THE MICROSTRUCTURE OF SHOCKED XENOTIME

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Shock microstructures in refractory accessory minerals such as zircon [1,2,3] and monazite [4] provide crucial evidence for deciphering impact-related deformation in a wide variety of planetary materials. Here we use electron backscatter diffraction (EBSD) analysis to describe the first occurrence of shock deformation in xenotime, YPO_4, from a shocked quartz-bearing shatter cone in granite at the Santa Fe impact structure (USA) [5]. The shatter cone sample was collected from a well-exposed outcrop of nested shatter cones along NM State Highway 475, west of Hyde Memorial State Park, in the southern Sangre de Cristo mountains ~8 km northeast of Santa Fe, New Mexico [5], and prepared as a polished thin section. Xenotime is isostructural with zircon (tetragonal, 4/m2/m2/m, space group I4a/amd), requiring collection of simultaneous energy dispersive spectroscopy elemental maps during EBSD analysis to fully distinguish the two phases. Zircon was not detected with any of the analyzed xenotime grains. Backscattered electron imaging shows that shocked xenotime grains contain multiple orientations of closely spaced (0.25 to 1 µm) planar fractures, similar to those previously reported in both zircon and monazite. Electron backscatter diffraction mapping reveals that planar fractures occur in orientations parallel to crystalographic a-axes, and also in {112}. High resolution EBSD analysis using a 50 nm step size shows that some of the planar microstructures in {112}contain deformation twin lamellae defined by disorientation relationships of 65° about {110}. The deformation twin lamellae range from 50 to 200 nm in width, and occur in up to three crystallographic orientations in a given grain. Other impact-related features, such as discrete low angle boundaries and broader planar deformation bands, accommodate cumulative misorientation of 5-6° across the grains, and record crystal plastic deformation by dislocation creep. The presence of shocked quartz with decorated PDF in the shatter cone and the absence of shock twins in co-existing zircon indicates peak shock pressure experienced by the xenotime grains was at least 5-10 GPa based on quartz [5], but less than 20 GPa based on zircon [6,7]. The {112} deformation twins in xenotime have not previously been reported in nature, and we propose that they constitute a diagnostic record of shock metamorphism. The xenotime twins are analagous to {112} twins in zircon [8-14], which provide diagnostic evidence of shock deformation. The presence of deformation twins in xenotime, a widely used U-Pb geochronometer, can therefore be used to identify hypervelocity deformation in shocked rocks, detrital grains and other materials, and may be particularly ideal for recording low pressure (<20 GPa) shock conditions that do not produce shock microstructures in zircon.

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