COMPARISON OF DIFFERENT SPECTROSCOPIC TECHNIQUES IN INVESTIGATING SHOCKED PLAGIOCLASE.

L. Pittarello[1] J. Fritz[2], J. Roszjar[3], C. Lenz[4], C. Chanmuang N.[4], and C. Koeberl[1,3], [1]Department of Lithospheric Research, University of Vienna, Austria (lidia.pittarello@univie.ac.at), [2]Saalbau Weltraum Projekt, Heppenheim, Germany, [3]Natural History Museum, Vienna, Austria, [4]Institute of Mineralogy and Crystallography, University of Vienna, Austria.

Introduction: Shock metamorphism is important in the history of the Solar System. The transformation of plagioclase, one of the most abundant minerals on the surface of terrestrial planetary bodies, into diaplectic glass [1] (often referred to as maskelynite for plagioclase composition [2-4]) is commonly used together with shock effects in olivine to evaluate the degree of shock metamorphism in meteorites (e.g., [5-6]). Amorphization of plagioclase is generally identified with measurement of its refractive index with the optical microscope ([7-8] and references therein). However, this technique has been progressively supplemented by more rapid methods based on X-ray diffraction (e.g., [9,10]) and visible/near-infrared spectroscopy [11]. Raman spectroscopy (e.g., [12] and cathodoluminescence (CL) [13-16] are further spectroscopic techniques that have been proposed to characterize shock effects in plagioclase. Here, we apply several spectroscopic techniques, including micro-Raman spectroscopy, cathodoluminescence, and photoluminescence (PL; e.g., [17]), combined with optical and electron microscopy, to characterize the degree of amorphization in experimentally shocked plagioclase.

Methods: A circular slab (15 mm in diameter and 0.6 mm thick) of troctolite (sample B59- 36-A) was shocked using the reverberation technique at 28 GPa, after pre-cooling to 77 K, at the Ernst Mach Institute for High-Speed Dynamics in Freiburg, Germany [18]. Hand-picked plagioclase-bearing clasts, mounted and polished for petrographic studies, were investigated by micro-Raman spectroscopy and PL (Institute of Mineralogy and Crystallography, University of Vienna), optical CL (Department of Lithospheric Research, University of Vienna), and scanning electron microscope (SEM)-CL and spectral CL (Natural History Museum, Vienna). Major and minor element composition of the selected grains was additionally analyzed with a CAMECA SFive field-emission electron microprobe (Department of Lithospheric Research, University of Vienna).

Results: Three plagioclase clasts out of the eight selected from the investigated sample, all with composition $An_{55\pm1}$ and lacking of chemical zoning, exhibit remaining patchy crystallinity, whereas the others are completely isotropic. Amorphous domains are characterized by substantial peak broadening as observed for the major Raman modes of plagioclase via confocal Raman spectroscopy and for crystal-field split PL emissions of Nd^{3+}. Optical and panchromatic CL highlight the presence of abundant luminescence centers, which do not correspond to visible inclusions, in domains with remaining optical birefringence. The isotropic domains show a dark blue luminescence. SEM-CL spectra of the birefringent plagioclase display emission bands, which can be assigned to Mn and Fe substitutions. These bands are progressively broadened and finally disappear in optically isotropic domains, even though the related trace element abundances do not show any variation.

Discussion and conclusions: The observed heterogeneous distribution of amorphous domains within single, shocked grains further supports the importance to evaluate shock effects on a statistically meaningful number of grains using a variety of techniques. Whereas optical microscopy allows a first approximation of the amorphization of plagioclase and with contribution from the whole thickness (30-40 µm) of the thin section, spectroscopic techniques provide structural information down to a few µm from the surface. The comparably high spatial resolution may be favored among the classical application of optical microscopy to highlight local effects. Furthermore, Raman, PL and CL spectroscopy is not restricted to petrographic thin-sections, but allows the application to grains or polished samples to evaluate shock effects in valuable rocks, without requiring the preparation of a thin section.

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