Zircon Breaking Badd: Fingerprinting impact histories from $ZrSiO_4$ and zirconia microstructures

NICHOLAS E TIMMS[1*], AARON J CAVOSIE[1], TIMMONS M ERICKSON[1], MARK A PEARCE[2], STEVEN M REDDY[1], MARTIN SCHMIEDER[3], ERIC TOHVER[4], MIKE ZANETTI[5], AXEL WITTMANN[6]

[1]Curtin University, Bentley, WA 6102, Australia
*n.timms@curtin.edu.au
[2]CSIRO, Kensington, WA 6151, Australia
[3]Lunar and Planetary Institute, Houston, TX, USA
[4]University of Western Australia, Crawley, WA 6009, Australia
[5]University of Western Ontario, London, ON, Canada.
[6]Arizona State University, Tempe, AZ 85287, USA

We present a new approach to reconstruct the history of zircon ($ZrSiO_4$) that has experienced extreme conditions associated with impact events. At high pressure conditions, zircon can undergo multiple transformations, including twinning [1, 2, 3, 4, 5] and conversion to reidite [1, 6, 7, 8]. Granular textures are also indicative of high-grade shock metamorphism [9, 10, 11]. Dissociation by the reaction $ZrSiO_4 \rightarrow ZrO_2 + SiO_2$ occurs above 1670 °C at 1 atm, and reaction products can undergo polymorphic transformations and reversion to zircon and baddeleyite (Badd) upon cooling [12]. All of these phase transformations result in specific, predictable crystallographic orientation relationships [3, 4, 7, 8, 12, 13]. We present new pressure-temperature diagrams of the phase transformations of $ZrSiO_4$ and their dissociation products under extreme conditions using available empirical and theoretical constraints. These diagrams provide a context in which to interpret natural samples.

Electron backscatter diffraction data from zircon from three impact structures (Ries, Acraman, Mistatstin Lake) reveals a range of different microstructrues and phases. We show how the crystallographic orientation relationships within and among phases fingerprint the specific reaction history that can then be mapped in pressure-temperature space.

[1] Leroux et al., 1999 GCA; [2] Moser et al., 2011 Can J Earth Sci; [3] Timms et al., 2012 Met & Plan Sci; [4] Erickson et al., 2013a Am Min; [5] Erickson et al., 2013b GCA; [6] Glass et al., 2002 Am Min; [7] Cavosie et al., 2015 Geology; [8] Reddy et al., 2015 Geology; [9] Bohor et al., 1993 EPSL; [10] Wittmann et al., 2006 Met & Plan Sci; [11] Tohver et al., 2012 GCA; [12] Kaiser et al., 2008 J Eur Ceram Soc; [12] Smith and Newkirk, 1965 Acta Cryst; [13] Bansal and Heuer, 1972 Acta Met.