APOLLO 17 MATERIALS VIEWED FROM 2-4 MM SOIL PARTICLES: PRE-SERENITATIS HIGHLANDS COMPONENTS.

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Among the highlands lithologies of 2-4 mm rock fragments in North Massif soil 76503, we have found a compositional group, low in incompatible element concentrations, that we interpret as representing the pre-Serenitatis surface. A component of these materials is an igneous-textured lithology that we believe formed in large impact melts. These are compositionally similar to, and possibly precursors of, many of the granulitic breccias that appear to be mixtures of ferroan and magnesian-suite rocks. The polymict, or *old, upper-crustal breccias*, along with granulitic breccias and the endogenous igneous lithologies found particularly at the North Massif stations, constitute the poorly consolidated portions of North Massif. Highland samples from the South Massif, on the other hand, are enriched in materials of the competent, impact-melt breccias formed by the Serenitatis impact. The competent melt-breccias contain clasts of most of the pre-existing surface materials, but they also contain components not found in the rocks of the poorly consolidated massif materials.

Although the breccia boulders from the North and South Massifs are in many ways similar, the soils collected at the South Massif stations differ substantially from those of the North Massif [1]. We believe that the soil and rake samples collected away from the boulders [2], including 76503, sample, in part, poorly consolidated Massif materials which are distinct from materials constituting the Station 6 boulders, i.e., Serenitatis impact-melt breccia. Soils from North Massif stations, particularly Station 6, have a combination of highlands components distinctly different from South Massif [1]. A combination of an anorthositic-norite component and very magnesian norite and troctolite components is relatively abundant in the North Massif soils, yet the very magnesian components are minor or absent from South Massif soils based on mixing-model results [1]. This leads to the interpretation that the Massifs are stratified such that South Massif soils contain a high proportion of melt-breccia debris rich in incompatible trace elements (ITE) from upper levels of the massif, brought to the sampling site by landslide or ejecta surge following secondary impacts of Tycho [3], whereas the higher proportion of ITE-poor highlands components in the North Massif soils might mean that they sample, in part, a lower level free of Serenitatis impact melt.

Highlands lithologies and pre-Serenitatis upper-crustal breccias. The ITE-poor highlands lithologies of rock particles in 76503, sampled away from the Station 6 boulders [3] are mainly: (1) igneous fragments of troctolitic anorthosite and cataclastic noritic and gabbroic-anorthosite breccias; (2) several groups of granulitic breccias, and compositionally equivalent, but lithologically diverse variants; and (3) a lithologically diverse group of feldspathic, old, upper-crustal breccias [4,5]. Of special interest are the complex, polymict breccias of group (3). These breccias are uncontaminated by mare materials and low in incompatible trace element concentrations (Figure 1). Mineral clasts include very magnesian olivine and orthopyroxene and very calcic plagioclase, indicating magnesian-suite igneous precursors. In addition to magnesian-suite assemblages and granulitic breccias, lithic fragments include ferroan gabbroic anorthosite, with coarsely exsolved, ferroan pyroxenes. Some of these breccias have regolith components such as rounded, glassy melt clasts, similar to the lunar highlands meteorites, which are considered to be regolith breccias [e.g., 6]. Fine-grained melt clasts have compositions ranging from 16 to 22 wt.% alumina ("LKFM"), but these constitute only about 10% of the breccias. We suggest that these regolith breccias reflect the pre-Serenitatis upper crust in this region of the Moon.

