Origins: From the Protosun to the First Steps of Life
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Soil Characterization: Martian Analogues

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1. Introduction

The investigation of microbial life and/or inorganic biosignatures on Mars has been done mainly by the study of analogue environments on Earth. The nature of the ferriferous regions in Brazil seems to be suitable, as a substantial sources of extremophiles (Duarte *et al.* 2012; Camêlo *et al.* 2018) and potential source of inorganic biosignatures. This work is aimed to improve the knowledge needed to test the possibility of present or evidence of past life on Mars by characterizing samples of the iron-rich soil of the region of Diamantina, located at the center of Brazil. This characterization consists of examining the atomic and molecular compositions and the structural, mechanical and optical properties of the soil. This is done by applying different experimental techniques, such as thermo-gravimetry and X-ray spectroscopy. The molecular and atomic structure had been measured through, both, X-ray diffraction and fluorescence at LNLS (Brazilian Synchrotron Light Laboratory - Campinas). Also, the volatile content was investigated through thermo-gravimetry in a high-temperature furnace.

The sample of soil was extracted from region nearby the Red river, at the city of Diamantina - MG, Brazil. In the present work, we show the results of three different techniques applied to examine the sample: X-ray powder diffraction, x-ray fluorescence, both measured in two beamlines at the LNLS, and thermo-gravimetry, at the chemical lab of the LNLS.

2. Experimental Procedures

X-ray powder diffraction: The XRD1 beamline at the LNLS is a dedicated X-ray diffraction beamline. Monochromatization is performed using a double-crystal Si (111) monochromator. The system is calibrated to use a well determined energy of 12 keV, with of photon flux of $7.8{\times}10^9$ photons s^{-1}. It was used NIST standard reference materials (SRM): Si (SRM 640d) and LaB_6 (SRM 660b). The SRM as well as the sample were placed, respectively, inside 0.3 and 0.7 mm-diameter borosilicate capillaries, which are fixed in ferromagnetic stainless steel holders. They are connected with a magnetic tip attached to the three-circle N3050-P1 diffractometer, which is able to rotate, spinning the sample at ∼300 r.p.m. during the measurements. A MYTHEN 24K detector was used. All measurements were done at room temperature (Carvalho *et al.* 2016).

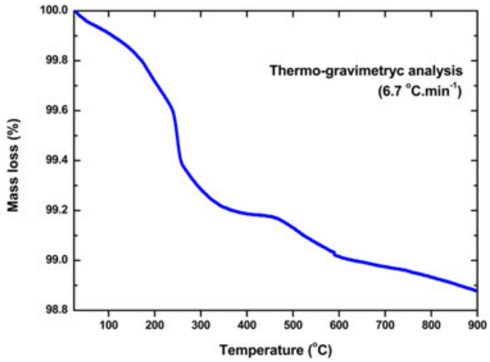

Figure 1. Thermo-gravimetryc analysis of a soil sample from Diamantina-MG (Brazil), suggesting its natural highly dry state.

X-ray fluorescence: The XRF beamline at the LNLS is a dedicated X-ray fluorescence spectroscopy beamline. It is equipped with a silicon (111) channel-cut crystal monochromator. The measurements were performed with the micro-XRF setup, which include an optical microscope with motorized zoom, and X, Y, Z, Θ_z sample stages that are fully remote controlled. The beamline operates between 5 to 20 keV of photon energy. It was used the white-beam mode, with $\sim 1 \times 10^{10}$ photons s^{-1}. The fluorescence detection is performed by energy-dispersive solid-state detectors, equipped with HPGe and Si(LI) crystals. For soil analysis, NIST SRM 2711a, containing 25 elements in 50 g of dried, powered soil was used. With this technique, it is possible to detect fluorescence of the electronic K-shell of elements with $Z > 13$ (Perez *et al.* 2002).

Thermo-gravimetry: Thermo-gravimetric analysis (TGA) is a method of thermal analysis in which the mass changes of a sample (in the scanning mode) are measured as a function of increasing temperature, with constant heating rate. The mass loss indicate the mass of the volatile content of the sample. It was applied a ramp of temperature to examine the sample of 6.7^oC min^{-1}, up to a temperature of 900^oC.

3. Results and Discussion

The complementarity of the XRD and XRF techniques suggest the presence of quartz (SiO_2) and hematite (Fe_2O_3). These crystalline patterns on the Mars surface are widely known (Morris *et al.* 2000; Ming *et al.* 2008). Also, there is no evidence of the presence of phyllosilicate minerals. Thermo-gravimetry analysis (Fig. 1) showed weight losses of $\sim$1 wt% at 600^oC. For comparison, from Allen *et al.* (1998), JSC Mars-1, a well-known Martian analog soil, has a large volatile content, with losses of 21.1 wt% in the same conditions. Viking in situ experiments of the Martian soil released 1.0 wt% water from samples heated at 500^oC (Allen *et al.* 1998), which suggest that the Martian regolith is extremely dry (Biemann *et al.* 1977). So, our results show good evidence that Diamantina's soil can be a good candidate for Martian simulant.

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References

Allen, C. C., Jager, K. M., Morris, R. V., Lindstrom, D. J., Lindstrom, M. M. & Lockwood, J. P. 1998 in: R. G. Galloway, & S. Lokaj (eds.), *Space 98*, Proc. Sixth Int. Conf. Expos. on Engineering, Construction, and Operations in Space (Albuquerque), p.469

Biemann, K., Oro, J., Toulmin, P., Orgel, L. E., Nier, A. O., Anderson, D. M., [...] & Lafleur, A. L. 1977, *J. Geophysical Res.* 82, 4641

Camêlo, D. L., Gilkes, R. J., Leopold, M., Silva, A. C. & Vidal-Torradoa, P. 2018, *Catena*, 170, 397

Carvalho, A. M. G., Araújo, D. H. C., Canova, H. F., Rodella, C. B., Barrett, D. H., Cuffini, S. L., Costa, R. N. & Nunes, R. S. 2016, *J. Synchrotron Rad.* 23, 1501

Duarte, R. T. D., Nóbregal, F., Nakayama, C. R. & Pellizari, V. H. 2012, *Int. J. Astrobiology*, 11, 325

Ming, D. W., Gellert, R., Morris, R. V., Arvidson, R. E., Brückner, J., Clark, B. C, Cohen, B. A., dUston, C., Economou, T. [...] & Zipfel, J. 2008, *J. Geophysical Res.* 113, E12S39

Morris, R. V., Golden, D. C., Bell III, J. F., Shelfer, T. D., Scheinost, A. C., [...], Ming, D. W., Allen, C. C. & Britt, D. T. 2000, *J. Geophysical Res.* 105, 1757

Pérez, C. A., Bueno, M. I. S., Neuenshwander, R. T., Sánchez, H. J., & Tolentino, H. 2002, *Review of Sci. Instrum.* 73, 1563