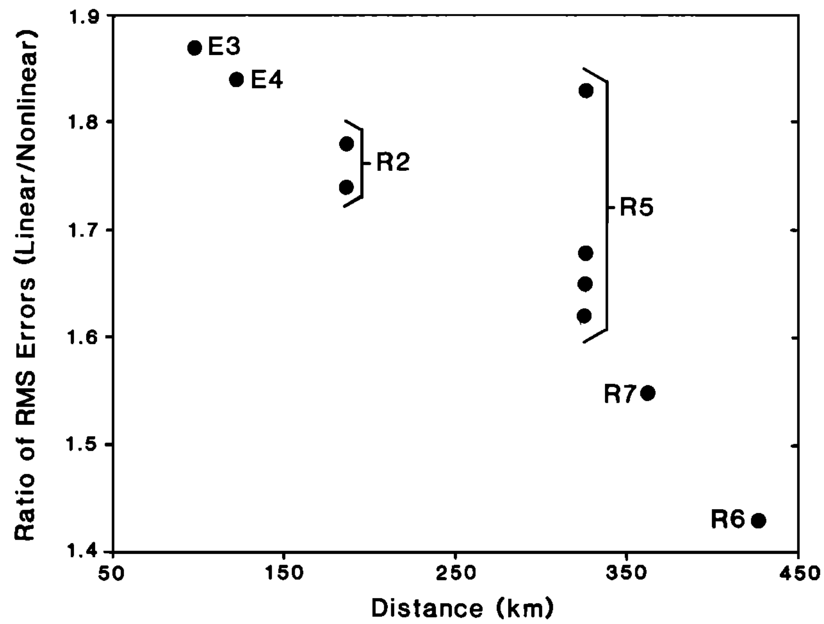

Fig. 11. Ratio of rms errors in principal components analysis of telescopic spectra using linear and nonlinear mixing models (see text), plotted as a function of distance along a Copernicus ray. A high ratio value indicates that the data fit the nonlinear intimate mix model better. A lower ratio value indicates that the data are better described by the linear (patchy) mixing model.

ray can be estimated from the reflectance mixing model systematics. These local/foreign estimates for ray material can be compared to related predictions from the ballistic studies. In addition, the type of mixing of primary and local material that is most consistent with modeling of the reflectance data provides information about the physical state of material along the ray.

For areas along Copernicus's ray that lack craters larger than about 100 m the reflectance mixing systematics of Figure 9 are best described by a mixing line between mature highland soils (e.g., E5) and mature mare soil (e.g., M1) rather than mixing between immature and mature mare soils. This soil maturity has been achieved after the highland and mare components were mixed. Since the rms values for the telescopic spectra (Table 5) are the lowest for the nonlinear analysis using PCA of the single scattering albedo data, the calculated proportions are chosen for comparison from Table 4 using M1 and E5 as end-member representations of local and foreign ray material, respectively. The ratio of local/foreign material can be estimated from the fraction of these end-members for each ray area. This ratio is somewhat comparable to the ballistic μ of *Oberbeck et al.* [1975] which is defined as the ratio of mass ejected from secondary (local) craters to the mass of impacting primary crater ejecta. These two ratios are compared in Figure 12 and plotted as a function of radial distance from Copernicus [after *Oberbeck et al.*, 1975].

There are clearly significant differences in the physical basis of these two ratios. The reflectance data measure properties of the upper few millimeters of surface material. Estimates of local/foreign material in the ray assume that appropriate com-

TABLE 4. Calculated Proportion of End-Member Components at Measured Areas Along Copernicus Ray

Area	End-Members E5	M1A	CM
E5	1.00	0.00	0.00
W3	1.01	−0.04	0.03
F3	1.00	−0.03	0.03
E3	0.74	0.23	0.02
E4	0.65	0.40	−0.05
R2A	0.42	0.62	−0.03
R2C	0.36	0.69	−0.05
R5X	0.27	0.72	0.01
R5C	0.27	0.75	−0.01
R5D	0.21	0.79	0.02
R5A	0.18	0.79	0.03
M1A	0.00	1.00	0.00
M1C	−0.06	1.06	−0.003
M1X	−0.06	1.08	−0.02
M1D	−0.04	1.01	0.03
R7	0.04	0.84	0.12
R6	0.02	0.81	0.17
CM	0.00	0.00	1.00

TABLE 5. Residual Errors (rms) of the Difference Between the Measured Reflectance Spectrum and a Calculated Spectrum Based on the First Two Principal Components of PCA That Defined the Proportion of End-Members E5, M1A, and CM.

Area	Linear Model	Nonlinear Model	Ratio
E3	1.26e − 3	0.674e − 3	1.87
E4	1.33	0.723	1.84
R2A	1.17	0.657	1.78
R2C	1.68	0.966	1.74
R5X	1.15	0.625	1.84
R5C	1.77	1.090	1.62
R5D	1.41	0.840	1.36
R5A	1.51	0.915	1.65
R7	1.05	0.680	1.54
R6	0.965	0.675	1.43

The linear model describes checkerboard or patchy areal mixing. The nonlinear model describes intimiate mixing at the granular level.