RE-EVALUATION OF THE CHESAPEAKE BAY CRATER IMPACT AGE: NEW ^{40}AR-^{39}AR STEP-HEATING RESULTS FOR NORTH AMERICAN TEKTITES.

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Introduction: During the late Eocene at least 2 large and 2 smaller impact craters were formed on Earth: Chesapeake Bay (85 km Ø; 35.3 ± 0.1 Ma: [1]), Popigai (100 km Ø; 35.7 ± 0.2 Ma: [2]), Mistastin (28 km Ø; 36.4 ± 4 Ma: [3]), and Wanapitei (7.5 km Ø; 37.8 ± 1.6 Ma: [4]). Coeval with the formation of these impact craters, a 2 Ma increase in the flux of ^{3}He-rich extraterrestrial material occurred in the late Eocene [5], which was interpreted by these authors to have resulted from a comet, or by [6, 7] as due to an asteroid shower.

Chesapeake Bay crater: Chesapeake Bay crater is centered near the present mouth of Chesapeake Bay in eastern Virginia, U.S.A.. The biochronologic age was determined using different microfossils (plankton, foraminifera, bolboformids and calcareous nannofossils) in the marine sediments bracketing the ejecta, the North American (NA) tektite strewn field [8]. However, the stratigraphic ranges of key species of planktonic foraminifera and calcareous nano-fossils are apparently not isochronous with the distal ejecta of the Massignano section (Italy) and other sections drilled at DSDP 612 in the Chesapeake Bay crater (Exmore breccias, Chickahominy Formation [9-12]). The radiometric age of Chesapeake Bay of 35.3 Ma was determined by the ^{40}Ar/^{39}Ar total fusion method on North American (NA) tektites and microtektites [1, 13&14], and K-Ar age of tektites [15]. ^{40}Ar/^{39}Ar total fusion and K-Ar ages are based on the assumption that tektites are pure quenched glass, i.e., all georgiaites and bediasites did not gain or lose any Ar after formation. Particularly, it has been assumed that during the 900 to 2300 km travel through the atmosphere, the melt did not retain any relict ^{40}Ar, or the tektites did not lose any ^{40}Ar from the *in situ* ^{40}K decay after formation (e.g., weathering). However, careful inspection of tektites using SEM, EMPA and optical microscopy shows that these samples are heterogeneous and composed not only of quenched glass but also of clasts and voids/bubbles (Fig. 1).

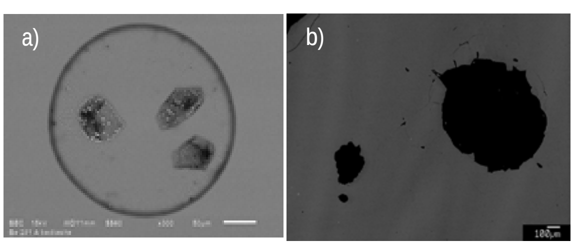

Figure 1 BSE images of a) bediasite showing inclusions, i.e. a devitrified glass spherule with irregularly shaped clasts showing dendritic texture, and b) georgiaite showing voids of different sizes, possibly containing excess argon.

Furthermore, along the recent USGS-ICDP drill core Eyreville-B, [16] found two layers of impact melt (samples W-61 from 1401.84 - 1409.37 m and W-84 from 1450.2-1451-51 m depth). Preliminary single- or multi-grain analyses by [19] from fragments removed from a crushed bediasite and a georgiaite and two impact melt rock samples of the Eyreville-B core [16], were obtained at the Berkeley Geochronology Center, using the Fish Canyon sanidine (FC-2) monitor with 28.02± 0.08 Ma (1σ, [17]) and the decay constants of [18]. IR-laser ^{40}Ar/^{39}Ar total fusion results yield (measured against FC-2) for 10 fragments from one bediasite a mean age of 35.3±0.52 Ma, and for 10 fragments from one georgiaite a mean age of 35.5±0.52 Ma [19]. These ages are comparable to published work on NA tektites of 35.3 ± 0.1 Ma (against Taylor Creek sanidine, t=28.34±0.14 Ma (1σ)) [1] and 35.5±0.5 Ma (against Bern 4B biotite, t=17.33±0.10 Ma [13&14]). However, the data spread for a single bediasite or georgiaite show a ~1-2 Ma age range suggesting heterogeneity at the level of one specimen. IR-laser ^{40}Ar/^{39}Ar step heating on several fragments obtained from a bediasite and a georgiaite [19] gave complex release patterns indicating that likely either more than one phase was degassed or that partial loss of radiogenic ^{40}Ar occurred.

