TEM AND XRD INVESTIGATION OF IMPACT GLASS ALTERATION PRODUCTS IN TERRESTRIAL CRATERS: AMORPHOUS MATERIALS, PHYLLOSILICATES AND EVERYTHING IN BETWEEN

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Introduction: Impact cratering is one of the most ubiquitous geologic processes shaping the surface of all solid bodies in our solar system. Impacts are a major source of clay minerals and poorly crystalline, clay-like materials on Earth and Mars [1,2]; phyllosilicates and related clay-like phases comprise an incredibly complex group of materials, and their characterization, even in controlled laboratory settings, remains a challenging endeavor. The nature and origin of clay minerals and amorphous materials on Mars, which form a major component (~20-70 wt %) of rock and soil samples in Gale Crater, have remained ambiguous [3]. These amorphous phases likely fall on a spectrum between pristine volcanic and/or impact-produced primary materials and phases formed from aqueous alteration. We hypothesize that the sediments and lithologies in Gale Crater and elsewhere on Mars contain altered impact products; here we present initial results from a study characterizing materials produced from impact glass alteration – clay minerals, poorly crystalline/amorphous materials – in terrestrial craters using Transmission Electron Microscopy (TEM), powder X-ray diffraction (XRD) and chemical (EDS) analysis. We will discuss datasets from two localities: the Chicxulub impact structure upper peak-ring [4] and impact breccias from Aumühle quarry in the Ries crater, Germany.

Background and Methods: The peak-ring lithologies of Chicxulub were rapidly buried under post-impact sediments and subsequently altered by the post-impact hydrothermal system [4-7]; as a result, various secondary hydated silicates including a nanocrystalline, glassy material referred to palagonite, or hydrated glass, are well-preserved. This Al-Si-rich phase is thought to represent an intermediate stage of alteration between pristine silicate glass and more advanced alteration products [5]. The first sample selected for TEM analysis was a clast of altered glass from the impact melt-bearing breccia (Unit 2) composed primarily of a hydrated, poorly crystalline component that, despite being altered, shows relict schlieren and melt immiscibility textures between two original end-member compositions. Preliminary characterization shows altered glass is generally Mg-Fe rich, with nano-scale crystallinity and textures that are distinct from the coarser-crystalline smectite. Samples from the Ries crater Germany contain abundant impact glass at various stages of hydration in addition to other alteration minerals (e.g., phyllosilicates, carbonates). Ultra-thin sections for TEM characterization were created using focused ion beam (FIB) systems. XRD data were obtained on (unoriented) bulk, micronized glass clasts.

Results and Discussion: Initial TEM results show the altered glass from Chicxulub comprises three broad categories of material: (1) a phyllosilicate component, (2) a single sheet-like component, and (3) an amorphous component. The green palagonite appears to be better crystallized, showing a platy texture typical of a 2:1 or possibly a 2:1:1 clay mineral, and a d(001) of ~14.3 Å. The brown palagonite, however, is texturally distinct and has a d(001) between ~4.6 to 5 Å, resembling a single layer structure. Both types contain a significant amorphous component. Corresponding pXRD analysis of bulk (unoriented) crushed glass clasts shows d(060)'s of ~1.50 and ~1.54 Å, suggesting both a trioctahedral and dioctahedral clay mineral component is present [5].

Although this work is still in the early stages, these results show that the green palagonite in these samples is likely better crystallized than the brown, and can be interpreted as a smectite or possibly a chloritic clay mineral. Previous work characterizing the Na-satuated <0.2 μm size fraction of the same lithology in the Chicxulub peak ring showed atypical smectite d(001)'s of ~14.32 to 14.91 Å at 54% relative humidity (RH) (a Na-saturated smectite should swell to ~12.5 Å in 54% RH). Those same samples also failed to collapse completely at 0% RH, a behavior attributed to weakly bound metal-hydroxylated material or possibly organics in the interlayer site. This brings to question the relationship among the clays, the amorphous component and the single-layer phase, which can be tentatively interpreted as possibly a brucite or gibbsite-like structure. We will focus on determining the chemical composition and relationship of these phases to one another and expand the current sample set to include glass-rich impact breccias from the Ries crater in Germany. These datasets can then be compared to those from other terrestrial environments, notably altered volcanic sediments where amorphous materials have been identified, as well as amorphous materials and phyllosilicates characterized by the CheMin instrument on the *Curiosity* rover in Gale Crater to evaluate formation processes of amorphous materials on the martian surface.

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