INITIAL RESULTS OF STRUCTURAL ANALYSIS OF UREILITES TO INVESTIGATE THE POSSIBLE OCCURRENCE OF SHEAR DEFORMATION ON THE UREILITE PARENT BODY. B. J. Tkalcec and F. E. Brenker, Goethe University, Institute of Geoscience, Altenhöferallee 1, 60438 Frankfurt am Main, Germany. tkalcec@em.uni-frankfurt.de

Introduction: Although the ultramafic composition [1] of ureilites indicates that they derive from a large, differentiated asteroid, the wide variety in ureilite $\Delta^{17}O$ values indicates that the ureilite parent body (UPB) never completely melted [2]. One explanation is that, according to age models based upon Hf-W data [3], accretion of the UPB at ~1.6 Ma after CAI formation was relatively late compared to that of iron meteorite parent bodies (more than ~1 Ma earlier). The amount of ^{26}Al provided by such a late accretion would be insufficient for total melting [3], preventing the UPB from achieving complete differentiation. This is supported by the smaller ^{182}W deficits of ureilites relative to those of most magmatic iron meteorites [3] which indicate that silicate melt extraction on the UPB postdated core formation on iron meteorite parent bodies by 2-3 Ma. Furthermore, geochemical data [4] attest to an efficient segregation of S-rich metallic Fe-FeS melts but with hampered core formation due to insufficient percolation. In order for a small S-rich core [5] to be achieved on the UPB, other factors, such as shear deformation, must be considered that could enhance the segregation rates of liquid metal from silicate matrix [6]. We have begun a structural investigation of olivine-rich ureilites to determine whether there is any evidence for plastic deformation that would attest to the occurrence of shear deformation on the UPB. Here we present our first results for three ureilite samples.

Samples: Three unbrecciated ureilite samples were investigated: NWA 8551 as thick section, NWA 7630 as 30 µm thin section and NWA 7525 as thick section. They were classified by the Meteoritical Bulletins (Nos. 103 and 102) and as no shock, low shock and medium shock, respectively, and all with low-weathering. NWA 8551 is composed of coarse-grained (1-2 mm) olivine and pyroxene grains that are texturally equilibrated, displaying triple junctions and Fe-depleted rims. NWA 7630 is of dunitic composition with 90 vol% olivine and minor pigeonite. NWA 5725 is composed of olivine and pigeonite with some graphite and metal grains.

Analytical Methods: The samples were initially investigated using using scanning electron microscopy (SEM) to compile an overview of the sample surface with stitched BSE images. This provided us with phase distribution information and facilitated the determination of any foliation. Geochemical information was provided in more detail by energy dispersive x-ray (EDX) analysis. Finally, electron backscatter diffraction (EBSD) was performed both on olivine grains in all three samples to investigate any shape-preferred (SPO) or lattice-preferred (LPO) orientation. An accelerating voltage of 15 kV and a working distance of 20 mm were maintained. Only measurements with a mean angular deviation <1.0 (manual) and <1.3 (automatic scanning) were accepted and recorded. Ambiguous results were verified using EDX.

Results: The non-shocked NWA 8551 displayed an ENE-WSW foliation and Fe-oxide veins. Many grains were elongated in a NE-SW orientation and several grains were observed to be fish or sigma-shaped. Cauliflower-features are present mainly around the Fe-oxide veins and olivine grain and subgrain boundaries but absent at pyroxene boundaries. Closer investigation showed these features to consist of abundant fine-grained “tadpole”-shaped Fe-oxide grains. EBSD results of NWA 8551 show a preferred orientation with a fabric strength quantified by an M-index of 0.13.

The low-shocked dunitic NWA 7630 displays NW-SE trending veins and cracks. The grains appear elongated and squeezed and display a visible NW-SE shape-preferred orientation. Some show triple junctions and subgrain formation. Intragrain cracks trend NE-SW, perpendicular to the NW-SE grain orientation. EBSD results show a clear preferred orientation with a fabric strength quantified by an M-index of 0.16. The 100 axes show a maxima perpendicular to the foliation, whereas the 001 axes show clear girdles along the foliation.

The medium-shocked NWA 5725 displays abundant equant, olivine grains, some are subrounded and many display triple junctions. Also present are a few elongated grains. Fe-oxide is present at grain boundaries. Coarse transgrain cracks trend NW-SE whereas finer intragrain veins trend NE-SW within the larger grains. EBSD results show a preferred orientation with a fabric strength quantified by an M-index of 0.05.

Discussion: All three samples showed some kind of preferred orientation indicating deformation has indeed occurred. However, the interpretation of the results does not yet offer a clear pictures as to the nature of the deformation. With NWA 8551 the occurrence of several fish or sigma-shaped grains supports the occurrence of shear deformation. The Fe-oxide cauliflower features indicate mineral transition at the olivine grain and subgrain boundaries. The coarse size and small number of grains, however, requires verification of the data points acquired for EBSD with a view to one point per grain. In NWA 7630 elongated olivine grains attest to plastic deformation, yet the apparent a-axis fabric is as yet unprecedented in terrestrial olivine and requires further investigation. In NWA 7525 the dominance of equant olivine grains observed in NWA 7525 stands in contrast to the Meteoritical Bulletin observations of "stretched" grains with a "squeezed" appearance. This may be due to sampling biasing with regard to the cut surface of the thick section sampled. Observed clusters of equant olivine crystals with triple junctions show fewer internal cracks and appear younger, possibly representing grain size reduction from dynamic recrystallization, inferring stress exposure.

Conclusion: These initial results collectively suggest the occurrence of shear deformation on the UPB but require the addressing of various issues before conclusive inferences can be made.

References: [1] Mittlefehldt D. W. et al. (1998). In: Papike J.J. (Ed.), Planetary Materials: 195. [2] Claydon R. N. & Mayeda T. K. (1996). *Geochim. et Cosmochim. Acta* 60:1999-2017. [3] Budde G. et al. (2015) *Earth and Plan. Sci. Lett.*430: 316-325. [4] Barrat J. A. et al. 2015. *Earth and Plan. Sci. Lett.* 419:93–100. [5] Warren P. H. et al. 2006. *Geochimica et Cosmochimica Acta* 70:2104-2126. [6] Rushmer T. & Petford N. 2010. *Geochemisry Geophysics Geosystems* 12: Q03014.