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Aqueous alteration and putative microbial mediation in NIPR L chondrites

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Abstract

This work emphasizes aqueous and putative microbial mediation of NPR L chondrites. The microbial mediation is studied by optical microscopy (biogenic minerals, textures, morphology) and by FTIR-ATR spectroscopy (organic material, composition of fine-grained altered part: serpentine, iron oxides, amphibole).

1. Introduction

Chondrite constituents are considered as solar cloud condensates and surviving primordial dust grains accumulated in chondrules and minerals. The chondrites are fragments of asteroidal sized parent bodies where several transformation processes occurred: thermal metamorphosis, impact induced shock transformations and aqueous alteration. The aim was a high resolution textural and mineralogical characterization of the transformation products of UOC. The first overview of petrographical studiers of NIPR Collection L series have been made by [1], [2]. The shock metamorphic features (planar fractures, mosaicism) observed in all of studied samples [3].

2. Samples and methods.

Four Antarctic L chondrite thin section (30 µm) were studied: Y74191 (L3), Y74355 (L4), Y79057 (L5) ALH769 (L6).

High resolution petrographic structural, textural studies were undertaken on four thin sections using a petrographic microscope (OM). We used FTIR-ATR spectroscopy (Bruker Vertex70 device attached Hyperion2000 microscope, detection between 600-4000 cm^{-1}) for the determination and distribution of micro-mineralogy and organic compounds.

3. Petrography

Yamato-74191 (L3) chondrite: The sample has a fine-grained groundmass and the chondrules have sharp rims. The inhomogeneity in pyroxenes of the measured samples are well observed. The thin section consists of 45% olivine and 55% pyroxene phenocrysts. The chondrules are generally about 0.8 mm in diameter, but larger chondrules with diameter between 1 and 1.5 mm, and smaller ones with diameter between 0.1-0.3 mm can also be observed.

Yamato-74355 (L4) chondrite: The Yamato-74355 consists of well-formed round-shaped chondrules (60%), chondrule fragments (10%) and fine-grained groundmass (20%) with olivine and pyroxene phenocrysts (10%) of about 0.03 and 0.12 mm in diameter. (The abundance ratio for phenocrysts is 55% olivine and 45% pyroxene.) The average diameter of chondrules is 0.1-2 mm. There are opaque patches consisting of troilite and metallic iron and having diameter between minimum 0.4-0.7 mm and maximum 2-3 mm.

Y-790957 (L5) chondrite is a strongly brecciated chondrite with a small number of chondrules but large number of mineral fragments having 0.03-0.1 mm size on average. The whole sample has porphyritic texture.

Allan Hills-769 (L6) chondrite: The sample consists of chondrules, crystals, chondrule fragments and recrystallized groundmass. The size of chondrules and chondrule fragments varies between 1.2 – 3 mm.

4. Putative microbial features

Mineralized microbially produced texture (MMPT) in the form of pearl necklace-like, vermiform inner signatures, embedded in the stone meteorites has been observed for the first time. Our observations (OM) focused on the iron-containing opaque grains, glass, olivines and pyroxenes, which were well populated by micrometer-sized microbial filamentous elements and clusters in their boundary region within the matrix and inside the minerals. In the chondritic textures we observed that microbial "invasion" started in the fine-grained matrix and extended into the chondrules mainly through the Fe-containing minerals. The MMPT is very extensive, reaches 70-80 % of the sections, and is intimately woven in the full cross-section of the thin sections of the whole stone meteorite. All thin sections showed signs of Fe mobilization and oxidation (reddish-brown haloes around mineral grains, reddish-brown filaments) (Fig. 1).

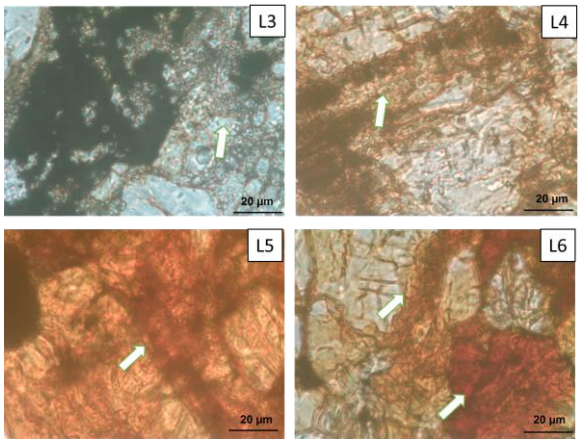

Fig. 1: Putative microbial mediation in NIPR L series (shown by arrows) – necklace-like filamentous FeOB

5. FTIR-ATR

The iron-oxidizing microbial structures have a mixed composition containing iron oxides (ferrihydrite, goethite, hematite) [4] with serpentine [5], in host minerals olivine [5], and pyroxenes (diopside, enstatite) [5], and opaque minerals (troilite, chromite) [5] (Table 1). Hydrocarbon compounds were also detected (long chain hydrocarbon, diene; and C-H stretching of aliphatic hydrocarbons [6]. The presence of olivine and serpentine spectra proves the weathering of olivine, while the appearance of ferrihydrite and hematite corresponds to bacterial originated remobilization of iron from olivine and troilite (Fig. 1). IR vibrations of isoprenoids were also detected [6]. Moreover in weathered part of chondrules hornblende [5] was detected, which indicates aqueous alteration. This phase was firstly described in Tieschitz meteorite [7]. The microbial mediation was observed in other L chondrites from Hungary [8]

Summary and Conclusions

Our data confirm dense and invasive microbially mediated contamination in the chodrites, supported by microtexture, micromineralogy and embedded organic compounds, which effected most of the mass of the samples. As the transformation processes are supposed to happen on the parent bodies, it raises contradictions concerning a possible terrestrial contamination as it seems that these products manifest in microbially mediated texture. In our study we offer basically different interpretation to solve these contradictions.

Table 1: Biogenic minerals and organic compounds of studied NIPR L series: The occurrence of minerals and organic compounds can be seen in columns.

	No. spectra	42	21	25	**22**
Mineral phase	**References**	**NIPR L3**	**NIPR L4**	**NIPR L5**	**NIPR L6**
olivine	5	20	14	11	8
serpentine	5	7	4	6	11
enstatite	5	3	2	2	2
diopside	5	4	1	0	1
feldspar	5	0	0	1	0
hornblende	5	0	0	3	1
ferrihydrite	4	5	0	0	0
troilite	5	9	4	2	4
chromite	5	0	0	1	0
hematite	4	0	0	0	0
goethite	4	2	0	5	0
Organic compounds		0	0	0	0
v C=C/C-O	6	7	0	0	0
vs CO	6	7	0	0	0
d CH2	6	37	18	4	6
C-N, CH deformation	6	40	0	0	2
C-N N-H amide II	6	40	18	16	10
C=C asym. Stretch	6	0	0	0	0
amide I	6	40	18	16	4
C=O, C-N, N_H					
v as COOH	6	0	0	0	0
C-O	6	0	0	0	0
CO	6	42	21	21	18
CO	6	42	21	21	18
C-H sym. Stretch CH2	6	42	17	21	8
C-H asym. Stretch CH2	6	42	17	17	8
CH2 /C=C	6	0	0	4	0
OH	6	8	12	8	4

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