Cooling rates and vesiculation of shock melt pockets in shergottites

Conference or Workshop Item

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Morland Z.[1], Krzesińska A.M.[2,3]

[1]SEES, The University of Manchester, Oxford Road, Manchester, M13 9PL, UK.

[2]Dept. Earth Sciences, Natural History Museum, Cromwell Road, SW7 5DB, London, UK.

[3]Institute of Geological Sciences PAS, Wroclaw, Poland.

Corresponding author: *zoe.morland@hotmail.co.uk*

Shergottites, young subsurface Martian basalts [1], record intensive shock metamorphism [2]. Melt pockets, products of shock, are highly vesiculated reflecting the entrapment of volatiles [3] and/or atmospheric gas [4]. However, vesicle origin is not fully recognised [5]. Here we interpret the formation of vesicles in a fragment of olivine-phyric shergottite SaU005 (BM.2000,M40, 0.95g). Using X-ray CT a 3D map of shock products and enclosed vesicles was generated. Additionally, we studied textures and compositions of quenched melt pocket material in two sections, using SEM-EDX and correlated this with analysis of vesicle volume and distribution.

Shock melt pockets in SaU005 are sub-rounded objects (up to 1-2mm) obscuring original grain boundaries. Large pockets have a basaltic bulk composition, lack high-pressure polymorphs and are depleted in volatiles: S, P and Cl compared to the bulk host composition. Texturally, the pockets are composed of glass and quenched olivine and pyroxene crystallites. Smaller crystallites populate pocket boundaries, whereas larger swallowtail dendritic crystallites dominate the centre. Glassy pocket boundaries accommodate abundant small (20-40 µm) vesicles, whereas inside vesicles are rarer, but larger (200-500 µm).

Lack of high pressure polymorphs indicate that quenching occurred during the decompression stage only. This relatively long quench time enabled volatile release from the shock melt, accounting for the vesiculation. Textural changes of crystallites in melt pockets reflect heterogeneous cooling rates. A slower cooling rate in the pocket interior allowed volatiles to migrate and coalesce into larger vesicles towards the centre. Therefore, there is a distinct correlation between cooling rates and vesicle size and distribution.

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References: [1] Jones, 2015. MaPS 50: 674. [2] Walton et al., 2014. GCA 140: 334. [3] Boctor, 2003. GCA 67:3971. [4] Bogard & Johnson, 1983. Science 221: 651. [5] Shaw & Walton, 2013. MaPS 48: 758.