

FT-IR MICRO-SPECTROSCOPY OF FINE-GRAINED PLANETARY MATERIALS: FURTHER RESULTS

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Introduction: Dust is the basic building block of all bodies formed in the solar system, including planets, comets and asteroids. Information about the composition of the dust is available from two sources. The first is from grains that can be analysed in the laboratory (e.g., meteorites, presolar grains in meteorites, IDPs (interplanetary dust particles) and GEMS (glass with embedded metal and sulfides) within IDPs). Dust also occurs in many astrophysical environments – around stars, ejecta from supernovae, in the interstellar medium, in dust clouds, so another source of data comes from astronomical observations, e.g. the ISO satellite.

To identify certain mineral phases in astronomical spectra, IR spectra obtained in laboratories of ‘pure’ minerals are needed for comparison. So far mainly amorphous glasses [e.g. 1] or fine grained smokes [2] have been used as standard materials, rather than natural minerals. These studies also mostly concentrated on pure end members, which are rare in nature. Minerals from meteorites are probably a better fit for the astronomical analyses, since they formed in a similar environment to the dust grains. The aim of this project is to compile a database of infrared and optical spectra of well characterized minerals from representative meteorites. In addition to whole grain and powder analyses, we also try to obtain spectra *in situ* from bigger samples (e.g. thin sections) to get information from mineral phases in their petrological context.

In a first step, we used a reflectance technique (ATR) to obtain spectra from parts of the LL3.6 ordinary chondrite Parnallee [3]. In this method, a Ge-crystal with ~70 micron diameter is directly placed on the sample to obtain spectra that are similar to those observed in transmission analyses. We also presented data for standard olivines with varying forsterite (Fo) contents obtained by a diffuse reflectance method. Here we present preliminary data from a third technique, direct transmission analysis of forsterite-rich olivines within a thin section from Parnallee.

Techniques: First a conventional petrological thin section was prepared, with a lower thickness (~20 compared to the normal 30 microns), using a special resin that allows the section to be demounted from the holder after preparation. The specimen was then supported on a KBr pellet for the FT-IR transmission analyses.

IR spectra were obtained with a Perkin Elmer Auto Image FT-IR microscope over a wavelength range of ~ 2.5 to 16 microns (4000 to 600 cm^{-1}) using an aperture of 20 microns. In each measurement, 20 scans were added, the resolution was 4 cm^{-1} . For comparison, an olivine (Fo₈₀) spectrum was measured from a pellet in absorption mode. Here we used the Perkin Elmer Spektrum One workbench. All data are presented in relative absorption (A).

The chemical composition of the analyzed areas was measured with SEM (Jeol 5900LV Analytical SEM) at the EMMA facilities at the NHM, using 20 KeV probe current.

Results: All analyses of olivines show interference fringes [4], sinusoidal waves overlaying the spectra generally at higher wavenumbers (> ~1200 cm^{-1}) (Fig.1). While no such features are directly visible between 1200 cm^{-1} to 600 cm^{-1} , where the major silicate IR bands occur, we cannot rule out any influence in this part of the spectrum. To avoid any crystallographic orientation problems, all 14 IR analyses of olivine grains with similar composition (ranging from Fo₇₂ to Fo₈₃) have been averaged (Fig.2). In the same process, most of the interference fringes vanished.

When the average olivine spectrum (Fo₇₅) is compared with a spectrum obtained by conventional transmission from a pellet of a standard olivine with similar composition (Fo₈₀), we see that two smaller bands at ~980 cm^{-1} and ~840 cm^{-1} are at nearly identical positions in both spectra. These bands are also good indicators of the Fe/Mg ratio in olivines [5]. However, the major central band at ~885 cm^{-1} is probably shifted towards higher wavenumbers in the Parnallee olivine spectrum. It is also possible that this band is barely visible as shoulder at ~900 cm^{-1} in the Parnallee section. A reason for this shift could be contamination with other parts of the sections, owing to the fine grained nature of Parnallee, as well as the small aperture used. While some influence from surrounding parts couldn't be avoided, the extent should be usually negligible. A further explanation could be peak shifting resulting from high absorbance ($A=1.7$), or light leakage effects [6]. The generally broader shape of the olivine Parnallee spectrum – the band at ~980 cm^{-1} basically merges with the main peak – also points in this direction. In earlier ATR measurements of olivines [3], also a shift of the same peak was observed, but here towards lower wavenumbers [7].

