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Infrared spectral analysis of chondrule alteration in NWA 2086 CV3 meteorite

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Abstract

Analyzing a thin section of the NWA 2086 CV3 meteorite with infrared spectroscopy and ATR detector in contact mode, characteristic changes were observed in peak positions according to the Fe/Mg ratio in olivine. This method was able to identify the alteration at such a low level where optically it could not be realized yet. The alteration happened in olivine along the chondrule's rim without observable fractures, thus probably some metasomatism has taken place there producing changes without observable fracturing inside the mineral.

1. Introduction

We analyze the alteration of olivine crystals in one chondrule in the NWA 2086 CV3 [1,2,3,4] meteorite with Fourier Transformational Infrared Spectroscopy. The aim was to determine the characteristics of peaks in the reflected IR radiation and correlate it to composition of the minerals.

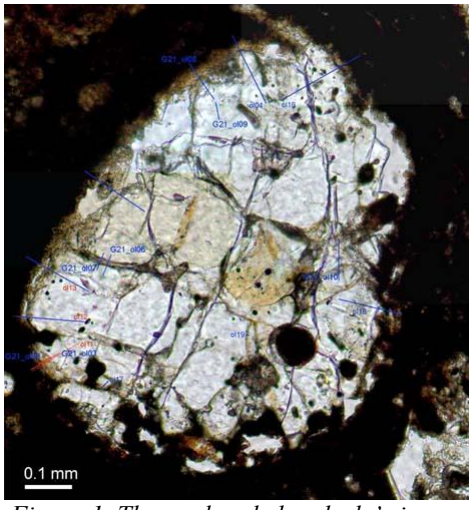

Figure 1. The analyzed chondrule's image with 1N in optical microscope.

2. Methods

For textural analysis polarization microscope NICON Eclipse E600 POL was used with magnifications of 40, 100, 200, 400 times. Elemental composition of certain sections of the sample was used with 1-2 micrometer spatial resolution with thin graphite cover layer deposited under vacuum, using a JEOL Superprobe 733 electron microprobe with INCA Energy 200 Oxford Instrument Energy Dispersive Spectrometer. The analytical circumstances were 20 keV acceleration voltage, 6 nA beam current and count time of 60 sec for the spot measurement and 5 minutes for linescan analysis. We estimated the detection limit for main element identification below 0.5 % based on earlier measurements with various samples.

For IR spectral analysis Bruker Vertex 70 FTIR and Hyperion 2000 microscope plus ATR objective with contact method was used to record infrared spectra of the minerals in the very thin surface layer of the one side covered and polished thin section of NWA2086 meteorite.

3. Results

The following basic peaks, regarding both its location and relative intensity were surveyed along radial profiles crossing the perimeter of the chondrule, where alteration products could often be observed [5]. We focused on the peaks indicated in Figure 2. The same locations of profiles were surveyed by electron microprobe analysis in order to get accurate elemental composition, and its change along the profile. As both the contact ATR and the microprobe survey analyzing the same thin surface layer of the meteorite they could be compared and the role of compositional change produced shift in peak positions could be determined.

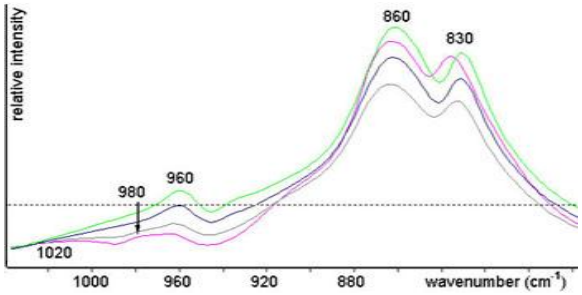

Figure 2. Four example spectra of olivine with the mains peaks indicated by their wave number

During the analysis the v1 mode profiles ranged between 829-839 cm^{-1}, whereas the major band of v3 mode occurs in range 859-865 cm^{-1} [6,7]. There were minor bands of v3 mode 965-974, 982 in our profiles. An example on the measurement points along a profile can be seen in Figure 3 a inset, while the corresponding spectral shapes are indicated in Fig. 3 b inset. Numbering of individual spectra correspond to: 1. intact, 2. altered with increased Fe and decreased Mg content but looks, 3. even more altered, 4. most altered that is equal in composition with the matrix.

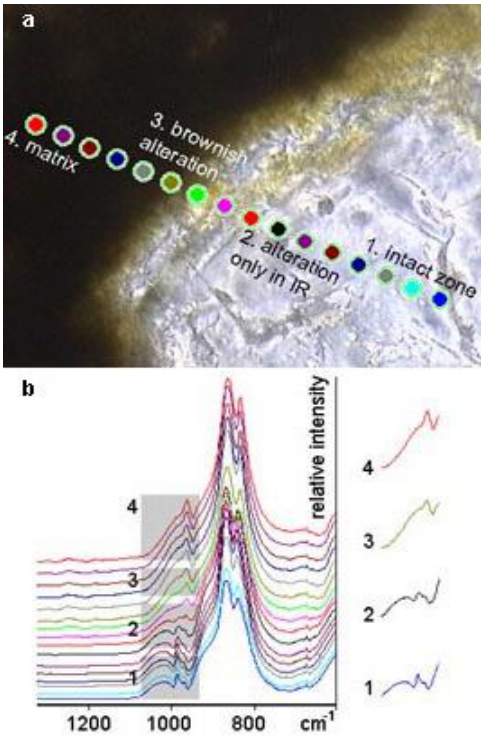

Figure 3. Location of IR measurements (a) and spectral shapes at these points (b), with three different types of alteration level (1, 2, 3, 4)

3. Conclusions

Correlating spectral shapes and microprobe based compositions, the Fe/Mg ratio was increased according to the level of alteration closer to the chondrules' perimeter inside olivine crystals from 80-120 micrometer inward from the chondrule's perimeter. Along the Fe increase characteristic change happened in the IR spectral shapes: the position of 830 (and occasionally 860 cm^{-1}) peak shifted to smaller wave number, while the shallow peak at 1020 disappeared, and a new peak around 960 cm^{-1} emerged.

These changes were mainly produced by the change in crystalline structure from Fe/Mg substitution during the alteration. The correlation between the Fo ratio and the peak position shift was best at the 830 cm^{-1} peak, where they show R^2=0.5-0.7 for the firstly analyzed profiles. The alteration with this IR method is could already be identified at such low level where optical microscopic appearance is still the same as the intact olivine. The laboratory based infrared analysis of meteorites is a useful way not only for the detection of hydration [8] and carbon containing materials [9] but also for mineral alteration in general [10].

4. Acknowledgements

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