EXAMINATION OF MULTIPLE LITHOLOGIES WITHIN THE PRIMITIVE ORDINARY CHONDRITE NWA 5717. M. J. Cato[1,2] , J. I. Simon[2], D. K. Ross[2,3,4], and, R. V. Morris [1]Geosciences and Natural Resources Dept., 331 Stillwell Building, Western Carolina Univ., Cullowhee, NC, 2872, USA, mjcato1@catamount.wcu.edu, [2]Center for Isotope Cosmochemistry and Geochronology, ARES, NASA JSC, Houston, TX 77058, USA, [3]Jacob JETS, NASA Johnson Space Center, Houston, TX 77058, [4]UTEP-CASSMAR.

Introduction: Northwest Africa 5717 is a primitive (subtype 3.05) ungrouped ordinary chondrite which contains two apparently distinct lithologies. In large cut meteorite slabs, the darker of these, lithology A, looks to host the second, much lighter in color, lithology B (upper left, Fig. 1). The nature of the boundary between the two is uncertain, ranging from abrupt to gradational and not always following particle boundaries. The distinction between the lithologies, beyond the obvious color differences, has been supported by a discrepancy in oxygen isotopes and an incongruity in the magnesium contents of chondrule olivine [1].

Here, quantitative textural analysis and mineralogical methods have been used to investigate the two apparent lithologies within NWA 5717. Olivine grains contained in a thin section from NWA 7402, thought to be paired to 5717, were also measured to re-examine the distinct compositional range among the light and dark areas.

Procedure: Particles from a high-resolution mosaic image of a roughly 13x15cm slice of NWA 5717 were traced in *Adobe Photoshop*. Due to the large size of the sample, visually representative regions of each lithology were chosen to be analyzed. The resulting layers of digitized particles were imported into *ImageJ*, which was used to measure their area, along with the axes, the angle from horizontal, and the centroid coordinates of ellipses fitted to each particle following the approach of [2]. Resulting 2D pixel areas were converted to spherical diameters employing the unfolding algorithm of [3], which outputs a 3D particle size distribution based on digitized 2D size frequency data. *Spatstat* was used to create kernel density plots of the centroid coordinates for each region. X-ray compositional maps, microprobe analyses, and Mossbauer spectroscopy was conducted on a thin section of NWA 7402, tentatively paired to NWA 5717 [4].

Results: The macro textural data produced in this study cannot confirm the presence of two distinct lithologies. As shown in Table 1, neither lithology differs greatly from the other in any textural aspect. While this difference appears to be significant, it becomes important to assess whether it is truly a result of separate lithologies or larger scale heterogeneity within the sample as a whole affecting individual digitized regions.

Sample Portion	Angle from Horiz.	Circular Diameter (μm)	Aspect Ratio	Vol. % Grains
All	81.4±49.9	393±649	1.67±0.55	0.87
Dark	79.7±49.1	423±657	1.69±0.58	0.88
Light	84.4±51.1	337±644	1.64±0.50	0.85
NWA 5717	**Core Fa**	**Rim Fa**	**Ferroan Ol Cr_2O_3**	**$\Delta^{17}O$**
Dark	9.7-20.8	16.2-35.6	0.23-0.91	0.539, 0.554
Light	0.03-3.4	17.2-27.5	0.28-0.78	0.061, 0.080
NWA 7402	**Fa Range**	**Fa Avg.**	**Ferroan Ol Cr_2O_3**	
Dark	0.46-29.8	15.1	0.01-0.78	
Light	0.29-29.6	11.6	0.07-0.62	

Table 1. Comparison between proposed lithologies in NWA 5717 and 7402 data (cf. [5]). Angle from horizontal, circular diameter, aspect ratio, and volume percent means are a result of digitization. Reported uncertainties are standard deviation from the mean. Core Fa, rim Fa, Cr_2O_3, and oxygen isotopes were reported in [1], which contains ranges and multiple measurements.

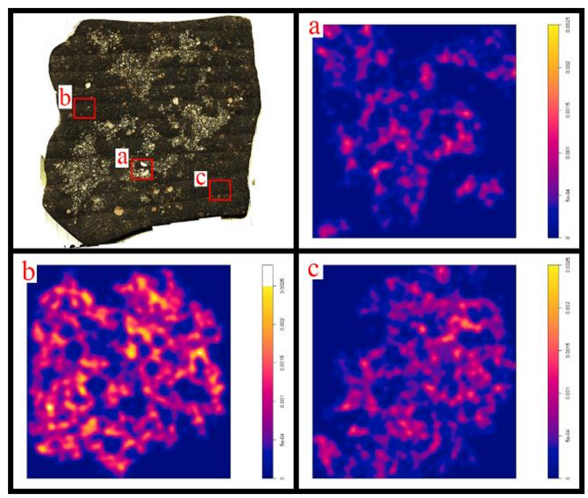

Figure 1. (upper left) Low-resolution mosaic image of NWA 5717 slab showing independence of grain size variations to lithology. Regions (b) and (c) both contain only the dark and (a) is primarily the light lithology. (insets) Kernal density plots of three regions within the slab of NWA 5717 with increasing density as the color shifts from blue to yellow show potential particle 'clumping'.

Figures 1 and 2 show localized particle size heterogeneity that extends across the entire sample, but that it is largely irrelevant of the lithologies boundaries. The kernel density plots in Figure 1 along with the spread in Figure 2a confirm the existence of a broad particle size distribution similar to that reported by [6,7] for the Allende chondrite. The size distributions b and c in Figure 2, however, show that within individual digitized regions both the light and dark lithologies are indistinguishable. Due to the possibility of inconsistencies in sampling, regions that appeared unreliable in the smallest size fraction post-processing (<200 um), cf. [8] are not shown.

