PRESERVATION OF ORGANIC MATERIALS DURING HYPERVELOCITY IMPACT EXPERIMENTS.

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Introduction: The survivability of carbonaceous compounds during hypervelocity impacts has particular importance in exobiology, astrobiology, and origin of life studies. The delivery of biotic organics such as amino acids, which are found in meteorites [1], during impact is an important hypothesis for the source of life's early organics [2]. Furthermore, trapping or preservation of target organics can provide clues to a target's original organic content, including that of extraterrestrial targets such as Mars. Historically, it was believed that no organic material could survive the intense temperatures and pressures involved in major hypervelocity impacts, but more recently this assumption has been challenged. First, impact glasses from Argentina have been shown to entrain fragile grasses and water [3, 4]. Second, hypervelocity impact experiments [4] reproduced this process using hypervelocity impact experiments. The survivability of organic amino acids [5] and polycyclic aromatic hydrocarbons (PAHs) [6] during high shock using flat plate experiments have set constraints on limiting conditions for suvival. Here, however, we used the light-gas gun facility at the NASA Ames Vertical Gun Range (AVGR) to conduct three-dimensional experiments to assess the mechanism and potential for survival of amino acids and PAHs in organic-rich targets under open conditions.

Experimental Methods: Impact experiments were conducted at the NASA AVGR. Organic analyses were conducted at organic geochemical laboratories at Brown University. PAHs were chosen for study due to their known stability under high temperatures relative to other small organics, whereas amino acids represent a more extreme case of survival during impact.

AVGR Experiments. Two target types were used. The first consisted of the dry amino acid L-norvaline or a mixture of PAHs with varying stabilities mixed with sieved 100-200 sand. In the second case, L-norvaline was frozen into 5 cm-diameter wafer of ice embedded in the 100-200 sieved sand target. Blank tests were also conducted, i.e., targed sand contained no organics. L-norvaline was chosen as a model amino acid for several reasons: a) it is non-racemizable through normal means due to the presence of an α-methyl group, allowing the potential for an analysis of chiral changes during impact; b) it is non-proteneic, which avoids an otherwise difficult to avoid dilemma of biogenic contamination; and c) it has been found in carbonaceous chondrites [7]. Inert Pyrex projectiles were launched at two different speeds (4.5 and 5.5 km/sec) and at two different angles (30° and 90° from the horizontal) in order to assess different extremes.

For this preliminary study, our strategy is to assess the survivability of different organic materials trapped within vesicles or entrainged in seams within impact melt.

Organic Analysis. Recovered vesicular impact glasses and agglutinates were cleaned with organic solvents to remove surface contaminants prior to analysis. Procedural blanks were run alongside samples in order to assess contamination due to laboratory handling. Glass was crushed in a mortar to release trapped organics; polycylic aromatic hydrocarbons were extracted in organic solvents for analysis. Amino acids were extracted with hot HPLC-grade water and separated and purified by ion-exchange chromatography. Experimental blanks were divided and processed with both methods. All analyses were conducted by GC-MS or HPLC-MS.

Discussion: This work presents preliminary studies that reflect a greater goal of understanding the potential for hypervelocity impacts to entrain, trap, or distribute carbonaceous material from within a carbon-bearing target. The trapping of organics in impact glass presents a potential venue for searching for early terrestrial organics, and glass-trapped carbon could represent a record of organic material present at the time of impact. On Mars, impact glass could represent another method for searching for organic or even biotic material that might have once been present on the surface. Once generated, glass-trapped organics would not be prone to degeneration or alteration. Other ongoing experiments are assessing the survival of organic-laden projectiles. The delivery (and survival) of meteoritic organics on early earth, Mars, or even the present-day Moon is largely unexplored.

References: [1] Pizzarello, S. and Cronin, J. R. (1983) *Advances in Space Research, 3*, 5-18. [2] Chyba, C. and Sagan, C. (1992) *Nature*, *355*, 125-132. [3] Schultz, P. H. and Harris, R. S. (2005), *Exobiology PI Meeting Abstracts* (August). NASA Ames Research Center; [4] Harris, R. S. and Schultz, P. H. (2007), *LPSC 38*, no. 2306; [5] Blank, J. G. *et al*., (2001) *Origins of Life and Evolution of Biospheres*, *31*, 15-51. [6] Mimura, K. and Toyama, S. (2005) *Geochimica et Cosmochimica Acta*, *69*, 201-209. [7] Cronin, J. R. and Pizzarello, S. (1997) *Science*, *275*, 951-955.

