Compositional variations of particles from North Ray Crater soil 67513 and implications for the composition of the lunar highlands. B. L. Jolliff, Dept. of Earth & Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University, St. Louis, MO, 63130

Samples of rocks and soils from the rim of North Ray Crater (NRC) at the Apollo 16 site offer a glimpse of the lunar crust brought up from several hundred meters depth by the formation of the crater. Many of the polymict breccias and surface soils from other Apollo 16 sample stations have compositions presumably dominated by Cayley materials deposited during the Imbrium basin impact [1,2]. The NRC samples are potentially the most representative of uncontaminated Descartes material, (presumably Nectaris basin ejecta), characteristic of the "Old Eastern Highland Rock Suite" [2], excavated late in the geologic history of the Apollo 16 site. We have determined, by INAA, compositions of 100 2-4 mm particles from 67513 and of associated <1 mm soil (67511) to test this hypothesis and to determine the compositional character of dominant KREEP-poor or non-Cayley components. The compositional distribution is distinctive, containing some KREEP-bearing components apparently of the "Young Western Highland Rock Suite" [2], but also containing incompatible trace element (ITE) poor components.

Compositions of the 67513 particles are restricted in range compared to NRC compositions determined previously [e.g., 3,4,5]; however, there is an ITE-poor, mafic component that is not represented among previously analyzed materials. The compositional distribution of 67513 particles is illustrated in Figures 1-4. Particles that have the highest CaO concentrations are almost entirely plagioclase (Fig. 1). Many of the other particles are dimict or polymict breccias made of mixtures of anorthositic material and more mafic breccia lithologies. The plot of Sm and Sc concentrations (Fig. 2) shows two distinct trends of trace element distributions. Compositions extending to high Sm concentrations (trend A) reflect a noritic or mafic impact melt breccia component rich in ITE [3,6]. The second trend (B) extends to relatively high Sc concentrations at very low ITE concentrations. The fact that a large number of compositions fall along this trend could be interpreted as a mixing line made up of the mineral components of a rock type such as anorthositic gabbro. Compositions of several rocks from NRC also fall along trend B (67667 feldspathic lherzolite [7]; 67015,354 ilmenite gabbro [5]; and 67975,131N alkali gabbronorite [3]); perhaps these are members of a rock series related to trend B. On a plot of Sm and Yb concentrations, these particles have a slope distinctly higher than that of particles that have ITE-rich components (Fig. 3). This presumably means that clinopyroxene is the Sc-bearing mafic component. This is supported by the fact that particles with high Sc/Sm also have relatively high CaO concentrations (Fig 1.).

The compositional distribution of the 67513 particles appears to be unrelated to the main trend of compositions of Apollo 16 surface soils shown by [6] (Fig. 4). The main Apollo 16 soil trend is one of relatively recent mixing of anorthositic Descartes and ancient regolith breccia (ARB) materials with previously well mixed Cayley soil. The compositional distribution of Apollo 16 ARBs possibly reflects mixing of ITE-rich mafic melt breccias with an ITE-poor component that is similar to the average composition of the granulitic breccias from NRC [3,8]. The mean composition of the series of 67513 particles that have high Sc/Sm is substantially more mafic (10-12 ppm Sc, 5-6 wt.% FeO) than most granulitic breccias and far poorer in ITE (<1 ppm Sm) than average feldspathic fragmental breccia compositions (e.g., 67975, ~15-25 ppm Sm [3]). Sample 67513 thus appears to represent a different association of materials than that of either the granulitic or feldspathic fragmental breccias from NRC. We are testing whether this is related to the stratigraphic position of source materials within NRC as previously suggested [2] by analyzing similar splits of other NRC soils.

The component of the 2-4 mm particles that is relatively mafic (7-14 ppm Sc) and low in ITE concentrations has a very similar average composition to that of lunar highland meteorites. In fact, the mass weighted mean composition of 100 particles from 67513 is very similar to the bulk composition of MAC88105 except for lower concentrations of meteoritic siderophile elements in 67513. NRC soil 67511 is relatively ferroan (Mg' ~0.63), similar to the

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most ferroan of the meteorites. These soil particles may be samples of highland crustal rocks uncontaminated by mare basalt and KREEP-rich rocks, although their average composition is substantially more mafic than the "primordial eastern upper crust" composition calculated by [2]. Perhaps the anorthositic Descartes materials are from particularly plagioclase-rich strata that are petrogenetically related to the more mafic rocks that are an important component of the 67513 2-4 mm particles and with which the anorthositic compositions form a tight mixing line (Fig. 2, trend B). Further study of the particles that have low ITE and high Sc concentrations may give us better insight to an important component of the highland crust that is under-represented among the analyzed large rock samples. This work represents the initial stage of compositional characterization of the particles. Detailed petrography of select particles will follow.

