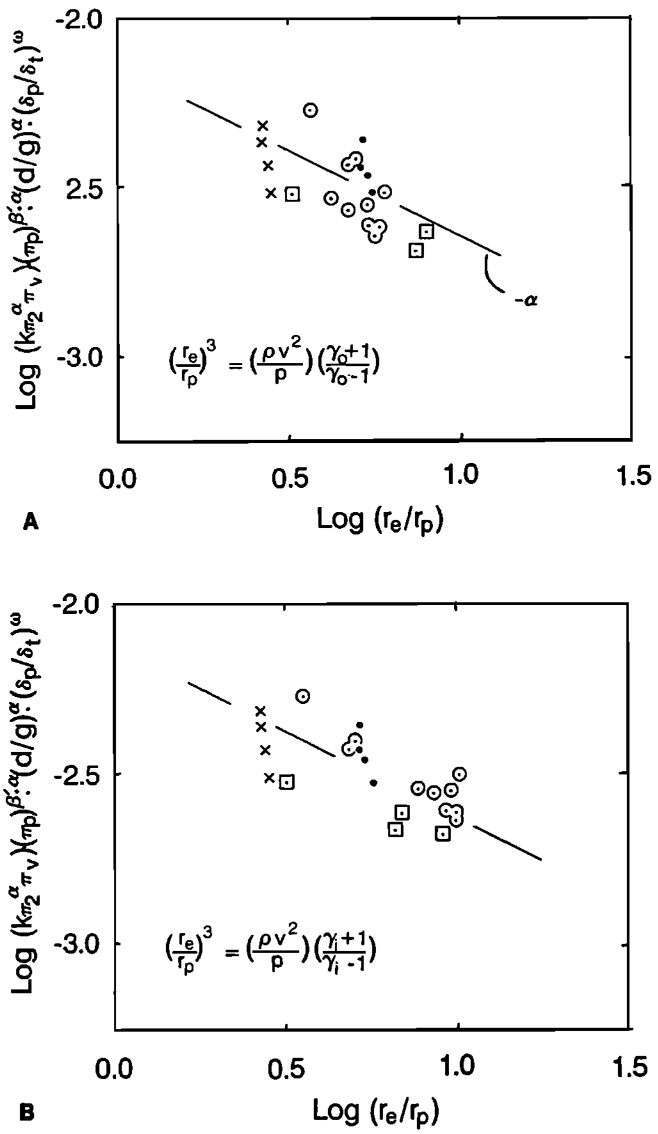

Fig. 16. Cratering efficiency corrected for gravity scaling ($k\pi_2{}^{\alpha}\pi_v$), ambient atmospheric pressure ($P/\delta_t v_i{}^2$), aerodynamic drag (d/g), and wake-blast enhancement ($P_s\ \delta_t Q$) for pumice and expressed in terms of the effective radius of the air disturbance r_e scaled to the projectile radius r_p. Figure 16*a* assumes that (r_e/r_p) is given by equation (22) with the values of γ corresponding to ambient conditions. Figure 16*b* incorporates the observation that high velocity impacts (>5 km/s) under high ambient density ($\rho/\rho_0 > 0.9$) exhibit considerable ionization; under such conditions it is assumed that γ for all gases approach a common value of 1.1. Lower velocity (< 3 km/s) impacts or lower density conditions ($\rho/\rho_0 < 0.7$) are represented by ambient conditions for γ.

disturbance and the impactor. At very high velocities ($M > 10$), the air disturbance changes the effective impactor dimension. The potential contribution of the wake to cratering efficiency can be observed in experiments where the projectile and wake blast are separated. At low velocities ($M < 10$) and high ambient atmospheric densities, the projectile wake creates a backpressure contained by the transient cavity. This backpressure offsets the effect of static ambient pressure. The apparent minimal atmospheric pressure effects reported in earlier studies [*Holsapple*, 1980] can now be reconciled as the combined effects of minimal drag (large grain sizes) and offsetting wake blast.

If the dimensionless scaling parameters can be applied to broader planetary scales, then these results have implications for interpreting the size of craters on surfaces with contrasting atmospheric envelopes. A future contribution will explore these implications in greater detail. Here it suffices to note that ambient atmospheric pressure should affect gravity-scaling relations of Venus but will be minimal on the Earth and unrecognizable on Mars. Even in the absence of significant pressure effects, however, aerodynamic drag could play a role in reducing crater size if ejecta sizes are sufficiently small whether due to shock comminution or preimpact lithology. Finally, the intensely disturbed air mass accompanying impactors on Venus, Earth, and Mars may further reduce cratering efficiency by increasing the effective size of the impactor. Such a process will be most critical in substrates with low strengths (loose fragmental material and liquids). At issue remains the early time coupling between the airmass and solid surface targets. Additionally, the role of impact vaporization in offsetting or augmenting cratering efficiency needs to be examined. Experiments using easily volatized targets (dry ice, carbonates) reveal that the early time vapor plume for vertical impacts resembles an upward directed jet exhaust but rapidly disappears. Off-vertical impacts, however, result in the vapor plume moving downrange and decoupling from the impact [see *Schultz and Gault*, 1990]. Further experiments should permit testing the sensitivity of cratering efficiency to such processes.

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