THE ORIGIN AND PROCESSING OF MAGNESIAN GLASS IN LUNAR METEORITE NORTHWEST AFRICA 10404.

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Introduction: Northwest Africa (NWA) 10404 is a unique, lunar meteorite [1,2]. Its chemical composition suggests a feldspathic character with moderatly low abundances of incompatible elements. Petrographically, it is composed of a mostly vitric, highly vesicular matrix that embeds mineral and lithic clasts dominated by anorthite-rich types. Another prominent clast type are partly devitrified glass fragments that exhibit reaction textures. Our study focuses on these glass fragments with the objective to resolve their petrogenesis and precursor rocks.

Sample & Methods: We analyzed the composition and petrography of 20 glassy clasts in our 4.8 cm^2 petrographic thin section of NWA 10404 with a Jeol JXA-8530F electron microprobe at the LeRoy Eyring Center for Solid State Science at Arizona State University. Least squares melt mixing calculations using the method of [3] were then used to determine possible lunar progenitor rocks that produced the glasses in NWA 10404.

Results: *Petrography of glassy clasts.* The 20 glass clasts are 0.6 to 2.7 mm in size. Ten of them exhibit relict, isotropic cores <5 to >70% of the particles' areas. More commonly, the glassy clasts are composed of a crypto-crystalline mesostasis that contains fibrous crystals. Shapes range from rounded to amoeboid and sub-angular, some are corroded and show voids at the contact with the vitric breccia matrix. Most glassy particles contain round to oval vesicles up to 0.3 mm in size. Some glass particles exhibit protrusions into the breccia matrix. In other particles, there is evidence for small-scale assimilation of clastic matrix material and embayments where plastic deformation of the glassy material is evident. A few glass particles exhibit relicts of complex rims that may include fine accreted ash particles. Other rims show radial shrinkage cracks that are sometimes associated with acicular to blade-shape crystals. Typically, such rims are discontinuous and vary depending on the nature of the host breccia, suggesting some reaction with a hot breccia groundmass.

Compositions of glassy particles: The 20 analyzed glassy particles are remarkably similar in composition; there is no significant compositional difference between the relict cores and cryptocrystalline domains surrounding them. All are feldspathic (26.5–28.2 wt% Al_2O_3) and their CIPW-normalized compositions suggest they are troctolitic anorthosites, noritic anorthosites, and anorthositic norites [4]. Their Mg/(Mg+Fe) [mol%] range from 73–82. Na and K concentrations are typically below or close to 0.03 wt%; average Ca/(Ca+Na+K) [mol%] of 99 suggest Na and K were lost during the formation of these glasses. Analyses that are on the porous outer rims show slight enrichments in Na_2O. All glassy components have low Mg/Al [wt%] of 0.27-0.37, indicating impact origins [4]. Ni and Co abundances are typically near or below 0.02 wt% in the glassy particles and no metal or troilite was found as inclusions in them.

Mixing calculations: Preliminary melt mixing calculations (following [3]) indicate the average composition of glassy particles in NWA 10404 could have been generated by mixing 3 to 8 wt% Mg-rich lunar lithologies such as troctolites, gabbronorites and/or dunites [6] with the estimated composition of the feldspathic upper crust [7]. If ferroan anorthosite compositions are used, only an addition of ~25 wt% mela-olivine gabbro norite 67667 yields reasonable results; our melt mixing calculations indicate ordinary chondrites are unlikely admixed impactor components.

Discussion: Lunar meteorite NWA 10404 contains Mg-enriched glassy clasts whose shapes and contact relationships suggest they were emplaced as impact spherules and deformed during reheating of the regolith breccia. The concentric devitrification textures suggest reheating occurred during the event that vitrified and vesiculated the breccia groundmass, which was likely the impact that launched NWA 10404. The glassy clasts are more magnesian and depleted in thermally labile elements than the whole rock composition of NWA 10404. This supports their interpretation as impact spherules that lost thermally labile elements during fusion and a formation distant from the regolith in which they were emplaced. We identified feldspathic crust with admixed Mg-rich lunar rocks as plausible source lithologies for the glassy clasts in NWA 10404. This could indicate formation in a large cratering event that excavated deep-seated lithologies or an impact in the feldspathic highlands where Mg-rich lithologies occur. Alternatively, a Mg-rich achondritic impactor may have been the source for the magnesian character of the glassy clasts in NWA 10404.

References: [1] Korotev R. L. & Irving A. J. 2016. Abstract #1358. 47th Lunar & Planetary Science Conference. [2] Kuehner, S. M. et al. 2016. Abstract #2246. 47th Lunar & Planetary Science Conference. [3] Korotev R. L. et al. 1995. *Journal of Geophysical Research* 100:14,403–14,420. [4] Stöffler D. et al. 1980. *Conference on the Lunar Highlands Crust*, Papike J. J. & Merrill R. B. (eds.):51–70. [5] Delano J. W. 1986. *Proceedings of the Lunar and Planetary Science Conference* 16:D201–D213. [6] Papike J. J. et al. 1998. *Planetary Materials*, Papike J. J. (ed.) Reviews in Mineralogy v. 36: 5-1–5-234. [7] Korotev R. L. et al. 2003. *Geochimica et Cosmochimica Acta* 67: 4895–4923.