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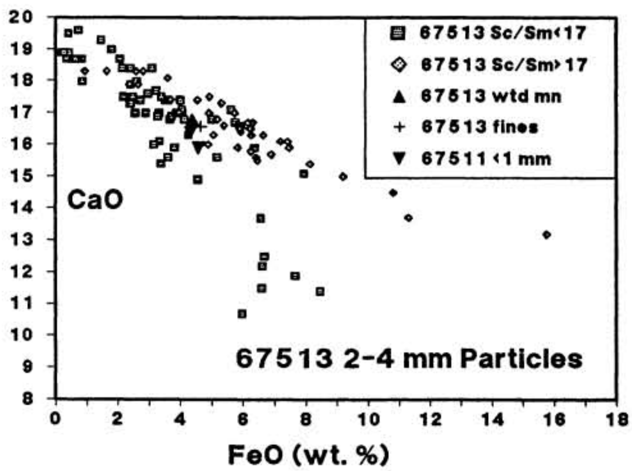

Figure 1. Plot of CaO and FeO concentrations (wt. %) of 67513 2-4 mm particles and 67511 <1 mm.

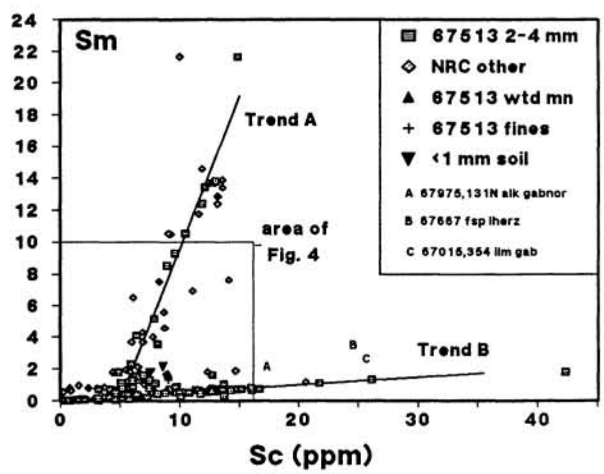

Figure 2. Plot of Sm and Sc concentrations (ppm) "NRC other" from [3,4,5,7].

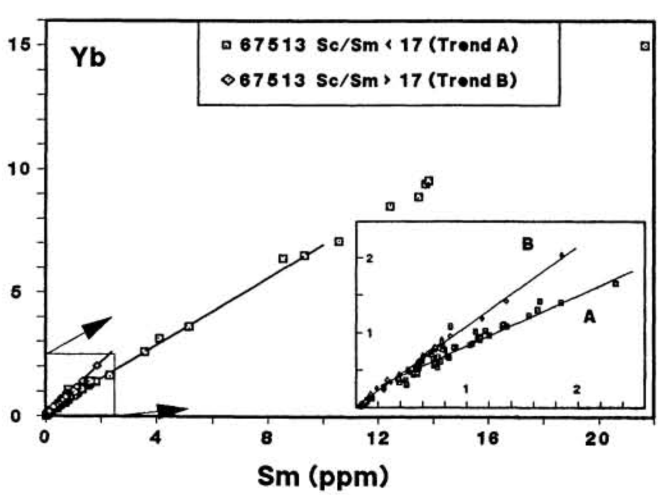

Figure 3. Plot of Yb and Sm concentrations (ppm) Lines based on linear regression: n=65 for Trend A; n=35 for Trend B.

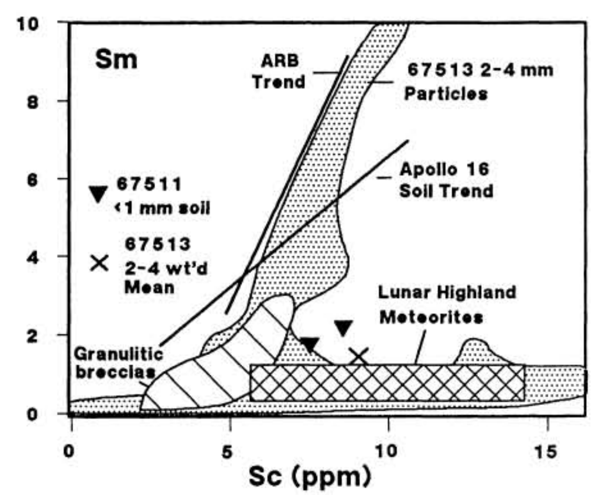

Figure 4. Plot of Sc and Sm concentrations (ppm) ARB and Apollo 16 soil trends from [6]. Lunar meteorite field from [9]. Granulitic breccia field from [3].