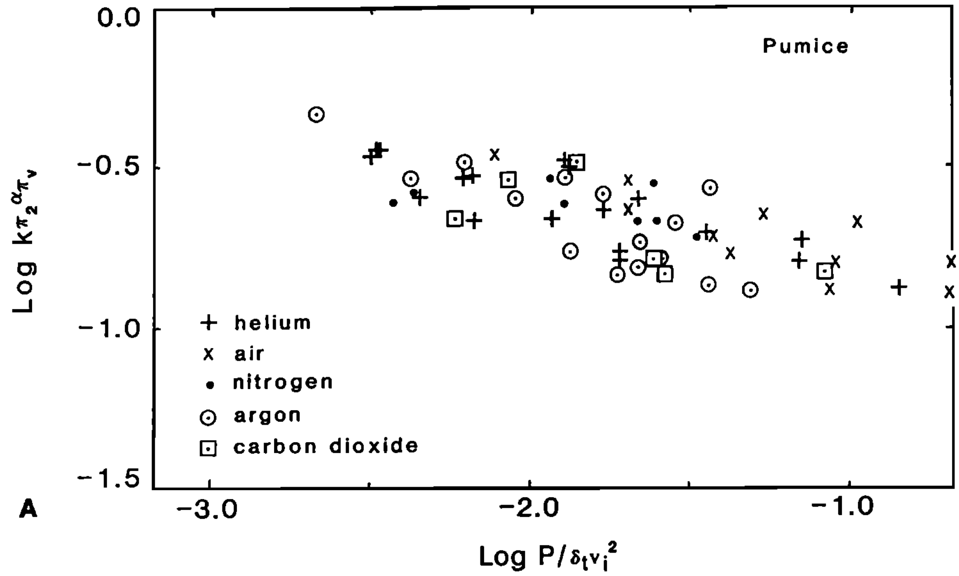

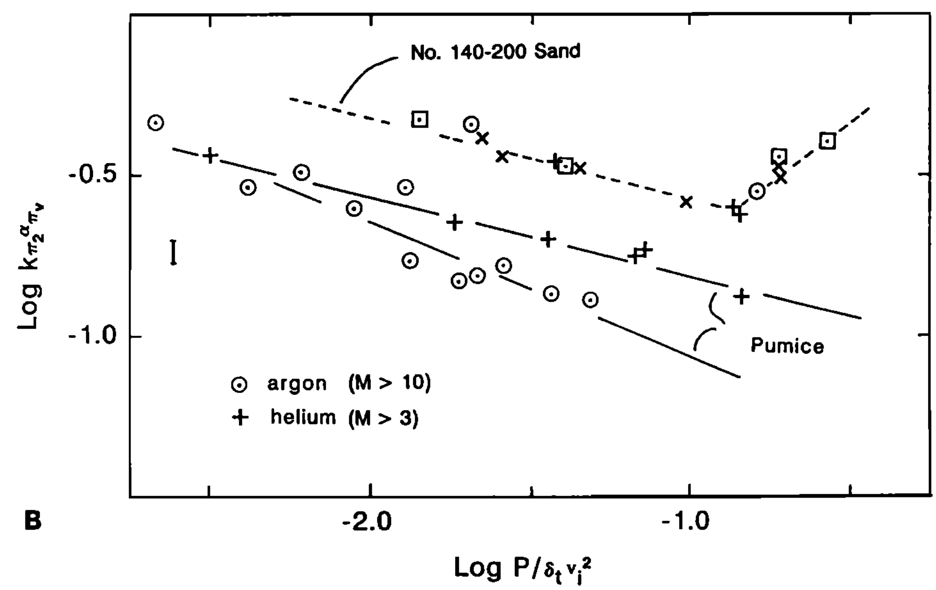

Fig. 7. (*a*) Change in cratering efficiency for impacts into compacted pumice under all types of atmospheric compositions as a function of ambient atmospheric pressure (*P*, in bars) scaled to specific energy of impact (velocity *v* is the controlling variable for a given target and is shown here in kilometers per second). Although a clear decrease in cratering efficiency is observed, the over all scatter for all data is much greater than what is observed for impacts under vacuum conditions and for data subsets isolating gas type and impact velocity. (*b*) Contrast in atmospheric effects on cratering efficiency for impacts under contrasting densities. High velocity (log π_2 ~= -8.5) impacts under an argon atmosphere exhibit a significantly greater decrease in cratering efficiency, low-velocity impacts (log π_2 ~= -7.7) into pumice under low-density. The data merge, however, at small values of the pressure parameter. Inclusion of the factor (equation (10*d*)) would result in a relative shift to the left for the pumice data in argon without affecting the slope. Sand data for low-velocity impacts by 0.635-cm spheres are shown for comparison. Under low-density atmospheres ($\rho/\rho_0 < 0.25$), low-velocity data for both sand and pumice exhibit very similar dependences on the pressure parameter even though the cohesive properties differ significantly. Under high-density atmospheres (argon), however, cratering efficiency decreases in pumice but increases in sand. These contrasting responses at high atmospheric densities suggest that gas density and composition (viscosity and Mach number) also may play a role. Vertical bar shows the effect of a 15% error in calculating the impact velocity (pressure *P* is in bars; impact velocity *v* is in kilometers per second; and density is in grams per cubic centimeter).

C_D), density ratio of atmosphere to ejecta, and Froude number describing the ejecta flow field. It is assumed that the basic cratering flow field created in response to reflection of shock wave from the free surface [see *Gault et al.*, 1968] is unchanged. Under the available range of atmospheric conditions, this assumption is probably valid.

The quantitative effect of drag on cratering efficiency can be assessed by correcting the observed cratering efficiency for atmospheric pressure through equation (10*c*) and deriving the empirical dependence on equation (11). An alternative approach assumes that aerodynamic drag forces replace gravitational forces in modifying crater growth, just as the effects of pressure might be expected to replace the effects of strength (equation (9)). Drag now can be incorporated in the π_2 parameter (equation (3)):

$$\pi_2' = (3.22(d+g)r)/v^2 \qquad (12a)$$

$$\pi_2' = \pi_2((d+g)/g) \qquad (12b)$$