Supplementary Material

Materials and methods

1. Biosignatures

For Raman spectroscopy, a Renishaw InVia microRaman spectrometer was used at the Centro Nacional de Pesquisa em Energia e Materiais (CNPEM), coupled with a 785 nm laser. Analysis was performed in the static mode of measurement. The laser intensity was adjusted to 5% for anatase and 50% for the rock matrix, point spectra with the center at 750 cm-1, and 100 accumulations were performed of 10 s each. The software Origin Pro 8 was used for the visualization and processing of the Raman spectra, such as the removal of cosmic rays, baseline and scaling.

2. Biogenicity

For the scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS) analyzes we used the Quanta 650FEG equipment of the National Nanotechnology Laboratory (LNNano), in high vacuum (1.3 x 10-2 Pa), low vacuum (10-200 Pa) and environmental (130- 2600 Pa) modes. This equipment has secondary and backscattered electron detectors (ETD and vCD).

For the Raman spectroscopy, we used the same equipment and laser as employed for the biosignature investigation. In this case, the parameters for the point analysis were: 5% laser power; an exposure time of 10 s; and an objective of 20x. For the Raman mapping, we used StreamLine mode, with 50% laser power, an exposure time of 2 and objective of 20x. The maps were later processed with WiRE software.

For the Micro-CT analysis of the ovoid structures, samples were imaged at the light station W2 of the DORIS storage ring (DESY, Hamburg, Germany), where it was achieved better contrast between the more and less dense regions, when compared with other X-ray methods (Bidola et al., 2015). This beamline is mainly composed of a sample manipulator stage and a detector equipped with a CCD camera, coupled with lens of 3,056 × 3,056 pixels. The range of the beamline energy line can be set between 8 and 300 keV and its maximum field of view is 70x5 mm.

3. New experimentations

First experiment:

We have used 24 fresh specimens of *Anchoviella lepidentostele* in this experiment. Twelve bottles of 2 L were used as recipients. In each one, 4 cm of sandy sediment was inserted as a base for "resting" the fish in a horizontal position. Three specimens were covered by 7 cm of sediment, three by 14 cm, and finally three by 21 cm of sediment. In another twelve bottles the same procedure was performed, using clay.

The bottles were opened four weeks after the beginning of the experiment to observe possible differences in decomposition. Fishes were rescued, gently cleaned with brush and observed under a stereomicroscope in order to detect morphological deformation and loss of anatomical parts.

Second experiment:

We have used 108 fishes, deposited in three groups of 12 recipients (polyethylene, 500 ml). Each group contained a different type of sediment (soil, sand or clay). The recipients were sealed to limit oxygen diffusion, simulating, as far as possible, a euxinic/anoxic environment (*e.g.*, lake bottom). The opening of the recipients and rescue of the fish samples was performed at intervals of 15 days, totaling 24 weeks of experiment.

After being removed from the containers, the specimens were carefully cleaned with brushes. Subsequently, they were analyzed under stereomicroscope, always comparing with fresh control

specimens (which were not submitted to experimentation), to detect altered and/or missing parts in the morphology.

We have used Raman vibrational spectroscopy for mineralogical investigations. Analysis were performed in an *in vitro* Renishaw microRaman at the Research Unit of Astrobiology of the University of São Paulo (NAPAstrobio, PRP-USP), using d 785 nm lasers with 300 mW of total power, with variable times of exposure and accumulations. Spectra were processed using OriginPro 8 software.

Some Raman spectra were processed in the Raman Environment program (WiRE ™) for baseline determination and normalization process, by the maximum intensity method. The statistical data were obtained by calculations of relative intensity (IRraman). To measure the crystallinity of the bone mineral we performed full width at half maximum (FWHM) for the bands of biopatite, by the "curve fit" method, which allows the construction of the curve that adapts to the spectral data obtained.