INTERACTION BETWEEN EJECTA VAPOR PLUMES AND ATMOSPHERES, WITH APPLICATION TO THE KT EXTINCTIONS, **A. M. Vickery, Lunar and Planetary Lab, University of Arizona, Tucson, AZ 85721**

Alvarez et al. (1) first proposed, on the basis of anomalously high concentrations of Ir in the boundary clay layer, that the Cretaceous-Tertiary (KT) mass extinctions were caused by a large-scale impact. We previously (2) investigated the effects of the vapor plumes generated by impacts on atmospheric erosion. We also estimated the amount of impactor material retained by the earth, in an attempt to constrain the size of the KT impactor. In this first set of calculations, we assumed that only the highest energy portion of the vapor contributes significantly to atmospheric erosion, and that the projectile material is concentrated in the outer, faster portion of the vapor plume. The latter assumption minimizes the amount of projectile material retained by the earth and thus gives an upper limit to the minimum size impactor required to deposit sufficient Ir to be consistent with the observed concentration in the KT boundary layer. In the present work, I investigate the effects of varying these assumptions.

The initial internal energy of the vapor is estimated by impedance-matching (3). In some cases, the latent heat of vaporization is subtracted from this initial internal energy, and in others, it is not (under the assumption that the vapor will condense during expansion and the latent heat will be added back to the remaining vapor). We contrast the effects of having the projectile concentrated in the outer portion of the vapor plume with the case in which the vapor is well-mixed. We also contrast the effects of including all vapor (which lowers the average internal energy of the plume but increases its mass) against the case of including only the highest energy vapor. The plume is assumed to expand in a manner described by Zel'dovich and Razier (4), rapidly reaching a maximum expansion velocity. The momentum of the vapor with velocity $u \geq u_{esc}$ is divided by the mass of impact gas with $u \geq u_{esc}$ plus the mass of the overlying atmosphere for zenith angle increments of 0.25° to give the mean velocity of the combined masses. If this mean velocity is greater than u_{esc}, the overlying atmosphere is presumed to be lost from the earth. The maximum zenith angle for which escape occurs is θ_{esc}. For zenith angles greater than θ_{esc}, all the projectile material within that sector is retained. Because the velocity within the vapor plume varies linearly from zero at the center to a maximum at the leading edge, some projectile material may be retained even in the sector $0 \leq \theta \leq \theta_{esc}$ (This is certainly true if the vapor is well-mixed, and may be true if the projectile is concentrated in the outer portion of the cloud.)

Figure 1 shows θ_{esc} as a function of impact kinetic energy for asteroidal impacts at 20 km/sec. Case 1, with only the highest energy vapor and latent heat (ΔH) added, is the most efficient, and Case 3, all vapor with ΔH subtracted, is the least efficient at atmospheric blow-off. Case 2, highest energy vapor with ΔH subtracted, is equally efficient as Case 4, all vapor with ΔH added. Figure 2 shows θ_{esc} vs. impact energy KE for Case 1 impacts; the curves correspond to different impact velocities, u_i. There is no escape for $u_i < 15$ km/sec, and no escape at 15 km/sec for KE < 10^{24} J ($m_i \cong 10^{16}$ kg). Blow-off is much more efficient at 20 km/sec; for ui ≥ 25 km/sec, there is not much difference in blow-off efficiency.

Figures 3 and 4 show the effect on the amount of impactor retained by the earth of assuming that the projectile is concentrated in the outer portion of the plume vs. being well-mixed for cometary impacts in which only the highest energy vapor is considered. The results are similar at all velocities for impactor masses $m_i \leq 10^{15}$ kg. For $u_i > 30$ km/sec and $m_i > 10^{17}$ kg, none of the projectile is retained if the projectile is concentrated in the outer portion of the plume. At the highest energies considered, even the mixing case gives only ~ 5% impactor retention. When all vapor is included (and assumed to be well-mixed), the results are similar to the high energy mixing case (Figure 4) at low u_i, but ~ 10 times as much projectile is retained at the highest u_i.

REFERENCES: (1) Alvarez, L. W., W. Alvarez, F. Asaro, and H. V. Michel (1980) *Science* **208**, 1095-1108. (2) Vickery, A. M. and H. J. Melosh (1990) Proceedings of the Conference on Global Catastrophes in Earth History, in press. (3) Gault, D. E. and E. D. Heitowit (1963) Proceedings of the Sixth Hypervelocity Impact Symposium, vol 2, 419-456. (4) Zel'dovich, Y. B. and Y. P. Razier (1966) Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena, Academic Press, New York, 916 pp.

Figure 1

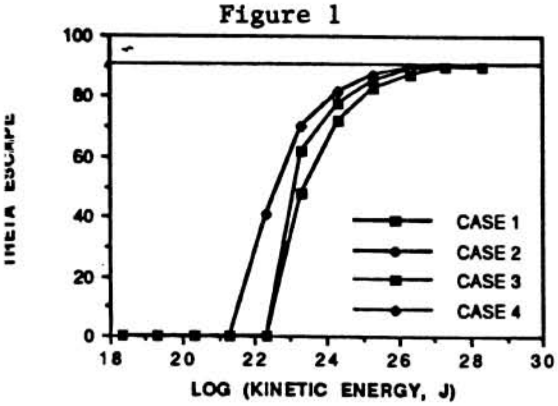
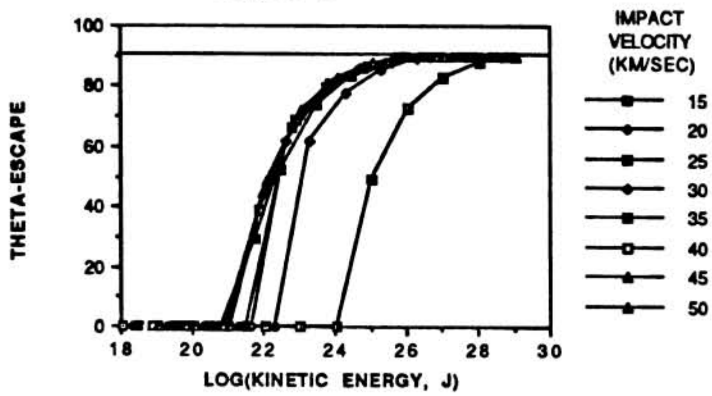


Figure 2



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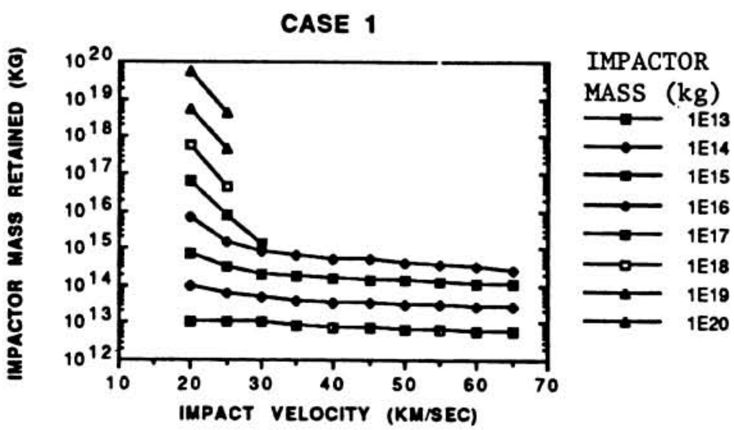

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