HIGH IRON WADSLEYITE IN SHOCKED MELT DROPLETS OF CB CHONDRITE QC 001. T.E. Koch[1*], F.E. Brenker[1,2], D.J. Prior[3], K. Lilly[3], A.N. Krot[2], M. Bizzarro[4]. [1]Goethe University Frankfurt, Altenhöferallee 1, 60438 Frankfurt am Main, Germany, [2]Hawai‘i Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, University of Hawai‘i at Mānoa, Honolulu, HI 96822, USA. [3]University of Otago, Department of Geology, 360 Leith Street, Dunedin 9016, New Zealand. [4]Centre for Star and Planet Formation, Natural History Museum of Denmark, Copenhagen, Denmark. *tamara_koch@ymail.com

Introduction: Wadsleyite, the high-pressure phase of $(Mg,Fe)_2SiO_4$ olivine in spinneloid III structure, is one of the most abundant phases in the Earth transition zone. It is frequently found in shocked meteorites including ordinary chondrites and the CB chondrites Gujba and Quebrada Chimborazo (QC) 001 [1–3]. Experimental work at conditions relevant for the Earth's transition zone (< 1873 K) yield that the Fe content of wadsleyite seems limited to < Fa_{35}. Above this Fe-content, as long as no Fe^{3+} is involved, olivine directly transforms to ringwoodite. However, Finger et al. [4] synthesized a single wadsleyite crystal with Fa_{40} at 15.2 GPa and 1973 K, which should lie within the ringwoodite stability field of the Mg_2SiO_4 – Fe_2SiO_4 phase diagram [5]. The Fe_2SiO_4 endmember requires much lower pressures to transform directly from olivine (fayalite) to its high pressure polymorph ringwoodite (ahrensite) [6].

The FeO content of natural wadsleyites depends on the transformation mechanism [3]. Wadsleyites in ordinary chondrites, mostly coexisting with ringwoodite, show values of $Fa_{6\text{-}20}$ [e.g., 6, 7], whereas wadsleyite grains studied in barred olivine fragments in shock melted areas in the CB_a chondrite Gujba range in composition from $Fa_{1.3}$ to $Fa_{3.7}$ [1].

CB Chondrites: CB chondrites are a rare group of metal-rich carbonaceous chondritic meteorites with characteristics that sharply distinguish them from other chondrites [9]. Further, they reached higher shock stages (S3–S4) than any other carbonaceous chondrite groups, contain high-pressure phases, and have a high content of silicate and metal shock melts. The silicate shock melts are significant more FeO-rich than the chondrules [10].

Methods: The chemistry and texture of silicate melt droplets in QC 001 were studied using high resolution scanning electron microscopy (FEG-SEM) and electron probe microanalysis (FEG-EPMA). Confocal Raman spectroscopy was used to identify high-pressure phases and their spatial distribution. Further, Nano-EBSD was performed to map different phases in melt droplets in order to get a much higher resolution than from Raman spectroscopy. At last, transmission electron microscopy on focused ion beam (FIB) section of these droplets was used to obtain detailed high-resolution images and structural information.

Results: During a detailed investigation of silicate melt droplet within metal in QC 001, we observed wadsleyite grains with unusual high Fe-contents ranging from Fa_{30} to Fa_{56} which is in contrast to wadsleyite grains found in any other meteorite and against experimental predictions.

Raman analysis of silicate melt drops in metal yields wadsleyite, mostly within the core rimmed by olivine (Fig. 1).

Nano-EBSD mapping combined with HR-EDX was performed at four regions across silicate melt droplets with diameters ranging from 5 to 20 µm located within the metal matrix. The indexed EBSD pattern analyses identified these as Fe-rich wadsleyite and Fe-poor olivine (Fig. 2). Two of the studied droplets consists mostly of wadsleyites with $Fa_{44(1)}$ (n = 2), within one droplet a wadsleyite with a Fe content of Fa_{56} was found coexisting with low-Ca pyroxene. A group of three melt droplets consists mostly of Fe-poor olivine $Fa_{13(1)}$ (n = 3) with a small amount of wadsleyite grains located in the center with $Fa_{33(1)}$ (n = 2) . The last area studied consists of a low-Ca pyroxene grain surrounded by a layer of olivine grains followed by wadsleyite grains. In general, the wadsleyite is higher in Al (1.2(2) at%) compared to olivine (0.43(8) at%).

