Assessing new biogenicity criteria of microfossils with a novel 3D imaging approach

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Microfossils are morphological biosignatures of microorganisms preserved in the geological record and comprise the oldest direct record of life on Earth. However, due to the high level of geological processing over billions of years, the micrometric size and the chemical composition (highly dense and homogeneous rocks), the study of such structures has been limited, and many questions about their morphology, preservation and specially biogenicity remain unsolved. The use of nanometric resolution imaging techniques based on different physical phenomena has been proposed as a potential approach to overcome these limitations, exploring both the morphology and chemical composition of the samples, preferably in a non-destructive way.

Here we present a novel non-destructive approach applying Synchrotron X-Rays 3D Ptychography [1] to investigate the ultrastructure of microfossils and putative morphological biosignatures with 3D nanometric resolution. We analyzed a set of Precambrian undisputed microfossils and putative ones of different morphologies and states of preservation. Our results provide novel features of the 3D preserved ultrastructure of these specimens and adds significant contribution to the debate of the biogenicity criteria for morphological biosignatures, presenting a novel approach to resolve putative terrestrial biogenic structures, as well as from meteorites and near-future sample return missions.

[1] Dierolf M. et. al, (2010) *Nature.* "Ptychographic X-ray computed tomography at the nanoscale."