SERPENTINISATION OF CHONDRULES IN THE MURCHISON CM CARBONACEOUS CHONDRITE BY CENTRIPETAL REPLACEMENT AND CEMENTATION

M. R. Lee and P. Lindgren. School of Geographical and Earth Sciences, University of Glasgow, Glasgow G12 8QQ, U.K. E-mail: Martin.Lee@glasgow.ac.uk

Introduction: Aqueous alteration of CM carbonaceous chondrites has resulted in the loss of some or all of the original constituents of their matrix, chondrules and fine-grained rims. The processes and products of alteration have been explored mainly through mineralogical, chemical and isotopic analysis of the matrix [1-4], or bulk samples [5,6]. Preservation of chondrules is also related to the overall degree of alteration [1,4], and compositional relationships between primary silicates and replacive serpentines have provided new insights into the length-scale of the aqueous system [7,8]. Here we have sought to explore the mechanisms of serpentinisation of chondrule phenocrysts by studying Murchison, which is one of the least altered CMs and so should reveal processes during the earliest stages of water-mineral interaction.

Methods: We studied a polished block of Murchison (BM1970,5 P19262) loaned by the Natural History Museum (London). Grains of forsterite and clinoenstatite in type IAB chondrules were characterised by backscattered electron imaging, and their crystallographic orientations were measured by electron backscatter diffraction (EBSD) using a FEI Quanta 200F SEM. Foils for TEM were cut using a FEI DuoMill FIB instrument, and studied using a FEI T20 TEM.

Results and discussion: The forsterite phenocrysts contain veins of finely crystalline serpentine <10 micrometres wide. Most veins have serrated walls and lie parallel to (001). The serpentine fill is compositionally banded, and interfaces between bands are usually serrated. These properties indicate that the forsterite-hosted veins formed by crystallographically controlled centripetal replacement. Clinoenstatite grains have a 'skeletal' appearance [7] due to the presence of veinlets and rectilinear patches of serpentine. The veinlets lie parallel to (001), and in (010) sections of clinoenstatite grains the walls of the patches are defined by (001) and (100) planes. The (001)-parallel walls have a comb-like structure on the sub-micrometre scale, which is due to the presence of a high density of slot-shaped pores whose walls are parallel to orthopyroxene lamellae. The patches are filled by sub-micrometre sized grains of polyhedral serpentine [3] that formed by cementation of pore spaces; some of these pores originated as contraction cracks whereas others formed by dissolution. These results demonstrate the strong controls on chondrule serpentinisation by the microstructures of silicate phenocrysts.

References: [1] Browning et al. 1996. *Geochim. Cosmochim. Acta* 60:2621-2633. [2] Chizmadia and Brearley 2008. *Geochim. Cosmochim. Acta* 72:602-625. [3] Zega et al. 2006. *Meteoritics & Planetary Science* 41:681-688. [4] Rubin et al. 2007. *Geochim. Cosmochim. Acta* 71:2361-2382. [5] Howard et al. 2011. *Geochim. Cosmochim. Acta* 75:2735-2751. [6] Alexander et al. 2013. *Geochim. Cosmochim. Acta* 123:244-260. [7] Hanowski and Brearley 2001. *Geochim. Cosmochim. Acta* 65:495-518. [8] Velbel et al. 2012. *Geochim. Cosmochim. Acta* 87:117–135.

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