EXTRACTING COMPOSITIONS FROM RAMAN SPECTRA OF RINGWOODITE IN THE HEAVILY SHOCKED GROVE MOUNTAINS METEORITES

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Introduction: Micro-Raman spectroscopy is a powerful tool of identifying high-pressure polymorphs of minerals found in heavily shocked meteorites. Moreover, previous measurements of Raman spectra of olivine, pyroxene and oxides demonstrated significant peak shifts related to compositions [1-4]. This feature has potential applications for simultaneous measurements of structures and compositions of extraterrestrial materials in future space exploration [5,6]. Here we report the first discovery of Raman wavenumber shifts of ringwoodite, the spinel-structured high-pressure polymorph of olivine, resulting from Fe and Mg cation substitution. We develop calibration equations to obtain compositions of ringwoodite from Raman peak shifts.

Results: Ringwoodite studied in this work was mainly found in the heavily shocked Grove Mountains (GRV) 052049 meteorite (L6) [7]. It usually occurs as rims of olivine grains in rounded clasts entrained in shock-induced melt veins. In back-scattered electron image mode of SEM, the ringwoodite grains show different brightness even within same assemblages, suggestive of a wide range of composition. Quantitative analyses of the ringwoodite grains were carried by EPMA, leading to Fo-contents (Mg/Mg+Fe atomic ratio) ranging from 73 mol% down to 19 mol% in comparison with the homogeneous olivine ($Fa_{24.0\pm0.4}$) in the host meteorite. Micro-Raman spectra of these grains with known Fo-contents were measured. They show two strong bands close to 790 cm^{-1} (labeled as DB1) and 840 cm^{-1} (labeled as DB2), and weak one close to 290 cm^{-1} (labeled as SB0). Other bands at 370 cm^{-1} and 600 cm^{-1} [8] are very weak.

The DB1 position of ringwoodite varies monotonically with composition, increasing from 781 cm^{-1} to 799 cm^{-1} with the Fo-content from 19 mol% to 71 mol%. DB2 has only a small shift, and it can be affected by the coexisting olivine that has a strong band between 838-857 cm^{-1} [1]. SB0 is weak but was clearly identified. Its position also varies with composition, and the peak shift range is about 15 wavenumber, increasing from 284 cm^{-1} to 299 cm^{-1} with increasing Fo-content from 19 mol% to 71 mol%. Preliminary analysis of the raw paired Raman and EPMA data derived equations of: (1) Fo mol% (DB1) = $4.483X_1$-1258 (r^2=0.84), and (2) Fo mol% (SB) = $2.996X_0$-2325 (r^2=0.78), where X_1 and X_0 refer to DB1 and SB0 positions.

Potential applications: The monotonic relationship between Raman band shifts and composition of ringwoodite may be used to identify structure and composition of ringwoodite in future space exploration. It also provides with a possibility of on-line determining composition of ringwoodite growing in diamond anvil cell.

References:. [1] Kuebler K. E., et al. 2006. *Geochimica et Cosmochimica Acta* 70: 6201-6222. [2] Wang A., et al. 2001. *American Mineralogist* 86: 790-806. [3] Wang A., et al. 2004. *JOURNAL OF RAMAN SPECTROSCOPY* 35: 504-514. [4] Smith D. C. 2005. *Spectrochimica Acta Part A* 61: 2299-2314. [5] Haskin L. A., et al. 1997. *Journal Geophysical Research* 102: 19293–19306. [6] Hochleitner R., et al. 2004. *Journal of Raman Spectroscopy* 35: 515-518. [7] Feng L., et al. 2007. *Meteoritics & Planetary Science* 42: A45. [8] McMillan P. and Akaogi M. 1987. *American Mineralogist* 72: 361-364.