

EVOLUTION OF CRYSTALLINE TARGET ROCKS AND IMPACTITES IN THE CHESAPEAKE BAY IMPACT STRUCTURE, ICDP-USGS EYREVILLE B CORE. J. Wright Horton, Jr.¹, Michael J. Kunk¹, Harvey E. Belkin², John N. Aleinikoff³, John C. Jackson⁴, and I-Ming Chou⁴, ¹U.S. Geological Survey, MS 926A, Reston, VA 20192, USA, whorton@usgs.gov, ²U.S. Geological Survey, MS 956, Reston, VA 20192, USA, ³U.S. Geological Survey, MS 963, DFC, Denver, CO 80225, ⁴U.S. Geological Survey, MS 954, Reston, VA 20192, USA.

Introduction: The ICDP-USGS Eyreville core-holes in the late Eocene Chesapeake Bay impact structure (CBIS) were drilled during 2005-2006 on the Delmarva Peninsula 7 km northeast of the town of Cape Charles, Virginia [1]. The drilling penetrated the moat (deepest part) of the central crater that surrounds the central uplift as delineated by seismic and gravity surveys [2,3]. This study of the Eyreville B core from 1,766.2 to 1,095.7 m depth covers the deepest lithologic assemblages 1-4 in Table 1, which are overlain by sediment-avalanche deposits [4], ocean-resurge sediments [5], and post-impact sediments [6].

Table 1. Composite geologic section for Eyreville cores A, B, and C [7,8]; shaded units discussed herein.

<i>Depth in meters</i>	<i>Lithologic assemblage</i>
0 - 443.9	8: Post-impact sediments
443.9 - 618.2	7: Diamicton with clasts in muddy glauconite-quartz sand matrix (ocean-resurge sediments)
618.2 - 866.7	6: Nonmarine sediment blocks injected by glauconite-quartz sand
866.7 - 1,095.7	5: Nonmarine sediment blocks (sediment-avalanche deposits)
1,095.7 - 1,371.1	4: Granitic rocks (transported)
1,371.1 - 1,397.2	3: Gravelly sand & lithic blocks (basal, mixed avalanche deposit)
1,397.2 - 1,474.1	2c: Suevite (melt-rich)
1,474.1 - 1,551.2	2b: Suevite (melt poor) with abundant cataclastic gneiss blocks
1,551.2 - 1,560.2	2a: Graphite-rich cataclasite
1,560.2 - 1,766.2	1: Schist, gneiss, granite/pegmatite

Assemblage 1. Schist, gneiss, and granite/pegmatite: The deepest rock assemblage consists of multiply deformed, basement-derived mica schist, gneiss, local mylonitic rock, and granite pegmatite grading into coarse granite. The mica schist commonly contains graphite and knots of fibrolitic sillimanite. Ductile fabrics and folds are inherited from the pre-impact basement, but brittle to semi-brittle structures need closer study to determine which are pre-, syn-, or post-impact. Cataclastic deformation is much more pervasive than that observed outside the structure, and the drilling did not reach undisturbed rock. The rocks locally are cut by dikes of breccia, including suevite,

which decrease with depth in size and abundance [7,9]. Shocked minerals are lacking in this assemblage except in association with breccia dikes. ⁴⁰Ar/³⁹Ar plateau ages of muscovites from the pegmatite indicate cooling through the 350°C isotherm at ~244 Ma [9] without disturbance by the ~35.5 Ma impact. Muscovites in the pegmatite have unusual fine striations and microcrenulations [9].

Assemblage 2. Suevite and lithic blocks: Graphite-rich cataclasite (2a) at the base of this assemblage contains fault-bounded slices of rocks from above and below, and slickensided faults indicate thrusting or reverse slip. The graphite-rich cataclasite is overlain by (2b) lithic-clast-rich suevite (melt poor) with abundant boulders and blocks of cataclastic gneiss up to 20 m across. The gneiss is distinct from basement-derived rocks in Assemblage 1 and locally grades into cataclasite. The upper suevite (2c) is melt rich, and in the uppermost few meters, grades locally into clast-rich impact-melt rock having melt in the matrix.

Impact-melt clasts in the suevite include anhydrous to hydrous glasses that are commonly flow laminated, partly devitrified, and variably altered. Meniscus-like textures between glasses of different composition indicate immiscible silicate melts at quench. Coexisting sulfide melts now appear as small Fe+S ± Ni spheres. Tiny crystals of the oxide minerals chrome spinel, baddeleyite, and corundum in silicate glass indicate high-temperature crystallization under conditions of silica undersaturation. X-ray diffraction (XRD) indicates that melt glass is partly altered to well-crystallized Fe-rich smectite.

