NORTHWEST AFRICA 8709: A RARE BUT REVEALING TYPE 3 ORDINARY CHONDRITE MELT BRECCIA.

A.M. Ruzicka[1], M. Hutson[1], J.M. Friedrich[2], P.A. Bland[3], R. Pugh[1] [1]Portland State University, Portland, OR, USA. E-mail: ruzickaa@pdx.edu. [2]AMNH, Dept. Earth and Planetary Sciences, NY, NY 10024 USA and Fordham University, Dept. Chemistry, NY, NY 10458 USA. [3]Dept. Applied Geology, Curtin University, GPO Box U1987, Perth, Western Australia 6845, Australia.

Introduction: NWA 8709 is classified as an L3-melt breccia consisting of chondrules and fragments set in an igneous-textured matrix composed chiefly of fine-grained (<5-10 µm) silicates together with metal-sulfide globules that can reach up to ~40 µm in diameter [1]. Such melt breccias are exceedingly rare (they comprise only ~0.1% of all ~43,000 named ordinary chondrites) and type 3 melt breccias are rarer still, with only one other known (NWA 7120) [1]. Despite their rarity, they provide important clues for shock-processing, especially for compaction processes that must have contributed to the lithification of what are expected to have been initially porous primordial chondritic agglomerates [2].

Methods: We studied the petrography, chemistry, and structure of NWA 8709 with optical microscopy, SEM, EMPA, ICP-MS, X-ray computed microtomography (µCT) methods, and oxgyen isotope analyses to better understand the physical, chemical, and thermal processes affecting the rock.

Results: Our data show that all of the matrix in NWA 8709 was melted, to form a fine-grained assemblage dominated by low-Ca pyroxene (Wo_{1-8} Fs_{8-22}), olivine (Fa_{15-19}), feldspathic glass, sulfide (troilite) and metal (martensite). The mesostasis portions of chondrules also were partly melted, by a shock event that resulted in shock stage S4 characteristics for chondrule olivine. Largely unmelted chondrule olivine (range Fa_{2-21}, commonly Fa_{15-18}) and low-Ca pyroxene (range Fs_{2-22}) grains are locally "blackened" with troilite-rich inclusions and veinlets, whereas other areas are not blackened in the same way probably because they solidified from melt. Chondrules are tightly packed, sometimes sintered, with long axes aligned. Affinity with L-group chondrite is inferred on the basis of chondrule size (commonly up to ~0.7 mm diameter) and O-isotope composition ($\delta^{18}O = 4.83 \pm 0.34$ ‰, $\delta^{17}O = 3.34 \pm 0.15$ ‰, N=4), but mineral chemistry is not fully consistent with established chondrite groups and most closely resembles H chondrites.

Discussion: The data for NWA 8709 show an apparent mismatch between melted matrix and largely unmelted, deformed chondrules. However, these characteristics conform to those expected for shock-compaction of a mixture of porous matrix and non-porous chondrules, as hydrocode models show that heating effects will be concentrated in the matrix [2]. With compression of initial high-porosity matrix, complete melting of matrix could be achieved for impact velocities of ~5 km/s despite average chondrule peak pressure as low as 15 GPa. The rarity of ordinary chondrite melt breccias similar to NWA 8709 could be explained if most chondrites experienced a series of weaker initial shock compactions; NWA 8709 instead appears to have experienced a strong early shock compaction.

References: [1] *Meteoritical Bulletin Database*, http://www.lpi.usra.edu/meteor/metbull.php, accessed May 13 2015. [2] Bland P.A. et al. (2014) *Nature Communications* 5:5451, doi 10.1038/ncomms6451.