An uncommon terrestrial rock that was believed to be a meteorite

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Ureilites are achondrite meteorites, which can be associated to mantle restites, but containing up to 8 wt% carbon and which have experienced melting, smelting, and shock (e.g., Goodrich 1992; Goodrich et al. 2007). In the framework of a research project on isotopic zoning across olivine grains from selected ureilites (Chernonozhkin et al. subm.), a chip from Dyalpur was loaned from the Natural History Museum London (sample BM.51185). Petrographic and geochemical analysis of this sample revealed some features, which are not consistent with the previous characterization of Dyalpur and ureilites in general. However, as clasts with peculiar characteristics are not uncommon among ureilites (e.g., clast ALM-A with a trachyandesitic composition; Bischoff et al. 2014), we decided for further investigations. Oxygen isotopic ratios are close to the terrestrial fraction line, but this can also indicate mixing of different components by impact on the parent body (e.g., for angrites, Rider-Stokes et al. 2023). However, cosmogenic radionuclide measurements by accelerator mass spectrometry (Lachner et al. 2021) finally confirm a terrestrial origin of the sample. The (yet preliminary) upper limit of $^{26}Al/^{27}Al$ $4.4x10^{-12}$ corresponding to 0.3 dpm/kg (^{26}Al) measured is >60 times lower than the one of true Dyalpur sample, and also far lower than literature values for ureilites including Dyalpur (e.g., Aylmer et al. 1990).

The typically terrestrial features, including the occurrence of pargasite-hornblende amphibole and hazlewoodite (a Ni-sulfide), both never described before in ureilites, are associated with other features, which are quite uncommon for terrestrial rocks, such as the presence of carbon-rich veins inducing chemical reduction along their margin, and a Fo_{91} groundmass, embedding sub-rounded amphibole clasts. Geothermobarometric estimates (e.g., Hammarstrom & Zen 1986; Ridolfi & Renzulli 2012; etc.) on amphibole resulted in pressure estimate of 6-7 kbar and temperature estimate of 790-840 °C.

Terrestrial rocks presenting similar features are rare, mostly consisting of metasomatized peridotite-xenoliths in basalts recording breakdown of amphibole due to heating and decompression during transport (e.g., Ban et al. 2005; Kaeser et al. 2007). Further studies are planned to identify the nature of the sample and to reconstruct the case leading to its classification as Dyalpur ureilite in the collection of the NHM London.

Aylmer D, Vogt D, Herzog GF, Klein J, Fink D, Middleton R. (1990): Low ^{10}Be and ^{26}Al contents of ureilites: Production at meteoroid surfaces. - Cosmochim Acta 54, 1775-1784

Ban M, Witt-Eickschen G, Klein M, Seck HA. (2005): The origin of glasses in hydrous mantle xenoliths from the West Eifel, Germany: incongruent break down of amphibole. - Contrib Mineral Petrol 148, 511-523

Bischoff A, Horstmann M, Alix Barrat J-A, Chaussidon M, Pack A, Herwartz D, Ward D, Vollmer C, Decker S (2014): Trachyandesitic volcanism in the early Solar System. - P Natl Acad Sci USA 111, 12689 -12692

Chernonozhkin SM et al. (subm.): Early differentiation and core formation on the ureilite parent body recorded in the stable isotopic signatures of Fe, Zn and Mg.

Goodrich CA (1992): Ureilites. A critical review. - Meteoritics 27, 327-352

Goodrich CA, Orman vanJA, Wilson L (2007): Fractional melting and smelting on the ureilite parent body. – Geochim Cosmochim Acta 71, 2876

Hammarstrom JM, Zen E (1986): Aluminum in hornblende: An empirical igneous geobarometer. - Amer Mineral 71, 2876-2895

Kaeser B, Kalt A, Pettke T (2007): Crystallization and breakdown of metasomatic phases in graphite-bearing peridotite xenoliths from Marsabit (Kenya). - J Petrol 48, 1725-1760

Lachner J, Martschini M, Kalb A, Kern M, Marchhart O, Plasser F, Priller A, Steier P, Wieser A, Golser R (2021): Highly sensitive ^{26}Al measurements by Ion-Laser-InterAction Mass Spectrometry. - Int J Mass Spectrom 465, 116576

Rider-Stokes BG, Greenwood RC, Anand M, White LF, Franchi IA, Debaille V, Goderis S, Pittarello L, Yamaguchi A, Mikouchi Z, Claeys P (2023): Impact mixing among rocky planetesimals in the early Solar System from angrite oxygen isotopes. - Nat Astron (2023). https://doi.org/10.1038/s41550-023-01968-0

Ridolfi F, Ranzulli A (2012): Calcic amphiboles in calc-alkaline and alkaline magmas: thermobarometricand chemometric empirical equations valid up to 1,130°C and 2.2 GPa. - Contrib Mineral Petrol 163, 877-895