EVIDENCE FOR SIGNIFICANT CATION DISORDERING IN RINGWOODITE FROM NWA 5011 AND TENHAM SHOCKED CHONDRITE: A POSSIBLE DISORDERED UNRELAXED RINGWOODITE STRUCTURE.

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Introduction:

The collision of planetary bodies cause phase transition upon the original low pressure and high temperature minerals. Instead of the static pressure experiments the shock-metamorphic processes are very rapid natural events. In this condition the formed new mineral phases contain numerous structural defects and extraordinary features. In a few seconds or micro-seconds the main framework of new silicate structure could form, but the cation positions could be quite disordered. The ringwoodite which is the high-pressure polymorph of olivine could be form in L-type meteorites. Such types are the NWA 5011 and the Tenham. Formerly we described a new Raman peak position from the NWA 5011 ringwoodite [1], which was observed in the Taiban chondrite too [2]. Recently, we showed up this peak position from the Tenham, therefore this peak is presence in three different strongly shocked chondrites up to date. In this abstract we try to define this peak position in ringwoodite.

Results and Discussion:

NWA 5011: The selected area (Figs. 1 and 4) which was in the same ringwoodite aggregate have to be observable as colorless and blue color area. From this region we have collected six spectra, 3 from the colorless and 3 from the blue color areas. The following peak positions are observable on the spectrum from colorless domains: 712, 798, 845 and 918 cm^{-1}. The 712 and 918 cm^{-1} peaks are related to wadsleyite, but 798 and 845 cm^{-1} belong to ringwoodite. The peak positions of the blue color spectrum are as follows: 798 and 880 cm^{-1}. All spectra were collected in the same method, in which we used 532 nm laser wavelength during 600 sec on a 1 μm spot. The most characteristic difference between the two spectra is that the spectrum collected from colorless domain shows much higher intensity than the spectrum collected from blue colored one. The intensity of the two spectra has been normalized. Moreover, a characteristic peak at 880 cm^{-1} can be observed in the spectrum of blue domain, which has had interpreted as relict olivine or glass [3] or by Fe^{2+} cation disordering in tetrahedral sites [2]. The appearance of 880 cm^{-1} peak as a reason of partial occupancy in tetrahedral sites of ringwoodite by Fe^{2+} is an acceptable theory. However, the absence of 845 cm^{-1} peak (Fig. 1) as the most characteristic silica antisymmetric streching vibration in ringwoodite and the very weak character of 798 cm^{-1} peak have no explainable by this theory. If we accept the Fe^{2+} disordering theory in which the Fe^{2+} cations are in a part of the tetrahedral sites, and it belongs to 880 cm^{-1} peak, in this case we know theoretically give the minimum value for the cation disordering range from the collected raman spectra. The blue spectrum from Fig. 1 is not inverse spinel, because the SiO_6 octahedral vibrational modes are not present. Kiefer et al. [4] suggested a model for the transition from normal to inverse spinel at very high temperature. They assume an intermediate phase which is so called "disordered unrelaxed".

Because the blue colored spectrum contains the 798 cm^{-1} peak which is related to tetrahedral fourfold coordinated silica, the blue color spectrum is not an inverse structure yet. But, it may be a step towards inverse structure as a possible disordered unrelaxed or uncomplete transition.

TENHAM: The selected Tenham ringwoodite shows similar features to NWA 5011. The blue color spectrum shows peak positions at 797, 844, and 879 cm^{-1}. The colorless spectrum from same aggregate contains peaks at 798 and 844 cm^{-1} which are related to ringwoodite, and 712, 918 cm^{-1} peaks which are related to wadsleyite main vibrations (Figs. 2 and 3).

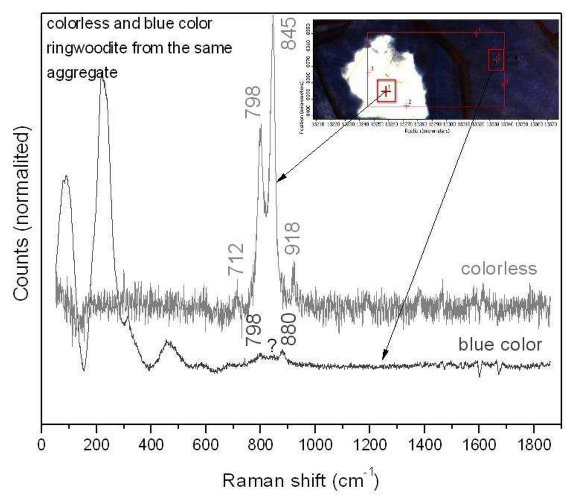

Fig. 1. *Colorless and blue color ringwoodite Raman spectra within the same aggregate from NWA 5011.*

Note the huge difference in intensity and the lack of the 846 cm^{-1} peak position in the blue color spectrum, but the presence of the 880 cm^{-1} peak. The 712 and 918 cm^{-1} peaks are related to wadsleyite in the colorless spectrum.

