EPSC Abstracts
Vol. 11, EPSC2017-500, 2017
European Planetary Science Congress 2017

Raman spectroscopy on experimentally shocked plagioclase and applications to the Martian regolith breccia NWA8171

M. C. Langenhorst (1), V. Iancu (1), N. Tarcea (1), F. Langenhorst (2) and J. Popp (1)
(1) Institut für Physikalische Chemie, Friedrich-Schiller-Universität Jena, Helmholtzweg 4, 07743 Jena, Germany, (2) Institut für Geowissenschaften, Friedrich-Schiller-Universität Jena, Carl-Zeiss-Promenade 10, 07745 Jena, Germany

Abstract

We present here Raman spectra of experimentally shocked plagioclase in order to calibrate the spectral changes as a function of shock pressure. The effects of shock compression are distinct band shift and broadening as well as appearance of new broad bands. The application of these data to a Martian meteorite show that it has experienced only weak shock metamorphism (< 5 GPa).

1. Introduction

Raman spectroscopy is extensively developed for remote and surface exploration missions to planetary bodies in our solar system [1]. It is regarded as a powerful technique to determine the mineralogical and chemical compositions of regoliths on these bodies. The minerals in regoliths and their structural states are however often modified by strong impact events. It is hence important to calibrate the spectroscopic changes of typical surface minerals as a function of shock pressure by aid of shock experiments. The applicability of the experimental Raman data can finally be tested on meteorites.

In this study we have used Raman spectroscopy to analyse the structural changes of experimentally shocked plagioclase (oligoclase). Optical, X-ray diffraction, Infrared (IR) spectroscopy and Electron Paramagnetic Resonance (EPR) data of some of our samples were previously reported by [2,3]. The Raman data were applied to NWA8171, the only known regolith breccia among the Martian meteorites [4].

2. Experiments and samples

High-explosive (TNT, Comp. B) shock experiments were carried out at the Ernst-Mach-Institut (Freiburg, Germany) on oligoclase from Lake Muskwa, Canada, with the composition $Ab_{78}An_{20}Or_2$ [2]. According to graphical impedance matching techniques, the pressures achieved were 26, 30, 34, 37.5, and 52.5 GPa.

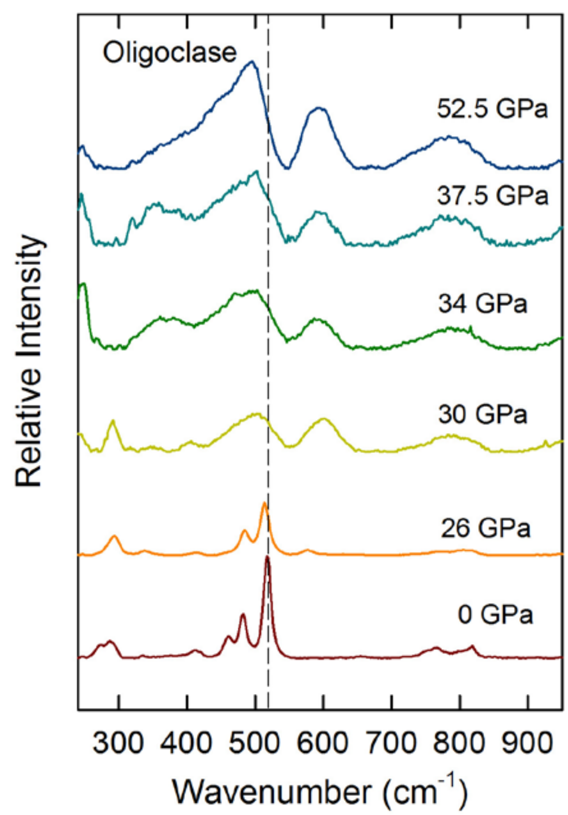

Figure 1: Raman spectra of unshocked and experimentally shocked oligoclase.

Raman spectroscopic measurements were performed using a RamanRXN1 device from Kayser Optical Systems Inc. equipped with a 785 nm laser. Other excitation wavelengths (514 nm, 532 nm and 1064 nm) were tested, as well. Strong fluorescence occurred in all measurements, especially in the spectra of highly shocked oligoclase. Measurements with the 785nm laser turned out to yield the best quality for the given set of samples.

