

COMPARISON OF CARBONACEOUS CHONDRITIC METEORITES USING DRIFTS VERSUS ATR INFRARED SPECTROSCOPY. Á. Skultéti¹ and Á. Kereszturi², ¹Geographical Institute, CSFK, MTA (H-1112, Budapest, Budaörsi str. 45., skulteti.agnes@csfk.mta.hu), ²Konkoly Observatory, CSFK, MTA (H-1121 Budapest, Konkoly Thege Miklós út 15-17., kereszturi.akos@csfk.mta.hu).

Introduction: The attenuated total reflection spectroscopy (ATR) and the diffuse reflectance Fourier transform infrared spectroscopy (DRIFTS) are also significant methods for the analysis of meteorites. Each technique characterizes the internal vibrations of particular molecular groups using different optical properties to detect the spectral bands. This work focuses on the analysis of meteorites partly to better understand the observational potential of infrared methods for the former AIM, currently HERA mission [1,2] and also to clarify the connections correlating these two methods from scientific point of view.

The ATR spectroscopy operates by measuring the changes that occur in a totally internally reflected infrared beam when the beam comes into contact with a sample [3]. While the DRIFTS instrument operates by directing the IR radiation into a sample cup, where it interacts with the grains, gets reflected off their surfaces, causing the light to diffuse or scatter, as it moves throughout the sample [4].

The ATR and DRIFT techniques identify the same chemical properties of the sample and produce similar spectra (with similar peak positions), but display different relative peak intensities and differences in the resolution of spectra [5] [6]. The DRIFT technique can result in spectra with increased resolution, reduced interference from water bands (OH vibrations of water are significantly lower) [6] and high sensitivity for sample particle size differences.

ATR spectra do not have the same level of resolution as the DRIFT technique, but the sample particle size do not significantly affect the spectra collected by ATR [7]. So different vibrational spectroscopy techniques (ATR, DRIFT) are not directly comparable to one another and may not be interchangeable [5].

Samples and Methods: During our analysis we used Vertex 70 Fourier Transform Infrared Spectroscopy with Attenuated Total Reflection Spectroscopy (ATR) and Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS). Each of the analyzed samples were powdered below 0.5 mm. The measurements usually were performed with the following parameters: resolution: 4 cm⁻¹, number of scans: 32, range: 4000-400 cm⁻¹.

The observed meteorites were the NWA 11469 CO3 type carbonaceous chondritic meteorite, [8] and

the Allende meteorite, which is classified as a CV3 carbonaceous chondrite [9].

Results:

NWA 11469 meteorite. Based on the ATR measurement the absorbance spectrum of the meteorite powder (4000-400 cm⁻¹) (Figure 1.) shows only a few peaks with higher absorbance and numerous others with weaker absorbance. During the interpretation of this spectra we could identify the characteristic bands of pyroxene minerals at 1070, 960, 872, 680, 669 cm⁻¹. The feldspar minerals have characteristic peaks at 721, 592 and 477 cm⁻¹, while olivine has bands at 837 and 477 cm⁻¹. In addition there are also bands of clay minerals (1653 cm⁻¹), carbonate (1458 cm⁻¹) and troilite (457 cm⁻¹).

Based on DRIFT measurements of the NWA 11469 meteorite powder its reflectance spectrum (4000-400 cm⁻¹) (Figure 1.) beside carbonate (1452 cm⁻¹) shows numerous weaker peaks between 1150 and 400 cm⁻¹. In this spectral region there are characteristic bands of feldspar minerals at 1148, 1082, 725, 648, 625, 577, 563, 534, 520, 469, 432, 422 and 415 cm⁻¹. Pyroxene minerals have peaks at 1082, 1028, 677, 667, 503, 484, 469 and 446 cm⁻¹, while olivine has bands at 838, 613, 520, 503 and 415 cm⁻¹. Moreover we also identified peaks of clay minerals (1642, 908, 838, 677, 520, 469 and 422 cm⁻¹), troilite (613, 457 cm⁻¹), spinel (677, 503 cm⁻¹) iron-oxides (793, 469 cm⁻¹).

Allende meteorite. Based on the ATR measurement its absorbance spectrum (4000-400 cm⁻¹) (Figure 2.) does not display significant bands above 1200 cm⁻¹, below this spectral region there are two strong peaks of olivine (480 cm⁻¹) and pyroxene (870 cm⁻¹), and there are also weaker bands and shoulders of these two minerals (olivine: 961 and 832 cm⁻¹ and pyroxene: 1069, 671 and 589 cm⁻¹).

