EPSC Abstracts
Vol. 13, EPSC-DPS2019-1-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Putative microbial mediation in NASA lunar sample set: microtextural features at high magnification

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Abstract

The NASA Lunar Educational Set is since 25 year in Hungary, curating by B. Sz. at Eötvös University. As non-destructive method, only high resolution optical microscopy is allowed by NASA. This method is good for microtextural studies of processes, where we found putative microbial features. To determination of microbial signatures Raman and FTIR spectroscopy would be requires to identify fine-grained biominerals and organic material, as the authors did by other meteorite and terrestrial samples.

1. Introduction

Observations of microtextures by OM in 1000x mag-nification: 12002 Lunar Sample is a medium grained olivine basalt with porphyritic texture [1, 2]. Olivine and pyroxene phenocrysts are surrounded by lath shaped pyroxene, feldspar and ilmenite. Our observations are focused on iron bearing silicates (pyroxene, olivine) and oxides (ilmenite) highly popu-lated in the NASA set. These minerals were surrounded and partly interwoven by microbial-like filamentous chains of beads (Fig. 1).

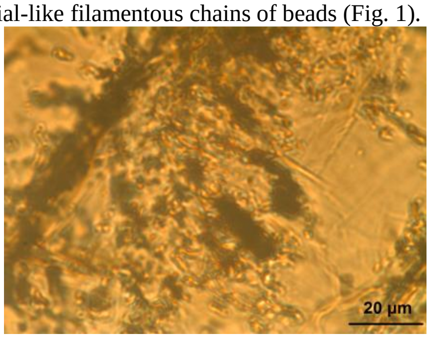

Fig. 1. Iron bearing silicates (pyroxene, olivine) and oxides (ilmenite) are found surrounded and partly interwoven by microbial-like filamentous chains of beads in the 12002 lunar sample.

70017 Lunar Sample is a medium grained ilmenite basalt (with high Ti content), where the large (frequently sector zoned) clinopyroxene crystals are interspaced by plagioclase feldspar and ilmenite. A bubble-like form developed from a fissure (Fig. 2). Both the bubble and the fissure were fulfilled by microbial-like filamentous mineralized biosignatures (A series of similar objects formed a front in the Mező-Madaras L3 chondritic sample, as earlier reported [4].

60025 lunar sample is a coarse grained brecciated (cata-clastic) anorthosite, in which rarely pyroxene is spotted. In the vicinity of the pyroxenes the texture was interwoven by mi-crobial-like filamentous biosignatures (Fig. 3).

2. Results and Discussion

Optical microscopy is the allowed study form for the NASA educational samples. We used it in extremely large magnifica-tion capacity in order to see the texture in fine details [3, 4, 5, 6, 7].

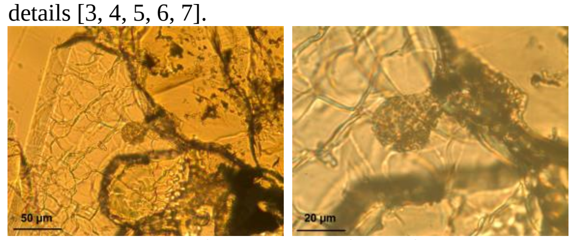

Figure 2: Bubble-like form developed from a fissure in the 70017 sample. The invasion bubble was fulfilled with microbial-like filamentous mineralized biosignatures.

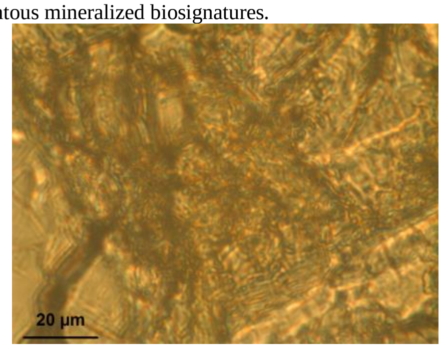

Figure 3: The mafic mineral region is highly interwowen by the micrometer-sized microbial filamentous biosignatures (sample 60025).

At this 1000x high resolution interwoven filamentous and vermiform inner signatures (mineralized biosignatures) were found. When this phenomenon is embedded in the terrestrial rocks it is a frequently observed and studied as a characteristic feature of the mineralized microbially produced texture (MMPT). These micrometer-sized microbial filamentous ele-ments form clusters at the fissure-mineral boundary regions. Especially the Fe-bearing minerals are involved in this phe-nomenon.

