CATCHING LIFE IN THE ICY PLUMES OF EUROPA AND ENCELADUS.

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Introduction: Icy plumes at Europa and Enceladus provide an opportunity to determine their habitability and presence of life by collecting ice particles in a pristine condition and transferring to on-board instruments.

The Cassini spacecraft has undertaken flythroughs of the Enceladus geyser plumes at speeds > 7 km/sec [1] where instruments such as the Cosmic Dust Analyser [2] and the Ion Neutral mass spectrometer [3] instruments detected spectrums from plasma generated by impacting plume ice particles. Cassini's measurements provided remarkable evidence of a salty ocean and hydrothermal vents under the ice, but these measurements were limited by the high flythrough speeds, where large organic compounds impacting the instruments were destroyed or altered [4].

A solution is to flythrough the plumes at slower speeds (e.g., speeds < ice melt speed at impact) collecting ice particles in pristine condition where cell structures or large biomolecules are intact for analysis. The Applied Physics Laboratory (APL) and NASA Ames Research Center (ARC) are undertaking studies to determine the feasibility of collecting ice in the plumes during 1.5 km/sec fly-throughs speeds.

Methods: (1) *Apparatus:* Plumes of 140° K ice

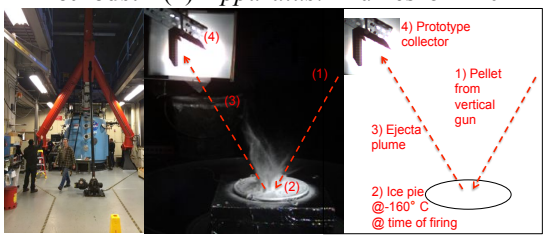
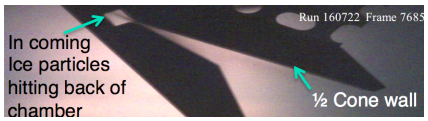


Figure 1: (*Left) ARC Vertical Gun. (Middle & Right) Prototype cone collector & ice pie setup.*

particles travelling up to 2.3 Km/sec, were created by firing 3 mm hollow aluminium pellets (up to 6 Km/sec) at liquid nitrogen cooled ice pies. The experiments were at the NASA ARC Vertical Gun (Fig 1).

Prototype Collectors (30° wall angled cone cross-sections) were positioned to catch the plume particles (Fig 1). Particles were filmed as small as 150 µm, impacting the cone and funnelled into a collection chamber (Fig 2). *(2) Cells Survival (A trial simulating the organics journey from Eceladus ocean to Collection):* Seawater form the Pacific ocean was used and frozen in the ice pie. Adenosine triphosphate (ATP), a lable biomarker was used as a proxy to estimate the amount of viable and/or intact cells in the: (1) sea water, (2) ice pie before pellet firing, (3) Ice pie after pellet firing, and (4) Sample chamber after collection (Fig 4).

(3) Computer simulation modelling: Simulation impacts were modelled of a 100µm particle impacting an aluminium surface at 30°, from 20 to 1500 m/sec, using ALE3D hydrocode from LLNL. Material modelling involved a simple equation of state using bulk modulus and stress/strain based failure criteria (Fig 3)



Left Figure 2: *Particle clouds entering sample chamber* @ 1.5 Km/sec.

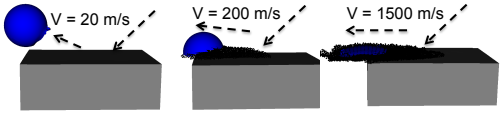


Figure 3: *Computer simulation at various speeds*

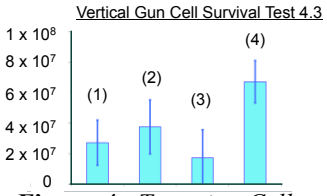


Figure 4: *Tentative Cell survival results. (1) Sea water, (2) Ice, (3) Ice post pellet shoot,(4) Collection*

Results: The Vertical Gun tests showed >95% particles at speed > 250 m/sec smashed at impact and flowed down the cone walls into the sample chamber. Clouds of particles of size < 150 µm diameter size were filmed flowing into the sample chamber at ~1.5 Km/sec (Fig 2). The cell survival trial showed significant survival and/or ATP preservation at ~1.2 km/sec impact. Some contamination may have occurred. The computer simulation correlated with the Vertical Gun results.

Conclusion: All results are tentative requiring further work and stricter contamination controls. However the Vertical Gun and computer simulation results show particles smash upon impact and flow into the sample chamber with >>95% efficiency. Cellular survival is significant suggesting large molecular biomarkers may remain intact for mass spectrometer measurement.

Refererences: [1] Krupp N. et al (2012) Icarus 433-447. [2] Srama R. et al. (2004) Space Science Reviews. 114: 465-518. [3] Waite J.H. et al. (2004) Space Science Reviews 114: 113-231. [4] Bertrand M. et al. (2009) astrobiology Vol 9, No 10.