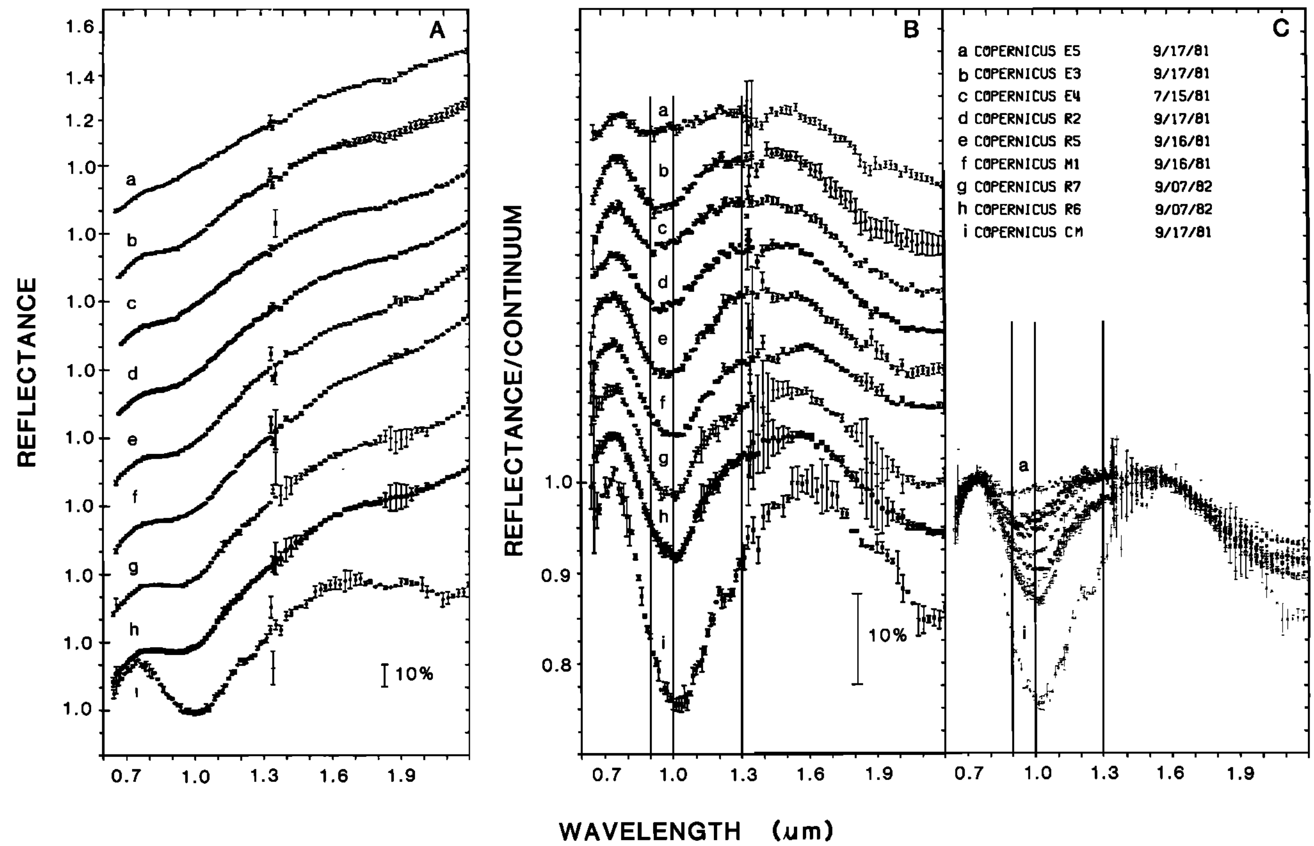

Fig. 4. Near-infrared reflectance spectra of small (~5 km) areas in or associated with Copernicus northern ray system (locations of these areas are shown in Figure 1*b*). (*a*) Reflectance scaled to unity at 1.02 μm and offset vertically. (*b*) Residual absorption after division by a straight line continuum. The order of spectra is the same as for Figure *a*, but the vertical scale is a factor of 4 greater. (*c*) Residual absorption spectra with no offset. Data for the fresh mare material exposed at crater Draper C (CM) exhibit the strongest absorption band near 1.0 μm.

local Apollo 12 basalts [*Marvin et al.*, 1971], nevertheless trends toward a basaltic composition and thus indicates basaltic material was also incorporated into the melt during the impact event. Although the actual thickness of the basalt at the target site is not known, it must have been sufficiently thin to allow melting and mixing of basalt and norite before ballistic ejection of the fragment-laden, KREEP-rich melt toward the Apollo 12 site. Additional minor components in 12033 that may have originated at the Copernicus target site include an apparently unique fragment of troctolite. This fragment exhibits melted and quenched grain boundaries that can best be explained by excavation of plutonic material during a major impact event [*Marvin and Walker*, 1985].

The mineralogy derived from both the near-infrared spectra of Copernicus and the Apollo 12 lunar samples suggests the following stratigraphy at the Copernicus target site: thin layer of basalt overlying an extensive noritic layer above a zone of troctolite. Which, if any, of these stratigraphically distinct compositions are directly associated with the KREEP component is unknown.

3. Spectral and Physical Properties of a Copernicus Ray

A sequence of small areas (each about 5 km in diameter) along Copernicus's northern ray system was chosen for detailed study (see Figure 1*b*). These areas (E5 to R5) were chosen to be in locations that were homogeneous at the scale of telescopic observations. For this sequence, areas were selected for study because they specifically did not contain large secondary craters. The spectral and physical properties of each studied area are discussed separately below. Two representative areas were also chosen within the low-Ti basalt substrate in Mare Imbrium, one to represent mature mare soils (M1; Figure 1*b*) and the other to represent fresh, more crystalline basaltic material (CM; Figure 1*b*). Two additional areas (R6 and R7) were also selected because of their presumed heterogeneity. Area R6 exhibits a very high surface roughness (at the 10-cm scale) based on radar backscatter measurements, while area R7 is centered on a prominent group of secondary craters. The areas associated with the ray itself are discussed in sequence below in order of increasing radial distance from the rim of Copernicus.

Near-infrared reflectance spectra have been obtained for these areas along the ray and neighboring mare (Figure 4). The diameter of each area observed telescopically was approximately 5 km, although it is estimated that repeated observations increased the effective spot size to about 10 km. For some areas (R5, M1), measurements were repeated for four independent observing runs to check for observational errors and phase effects. To complement these spectral measurements, albedo information was derived from *Pohn and Wildey* [1970]. Earth-based photography, Lunar Orbiter images and a few oblique Apollo photographs (Figure 5) of this Copernicus region were studied in detail to document surface mor-