

GRAVELLY SAND INTERVAL OF THE EYREVILLE DRILL CORE, CHESAPEAKE BAY IMPACT STRUCTURE, USA.

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Introduction: The Chesapeake Bay impact structure (35.3 Myr old and 85 km in diameter [1,2]) is located along the east coast of the United States. The ICDP-USGS Eyreville drill core, drilled at Eyreville Farm, Virginia, USA, reached a total depth of 1766 m and penetrated post-impact sediments, sedimentary breccias, a granitic slab (megablock), gravelly sand, impact breccias, and basement-derived schists and granites/pegmatites [3,4]. The gravelly sand interval (1371-1397 m depth) includes an amphibolite block and boulders of cataclastic gneiss and suevite. The gravelly sand can be thus divided into three intervals: upper interval – above the amphibolite block, middle interval – below the amphibolite block, and basal interval – below the cataclasite boulder (Fig. 1)

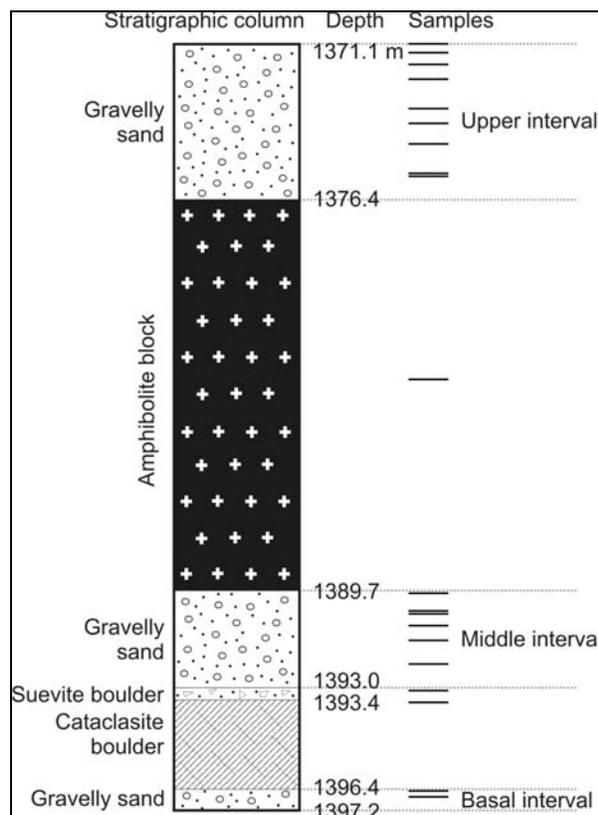


Fig. 1: Stratigraphic column for the gravelly sand interval (after [4]). Depth below surface in meters. Positions of investigated samples are marked.

Methods: Twenty samples of the gravelly sand interval were described macro- and microscopically, including modal point counting. Chemical composition of the samples was analyzed by X-ray fluorescence and instrumental neutron activation analysis. Further analyses included X-ray diffraction (XRD) of bulk sample powders as well as of clay fraction for selected samples. MicroRaman spectrometer and scanning electron microscope with an energy-dispersive X-ray (SEM-EDX) analyzer were used to identify some accessory minerals and for detailed studies of melt particles.

Results:

Petrography. The gravelly sand is gray to greenish in color, very poorly consolidated, and clast supported (Fig. 2). The sand is poorly sorted and generally massive, but crude size-sorting and subtle, discontinuous layers occur locally. The silt-clay matrix forms typically 30-40 vol%. The most abundant clasts are mono- and polycrystalline quartz (>50 vol% in most samples) and K-feldspar (mostly microcline; ~7 vol%). The clasts are mostly sand-sized, and gravel-sized clasts (>2 mm) are less abundant, though ubiquitous. The sub-mm clasts are angular to subangular and rarely subrounded; larger clasts are subrounded and rarely rounded. Other mineral clasts, including plagioclase and mica, occur only in accessory amounts. Accessory minerals comprise garnet, poikilitic staurolite, titanite, tourmaline, zircon, and possibly kyanite, as well as opaque minerals pyrite, marcasite, and rutile. Lithic clasts are sparse (only a few vol%) and include e.g., sandstone/wacke, siltstone, schist, gneiss, and granite. Melt particles were observed only in the samples from the basal interval. No glauconite was detected. The greenish mineral grains from the lowermost samples were identified as chlorite (using microRaman and SEM-EDX).

