Shocked Minerals in NWA 5011 L6 Chondritic Meteorite. Sz. Bérczi[1], Sz. Nagy[1,3], I. Gyollai[2], S. Józsa[1], K. Havancsák[1], G. Varga[1]., E. Pál-Molnár[3], A. Gucsik[4,5] [1]Eötvös University, Institute of Physics, Department of Materials Physics, CMSRG, H-1117, Budapest, Pázmány Péter sétány 1/a, Hungary, (bercziszani@ludens.elte.hu); [2]University of Vienna, Department of Litospheric Research, A-1090, Vienna, Althanstrasse 14., Austria, [3]Szeged University, Dept. Mineralogy and Petrology, H-6722, Szeged, Egyetem u. 2-6., Hungary, [4]Osaka University, 1-1 Machikaneyama, Toyonaka, Osaka 560-0043, Japan, [5]Konkoly Observatory of the Hungarian Academy of Sciences, H-1121 Budapest, Konkoly Thege Miklós út 15-17., Hungary

Introduction:

In high-pressure shock processes primary planetary rock forming minerals olivine $(Mg,Fe)_2SiO_4$, pyroxene $(Mg,Fe,Ca)SiO_3$, may transform into their dense polymorph minerals: These minerals can be found in the pressure and temperature conditions of the terrestrial transition zone of the Earth's upper mantle and in chondritic meteorites where transformation may occur as a result of shock waves from which the high activation energy of the transformation comes [1,2]. Here we report about observations of the olivine-ringwoodite, the pyroxene-pyrope and the pyroxene-akimotoite [3] transformations in a desert meteorite NWA 5011 L6 chondrite. Previously we found indications by Raman spectroscopy, now we extended confirmation of transformations by the Hikari camera measurements of the new scanning electron microscopy of the Eötvös University, Institute of Physics.

Methods:

The textural observations on NWA 5011 chondrite were done with a NICON E200 optical microscope and a 3D FEI Quanta scanning electron microscope (SEM) in backscattered electron (BSE) mode at Eötvös University, Institute of Physics. The phase identification was taken by micro-Raman spectrometry and Hikari Camera of the SEM.

Results:

The optical microscope investigation revealed frequent shock melt veins containing various minerals, mainly olivine, pyroxene, chromite and feldspar (Fig. 1). Feldspars were transformed into maskelynite. Several olivine grains lying along or in the vicinity of the shock melt veins contained ringwoodite in lamellar shape. (Fig. 2). Widths of lamellae fall into the range of 0.5 to 4 μm. In most cases the lamellae showed jagged, cloudy boundaries (Fig. 2). Distinct Fe-poor zones were observed between some lamellae and host olivine. The SEM composition analysis indicated that lamellae contained slightly higher FeO than the host olivine grain. The thickness of the Fe-poor zones was proportional with thickness of lamellae, which suggested Mg-Fe interdiffusion during the shock transformation.

Experimental works helped in interpolating the probable range of the pressure and temperature field of the observed ringwoodite transformation in the veins: pressure was about 16-20 GPa, and temperature was 1500 °C. The observed form of lamellar transformations may have been suffered by olivine grains in plastic deformations by shock loading [1].

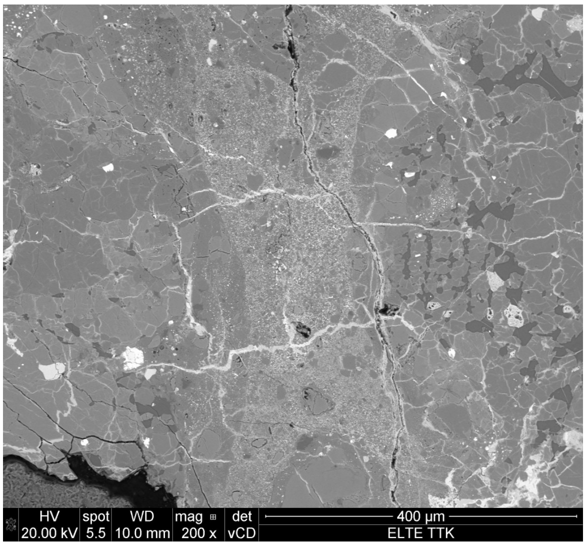

Figure 1. Shock vein in the NWA 5011 L6 chondrite.

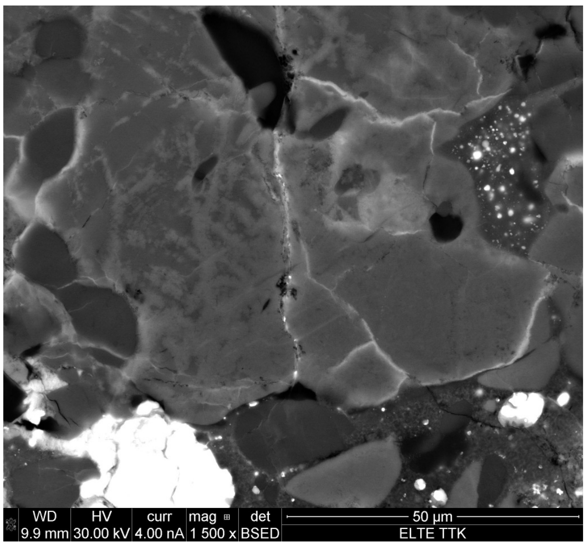

Figure 2. Olivine grain in the NWA 5011 L6 chondrite. Note the sulfide clast on the lower left side of the image.

