EVALUATION OF BIOGENICITY IN ROCKS RELATED TO BRAZILIAN PALEOZOIC GLACIAL EVENTS.
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Many sedimentary rocks, such as mudstones and siltstones, present structures that are easily confused with typical marks that occur in Microbial Induced Sedimentary Structures (MISS) and microbial mats. A better way to differentiate them is to test the biogenicity through morphological and chemical biosignatures, as well as texture patterns. Here, we test the biogenicity of rocks related to the deposition of a pro-glacial lake in contact with glacier margin during the glaciation range of Upper Paleozoic in Brazil. The samples belong to Itararé Group, Lower Permian from Paraná Basin, and were collected in Itu, São Paulo State, Southeastern Brazil. These rocks are known as Varvite of Itu, which are ritimites and present an intercalation of thicker clear layers, described as fine sandstone/siltstone, and thinner dark layers, described as a mudstone.

The biogenicity of these rocks were studied by using different techniques. Analysis include imaging techniques: scanning electron microscopy (SEM), transmission electron microscopy (TEM); X-ray analysis: energy X-ray dispersive spectroscopy (EDS) and Synchrotron based X-ray fluorescence (μ-XRF); and magnetic analysis: acquisition of isothermal remanent magnetization curves (IRM), hysteresis loops and first order reversal curves (FORC). Results from different analysis allow to determine some important findings. Firstly, thin sections and SEM/EDS analysis revealed that the dark layers presented fenestral fabric, domes and cavities generated by gas detachment, which were subsequently filled by siliciclastic material. The presence of phyllosilicates corroborate to the diagnosis of mudstones; however, some regions presented smooth grains covered by a material with texture that resembled extracellular polymeric substance (EPS), whith a composition compatible with polysaccharides (high carbon and oxygen, and low in heavier elements) detected by EDS. Magnetic data indicate the presence of two different magnetic phases, one with high coercivity (probably hematite) and other with low coercivity (attributed to magnetite). Low coercivity phase presents the major contribution for the magnetization. FORC diagrams show a slight central distribution which is compatible to biogenic magnetite signature. Also, we obtained additional indications that this magnetite may have biological origin, such as very small crystal size and uniform distribution in specific layers, presenting morphologies and typical marks of MISS. In these samples, it was also performed μ-XRF (X-ray Fluorescence) analysis at Brazilian Synchrotron Laboratory (LNLS), from which we obtained maps of elemental distribution in some areas, showing that the iron is distributed in the supposed laminations of MISS. Ferromagnetic minerals were extract of the dark layer, using the application of magnetic extraction with material dissolution [1], which posteriorly were analysed with EDS and TEM.

A plausible hypothesis for the iron distribution in this specific layers, as well as the very small crystal size (nanocrystals with 30 to 100 nm), is that they could be bacterial magnetofossils (from magnetossomes) deposited into the sediments. However, the diagenetic processes and the sample preparation, may have damaged the physical structure of the crystals, being possibly corroded and oxidized. Through the combination of data, we suggest that the iron minerals found in these samples have a strong indication of biogenic origin, but not excluding the participation of the inorganic sedimentary processes. Two possible origins for magnetite are compatible: produced by magnetotatic bacteria or by dissimilatory iron-reducing bacteria, under anaerobic conditions [2]. Both are compatible with the size of the crystals (nanoparticles), the magnetic behavior and the distribution only in specific regions of the analysed samples, in which it was found other evidences of biological participation, such as organic matter concentration and the presence of EPS. It is important to emphasize that the analytical technics being applied for the terrestrial samples on this work, in order to test their potential biogenicity, may contribute directly to the analysis of extraterrestrial samples, by in situ and ex situ methods. The results and interpretations obtained so far can be used for studies of structures resembling MISS on Mars, or on meteorites, for example.

References: [1] Strehlau, J. H. et al. (2014) JSR, 84, 1096-1106. [2] Lovley, D. R. et al. (1987) Nature, 330, 252-254.