Fig. 25a

Fig. 25b

Fig. 25c

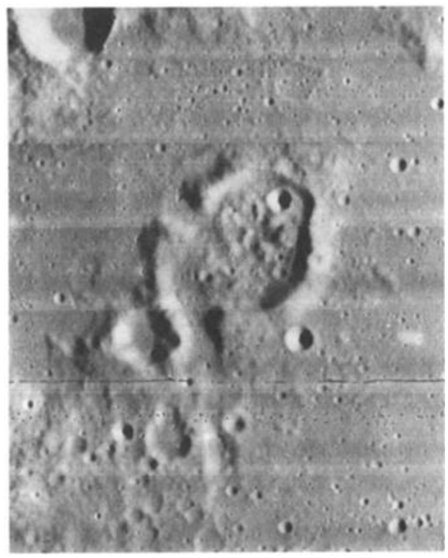

Fig. 25d

Fig. 25. Examples of large basin-related lunar secondary craters having features characteristic of clustered impact craters. The fine-scale surface textures (e.g., herringbone ridges) preserved around smaller recent lunar impacts (Figure 24) have been largely destroyed since the major impact basins were formed. Nevertheless, the crater rim profile, crater floor profile, and downrange scouring suggest groups of impactors. Figure 24*a* shows a 16-km-diameter secondary associated with Orientale. The exaggerated crater rim and downrange fan of ejecta resemble the crater in Figure 16*b*. Figure 24*b* shows an elongate secondary crater 19 km in diameter also associated with Orientale. The crater floor contains a mound, perhaps indicating a more tightly grouped impacting cluster than the cluster responsible for the crater in Figure 25*a*. Figure 25*c* illustrates shallow craters (arrows) with unusual central mounds that could be understood as Imbrium secondaries produced by clustered impactors. An open clustered impactor could have produced the hummocky-floored and ridgelike rim of the crater in Figure 24*d*. Lunar orbiter photographs (*a*) IV-174-H3, (*b*) 182-H2, (*c*) 101-M, and (*d*) 96-H2.

ballistic range approaches 1000 km with an impact velocity of 1.15 km/s. This range is about 3 R_c from the excavation crater rim (radius of R_c) or 0.8 R_c from the Apennine scarping. Geometric scaling of the cratering process [*Post*, 1974; *Schultz and Gault*, 1979; *Housen et al.*, 1983] indicates that the effective thickness t_e of debris arriving ballistically at such a distance (i.e., mass per unit area divided by the bulk density) scales approximately as $R^{0.5}$. To first order, such considerations predict t_e to be about 500 m. If t_e is taken to represent a single block (comprising a solid ejecta curtain of this thickness), then such a block impacting at 45° would excavate from 2.3 (extrapolated from pumice) to 10 (extrapolated from sand) times its own mass. Expressions used by *Oberbeck et al.* [1975] predict 11 times its own mass. As a cloud of ejecta impacting a surface with strength comparable to compacted pumice, an equivalent mass would excavate a factor of 1.2 times its own mass. Consequently, about 80% of the ejecta deposit could be primary material in contrast with 15–20% predicted by *Morrison and Oberbeck* [1975]. Table 2 permits additional comparisons for different size impactors.

The above exercises serve to illustrate that significant quantities of primary material can be preserved in ejecta deposits even at basin scales. Large solid blocks of ejecta embedded in an ejecta curtain indeed may produce relatively