

Synchrotron-based studies of fluids, mineral-water interfaces and glasses

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Synchrotron-based analytical methods have proved to be valuable in a wide variety of studies of fluids, glasses and mineral-water interfaces. This presentation is an overview of experiments of this nature being conducted at the GSECARS facility at the Advanced Photon Source (USA).

X-ray absorption fine structure (XAFS) spectroscopy is one of the principal methods used in these studies. One such microbeam application involves the determination of valence states for multivalent elements in igneous glasses, which in turn are used as proxies for oxygen fugacity inferences for both terrestrial and extraterrestrial magmas (e.g., Sutton *et al.* 2005). MicroXAFS is also used in ore-relevant studies to establish the speciation of metals in hydrothermal fluids. These applications involve measurements on fluid inclusions (both natural and synthetic) where the samples are analyzed in situ above their homogenization temperature using a heating stage (e.g., Berry *et al.* 2006).

Mineral-water interface studies aim to establish the atomic-scale structures of mineral surfaces, the structural and reactivity changes that occur during hydration and the resultant metal sorption properties of these surfaces. These in situ experiments typically involve combinations of x-ray reflectivity, crystal truncation rod, x-ray standing waves and grazing-incidence XAFS methods. A focus of this work is the determination of structural and reactivity changes of hydrated metal oxide surfaces (e.g., Eng *et al.* 2000).

Fluids can be imaged within objects using x-ray computed microtomography (CMT). One aspect involves the determination of the distribution and flow properties of multiphase fluids in soil columns (e.g., Culligan *et al.* 2006). CMT methods can also reveal transport paths of metals in plants (e.g., McNear *et al.* 2005).

References

- Sutton S.R., Karner J., Papike J.J., Delaney J.S., Shearer C.K., Newville M., Eng P., Rivers M., and Dyar M.D., (2005), *Geochim. Cosmochim. Acta* **69**, 2333-2348.
- Berry A.J., Hack A.C., Mavrogenes J.A., Newville M., and Sutton S. R., (2006), *Am. Mineral.* **91**, 1773-1782.
- Eng, P.J., T.P. Trainor, G.E. Brown, Jr., G.A. Waychunas, M. Newville, S.R. Sutton, and M. Rivers, (2000), *Science* **288**, 1029-1033.
- Culligan K.A., Wildenschild D., Christensen B.S.B., Gray W.G., Rivers M.L. (2006), *Adv. Water Res.* **29**, 227-238.
- McNear D.H., Peltier E., Everhart J., Chaney R.L., Sutton S., Newville M., Rivers M., and Sparks D.L., (2005), *Environ. Sci. Technol.* **39**, 2210-2218.

Raman spectroscopy of organics in Antarctic micrometeorites

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Introduction

Micrometeorites are expected to be the major source of the C flux from extraterrestrial materials delivered to the earth and might represent a major contribution to the pre-biotic organic matter on the early earth (Maurette 2006). On the other hand, organics from carbobaceous chondrites have been characterized non-destructively by means of Raman microspectroscopies (Raynal, 2003; Matrajt *et al.*, 2004).

Methods

Raman spectra have been measured on 73 points of 11 unmelted Antarctic micrometeorite (AMM) grains pressed on aluminum foils under a Raman microscope. Peak positions, full widths at half maximum (FWHM), band intensity ratios (I_D/I_G) and band area ratios ($A_D/A_{(D+G)}$ (%)) for D (defect: ~ 1360 cm^{-1}) and G (graphite: ~ 1600 cm^{-1}) bands were determined for the AMMs and compared with the literature data on carbonaceous chondrites and other cosmic materials.

Results and Discussion

The peak position and FWHM of G band of the AMMs are ranging from 1581 to 1593 cm^{-1} and from 87 to 133 cm^{-1} , respectively. These value ranges are almost the same as those for CM2 carbonaceous chondrites. The peak position and FWHM of D band for the AMMs are from 1357 to 1379 cm^{-1} and from 166 to 271 cm^{-1} , respectively. This region for the AMMs mostly overlaps with the region for CI1s. The D peak position range of the AMMs is similar to those for CM2 and CR2 chondrites. The I_D/I_G and $A_D/A_{(D+G)}$ (%) are ranging from 1.1 to 1.7 and from 65 to 78, respectively. These distributions of the AMMs are close to Orgueil carbonaceous chondrite (CI1). $A_D/A_{(D+G)}$ band area ratios (%) of the AMMs are in the similar range to those for CR2 and Tagish Lake carbonaceous chondrites.

These Raman features of macromolecular carbonaceous materials in the AMMs are similar to those in C1 and C2 chondrites. The AMMs studied here might have the aqueous alteration level higher than 2 and have possibly delivered useful organic components to the early earth.

References

- Matrajt G., Borg J., Raynal P. I., Djouadi Z., D'Hendecourt L., Flynn G. and Deboffle D. (2004), *A&A* **416** 983-990.
- Maurette M. (2006), *Micrometeorites and the Mysteries of Our Origins*. (Springer)
- Raynal P. I. (2003), *Ph. D. Thesis*, Université Peirre et Marie Curie, Paris, France