PETROGRAPHY OF THE SUEVITE-LIKE DEPTH INTERVAL (1397-1550 m) IN DRILL CORE EYREVILLE-B, CHESAPEAKE BAY IMPACT STRUCTURE, USA.

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Introduction: The Chesapeake Bay impact structure formed on the continental margin of Virginia. The oceanic impact involved a target with a water depth of 0-340 m on top of 400-1500 m unconsolidated siliciclastic sediments overlying a Neoproterozoic crystalline basement. The structure has a diameter of 80-95 km with a ~38 km diameter central crater. The central crater structure features a ~12 km wide central uplift surrounded by an annular moat that is bounded by an uplifted escarpment. This boundary is interpreted as the remnant of the transient cavity rim [1]. The USGS-ICDP Eyreville drilling is placed about 9 km NNE' off the presumed center of the structure in the central crater's annular moat [2]. The drilling reached a depth of 1776.2 m and recovered suevite-like impactites beween 1397 and ~1550 m. Here, preliminary petrography and petrogenetic implications of these rocks are presented.

Samples and Methods: Some 50 core samples were available for study along with continuous core box photographs courtesy of D.S. Powars, USGS. Petrographic analyses were performed on thin sections of all samples by optical microscopy and on selected thin sections by SEM and Raman spectroscopy. Image analysis was performed on core box photographs to distinguish components larger than 4 cm from smaller matrix components, and on 13 thin section scans for modal composition and orientation of particles according to the method of [3].

Results: Lithic clasts were divided into groups:

Sedimentary and metasedimentary clasts: This group is composed of siliciclastics with sedimentary layering and/or incipient formation of a metamorphic fabric. Some fossils may be present in these clasts. They comprise sand to claystones (sometimes with black tainting from organic matter and pyrite), shales, limestones and greywackes. Less frequently, arcoses and conglomerates occur.

Metamorphic rock clasts: This group comprises schists of greenschist metamorphic grade with a clear foliation due to aligned lepidoblastic micas and dynamically recrystallized quartz and feldspars. More rarely, graphitic schists occur. Also, felsic and mafic gneiss lithologies that are highly variable in composition, and epidotite and amphibolite are summarized in this group. These rocks are more coarse-grained than the schists, with recrystallized fabrics of quartz, feldspar, biotite and sillimanite and rare garnet.

Igneous rock clasts: This group comprises coarse-grained quartz pegmatoid, aplite, granitoids, and dolerite. Except dolerite, most igneous rock clasts are hard to distinguish from gneisses because in thin section, they also frequently exhibit dynamic recrystallization of quartz and feldspar, suggesting some greenschist metamorphic overprint. Moreover, many igneous and metamorphic rocks exhibit pervasive alteration of mafic minerals to chlorite and sericitization of feldspars.

The suevitic section is clearly polymict and contains heterogeneously distributed components with shock metamorphic overprints. In tectosilicates, the most frequent indication of shock metamorphism are decorated planar deformation features, suggesting shock metamorphic conditions between ~10 and 35 GPa [4]. Different types of shock stage IV impact melt particles occur. Identification of such impact melt particles is difficult because they scarcely exhibit shocked lithic clasts as inclusions and are generally devoid of liquidus phase microphenocrysts apart from occasionally occurring dispersed TiO_2 granules. The only melt particles with remnants of abundant liquidus phase phenocrysts were found in the thermally annealed surroundings of two intervals of clast rich impact melt rock. Moreover, melt particles are generally altered to phyllosilicates and zeolites. Identification of shock stage IV components is based on the presence of rare, thermally decomposed zircon inclusions [5]. Melt particles can be distinguished by shapes, colors and chemical compositions. Up to ~1468 m depth, angular, vesicular, shard-like particles <1 mm in size occur, sometimes in connection with size-sorted, graded suevite. Similar particles are present in the Exmore Beds above the suevite-like rocks, e.g. at 459.81 m. More frequently, angular to sub-rounded and ameboid particles with deformed vesicles and flow textures occur that indicate vigorous interaction with the host matrix while still viscous. They are translucent or brown colored, sometimes as swirled transitional types, and up to ca. 4 cm in size. Clasts with fluidal textured matrixes and relic subhedral inclusions with preserved rock fabrics were found to include zirconreidite grains, suggesting shock stage III with formerly fused feldspar [5]. Two larger pods of clast-rich, unbrecciated impact melt rock occur at 1401.84–1409.37 m and at 1450.2–1451.51 m. However, core box images indicate the presence of many more impact melt pods up to 21cm thick that are concentrated between 1397 and 1430 m. Apart from a ~150 cm thick block at 1432.26 m, clast sizes are <50 cm until ~1468 m.

