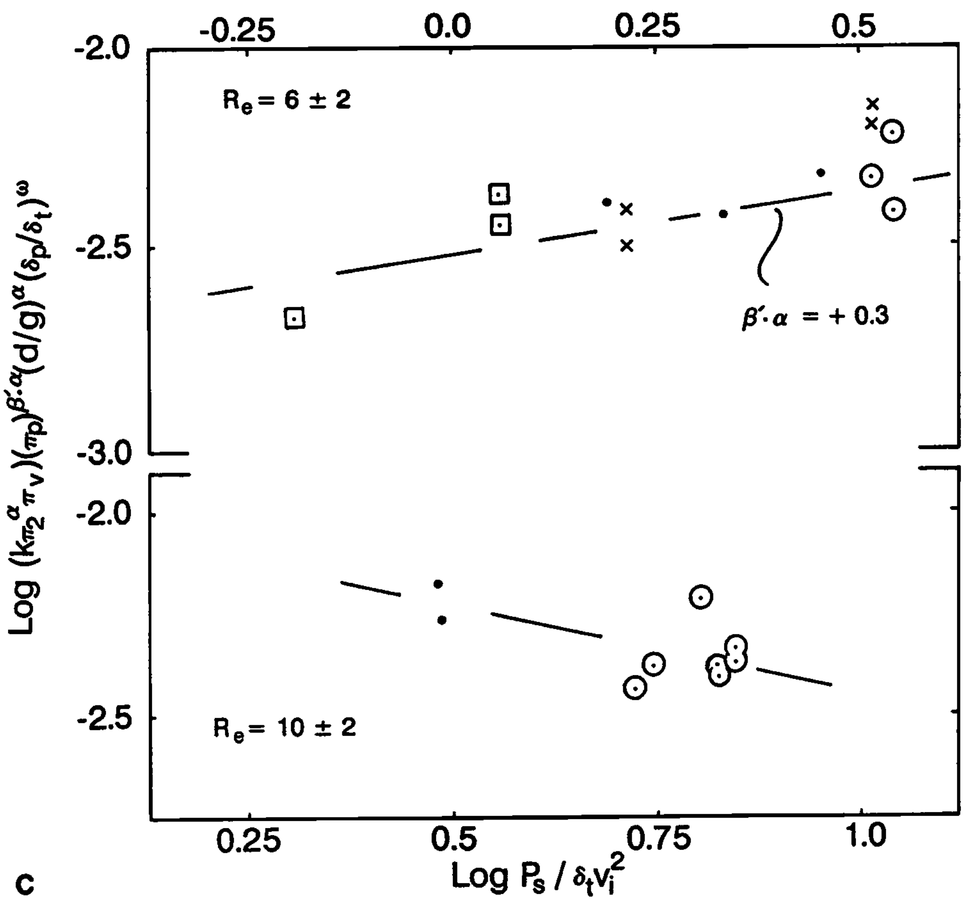
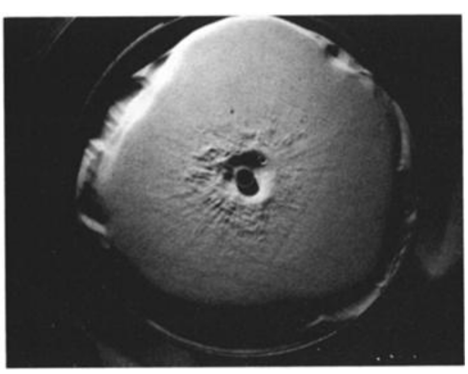



Fig. 14. (continued)

When both static (ambient) and dynamic (drag) atmospheric pressure control crater growth, the combined factors exhibit a functional dependence consistent with the coupling-parameter exponents suggested by *Holsapple and Schmidt* [1987]. In addition, however, the disturbed air mass accompanying the projectile at laboratory scales is observed to further modify cratering efficiency. The effect of projectile-atmosphere interactions depends on the degree of coupling between the air



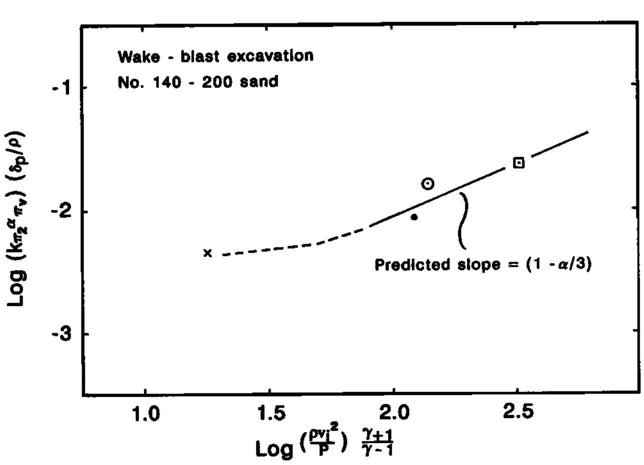



Fig. 15. Excavation of no. 140-200 sand by the atmospheric wake blast isolated from the impacting projectile. The projectile passed through an open tube in the target without interfering with the effects of the trailing wake. At high Mach numbers, the tube was 3.2 cm in diameter ($10r_p$), whereas at low Mach numbers it was reduced to 1.6 cm ($5r_p$). Figure 15*a* shows the wake-excavated crater around the tube for an impact velocity of 5.4 km/s and a $CO_2$ atmosphere at 0.66 bars. When referenced to the projectile mass, the displaced target mass due to the wake approached 10% of the total mass displaced by the combined projectile and wake. Figure 15*b* expresses the observed cratering efficiency of such projectile-less impacts in terms of the effective radius $r_e$ of the disturbed mass scaled to the projectile radius (equation (24)). Observations are consistent with theoretical considerations predicting that cratering efficiency should increase with $r_e/r_p$ with an exponent of $1 - \alpha/3$. These experiments reveal that the observed changes in cratering efficiency in sand and pumice at high atmospheric densities and Mach numbers (Figures 7*b*, 11, and 14) also might be expressible by a change in the effective radius of the impactor due to the surrounding and trailing disturbed air mass. With this perspective, augmentation in cratering efficiency should be less for $CO_2$ (larger $r_e/r_p$ leading to a smaller value of $\pi_v$). (Values of $\delta_p$ given in $g/cm^3$, while $\rho$ and $P$ are referenced to ambient air at one bar with $v$ in kilometers per second). The ratio of specific heats $\gamma$, is assumed for ambient conditions: $\gamma = 1.28$ (carbon dioxide), $\gamma = 1.4$ (air, nitrogen), $\gamma = 1.666$ (argon).