APPARENT LACK OF PLANAR DEFORMATION FEATURES (PDFs) IN EXPERIMENTALLY SHOCKED PLAGIOCLASE

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Introduction: The primary shock metamorphic petrographic texture is the presence of planar deformation features (PDFs) in silicates, most commonly observed in quartz and feldspar. These appear as sets of straight planes of amorphous material which are less than 2 μm thick with 2-10 μm spacing [1-7]. In both experimentally and naturally shocked quartz, PDFs occur at specific, predictable orientations, parallel to rational crystallographic planes of low Miller index and are diagnostic evidence of shock metamorphism [2-3,8]. PDFs are common in naturally shocked feldspar with an added complexity of twin plane-controlled morphologies where shock features occur in alternating twins [2, 9-10]. Based on a series of shock experiments, PDFs are generally believed to form under pressure conditions between 10 and 30 GPa (French and Koeberl and refs therein). However, our new petrography of experimentally shocked plagioclase shows an apparent lack of PDFs.

Samples and Methods: We have conducted optical petrography of experimentally shocked rocks containing essentially monominerallic plagioclase (bytwonite, andesine, and albite) spaning the range in shock pressures from 17 to 55 GPa [11-13]. Bytwonite was shocked to 17.0, 21.0, 21.5, 22.6, 25.5, 27.0, 29.3, 37.5, 38.2, 49.2, and 56.3 GPa. Andesine was shocked to 15.8, 24.9, 26.4, 28.4, 29.4, 29.6, 33.8, 34.5, 35.3, 37.6, 47.5, 50.0, 53.0, and 55.0 GPa. Abite was shocked to 17.0, 24.0, 25.5, 27.8, 29.0, 31.4, 34.8, 44.0, 50.0, and 55.8 GPa. Optical petrography was conducted on polished thin sections. Micro-FTIR point spectra of locations in the thin section were collected in the Center for Planetary Exploration at Stony Brook University using a Nicolet iN10MX FTIR microscope, equipped with a deuterated triglycine sulfate (DTGS) detector, with a spectral range of 400-4000 cm^{-1} (2.5-25 μm). We chose a spot size of 40 x 40 μm for these analyses, with spectral sampling of 8 cm^{-1}. Micro-Raman spectra were acquired using a WiTec alpha300R confocal imaging system equipped with 532 nm Nd YAG laser with 2.24 mW nominal power at the sample surface, and a 50X (NA=0.8) objective (spot size of 763 nm). Each analysis consisted of 240 1-second integrations that were averaged. Previous spectroscopic analyses of these samples were presented in [14-16].

Results: No samples show planar deformation features. One sample, bytwonite shocked to 22.6 GPa, shows microfaulted, offset and slightly rotated twins. However, micro-Raman and micro-FTIR spectroscopy of these samples does indicate clear evidence that these grains underwent internal crystallographic deformation in response to shock. In micro-Raman spectra, this is noted by decreases in intensity of characteristic peaks near 284, 408, 479, and 507, Δcm^{-1} and 507:481 peak ratios approaching 1 with increased shock pressure. In infrared reflectance spectra, this is noted by merging of the doublet near 1012 cm^{-1} for some orientations, and a broadening of the 725 cm^{-1} peaks.

Discussion: The lack of PDFs is surprising given these experimentally shocked samples cover the range of pressures typically associated with PDFs in quartz. One important differences between natural and experimental shock is strain, which may suggest that for shocked feldspar strain rate plays an important role in PDF formation. In addition, the homogeneous (monominerallic) nature of the samples may play a role in their lack of PDF development.

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