PRELIMINARY AGE OF IMPACT MELTS FROM THE CHESAPEAKE BAY IMPACT STRUCTURE.

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Introduction: The late Eocene Chesapeake Bay impact structure formed as a ~40 km diameter complex crater and collapsed to a ~85 km diameter structure on the continental margin of Virginia. The target was composed of ~1500 m of water and siliciclastic sediments on top of a crystalline basement [1]. The age of the Chesapeake Bay impact appears fairly well constrained:

1. Paleontogical studies of post-impact transitional sediments within the impact structrue suggest an age of 35.7 - 35.8 Ma [2];
2. Correlations with ejecta deposits in ocean drilling project sites indicate an age of 35.2 - 35.5 Ma [3].
3. Correlation of assumed sedimentation rates with magnetochrons and microfossil biozones yield an age of 35.78 Ma for the event [4].
4. Georgiaite and Bediasite tektites of the North American Strewn Field give weighted-mean total-fusion $^{40}Ar/^{39}Ar$ ages of 35.4 +/- 0.6 Ma [5] and 35.3 ± 0.1 Ma (±lσ) [3]; similar K-Ar ages of 35.2 +/- 0.7 Ma were found for Georgiaite tektites [6].
5. The oldest fission track ages of 35 Ma for Georgiaite tektites coincide with those of Bediasite tektites [7].

Especially the link of distal ejecta with the Chesapeake Bay event is problematic because four other impact structures are known with a late Eocene age that potentially produced impact ejecta: Popigai, Siberia, 100 km Ø, 35.7 ± 2 Ma [8], and in Canada Mistastin, 28 km Ø, 36.4 ± 4 Ma, Haughton, 20.5 km Ø, ~ 39 Ma, and Wanapitei, 7.5 km Ø, 37.2 ± 1.2 Ma [9, and references therein]. The ICDP-USGS Eyreville-B drilling, located through the annular moat, 9 km from the center of the Chesapeake Bay crater recently recovered a 154 m thick section of impact breccias and melt rocks [10,11]. These melt rocks provide a first opportunity to directly date the Chesapeake Bay impact.

Samples and Methods: Two samples of pristine impact melt rock were chosen for analysis. One represents a hypocrystalline, clast-rich melt rock that contains domains of glassy melt in-between orthopyroxene and spinel phenocrysts (Figs. 1 A-B). The other is a holocrystalline variety that cooled more slowly and is composed of orthopyroxene – spinel – plagioclase – sanidine – cordierite – quartz (tridymite, cristobalite ?) - biotite microphenocrysts (Figs. 1 C-D). Moreover, one Bediasite and one Georgiaite tektite were analyzed. Defocussed-beam electron microprobe analysis (EMPA) was carried out to determine the major and minor element compositions of the samples. IR-laser probe step-heating was performed on irradiated, hand-picked fragments of melt that were produced from ~ 5 mm thick sample slabs of each impact melt sample. Locations and states of preservation of the samples were checked microscopically on thin sections from the opposite faces of the sample slabs. Details on the analytical methods employed is given by [12].

Results: EMPA determined ~ 3 wt.% K_2O in the glassy, hypocrystalline melt [11] and ~8 wt.%. K_2O in the matrix of the holocrystalline melt. The glassy melt retained volatile contents of ~5 vol.%, which is indicated by consistent 95 wt.% totals. The Bediasite and Georgiaite tektites exhibit typical compositions within the compositional ranges reported in the literature (e.g., [13], [14]). Preliminary, mean $^{40}Ar/^{39}Ar$ total fusion ages for ten fragments of a georgiaite and of a bediasite are 34.64 ± 0.51 Ma and 34.58 ± 0.34 Ma, respectively. These ages are similar to ages reported previously [3-6], but display excess scatter (MSWD>6) suggestive of subtle. variable alteration. $^{40}Ar/^{39}Ar$ analyses on the holocrystalline melt are characterized by large MSWD (>>1) and a wide range of ages. Some hypocrystalline melt fragments show MSWD of ~1 and ages between ~44.8 and ~48.1 Ma.

Discussion: Radioisotopic dating of impact melts has been recognized as a potentially problematic endeavor [15]. Several complicating factors may prohibit the inference of meaningful ages such as the existence of inherited Ar, which cannot be thermally resolved from radiogenic Ar by incremental heating. In the case of the samples analyzed in this study, the hypocrystalline melt indicates strong disequilibrium. It preserved glassy melt and abundant incorporated tectosilicate clasts that indicate variable states of assimilation. Therefore, inherited radiogenic argon from variable sources poses an analytical challenge. The holocrystalline sample also contains incorporated tectosilicate clasts but the thorough crystallization suggests better equilibration.

