Phase transformations of granular zircon: To the beyond, and back

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Granular zircons are a most unusual morphotype of shocked zircon, consiting of aggregates of sub-μm neoblasts. Despite being reported from a number of impact environments [e.g., 1,2], formation conditions and mechanisms are essentially unconstrained, and have not been produced experimentally. Here we report a new occurrence of granular zircon, from Meteor Crater (USA), and use high resolution electron backscatter diffraction (EBSD) orientation data to resolve phase transformations involved in its formation. The granular zircons occur in a clast of highly shocked Coconino Formation sandstone comprised entirely of vesicular lechatelierite (fused SiO_2). EBSD data show that individual zircons are comprised of multiple neoblast domains, some with boundaries misorieted by 65°/<110>, the known orientation of {112} shock twins. Other domains have crystallographic c-axes in alignment with {110} of neighboring domains, a relationship consistent with the former presence of the high pressure polymorph reidite [3,4,5]. Nearly all the granular zircons contain ZrO_2 from partial dissociation of zircon. The genesis of Coconino Formation granular zircons thus started with transformations including shock-twinning and reidite formation (20-30 GPa), and likely produced a disordered $ZrSiO_4$ phase at peak conditions that retained crystallographic orientation memory. This phase then recrystallized to systematically oriented zircon neoblasts, some of which partially dissociated to ZrO_2 during shock unloading.

Formation conditions of granular zircon are not well constrained, however, it is often found in samples that experienced >50 GPa [6]. Dissociation of pure zircon occurs at temperatures of 1670 °C at 1 atm [7], but may differ for non-stoichometric natural zircon. Experiments indicate lechaterlierite formation at temperatures of 2200 °C [8], which, even briefly, would facilitate zircon dissociation. Granular zircon thus records a cumulative P-T history of extreme conditions produced during impact.

[1] Bohor et al. 1993 EPSL. [2] Kamo et al. 1996 EPSL. [3] Leroux et al. 1999 EPSL. [4] Cavosie et al. 2015 Geology. [5] Reddy et al. 2015 Geology. [6] Wittmann et al. 2006 MAPS. [7] Kaiser et al. 2008 J Eur Cer Soc. [8] Macris et al. 2014 Met Soc.