Identification of Pyroxene-Akimotoite Phase Transformation in NWA 5011 L6 Chondrite: Confirmation of the Preliminary Optical Observations Sz. Nagy[1,2], E. Pál-Molnár[1], K. Fintor[1], I. Gyollai[3], Sz. Bérczi[2], S. Józsa[2], A. Gucsik[4,5], M. Veres[6], Zs. Bendő[2] [1]Szeged University, H-6722, Szeged, Egyetem u. 2-6., Hungary, [2]Eötvös University, Institute of Physics, Department of Materials Physics, H-1117, Budapest, Pázmány Péter sétány 1/a, Hungary, [3]University of Vienna, Department of Litospheric Research, A-1090, Vienna, Althanstrasse 14., Austria,[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 M. út 15-17., Hungary, [6]Research Institute for Solid State Physics and Optics of the Hungarian Academy of Sciences, H-1525, Budapest, Konkoly-Thege M. út 29-33., Hungary.

Introduction:

The transformation of pyroxene to akimotoite (ilmenite-structured $MgSiO_3$) was observed in several previously works [1,2,3] from highly shocked chondritic meteorites. In general, the high pressure phase transformations occur just in or along the shock melt veins (SMV's) because of the activation energy by postshock-temperature. If decline rate of temperature is faster than pressure new high-pressure phases could form such as akimotoite, ringwoodite, Na-hollandite. We presented in our earlier works about the high-pressure mineralogy of NWA 5011 L6 chondrite as well as texture of shock melt veins. In this work we present the confirmation of partially transformed pyroxene to akimotoite by micro-Raman spectrometry including micro-Raman 2D and 3D mapping.

Sample and Methods:

For micro-Raman investigation and optical observation we have done a thin section in 35-40 µm thickness. This thickness was prepared to eliminate the micro-Raman features of epoxy glue. The optical observation was made with a Nikon Eclipse LV100POL polarization microscope in reflected light mode at Department of Petrology and Geochemistry of Eötvös University. The micro-Raman investigation was made at the Department of Mineralogy, Petrology and Geochemistry of University of Szeged by using a THERMO DXR Raman Microscope. Measurement settings was 532 nm laser wavelength 10 mW laser power 100X objective, spectral resolution was ~2cm^{-1}. The micro-Raman mapping was made in a grid network where the space resolution was 1 µm. Our mapping was covered an area of 36 X 29 µm with 1044 measuring points and almost 20 hours spectra collection time.

Results:

Lamellar features were observed in a survived pyroxene aggregate which is in the central area of a wide shock melt vein. The aggregate is about 1 mm in diameter. The survived aggregate is highly fractured and shows gradually high-pressure phase transformation from the boundary of shock melt vein towards inside of aggregate. The pyroxene fragment denotes two phase transitions: pyroxene-majorite and pyroxene-akimotoite. The pyroxene-majorite phase transformation exhibits on the boundary area of the shock-melt vein and partially transformed pyroxene to akimotoite. It is explicable that majorite is more stable in high temperature regime than akimotoite. The inside of pyroxene aggregate shows irregular appearance akimotoite transformation texture. The transformation areas are variable. There are between several nanometer to micrometer in range (Fig. 1). The micro-Raman mapping revealed that between the central zone of lamellae and untransformed pyroxene area the intensity of main vibrational mode of akimotoite at 800 cm^{-1} is continuous (Figs. 2 and 3). It is probably that transformation mechanism is good agreement with Tomioka and Fujino's theory (1998) [4], where they propose a "syncroshear" (two steps shear of oxygen sublattices by the sweeping of the partial dislocations and associating cation shuffling) mechanism. This mechanism could pass off without any long-range atomic diffusion in the case of intracrystalline transformation in the $MgSiO_3$ system. This hypothesis has evidently shown by EMPA investigation. The intracrystalline akimotoite lamellae do not show significantly changes in chemical composition and we did not find glassy products along the akimotoite lamellae and enrichment of Na and K elements, which might be show the partial melting. The observed raman peaks are as follows for akimotoite: 799, 618, 480, 408, and 285 cm^{-1}. In the raman spectrum of akimotoite (Fig. 4) appears a peak at 843 cm^{-1} and 930 cm^{-1} respectively, which are might be related to ringwoodite and majorite.

