DENDRITIC REIDITE FROM CHESAPEAKE BAY EJECTA AT ODP SITE 1073, OFFSHORE NEW JERSEY, USA: A HALLMARK OF DISTAL IMPACT EJECTA? A. J. Cavosie[1], M. B. Biren[2], K. V. Hodges[2], J.-A. Wartho[3], J. W. Horton, Jr.[4], and C. Koeberl[5], [1]Space Science and Technology Centre and the Institute for Geoscience Research, School of Earth and Planetary Science, Curtin University, Perth, Australia, [2]School of Earth and Space Exploration, Arizona State University, Tempe, AZ USA, [3]GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany, [4]U.S. Geological Survey, National Center, Reston, VA, USA, [5]Department of Lithospheric Research, University of Vienna, Vienna, Austria. Corresponding author: aaron.cavosie@curtin.edu.au

Introduction: Reidite ($ZrSiO_4$) forms at pressures >20 GPa during shock compression. However, there is no broad consensus on the nature of the polymorphic transformation. Here we describe a new habit of reidite in distal impact ejecta (offshore New Jersey, USA) from the ca. 35 Ma Chesapeake Bay impact event. The former zircon grain experienced near-complete conversion (89%) to reidite, which occurs as two distinctive habits: (1) intersecting sets of planar lamellae that appear dark in cathodoluminescence (CL); and (2) dendritic epitaxial overgrowths on the lamellae that appear luminescent in CL. A dendritic habit for reidite has not been reported previously. We propose a two-stage growth model for reidite in Chesapeake Bay impact ejecta: formation of lamellar reidite by shear during shock compression at ca. 40 GPa, followed by growth of dendritic reidite, also at high pressure, via recrystallization. The reidite dendrites are interpreted to nucleate on lamellae and replace damaged zircon adjacent to lamellae, which may be amorphous $ZrSiO_4$ or possibly an intermediate phase, all before quenching. These results provide new insights on the high-pressure polymorphic transformation over the microseconds-long interval of reidite stability during meteorite impact. Given the formation conditions, dendritic reidite may be a unique indicator of distal ejecta [1].

Understanding reidite formation: Disparate views exist as to whether the transformation to reidite is martensitic (shear based), reconstructive (diffusion based), or a hybrid process. Evidence for a martensitic transformation includes the near-instantaneous (microseconds duration) transformation [2, 3], preservation of Zr and Si coordination [4], and a systematic topotaxial relation to the host zircon [5]. Evidence for reconstructive transformation includes lower energy barriers for a reconstructive transformation [6, 7] and the interpretation that the relative arrangement of SiO_4 and ZrO_8 polyhedra changes [8]. The ubiquitous occurrence of micrometer-wide reidite lamellae in naturally shocked zircon is consistent with shear transformation [e.g., 9]. However, reports of both lamellar and granular reidite in the same zircon suggest multiple growth mechanisms can operate in some settings [9, 10].

Sample and Method: The grain analyzed is from Chesapeake Bay ejecta intersected at Ocean Drilling Program (ODP) Site 1073 Hole A [11]. The grain was mounted in epoxy, ground, and polished. Scanning electron microscopy, including backscattered electron (BSE), CL, and electron backscatter diffraction (EBSD), was performed in the John de Laeter Centre at Curtin University [1].

Results: EBDS orientation mapping reveals the grain consists of 89% reidite, and 11% zircon (Fig. 1).

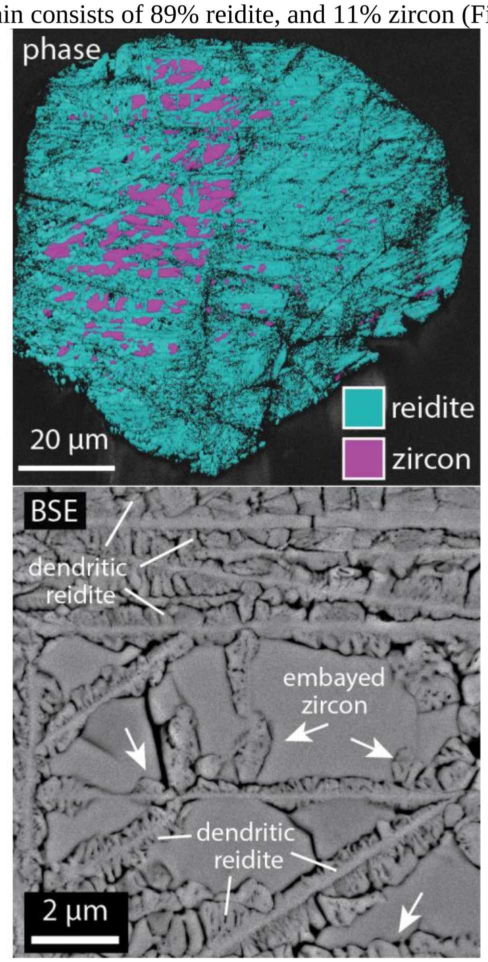

Figure 1. Top: Phase map showing distribution of reidite and zircon remnants. Bottom: BSE image showing zircon remnants embayed by dendritic reidite, both confined to spaces defined by intersecting reidite lamellae.

