

## CARBONATE AND SULFATE MINERALS IN THE CHASSIGNY METEORITE

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**Introduction.** Previous work documented carbonate and sulfate minerals in the shergottite, Elephant Moraine, Antarctica, A79001 (EETA79001) [1], and in the meteorite Nakhla [2]. Based on textural and microstratigraphic evidence, we concluded that Ca-carbonate and Ca-sulfate in EETA79001 and Nakhla formed from water-based solutions on the parent planet of the shergottite-nakhlite-chassignite (SNC) meteorites. We report here confirmation of similar carbonate and sulfate phases in the Chassigny meteorite.

Wright et al. [3] reported CO<sub>2</sub> from pyrolysis and combustion analyses of Chassigny and inferred that this meteorite contains traces of one or more carbonate minerals. Not all samples showed CO<sub>2</sub> release, however, and the carrier phase remained enigmatic. Because the carbonates in EETA79001 and Nakhla were independently detectable as CO<sub>2</sub> in evolved-gas analyses [4], the evidence for Chassigny was sufficiently strong to justify a mineralogical search by our previously established methods.

**Samples and Methods.** Several millimeter-sized grains of whole-rock material, supplied by I. P. Wright from the source material used by Wright et al. [3], were studied by scanning electron microscopy (SEM) and energy-dispersive X-ray spectrometry (EDS). Procedures followed those used previously [1,2], including direct EDS for carbon and oxygen. As before, carbon X-ray peaks intrinsic to mineral grains were unambiguously distinguished from those originating from vacuum-evaporated conductive coatings.

**Results.** Carbonates and sulfates in Chassigny seem to be more rare but otherwise they resemble those in EETA79001 and Nakhla. The carbonate and sulfate phases occur together along fractures in olivine (Fig. 1) and are reminiscent of similar occurrences in Nakhla. Carbonate and sulfate grains are irregularly shaped and small ( $\leq 10 \mu\text{m}$ ) which makes clean EDS analyses difficult; X-ray excitation across grain boundaries produces peaks attributable to the host silicates. In addition, the documented occurrences of carbonate involve grains that are closely intergrown with sulfates, thereby further complicating EDS analyses. Despite these analytical difficulties, it is clear that the phases in question are Ca-sulfate and Ca-carbonate. In EETA79001, the volumetrically dominant Ca-carbonate was identified as calcite by X-ray diffraction (XRD) analysis and Ca-sulfate identity as gypsum was inferred from its crystal habits [1]. The carbonates in our Chassigny samples are too rare to isolate for XRD and none of the crystals found to date reveal distinctive habits. Accordingly, proper identification of the minerals in question must await further work by transmission electron microscopy (TEM).

Our customary procedure of using fusion-crusted exterior chips as control samples to assess effects of terrestrial contamination and weathering [1,2,4] could not be implemented here for lack of exterior samples of Chassigny. Therefore, even though Chassigny is an observed fall, we cannot strictly exclude the possibility that the carbonates and sulfates reported here are of terrestrial origin. Nonetheless, the fact that they are so similar to occurrences in EETA79001 and Nakhla which, on microstratigraphic grounds, are pre-terrestrial in origin, draws the simplest interpretation of the Chassigny salts toward the hypothesis of pre-terrestrial origin. The occurrence of the Chassigny carbonates and sulfates as surface coatings on freshly fractured igneous silicates, but without companion signs of etching or oxidation (i. e., no "rust"), is contrary to what would be expected from ordinary weathering of mafic minerals at Earth's surface. "Rust" is virtually absent from the carbonate-sulfate deposits in EETA79001 and the aluminosilicate (possibly smectite-bearing) "rust" in Nakhla has been shown, on microstratigraphic grounds, to be most likely pre-terrestrial [5].

**Implications for SNC Meteorites.** With this confirmation of Ca-carbonate and Ca-sulfate in Chassigny, it is clear that all three SNC sub-groups contain evidence for histories involving aqueous solutions. Based on the limited samples available to this study, it appears that Chassigny is more poorly endowed with salt minerals than is EETA79001 or Nakhla. Nevertheless, it is significant that Chassigny contains traces of a Ca-carbonate/Ca-sulfate assemblage that resembles those in EETA79001 and Nakhla. Although SNC meteorites are fundamentally igneous rocks, traces of carbonate and sulfate strongly suggest that many, if not all, of these rocks were exposed to similar water-based, oxidizing fluids during their respective histories. Further work will be required to determine whether these fluids were of magmatic/deuteric origin or whether they were related to near-surface weathering processes on the SNC parent planet. In either case, complete diagnosis of these trace minerals should add an informative new dimension to inferences about the SNC parent body.

