Melt Particles in the Chesapeake Bay Impact Structure Eyreville Drill Core – A Progress Report.

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Introduction: The Chesapeake Bay impact structure, 35 Myr old and 85 km in diameter, is one of the largest and best preserved impact structures on Earth [1]. The structure was drilled in the central part at Eyreville in 2005-2006 during an ICDP-USGS drilling project. Three drill cores (Eyreville A, B, and C), intersecting the impact structure to a total depth of 1766 m, were recovered within the central zone of the structure in the deep crater moat.

The crater fill comprises post-impact sediments, sediment clast breccias and sedimentary megablocks (the so-called Exmore breccia beds, interpreted as resurge breccias), a large granitic and a small amphibolitic megablock, gravelly sand, impact breccia (IB; 1397-1551 m; [2]), and granites/pegmatites and mica schists [1]. In the upper part (above ~1474 m) the IB section consists of melt-rich suevite that contains two intervals (5.5 and 1 m thick) of impact melt rock [3]. In the deeper part of the IB section (below 1474 m) melt-poor suevite and polymict lithic impact breccia alternate with large blocks of cataclastic gneiss [2].

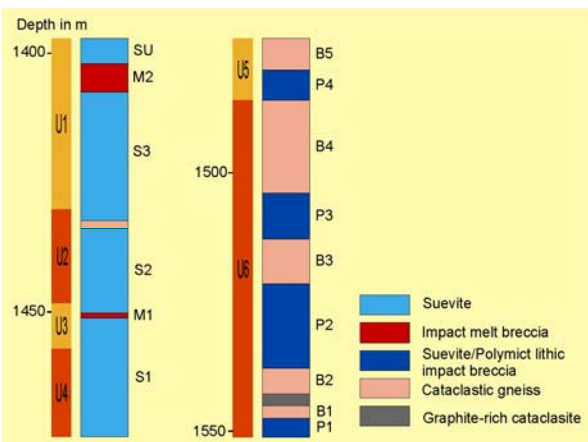

Fig. 1: Schematic stratigraphy of the impact breccia unit in the Eyreville core hole, Chesapeake Bay impact structure. Left column – subunits (U1-U6) defined by [4], right column - geologic column after [2].

Suevites and impact melt rocks: The suevite has a grayish, fine-grained clastic matrix and consists of a variety of rock and mineral clasts, melt particles, as well as secondary minerals (e.g., phyllosilicates). The impact melt rocks contain melt matrix mostly recrystallized to pyroxene or feldspar microlites. Lithic fragments comprise sedimentary, metamorphic, and igneous lithologies; their relative proportions vary significantly through the IB section. Mineral clasts include quartz, K-feldspar, plagioclase, muscovite, biotite, opaque (mostly pyrite) and other accessory minerals. Quartz grains in suevite show planar fractures and planar deformation features. Toasted appearance of quartz is very common (see also [5]) and ballen quartz occurs in melt-rich intervals.

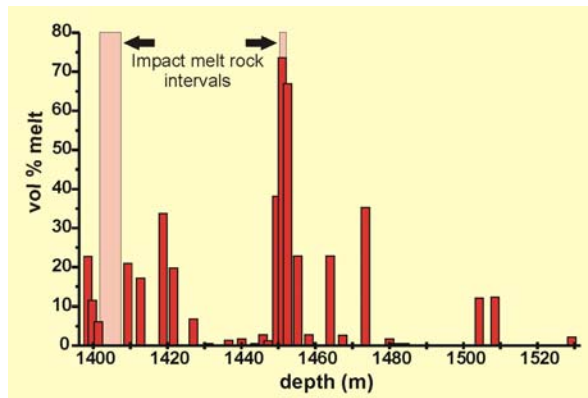

Fig. 2: Distribution of melt particles within the impact breccia section, Eyreville drill core, Chesapeake Bay impact structure. Diagram based on point counting of 28 suevite thin sections.

Melt fragments are most abundant near the top of the IB section (up to 34 vol% in the interval 1399-1422 m) and around 1450 m (up to 74 vol%); see Fig. 2. In the intervals (1402-1407.5 and 1450.2-1451.2 m) the suevite grades into impact melt rock. The millimeter- to centimeter-sized melt particles are mostly altered, commonly contain small undigested clasts and show flow structures.

Several major types of melt particles have been distinguished on the basis of color, micro-texture, and chemical composition: 1) clear, brownish, or greenish, unaltered glass, commonly with flow texture (dark and light colored schlieren); 2) brown melt, entirely altered to fine-grained phyllosilicate minerals, commonly with undigested clasts; 3) recrystallized silica melt; 4) melt with feldspar and/or pyroxene microlites; 5) dark brown melt (of shale precursor).

Results and Discussion: Melt is most abundant in the upper part of the impact breccia section and around 1450 m, where the suevite grades to impact melt rock. Below 1474 m the content of melt is low (less than ~12 vol%). The melt particles (up to >4 cm in size) are frequently ovoid to amoeboid in shape and show flow structures. As mentioned above, five different types of melt particles have been recognized: clear colorless to brownish glass (Fig. 3), melt altered to finest-grained phyllosilicate minerals (Fig. 4), recrystallized silica melt, melt with microlites, and dark brown melt.

