ABERRATION-CORRECTED STEM OF Q-RICH SEPARATES FROM THE SARATOV (L4) METEORITE.

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Introduction: Saratov is a thermally metamorphosed L4 meteorite in which nanodiamond and SiC are lost. However the carrier(s) of the “Q” noble gases, which are thought to date to the formation of the solar nebula or earlier, are retained. Recent analysis of the noble gas content of physical separates from acid-resistant residues of Saratov show very high Q-gas concentrations, with the AJ separate setting the record most Xe contained in a chondritic material [1]. Although it is most commonly believed that the carrier(s) of the Q-gases are carbonaceous, due to loss of the gases with oxidation treatment [2], the exact nature of the carbonaceous phase(s) has yet to be determined. Prior TEM studies of Q-containing residues from Allende [3] have indicated the presence of domains of curled graphene, however these residues contained multiple carbon morphologies, making it difficult to identify the true carrier(s). We report here on TEM and aberration-corrected STEM analysis of two nanodiamond- and SiC-free Saratov (L4) separates, AJ (most Q-rich) and AI (Q-rich).

Methods: Residues of Saratov (L4) were prepared by HF-HCl acid treatment and repeated colloidal separation [1]. AJ and AI are the non-colloidal and colloidal fractions, respectively, of the third separation. For electron microscopy studies, the samples were pipetted onto lacey carbon films on Cu TEM grids. Conventional bright-field imaging, high-resolution imaging and selected area diffraction studies were performed with the JEOL 2200FS TEM at NRL. Aberration-corrected STEM imaging and electron energy loss spectroscopy (EELS) studies were carried out with the Nion UltraSTEM 100 at ORNL, operated at 60 kV with a nominal probe size of 120 pm.

Results and Discussion: Conventional TEM results confirmed that both the AJ and AI separates contained aggregated carbonaceous material and chromite nanoparticles. The size of the of the carbon-chromite aggregates was significantly larger in the AJ samples than in the AI sample, although the C:chromite ratio appeared similar. Electron diffraction patterns obtained from the carbonaceous phase revealed distinct rings corresponding to graphene (100) and (110) d –spacings, but no evidence for (hk2l)-type graphite d-spacings. The carbon morphology was difficult to determine by TEM, due to the lack of crystallinity, and the overlap of multiple nanoscale domains. STEM images showed that sample consists of 1 to 100 nm graphene platelets with curled edges, and that the platelets are frequently stacked 2-5 sheets thick. EELS low-loss and C K-edge spectra confirm the sp^2 graphene bonding, without long-range graphitic order.

References: [1] Amari S. and Matsuda J. 2012. Abstract #1051 43rd Lunar & Planetary Science Conference. [2] Lewis et al. 1975. Science, 190, 1251-1262. [3] Matsuda J. et al. 2010 GCA, 74, 5398-5409.