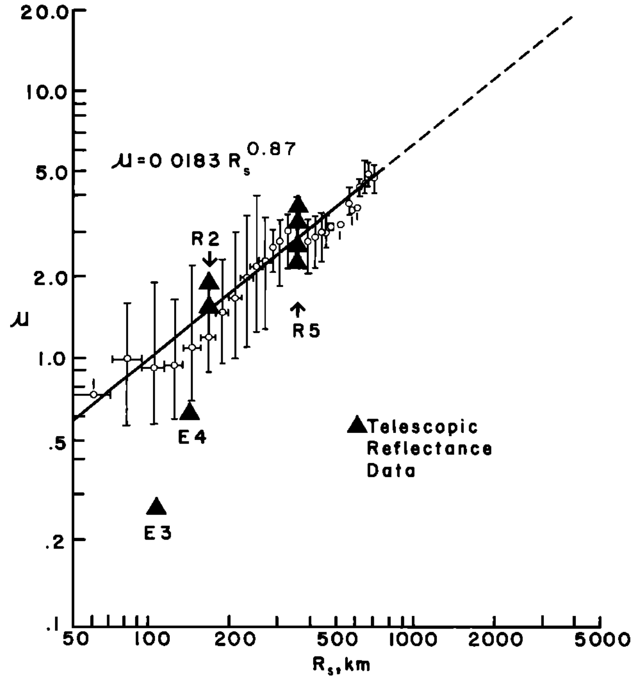

Fig. 12. Ratio μ of mass ejected from secondary craters of Copernicus to the mass of the projectile plotted as a function of range (open circles are data, and line is best fit, after *Oberbeck et al.* [1975]). The telescopic data are shown as triangles that represent the inferred proportions of primary ejecta (highland material represented by spot E5) to local mare material (represented by spot M1), as calculated from the reflectance data presented here.

positional end-members have been chosen and that the mixing systematics used to estimate proportions are valid. Determination of values for μ, on the other hand, is based on entirely different observations. The basic interaction of ejecta with substrate material has been studied in the laboratory using carefully controlled materials, with the results requiring scaling to planetary parameters. The values of μ given in Figure 12 were obtained using earthbased and lunar orbital images of secondary craters around Copernicus [*Oberbeck et al.*, 1975].

It is remarkable indeed that both approaches to understanding the relation of crater ejecta to local substrate provide the roughly similar projections displayed in Figure 12. Both show that the larger the radial distance from a major impact crater, the smaller the amount of primary ejecta that is incorporated within the ray, in relatively predictable proportions. For large craters such as Copernicus, however, there is still sufficient primary material within the areal extent of a ray to be detected on the surface hundreds of kilometers distant from the crater. For example, in the case of area R5, which is about six crater radii from the rim of Copernicus, measurable amounts ($\sim$20–25%) of primary ejecta of highland composition can be identified from the mixing model calculations summarized in Table 4.

There is a notable discrepancy, however, between the two approaches in descriptions of the proportion of primary material emplaced within three crater radii (> 150 km). Assuming that the substrate for ejecta deposits between Copernicus and the Carpathian Mountains is basaltic (consistent with the observed dark-haloed craters), the compositional measurements of the surface deposits within three crater radii of Copernicus, E3 and E4, show a much higher proportion of primary material (highland) than that predicted by *Oberbeck et al.* [1975] (Figure 12). A possible interpretation of this relates to the type of mixing that may occur in areas of thicker ejecta deposits nearer the crater. In a thicker, more continuous curtain of ejecta being emplaced near the crater, early ejecta would mix with the basalt substrate, but subsequently following ejecta would interact with this just-emplaced mixture. The last primary ejecta would interact with a substrate already highly contaminated with primary material, and thus the resulting surface material would give a spectral signature not representative of the average for the entire mixture.

The two ray areas (R7 and R6) that do not follow the mixing systematics for mature soils from E5 to M1 provide additional insight into localized processes associated with ray materials. As discussed in the previous section, these two areas have a different morphology than the other ray areas studied and exhibit properties that indicate a component of fresh or immature mare basalt for the area measured. This immature basalt component is evident in the maturation trends shown in Figure 10. It is proposed that the apparent spectral immaturity of R6 and R7 is caused by the exposure of relatively fresh subsurface material on the steep inner walls of craters or perhaps on large blocks of rock. This interpretation is supported by the high radar backscatter for areas R6 and R7. Within the telescope aperture the steep inner walls of craters would appear as local areas (patches) of less mature soil. From a spectral mixing viewpoint these immature patches should model as a linear (checkerboard) mixture with the surrounding more mature material. Areas R6 and R7 then should show the poorest fit to the nonlinear model in comparison with the other ray areas measured.

A test of this hypothesis was made by examining the rms errors for the ray spectra for the two mixing models (Table 5). Figure 11 shows the ratio of the rms errors for the linear versus the nonlinear models plotted against distance from Copernicus. Areas R6 and R7 have the lowest linear/nonlinear error ratios, which is consistent with the concept that they are expressing relatively more patchy (linear) spectral mixing. The patchy material component is interpreted to be fresher mare basalt. Although the rms ratio systematics for other ray areas in Figure 11 are not tightly constrained, there may be a general trend from granular (nonlinear) to patchy (linear) mixing with increasing distance from Copernicus. Since the reflectance measurements integrate over a few-kilometer area, increasing irregular patches with distance would not be surprising at this scale.

It should be noted again that the primary/local mixing ratio derived from these models uses the simplified description that the primary material is of highland composition and the local material is basaltic. A thicker mare at Copernicus would dilute the "highland" component in the primary ejecta. The proportion of primary material in the distal rays would thus be underestimated in this study, since only the highland component was used as a marker. If the mare basalt thickness for the Copernicus target area was more than the nominal several hundred meters estimated from *Schmitt et al.* [1967], a potential conflict would arise between these observations of a component of highland primary material at the distal regions of Copernicus ray and the results of experimental and field data concerning the depth of origin of ejecta. From both experimental investigations [*Stoffler et al.*, 1975] and field observations of terrestrial craters [*Horz and Banholzer*, 1980] it has been hypothesized that the material that now forms the distal portion of the ejecta pattern around any lunar crater would