THE (U-Th)/He ISOTOPE SYSTEM APPLIED TO THE DATING OF DISTAL EJECTA FROM THE CHESAPEAKE BAY IMPACT STRUCTURE.

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Introduction and Motivation: Impact glasses and melt rocks have historically been the preferred material for the dating of terrestrial impact structures, especially when high temperature geochronological systems are used (e.g., U/Pb, Rb/Sr and $^{40}Ar/^{39}Ar$). We also have dated numerous terrestrial impact structures using the (U-Th)/He method as applied to zircon, titanite, or apatite. The results typically fall into two categories: 1) a majority of dates that reflect a single age (e.g., minerals extracted from impact melt rock [1-2]), or 2) a wide range of dates that indicate varying degrees of shock-induced thermal resetting (e.g., minerals collected from melt-free impact breccias [3]). Here we report new (U-Th)/He data for zircons that are not from an impact structure, but instead collected from distal ejecta layers more than 300 km from the center of the Chesapeake Bay impact structure [4-5] off the east coast of North America.

Geologic Context of the Chesapeake Bay impact structure: The Chesapeake Bay impact structure consists of a 40 km central deep part and a surrounding annular trough (~85 km diameter) of collapsed, mobilized sediments [6-7]. It formed on the continental margin of what is now Virginia in a shallow-marine target of seawater, Cretaceous to Eocene poorly consolidated sediments, and underlying Proterozoic to Paleozoic crystalline rocks [6-8]. The Chesapeake Bay impact structure has been shown to be the source crater for the North American (NA) tektite strewn field [9] and associated distal ejecta found in the NW Atlantic [4-5].

Previous age determinations: The Chesapeake Bay impact structure has been indirectly dated by K-Ar and total fusion $^{40}Ar/^{39}Ar$ dating of NA tektites to yield ages of: 35.2 ± 0.6 Ma (2σ, n=6, [10]); 35.4 ± 0.6 Ma (2σ, n=7, [11]); 34.5 ± 0.2 Ma (2σ, n=5, [12]); and 35.3 ± 0.2 Ma (2σ, n=4, [7]). More recent step-heating $^{40}Ar/^{39}Ar$ tektite dates (33.14 ± 0.29 to 34.76 ± 0.36 Ma, 2σ) suggest that the structure may be slightly younger [13]. U-Pb single crystal dating of shocked zircons from the NA microtektite layer [4-5] yielded complex data with intercept ages of 400 ± 32 Ma and ~35.4 Ma [8]. This study provides (U-Th)/He zircon dates obtained from a distal ejecta layer to indirectly date the Chesapeake Bay impact.

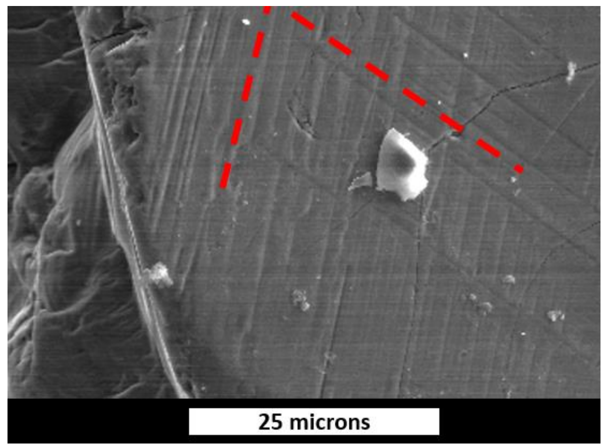

Fig. 1. Secondary Electron image of a zircon bearing planar features in two crystallographic orientations (red dashed lines).

Sample Material and Methods: Approximately ~30 cm^3 of unconsolidated upper Eocene sediment (Ocean Drilling Program site 1073A, core 72, section 4, interval 83-94 cm) was obtained from the IODP core repository in Bremen, Germany. The sediment sample was disaggregated in an ultrasonic bath and standard magnetic and heavy liquid methods were used to obtain heavy mineral separates. A Leica *MZ16* binocular microscope was used to select and determine the dimensions of 21 zircons (whole, intact grains) for dating using the (U-Th)/He method.