## CARBONATE AND SULFATE IN CHASSIGNY: Wentworth S. J. and Gooding J. L.

**References:** [1] Gooding J. L., Wentworth S. J., and Zolensky M. E. (1988) *Geochim. Cosmochim. Acta*, 52, 909-915. [2] Wentworth S. J. and Gooding J. L. (1989) *Lunar Planet. Sci. XX*, Lunar and Planetary Institute, Houston, 1193-1194. [3] Wright I. P., Grady M. M., and Pillinger C. T. (1990) *Lunar Planet. Sci. XXI*, Lunar and Planetary Institute, Houston, 1353-1354. [4] Gooding J. L., Aggrey K. E., and Muenow D. W. (1990) *Meteoritics*, 25, in press. [5] Wentworth S. J. and Gooding J. L. (1990) *Lunar Planet. Sci. XXI*, Lunar and Planetary Institute, Houston, 1321-1322.

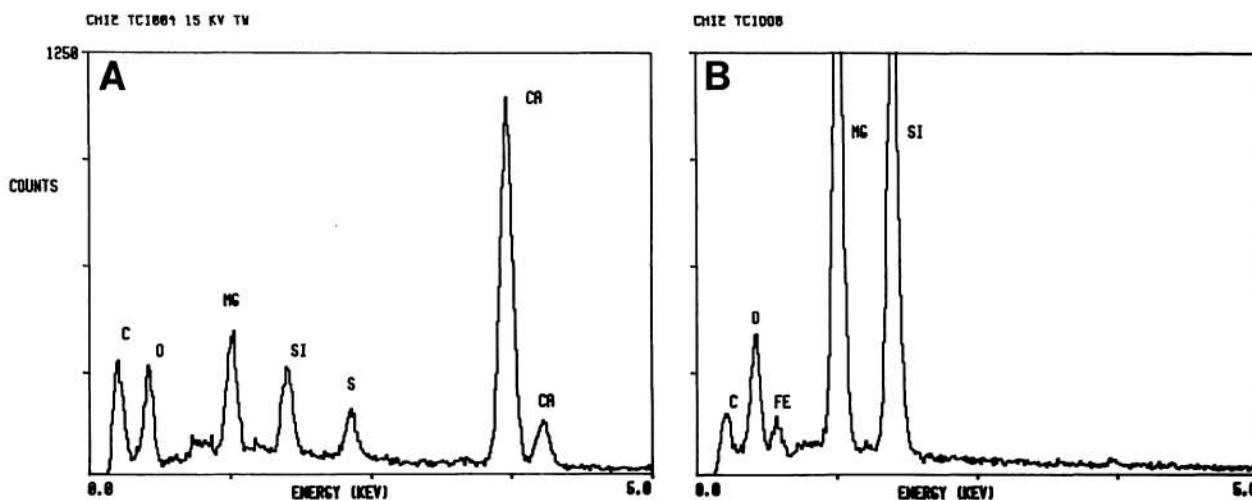
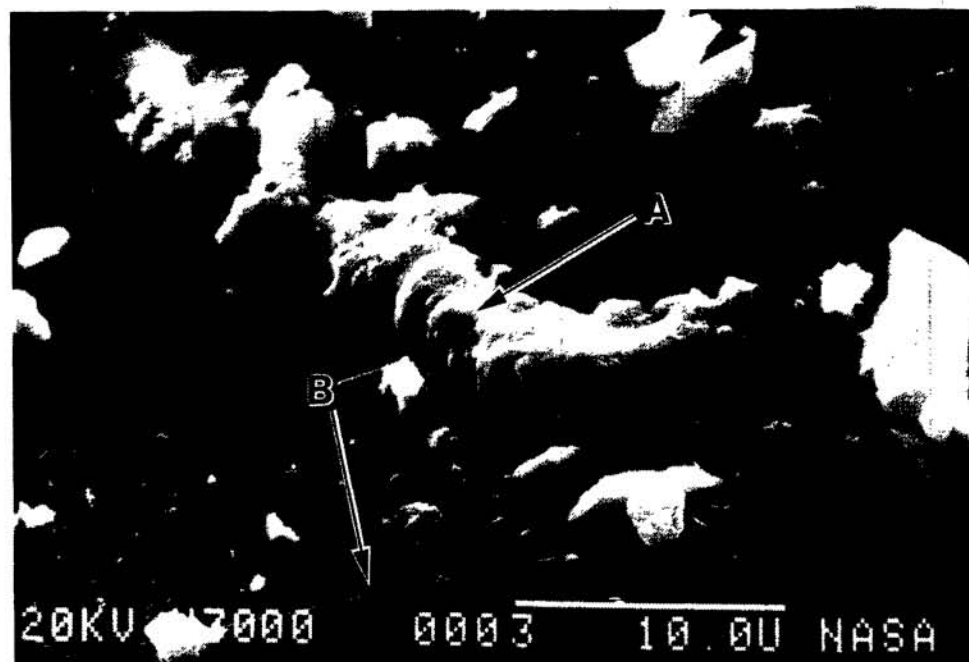


Figure 1. SEM image (10  $\mu$ m scale bar) and EDS spectra for Ca-carbonate/Ca-sulfate intergrowth (A) as a wall lining in freshly fractured surface of olivine (B) in Chassigny. The Mg and Si peaks in spectrum A are attributable to X-ray excitation of olivine underlying the small carbonate/sulfate grains.