We could determine the physical conditions of transformation from experimental studies therefore in the function of chemical composition of precursor pyroxene the crystallization pressure was about 20-23 GPa at 1500ºC.

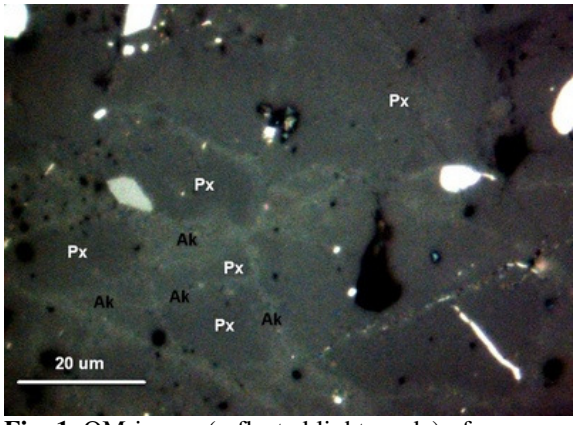

Fig. 1. OM-image (reflected light mode) of pyroxene (Px) and akimotoite (Ak) transformation area. The micro-Raman mapping was done in the left bottom corner.

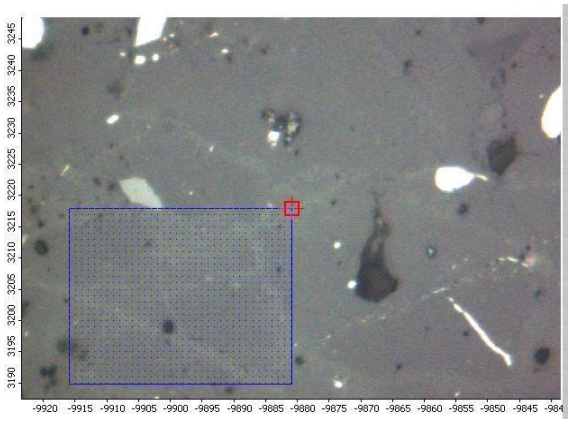

Fig. 2. The area of micro-Raman mapping. The blue rectangle area shows the grid network and contains 1044 measuring points.

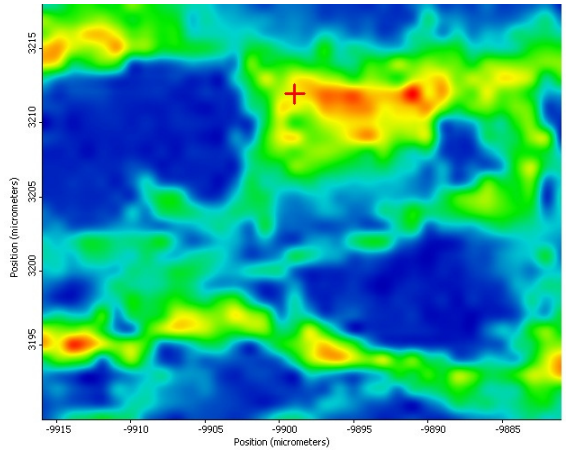

Fig. 3. Micro-Raman map which was created from 1044 spectra from blue rectangle area of Figure 2. The color variation from blue to red shows gradually growing intensity for 800 cm^{-1} major peak of akimotoite.

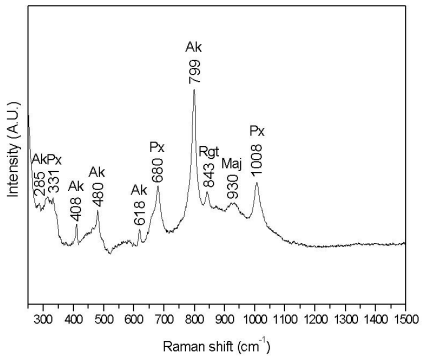

Fig. 4. Micro-Raman spectrum of akimotoite lamella from NWA 5011 chondritic meteorite.

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References:

[1] T. Ferroir et al., (2008) EPSL., Vol. 275., pp. 26-31; [2] Z. Xie and T.G. Sharp (2007) EPSL., Vol. 254., pp. 433-445; [3] N. Imae and Y. Ikeda (2010) Meteoritics & Planetary Science, 45, pp. 43-54; [4] N. Tomioka & K. Fujino (1998) American Mineralogist, 84, pp. 267-271.