We have found microbial MMPT in 8 of the 12 thin sec-tions of our No. 4. NASA set (12002, 12005, 14305, 15299, 60025, 70017, 70181 and 78235). In most cases the interwo-ven texture occurred in the inner regions of the samples. In the case of one lunar sample (70017) we observed that microbial texture "invaded" into the mineral region in a form of pocket bubble. Invasion started similarly at the fissure boundary interwoven region. The counterpart phenomenon was found in Mező-Madaras L3 chondrite (Fig. 4) [3].

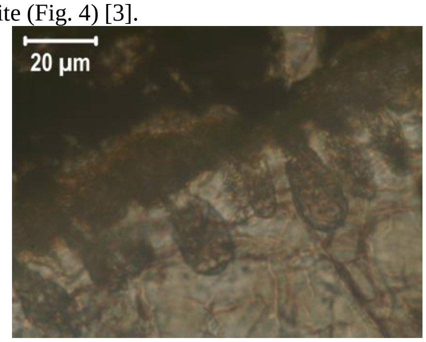

Figure 4: Series of invasion bubbles into weathered olivine in the Mező-Madaras L3 chondrite [3].

According to the terrestrial cases these observed microtextural features are characteristic to microbial mediation. In ter-restrial rocks and several interplanetary samples the measure-ments were extended to Raman, IR spectroscopy. The inter-woven texture in the regions of Fe containing minerals of the lunar samples are also characteristically similar to the mineral-ized microbially produced textures (MMPT) found in other planetary rock types as chondrites, Martian meteorites. There-fore we propose an interpretation that these microtextural ele-ments have been formed inside the lunar materials. This inter-pretation is based on a multi-hierarchical analysis, we have shown in the earlier works. This approach was summarized especially in the case of the microbial transformations of Mező-Madaras (Fig. 4) and Kaba [3, 4, 7].

3. Summary and Conclusions

Using high resolution optical microscopy we studied the mi-crotexture of the NASA lunar sample set. Probable evidences of putative microbial mediation were identified inside most of rock samples. We interpreted them using multi-method obser-vations of planetary materials as chondrites, Martian meteor-ites and terrestrial rocks samples and also structural hierar-chical complex interpretation (Fig. 5) [3, 4, 5, 6, 7]. Getting a more plausible picture, in situ micro-mineralogical and organic geochemical investigations are needed by Raman spectroscopy and FTIR. Our observations are in accordance with Zhmur and Gerasimenko (1999) who reported microbial components in the Luna 20 samples [8].

Terrestrial contamination is not probable, because there are no textural evidences of the contamination trending from the marginal parts of the sample towards the inner parts. Samples were stored in special box in safe conditions according to the NASA requirements. The box was opened only for the time of use of thin sections in the lectures.

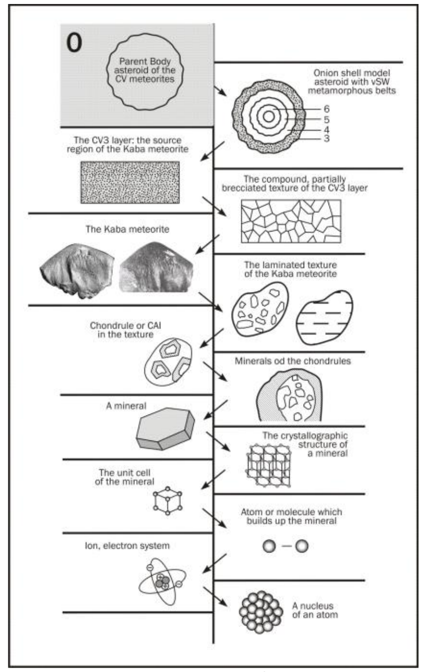

Fig. 5. Structural hierarchy sequence of a study when a chon-dritic sample (Kaba) is investigated. Arrows point from larger system toward lower level system structure. The measurements can be distributed and corresponded to one, or more related hierarchy levels. Here the drawing is focusing on the chondrule-bearing textural elements [7]

Acknowledgments:

Thanks to NASA JSC for the 25 years of loan of the Lunar Sample Thin Section Set.

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