

AN INFRARED STUDY OF THE MATRICES OF CI1 AND CM2 CHONDRITES. E. Quirico and L. Bonal
¹Laboratoire de Planétologie de Grenoble Bât. D de physique BP 53 38041 Grenoble Cedex 9 France
 (eric.quirico@obs.ujf-grenoble.fr)

Introduction: We report some preliminary results from an infrared study of matrix grains from 3 CI1 (Allais, Ivuna, Orgueil) and 3 CM2 chondrites (Murchison, Cold Bokkeveld, Murray). This study intends to provide new clues about the physical state and abundance of water within these objects, and to question the relevancy of the use of spectral data derived from terrestrial mineral for remote sensing of asteroidal or planetary surfaces.

Samples and experiments : Meteorites fragments have been provided by the Museum National d'Histoire Naturelle (Paris-France). Samples of various synthetic ferrihydrites have been provided by A. Manceau (LGIT – Grenoble France). Experiments were performed using a NICOLET NIC-PLAN IR-microscope and a PERKIN-ELMER SPECTRUM GX, using GLOBAR sources. The infrared spot was a 20x20 μm^2 square. Matrix grains were carefully selected under a binocular microscope (carbonate and sulfate grains and chondrules fragments were carefully avoided). Then, they were crushed between two glass slides and transferred onto a KBr window along the procedure described in [1].

The spectra are all affected by scattering effects, despite the careful crushing of the samples. The baseline has been manually corrected. Relicts of scattering effects, especially in the region of the water features around 3700-3000 cm^{-1} , are clearly observable. They prevent from accurate numerical deconvolution of the bands. The spectra have been normalized by setting to 1 the peak intensity of the stretching Si-O band at $\sim 1000 \text{ cm}^{-1}$.

Results : The bands in the spectra mirror the mineralogical composition and the presence of organic matter, revealed by the fingerprints of the CH_2 and CH_3 function around 2900-2800 cm^{-1} (Fig. 1). The Si-O stretching band at $\sim 1000 \text{ cm}^{-1}$, sensitive to long-range order, is rather unstructured and point to disordered phyllosilicates. The water features in the 3750-2500 cm^{-1} region are essentially controlled by compositional effects. In CI1, the OH narrow line at $\sim 3685 \text{ cm}^{-1}$ is consistent with Mg-rich serpentine and smectite. The broad feature is likely the combination of different components, including H_2O in clays and OH/ H_2O in ferrihydrite (FH). FH, which might account for $\sim 34\%$ of Fe in Orgueil [2], could not be identified. The spectral fingerprint of this

mineral is not observed in any of the spectra of the CI1 chondrites. This can be interpreted in two different ways : 1) the bands of FH are mixed with other bands, making lost its shape ; 2) FH in Orgueil is known to contain other elements than Fe (S, Ni), which might lead to spectral variations with respect to Fe-pure synthetic FH.

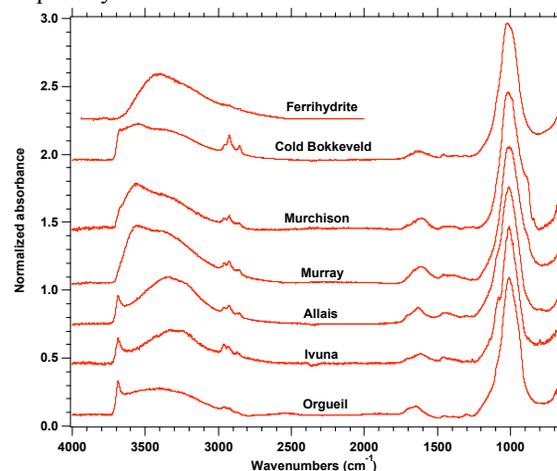


Figure 1 : Infrared spectra of the 6 studied chondrites and 6-lines ferrihydrite (courtesy of A. Manceau LGIT Grenoble).

