IMPACT-RELATED DEFORMATION OF ZIRCON

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Impact-related metamorphism of zircon ($ZrSiO_4$) can result in crystal-plasticity [1, 2, 3, 4], brittle fracturing [1], twinning [3, 4, 5, 6, 7, 8], transformation to reidite [9, 10, 11, 12], dissociation to ZrO_2 + SiO_2, and formation of a granular texture [13, 14, 15, 16, 17, 18]. The significance of these processes are twofold: 1. Some of the processes facilitate changes to the trace element compositions of zircon, and have been demonstrated to result in resetting of the U-Pb isotope system in zircon [4, 5, 18, 19], and in some cases can yield the age of impact [2, 4]; 2. Microstructures associated with impact processes form at different pressure and temperature conditions, and therefore can be used to investigate different shock conditions. The fact that zircon can survive extreme conditions associated with impacts, and even be preserved though metamorphic and sedimentary cycles [4, 7], means that zircon is a very useful tracer of impact events throughout the geological record. However, some uncertainty exists around conditions at which various shock metamorphic processes occur in zircon, and the effects on U-Pb geochronology are not always clear [18].

In this presentation, impact-related deformation microstructures in zircon will be examined in detail, especially techniques to reliably identify them, and how relationships among them can be interpreted in terms of processes. Data for zircon from several impact structures that preserve different transformations and microstructures associated with varying shock conditions are presented. Various phase transformations occur via specific, predictable crystallographic orientation relationships that have been identified using electron backscatter diffraction analysis (EBSD). We present new pressure-temperature diagrams showing the phase transformations among $ZrSiO_4$, SiO_2, and ZrO_2 polymorphs and under extreme conditions using available empirical and theoretical constraints. For each locality, the systematic crystallographic orientation relationships within and between shocked or thermally-altered zircon and its products constrain the specific reaction history in pressure-temperature space. The new $ZrSiO_4$-SiO_2-ZrO_2 phase diagrams can be used to provide a context in which to interpret microstructural observations with the pressure-temperature histories of terrestrial and extraterrestrial samples. The current limitations of this approach and future directions will be discussed.

[1] Nemchin et al., 2009 *Nat Geosci*; [2] Moser et al., 2009 *EPSL*; [3] Timms et al., 2012, *Met & Plan Sci*; [4] Cavosie et al., 2015a, *Geology*; [5] Moser et al., 2011 *Can J Earth Sci*; [6] Erickson et al., 2013a *Am Min*; [7] Erickson et al., 2013b *GCA*; [8] Thomson et al., 2014, *Geol Soc Am Bull*; [9] Leroux et al., 1999 *GCA*; [10] Glass et al., 2002 *Am Min*; [11] Cavosie et al., 2015b *Geology*; [12] Reddy et al., 2015 *Geology*; [13] Bohor et al., 1993 *EPSL*; [14] Wittmann et al., 2006 *Met & Plan Sci*; [15] Tohver et al., 2012 *GCA*; [16] Grange et al., 2013, *J Geop Res*; [17] Kaiser et al., 2008 *J Eur Ceram Soc*; [18] Schmieder et al., 2015, *GCA*; [19] Grange et al., 2013, *GCA*.