We assume that the significant change in the intensity between the blue and colorless spectra shows the variable cooling process within the same aggregate. The blue color spectrum looks like a "glassy property" material. This may reflect the material quality.

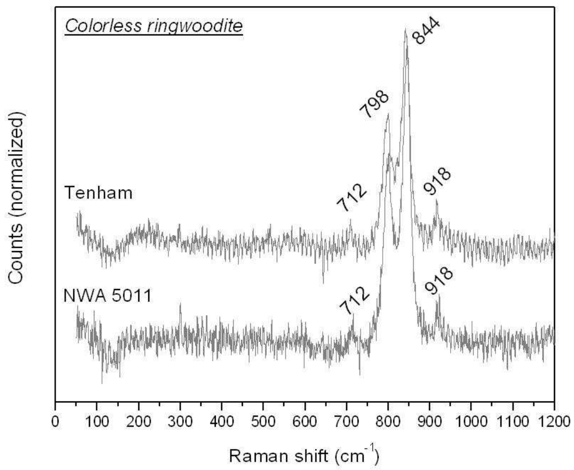

Fig. 2. *Colorless "ordered" ringwoodite raman spectra from NWA 5011 and Tenham chondrites.*

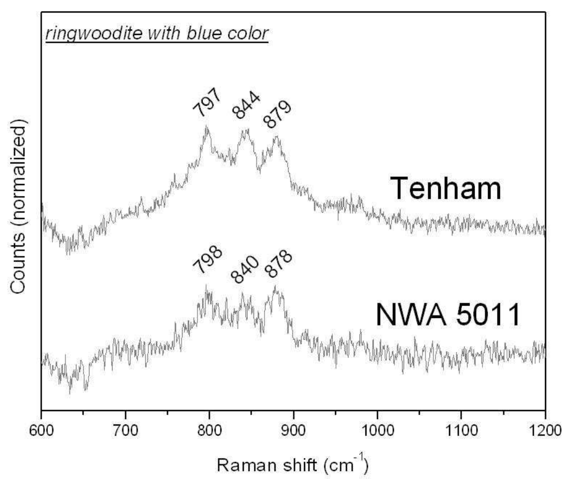

Fig. 3. *Blue color "cation-disordered" ringwoodite spectra from NWA 5011 and Tenham chondrites.*

Conclusion:

The significant intensity changes between the colorless and blue color ringwoodite spectra from NWA 5011 and Tenham chondrite show important internal structural stress. This internal stress can produce the Fe^{2+} cation disordering, which comes from the original heat distribution within the same aggregate. This is a gradient like feature, which may result in the peak near to 880 cm^{-1}. Because of the rapid cooling process, the structure does not have enough time to order. Firstly, the Si-tetrahedra can be form, and subsequently the cation positions. However, for the complete cation distribution also does not have enough time. Such structure could be "uncomplete", and it may be represented as disordered unrelaxed condition. Consequently, the appearance of a peak near to 880 cm^{-1} supposed to indicate a very high scale cation disordering in the ringwoodite structure of NWA 5011 and Tenham meteorites, and indicates diverse shock-metamorphic conditions between the different S6-type shocked chondrites.

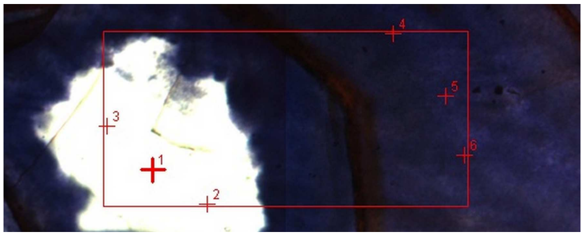

Fig. 4. *The six measured points (signed by red cross) within the selected ringwoodite aggregate from NWA 5011 meteorite. The width of picture is 150 µm. OM-image.*

References:

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[2] Acosta T.E. et al., (2012) LPSC 43, Abstract# 2725
[3] Nagy Sz. et al., (2012) 75th Annual Meteoritical Society Meeting, Abstract# 5013 [4] Kiefer, B. et al., (1999) American Mineralogist, 84, 288-293.