Shocked quartz is abundant in the suevite and lithic blocks within it. Two sets of planar deformation features (PDFs) are common, and three are visible in some grains. Ballen quartz, initially reported by [9], is observed locally in melt clasts and melt-rich domains, notably in rocks in which XRD shows evidence of cristobalite. Raman spectra of selected grains from the melt-rich suevite show that some consist of coesite + quartz. Coesite from the CBIS was first reported in samples from this core [9], and studies are in progress to understand its distribution with depth and lithology. Reidite (high-pressure polymorph of zircon) in the CBIS was first reported in samples from this core [9]. Raman spectra of Zr minerals selected under electron microprobe indicate that some consist of zircon + reid-

ite. Studies are in progress to assess the distribution of reidite with depth, lithology, and mineral associations.

Lithic clasts in the suevite include variably cataclastic, greenschist- to lower amphibolite-facies gneiss, metaplutonic rocks, and sub-greenschist-facies black shale previously unknown in the target.

Assemblage 3. Sand and lithic blocks: Above the suevite section is a remarkably different gravelly quartz sand (mostly poorly consolidated and unlithified) containing a block of amphibolite, a cataclastic boulder, a possible rip-up clast of suevite, and smaller lithic clasts. The lowest gravelly quartz sand contains altered melt clasts and has been interpreted as reworked suevite [7]; it is also slightly darker and more lithified, suggesting a hydrothermal overprint within meters of the underlying suevite. Individual detrital microcline grains from the sand have $^{40}\text{Ar}/^{39}\text{Ar}$ laser fusion ages of ~222-334 Ma, so maximum temperatures in the sand during and after the ~35.5 Ma impact must have been $< \sim 200^\circ\text{C}$.

Assemblage 4. Granitic rocks (slab): A 275-m granitic section overlies the gravelly sand and must be allochthonous. It is free of intervening material that would require more than one slab but is locally faulted and fractured. Cataclastic fabrics are lacking, except locally and near the base; and the rocks are not shocked. The main rock types are gneissic (layered) biotite granite, medium- to coarse-grained biotite granite, fine-grained biotite granite, and a red altered granite near the base [7]. The gneissic biotite granite has a SHRIMP U-Pb zircon age of 615 ± 7 Ma [9], which is similar to Neoproterozoic ages of granites from earlier drill cores in the structure. An undeformed, medium- to coarse-grained biotite granite has a SHRIMP U-Pb zircon age of 254 ± 3 Ma (Permian) [9].

Coastal Plain basement: Lithologic assemblages 1-4 contain different basement-derived target rocks that must have originated in different parts of the structure. They include multiply-deformed, upper-amphibolite-facies schist (and pegmatite) in assemblage 1, greenschist- to lower-amphibolite-facies gneiss and sub-greenschist-facies black shale in assemblage 2, an amphibolite block in assemblage 3, and Neoproterozoic to Permian granitic rocks in assemblage 4. This structural partitioning of basement-derived rocks is attributed mostly to the late, modification stage of crater formation.

Suevite formation within crater: The suevites formed mainly from crystalline basement and melt material. A paucity of clasts derived from the upper target layer of Coastal Plain sediments suggests that the suevite formed from debris that never left the crater [9,10] rather than as a fallback deposit. Unsculptured shapes of glass fragments suggest that they did not

travel far through the atmosphere. Modeling allows ~7 minutes for suevite deposition before being covered by collapsed, fluidized sediment [11]. The suevites may record a transition from lithic-block-rich ground surge [12] to hot, melt-rich deposition from the ejecta plume.

Fault detachment at base of suevite: The graphite-rich cataclasite zone marks a first-order, late syn-impact fault detachment separating the suevite and its shocked debris from deeper, unshocked, basement-derived schist and pegmatite [9]. The fault removed the original base of suevite and its substrate at this site. Kinematic analysis is in progress to determine the role of this fault in crater formation. The abundance of shocked minerals in the suevite is in sharp contrast with the unshocked rocks above and below it.

Emplacement of granitic slab: The source of the granitic slab is constrained by its lack of shock metamorphism. It probably detached and slid into the moat during collapse of the transient-crater rim [9], which expanded radially ~6 km [11] by gravity-driven collapse of material into the moat. Gravelly sand under the slab provided a low-friction substrate for emplacement of the slab along with overlying sediment-avalanche deposits.

Post-impact thermal history: Syn- and post-impact heating below the suevite was $< \sim 350^\circ\text{C}$ based on the undisturbed $^{40}\text{Ar}/^{39}\text{Ar}$ plateau age spectra of muscovites. Temperatures in sand above the suevite were $< \sim 200^\circ\text{C}$, based on undisturbed $^{40}\text{Ar}/^{39}\text{Ar}$ laser-fusion ages of detrital microcline. Ongoing studies will further constrain the thermal histories.

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