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Effect of pressure loading path on PDFs orientation of planar deformation features (PDFs) in shocked quartz.

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Shocked quartz is the most widely known and convincing evidence of asteroid impact. It is characterized by presence of amorphous shock metamorphic microstructures, i.e., planar deformation features (PDFs). The PDFs are detectable by the optical microscope as thin straight parallel lamellae, spacing less than 10 μm, commonly orientated parallel to rational crystallographic planes of low Miller indices such as, (0001), {101n}, {112n}, {1122} planes. Previous shock recovery experiments show that the crystallographic orientations of PDFs (e.g., {1012}, {1013}, {1122} orientation) are formed at different shock pressure [Horz et al., 1968; Langenhorst & Deutch, 1994]. Therefore, the distribution and frequency of PDFs orientations of shocked quartz can be used to estimate average shock pressure, which is one of the most crucial parameters to constrain impact process and mechanism on the Earth and other solid bodies in the solar system.

The mechanism for PDFs formation is considered as local amorphization caused by the lattice collapse, on the shock front during shock wave passing through the quartz crystal [Goltrant et al., 1992]. The elastic instabilities in the shear modulus of specific planes occur with shock intensity. Therefore, they should be sensitive to the pressure loading path especially to the most intense first shock.

However, previous pressure calibration schemes are based on compilation of different shock experiments with different shock loading path (i.e., single shock method and reverberation method) [e.g., Stoffler & Langenhorst, 1994]. In this study, we therefore conducted a series of shock recovery experiments in order to clarify a characteristic features of PDFs for different pressure and different loading path.

The shock recovery experiments were conducted in the National Institute for Material Science (NIMS) with a one stage propellant gun. Start materials are natural and synthetic quartz crystals. The velocity range of flyer plate was 0.5 to 1.8 km/s, which produces peak shock pressure from 5 to 40 GPa for reverberation samples, and from 5 to 25 GPa for single shock samples, based on the impedance matching method. Recovered samples were mounted on epoxy resin. Orientations of PDFs were measured with 4-axis universal stage (U-stage) microscope.

In our experiments, shocked quartz grains show PDFs under the shock pressure over 10 GPa. At pressure above 30 GPa, grains are almost transformed to totally amorphous glass, but still remains their original crystal shapes (diaplectic glass). We will compare the characteristic features of PDFs orientation distribution for quartz grains shocked both by single shock and reverberation methods, and also discuss the sensitivity to the two different pressure loading paths, and revisit the previous pressure calibration schemes.

Keywords: shock metamorphism, shocked quartz, planar deformation features, shock recovery experiment