Other potential problems could be alteration features. Although microscopic control was exerted on the samples for dating, alteration features like spherulitic devitrification due to hydration of glass, alteration to chlorite-smectites and mineralization of zeolites in vugs could potentially be a problem. However, if this were the case, younger ages would be expected. Such a trend was not observed in the melts but has to be considered for the analyzed tektites, which gave an age slightly younger than those previously reported [3,5-7].

Vugs in the melt rocks could potentially have served as traps for volatiles. Microscopic control did not indicate the presence of such vugs in the sampled domains, nor did it indicate the presence of fluid inclusions in glassy melt that could have trapped inherited argon.

Summary: The initial Ar-Ar results obtained by step heating of impact melt rocks from the Chesapeake Bay impact structure suggest that this material contains different ^{40}Ar components that are not straight forward to distinguish ^{40}Ar/^{39}Ar results for fragments of one bediasite and one georgiaite are slightly younger than, but within error of, ages previously reported [3-6]. Possible disturbances of the argon systematics in these samples will be studied by step-heating analysis. Further investigation of the impact melt data will be undertaken to determine, if different ^{40}Ar components (i.e. radiogenic vs. inherited) can be resolved.

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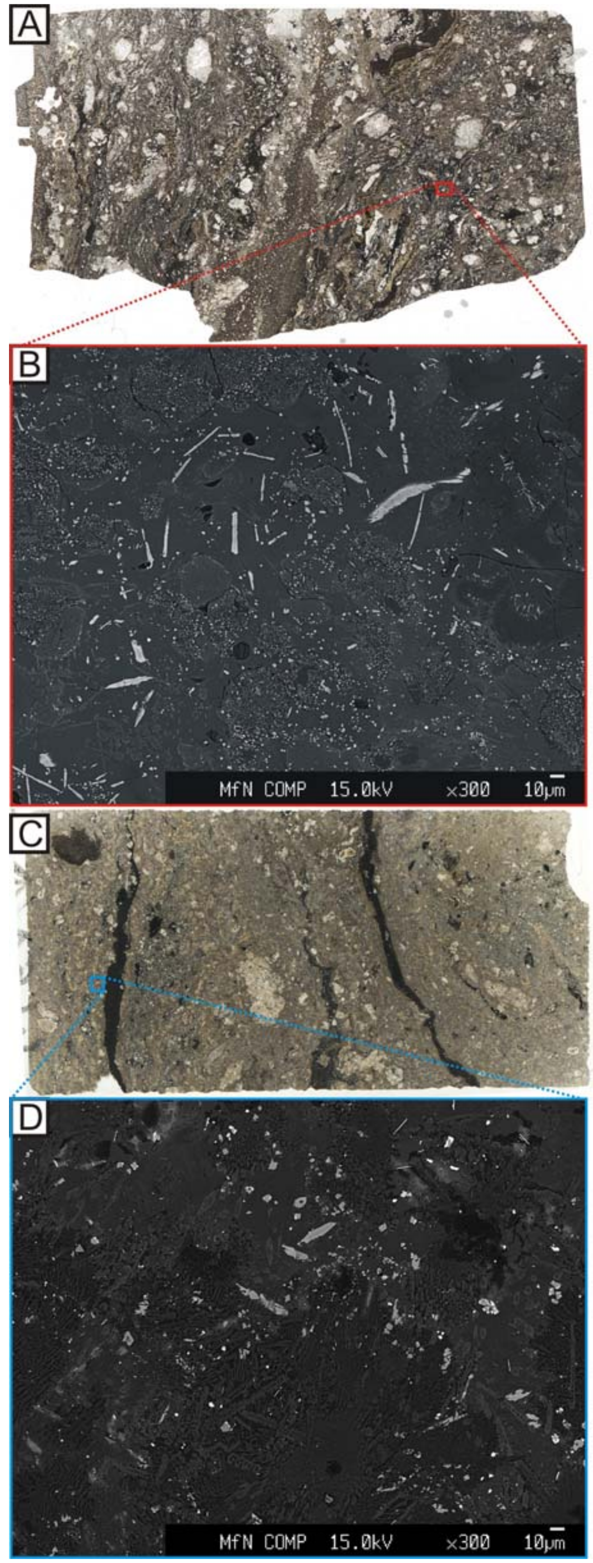

Fig.1 Melt rock samples, width ~4 cm (A and C).
A – Thin section scan of hypocrystalline melt rock;
B – SEM-BSE image of glassy melt, bright Opx laths, spherulitic Pl, dispersed Spl and assimilated quartz clast.
C - Thin section scan of holocrystalline melt rock;
D – SEM-BSE image of crystallized melt with radial Pl-spherulites, few bright Opx, dispersed, bright Spl, some euhedral zoned sanidine and cordierite.