WAVENUMBER SHIFTS IN RAMAN LINES OF SHOCKED OLIVINES;
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The residual stress retained in minerals gives information on the formation of extraterrestrial materials, because they have more or less experienced impact shock that causes shock deformation of minerals. We applied micro-Raman spectroscopy to estimating the residual stress in minerals (1) and measured small wavenumber shifts in Raman lines of the olivines shocked to different pressures.

Experiments: Olivine grains (Hawaii, Fe/(Mg+Fe)=0.14) were ground and were mixed with 8 wt% of graphite to make the powder sample. Each powder sample was pressed to make a pellet of about 30% porosity and was put in a stainless steel container. The sample was shock-loaded by a single-stage propellant gun at the Natl. Inst. for Researches in Inorganic Materials. The samples shocked to 31, 46, and 68 GPa were finished to thin sections.

Raman spectra were measured with a JASCO Raman spectrometer equipped with a microscope. The 488 nm line of an argon laser was focused to an area of about 1 μm diameter and the laser power was about 6 mW on the sample surface. The spectra were accumulated for 2 minutes and the peak position of a Raman line was determined by using Lorentzian fitting of the spectra. The room temperature was 19.9±0.1 ^{o}C. Details of measurement are described in our accompanying paper (1)

Results: Each sample contains various sizes of olivine grains, ranging from a few to about 100 μm and is studded with islands of carbonaceous materials up to about 100 μm in size. Raman spectra were measured for cores of large olivine grains in each sample. The spectra more or less show luminescent background. Some olivines show very weak Raman lines near 855 and 823 cm^{-1}, implying that olivine structure may be disordered by the shock pressure (2).

Fig. 1 shows shifts in the wavenumber position of Raman lines near 855 and 823 cm^{-1} for large olivine grains in the samples shocked to 31, 46, and 68 GPa. Solid circle shows an average value of the peak wavenumber position for about 20 olivine grains in each sample. Error bar shows the standard deviation (±σ) obtained from the 20 measurements. The average values of the peak position shift toward larger wavenumber as the shock pressure increases, suggesting that the sample shocked to a higher pressure has a larger compressive residual stress. This result seems to be consistent with that expected from shock experiments. The 855 cm^{-1} line seems to shift larger than the 823 cm^{-1} line, as the shock pressure increases. The residual stress may be caused by incomplete recovery of shock deformation or by deviation from static pressure. The wavenumber shift by the shock-pressure increase is, however, small compared with the standard deviation of the measurements. The standard deviation is one order of magnitude larger than that obtained from measurements for the same point of olivine (1). This result may imply that the applied shock-pressure is not necessarily uniform among olivine grains in the sample or that the degree of recovery from shock deformation is different among olivine grains by differences in the elevated temperature or grain size in the sample.

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Heymann and Cellucci (2) studied Raman spectra of shocked olivines and found spectral features probably due to the formation of "olivine glass". However, they do not report wavenumber shifts in Raman lines of shocked olivines. This may be due to too small shift compared with the wavenumber resolution of their measurements.

Precise measurements of the wavenumber position of Raman lines seem to be useful for evaluating the residual stress of shocked minerals.

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References: (1) Miyamoto M., Fujii N., and Ito K (1991) This volume.
(2) Heymann D. and Cellucci T. A. (1988) Meteoritics 23, 353-357.

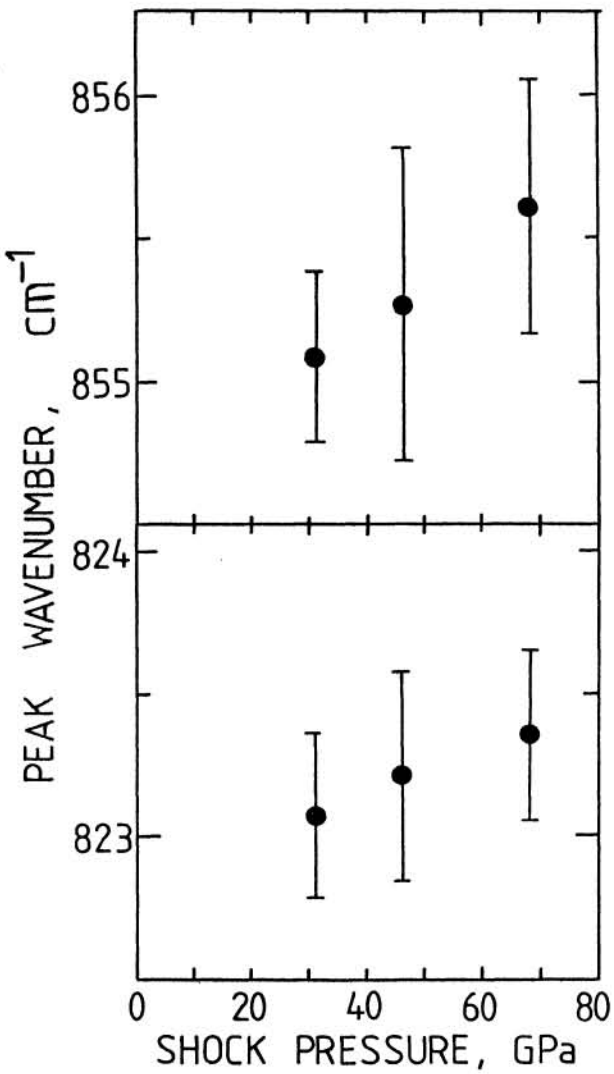

Fig. 1. Shifts in the wavenumber position of Raman lines of the olivines shocked to 31, 46, and 68 GPa. Solid circle shows an average value for cores of about 20 large olivine grains. Error bar shows the standard deviation (±σ) obtained from the 20 measurements.