Eight zircon fragments were not dated, but were imaged with a Scanning Electron Microscope (SEM) operated in Backscattered Electron (BSE) and Secondary Electron (SE) modes to assess the number of shocked zircon grains and (qualitatively) levels of shock metamorphism in these grains. ^4He was measured in 21 zircon grains using an Alphachron extraction system fitted with a quadrupole mass spectrometer. U-Th concentrations for each grain were measured by

ICP-MS following zircon dissolution. Additional details on typical (U-Th)/He analytical procedures used at the Group 18 Laboratories are presented in van Soest et al. [1].

Results: Shock metamorphic effects were observed in three of eight grains examined by SEM. Two zircons exhibit planar features (Fig. 1), which are indicative of moderate shock pressures (20-40 GPa, [14]). A third zircon appears to have partially decomposed to baddeleyite (Fig. 2), which is indicative of relatively high shock pressures (~95 GPa [15]).

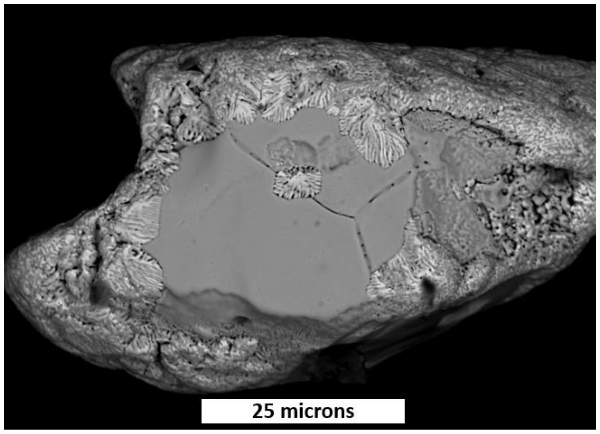

Fig. 2. BSE image of a zircon that has undergone partial decomposition to baddeleyite. Energy dispersive X-ray microanalysis line scans (not shown) indicate that the bright dendritic patterns are composed of ZrO_2 while the gray portions of the grain are composed of $ZrSiO_4$.

Twenty-one (U-Th)/He zircon dates range from 33.5 ± 0.9 to 305.1 ± 8.7 Ma (2σ, Fig.3). The three youngest dates overlap and define an error-weighted mean age of 34.9 ± 1.9 Ma (2σ of the mean), which we interpret as the shock-induced resetting age of the zircons at the time of the Chesapeake Bay impact.

Discussion and Conclusion: The large number of dates that are much older than the impact and the wide range of these old dates (~160 to 305 Ma) suggest that some of the zircon crystals in this sample may not have originated from the impact site, but were mixed with ejecta during deposition. An alternative interpretation is that some of these older grains originated from the impact site and experienced varying degrees of shock-induced resetting of their (U-Th)/He systems. Certainly, this seems to be the case for the crystals with young dates (<50 Ma). The remaining three dates with a weighted mean within uncertainty of previously reported $^{40}Ar/^{39}Ar$ tektite dates lend confidence that distal ejecta can, under appropriate circumstances, preserve a (U-Th)/He signature of the timing of impact.

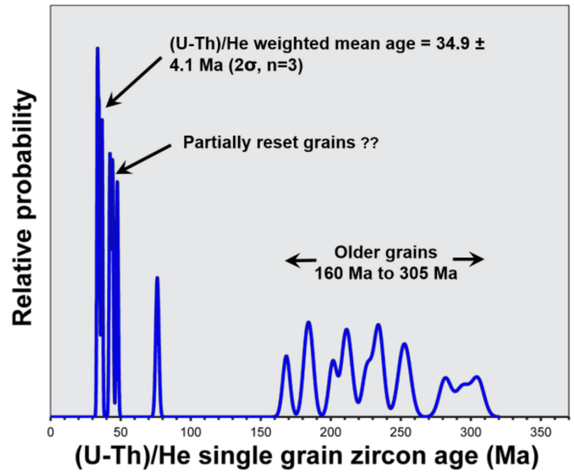

Fig. 3. Relative probability density plot for all 21 (U-Th)/He zircons dated from the ODP 1073 sediment drill core sample. The 3 youngest dates produce a weighted mean age of 34.9 ± 4.1 Ma (2σ , n=3), which agrees well with numerous NA tektite (i.e., impact glass) ages determined using high-temperature K-Ar and Ar-Ar methods.

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