SHOCKED ZIRCON FROM THE WOODLEIGH-1 CORE: THE LARGEST KNOWN SECTION OF COHERENT REIDITE-BEARING BEDROCK? Morgan A. Cox[1], Aaron J. Cavosie[1], Phil A. Bland[1], Katarina Miljković[1], and Michael T. D. Wingate[2].
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Introduction:

Reidite, the ~30 GPa high-pressure $ZrSiO_4$ polymorph, is a rare mineral that has only been reported from <10 impact structures and ejecta deposits over the last decade [e.g., 1]. The occurrence of reidite in coherent bedrock is scarce, which leaves open questions, such as whether it represents local high-P excursions, or if it can be used as a bulk shock indicator. Impact structures where reidite has been reported in impactites include Chesapeake Bay (Virginia, USA) [2], Haughton (Arctic Canada) [3], Ries (Germany) [1], and Rock Elm (Wisconsin, USA) [4], although its occurrence at each of these sites is limited to either centimeter-sized clasts within breccia (Ries, Rock Elm, Chesapeake Bay and Haughton) or within impact melt (Chesapeake and Haughton). Here we report the occurrence of reidite throughout a ~143 m section of drill core from the central uplift of the Woodleigh impact structure in Western Australia. The core is mainly granitic rocks that are heavily fractured in some parts, but lacks both breccia and impact melt, and thus represents the largest coherent section of reidite-bearing shocked bedrock thus far known. We also discuss the implications of these results for using reidite to estimate shock conditions in crystalline target rocks.

Woodleigh impact structure:

The Woodleigh impact structure is located ~50 km east of Shark Bay, Western Australia. The size of the buried structure is unknown but it has been suggested to be between 60 km [5] to 120 km [6] in diameter (Fig. 1). The central uplift of the structure was drilled in 1999; the Woodleigh-1 core recovered shock-deformed granitoid from 190.5 to 333.1 m [6]. The core consists of mainly granitic gneiss with no impact melt or breccia identified. The age of the structure is suggested to be between ca. 360 to 200 Ma, based on K-Ar dates from illites within bedrock [6] and Early Jurassic palynomorphs in shale and sandstone of the Woodleigh Formation, which filled the Woodleigh crater soon after impact [8].

Here we describe shocked zircon grains from Woodleigh-1 core samples that contain both {112} deformation twins and reidite. Reidite occurs as both lenses and lamellae in shocked zircon grains, some of which also contain {112} twins [7].

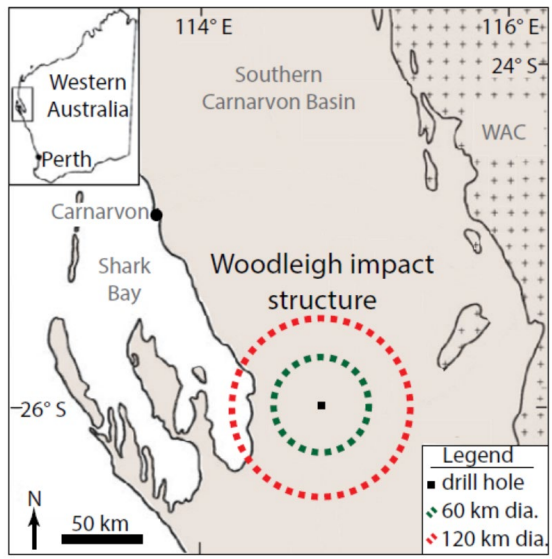

Figure 1. Location map of the Woodleigh impact structure in Western Australia [7]. WAC= West Australian Craton.

Sample and Methods:

Shocked Paleoproterozoic granitoids were sampled from basement rocks in the Woodleigh-1 core at several depths, including near the bottom (294.3 – 295.2 m, granitic gneiss sample 199093), near the middle (263 m, granodiorite sample 199090), and near the top (235 – 236 m, granodiorite sample 199086). Zircon grains from the samples were separated, mounted in epoxy, and polished. Grains were surveyed using backscattered electron (BSE) and cathodoluminescence (CL) techniques and analyzed for orientation with electron backscatter diffraction (EBSD) mapping at Curtin University. Grains were mapped at step sizes from 50 to 500 nm, with match units yielding high quality EBSD patterns.

