THREE VERY HIGHLY SHOCKED UREILITES NWA 4165, NWA 6871 AND NWA 7195: EVIDENCE FOR RECRYSTALLIZATION AND MELTING OF SILICATES AND VAPORIZATION OF GRAPHITE AND DIAMOND.

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Many ureilites have experienced significant shock, with the production of microdiamond from former graphite [e.g.,1]. However, some ureilites (including Almahata Sitta, [2]) have experienced much higher shock pressures and temperatures, resulting in complete recrystallization of olivine and pyroxene, and even partial melting. Three different, extremely hard ureilite stones from Northwest Africa have features indicative of extreme shock conditions that affected all of their constituent phases.

Each specimen consists of olivine ($Fa_{18.3-19.7}$) and low-Ca pyroxenes ($Fs_{17.3}Wo_9$; $Fs_{13.2}Wo_{3.6}$; $Fs_7Wo_{10.2}$) with accessory graphite, microdiamond, and in NWA 7195 unusually abundant irregular thin wisps and shreds composed of kamacite+taenite (11 vol.%) and troilite (12 vol.%). Based upon established shock stages for olivine [3], the total shock increased in the sequence NWA 4165 (S5/S6) → NWA 6871 (S6) → NWA 7195 (>S6).

NWA 4165: Olivine is recrystallized with intact original grain boundaries, and grainsize is 0.5 mm to 0.02 mm. Any shock characteristics from previous shock episodes were destroyed during recrystallization, as were reduction characteristics. Moderate thermal decomposition of graphite has apparently occurred, with retention of grain boundaries, loss of basal cleavage and some internal distortion, but diamonds are plentiful.

NWA 6871: Olivine is more recrystallized (grainsize <0.1 mm). Graphite is brecciated and, together with some kamacite, taenite and Ni-poor metal, is distributed throughout the brecciated, recrystallized matrix. Major loss of ribbon-like morphology in graphite is attributed to extensive thermal decomposition (sublimation?). “Graphite” is present as irregularly shaped, spongy globs containing SiO_2 flakes, possibly from partial melting and dissociation of enclosing silicates. Diamonds are sparse.

NWA 7195: Both olivine and pyroxene consist of aggregates of tiny subgrains (<0.02 mm), and have quench melt poikilitic texture together with interstitial glass. There is apparent compression flow orientation of matrix, metal and graphite. Graphite has apparently undergone severe thermal decomposition, and diamonds are sparse. Carbon, metal and silicate glass are intermixed at globular carbon boundaries, and there is evidence of elemental contamination in carbon from melted silicates. The distributed metal+troilite may represent admixed exotic impactor material.

Comparisons with Almahata Sitta: Our parallel studies of several thin sections of Almahata Sitta indicate an even higher shock stage, entailing complete melting of silicates with fine-grained quench crystallization (grain size <0.02 mm). Carbon globules and stringers enclosing tiny metal spheres and glassy silicate rafts imply that even carbon phases melted. Diamonds occur only in rare surviving graphite patches.

References: [1] Karczemska A. et al. 2009. *JAMME 37/2*: 292-297 [2] Zolensky M. et al. 2010. *MAPS 45*: 1618-1637 [3] Stöffler D. and Grieve R. 2007. *In* Metamorphic Rocks, eds. Fettes D. and Desmons J., p. 82-92. Cambridge Univ. Press.