A PUZZLING FRAGMENT FROM THE DYALPUR UREILITE: ANOMALOUS COMPONENTS, MICROSTRUCTURES, AND GEOCHEMISTRY

L. Pittarello[1], S.M. Chernonozhkin[2], S. Goderis[3], F. Vanhaecke[2], and H. Downes[4], [1]Naturhistorisches Museum Wien - NHMW (Burgring 7, 1010 Vienna, Austria; lidia.pittarello@nhm-wien.ac.at), [2]Ghent University - UGent (Krijgslaan 281-S12, 9000 Ghent, Belgium; stepan.chernonozhkin@ugent.be, frank.vanhaecke@ugent.be), [3]Vrije Universiteit Brussel -VUB (Pleinlaan 2, 1050 Brussels, Belgium, steven.goderis@vub.be) [4]Birkbeck University of London (Malet St., London WC1E 7HX, UK; downes@ucl.ac.uk)

Introduction: Ureilites are ultramafic achondrites largely accepted to be mantle restites of a disrupted asteroid, but their detailed petrogenesis is still debated [1,2]. Until the recent findings [3,4] and dedicated melting experiments [5], the only evidence of the missing felsic melts of the ureilite parent body (UPB) was represented by rare feldspathic clasts in brecciated polymict ureilites [6]. Dyalpur is a typical monomict breccia ureilite, recovered after a fall in 1872 in India [1]. Fragment BM.51185 extracted from the specimen curated at the Natural History Museum London (NHM-L) presents unique petrographic and geochemical features, which are not consistent with the earlier analyses of Dyalpur and other ureilites. Here, we present the results of detailed petrographic and geochemical studies on this fragment, in the attempt to constrain the nature of this specimen.

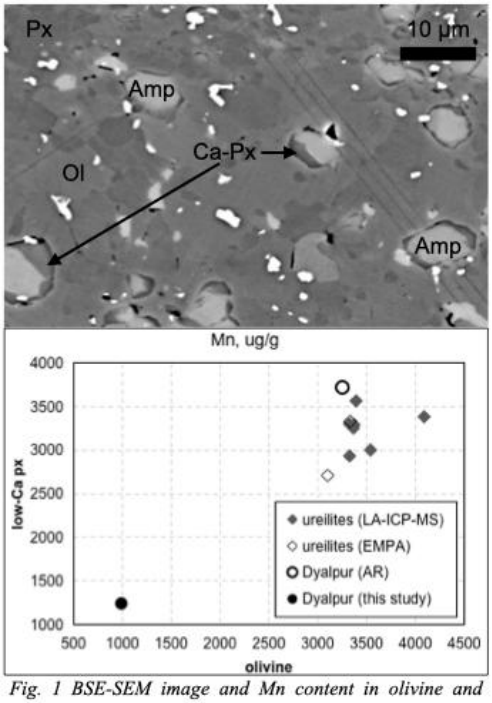

Fig. 1 BSE-SEM image and Mn content in olivine and pyroxene.

Methods: The BM.51185 polished mount was prepared at the NHM-L in 2019, and investigated by µXRF (VUB), SEM (VUB and NHMW), EMPA (NHMW), and LA-ICP-MS (UGent). SIMS oxygen isotopic analysis is ongoing at the CRPG Nancy (France).

Results: The fragment appears relatively homogeneous, crosscut by veins filled with refractory components (mainly graphite, with olivine clasts, chromite and troilite). The "homogeneous" material in fact consists of pargasite-hornblende amphibole clasts in an apparently glassy groundmass, containing micro-domains, mostly showing olivine (Fo_{91}), but also pyroxene (En_{90}) composition. The amphibole clasts display a rim of Ca-rich pyroxene ($Wo_{28}En_{69}Fs_3$) and Fe-Ni-Co tiny (<4 µm) sulfides are spread in the matrix (Fig. 1). Towards the veins, even though no shear is present and the margins are not extremely sharp, the typical Fe and Mg fractionation associated with reduction by secondary smelting of ureilites is observed. Major- and trace element compositions of olivine are different (Fig. 1) from those reported in the literature for ureilites and from previous analysis of Dyalpur fragments [1]. The same applies for the LREE-enriched patterns.

Discussion: The BM.51185 fragment presents petrographic and geochemical characteristics that are completely different not only from those reported for other fragments of Dyalpur [1 and A. Ross 2021, personal communication], but also from those for other ureilites [1,3,4,5]. Unless BM.51185 is the result of an accidental mix-up with another sample during the preparation, which is highly unlikely, this specimen reveals a highly unusual mineral assemblage and atypical geochemical trends, which are nevertheless indicative of an extraterrestrial origin. The subchondritic Fe-Mg-Mn composition of the groundmass suggests a cumulate origin, and its LREE-enriched patterns with positive Eu anomalies suggest contribution from low degree felsic melts of the UPB. However, the presence of an olivine melt with amphibole clasts, chromite and Co-bearing Fe-Ni-sulfides is extremely peculiar and difficult to explain. A possible hint might come from the oxygen isotopic composition.

Conclusion: If we assume that the BM.51185 is indeed a fragment of Dyalpur, representing a rare pocket of melt, cumulate, or xenolithic clast in the ureilite breccia, this fragment will provide further insights into the variety of processes that occurred on the UPB.

Acknowledgments: N. Almeida and H. Bates (NHM-L) are thanked for sample preparation and aid to try to reconstruct the history of the specimen. We thank A. Ross for having provided unpublished data on older fragment of the same sample from the NHM-L. W. Wegner (NHMW) is thanked for assistance with the EMPA.

References: [1] Goodrich C. A. (1992) *Meteoritics & Planetary Science* 27:327–352. [2] Rai N. et. al. (2020) *Geochemical Perspect. Lett.* 14:20–25. [3] Bischoff A. et al. (2014) *Proc. Natl. Acad. Sci.* 111:12689–12692. [4] Ziegler K. et. al. (2021) *LPSC 52,* Abstract #2548. [5] Collinet M. and Grove T. L. (2020) *Meteoritics & Planetary Science* 55:832–856. [6] Cohen B. A. et. al. (2004) *Geochim. Cosmochim. Acta* 68:4249–4266.