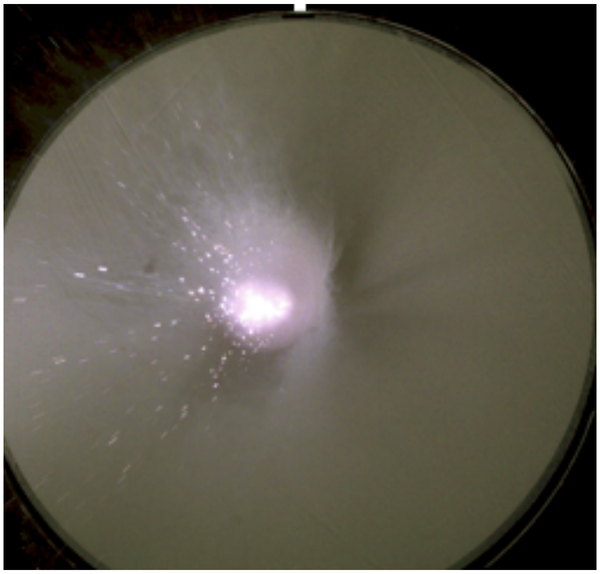

Figure 1: Oblique impact (30° from right) by 0.635 cm diameter Pyrex sphere (5.3 km/s) into dry amino acid powder on top of 100-140 sand. Image was 2.9 milliseconds after impact. Melt entrains organic material during ejection.

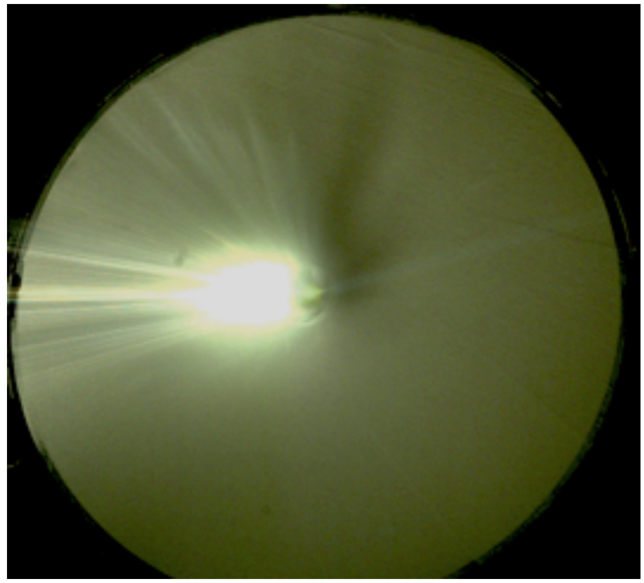

Figure 2: Oblique impact (30° from right) by 0.635 cm diameter Pyrex sphere (5.3 km/s) into a wafer of water-ice containing amino acid (embedded in 100-140 sand). Image was 0.28 milliseconds after impact. A small amount of residual atmosphere was left (5mm). While impact glass streaks downrange, unaffected material remains uprange.

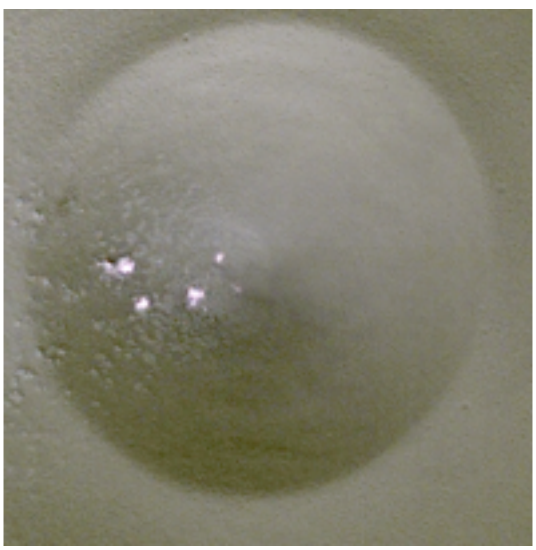

Figure 3 (left)**:** Recovered impact glasses used for analysis for the impact in Figure 1. Impact glass is driven downward and upward as part of crater excavation flow. Organic material is entrained within cooling glasses and rapidly quenches. This process occurs at a much larger scale in Argentina [3,4].