FRAGMENTS OF SEPARATED OPAQUE MATRIX FROM THE SEMARKONA UNEQUILIBRATED ORDINARY CHONDRITE; J. Craig[1], F. Sedaghatpour[1], A. Gucsik[1], D.W.G. Sears[1,2], [1]Arkansas Center for Space and Planetary Sciences, and [2]Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701,USA. (jpc05@uark.edu).

Introduction: Following a previous study on the thermoluminescence, composition, isotopic and petrographic properties of chondrules and chondrule fragments separated from the Semarkona chondrite [1], we have now examined physically separated fragments of opaque fine-grained matrix from the same meteorite. The unequilibrated ordinary chondrite Semarkona is the most primitive of ordinary chondrites, being low in TL sensitivity, high in mineral and phase heterogeneity, high in volatile elements and compounds having co-existing mineral phases that are far from equlibrium [2]. Our present objective is to physically and chemically characterize the matrix in order to better understand the primitive material of the early solar system [3, 4], compare it with interplanetary dust particles [5] and, eventually, compare the fine-grained matrix of the most primitive ordinary chondrites with particles collected by the Stardust mission [6].

Samples and Experimental Procedure: We selected samples of Semarkona matrix material designated SM-4-1 and SM-8-3 from residue of the previous CL analysis of Semarkona chondrules [1]. The ~1 mm samples were crushed using mortar and pestle and imaged with a petrographic microscope with video camera attachment. Relatively clean matrix was readily recognized by its fine-grained texture and dark appearance. Microscopic imaging of the crushed Semarkona matrix provided 4 samples, ~100 microns in size which were isolated and re-designated SM-4-1/1, SM-4-1/2 and SM-4-1/3, and SM-8-3/1 respectively. We imaged the particles at two magnifications using a Philips Model XL30 ESEM with EDS attachment under high vacuum. A low magnification was chosen initially to produce an image of the entire particle then a higher magnification was selected to show a ~10 µm area of the same particle.

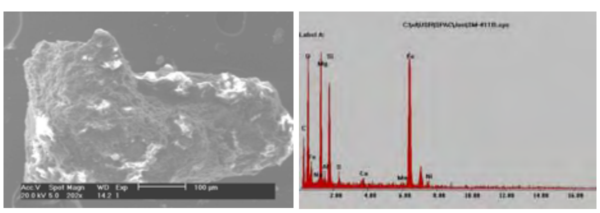

Figure 1. (a) Sample SM-4-1/1 and (b) EDS spectra of particle.

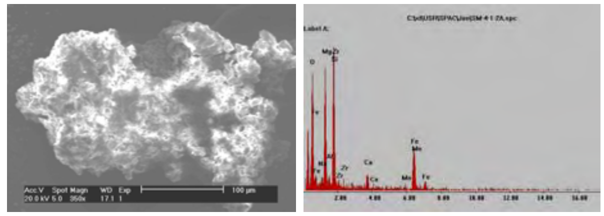

Figure 2. (a) Sample SM-4-1/2 and (b) EDS spectra of particle.

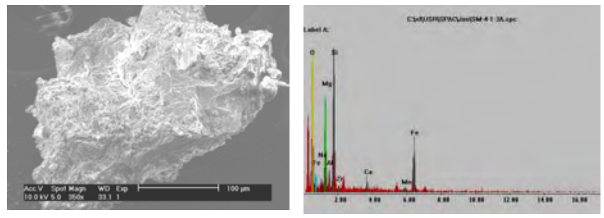

Figure 3. (a) Sample SM-4-1/3 and (b) EDS spectra of particle.

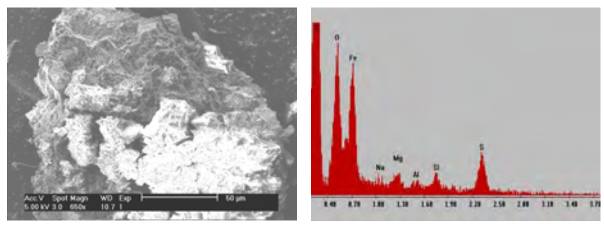

Figure 4. (a) Sample SM-8-3/1 and (b) EDS spectra of particle.

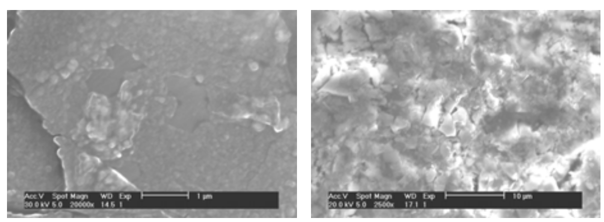

Figure 5. High magnification images of (a) SM-4-1/1 and (b) SM-4-1/2.

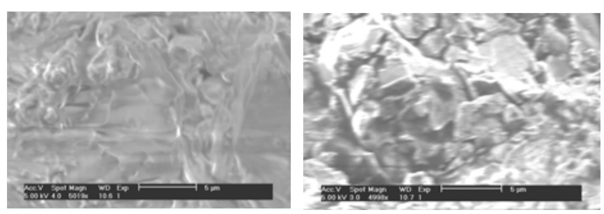

Figure 6. High magnification images of SM-8-3/1

Results: The four fragments of matrix discussed here were obtained from two coherent pieces of matrix isolated from the meteorite. All but one show the expected structure of blocky coherent fragments with fractures and included grains (Figs. 1a, 3a, 4a). One fragment (Fig. 2a) had an irregular fluffy appearance. This major difference in texture was despite three of the four pieces being from the same original blocky fragment. These differences in texture persist in the high magnifications (Figs. 5 and 6).