Preliminary sub-division: (1) ~1550-1468 m: “Basal lithic impact breccias and suevites” are dominantly composed of metamorphic rock clasts larger than 4 cm. Three ~5, ~9 and ~30 m thick brecciated and cataclased schist and gneiss blocks occur that are truncated by, and interbedded with polymict breccias. These polymict breccia intercalations frequently exhibit flow textured matrixes and alignments of clasts. Occasionally, they contain small, subrounded, heavily altered melt particles that amount to <1 vol.% of the modal composition. The lowermost altered melt particles were identified in a thin section from 1505.1 m depth. The larger blocks do not show a clear shock metamorphic overprint but in the polymict breccia intercalations, shocked tectosilicates occur throughout the sequence. Below ~1550 m, the larger lithic blocks dominate over polymict breccia veins that mostly do not include significant amounts of shocked components.

(2) 1451.51 – 1468 m: “Lower Suevites” are dominantly composed of components < 4cm in size and have some macroscopically visible melt particles that are mostly altered to zeolites and phyllosilicates. Some size graded intervals occur in the sequence as well as shard-shaped melt particles. However, melt particles are a minor constituent in this sub-unit. Most components >4 cm are sedimentary and metsedimentary rock clasts. Two 1 and 4 cm thick, aphanitic, green-brown melt pods occur in this sequence.

(3) 1450.20 – 1451.51 m: “Lower Impact Melt Rock” (LMR) is a clast-rich, hypocrystalline impact melt rock. It exhibits a characteristic flow texture, microphenocrysts, and locally has interstitial remnants of pristine, glassy melt. More detail about this sub-unit is presented in [6].

(4) 1450.20 – 1409.37 m: “Middle Suevites” are bounded by impact melt rock. This deposit is dominated by components < 4cm of variegated rock types. It contains abundant melt particles and only near the contacts to impact melt rock, ameboid fragments and apophyses of melt rock occur. Several aphantic melt pods up to 21 cm in thickness occur in this sub-unit. Again, graded intervals are present.

(5) 1409.37 – 1401.84 m: “Upper Impact Melt Rock” (UMR) is a holocrystalline, clast-rich impact melt rock that is structurally and compositionally similar to the LMR. A detailed description of this sub-unit is given in [6].

(6) 1397.18 - 1401.84 m: “Upper Suevite” is matrix-dominated; several up to 9 cm thick, aphanitic melt pods occur. Shard-like melt particles exhibit rims of chamosite. Fluidal textured melt particles occur as well, some with interfingered contacts towards the matrix and with sub-vertical orientation (at 1399.4 - 1400.1 m). There is a distinct contact metamorphic gradient in this deposit towards the underlying UMR. A mantled clast was found in this deposit. The maximum component size in this deposit is smaller than in the other sub-units, and breccia-in-breccia textures may also be present. Larger lithic clasts are mostly sedimentary and plutonic rock types. The contact to the overlying Exmore Beds is a sharp, undulating fault on the bottom of dm-size sedimentary clasts. Petrography suggests that in contrast to the overlying resurge deposits (Exmore Beds), microfossils and glauconite pebbles do not occur ubiqubituously in the suevite-like section.

Petrogenetic implications: Taking into account the clast size distribution and scarcity of melt fragments, the suevite-like sequence appears to be a ground-surge deposit below 1468 m. Above this depth, a mixture of fallback and ground-surge material appears present because rapidly quenched, likely airborne melt particles and graded sections occur. Towards the top, fallback material appears to be dominant with airborne components indicated by shard-like melt particles, mantled particles, and distinct size sorting of components. The temporal duration of the deposition of this unit is constrained by numerical models to ca. 6 min [7,8]. Lithostatic loading with ~950 m of resurge debris (Exmore Beds) asserted a pressure of ~20-25 MPa that likely led to flattening and consolidation of the suevite-like sequence.

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