GEMS-LIKE MATERIAL IN PARIS MATRIX AND GEMS IN INTERPLANETARY DUST PARTICLES: AN EDX AND EELS COMPARISON

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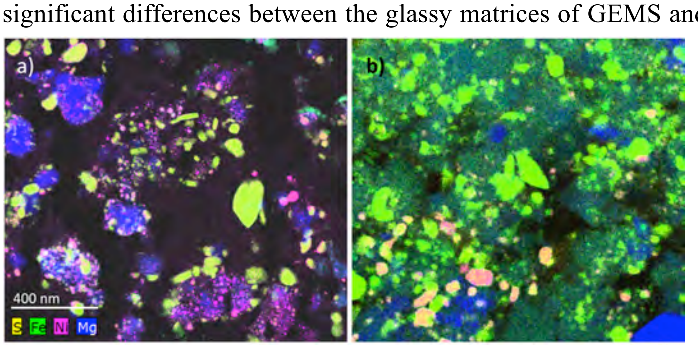
Introduction: The Paris meteorite is the least altered CM chondrite yet identified [1]. It is a breccia of lithologies that have undergone a range of aqueous alteration, sometimes with poorly defined boundaries. In the least altered regions, the Paris matrix contains amorphous silicate material (ASM) that is approximately chondritic in bulk composition and contains Fe-sulfide nanograins [2]. Because of these similarities to GEMS (glass with embedded metal and sulfides) in chondritic-porous interplanetary dust particles (CP IDPs), it has been suggested that GEMS grains may have been the building blocks of the CM matrices [2]. The amorphous silicate GEMS grains in CP IDPs are of considerable interest, because some are demonstrably presolar and thus remnants of the original interstellar amorphous silicate dust that dominated the rock-forming dust in the presolar molecular cloud [3]. Recent studies of the organic distribution in GEMS further support their formation in cold presolar environments [4]. Here, we apply our newly developed method of TEM sample preparation [5] to prepare sections sufficiently thin to enable comparison of the glassy matrix of the AMS in Paris and the glassy matrix of GEMS in CP IDPs, excluding inclusions. (See Villalon et al., this volume, for discussion of inclusions in Paris ASM.) We carried out a side-by-side comparison of GEMS in CP IDPs with the GEMS-like ASM in Paris using spectral imaging by two methods, energy dispersive X-ray spectroscopy (EDX) and electron energy loss spectroscopy (EELS), and we describe the differences observed.

Materials and Methods: A petrographic section of Paris, 2010-7, provided by the Muséum National d'Histoire Naturelle (Paris, France), was first mapped by back-scattered electron (BSE) imaging and EDX in the FEI Helios 660 dual beam focused ion beam instrument (FIB-SEM) at the University of Hawai'i to identify regions that retain Fe as metal. Electron transparent TEM sections were (and are being) prepared from matrix material and fine-grained chondrule rim material from a total of 5 locations in minimally-altered regions of Paris matrix. CP IDPs were prepared by ultramicrotomy. The FEI Titan (scanning) transmission electron microscope (S/TEM) at the University of Hawai'i is used for conventional and STEM imaging, nanodiffraction, and individual EDX and EELS analyses. Another Titan S/TEM at the Molecular Foundry, with a quadruple Bruker silicon drift detector EDX system is used for high spatial resolution elemental mapping by EDX. Finally, a JEOL F200 S/TEM with a Gatan Continuum GIF spectrometer is used for high spatial resolution EELS spectral imaging (mapping).

Results and Discussion: Initial analyses from one location in the ASM in Paris show the ASM regions have little void space and some surrounding organic carbon. ASM material has poorly defined boundaries, but regions bounded by carbon appear comparable in size to GEMS in CP IDPs. Sulfide inclusions are generally larger (~20-200 nm) than most metal and sulfide inclusions in CP IDP GEMS (~1-30 nm). Within the Paris ASM, the Fe content in the glassy matrix is higher than that of GEMS, likely the result of some aqueous processing in even the minimally-altered lithologies. Fe is fairly uniformly distributed in the glassy phase and concentrated in sulfide inclusions, similar to the amorphous silicate material reported in Acfer 094 [6]. EELS confirms the very low Fe content in GEMS glassy matrix versus higher, oxidized Fe content in the Paris ASM glassy matrix. Our initial results indicate significant differences between the glassy matrices of GEMS and of GEMS-like material in the Paris meteorite matrix, but it remains unclear if, or how, they may be related. It is possible that the first location in Paris ASM that we have analyzed, although from a region containing Fe metal, is more altered than the subsequent locations that have been extracted, and we will report on additional locations analyzed.



← Figure 1: Element maps extracted from EDX spectral imaging on (a) LT 29, a fragment of CP IDP U220GCA and (b) Paris meteorite matrix. Scale bar and color legend apply to both images.

References: [1] Hewins R. H. et al. (2014) *Geochimica et Cosmochimica Acta* 124:190–222. [2] Leroux H. et al. (2015) *Geochimica et Cosmochimica Acta* 170:247–265. [3] Messenger S. et al. (2003) *Science* 300:105–108. [4] Ishii H. A. et al. (2018) *Proceedings of the National Academy of Sciences* 115:6608–6613. [5] K. K. Ohtaki et al. (2019) in preparation. [6] Hopp T. and Vollmer C. (2018) *Meteoritics & Planetary Science* 53:153–166.