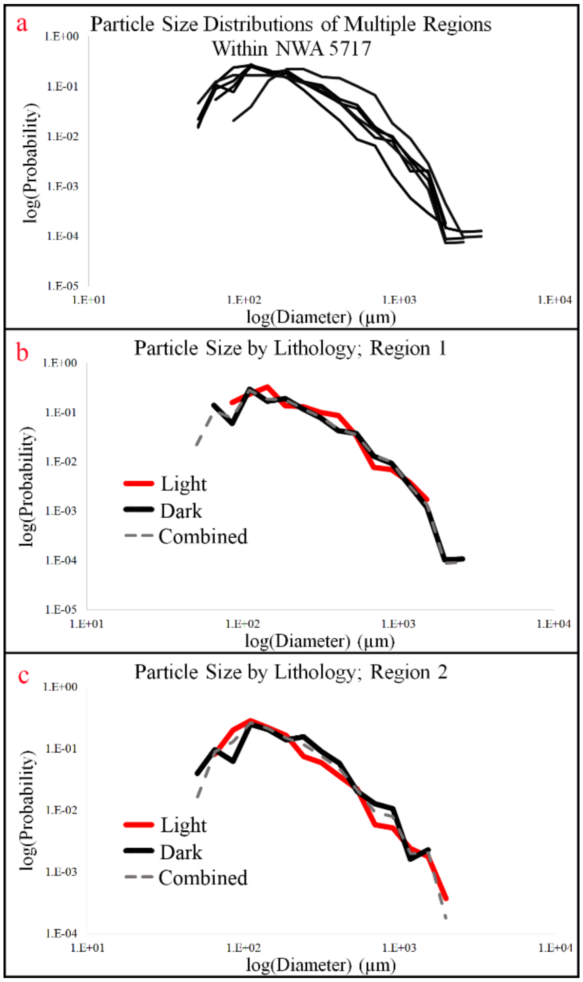

Figure 2. Log-log plot showing particle size versus normalized relative frequency. Chart (a) contains a suite of complete regions from across the sample, with (b) and (c) showing the breakdown between light and dark lithologies within two separate regions.

In contrast to NWA 5717, shown in Table 1 [1], chromium content of the olivine from NWA 7402 lithologies are indistinguishable. Moreover, they do not fall on the trend established for unequilbrated ordinary chondrites [9] consistent with the work of [4].

Likewise, X-ray compositional maps of NWA 7402, shown in Figure 3, provide little visual evidence for any heterogeneity between the lithologies beyond a slight increase in sulfide and metallic iron grain size in the light region [5]. This is confirmed with Mossbauer spectra, which shows small peaks for sulfides and metallic iron in the light lithology not present in the dark lithology (subset fig. 3).

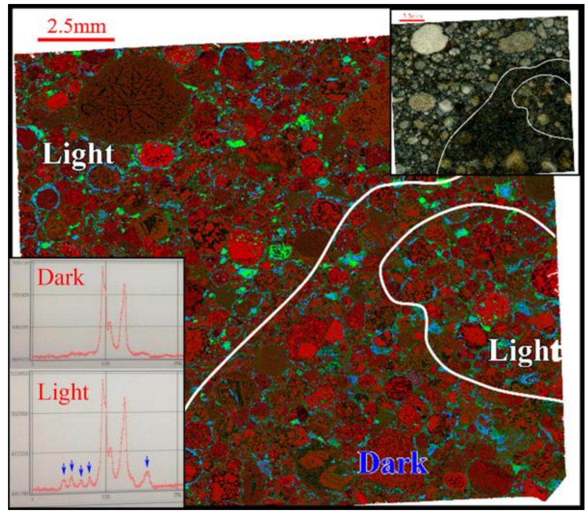

Figure 3. X-ray composite map of a thin section of NWA 7402 with R=Mg, G=Fe, B=S; Green=Metallic Iron & Iron Oxides, Red=Mg bearing silicates, Teal=Sulfides. White line roughly denotes boundary region. Subset image of pre-cutting thin section area (top right) and Mossbauer spectra (bottom left) with arrows denoting metallic iron peaks.

Preliminary Conclusions: (1) We were unable to show any significant differences between the light and dark lithologies based on either our textural analyses for chemical data. The inconsistencies between our major element data and that presented by Bunch et al. may be a result of an incorrect pairing with NWA 7402. Additional direct chemical measurements of NWA 5717 are needed.

(2) Could NWA 5717 indicate particle 'clumping' and minimal alteration (light) and nebular alteration (dark)? This hypothesis is supported by the "heavy" oxygen signature and the breakdown of the sulfide and iron metal gains in the dark regions of NWA 5717 (Figure 4, and confirmed by Mossbauer). A more thorough examination of the oxygen isotopes within individual chondrules along with further textural analysis of the two lithologies have the potential to provide important insight into nebular alteration and/or accretion (Cuzzi et al., this meeting) of primitive planetary bodies in the protoplanetary disk.

References: [1] Bunch, T. E. et al. (2010) 41st *LPSC*, Abst. #1280. [2] Tait, A. W. et al. (2016) *EPSL*, 454, 213-224, [3] Cuzzi, J. N. and Olson, D. M. (2016) *MAPS, in press*. [4] The Meteorit. Bull. No. 104 [5] Jilly-Rehak, C. E. et al. (2016) *Chemie der Erde*, 76, 111-116, [6] Fisher, K. R. et al. (2014) 45th *LPSC*, Abst. #2711, [7] McCain, K. A. et al. (2015) 46th *LPSC*, Abst. #2896, [8] Srinivasan, P. et al., (2013) 44th *LPSC*, Abst. #2580, [9] Grossman, J. N. and Brearley, A. J. (2005) *MAPS*, 40, 87-122.