URANIUM AND ZIRCONIUM ENRICHMENTS IN LIBYAN DESERT GLASS: ZIRCON, BADDELEYITE, AND HIGH TEMPERATURE HISTORY OF THE GLASS.

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INTRODUCTION. Libyan Desert Glass (LDG) is an enigmatic natural glass found in an area of at least 3500 km² between sand dunes of the southwestern corner of the Great Sand Sea in western Egypt, near the border to Libya. The glass shows irregular shapes with signs of sand abrasion and other erosion features. The age of the glass, as determined by the fission track method, is around 29 Ma [1]. Chemically, LDG is remarkably homogeneous with about 96.5-99 wt.% SiO_2. Major and trace element abundances fall into a narrow range (see, e.g., Fudali [2], Barnes and Underwood [3], Weeks et al. [4], and Koeberl [5]), although some trace elements, such as the rare earth elements, occur at levels typical for upper crustal rocks [4-6]. The origin of LDG is the subject of a controversy which is still not settled. The majority of workers favor an origin by impact, although there are some differences to "classical" impact glasses, and no impact crater has been found to be associated with the glass occurrence. A relatively high water content of about 0.15-0.2 wt.% was reported by Frischat et al. (e.g., [7]), which is not typical for impact glasses. Furthermore, Jux [8] claims to have found neogene microfossils in the glass (!) and argues vividly for some kind of a sol-gel origin of LDG. Our study aims at providing further evidence for an impact origin of LDG.

SAMPLES AND METHODS. During the determination of fission track ages in several LDG samples, high local concentrations of uranium were noted in some sections from the study of the distribution of fission tracks after etching. These samples were then studied by electron microprobe to determine the major element chemistry of the high-U zones.

RESULTS AND DISCUSSION. Fig. 1 shows the results of the study of the uranium-rich zones. There is a good positive correlation between the concentrations of U and Zr. Two main groups of Zr/U rich zones were found. One type (very high in Zr and U) coincides with baddeleyite which is also visible by optical microscopy. Baddeleyite (ZrO_2) is a breakdown product of zircon and was described earlier by Kleinmann [9], who also found some remnant zircon crystals that were only partly transformed into baddeleyite. The other group was not evident from optical microscopy, but was only found from the uranium enrichments in the glass. In these cases, Zr was also found at the same locations that showed U enrichments. In both cases, the distribution of U (as determined from the fission tracks) and Zr follows flow structures and schlieren-like structures, clearly indicating glass flow. In the case of the second group of Zr/U rich zones, the baddeleyite was already diluted in the flowing glass, and the structures of that flow are preserved. The mere fact of baddeleyite occurrence (which requires temperatures of 1500-2000°C) and the unambigous evidence for glass flow are in clear contradiction to any low temperature origin as suggested in [8]. Fig. 1 shows also that the Zr/U correlation from the baddeleyite is not identical with the Zr/U correlation in the bulk LDG samples. The U content of the bulk LDGs is about 10 times higher than what would be expected if all U would be supplied by zircon. Fig. 2 shows the REE patterns of LDG (from 11 samples; Koeberl, [5], and in prep.) in comparison with local sand and sandstone (from Weeks et al. [4]), and the pattern of zircon [10]. The zircon pattern has been recalculated to show the contribution to the REE pattern if all Zr in the LDG is supplied by zircon. Obviously, the contribution of zircon to the REE pattern is less than 5-20% even for the heaviest REE (which seems not to be the case for the Gilf el Kebir (GeK) sandstone (data from [4]), where the HREEs are dominated by zircon). This is in clear agreement with the uranium correlation. The same sands and the sandstone (from [4]) are also plotted in Fig. 1 (solid triangles), showing that neither of them has U contents high enough to contribute U to the bulk LDG (for the two sands that have Zr contents comparable to LDG, the U seems to be dominated by zircon). The REE pattern of the Camp F sand is incomplete, but the LREE pattern fits the LDG well; however, this sand cannot be the sole precursor, as evident from the Zr/U correlation. This is in line with Murali et al.'s [6] conclusion, who suggested desert sand (e.g., similar to Ain Dalla sand) and surficial Fe-cemented alluvial or some Nubia sandstone as precursors. From our Zr/U and REE data we conclude that none of the sands or sandstones analyzed so far, or mixtures thereof, are the sole precursors of LDG. Some admixture of monazite and/or apatite (e.g., from some type of sediment) seems likely to explain both the excess U and the REE patterns.

