ZIRCON MICROTEXTURES FROM THE MANIITSOQ IMPACT STRUCTURE, WEST GREENLAND.

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Introduction: The deeply eroded, 3.0 Ga Maniitsoq structure in southern West Greenland [1] comprises a central, cataclastic and mechanically mixed body, the 35 x 50 km large Finnefjeld domain [2] and a surrounding 'Melt zone' up to tens of kilometres wide with evidence of shock melting of mainly K-feldspar [3], – a rarely used but nevertheless diagnostic feature of hypervelocity impacting [4]. Present exposures are 20–25 km below the impacted surface. The mapped components of the Maniitsoq structure comply with iSALE modelling of a dunitic bolide 30 km large impacting at 17 km/s into 40 km thick, preheated continental crust [5]. Here we report microstructures consistent with shock metamorphism in zircon grains from two localities ~40 km apart on either side of the Finnefjeld domain at 65°21.4'N, 51°33'E and 65°15.4'N, 52°15.6'E, respectively.

Analytical methods: Secondary and backscattered electron images using standard imaging techniques at the Zeiss Gemini Sigma 300 VP and Tescan Mira3 scanning electron microscopes at GEUS and Lund University, and EBSD analysis on the latter instrument. The sample was polished in colloidal silica and carbon coated with 5 nm, and tilted 70° for analyses at an accelerating voltage of 20 kV, using Oxford Instruments Aztec and Channel 5 Software. A single wild-spike correction was made to remove noise.

Zircon microstructures in sample 257543, east of the Finnefjeld domain: Equant, mostly bipyramidal zircon grains 100–200 µm large were extracted from a quartz-plagioclase (-biotite) rock (possibly a former pegmatite) in an impact breccia. In thin section also cataclastic and disintegrated zircon grains were observed. BSE images (Fig. 1) document persistent planar microstructures throughout the external surfaces of almost all investigated grains. They are completely straight and occur in up to at least three mutually cross-cutting directions with a spacing down to 1 µm or less, and cut growth zonation. Preliminary EBSD analysis supported by optical observations in thin section suggests that they consist of panels of crystalline zircon without twinning or misorientation, alternating with very thin panels without EBSD signal which might therefore be either metamict or amorphous (Fig. 2). In this preliminary study we have not identified associated twinning, lattice distortion, reidite or crystallographic re-orientation indicative of potential former reidite.

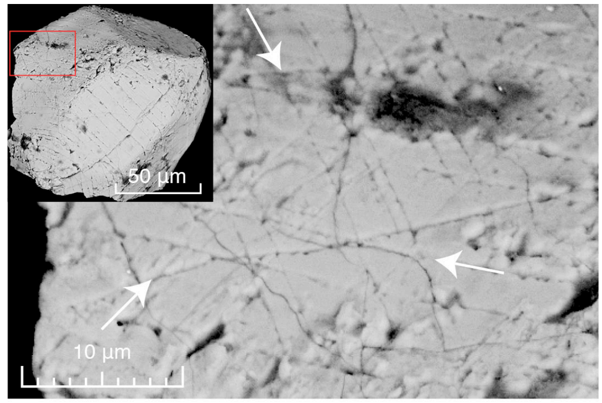

Fig. 1. Euhedral zircon grain (sample 257543) with three equivalent, mutually intersecting sets of micron-scale planar microstructures and more widely spaced planar fractures.

The planar microstructures have been exploited by planar fractures (PFs) with a spacing of >10 µm and common offsets, similar to recent descriptions of shocked zircon, e.g. [6]. Interior PF surfaces are micro-cataclastic and also contain buckshot-shaped granular zircon and zircon neoblasts around 1 µm large. Other grains have solid, near-perfect euhedral shells only a few micrometres thick with traces of closely spaced, planar microstructures and largely cataclastic interiors, where granular zircon and zircon neoblasts also occur.

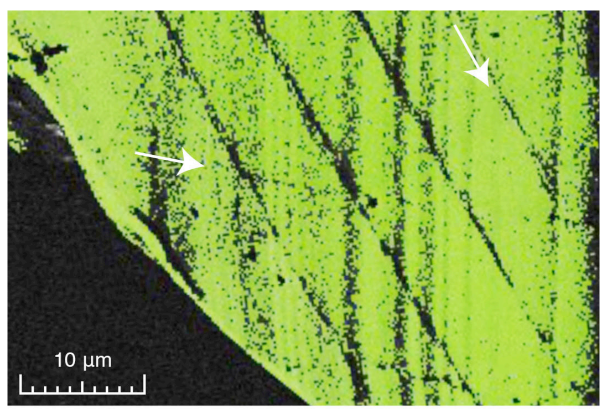

Fig. 2. Preliminary EBSD Band Contrast + IPF image (resolution 0.1 µm) displaying lamellar structure in a zircon fragment (sample 257543). A vertical orientation with diffuse boundaries is parallel to growth zonation. Two other orientations with more well-defined boundaries are invisible in BSE and CL images.