Samples and methodology:

To better re-evaluate the age of North American tektites and implicitly the Chesapeake Bay crater, material from rim and core areas of three bediasites (Be281-A, Be281-B and Be283) were irradiated at the Sacavém Reactor in Lisbon, Portugal for 17hours. Samples and 10 aliquots from each neutron fluence monitors, FC-2 and Bergell granodiorite biotite (HD-B1), were loaded into vacuum sealed pure-silica vials. Argon was extracted from samples by using a high-frequency induction furnace at the Univ. of Heidelberg. All data were corrected for background, blank, interference and decay.

^{40}Ar/^{39}Ar step heating results: Bediasite rim and core material was studied separately in order to evaluate gain or loss of Ar by the tektites. To date, a total of five aliquots have been analyzed for ^{40}Ar/^{39}Ar release over 16 to 21 heating steps (Table 1; Figs. 2-4). This includes a pair of rim and core fractions from one bediasite (Fig, 3), and also undifferentiated material from a georgiaite. Overall, the initial 5-10 % ^{39}Ar released are characterized by high apparent ages associated with argon having atmospheric ^{40}Ar/^{36}Ar ratios (Fig. 2). For all 5 samples, the following age plateaux comprising most of the ^{39}Ar release vary from 33.14±0.29 Ma (youngest aliquot) to 34.76±0.36 Ma (oldest aliquot) (errors 2σ).

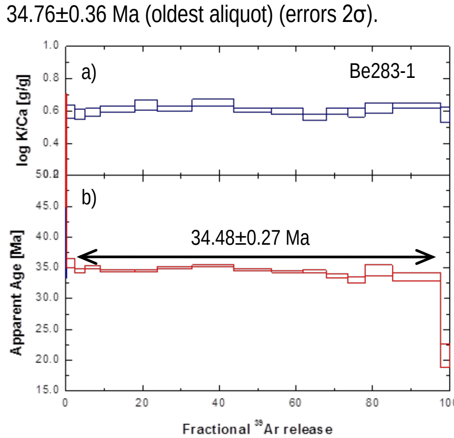

Figure 2 Results for bediasite Be283-1: a) Plot of log K/Ca vs. fraction of ^{39}Ar release. b) Apparent age vs. fraction of ^{39}Ar release.

Sample	aliquot	% ^{39}Ar	Age (Ma)	Total # heating steps
Be281-Ac2	core	91	33.57±0.49	17
Be281-Ar2	rim	56	33.14±0.29	21
Be281-Bc2	core	83	34.39±0.35	20
Be283-1	bulk	96	34.48±0.27	16
Georgiaite	bulk	79	34.76±0.36	20

Table 1 Summary of the $^{40}Ar/^{39}Ar$ step-heating results for three bediasites and one georgiatite (2σ). Aliquots of core and rim are shown.

In an inverse isochron diagram, all heating steps form a mixing line between trapped atmospheric argon with a $^{40}Ar/^{36}Ar$ value of ~295.5 and a radiogenic ^{40}Ar component (Fig. 3). The logK/Ca plot shows constant ratios of ~0.6 over the entire ^{39}Ar release (e.g., Fig.2).

