Linking volatiles and microstructures in apatite from eucrites.

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Introduction: Volatile elements play a key role in the dynamics of planetary evolution. As such there has been significant interest in their abundance and isotopic composition, particularly in the trace mineral apatite which is known to contain appreciable amounts of volatile elements [e.g. 1-4]. Whilst these works account for the textural context of the apatite grain and the surrounding minerals, the internal microstructure of the apatite has not been considered. Electron Backscatter Diffraction (EBSD) in extraterrestrial samples has mostly been used to interpret the microstructures of zircon/baddeleyite for age dating and larger-scale plastic deformation features of samples [e.g 5-7]. Recently, however, the microtextures of meteoritic and lunar apatite and merrillite have been investigated [8-10]. As apatite is one of the major hosts of volatiles in planetary materials, any variation in structure observed may affect its volatile composition. In this study we therefore investiage the microstructure of apatite grains in eucrites with previously reported H [11] and preliminary Cl [12] isotopic data in order to investigate the relationship between crystallographic features and their volatile contents and isotopic compositions.

Samples and Methods: Two samples were analysed using EBSD. These are the basaltic eucrite Dar al Gani (DaG) 844 and residual eucrite DaG 945. The Meteoritical Bulletin report these samples as having a shock grade of S2 and S1 respectively[13]. DaG 844 is a polymict basaltic eucrite in which apatite has a moderate volatile abundance and terrestrial/chondrite-like isotopic compositions. DaG 945 is a granulitic residual eucrite in which apatite display an anomalously high δ^{37}Cl value. The lattice orientation, internal microtexture, and structural disorder of the same apatite grain were investigated using EBSD on a Zeiss Supra 55VP located at The Open University. The step size used was 300 nm with binning ranging from 2 × 2 µm to 4 × 4 µm.

Results and Discussion: EBSD maps were collected for two apatite grains in DaG 844 and three in DaG 945. Apatite in DaG 844 do not produce resolvable EBSD patterns at the length scales of our analyses. Surrounding pyroxene shows a granular texture, implying recrystallisation. The structural degredation of apatite could be caused by the shock event(s) that led to brecciation of the rock. Grains of apatite, as well as of surrounding plagioclase and pyroxene, in DaG 945, on the other hand, are all very crystalline under EBSD length scales with no obvious signs of internal structural disorder. An abundant silica phase, however, associated with apatite, appears entirely amorphous. Each apatite grain shows a single crystallographic orientation. These undisturbed crystals could be either a primary magmatic feature or indicative of complete recyrsallisation. DaG 945 is known to have undergone prolonged thermal metamorphism, which could have facilitated recrystallization of apatite, with short episodes of low degrees of partial metling [14]. The DaG 844 apatite grains are linked to an appreciable amount of H_2O (~ 3700 ppm) and Cl (~ 1450 ppm) and terrestrial-like δD and δ^{37}Cl values (~ − 107 ± 72 ‰ and + 2.35 ± 1.18 ‰ respectively) [11]. For DaG 945, low H_2O and Cl contents are observed (~ 100 ppm and ~ 30 ppm respectively) [11]. Despite this, the δD values of apatite are similar to that of DaG 844 (~ + 12 ± 190 ‰). The Cl isotopic composition of DaG 945, however, is significantly enriched in ^{37}Cl with δ^{37}Cl of ~ + 35 ‰. If the thermal metamorphism that affected DaG 945 recrystallised apatite, it is possible that the volatile abundance and isotopic compositions could have been affected. If this was the case then we would expect to see both H and Cl isotopes affected, something not observed as δD values of apatite in DaG 945 are similar to other eucrites [11, 15]. Therefore, either DaG 945 apatites are primary in origin, or the recrystallisation during metamorphism did not affect their indegeneous isotopic compositions. This preliminary work appears to provide new support for the conclusion that metamorphic grade of eucrites [16] has little effect on the volatile composition of apatite. Further work will be conducted on additional apatite in eucrites to improve our understanding of how the internal structure is linked with their volatile composition.

References: [1] Sarafian A. R. et al. (2017) *Earth and Planetary Science Letters* 459:311-319. [2] Barnes J. J. et al. (2014) *Earth and Planetary Science Letters* 390:244-252. [3] Bellucci J. J. et al. (2017) *Earth and Planetary Science Letters* 458:192-202. [4] Hallis L. J. et al. (2012) *Earth and Planetary Science Letters* 359-360:84-92. [5] Tkalcec B. J. and Brenker F. E. (2014) *Meteoritics and Planetary Science* 7:1202-1213. [6] Darling J. R. et al. (2016) *Earth and Planetary Science Letters* 444:1-12. [7] White L. F. et al. (2017) *Nature Comminications* 8:15597. [8] Adcock C. T. et al. (2017) *Nature Communications* 8:14667. [9] Černok A. et al. *In Preparation*. [10] Dyl K. A. et al. (2012) *LPSC XLVI* Abstract 2927. [11] Barrett T. J. et al. (2016) *Meteoritics and Planetary Science* 51:1110-1124. [12] Barrett T. J. et al *In Preparation*. [13] Rubin A. E. et al (1997) *Geochimica et Cosmochimica Acta* 61:847-858. [14] Yamaguchi A. (2009) *Geochimica et Cosmochimica Acta* 73:7162-7182. [15] Sarafian A. R. et al. (2014) *Science* 346:623-626. [16] Takeda H. and Graham A. L. (1991) Meteoritics 26:129-134.