Chemical content and Molecular Variations in the Didim (H3-5) Meteorite via μ-Raman and nano-FTIR Imaging

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Didim: an H3-5 meteorite

Didim fell in early February of 2007 in Didim, Turkey. Multiple stones were recovered from the fall area and some meteorite fragments were secured for research by MEO. Initial work on Didim showed that this meteorite contains multiple lithologies and clasts of different petrologic types even in a single stone [1]. Namely, a mixture of H5 clasts in an unequilibrated H3 host was observed in Didim (hence the classification of H3-5). Identifying these mixtures even in a single stone provides a unique opportunity to investigate its molecular composition that contains varying degree of equilibrium with varying mineralogy. Here, we present results of our detailed multi-technique spectroscopic investigation on the Didim meteorite.

Experiments

Micro-Raman 2D and 3D spectroscopic data were collected from a polished thick section of the sample at the Science and Technology Application and Research Center of Canakkale Onsekiz Mart University, Turkey (COBILTUM) using a WiTec alpha300R confocal Raman imaging system equipped with a 532 nm Nd:YAG laser and a 50× objective (NA = 0.8). For the 3D tomographic dataset, following the methods of [2], we measured a particular region (40×40 μm^2 area) for a depth of 15 μm with 1 μm depth resolution, resulting in 15 two dimensional datacubes. Intensity distribution maps of individual chemical components were generated by integrating the signal between the spectral endpoints of Raman peaks for each 2D datacube. Nano-FTIR datasets were collected on the same sample using a commercial s-SNOM system (neaspec GmbH) equipped with a broadband DFG laser at the Institute of Accelerator Technologies of Ankara University, Turkey. We collected the nanoFTIR spectra with 20 nm spatial and 4 cm^{-1} spectral resolution from selected areas at the surface of Didim within the 1600–850 cm^{-1} spectral range to investigate the peaks in the molecular fingerprint region and detect various functional groups. All AFM scans were done in non-contact mode using A-NCPt cantilever (res. freq.: 285 kHz, spring constant: 42 N/m).

Acknowledgements

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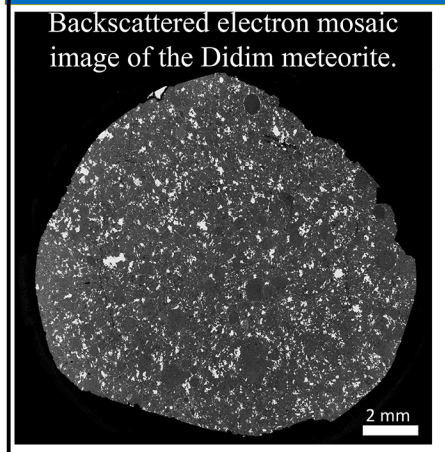
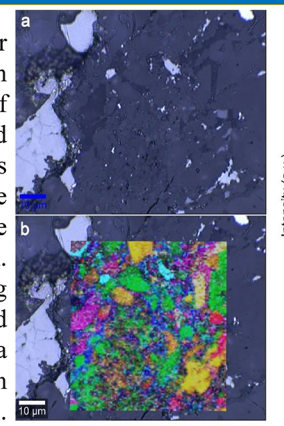
References

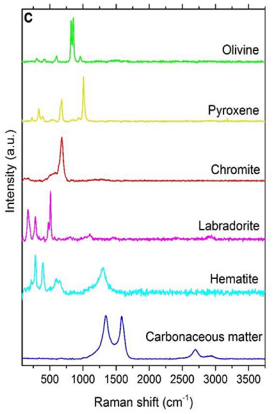
[1] Weisberg, M.K., Smith, C., Benedix, G., Folco, L., Righter, K., Zipfel, J., Yamaguchi, A. and Aoudjehane, H.C. 2008. The Meteoritical Bulletin, No. 94, September 2008. Meteoritics and Planetary Science, 43(9), pp.1551-1584. [2] Yesiltas, M., Jaret, S., Young, J., Wright, S.P. and Glotch, T.D. 2018. Three-Dimensional Raman Tomographic Microspectroscopy: A Novel Imaging Technique. Earth and Space Science, 5(8), pp.380-392.

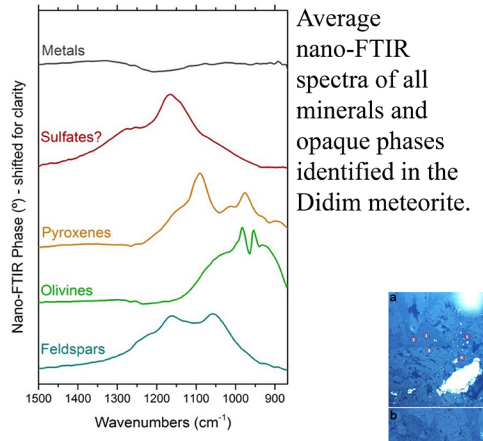
Results



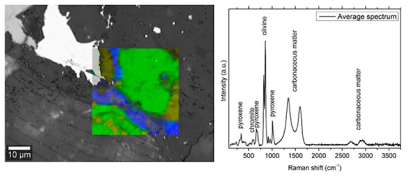


False-color distribution map of identified compounds overlaid on the visible micrograph. Corresponding color-coded Raman spectra are shown in the right panel.

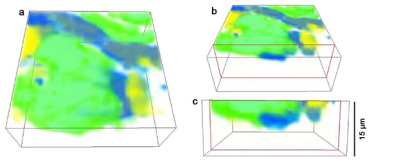


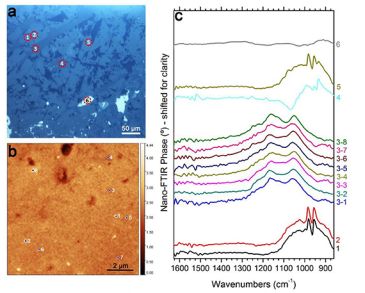


Average nano-FTIR spectra of all minerals and opaque phases identified in the Didim meteorite.

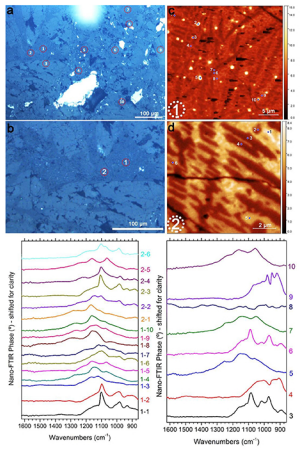


Identification of indigeneous carbon underneath olivine. Olivine, pyroxene, and carbonaceous material are shown in 3D. Average Raman spectrum of this location is shown in the top-right panel.

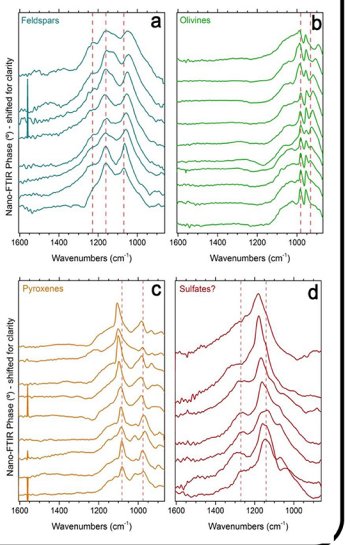




Visible micrograph and AFM image of a location (left). NanoFTIR spectra of spots and 20 nm sized points are shown on the right panel.



Similar nano-FTIR data of another location on the surface of Didim.



Observed nano-scale compositional variations in Didim. Vertical dashed lines are shown for visual reference.