TEM INVESTIGATION OF SHOCK-INDUCED POLYMORPHIC TRANSFORMATION OF OLIVINE.

L. Pittarello[1], G. Ji[2,3], D. Schryvers[2], A. Yamaguchi[4], V. Debaille[5], and Ph. Claeys[1]. [1]Earth System Science, Vrije Universiteit Brussel, Belgium (lidia.pittarello@vub.ac.be). [2]Electron Microscopy for Materials Science, University of Antwerp, Belgium. [3]currently at Unité Matériaux et Transform., Université Lille 1, France. [4]National Institute of Polar Research, Tachikawa, Japan. [5]Lab. G-Time, Université Libre de Bruxelles, Belgium.

Introduction: The occurrence of ringwoodite as high-pressure polymorph of shocked olivine within shock veins in meteorites is relatively common, e.g., [1]. In some cases, shocked olivine displays a complex structure, with high-Fe ringwoodite rimming low-Fe olivine and fine-grained lamellae of undefined phases occurring in the olivine core [2-4]. Similar features were observed in the sample A09584 and were further investigated by scanning electron microscopy, electron microprobe, Raman spectroscopy, and transmission electron microscopy.

Shock veins and olivine clasts: In the investigated sample, classified as L6 [5], shock veins are 1-2 mm wide blackish portions under transmitted light, generally localized along grain boundaries. The shock veins consist of clasts, mostly of olivine and pyroxene, suspended in a glassy matrix, partially crystallized in 10 µm microlites with olivine composition. Olivine clasts are rimmed by a 50 µm thick layer of ringwoodite, which has a higher Fe/Mg ratio than the unshocked olivine (UO). The core of these clasts contains a dense network of dark (in BSE-SEM images) lamellae and whitish domains, whose nature could not be determined other than with TEM.

TEM results: The ringwoodite rim consists of an aggregate of hypidiomorphic grains, which have an average size of 500 nm and exhibit internal features that resemble stacking faults. The clast core contains: (a) domains with nanocrystals of either olivine or wadsleyite, with strong shape preferred orientation and lower Fe/Mg ratio than the UO, and (b) veinlets of maximum 500 nm in thickness, composed of equigranular nanocrystals of olivine, with higher Fe/Mg ratio than the ringwoodite and the UO and with random orientation. No amorphous material has been detected.

Discussion: Our observations are in agreement with the most accepted hypothesis for the formation of the ringwoodite rim, which is solid state transformation due to diffusion controlled growth under high temperature conditions [2-4, 6]. An alternative explanation is fractional crystallization from olivine melt under shock pressure conditions [7], but an intermediate layer of wadsleyite should have formed. However, a pressure-composition phase diagram calculated for an ambient temperature of 1600°C [8], might explain also the different Fe/Mg ratios in the coexisting olivine, wadsleyite and ringwoodite. The peak pressure in the compression stage corresponds to a "triple point", where ringwoodite and wadsleyite, with respectively high and low Fe/Mg compositions, formed from olivine. The following release wave triggered melting of the remaining olivine along veinlets. The melt, enriched in Fe, lately crystallized as olivine.

References: [1] Langenhorst F. 2002. *Bull. Czech Geol. Survey* 77:265-282. [2] Feng L. et al. 2011. *Am. Mineral.* 96:1480-1489. [3] Xie Z. et al. 2012. Abstract #2776, 43rd LPSC. [4] Walton E.L. 2013. *Geochim. Cosmochim. Ac.* 107:299-315. [5] Yamaguchi et al. 2014. *Meteorite Newsl.* 23. [6] Kerschhofer L. et al. 1998. *Mineral. Mag.* 62:617-638. [7] Miyahara M. et al. 2008. *Proc. Nat. Acad. Sci.* 105:8542-8547. [8] Agee C.B. 1999. *Rev. Mineral.* 37:165-203.