Five unique orientations of lamellae are present (Fig. 2). The lamellae are generally ~250 nm in width and as much as 50 μm long, although most are shorter. The lamellae appear to have formed simultaneously, as all orientations both truncate and are cross-cut by lamellae in other orientations. CL images reveal that lamellae are dark and have planar boundaries, whereas dendrites are conspicuously luminescent (Fig. 2). Only two main orientations of reidite are present; both are misoriented from the host zircon by 90°/<110>; each preserves alignments of (001)-zircon and {110}-reidite, and they mutually share a {110} direction. The above systematic orientation relationships are known from transmission electron microscopy [5] and have been described previously in EBSD studies of reidite from other localities [e.g., 9, 10].

Discussion: Dendritic reidite in Chesapeake Bay impact ejecta is fundamentally different from reidite occurrences in shocked bedrock [12] and impact breccias [e.g., 9]. Shock-recovery experiments report increasing proportions of reidite co-existing with zircon above 20 GPa, including 5%–15% at 30 GPa, 30%–70% at 40–42 GPa, and complete conversion at 52–60 GPa [2, 5, 13]. We envision a 2-stage model, whereby Stage 1 involves formation of pervasive lamellar reidite in multiple orientations by means of shear-based transformations of zircon at pressures at or above 40 GPa during shock compression. This creates a dense network of lamellae which isolates polygons of remnant zircon (Fig. 1). Stage 2, also at high-pressure conditions, initiates when damaged zircon adjacent to reidite lamellae undergoes a reconstructive transformation, resulting in epitaxial nucleation of dendritic reidite on the lamellae (Figs. 1,2). The structure of the pre-dendrite state of $ZrSiO_4$ is not known; it is not clear if it consisted of defect-rich zircon; of amorphous (diaplectic) $ZrSiO_4$, as has been found adjacent to reidite lamellae in shock experiments [5]; or if a recently proposed metastable high-pressure, low-symmetry $ZrSiO_4$ polymorph formed [8, 14]. Each of the above materials would lower kinetic barriers to forming reidite relative to undamaged zircon. Regardless of formation mechanism, dendritic reidite is distinctive, and has thus far not been reported in bedrock. Given the high-pressure, rapid quench conditions experienced by some components of distal ejecta, we propose that dendritic reidite may be unique to such deposits.

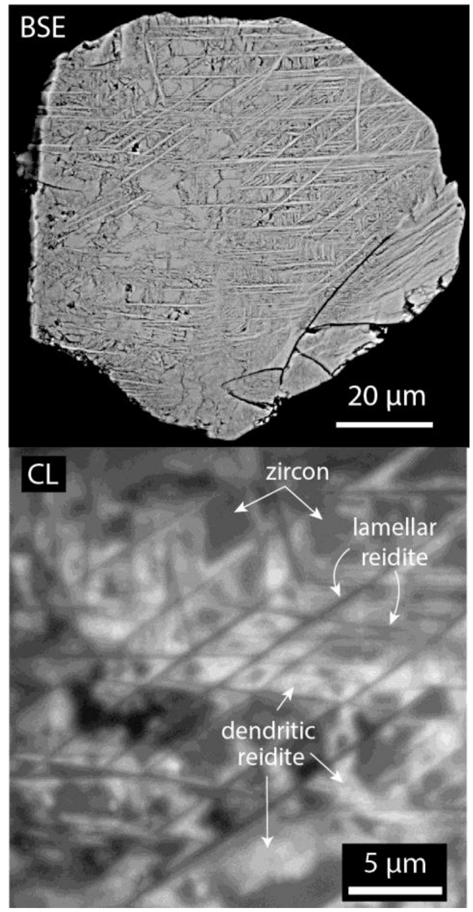

Figure 2. Top: BSE image showing a dense network of reidite lamellae intergrown with dendritic reidite. Bottom: CL image showing remnant zircon (dark), reidite lamellae (dark), and dendritic reidite (luminescent).

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