EPSC Abstracts
Vol. 13, EPSC-DPS2019-543-1, 2019
EPSC-DPS Joint Meeting 2019

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

Grainsize and temperature effects on reflectance spectra of meteorites

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Abstract

The grainsize and temperature dependent diffuse reflectance infrared Fourier transform spectroscopy (DRIFTs) measurements of carbonaceous and normal chondrites account for previous results of peak changes with grain size and temperature.

1. Introduction

Based on previously observed asteroid surfaces, the grain size of regolith can have really different grain size of different asteroids, and the temperature is depending on daypart. During the recognition of asteroids by meteorite infrared spectroscopic analysis it is important, that gives information on processes in parent bodies [1, 2] like melting of meteorites [3], shocks [4] and wet alteration [5, 6] inside parent bodies. To better interpret of reflectance spectra of asteroid surface, grainsize- and temperature effects should be also considered. Chemical composition, grain size, physical state and temperature of the analyzed samples are important factors, whose variation cause changes in the spectral features (peak position, shape, width (FWHM), depth, area and intensity) of the reflectance spectra.

2. Methods

During our work as a part of the NEOMETLAB ESA project, numerous meteorite samples (e.g. Allende, NWA 869, NWA 11469, NWA 10580, NWA 11469+869 mixture, Csátalja) were measured at different grain sizes (>1 mm - few hundred μm) and temperatures (between +150 and -150 °C) to see how these parameter changes influence the properties of the reflectance spectra. The measurements were made by FTIR Vertex 70 Infrared spectrometer with a Praying Mantis Diffuse Reflectance Accessory, and usually were performed with the following parameters: resolution: 4 cm^{-1}, sample scan time: 512, covered wavelength range: 4000-400 cm^{-1}.

3. Grainsize effect

In case of infrared reflectance spectroscopy several spectral features depending on grain size. So the grain size among others affects the scattering type (“surface to volume ratio”), the amount of absorbed and scattered radiation, the depth, slope, area, width (FWHM), shape and position of bands, the spectral contrast of reflectance spectra and the amount of adsorbed water.

4. Temperature effect

The reflectance spectra of mafic silicates highly changes with temperature [7, 8, 9] modifying peak positions, shapes, and intensities, placement of bands and signal-to-noise ratio. The temperature-dependent spectral properties of different minerals [10] contain compositional information that is complementary to the reflectance spectra [11].

4. Results and discussion

Different grain sized (<0.5 mm, 0.5-1 mm, >1 mm) Allende meteorite powders showed the increase of reflectance (relative band strength) with decreasing grain size in the total spectral range (1400-400 cm^{-1}), as it was described by [12, 13, 14], because as grain size becomes smaller, less radiation is absorbed and the reflectance increases [15] (Fig. 1.). The absolute and relative band strengths were increased mainly with decreasing grain size (1400-400 cm^{-1}).

Different grain size samples of mineral standards (feldspar, olivine, pyroxene) showed reststrahlen bands in the short wavenumber region (~1300-400 cm^{-1}). The reflectance of these bands decreased with decreasing grain size as it was observed by [14, 16]. Allende powders showed with decreasing grain size the peak positions shift to longer wavelengths, as it was also observed by [17]. Between >1 mm and <0.1 mm grain size this shift is about 3.1-7 cm^{-1}.

The pattern of different temperature spectra of different meteorites (e.g. Allende, NWA 10580, NWA 869, NWA 11469, Csátalja) is similar; and mainly display the same peaks and positions, sometimes with some confusion in the 500-400 cm^{-1} spectral region (Figure 2.).

The reflectance/intensity of the spectral bands changed with temperature, in most cases decreased with decreasing temperature but in some cases the reflectance temperature relationship changed in an opposite way. Based on our results, grain size and temperature related intensity of diffuse reflectance changed according to the literature based expectations, however further analysis is necessary to clarify some questionable cases.

Acknowledgements

This work was supported by the NEOMETLAB ESA project and the GINOP-2.3.2-15-2016-00003 fund of NKFIH.

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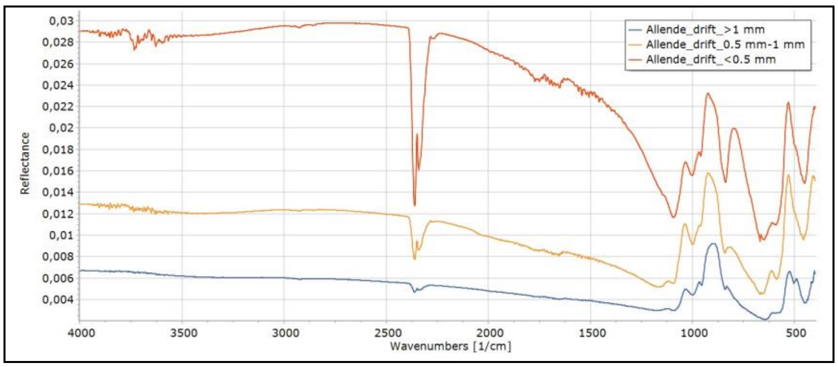

Figure 1. Reflectance spectra (1400-400 cm^{-1}) of different grain size (>1 mm, 0.5-1 mm, <0.5 mm) Allende meteorite

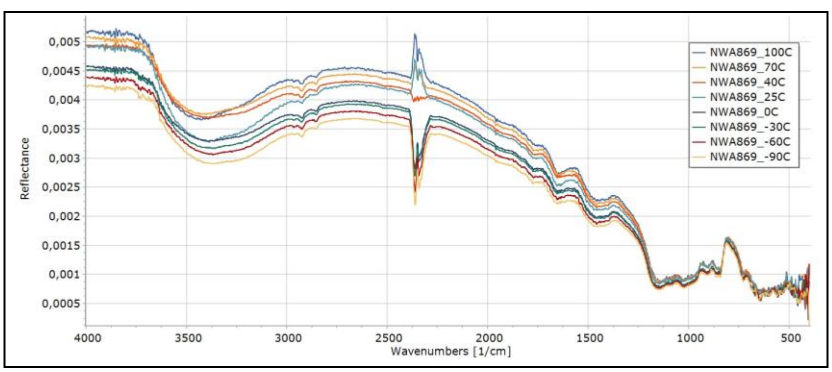

Figure 2. Reflectance spectra (1400-400 cm^{-1}) of different temperature (between 100 and -90 °C) NWA 869 meteorite