DIAMOND, BUCKY-DIAMOND, GRAPHITE-DIAMOND, AL-SILICATE, AND STISHOVITE IN THE GUJBA CB CHONDRITE

L.A.J. Garvie[1], P. Németh[2], P.R.Buseck[3,4], [1]Center for Meteorite Studies, Arizona State Univ., USA. [2]Institute of Nanochemistry and Catalysis, Chemical Research Center/Hungarian Academy of Sciences, H-1025 Budapest, Hungary. [3]School of Earth and Space Exploration, Arizona State Univ., USA. [4]Department of Chemistry and Biochemistry, Arizona State Univ., USA.

Introduction: Gujba is a coarse-grained carbonaceous chondrite dominated by silicate globules, large metal globules, and dark interstitial matrix [1]. It shows evidence of shock stage S2 [1]. Features indicating higher shock pressures are evident in the matrix, consisting of fine-grained metal and silicate that resembles the shock veins in ordinary chondrites. Several high-pressure (HP), shock-produced phases occur. These include majorite, wadsleyite, and coesite [2]. The wadsleyite and majorite indicate maximum localized pressures and temperatures of ~19 GPa and ~2000 °C [2]. There are no prior reports of diamonds in Gujba, but they were described from Bencubbin, where some of the diamonds are thought to have formed via solid-state transformation of pre-existing graphitic material from an intense shock event [3]. As part of our ongoing study of the fine-grained materials in primitive meteorites, we used transmission electron microscopy (TEM), selected-area electron diffraction (SAED), and electron energy-loss spectroscopy (EELS) to investigate the acid-insoluble material from Gujba.

Methods: The HF/HCl residue was separated by acid digestion of several millimeter-sized pieces of the dark interstitial matrix. The acid removed most silicates, sulfides, and metals, leaving a black powder. A droplet of the residue in suspension with water was dried on a Cu TEM grid coated with lacy-C. TEM data were acquired where electron-transparent areas of the residue protruded over the holes of the grid. High-resolution (HRTEM) and SAED data were acquired with Tecnai F20 and JEOL JEM 4000EX electron microscopes. EELS data were acquired with a GATAN 766 DigiPEELS spectrometer attached to a Philips 400-ST TEM.

Results and Discussion: TEM images of the acid residue show abundant carbonaceous aggregates and lath-shaped stishovite. Stishovite laths to 1 micron long are common. A combination of HRTEM, SAED, and EELS measurements from multiple carbonaceous aggregates show a range of crystallinities and structures that include amorphous to poorly graphitized carbon, well-ordered graphite, rounded to euhedral diamonds, and clumps of nanodiamonds. Hollow, amorphous carbonaceous nanoglobules similar to those in primitive meteorites [4] also occur. A crystalline phase with composition $Al_{1.95\pm0.2}SiO_{4.98\pm0.5}$ occurs in the residue, but its cell constants do not match those of any known Al silicate. Prominent in the HRTEM images are 50-nm particles that show various proportions of parallel 0.350- and 0.206-nm fringes that presumably reflect highly local regions of graphite and diamond structure, respectively. Associated with the graphite-diamond are rare bucky-diamond composed of a nanodiamond core surrounded by curved graphite layers. The unique HP mineral assemblage in Gujba may be the result of its unusual macroscopic structure composed of mm-sized spheres surrounded by silicates. Shockwaves traveling through materials of highly variable densities produce heterogeneous and localized shock pressures and temperatures [5].

References: [1] Rubin A.E. et al. 2003. GCA 67, 3283. [2] Weisberg M.K., Kimura M. 2010. MAPS 45,873. [3] Mostefaoui S. et al. 2002. EPSL 204,89. [4] Garvie L.A.J., Buseck, P.R. 2004. EPSL 224, 431. [5] Stöffler et al. 1991 GCA 55, 3845.