For CM2 chondrites, variations within and between objects are larger. Though the spectral properties of some minerals (e.g. tochilinites), are unknown, such variations are consistent with the broad range of Fe-abundance in serpentines, by far the most abundant phyllosilicate in CM2 [3]. This clearly suggests that the spectral properties of serpentines in the 3700-2500 cm^{-1} are very sensitive to the cationic composition. To our knowledge, no experimental data are available for Fe-rich serpentine. Some measurements should be done. Using Mg-rich spectra of serpentine could be misleading for remote-sensing applications (asteroids, Mars, etc.).

From a practical point of view, using infrared spectroscopy allows to quickly and easily discriminate CI1 from CM2 matrices, and to report internal variabilities. The derivation of H_2O abundance from these spectra can be attempted, with cautions. It should be emphasized that the absorption cross-section of water (OH and H_2O) are not known, and likely depend on the host mineral. In this work, we have assumed these variations to be weak, and

that averaging all features over the wide spectral range $3700\text{-}2500\text{ cm}^{-1}$ compensates partly these variations. We have then obtained a “semi-quantitative” H_2O abundance, for each meteorite (Fig. 2). The results show that the abundance of water varies within a factor of 2. The variation seems to be correlated to the degree of aqueous alteration in CI1 [4] – but not in CM2 chondrites. On the other hand, the abundance of $\text{OH}/\text{H}_2\text{O}$ in CI1 is not globally higher than in CM2. This suggests that the higher CI1 abundance reported in literature [5] originates from the widespread sulfate grains. As these latter are, for most of them, terrestrial alteration products [6], this water might be terrestrial. Furthermore, considering the presence of chondrules in the Tagish Lake chondrite, which has a CI1-like matrix [7], this questions the definition of the degree of aqueous alteration in these objects.

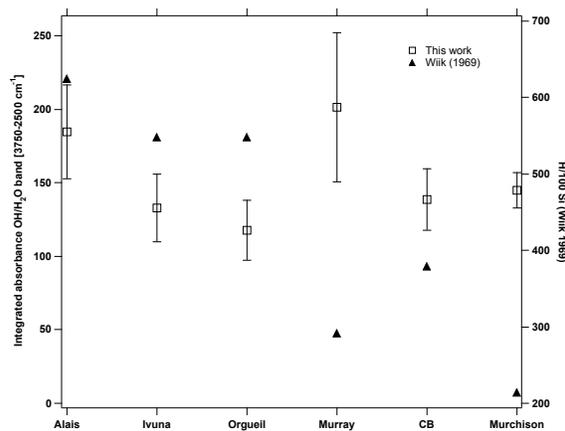


Figure 2 : $\text{OH}/\text{H}_2\text{O}$ abundance (integrated intensity of infrared features over the range $3750\text{-}2500\text{ cm}^{-1}$) compared to H abundances from Wiik (1969). The abundance of water in the matrix is comparable in CI1 and CM2 chondrites. The high CI1 value reported in literature is due to water bearing sulfates, of terrestrial origin.

Conclusion : Preliminary results from this study suggest that :

- Infrared spectroscopy is a powerful tool in order to discriminate easily CI1 from CM2 matrices ;
- The abundance of water in these matrices varies within a factor of 2, without correlation with the degree of aqueous alteration, except maybe in CI1 chondrites ;
- The high abundance of water in CI1 likely originates from hydrated sulfates, which are

mostly of terrestrial origin. Along with the discovery of chondrules in the Tagish Lake chondrite, this questions the definition of the degree of aqueous alteration ;

- The spectra of CM2 strongly suggests that the spectral properties of serpentines are very sensitive to Fe-content. Using spectra of terrestrial Mg-rich serpentines for planetary remote sensing could be then misleading.

References: [1] Raynal P-I et al. (2000) *PSS* 48, 1329-1339 [2] Tomeoka K. and Buseck P. R. (1988) *GCA* 52, 1627-1640. [3] Zolensky M. et al. (1993) *GCA*, 57, 3123-3148. [4] Endress M. and Bischoff A. (1996) *GCA*, 60, 489-507. [5] Wiit et al. (1969). [6] Gounelle M. and Zolensky M. (2001) *Meteoritics & Planet. Sci.* 36, 1321-1329. [7] Keller L. P. and Flynn G. J. (2001). *LPS XXXII*, Abstract #1639.