The changes observed in spectral features were used to infer the shock conditions in the Martian meteorite NWA8171, a polymict regolith breccia with a basaltic bulk composition. The most abundant phase in this meteorite is plagioclase (andesine).

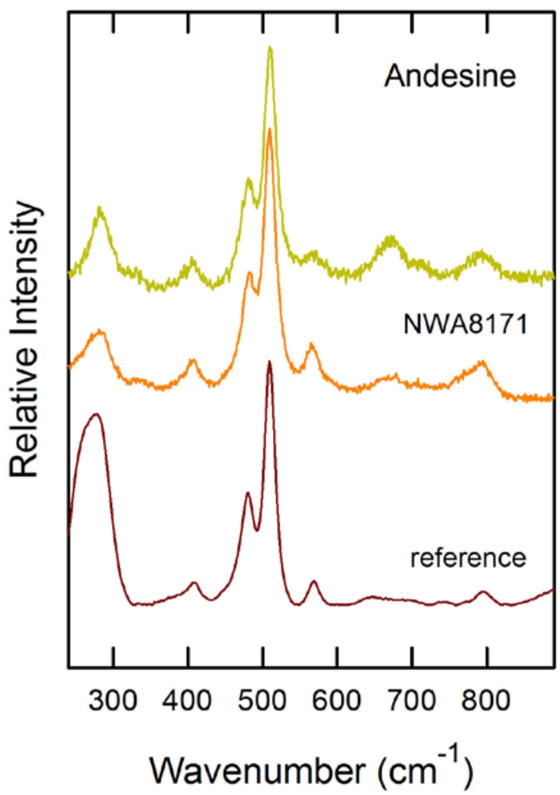

Figure 2: Comparison of Raman spectra of reference andesine with those of andesine in NWA8171.

3. Results and discussion

Fig. 1 shows a compilation of Raman spectra of unshocked and shocked oligoclase samples. The unshocked crystalline oligoclase shows several well-defined Raman active vibrational modes:

Lattice and deformation modes between 100 and 350 cm^{-1}, symmetric T–O stretching modes and O–T–O deformation modes in TO_4 groups between 400 and 550 cm^{-1}, and asymmetric T–O stretching modes and O–T–O deformation modes in TO_4 groups at even higher wavenumber [5].

The Raman spectra of shocked oligoclase display much broader bands and an increase of the fluorescence background. The strongest Raman band is at 517 cm^{-1} for the unshocked sample. It systematically broadens and shifts to lower wavenumbers as a function of increasing pressure. The band is centred at 513, 506, 497, and 495 cm^{-1} for pressures of 26, 30, 34 and 52.5 GPa, respectively.

We also note the appearance and intensity increase of two broad bands in spectral range of the asymmetric modes at about 600 and 790 cm^{-1}. These observations point to a progressive distortion and amorphization of the plagioclase structure.

The Raman spectra of reference andesine and oligoclase are overall very similar (Figs. 1 and 2); there are only subtle spectral differences due to the different compositions of both plagioclases. The main band in the reference andesine spectrum is at 509 cm^{-1}. The Raman bands of andesine from NWA8171 are only slightly broader and are not shifted with respect to the reference spectrum. Therefore we conclude that the plagioclase in the Martian regolith breccia has only experienced weak shock metamorphism (< 5 GPa). This conclusion is in line with optical observations that reveal undulatory extinction only in few grains.

Further Raman measurements are in progress to extend the database to a larger variety of plagioclases and to test the applicability of band shifts and broadening as pressure calibrants.

Acknowledgements

V.I., N.T., F.L. and J.P. acknowledge 'Deutsches Zentrum für Luft- und Raumfahrt (DLR)' for the financial support (grant nr. 50QX1301). F.L. thanks the Deutsche Forschungsgemeinschaft for funds provided by the Leibniz programme (LA 830/14-1).

References

[1] Wang A. et al. (2015) *Planetary and Space Sciences, 112,* 23-34.
[2] Ostertag R. (1983) *JGR, 88,* B364-B376.
[3] Langenhorst F. (1989) *Meteoritics, 24,* 291.
[4] Agee A.B. et al. (2013) *Science, 339,* 780-785.
[5] Freeman J. J. et al. (2008) *Canadian Mineralogist, 46,* 1477-1500.