxides, phosphates to name but a few, are well known. Other kinds of microbial influence on minerals include corrosion, element leaching and structural defects (stunted crystal faces, stunte crystal growth) induced by the fixation of organic molecules on the growing mineral crystal faces [1]. Recently, metastable minerals associated with other fossilised traces of life have been described from the rock record [2-4]. Metastable minerals could be a novel addition to the known range of biosignatures of relevance for the forth coming in situ missions to mars..

In this contribution we describe metastable aragonite associated with a 3.3 Ga-old microbial mat from the Barberton Greenstone Belt.

Metastable aragonite in a 3.3-Ga-old microbial mat from Barberton, South Africa: We identified aragonite in the calcified, degraded organic matrix of a 3.3 Ga-old photosynthetic microbial mat that has undergone regional lowermost greenschist metamorphism [3]. The aragonite occurs as 5-10 nm-sized crystallites that have nucleated onto the alveolar organic substrate (Fig. 1). It was identified by HRTEM analysis of the carbonate crystallites that documented interplanar distances of 0.335 nm, corresponding to the d111 interplane of the carbonate phase aragonite. Fast Fourier Transform imaging of the nanocrystals shows a cloudy-spotty ring (corresponding to d = 0.335 nm), typical of the diffraction pattern generated by multiple crystallites with variable rotational orientation. In composition, apart from Ca as the cation, it is characterised by minor Mg, as well as trace amounts of Fe and Cr. The addition of Mg and other trace elements is common in aragonite.

The aragonite most likely precipitated as a result of the activity of heterotrophic degradation of the organic matter in the mat by sulphur reducing bacteria. Normally aragonite converts rapidly to calcite but, in the case of the 3.3 Ga-old microbial mat, recrystallisation was inhibited by the organic matrix in which the carbonate phase precipitated. A similar situation was found with 2.7 Ga-old aragonites associated with microbial organics [2]. An additional factor in the preservation of the aragonite is that the microbial mat was preserved by permeation by hydrothermal silica as it was living which effectively "locked" the already-formed minerals and prevented further alteration.

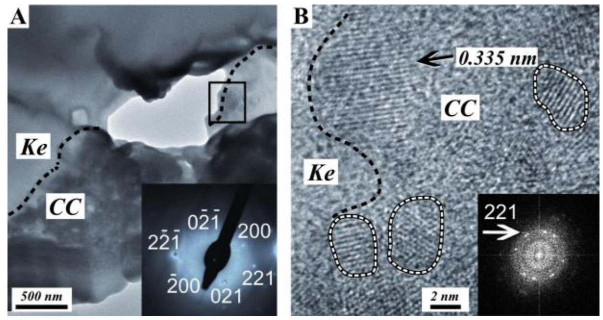

Fig. 1. Metastable aragonite embedded in the organic matrix of a 3.3 Ga-old microbial mat from Barberton, South Africa

Discussion and conclusion: Aragonite is typically an unstable phase that rapidly converts to calcite and is therefore rare in the geological record [2,5]. However, we have shown that aragonite nanocrystals can survive lowermost greenschist metamorphism and 3.3 Ga of geological history. The microbial mat formed in situ on the early Archaean sediment surface and was calcified and then immediately silicified in situ [3,4]. The syngenicity of mat formation, calcification and silicification is documented by structural and compositionnal mat characteristics, the age of the organic molecules (mostly aromatic structures), the nucleation of the crystallites onto the organic matrix, and the composition of the aragonite (the ambient environment was enriched in elements such as Fe and Cr leached from the ultramafic/mafic volcanics).

The association of a metastable mineral phase with organic carbon could be considered to be sufficient indication of potential biogenicity for a rock containing these signatures to be selected for more detailed analysis in situ on Mars and for return to the Earth. This scenario is of relevance for the forthcoming international 2018 mission to Mars in which arm mounted instruments may be used to preselect samples for more detailed mineralogical, elemental and organic analysis in the Pasteur laboratory.

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