CO-FORMATION OF RINGWOODITE, WADSLEYITE, AND OLIVINE IN SHOCK VEINS.

L. Pittarello[1], G. Ji[2,3], A. Yamaguchi[4], D. Schryvers[2], V. Debaille[5] and Ph. Claeys[1], [1]AMGC, Vrije Universiteit Brussel, Belgium (lidia.pittarello@vub.ac.be). [2]EMAT, University of Antwerp, Belgium. [3]UMR, Université Lille, France. [4]NIPR, Tachikawa, Japan. [5]Lab. G-Time, Université Libre de Bruxelles, Belgium.

Introduction: The high-pressure polymorphs of olivine ringwoodite (Rwd) and wadsleyite (Wds) are common in shock veins in ordinary chondrites [1]. Ringwoodite is generally observed rimming olivine clasts [2-4]. Locally, the core of olivine clasts exhibits a complex structure, which suggests coexistence of different phases (e.g., [2-4]). Here we present a detailed characterization of these features with Transmission Electron Microscopy, investigating a clast in shock vein in the L6, A 09584 meteorite [5], kindly provided by the National Institute of Polar Research, Tachikawa, Japan. An interpretation of the formation process is also proposed.

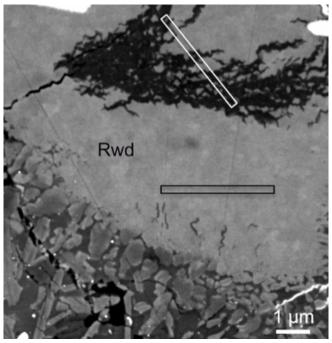

Fig. 1 *BSE-SEM image of a shocked olivine clast in A 09584.*

Results: The meteorite A 09584 probably belonging to a series of more than twenty paired meteorites, which were collected in East Antarctica by a joint Japanese-Belgian mission in 2009. Shock veins are 1-2 mm in thickness and are preferentially located along grain or chondrule margins. The matrix consists of a glassy groundmass and fine-grained aggregates of olivine acicular crystals, resembling magmatic microlites. Clasts have composition corresponding to olivine, pyroxene and plagioclase. Olivine clasts exhibit a 50 µm rim of ringwoodite and the core consists of dense network of lamellae with different composition in the olivine range (Fig.1). In detail, the ringwoodite rim consists only of equigranular nanocrystals with an average size of 500 nm and random orientation, but with internal features that resemble stacking faults and with a lower Mg# than that of olivine in the unshocked meteorite. In the core of clasts, lamellae of iso-oriented nanocrystals, with average size of 1 µm in length and 200 nm in width, are crosscut by veinlets, which consist of randomly oriented nanocrystals. The iso-oriented crystals consist of olivine and possibly wadsleyite, with relatively high Mg#, whereas the veinlets contain only olivine, with a slightly lower Mg#.

Discussion and conclusions: Formation of the ringwoodite rim is commonly related to solid state transformation due to diffusion controlled growth under high temperature conditions [2-4, 6]. An alternative hypothesis is fractional crystallization from olivine melt under shock pressure conditions [7], but in such case an intermediate layer of wadsleyite should form. Our TEM observations are consistent with the formation of the low Mg# ringwoodite rim by solid state transformation. For complex features in the core, we have proposed a different interpretation (see [8] for further details). Considering that under certain conditions in a polymineralic assemblage, the shock pressure for the formation of ringwoodite could be lower than estimated in shock recovery experiments [9] and that the shock pulse might have lasted longer than the quench in relatively thin shock veins [10], we assume that for a short time interval shock pressure reached equilibrium. This allows the use of a pressure-composition phase diagram calculated for an ambient temperature of 1600°C [11], which explains the observed coexistence of phases and their compositions. According to this diagram, the possible simultaneous formation of ringwoodite and wadsleyite, for likely solid state transformation occur at about 13 GPa and the resulting phases have low and high Mg# respectively (Fig. 2). The subsequent shock unload may have triggered formation of cracks and melt. The olivine melt has later crystallized as olivine, according to the ambient conditions. The result is the occurrence of veinlets of fine-grained olivine, with low Mg#, crosscutting the clast core.

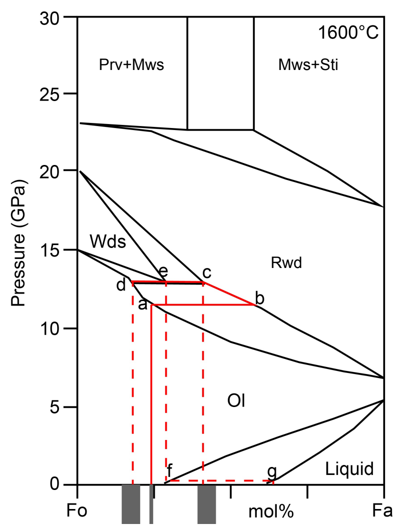

Fig. 2 *Phase diagram, after [11].*

References: [1] Langenhorst F. 2002. *Bulletin of the Czech Geological Survey* 77:265-282. [2] Feng L. et al. 2011. *American Mineralogist* 96:1480-1489. [3] Xie Z. et al. 2012. Abstract #2776, 43rd Lunar & Planetary Science Conference. [4] Walton E.L. 2013. *Geochimica et Cosmochimica Acta* 107:299-315. [5] Yamaguchi et al. 2014. *Meteorite Newsletter* 23. [6] Kerschhofer L. et al. 1998. *Mineralogical Magazine* 62:617-638. [7] Miyahara M. et al. 2008. *Proceedings of the National Academy of Sciences.* 105:8542-8547. [8] Pittarello L. et al. 2015. *Meteoritics & Planetary Science* 50:944-957. [9] Sharp T.G. and DeCarli P.S. 2006. In Meteorites and the early solar system. Lauretta and McSween Eds. The University of Arizona Press. pp. 653–678. [10] Shaw C.S.J. and Walton E. 2013. *Meteoritics & Planetary Science* 48:758-770. [11] Agee C.B. 1999. *Reviews in Mineralogy and Geochemistry* 37:165-203.