Zircon microstructures in sample 525326, southwest of the Finnefjeld domain: Prismatic zircon grains up to 300 µm long were retrieved from a total-melt patch (as opposed to partial, anatectic melting) derived from a tonalitic orthogneiss [7].

Ribbons. Surfaces of zircon grains in sample 525326 display a wide range of ribbon-like microtextures that grade into each other from fine to coarse and eventually constitute a new outer coat. A first appearance of several sets of tiny parallel microribbons up to ~1 µm wide seems to have developed into open, micrometre-scale networks with elevations of 1–2 µm on some or all grain surfaces (Fig. 3A). Coarser, interconnected ribbons form semicontinuous coats with higher elevations above the original surface. The ribbons typically have oblique, subparallel orientations in one or several directions that may imply initial crystallographic orientation control (Fig. 3B). A late stage in the visual progression is a smooth, more or less complete new coat of zircon. Small 'voids' where coat is missing are bounded by junctions of adjacent coats each with convex fronts, just as if liquids had been flowing in from several sides but were arrested before the coating was complete.

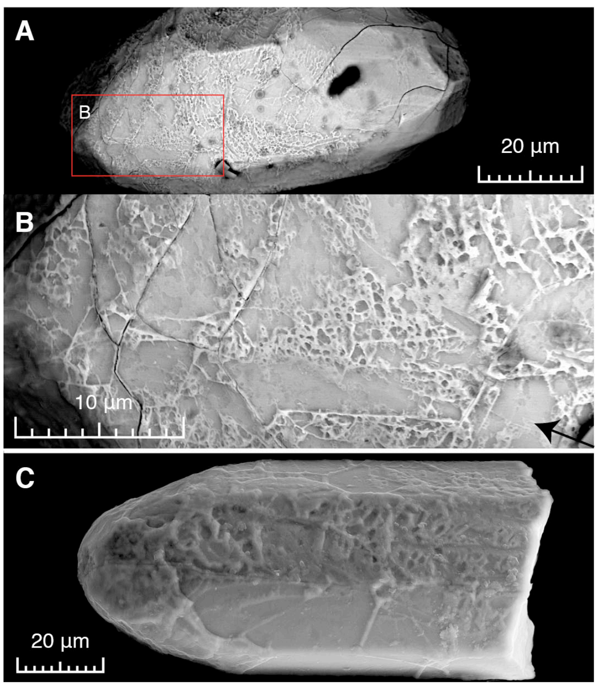

Fig. 3. Incipient and coarser ribbon microstructure in zircon, sample 525326. Note sub-micrometre scale features at arrow (**A**, **B**) and preferred oblique orientation of coarser ribbons (**C**) in another grain, which form a partial coat the original surface.

Granular zircon. Sample 525326 also contains granular zircon, visible as grape-like clusters of rounded, sub-micron-scale grainlets on the surfaces of cloudy, barrel-shaped grains, as larger granules side by side on one or more faces of prismatic crystals, and as granules up to ~3 µm large that form the interior of broken grains with partly integer shells (Fig. 4).

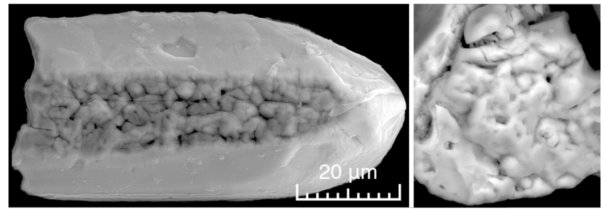

Fig. 4. Granular interior structure in zircon, sample 525326.

Discussion: The deep exhumation and inferred giant size of the Maniitsoq structure imply that shock conditions (*P*, *T*, duration of *T* excursion) and zircon shock phenomena might have diverged from those observed in various other terrestrial impact structures. The distribution of PFs with spacing >10 µm in sample 257543 in several respects resemble PFs in Vredefort zircon, e.g. [8], although the former yield null-EBSD signals and no twinning has been recorded. The penetrative and mutually crosscutting, very closely spaced lamellae in up to at least three directions and without EBSD indexing do not precisely match any of the many different planar zircon microstructures described from other impact structures. More detailed work will show if they might constitute the first planar microstructures in zircon that closely resemble quartz PDFs.

The zircon in sample 525326 contains both granular textures and a conspicuous, not previously observed, surficial ribbon-like microstructure grading into a secondary coating of grain surfaces. The incomplete coats resemble quenched high-temperature melts known from fulgurites and experimental petrology. We emphasise that an interpretation of the ribbons and coats as evidence of direct melting and quenching of zircon is both tentative and highly provisional, and requires further documentation. It is considered that instantaneous shock melting of zircon might take place if the temperature was high enough; the stability of reidite above 1200°C is not well explored [9], and dissociation of shocked zircon to ZrO_2 and SiO_2 above 1675°C involves a chemical reaction and is hence not instantaneous.

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