NanoGordian shocked mineral knots untied with EBSD

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Shock deformation caused by meteorite impact produces near instantaneous excursions in stress, pressure, and temperature that damage rocks and drive mineral transformations. Some of the more difficult challenges are detecting the former presence of minerals that form briefly at high-pressure or high-temperature conditions, but subsequently transform back to phases stable at ambient conditions. The back-transformation can leave a trail of 'microstructural breadcrumbs', such as complex transformation twins and/or neoblastic textures that do not result from any other natural process. These complex mineral occurrences thus are viewed as nano-Gordian shocked mineral knots; they result primarily from extraterrestrial processes, and with rare exception, have no endogenic equivalents. The crystallographic-controlled nature of such transformations can readily be detected by electron backscatter diffraction (EBSD) orientation analysis. EBSD can quantify characteristic misorientation relationships defined by angle-axis relations that result from the systematic transformations, with routine orientation analysis at the 50 nm scale. Reconstruction of the former parent phase through orientation analysis of the stable phase has been termed 'phase heritage' [1]. Phase heritage analysis has detected the former presence of reidite, a high-pressure polymorph of $ZrSiO_4$, in recrystallized granular neoblastic zircon from impact glasses and impact melt rocks [1-3]. Phase heritage has also been applied to zirconia polymorphs. The former presence of both cubic- and tetragonal-zirconia, high-temperature polymorphs, have been detected through phase heritage analysis of twinned monoclinic zirconia (baddeleyite) formed by dissociation of zircon in impact melt [1]. Orthorhombic zirconia, a high-pressure zirconia polymorph, has been detected through analysis of twinned baddeleyite in shocked bedrock [4]. Phase heritage analysis of complex twins in shocked monazite has revealed the former presence of a formerly unknown high-pressure tetragonal-$CePO_4$ phase [5]. Examples will be discussed in the context of using nano-scale analysis to untangle complex Gordian shocked mineral knots. References. [1] Timms et al. 2017 Earth Sci. Rev. [2] Cavosie et al. 2016 Geol. [3] Cavosie et al. 2018 Geol. [4] White et al. 2018 Geol. [5] Erickson et al. Geol. *in press*.