Pre-Serenitatis aluminous impact melts. Some lithic clasts within the 2-4 mm highlands rock fragments have anorthositic-gabbro assemblages and textures ranging from cataclastic, relict igneous to granulitic breccia. These have mineral compositions that plot in the gap between magnesian and ferroan-suite rocks on An-Mg' diagrams. These we interpret as having originally crystallized in an impact-melt of magnesian and ferroan-suite igneous lithologies such as occur as clasts in the same rocks. Evidence of generally shallow "melt" origin is that pyroxenes are not exsolved, and olivine CaO concentrations are intermediate between deep, slowly cooled plutonic values and basaltic, rapidly cooled values, i.e., 0.1-0.3 wt.%. Compositions of these aluminous impact melts are relatively feldspathic, e.g., 25% alumina (Table 1). The composition shown in Table 1 is similar to a typical moderately magnesian granulitic breccia and to Allan Hills 81005 magnesian lunar-highlands meteorite [7]. If we cast this composition in terms of known, endogenously igneous lithologies, the following proportions are indicated: 35% gabbroic anorthosite, 30% anorthositic norite, 20% troctolitic anorthosite, and 10-15% ferroan anorthosite or ferroan gabbroic-anorthosite. This composition is dominated by magnesian-suite lithologies, but a substantial ferroan component is suggested, more than is indicated by the scant representation in the Apollo 17 sample collection. We interpret the breccias that contain these clasts as having formed atop a large impact melt or group of impact melts. The minerals of many granulitic breccias and basaltic-textured, impact-melt lithologies also plot in the gap on An-Mg' diagrams. These, too, are members of the suite of impact-melt derivation older than Serenitatis.

The crust in the pre-Serenitatis region was dominated by Mg-suite plutonic rocks, but also contained minor ferroan-suite rocks; these were very well mixed by pre-Serenitatis impacts. We see evidence in these small breccia fragments of the regolith which developed on this surface before the Taurus-Littrow Valley was created. The friable massif material, as sampled by the Station 6 soils, is rich in these older crustal components. The competent melt-breccias of the massifs contain these materials as clasts, but they also contain more mafic and compositionally evolved lithologies, perhaps derived deeper, not seen among clasts in the older breccias.

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Table 1. Comparison of compositions of pre-Serenitatis impact melt, magnesian granulitic breccia, and ALHA 81005 lunar-highlands meteorite.

	76503 ,7109 Melt	Avg Magn Granulitic Breccia	Highlands meteorite ALHA81005
SiO2	45.2	44.9	45.8
TiO2	0.5	0.4	0.3
Al2O3	25.6	25.8	25.7
FeO	4.7	5.5	5.5
MgO	7.5	8.1	8.2
CaO	15.0	14.5	15.0
Na2O	0.41	0.46	0.30
Mg'	74.0	72.4	72.7
Cr	906	841	890
Sc	8.9	7.8	9.1
La	5.1	4.4	2.0
Eu	0.99	0.82	0.69
	this work	Lit. Average	[7]

Precursors of 76503,7109:

Gabbroic Anorthosite	-	35%
Anorthositic Norite	-	30%
Troctolitic Anorthosite	-	20%
Ferroan "Anorthositic"	-	10-15%

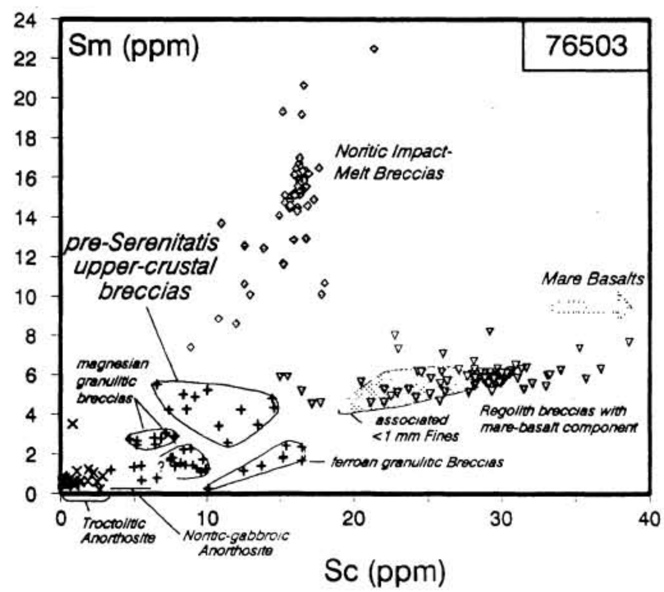

Figure 1. Plot of Sc versus Sm concentrations of 2-4 mm soil particles from 76503, North Massif. Mare basalts not shown. Samples whose compositions lie in fields labelled granulitic breccias are texturally diverse.