Based on the DRIFT measurement of Allende meteorite powder, its reflectance spectrum (4000-400 cm⁻¹) (Figure 2.) shows numerous bands between 1200 and 400 cm⁻¹. In this spectral region there are characteristic bands of pyroxene minerals at 1093, 669, 591 and 451 cm⁻¹. Olivine has peaks at 958 and 838 cm⁻¹, while feldspar minerals have characteristic bands at 1092, 1002 and 649 cm⁻¹.

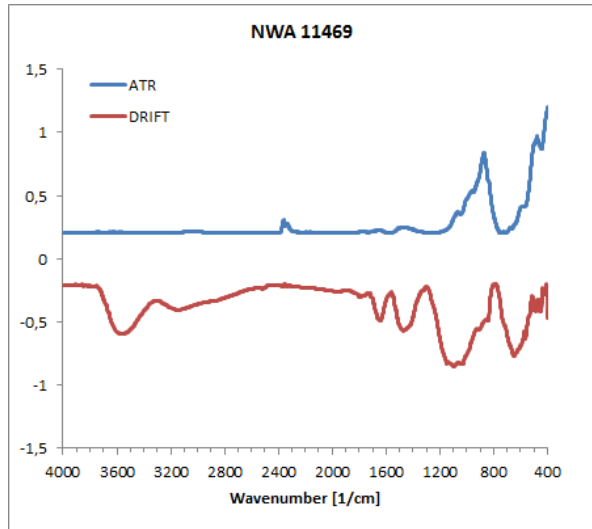


Figure 1. ATR and DRIFT spectra (4000-400 cm^{-1}) of NWA 11469 meteorite

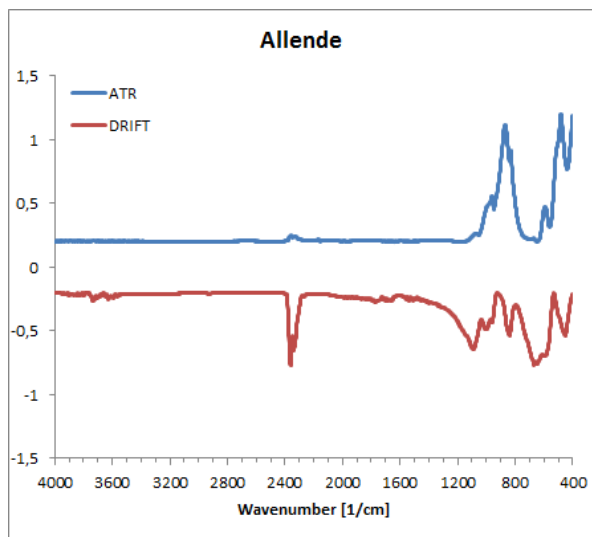


Figure 2. ATR and DRIFT spectra (4000-400 cm^{-1}) of Allende meteorite

Summary and Conclusions: The attenuated total reflection spectroscopy (ATR) and the diffuse reflectance Fourier transform infrared spectroscopy (DRIFTs) are both applicable to analyze meteorites and identify typical minerals. The main minerals of meteorites such as olivine, pyroxene and feldspar are identifiable both on the ATR and DRIFT spectra. The two spectra show similar pattern, but in case of DRIFTs the same scan number provide spectra with higher noise and less S/N value, while the ATR spectrum characterized by smooth and distinct peaks with minimal noise. However due to the increased resolution of DRIFT spectra these main minerals and also the other forming minerals (clay minerals, troilite, spinel and iron-oxides) have more characteristic bands. Therefore the DRIFT spectra enables the easier identification of meteorite minerals.

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References: [1] Michel et al. 2016. *Acta Astronautica* 93, 530-538. [2] Kueppers et al. 2018 LPSC #1144. [3] Stuart, B. (2004) Wiley, p. 203. [4] Drochner, A. and Vogel, G.H. (2012) In: Schäfer, R. and Schmidt, P.C. (2012) Wiley, p. 846. [5] Beasley, M.M. (2014) *Journal of Archaeological Science* 46, 16-22. [6] Haberhauer, G. and Gerzabek, M.H. (1999) *Vibrational Spectroscopy* 19, 413-417. [7] Beasley, M.M. and Carman, C. (2009) *Am. J. Phys. Anthropol.* 138 (S48), 87. [8] Brearley, A. (1993) *Geochimica et Cosmochimica Acta* 57(7), 1521-1550. [9] Green, H.W. et al. (1971) *Science*, 172, 936-939.