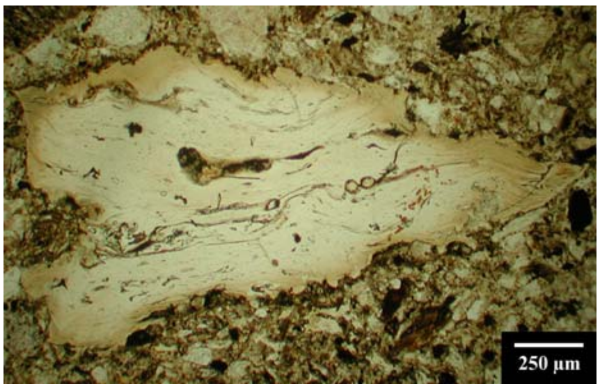

Fig. 3: Example of melt particle, type 1 (clear to brownish/greenish unaltered glass), sample CB6-098, depth 1418.8 m, Eyreville drill core.

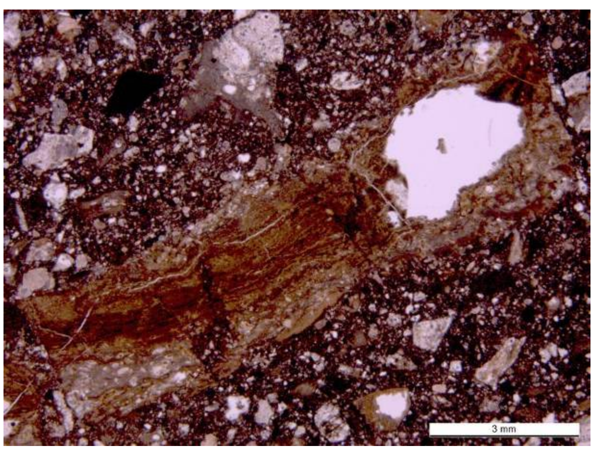

Fig. 4: Example of melt particle, type 2 (brown melt, entirely altered to fine-grained phyllosilicate minerals), sample CB-093, plane polarized light, depth 1399.2 m, Eyreville drill core. Scale bar 3 mm.

Most of the melt particles are altered. Particles of the clear unaltered glass, some with shard-like shapes, occur in the upper part of the impact breccia, mostly around 1415 m. The melt with microlites occurs mainly as matrix of the impact melt rock and only rarely as melt particles. The chemical composition of melt particles was determined by SEM-EDX and it was found that the petrographically different types of melt particles have distinct chemical composition. The composition of the melt particles was subjected to HMX mixing calculations [6].

The melt particles of type 1 and 4 were best modeled as mixtures of target lithologies (Potomac Formation and crystalline basement lithologies), whereas for melt types 2 and 5 mixtures of rock-forming minerals (quartz, anorthite, and mica) are the best models for precursors. The silica melt (type 3) is probably a melt of quartz or a silica-rich rock. The dark-brown melt could be a melt of a shale or a fine-grained sediment, based on the appearance and chemical composition similar to the fine-grained sedimentary clasts (mudstones) in the suevite (as analyzed by SEM-EDX). Our results suggest that no widespread homogenization of the melt took place. The original composition of especially the altered melt particles could have been modified by hydrothermal alteration.

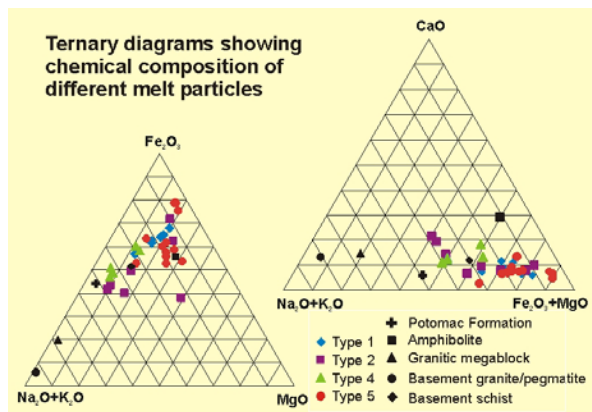

Fig. 5: Ternary diagrams that show a comparison of the composition of the five different types of impact melt particles in the Eyreville core, as well as potential precursor materials. (see [6] for details).

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References: [1] Gohn G. S. et al. (2006) *EOS* 87, 349 & 355. [2] Horton J.W. et al. (2008) LMI abstracts, South Africa. [3] Wittmann et al. (2008) *LPSC XXXIX* Abstract #2435. [4] Bartosova K. et al. (2009a) (Petrology) in: *Geological Society of America Special Paper* (Chesapeake Bay Drilling Project volume), in press. [5] Ferrière L. et al. (2009) this meeting. [6] Bartosova K. et al. (2009b) (Geochemistry) in: *Geological Society of America Special Paper* (Chesapeake Bay Drilling Project volume), in press.