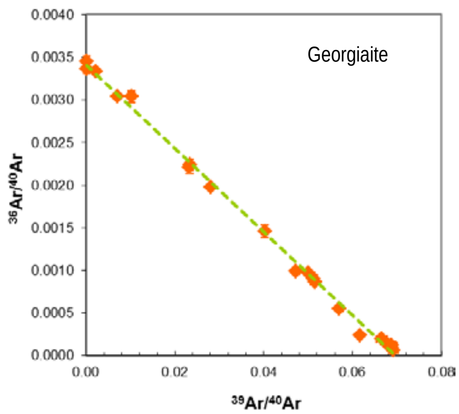

Figure 3 $^{39}Ar/^{40}Ar$ vs. $^{36}Ar/^{40}Ar$ for the georgiaite.

For tektite Be281-A, samples from core and rim were analyzed (Fig.4). The age obtained for each sample is within error the same (Table 1). However, the relatively large error shown by the core sample makes it difficult to determine if there is actually a difference among an individual tektite. To evaluate this, further duplicate runs are in progress.

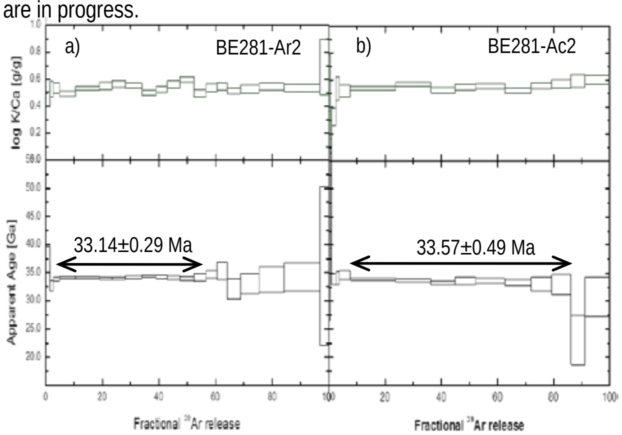

Figure 4 Resuls for Bediasite Be281-A: a) Apparent age spectrum and K/Ca vs. fraction of ^{39}Ar release for rim aliquot Be281-Ar2. b) Apparent age spectrum and K/Ca vs. fraction of ^{39}Ar release for core aliquot Be281-Ac2.

Summary: $^{40}Ar/^{39}Ar$ data acquired from tektite material associated with the Chesapeake Bay impact crater suggest that total fusion ages obtained from individual fragments (though performed on samples smaller than those used for step heating, therefore providing some kind of spatial resolution) should be cross-checked by step heating age spectra in order to evaluate a reliable age, together with careful neutron flux determination and SEM and EMPA inspection. The shape of our step heating age spectra provided evidence that the samples selected and prepared by us did neither contain excess ^{40}Ar, nor experienced secondary loss of radiogenic ^{40}Ar. Some minor redistribution effects by ^{39}Ar recoil seem possible. Presently acquired data suggest that the age of the Chesapeake Bay impact structure is probably slightly younger than the 35.3 Ma reported by [1, 13-15].

Current and future work: $^{40}Ar/^{39}Ar$ analyses on tektites and the first impact melt found [17] within the USGS-ICDP drill core Eyreville-B are in progress. This includes rim and core material from 3 bediasites and duplicates. To evaluate the possible presence of excess argon or mass-fractionated atmospheric argon in voids and bubbles, non-irradiated tektite material will be crushed under vacuum conditions with subsequent analyses of the gas. Furthermore, SEM and EMP investigations will be finalized to characterize the clasts observed within the different NA tektites. For the irradiation at the Sacavém Reactor, a total of 20 aliquots of age monitors were included in the irradiation package: 10 FC-2 aliquots and 10 HD-B1 aliquots. Considering the given uncertainty for the FC-2 monitor [17, 20-22], which was used during irradiation for previous $^{40}Ar/^{39}Ar$ analyses by [19], the current aim in using two age monitors in the same irradiation package is to cross-check the monitor ages and to verify the flux gradient of the Sacavém reactor.

Acknowledgements: Dr. Ingo Leya, Dr. Axel Wittmann and Mr. Hal Povenmire provided material for this study. Dr. Paul Renne facilitated access to the $^{40}Ar/^{39}Ar$ instrument at the Berkeley Geochronology Center for preliminary analyses by VAF. Financial support to VAF has been provided by Deutsche Forschungsgemeinschaft FE 1211/1-1.

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