SEARCH FOR MICROFOSSILS IN CARBONACEOUS CHONDRITES.

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Introduction: The seminal reports [1,2] on the discovery of 'organized elements' in carbonaceous chondrites interpreted as remnants of organisms indigenous to the host meteorites has triggered a search for and a study of organic matter in extraterrestrial materials. These efforts led to identification of a number of organic compounds including amino acids, but yielded no evidence for live organisms. Nearly dead, the idea on the presence of ancient life in meteorites was rejuvenated by the report on possible bacterial remnants in the martian meteorite ALH 84001 [3].

Since then, several groups [4-6] found a number of microstructures in interiors of carbonaceous chondrites dubbed as 'fossils' based on morphological similarity to fossils from the ancient terrestrial rocks [7]. Hereafter, for the sake of consistency we use this term to describe meteoritic filamentous objects regardless of whether these are true fossils or not.

Two most important issues drawing skepticism of the broad scientific community are: (1) how to distinguish these meteoritic 'fossils' from terrestrial contamination and (2) how to prove their biotic origin.

The first issue was addressed in a recent review [7] of N contents in a wide variety of living, dead and fossilized biological materials, including filaments from carbonaceous chondrites and ancient terrestrial rocks. The quantitative EDX spectra showed that N contents in living organisms range between ~2 and 18 at.% while in the meteoritic filamentous objects it is well below 2 at.%, similar to the N range in the fossils from ancient rocks. In addition, the elemental compositions of meteoritic filaments, while being very different from the known living or dead biological materials, are identical to the host meteorite matrices suggestive of indigenous nature of these filaments. While this approach seems to provide a means for establishing indigenous nature of meteoritic filaments, the reported low N contents in them require a more comprehensive study involving high precision instruments such as ion microprobes (SIMS).

The second issue remains unresolved. It appears that any successful technique for distinguishing of biotic from abiotic filaments would require a multi-element isotopic study of organic matter from such filaments in addition to their elemental analysis. Given the small size of meteoritic filaments, such a study can only be accomplished with an ion microprobe.

Recently we began a search for 'fossils' in carbonaceous chondrites and IDPs aiming at their extraction and subsequent elemental and isotopic studies. Here we report on identification and separation of such materials from the Orgueil (CI) and Pollen (CM2) carbonaceous chondrites.

Sample Handling & Analytical Techniques: Small chunks from the freshly fractured interior portions of each meteorite were gently crushed in a sapphire mortar and deposited onto gold foils for preliminary investigation using our SuperProbe 733. To avoid any possible contaminations and artifacts, samples were not carbon coated. Then, using a micromanipulator, the objects of interest were detached from the meteoritic substrate and relocated onto either new gold foils (for high-resolution SEM studies) or silicon wafers (HR SEM followed by SIMS). This procedure intends to eliminate possible interferences with matrix materials during future isotopic analysis.

The morphology and chemistry of these samples were studied in detail using the Supra55VP Field Emission Scanning Electron Microscope (FESEM) at the Harvard University Center for Nanoscale System.

The samples to be studied with NanoSIMS 50 at The National Resource for Imaging Mass Spectrometry (NRIMS, Boston, MA) we deposited on the silicon wafers instead of gold foils in order to comply with the analytical protocol developed for organic materials.

Results and Discussion: So far, 'fossils' were found only in Orgueil. The objects found could possibly be interpreted as mineralized remains of filaments similar to those found by [7-9]. For example, two clusters of Orgueil fossils (Fig. 1) are attached to the surface of a silicate substrate. Morphologically these are very similar to the Orgueil fossils described in [10, 11]. Fig. 2 shows one of the detached and re-located Orgueil 'fossils'. Two more 'fossils' attached to the meteorite surface are shown in Fig. 3. The morphology and the way they attached to the silicate substrate are very similar to the filaments in the Ivuna CI1 [9]. In contrast to the Ivuna filaments, the Orgueil filament's EDX spectrum (Fig. 3) has no well-defined sulfur peak. However, the presence of a shoulder on the Au peak suggests that a weak S peak is overlapped by a strong Au signal from the foil. The appearance of the filaments suggests that these 'fossils' were embedded into the Orgueil matrix.

The quantitative EDX spectra of the some Orgueil show the C, O, Al, Mg, Si and Fe peaks. The lack of the S peak in some analyses most likely results from the interference with the Au peak from the foil. So far, we found no N in our samples, which may be an artifact of a high background of standardless EDX spectral analysis. The planned SIMS analyses of our samples could resolve this issue.

