ABIOTIC GRANULAR ALTERATION TEXTURES IN 35 MYR OLD IMPACT GLASS FROM 1.4 KM DEPTH IN THE CHESAPEAKE BAY IMPACT STRUCTURE

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The search for life in the deep subsurface of the Earth or Mars requires the identification of robust biosignatures. We investigated the colonization of impact melt glasses in suevitic breccia from 1.4 km depth in the Chesapeake Bay impact structure, USA [1]. The samples we analyzed come from a section in the crater characterized by a heterogeneous assemblage of rock fragments including melt glasses and that hosts a present-day microbiota documented by molecular methods and direct enumerations [2].

In 2005, the Chesapeake Bay impact structure (CBIS) was drilled by the International Continental Drilling Program-United States Geological Survey (ICDP-USGS) [3]. The impact structure was formed in the upper Eocene ~35.4 Ma ago in a shallow marine environment (water depth <350 m) underlain by a few hundred meters of lower Tertiary and Cretaceous sediments on Neoproterozoic and Paleozoic basement. The crater has a diameter of ~85 km and lies in the Atlantic margin of Virginia, USA (Figure 1) [4]. It has a ~900 m high central uplift surrounded by a central crater (~35 km diameter), which is itself surrounded by an annular trough and an outer region of fractured rock containing irregular concentric and radial faults. The structure is one of the best preserved examples of a large marine impact. The silicate glasses were recovered from 1.4 km depth after drilling through a granite megablock.

The silicate glasses, which display variable composition (56-83% SiO_2) and immiscibility textures on account of rapid quenching, contain granular alteration textures at the interface of the glass and clay alteration products (Figure 1).

The textures are made of ~1 µm clay in-filling and hollow cavities which group together and locally form elongate zones reminiscent of tunnels (Figure 2). However, focused ion beam sectioning and TEM mapping does not reveal carbon, and no obvious elemental depletion patterns were observed in the glass in proximity to the alteration zones. No microbial structures were observed.

The presence of titanium oxide crystals of ~2-5 µm in diameter along healed fractures, weathering of immiscible iron sulphide spheres within the silicate glass, granular alteration textures associated with hydrothermal alteration and post-hydrothermal alteration of glass along fractures, are the products of multistage abiotic processes and not the results of biological activity.

Similar granular alteration textures are found in many volcanic hyaloclastites, of both terrestrial and marine origin [5,6]. Our work advances our ability to discriminate abiotic and biotic alteration in glass-bearing melt rocks in terrestrial and extraterrestrial materials.

Figure 1. Granular alteration textures at the glass/clay interface in impact glass from the Chesapeake Bay impact structure.

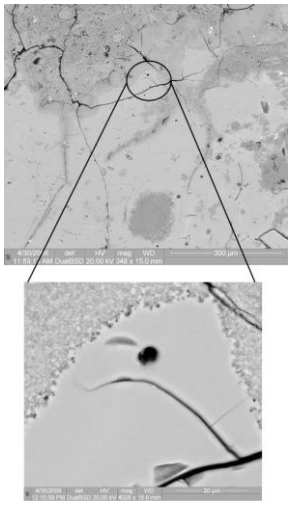
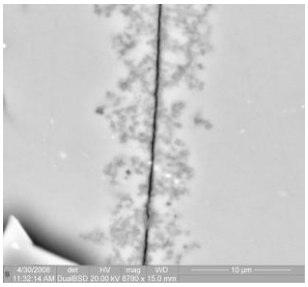


Figure 2. Granular alteration textures within impact glass showing spherical structures and bunch-like conglomerates.



References: (1) Belkin HE, Horton JW. (2009) GSA Special Paper 458. (2) Cockell CS (2009) GSA Special Paper 458. (3) Gohn GS et al. Science 320, 1740-1745. (4) Horton JW et al. USGS Professional Paper 1688. (5) McLoughlin N. et al. (2007) Astrobiology 7, 10-26. (6) Cockell CS et al. (2009) Geobiology 7, 50-65.