EPSC Abstracts
Vol. 12, EPSC2018-498, 2018
European Planetary Science Congress 2018

μ-IR + SEM/EDS combined technique for Carbonaceous Chondrite meteorites characterization as possible analogues of Hayabusa2 and Osiris-REx asteroid targets

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Abstract

We used the Infrared μ-spectroscopy (μ-IR) and Scanning Electron Microscope with Energy Dispersive Spectroscopy (SEM/EDS) coupled technique on CM2 and CV3 Carbonaceous Chondrites (CC) meteorites, as possible analogues of the Hayabusa2 and Osiris-REx Space Missions asteroid targets. Chondrules, CAIs, and mineral inclusions were identified and analysed in detail in the spectral region 7-15 μm by using μ-IR. Chemical information on chondrules, inclusions and matrix were acquired by using SEM/EDS technique and the results were combined with the main absorption bands, Christiansen and Reststrahlen features identified. This technique is going to be applied to CI, CR and CK meteorites because of their strict relation with C-type and B-type asteroids.

1. Why study Carbonaceous Chondrites?

Different groups of Carbonaceous Chondrite were associated with different asteroidal parents and most are thought to come from low-albedo C-type asteroid, the most abundant type between 2.7 A.U. and 3.7 A.U. [1]. In particular, CI, CM and CI/CM unusual are consistent with C-type asteroids [2,3] while from recent spectral analysis CK, CO and CV can be associated to B-type asteroids (e.g., Pallas group) [4]. Thus, in order to know the asteroids evolution and to support the space data interpretation from remote-sensing infrared spectroscopes, the mineralogical and spectral analysis on extraterrestrial samples are fundamental. We applied μ-IR + SEM/EDS combined technique to CM2 and CV3 meteorites, as possible analogues of 101955 Bennu (B-type) and 162173 Ryugu (C-type), targets by Hayabusa 2 and Osiris Rex missions [5,6].

2. CCs samples and measurement procedure

We analysed the following meteorites: 1. Murchison (CM2 group); 2. NWA8267 (CM2 group), characterized by small chondrules and refractory inclusions [7]; 3. Allende characterized by coarse-grained, Al-rich inclusions and chondrules [8] and 4. NWA2086 (CV3 group) with considerable amount of large mm-size chondrules and Calcium Aluminum Inclusions (CAIs), many surrounded by igneous rims [9]. A preliminary analysis was performed by using a Stereo Microscope (Leica M205c) equipped with a digital camera in order to select the sample regions characterized by a significant mineralogical heterogeneity (e.g. chondrules, inclusions) (Fig.1).

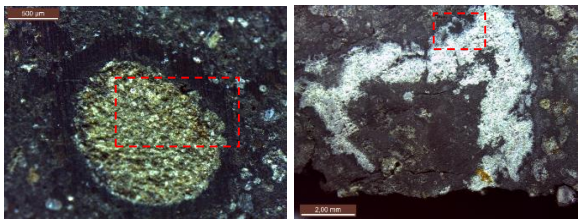

Figure 1. Examples of selected regions analysed with the μ-IR+SEM/EDS technique. *Left*: NWA8267 (CM2) chondrule. *Right*: Allende inclusion (CV3).

The infrared spectra of selected regions (Fig.2a, 2b) were acquired with μ-IR Microscope (mod. Bruker Hyperion 3000) and analysed in the spectral range: 7-15 μm. The Christiansen features and Reststrahlen bands of the main minerals were identified and coupled with chemical data provided by SEM/EDS technique. Preliminary results are summarized in Table 1.

Table 1. Reststrahlen and Christiansen features identified and compared with SEM/EDS data.

CC samples	Res. - Christ. features (μm)	μ-IR minerals	SEM minerals
Murchison - inclusion	9, 9.9,10.5, 11.6 - 8.4	olivine, low-Ca pyroxene, serpentine	olivine, serpentine
NWA8267 -chondrule	9.1, 9.8, 10.5 - 8.5	low-Ca pyroxene	low-Ca pyroxene
NWA2086 - chondrule	9.1, 10.8 – 8.3	clino-pyroxene, olivine, Anorth.	Mg-rich olivine, sulphides
Allende - inclusion	9.1, 10.3, 11.1, 15 – 8.5	clino-pyroxene, melilite, spinel	-

3. Discussion and results

The combined data μ-IR+SEM/EDS technique (Fig. 2c, 2d) of chondrules and inclusions indicate that the main spectral bands:

- in Murchison can be ascribed to the Fe-rich olivine, to a pyroxene mixture and phyllosilicates [7];
- in NWA8267 can be assigned to a mixture of low-Ca pyroxene an sulphides [10];
- in NWA2086 can be ascribed to Mg-rich olivine, clinopyroxene and phyllosilicates in the intact chondrules and Fe-rich olivine in matrix area [9];
- in Allende can be ascribed to clinopyroxene, melilite and spinel (inclusion) and Fe-rich olivine (matrix) [8].

The analysis is going to be extended to other CCs class like CK and CO as well CM/CI anomalous and comparing the results with C-type and B-type asteroids data to find similar spectral features. In order to help the analysed CC sample characterization, FT-IR spectra of packed powder meteorite samples should be acquired between 1.5 and 4.2 μm in order to identified the distinct absorption band and their relationship with minerals founded with μ-IR+SEM/EDS combined technique. Thus, these combined analyses will provide a comprehensive mineralogical framework of Carbonaceous Chondrites meteorites, which will help the returned samples characterization of next sample return missions.

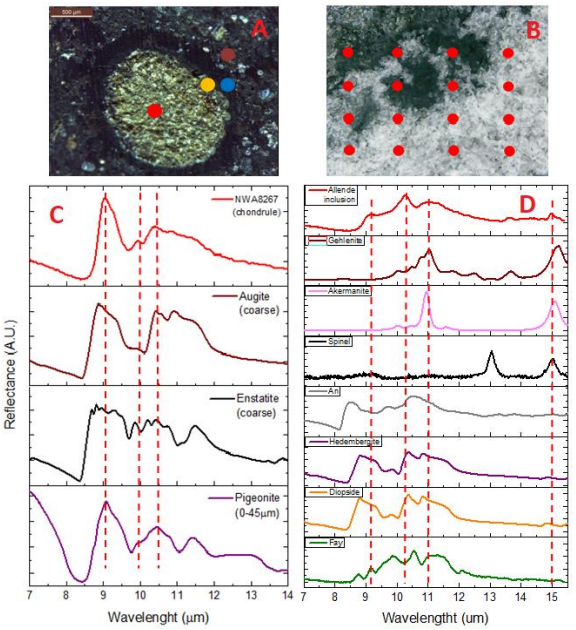

Figure 2. A, B: selected areas and μ-IR measurements location. C, D: μ-IR spectra in comparison with main minerals.

Acknowledgments

This work is supported by the Italian Space Agency, PRIN-MIUR and Regione Campania. This research has been performed using the spectra from ASTER database (courtesy of the JPL) and RRUFF database.

References

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