Results and Discussion:

A total of 39 zircon grains, 16 from sample 199093, 18 from sample 199090, and 5 from sample 199086, were analyzed by EBSD to search for evidence of shock deformation. All three samples contain reidite and deformation twins, with 30 grains containing reidite, and 16 reidite-bearing grains also containing {112} shock deformation twins. Only one orientation of reidite is observed in each grain (Fig. 2). Reidite in all grains records a close alignment of $<110>_{reidite}$ with the host

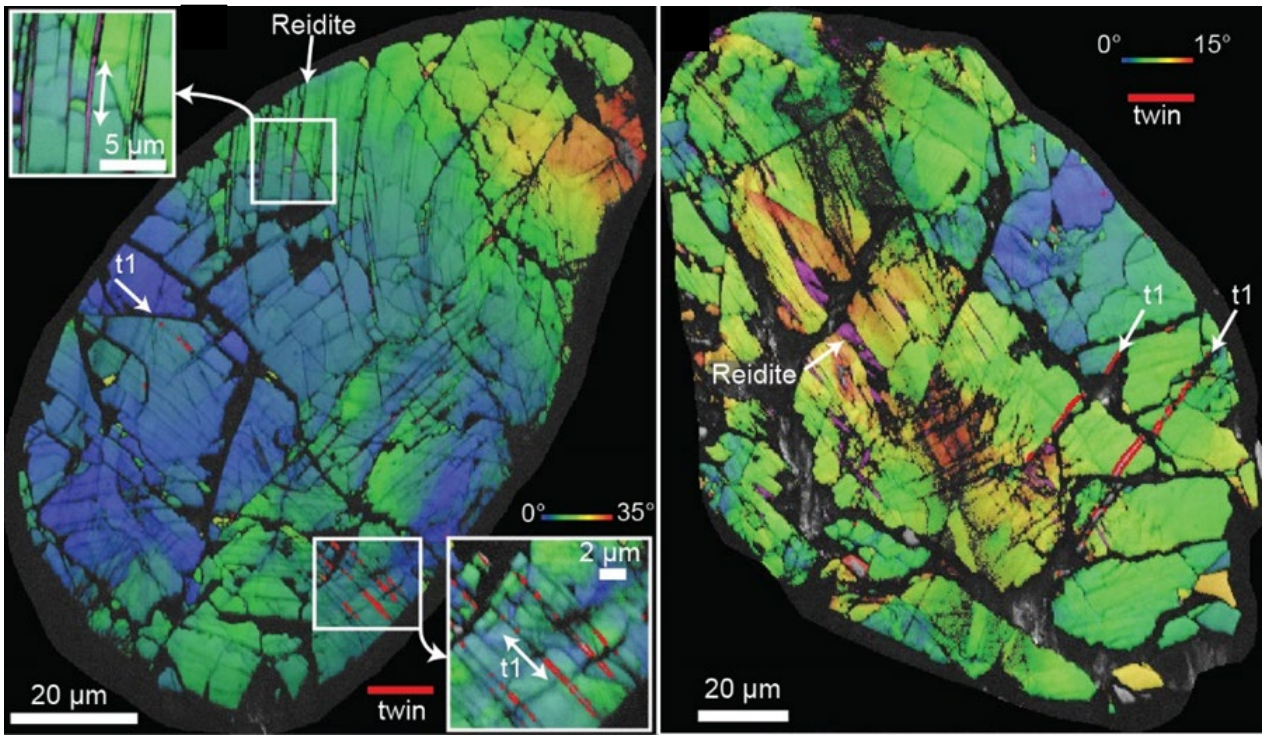

Figure 2. Texture component maps of zircon grains showing up to 35° of crystal plastic deformation. {112} twins are represented in red, reidite lamellae are represented by purple. An example of lamellar reidite is on the left; an example of irregular reidite lenses is on the right.

[001] zircon and both phases also share a <110>, as has been described previously [e.g., 1,4,7]. The {112} deformation twins identified in zircon grains occur in up to three different orientations in a single grain, with over 50 twin lamellae also identified in a single grain [7]. In all cases, the twins are misoriented from the host grain by 65°/<110>.

Some zircon grains contain reidite that is off-set along {112} deformation twins [7]. The grains contain one orientation of reidite and {112} deformation twins, but the reidite occurs as irregular lenses in one grain and straight lamellae in the other. The {112} deformation twins are well developed, extending fully across the grains. The reidite lenses are discontinuous, whereas the lamellae are continuous. Reidite is offset along {112} twins by up to 2 µm. Both the reidite and the {112} deformation twins are undeformed.

Reidite is interpreted to have formed during initial compression. Reidite was later offset along {112} twin planes during crustal extension and uplift caused by the rarefaction wave during excavation [7]. This is similar to twins in zircon from the Vredefort Dome, which have previously been ascribed to form by the rarefaction wave during excavation [9].

The extensive presence of reidite in zircon grains described here suggests that the Woodleigh-1 core appears to represent the largest coherent mass of intact reidite-bearing bedrock thus far documented. All other known reidite occurrences are at the cm-scale, as compared to the 60 m section documented here, which is likely representative of the entire 143 m length of core. This may be the first unambiguous example where the occurrence of reidite records the bulk rock shock pressure. The Woodleigh-1 example therefore demonstrates that reidite is a diagnostic indicator of shock conditions which can be used to systematically survey the distribution of shock within crystalline target rocks at impact structures where zircon is present, and where conditions reached reidite stability (e.g., >30 GPa), without melting.

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