

EVIDENCE OF FORMER REIDITE IN GRANULAR ZIRCON FROM LIBYAN DESERT GLASS

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Introduction: Libyan Desert Glass (LDG) is one of the most enigmatic natural glasses known. The two main hypotheses for its origin include melting by meteorite impact, and melting caused by a large airburst. Here we report the occurrence of granular zircon grains in LDG that are comprised of neoblasts with orientation relations that record the former presence of reidite, a high-pressure polymorph of ZrSiO_4 . The former presence of reidite requires LDG to have been produced by an event that generated high-pressure shock waves. These data represent the first report of high-pressure shock deformation from material contained within LDG, and strongly favor an origin of LDG during the formation of an impact crater, rather than from an airburst alone.

Libyan Desert Glass (LDG): The LDG field occurs over several thousand square kilometers in the desert of western Egypt, near the Libyan border [1]. LDG is high-silica glass (~98 wt. % SiO_2), and is pale yellow in color. LDG formed ~29 Myr ago during high-temperature fusion of a quartz-rich source; high-temperature indicators in LDG include lechatelierite, α -cristobalite (after β -cristobalite), baddeleyite (after zircon), and mullite [2,3]. A meteoritic component has been reported in LDG [4]. Shocked quartz has been reported in float [5] and bedrock [6] samples of sandstone from the LDG field, however, no evidence of high-pressure shock deformation has been reported in LDG, until now. In the absence of an identified source crater, and definitive evidence for high-pressure shock deformation in LDG, the two competing hypotheses for the origin of LDG are that it represents melt formed during a meteorite impact [e.g., 1], or that it represents melt formed during a low-altitude airburst [7].

Samples and methods: Seven samples collected from the LDG field by one of us (CK) were analyzed; all are typical LDG samples, consisting of translucent yellow glass with both dark and light inclusions. A total of 101 zircon grains were documented. Backscattered electron (BSE) images were collected for all grains, and electron backscatter diffraction (EBSD) orientation maps were collected on a sub-set of representative samples. Conditions for EBSD analysis of zircon were similar to those described previously [e.g., 8]. Typical step size ranged from 50 to 100 nm.

Results: Three microstructures were observed in BSE images of zircon in LDG. The dominant population of grains (65%) consists of grains that fully dissociated to zirconia (now baddeleyite). The second largest population of grains (24%) consists of grains that are interpreted to have dissociated to zirconia, and then back-reacted with the melt to form neoblastic zircon. The third population of grains (11%) consists of granular zircon grains comprised of μm -sized neoblasts that either did not dissociate, or only partially dissociated along grain margins in contact with melt. No pre-impact microstructural features are preserved in the 101 LDG zircons analyzed.

Results of the orientation analysis are focused on the preserved granular grains; the dissociated grains will be discussed elsewhere. Orientation maps were collected for 8 of the 11 granular grains. The data reveal that 5 of the grains consist of zircon neoblasts with either a single orientation, or they contain broadly dispersed neoblast orientations that do not define orientation clusters. In contrast, three of the granular grains are comprised of 2 or 3 neoblast orientation clusters with systematic $90^\circ/\langle 110 \rangle$ relations among the neoblast clusters (Fig. 1).

Discussion: Granular zircon grains with systematic neoblast orientation clusters form when shocked zircon is partially transformed to reidite, and then reverts back to zircon neoblasts at lower pressure and/or higher temperature [9,10]. Recognition of the hallmark systematic neoblast orientation clusters in such grains provides a quantitative method to identify the former presence of reidite in grains where it is no longer present. Such grains have been referred to as 'former reidite in granular neoblastic zircon', or FRIGN zircon [8]. Occurrences of FRIGN zircon are only known from impact glasses [8, 11-12] and impact melt rocks from impact craters [8, 10, 13-14]. Identification of former reidite in granular zircon in LDG represents the first evidence for high-pressure shock deformation reported from relict phases in LDG, and uniquely requires the glass to have formed during an event that generated high-pressure shock waves. LDG is thus not an example of a ~100 Mt level 'LDG-class' airburst, as has been previously suggested [15]. There are no confirmed examples of a ~100 Mt level airburst in the geological record.

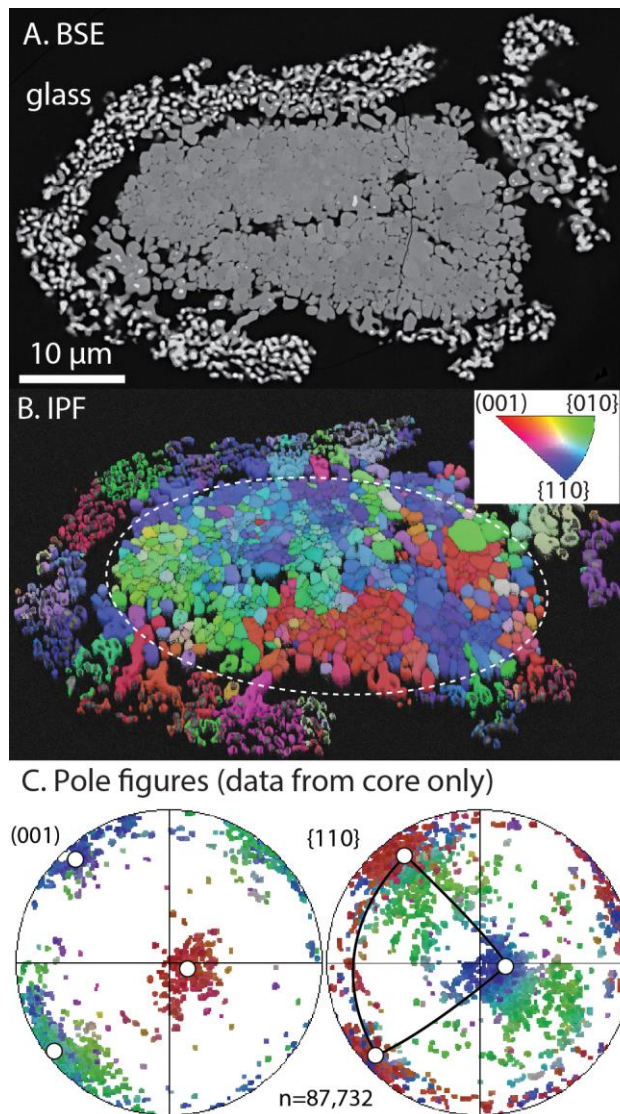


Figure 1. Example of a granular zircon in Libyan desert glass that preserves evidence of former reidite. A) BSE image, showing a granular neoblastic zircon core surrounded by a semi-detached rim that dissociated to zirconia. The rim partially back-reacted with melt, forming a second generation of neoblastic zircon. B) Orientation map (IPF) showing many different neoblast orientations. C) Pole figures showing data from the granular core (see oval in B), which is comprised of three neoblast orientation clusters. Each cluster preserves a $90^\circ/\langle 110 \rangle$ relation with the other clusters (note coincidence of [001] and $\langle 110 \rangle$ clusters). The systematic relations among neoblast orientation clusters provides the critical evidence for the former presence of reidite.

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