Conclusions: Transmission analyses of demounted thin sections offer an opportunity to obtain spectra even of very small areas. However, spectral artifacts possibly caused by the sample thickness demand more future work on this technique (e.g. thinning of sample).

References: [1] Jaeger C. et al. (1994) *Astronom. & Astrophys.* 292, 641-655. [2] Nuth J. A. III (1996) *In: Proc. NATO ASI on the Cosmic Dust Connection* (ed. J.M. Greenberg), Kluwer, Netherlands, 205-221 [3] Morlok A. et al. (2003) *MAPS* 38-7, A63 [4] Raynal P.I. et al. (2000) *Planetary and Space Sci.* 48, 1329-1339 [5] Koike C. et al. (2003) *Astronom. & Astrophys.* 399, 1101-1107 [6] Hofmeister et al. (2000) *In: Proc ISO beyond the Peaks* [7] Morlok A., Grady M., Koehler M., Jones G. (2004) in Prep.

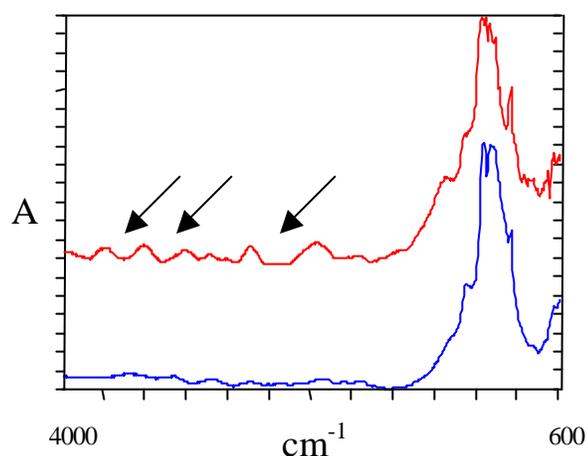


Fig.1: Comparison of IR-spectra of a single olivine grain in Parnallee thin section (red, top) and average spectra of 14 olivines from the same thin section (blue, bottom). The single analysis shows wave-like interference fringes (arrows). These mainly vanish in the averaged spectra. Data presented in relative absorbance, both spectra are normalized to the same height for better comparison.

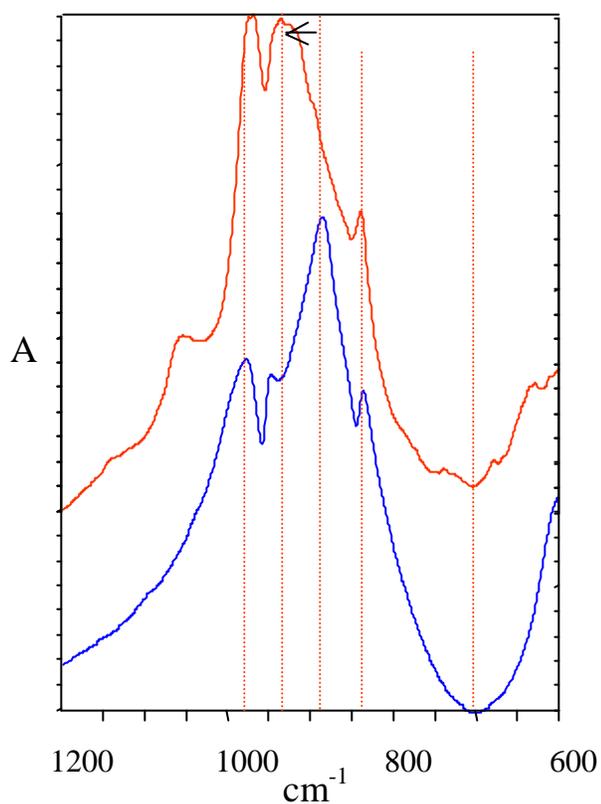


Fig.2: Comparison of IR transmission spectra from Fo_{80} standard olivines (bottom, blue) and the average of 14 transmission analyses of $\sim\text{Fo}_{76}$ olivines from Parallee (top, red). The vertical red dotted lines compare important bands at $\sim 980 \text{ cm}^{-1}$, 885 cm^{-1} and 840 cm^{-1} . The arrow marks the shift of the main band. All in relative absorbance (intensities have been normalized to the same heights for comparison).