Compositionally, all four fragments contain abundances of most elements that are within a factor of about two of CI composition, and very similar to the average composition of opaque matrix given by earlier workers (Fig. 8). In fact, fragment SM-4-1/1 has a composition indistinguishable from mean Semarkona, including a sulfur depletion relative to CI chondrites. One region on SM-8-3/2 (region 2) has depletions in Si and Mg and is presumably a region enriched in feldspar. SM-4-1/2 contained high Na, Al, Ca (possibly) and Mn, suggesting that this fragment might be enriched in feldspathic glass. In samples SM-4-1/2 and SM-4-1/3 the analysis contained 1.72 and 1.24 wt% zirconium.

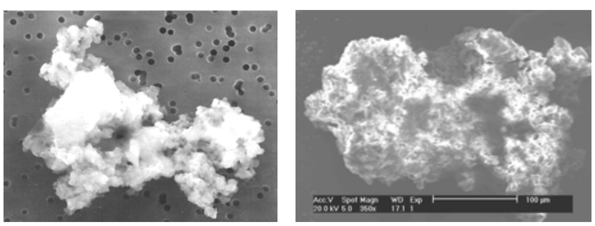

Figure 7. Comparison of a porous interplanetary dust particle (left) [4] and SM-4-1/2 (right).

Discussion: It is significant that one of our four matrix fragments (from two pieces originally extracted from the meteorite) had a porous texture: a texture that showed a marked difference from the others and a great similarity to porous IDPs (Fig. 7). This is despite Semarkona being a well-lithified rock. We speculate that most fragments mechanically removed from the meteorite will have contact surfaces, produced by pushing the porous matrix against mineral grains or chondrules. Only occasionally will a truly interior texture be revealed, and then it will be the fluffly texture of SM-4-1/2. This being so, we are observing in fragment SM-4-1/2 the original texture of the fine-grained matrix, a texture similar to that produced in various comet simulations and theoretical models where fine dust aggregates come together under microgravity to produce the primitive material that was the starting material of solar system solids [8].

Alternatively, this fluffy texture could be the result of hydrothermal alteration of compact fine-grained matrix. Consistent with this, the feldspathic composition is more prone than mafic phases to aqueous alteration. However, if this were the case we might expect to see depletions in Ca, which is not observed.

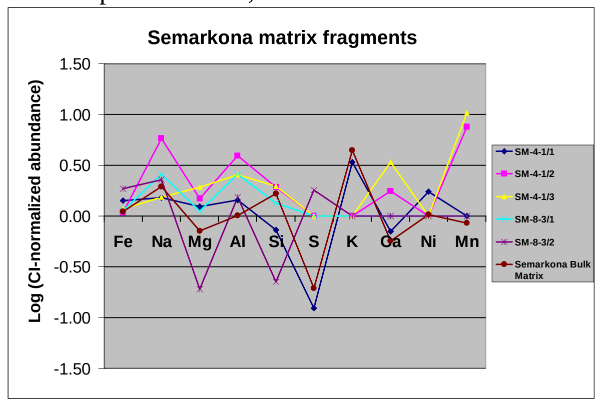

Figure 8. Elemental abundances of the four 100-μm matrix samples extracted from the Semarkona meteorite, normalized to CI abundances. The Semarkona bulk matrix data are the average of six 10 μm beam EMPA analyses [7]. Despite their small size and means of extraction from the meteorite, the fragments are close to CI in composition and SM 4-1/1 is remarkably close to mean Semarkona opaque matrix.

The presence of Zr is most readily explained by the presence of monoclinic ZrO_2 (badelleyite [7]). According to Rubin, this phase has been observed in CV3 and CO3 chondrites where it is thought to form by shock-induced thermal decomposition of presolar tetragonal $ZrSiO_4$ via the following reaction:

$$ZrSiO_4 \rightarrow ZrO_2 + SiO_2$$

Conclusion: Fragments of fine-grained opague matrix (~100 μm) handpicked from the Semarkona LL3.0 chondrite have compositions resembling bulk analysis of the matrix and CI chondrites, suggesting that the matrix is fairly homogeneous. Textures sometimes resemble those of fluffy IDP's. Baddelleyite is probably present as an altered primary phase.

References: [1] Sears *et al*. (1995) *Meteoritics* **30** 169-181. [2] Sears *et al.* (1980) *Nature* **287**, 791-795. [3] Gucsik *et al.* (2007) *LPS XXXVIII*, (this volume). [4] Huss *et al.* (1981) *GCA* **45**, 33-51. [5] Bradley and Brownlee (1991) *Science* **251**, 549-552. [6] Brownlee *et al.* (2006) *LPS XXXVII* #2286. [6] Hutchison *et al*. (1987) *GCA 51*, 1875-1882. [7] Sears *et al.* (1999) *MAPS* **34**, 497-525. [8] Rubin A. (1997) *MAPS*, **32**, 231-247.