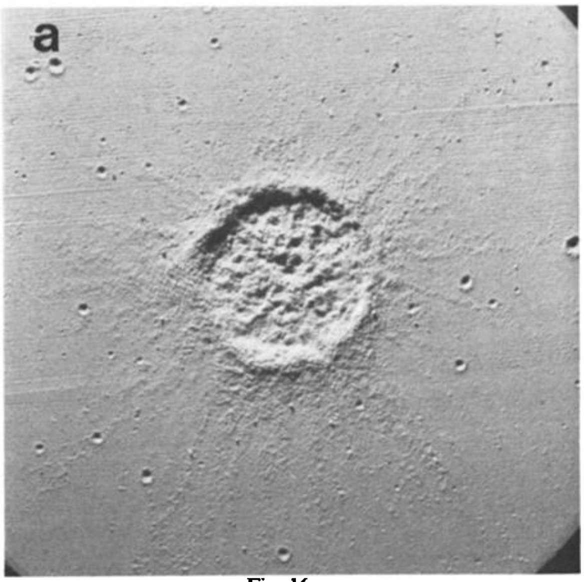

Fig. 16*a*

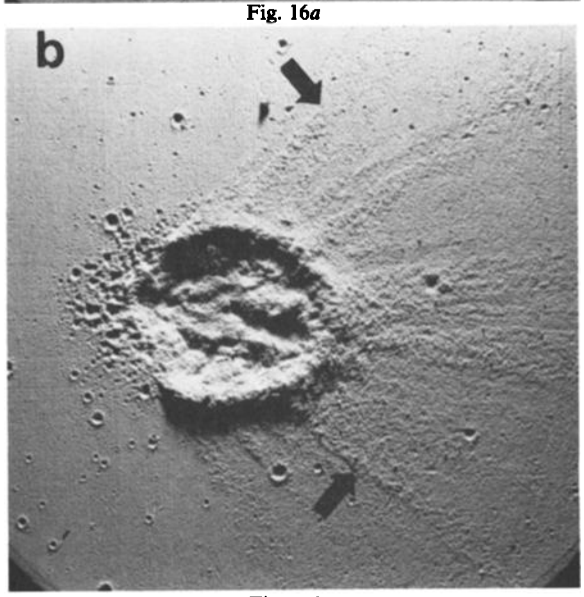

Fig. 16*b*

Fig. 16. Comparison between vertical and oblique (45°) impact into compacted pumice for comparable velocities and dispersions. Vertical clustered impactors produce radial and subradial spokes (Figure 16*a*, 830526) for 1.77 km/s impact and 7.0-cm dispersion. The 45° oblique impactor (Figure 16*b*, 830538) produces a pattern of V-shaped ridges (arrow above) pointing uprange for 1.62 km/s impact and a 6.3-cm dispersion (normal to impact direction). The distal ends of the ridges bend downrange (arrow below). In addition, a narrow downrange fan of concentrated ejecta develops.

ejecta at a given time forms a conical ejecta curtain. Before the crater has reached its maximum size, the trajectories in the ejecta curtain are approximately parallel to the curtain boundary; after crater formation, trajectories become more normal to the curtain boundary. Consequently, the ejecta curtain represents an outward moving wall of debris. The ejecta curtain has been studied in the laboratory (D.E. Gault, unpublished data, 1975) by positioning a horizontal plate such that only one half of the growing cavity is exposed, thereby slicing the ejecta curtain and permitting measurements of the ejecta curtain thickness. This technique minimizes the interejecta collisions produced by experiments incorporating a slitted barrier [see *Oberbeck and Morrison*, 1976]. The measured ejecta curtain thicknesses at the base are about 7% of the apparent crater diameter within $1R$ of the rim and 10% at greater distances. The thickness of the base of the ejecta curtain does not become thinner at greater distances from the crater, but the spatial density of the curtain is reduced. Thus the ejecta curtain maintains a finite width throughout deposition and is composed of many individual ejecta fragments which reduce in number with increasing distance from the crater rim.

At laboratory scales the back edge of the ejecta curtain arrives about 20 ms after the leading edge. At much broader scales the time between first and last arrival of material at a given distance from the crater would become much greater, thereby increasing the interference with secondary crater formation by individual ejecta blocks. If we geometrically scale laboratory ejecta curtain thickness to planetary-scale craters, then a 100-km-diameter crater may have an ejecta curtain about 6 km thick and an Imbrium size basin about 30 km thick (for precollapse cavity diameters of 60 and 600 km, respectively).

An alternative estimate of ejecta curtain thickness can be based on thicknesses of ejecta deposits. If the excavation cavity of a large planetary-scale crater grows in the same manner as a laboratory impact into sand [see *Grieve et al.*, 1981; *Croft*, 1981; *Schultz et al.*, 1981], then ejecta thickness increases approximately as $R^{1/2}$ at a given relative distance from the crater rim [see *Schultz and Gault*, 1979; *Housen et al.*, 1983]. Near the crater rim (within $0.5R$) the ejecta curtain thickness can be related to the thickness of the emplaced ejecta deposit. Such an approximation is an oversimplification due to scouring and subsequent flow of the deposit; nevertheless, this assumption provides an order-of-magnitude estimate. The average ejecta deposit thickness at $0.3R$ from the rim of the lunar craters Jehan (4.6 km diameter) and Hadley (5.7 km) is about 130 and 150 m, respectively (Lunar Topo photo maps). A 60-km precollapse diameter crater (Copernicus?) has a deposit of primary ejecta material about 500 m thick near the present postcollapse rim as extrapolated by scaling relations and observed for lunar craters. The minimum ejecta curtain thickness t_c is related to the ejecta deposit thickness t_e, by $t_e = t_c \sin\theta$, where θ is the angle of impact with respect to the surface. Both laboratory [*Gault et al.*, 1968] and theoretical models [e.g., see *Orphal et al.*, 1980] indicate an ejecta curtain inclined about 45° from the surface. Therefore the minimum ejecta curtain thickness for a 100-km-diameter crater is about 700 m. Models of ejection favored by *Oberbeck* [1975] suggest impact angles closer to 15°, thereby indicating a minimum ejecta curtain thickness of 2 km.

Estimates based on ejecta deposit thicknesses are significantly smaller than those provided by scaling laboratory-measured ejecta curtain thicknesses because the curtain is not simply an in-flight blanket of debris with density equivalent to the final deposit. For example, at $0.3R$ from the rim of a 30-cm-diameter laboratory crater in sand, the observed ejecta thickness is about 2 mm. Thus the observed width of the ejecta in the curtain (10% of the crater diameter) at this distance is about 10 times the thickness of the deposit. The extrapolated curtain thickness of the same bulk density for a 100-km-diameter crater becomes 7 km for 45° ejection/impact angles and 20 km for 15° ejection/impact angles: values consistent with the previous method that simply scales ejecta curtain thickness as a function of crater diameter.

The relative width of the ejecta curtain, therefore, is thin