IMPACT VAPORIZATION OF VOLATILE-RICH TARGETS; EXPERIMENTAL RESULTS AND IMPLICATIONS; P.H. Schultz, Dept. Geological Sciences, Brown University, Providence, RI 02912.

Previous exploratory experiments at the NASA–Ames Vertical Gun Range (AVGR) revealed that impacts into dry-ice targets (1, 2) at low angles enhanced vaporization. Ongoing studies are providing estimates of the amount of vaporization as functions of impact angle, impact velocity, and different target/projectile types as well as phenomenology that may be applied to broader planetary-scale events.

Experiments: Five contrasting target compositions included dry-ice (powder and block), calcium carbonate (powder and Iceland Spar from Chihuaha, Mexico), powdered dolomite, water-ice, and silicates (sand and pumice). Aluminum spheres (0.635 cm diameter, 0.376g) provided the nominal impactor type since previous experiments (1,2) had revealed that the reaction between the aluminum impactor and available oxygen produced small quantities of AIO, thereby resulting in a brilliant self-luminous cloud recordable at very high frame rates (35,000 fps). Additional impacts by lexan and nylon spheres and different ambient atmospheric compositions (air and argon) not only demonstrated that the exothermic reaction producing AIO had little effect on the energy in the cloud but also revealed that the target (not the ambient atmosphere) provided the source of oxygen. Impact angles included 90°, 45°, 30°, 15°, and 7.5° from the horizontal with velocities from 3.0 km/s to 6 km/s. The cloud, caused by a high-velocity vapor permitted estimates of the energy lost in the cloud in a manner consistent with the description by Taylor (3). Measurements of the size of the cloud as a function of time permit estimates of contained energy. As impact velocities exceed a certain range (=4 km/s for dry-ice; ~5 km/s for CaCO₃), the vapor cloud energy approaches a maximum of about 50% of the original impactor energy. Although large, this fraction does not violate energy conservation since the ricochet and concomitant ejecta are observed to contain 30% (4,5) and the excavated ejecta, about 7% (4). An impact-induced vapor cloud under very low atmospheric densities (<1 mm) reach an asymptotically limited velocity theoretically related to the contained energy, and observed velocities are in close agreement with analytical approximations given in (6). Combining the observed energy in the vapor cloud with the expansion velocity yields an estimate of the vaporized mass. Figure 1 reveals that almost 10 projectile masses of the CaCO₃ targets are vaporized at 15°, a quantity comparable to dry-ice but six times more than dolomite, and that the vaporized mass increases as the square of the impact velocity as theoretically calculated in (7,8). The estimate for water-ice is a preliminary minimum value owing to the poor visibility of the vapor cloud; the quantity of vapor decreases with increasing impact angle with 50 times less released at 90° (Fig 2).

Applications: Martian ejecta facies may record the effects of a strong blast created by impact-released, near-surface volatiles (9). Very fresh, small (<10 km in diameter) craters at high latitudes typically exhibit faint distal ejecta lobes extending up to 15 crater radii from the impact. Erosion of terrain surrounding numerous small craters at the same latitudes is typically limited to comparable distances, thereby creating pedestal craters (Figure 3). Previous interpretations suggested that distant ejecta deposits may shield the underlying surface from wind erosion (10) but it can be shown that the quantity of ejecta at such distances is extremely small and not expected to be uniformly distributed. It is proposed here that the extreme distal lobes and differentially eroded (certain near-rim morphologies (9,11) are not affected.

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Figure 1. Vaporized mass ($M_v$) contained in the expanding cloud above the impact relative to the projectile mass ($M_p$) as a function of impact velocity for a 15° impact angle. Targets include dry-ice blocks ($CO_2$-B), calcium carbonate powder ($CaCO_3$-P), calcite crystals ($CaCO_3$-B), water-ice block ($H_2O$-B), and powdered dolomite ($dolomite$-P). Open circle and cross symbol indicates an impact by a 0.635 cm nylon sphere; all other impacts represent impacts by 0.635 cm aluminum spheres.

Figure 2. Effect of impact angle on the quantity of vapor released in projectile masses for calcite and calcium-carbonate powder.

Figure 3. Erosion-resistant zone surrounding a large (9 km) "pedestal" crater in the southern hemisphere. This zone may reflect effects of strong winds created by impact-generated volatiles released from an otherwise easily eroded volatile-rich surface layer.