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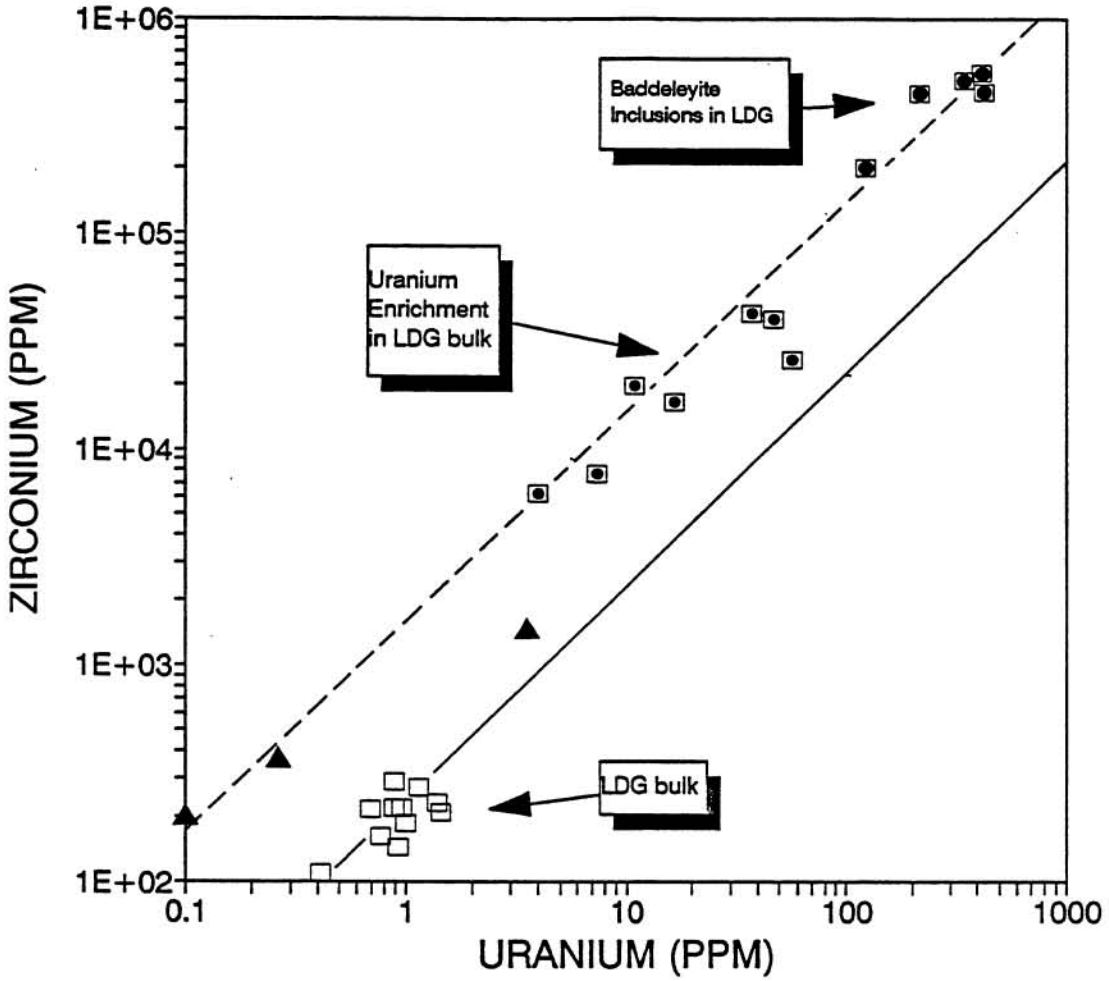

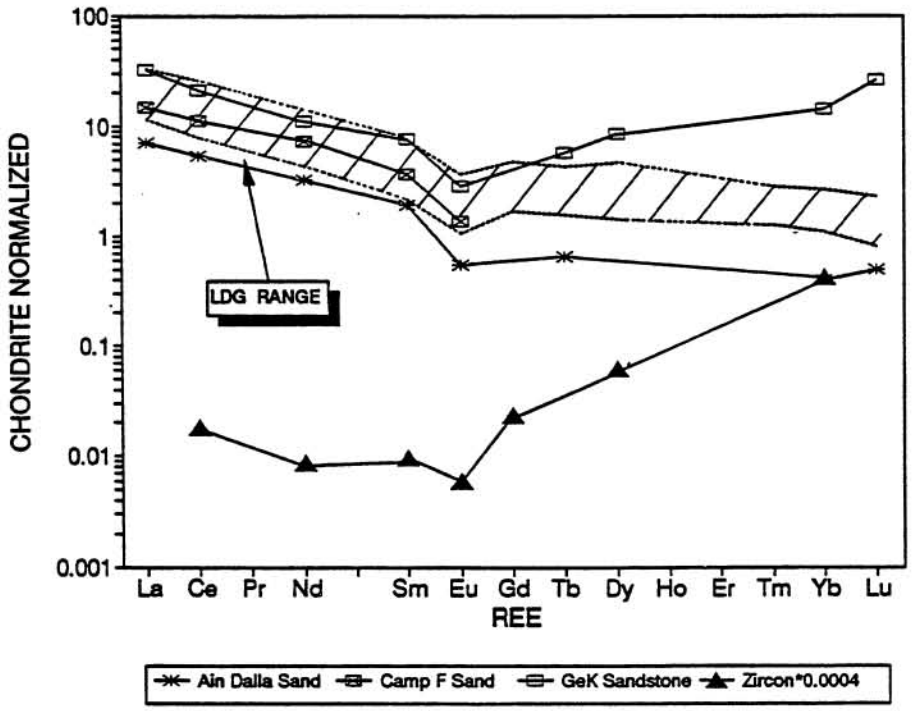

Fig. 1. Correlation of U and Zr in bulk LDG (data from Koeberl, [5], and in prep.), baddeleyite inclusions (U=123-483 ppm), and U-rich zones (U=4.0-56.8 ppm), and local sands and sandstone (from [4]). It is evident that there is excess U in the bulk LDG that cannot be explained by a contribution from zircon alone.
Fig. 2. Range of REE patterns in bulk LDGs (from Koeberl, [5], and in prep.), and two local sands and one sandstone (from [4]), compared with the pattern of zircon [10] recalculated to the level present if Zr in bulk LDG is solely derived from zircon.