Future work: Before the conference, we expect to carry out elemental mapping of the objects shown in Figs.2 and 3 as well as to measure concentrations and isotopic compositions nitrogen, carbon, sulfur, silicon and oxygen. The work will be done using the NRIMS Cameca NanoSIMS instrument.

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References: [1] Claus G. and Nagy B. (1961) *Nature 192*, 594-596. [2] Nagy B., Claus G., and Hennessy D. (1962) *Nature 193*, 1129-1133. [3] McKay D. S. et al. (1996) *Science 273*, 924–930. [4] Hoover R.B. et al. (2003) *SPIE 4859*, 15-31. [5] Gerasimenko L.M. et al. (1999) *Paleontological Journal* 33, 439- 459. [6] Zhmur S.I. et al. (1997) *Geochemistry International 35*, 58- 60. [7] Hoover R.B. (2009) *SPIE* 7441, 03 1-15. [8] Hoover R.B. (2005) *SPIE* 5906, 166- 182. [9] Hoover R.B. (2008) *SPIE* 7094, 03 1-15. [10] Storrie- Lombardi M.C. and Hoover R.B. (2005) *SPIE 5906*, 183-196. [11] Hoover R.B. (2006) *Biogeoscieces discussions 2*, 23- 70.

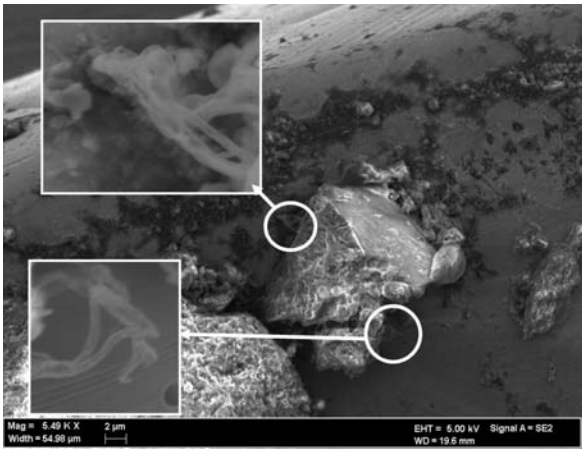

Fig. 1. Secondary electron images of the possible filaments from Orgueil (CI1) meteorite taken at 5 kV.

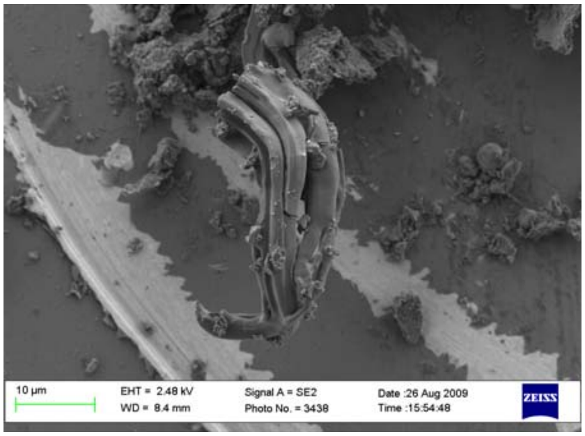

Fig. 2. Secondary electron image of possible filaments from Orgueil taken at ~2 kV.

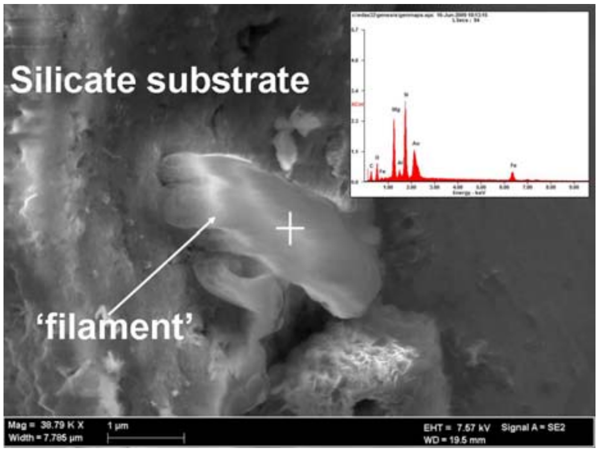

Fig. 3. A filament attached to a silicate substrate of the freshly fractured surface of Orgueil. The object is deposited on a gold foil. The image was taken at ~7 kV. The EDX spectrum shows no detectable nitrogen.