THE VOLUME OF IMPACT MELT IN THE CHESAPEAKE BAY CRATER. A. Wittmann[1], W. U. Reimold[2] [1]Lunar and Planetary Institute, Houston, TX 77058, USA, wittmann@lpi.usra.edu, [2]Museum of Natural History (Mineralogy), Humboldt-University, Invalidenstr. 43, 10115 Berlin, Germany, uwe.reimold@museum.hu-berlin.de.

Introduction: The late Eocene Chesapeake Bay impact structure formed as a ~40 km diameter complex crater on the continental margin of Virginia that collapsed to a ~85 km diameter final structure [1]. The target was composed of ~1500 m of water and siliciclastic sediments on top of a crystalline basement [2]. An ICDP-USGS drilling through the annular moat of the crater recently recovered a 154 m thick section of impact breccias and melt rocks below 1397 m of resurge debris and post-impact sediments [3]. These ground-zero deposits recorded the earliest cratering processes and potentially contain information about the effect of volatiles on the formation of impactite deposits in a large terrestrial impact structure.

Samples and Methods: Impact melts were characterized microscopically in 69 drill core samples from the continuous section of impact breccias and melt rocks. A continuous set of digital photographs of core boxes courtesy of David S. Powars, USGS, was then used to determine the amount of melt within the section. These observations were confirmed at the USGS drill core repository.

Results: The main mass of impact melt in drill core Eyreville-B is concentrated in two 5.5 and 1 m thick bodies of clast-rich impact melt rock. In addition, many small-scale occurrences of pods and particles of impact melt occur within suevites. Their distribution is limited to the upper part of the pre-resurge section (Fig. 1) and add to a cummulative maximum amount of ~17 m. The Chesapeake Bay crater has no continous melt sheet. Throughout the resurge deposits, a melt component <0.3 vol. % occurs that locally accounts for up to 63 vol% in thin sections with melt shards [4].

Discussion: Extrapolating the amount of melt to a circular area of a 28 km diameter transient cavity gives an estimate for a total mass of melt that was retained within the crater of at most 10.5 km^3. This agrees with findings of a test drilling into the central uplift, which recovered a ~114 m thick, largely suevitic impact breccia deposit [3]. Moreover, gravity and magnetic survey data modeling predicted the presence of impact melt bodies with an approximate volume of 0.4 - 7 km^3 [5] that surround the central peak. The approximate amount of ~10 km^3 is less than 0.5 % of the ~230 km^3 of impact melt that are predicted from scaling relationships of [6] for terrestrial impact structures in crystalline basement targets. Taking scaling relationships at face value, a melt sheet with an average thickness of ~ 370 m could have formed from the amount of melt produced from an impact event the size of Chesapeake Bay. Possible causes for the low melt volume in the Chesapeake Bay crater are:

Removal / reworking of melt by the resurge flow. At the site of the drilling, a continuous melt sheet should have been preserved if it had formed. Typically, melt sheets in complex craters in this structural position are overlain by slump and fallback suevites [7]. Such rocks are present in the upper 35 m of the sequence (sub-units S3-SU). Blocks or boulders of impact melt rock of a thicker, reworked melt sheet were never described from the resurge deposits and melt fragments and shocked tectosilicates are a minor component therein [2, 4].

A strongly oblique (<30°) and / or a slow impact. This would cause a lower amount of impact melt and a shallower transient cavity floor with a decreased shock metamorphic overprint [8]. A low angle of impact is expected to produce a depressed crater rim, which could have better accommodated resurge of a shallow ocean [9]. Geophysical data for Chesapeake Bay suggest an asymmetrical geometry of the limits of the central crater [2]. Geogphysical modelling reveals an ovoid central peak with a central magnetic anomaly that is offset from the center of the structure [5]. These authors suggest a likely effect of target geometry on this feature but also discuss the possibility of a highly oblique impact with a NW-SE trajectory to produce this feature. The distribution of tektites in the North American strewn field to the SE of the impact site may be another indicator for such an oblique impact trajectory [10]. However, impact parameters that influence the amount of melt produced, e.g. velocity of the projectile and its size, are hard to constrain.

