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FT-IR and µ-IR characterization of HED meteorites in relation to infrared spectra of Vesta-like asteroids

M. Ferrari (1), F. Dirri (1), E. Palomba (1), S. Stefani (1), A. Longobardo (1) and A. Rotundi (2,1)

(1) Institute for Space Astrophysics and Planetology, IAPS-INAF, Via del Fosso del Cavaliere 100, 00133, Rome, Italy.
(2) Dipartimento di Scienze e Tecnologie, Università degli Studi di Napoli "Parthenope", CDN, IC4; 80143 Naples, Italy.
(marco.ferrari@iaps.inaf.it)

Abstract

We present the results of the FT-IR and µ-IR study of three Howardite-Eucrite-Diogenite meteorites (HEDs) [1] compared to the spectroscopic data collected by VIR onboard Dawn spacecraft [2]. The origin of this group of achondrites is thought to be linked to the asteroid 4 Vesta [3], hypothesis lately reinforced by the data provided by the Dawn mission [4].

1. Introduction

In order to acquire a fuller grasp of remotely sensed compositional data, it is fundamental to compare them to analogue samples analyzed by means of spectroscopy techniques. Here we report a FT-IR and µ-IR spectroscopy combined study of three HED meteorite samples: 1) NWA 7159, a monomictic brecciated eucrite consisting of exolved orthopyroxene and anorthite with accessory silica polymorph and ilmenite; 2) NWA 7490 a diogenite with a cumulate texture dominated by orthopyroxene, with Ca-plagioclase, minor olivine and chromite and troilite as accessory minerals; 3) NWA 2698, an howardite with eucritic pyroxene.

2. Experimental set up

For the FT-IR analyses on meteorites powder we used a Fourier transform interferometer (mod. Bruker Vertex 80) operating in the range of 0.8 to 2.4 µm using the InGaAs detector and from 2 to 14 µm with the MCT detector. All spectra were acquired with an incidence angle (*i*) of 30° and an emission angle, (*e*) of 30°. For µIR-spectroscopy, we used a microscope (mod. Bruker Hyperion 3000) connected to the Vertex 80 interferometer, this set-up (working range 2-14 µm) is able to acquire spectra in reflection mode on single feature with minimum dimensions of 50 µm.

3. Discussion

The FT-IR analysis performed on meteorite powders provided bulk information on the mineralogy of the samples. The mid-IR reflectance spectra of the three analysed achondrites are showed in figure 1.

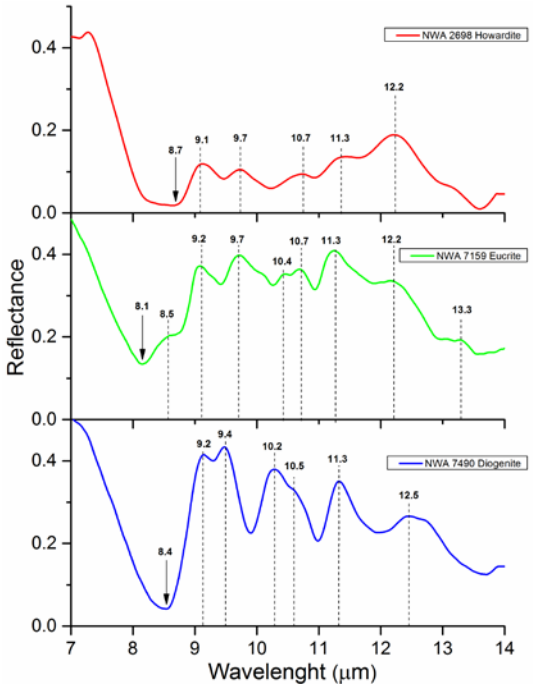

Figure 1: Reflectance spectra of NWA 7490, NWA 7159 and NWA 2698; the Christiansen features are marked by arrows, while the Reststrahlen features are marked by dotted line.

