LOOKING INSIDE THE EARLY-TIME RADIATION PLUME FOR HYPERVELOCITY IMPACTS.

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Introduction: Previous studies describe the evolution of impact generated vapor plumes from above [1]. Here, a new approach is tested whereby early-time self-luminous ejecta products are examined using quarter-space experiments with spectral measurements. At early times, the forming cavity is on the order of centimeters. Hence, the pointing accuracy and small detection regions are necessary. This method allows a view exclusively inside the forming crater. To prove the usefulness of this method we impacted into several materials.

The radiating gas plume due to impact has four components: the jetting phase, a downrange-moving vapor cloud, a slower expanding vapor cloud and a vapor plume that grows from containment in the cavity [2]. In addition, significant thermal debris evolves inside the growing transient crater. This study probes the fourth component as well as the thermal component and compares it with the downrange jetting phase and slower moving expanding phases.

Experimental Method: Quarter-space experiments reveal a cross-sectional view of the forming crater. Natual cratering and most studies occur in half-spaces, i.e., a flat surface with the impact occurring near the center. The quarter space is formed by impacting near the edge of a clear acrylic window parallel to the projectile's trajectory so the window protrudes both above and below the surface. This method does not significantly impede or affect the crater formation. The final crater appears as half of a regular crater.

Target materials included: silicates (powdered pumice and quartz sand) in order to assess the thermal characteristics during formation; a fine and a coarse dolomite powder to look at the vaporization during formation; and quartz sand with a projectile diameter layer of dolomite (.0635 cm) on top to explore the depth of the interactions. Pyrex spheres (.0635 cm diameter) were used to minimize the projectile contribution to the spectra.

The foreoptics collect light from small 2.5 cm diameter regions on the crossectional plane. Three detectors simultaneously collect light. One unit is centered above the surface 10 cm downrange to look at the jetting phase. The second is centered just above the point of impact. The third is centered just below the point of impact to look inside the transient crater. All pointing is verified with a high speed video camera that records the impact event every 2 ms.

The spectroscopic instruments are McPherson monochromators with Oriel gated, intensified CCD cameras. The monochromators have spectral resolution down to 0.05nm, spectral range from 190nm to 1300nm. We chose a spectral resolution of 0.2 nm to increase the spectral range. The foreoptics include a custom made McPherson telescope and fiber optic system that precisely defines the detection area.

The impact experiments were performed at the NASA Ames Vertical Gun Range. Early times were captured with spectrometer/camera exposures of 0 to 50 microseconds. Impacts were made at angles of 30 and 60 degrees from horizontal. The projectile velocities were similar and range from 5.6-5.9 km/s. The spectral range 475-550 nm was chosen from previous work into dolomite to display atomic and molecular lines [1].

Results: All materials showed distinct spectra in the three detection regions. The point above impact consistently exhibits the strongest atomic emissions with a thermal overprint. Downrange spectra are dominated by blackbody radiation and strong molecular bands. The point just below impact always exhibited poor signal.

Silicates. Both powdered pumice and No. 24 sand display a blackbody curve above the point of impact and poor signal both below the surface and downrange.

Coarse dolomite. Impacts at 60 degrees into coarse dolomite indicate that the early transient cavity contains vapor phases. Spectra there have atomic Ca lines and very little indication of molecular CaO lines. The region above the point of impact, however, exhibits molecular CaO and atomic emissions. The downrange component displays strong molecular lines and no atomic lines.

Fine dolomite. Both 30 degree and 60 degree impacts into the fine dolomite (<25microns) resulted in poor spectral features in all three regions.

Layered sand and dolomite. Layering the fine dolomite (one projectile radius) over the coarse sand enhanced both the atomic (Ca) and the molecular signal (CaO) above the impact point. Signal below the impact point continued to be poor and the downrange component contains mostly thermal blackbody radiation with some molecular CaO.

High speed video reveal these characteristic changes in the vapor cloud as it evolves from opaque to optically thin during the formation of the cavity.

Conclusions: First, Quarter-space experiments allow probing inside the transient cavity and conditions within the expanding vapor and thermal plumes. Second, even a thin layer of volatile rich material (dolomite) results in vapor plumes that exhibit molecular emissions downrange but atomic emissions within the transient crater. Third, addition of silicate particulates to dolomite powder enhance the generation of thermal decomposition of the dolomite powder. Fourth, such experiments will help understand the evolution of the impact flash by looking inside the process [3,4]. Finally, such experiments should provide new reference data for numerical codes.

References:

[1] Sugita S. et al (1998) *JGR, 103*, 19427-19441. [2] Schultz P. H. (1997) *JGR, 101*, 21117-21136. [3] Ernst C. M. and Schultz P. H. (2003) *LPS XXXIV,* This Volume. [4] Ernst C. M. and Schultz P. H. (2003) *LPS XXXIII,* Abstract #1782.