XRD analyses. The bulk XRD analysis confirmed the same main constituents as found in the microscopic studies (quartz and K-feldspar). In a sample from the basal interval also muscovite and chlorite was detected. The clay fraction analyses revealed that all samples have comparable assemblages of clay minerals, only the intensities of peaks in diffractograms are slightly different. The main clay minerals are smectite

and kaolinite. Also traces of mica, K-feldspar, and possibly quartz were detected.

Geochemistry. Geochemical analyses show that the gravelly sand is silica-rich (mostly >80 wt% SiO₂). Trends with depth include a slight decrease in SiO₂ and slight increase in Fe₂O₃. The lowest SiO₂ values were detected in samples from the basal interval, which have high matrix proportions and contain material reworked from the suevite. Contents of Na₂O, K₂O, and CaO do not show any particular trends. Siderophile element contents and Cr concentrations are low in the analyzed samples (compared to sedimentary breccias above or suevite below [5]). Geochemical harmonic least-squares mixing (HMX) calculations suggest, that the basal interval of the gravelly sand is a mixture about 61% of the gravelly sand (as found in the middle and upper interval) and 39% of the underlying upper suevite.

Differences among the subintervals. There are some differences between the three subintervals of the gravelly sand. Gravelly sand from the middle interval contains more abundant clay minerals and displays more variable chemical compositions than the sand from the upper interval. This is in agreement with the fact that samples of the middle interval have higher proportion of matrix according to the modal point counting analyses. The basal interval has a lower SiO₂ content (<80 wt%), less K-feldspar, and more mica. Samples from this basal interval are more diverse in composition (have lower SiO₂ content and higher content of Al₂O₃, Fe₂O₃, and Na₂O) and they contain more lithic clasts and melt particles that are probably reworked from the underlying suevite.



Fig. 2: Gravelly sand sample KB3-09 from the upper gravelly sand interval, 1375.46 m depth.

Comparison with Exmore diamicton members:

When the gravelly sand is compared with the diamicton members of the Exmore Formation [6], it is obvious that these Exmore members contain more matrix (commonly >40 vol%, [7]). Glauconite is an important

component of the Exmore diamicton members (~2 vol%, [6,7]), but is absent in the gravelly sand interval. Also the feldspar content is different; K-feldspar is more abundant and plagioclase is less abundant in the gravelly sand compared to the Exmore diamicton members [7]. No carbonate fossils were observed in the gravelly sand. Melt particles were found only in the basal gravelly sand interval, whereas in the Exmore diamicton members several layers with abundant melt particles were noted [7]. In addition to smectite and kaolinite, also minor amount of illite and glauconite were detected in the clay fraction of the Exmore diamicton members [8].

Conclusions: Our mineralogical and geochemical results are in agreement with previous studies and interpretations that the gravelly sand is an avalanche deposit derived mainly from the non-marine Potomac Formation in the lower part of the target sediment, in contrast to polymict diamictons higher in the core that have been interpreted as ocean-resurge debris flows. The absence of marine microfossils and glauconite indicate a non-marine source material. The chemical composition of the gravelly sand samples is similar to some samples of the Potomac Formation analyzed by [9]. The mineralogy and geochemistry of the gravelly sand are typical for a passive continental margin source without discernible mixing with marine sediments during the impact remobilization and redeposition. Reworked melt particles and rip-up clasts derived from the suevite are found only in the basal part.

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