Stacking of slumped breccia layers in the moat. A buried melt sheet below allogenic breccias was not resolved in a seismic experiment across the drill site [11]. Nor is such a scenario indicated by magnetic and gravimentric data [5]. Commonly, the basic stratigraphy of the transient cavity is retained in complex craters with a continuous melt sheet on top of polymict breccias and the autochthonous, shocked basement [7]. These authors also suggested that excavation efficiency decreases with increasing transient cavity size as a consequence of greater velocity attenuation in the melt. Therefore, the pre-resurge section in the Eyreville drilling appears typical for a crater filling sequence of a small complex crater with a disrupted or missing melt sheet. The amount of impact melt encountered within the transient cavity is deficient with regard to observational scaling relationships from craters that dominantly formed in crystalline basement.

Increased excavation efficiency from sediments. Craters that form dominantly in sedimentary targets excavate more efficiently due to excessive release of volatiles [12]. These authors predicted that the proportions of recognizable impact melt rocks at craters in largely sedimentary targets is two orders of magnitude less than at similar size craters in crystalline targets. Similar low abundances of impact melt are retained at the Ries Crater, Germany, the Haughton crater, Canada, Bosumtwi,, Ghana, and the Logoisk crater in Belarus [6, 13].

Following [14], the discrepancy between the amount of melt retained in a crater could relate to the proportion of the sedimentary target at depth of excavation and melting. At Chesapeake Bay, a thickness of sediments and water column of ~1200-1500 m at the center of the structure can be assumed, which translates to a relative proportion of 40-50 % of the excavation depth [15] and ~25 % of the maximal depth of melting [6]. This relationship may account for the melt deficient central crater at Chesapeake Bay and the dispersal of melt to form the North American tektite strewn field and microtektites that are known from ODP sites across the world.

Conclusions: The ICDP-USGS Eyreville B drilling revealed the presence of ~17 m of impact melt in a 154 m thick continuous sequence of pre-resurge impact breccias and melt rocks. No continous melt sheet formed at Chesapeake Bay. A high sedimentary target component led to a dispersal of melt to form the North American tektite strewn field and microtektites.

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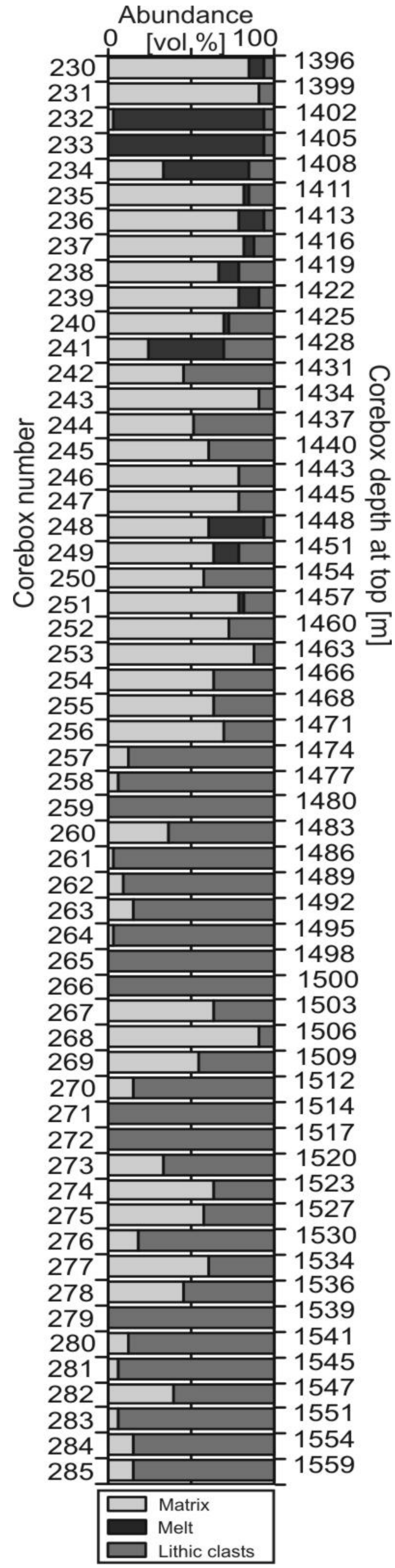

Fig. 1 Melt pods and lithic clasts >4,8 cm in impact breccia section of drill core Eyreville-B.