The position of the Christiansen feature and of the main bands are summarised in table 1. The spectrum of NWA 2698 meteorite (red in fig. 1) shows the bands at 9.1, 10.7 and 11.3 µm that can be attributed to pigeonite, whereas the bands at 9.7 and 12.2 µm are ascribed to calcium plagioclase. The Christiansen feature at 8.7 µm is consistent with the presence of pyroxene. The bands at 9.2, 10.4, 10.7 and 11.3 µm in the spectrum of NWA 7159 meteorite (green in

fig.1) can be attributed to pigeonite. The bands at 8.5, 12.2 and13.3 µm are due to the presence of anorthite, in agreement with the value of the Christiansen feature at 8.1µm.

Table 1: Result of the IR characterization of the constituents present in the three analysed meteorites.

Sample	Christiansen feature (µm)	Main spectral bands (µm)	Mineral
NWA 2698		9.7 and 12.2	anorthite
	8.7	9.1, 10.7 and 11.3	pigeonite
NWA 7159		9.2, 10.4, 10.7 and 11.3	pigeonite
	8.1	8.5, 9.7, 12.2 and 13.3	anorthite
NWA 7490		12.5	anorthite
		9.2 and 12.5	forsterite
	8.4	9.4, 10.2, 10.5 and 11.3	hypersthene

The reflectance spectrum of NWA 7490 shows the bands at 9.4, 10.2, 10.5 and 11.3 µm attributable to pyroxene hypersthene. The band at 9.1 µm can be attributed to Mg-olivine whereas the band at 12.5 µm can be due to the contribution of both Mg-olivine and anorthite. The Christiansen feature is in the range of the pyroxene values. If the FT-IR analysis on meteorites powder provided bulk information on the samples, the µ-IR analysis provided reflectance spectra of single minerals, corroborating the results of the bulk composition and excluding possible alteration of the principal minerals. By means of combined analyses we obtained a comprehensive mineralogical framework for the HEDs. It was proven that the mineralogical heterogeneity of the HED meteorites is consistent with the spectroscopic diversity seen on Vesta, thus this study helps in better constraining and characterising the reflectance spectra performed on Vesta-like bodies. A complete characterization of these samples using techniques that provide mineralogical composition, such as XRPD, and techniques that provide chemical and textural information, such as SEM/EDS, are being considered for the future.

4. Summary and Conclusions

IR spectra acquired on the three HED meteorites indicate that:

- the pyroxene of NWA 2698 is a pigeonite in accordance with the composition of the eucritic pyroxene, as reported in the Meteoritical Bulletin N°90;
- the NWA 7159 sample shows a predominant presence of anorthite, as confirmed by the value of Christiansen feature. The presence of pigeonite is in accordance with the pyroxene composition reported in the Meteoritical Bulletin N°104;
- the meteorite NWA 7490 shows the presence of Ca-plagioclase and Mg-olivine, in addition to the predominant occurrence of hypersthene, as reported in the Meteoritical Bulletin N°101.

Basing on the obtained results, the near-IR spectra of these HEDs are directly comparable to those acquired by the in-flight spectrometer on 4 Vesta asteroid (Fig. 2) [5].

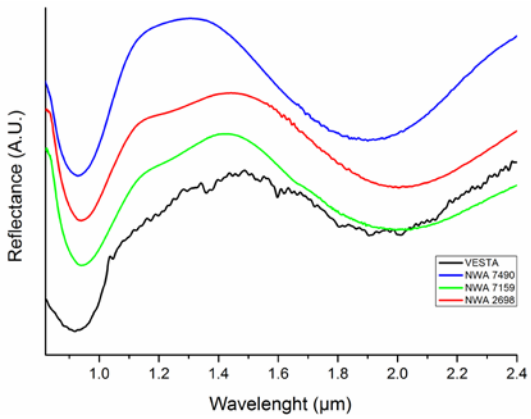

Figure 2: Near-IR reflectance spectra of NWA 7159, NWA 7490, NWA 2698 samples compared to the average spectrum of 4 Vesta asteroid [5].

Acknowledgements

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