A FIB section was taken for further detailed studies from an irregularly shaped silicate melt droplet within the metal matrix. The silicate part in this section consists of two areas showing different grain sizes. Olivine laths next to a high-Ca pyroxene laths are located between these areas. The olivine laths show $Fa_{36–47}$ except a small area in the middle with Fa_{12}. The olivines in the finer-grained area have ferroan composition ($Fa_{33–37}$). The coarse-grained area consists mainly of rounded wadsleyite grains with $Fa_{34–56}$ (n = 8) and stacking disorder along (010). Further, one SAED pattern of a grain with similar composition to the wadsleyites in the coarse grained area indicate the presence of Fe-rich ringwoodite (ahrensite) with $Fa_{50(5)}$ (n = 2).

Discussion: The shock conditions of CB chondrites are estimated as >19 GPa and >2273 K [1, 2]. The high-temperature is based on the presence of majorite.

Experimental data show that with increasing temperature the two phase field of olivine and wadsleyite shifts towards more fayalitic compositions [5]. Our findings shows the need to determine the $(Mg,Fe)_2SiO_4$

phase diagram towards much higher temperatures and to include Al.

As a conclusion, we suggest that the Fe-rich wadsleyites crystallized from a Fe-enriched melt produced by a mixture of partial molten Fe,Ni-metal and silicate at very high temperature >2000 K and pressure < 15 GPa.

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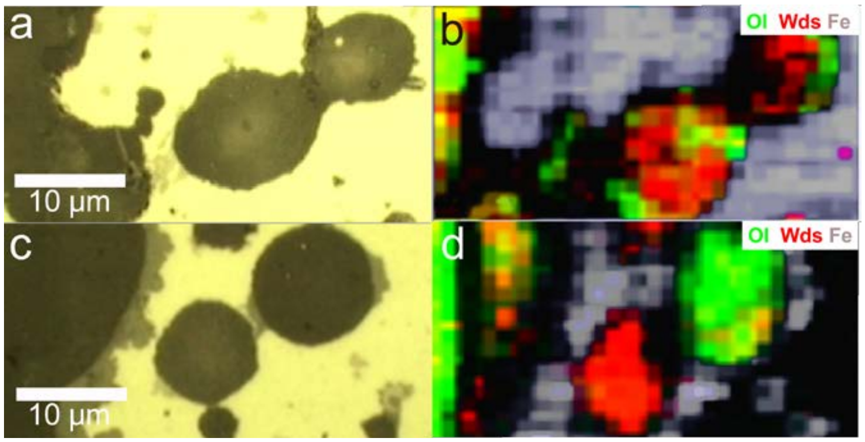

Fig 1. Transmitted light images (a, c) and Raman phase maps (b, d) of silicate melt droplets whithin metal. Olivine (green); wadsleyite (red); metal matrix (grey).

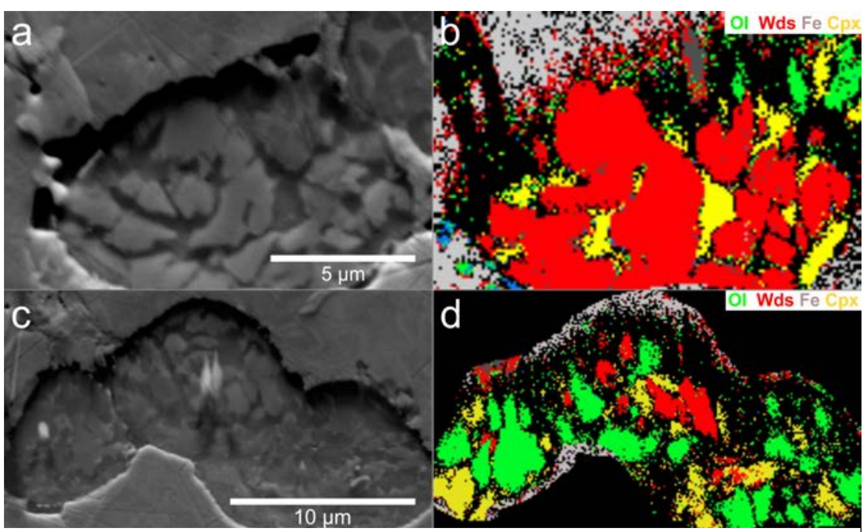

Fig 2. Two exemplary secondary electron (SE) images (a, c) and micro-EBSD phase maps (b, d) of silicate melt droplets in metal. Olivine (green), wadsleyite (red), low-Ca clinopyroxene (yellow); metal matrix (grey).