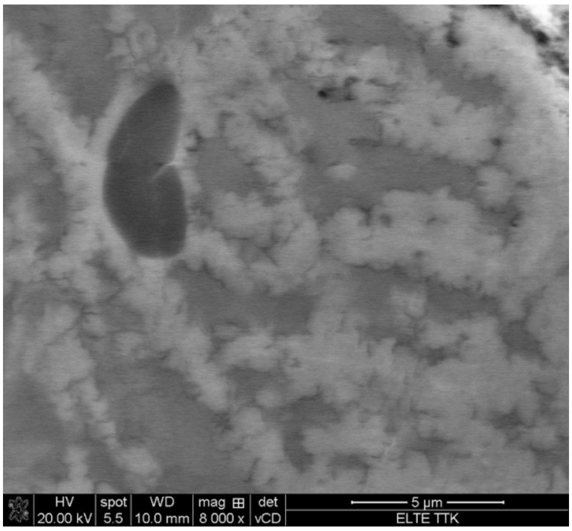

Figure 3. High pressure olivine transformed lamellar ringwoodite (light gray) in 8000X magnification BSE image of the SEM of Eötvös Loránd University. Scale bar: 5 micrometer.

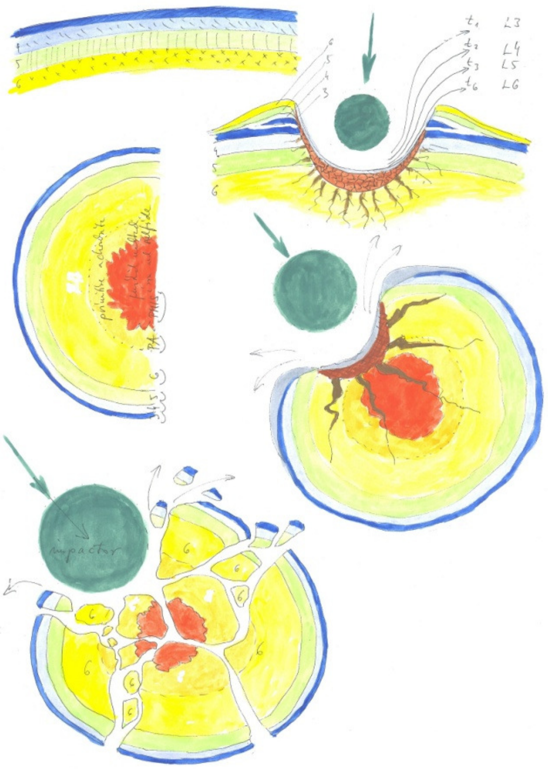

Figure 4. Events at the onion shelled L asteroid are suggested. A., An outer normal layering of L3, L4, L5 and L6 strata from top to down direction. B., An asteroid sized scale of these outer layers, and their relation with the inner layers of PA – primitive achondrites, MA – partially melted and iron enriched regions in the centre. C., Scenario 1st: The impactor is a smaller body causing impact crater. D., A larger impactor almost disrupted the parent body. E., An even larger impactor desrupts the L parent body and produces great number of L6 fragments.

The Source Region of the NWA 5011 chondrite within the L Parent Body:

Our NWA 5011 L6 chondrite sample belongs to the most populated petrologic type among the L chondrites. The L chondrite samples are heavily shocked, and there were found an extended shower of L chondrites even in the Ordovician [5] , too. Because of their heavily shocked character the L chondrites are thought to have been origined from the disruption of an asteroidal sized parent body. The disruption time (470 Ma) is in a good agreement with that of the Ordovician shower (467 Ma).

On the basis of the observed structural characteristics of the NWA 5011 chondrite we postulated 3 scenarios about its origin. They can be distinguished by the ratio of the diameter of impactor and parent body. We show the details on the Figure 3. An onion shelled L-asteroid is suggested as initial host, with outer normal layering of L3, L4, L5 and L6 layers from top to down direction. Figure 3/A. shows the surface layers, Figure 3/B. shows the asteroid sized scale of these outer layers and the inner layers of PA – primitive achondrites, MA – partially melted and iron enriched regions in the centre.

Conclusions:

Earlier indications of the high pressure minerals in the NWA 5011 chondrite were observed on the basis of Raman spectroscopy [3,4]. Spectroscopy measured local bond characteristics of atomic neighbors while the Hikari camera of the SEM made it possible to observe the global crystal structure of the transformed minerals. Further studies are continued in identification of the high pressure minerals in NWA 5011.

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References: [1] M. Chen, H. Li, A.E. Goresy, J. Liu, and X. Xie (2006) Meteoritics & Planetary Science **41,** 731-737. [2] M. Chen, A.E. Goresy, and P. Gillet (2004b) Proc. Natl. Acad. Sci. U.S., **101,** 15033-15037. [3] Sz. Nagy, I. Gyollai, S. Józsa, Sz. Bérczi, A. Gucsik, M. Veres (2011): Transformation of pyroxene to akimotoite (MgSiO3-ilmenite) in NWA 5011 L6 chondrite. EPSC-DPS2011-792. 6. European Planetary Science Congress, EPSC-DPS Joint Meeting 2011. [4] Sz. Nagy, I. Kubovics, S. Józsa, A. Gucsik, Sz. Bérczi, I. Gyollai (2009): Occurence of Ringwoodite Grains in the Highly Shocked Meteorite of NWA 5011. 32nd NIPR Symposium on Antarctic Meteorites, pp. 47-48; [5] Greenwood, R. Schmitz, C. B., Bridges, J. C., Hutchison, R., Franchi, I. A. (2007): Disruption of the L chondrite parent body: New oxygen isotope evidence from Ordovician relict chromite grains. *Earth and Planetary Science Letters*, **262,** No. 1-2. P. 204-213.