APOLLO 17 SOIL SURVEY AND COMPARISONS AMONG NONMARE LITHIC FRAGMENTS FROM APOLLO AND LUNA 20 SOILS, G. J. Taylor*, M. J. Drake*,** and U. B. Marvin, Smiths. Astrophys. Obs., Cambridge, Mass. 02138.(*Now at Wash. Univ., St.Louis, Mo. 63130;**Univ. of Ariz., Tucson, Az. 85721)

This report has two purposes. One is to present the results of a census of the particles in four 1-2mm soil samples from Apollo 17, revising a previous one(1). The samples studied were 72502,12(S. Massif), 76502,12(N. Massif), 78502,10(Sculptured Hills), and 75082,5(Camelot Crater). The other purpose is to compare the compositions of suites of nonmare lithic fragments found in lunar soils.

Apollo 17 Soil Survey. We divided the Apollo 17 soil particles into the categories listed in Table 1. In addition to common regolith degradation products such as impact-glasses, glass-bonded aggregates, and soil breccias, the Apollo 17 soils contain a variety of lithic fragments. Brief descriptions of each type follow. Mare basalts are characterized by abundant mafic silicates and ilmenite. Our petrographic definition of ANT fragments considers trace-element concentrations by excluding all rock fragments that contain K-rich interstitial glass and/or phosphate phases(i.e., KREEP). It turns out that fragments so classified are highly feldspathic, consistent with the chemical definition(2,3). The Apollo 17 soil also contains poikilitic noritic particles(similar to rocks 76055 and 77135; see ref 4) and recrystallized noritic breccias(in Warner's categories 5 through 7). Both of these lithologies contain significant quantities of interstitial glass and phosphate phases (Table 3). Many of the Apollo 17 soil fragments are dark-colored and fine-grained, texturally similar to Warner's category 4 and to the groundmass of rock 72255. Although these are as rich in mafic silicates as the poikilitic and recrystallized KREEP-enriched noritic breccias, we had originally (1) classified them as ANT because no phosphate phases or K-rich interstitial phases had been observed. However, defocussed-beam microprobe analyses indicate that the particles contain approximately the same levels of K_2O (0.1-0.5 wt.%) and P_2O_5 (0.2-0.4 wt. %) as do the coarser-grained, KREEP-enriched noritic fragments. Apparently, the rocks are so fine-grained that residual phases, if present, are smaller than the resolution of the microscope. (The particles now classified as ANT are sufficiently coarse-grained to permit our glass-phosphate criterion to be used.) The relative proportions of each type of Apollo 17 fragment is given in Table 1. The results are in good agreement with those reported by Papike et al(6) who studied the 2-4mm fractions of the same samples.

Comparisons Among ANT Fragments. Although ANT fragments have the same range of textures at all landing sites (7,8), there are differences in their compositions. Table 2 lists the averages of modal analyses made on ANT fragments; see (9) for experimental details. Note that the average modal plagioclase abundances are essentially equal in Apollo 17 and Luna 20 soils and that both of these samples contain less plagioclase than Apollo 11, 15, or 16.

Comparisons Among KREEP-Enriched Fragments. KREEP lithic fragments also exhibit site-to-site compositional variations. Table 3 lists average modal analyses of suites of noritic breccias. Except for poikilitic fragments in

NONMARE LITHIC FRAGMENTS

Taylor, G. J. et al

the Apollo 16 soils, modal plagioclase contents are nearly equal at all sites. However, the Apollo 14 norites are richest in KREEP: They contain significantly more K-rich interstitial glass and phosphate phases than do any of the others. The minor differences in the abundances of these substances among the lower-KREEP group are not statistically significant. We have also made numerous defocussed-beam microprobe analyses of KREEP-enriched lithic fragments. Although this method of bulk chemical analysis is frequently assailed, we feel that comparisons of large numbers of analyses obtained by the same procedures are useful. Consequently, we have constructed histograms of the atomic Fe/(Fe+Mg) ratio (Fig. 1). Note the wide variation in Fe/(Fe+Mg); the values range from 0.15 to 0.58. However, the majority is in the range 0.25-0.45. Also note that the Apollo 12 and 14 KREEP-enriched noritic fragments are clearly more iron-rich than those from soils collected during other missions.

REFERENCES

1.) M. J. Drake et al, EOS 54, 584-585(1973).
2.) M. Prinz et al, Contr. Mineral. Petrol. 32, 211-230(1971).
3.) K. Keil et al, Earth Planet. Sci. Lett.13, 243-256(1972).
4.) J. Warner et al, EOS 54, 620-621(1973).
5.) J. Warner, Proc. Third Lunar Sci. Conf., vol. 1, 623-643(1972). MIT
6.) J. J. Papike et al, EOS 54, 601-603(1973).
7.) G. J. Taylor et al, Geochim. Cosmochim. Acta 37, 1087-1106(1973).
8.) G. J. Taylor et al, Proc. Fourth Lunar Sci. Conf., vol. 1, 553-568(1973).
9.) G. J. Taylor, Earth Planet. Sci. Lett. 16, 263-268(1972).

Table 1. Relative abundances (%) of particle types in Apollo 17 1-2 mm soils.

	72502,12	76502,12	78502,10	75082,5
No. of particles	129	143	95	117
ANT fragments	7.8	13.3	8.4	4.3
Poikilitic norites	2.3	7.7	3.2	
Recrystallized norites	24.8	5.6	1.1	1.7
Dark, fine-grained fragments	21.7	4.9	0.0	0.0
Porous, loosely-consolidated fragments	0.8	0.0	2.1	0.0
Feldspathic basalts	1.5	2.1	0.0	0.0
Mare basalts	0.0	5.6	32.6	68.4
Homogeneous glass	1.5	0.0	1.1	0.0
Ropy glass	0.0	1.4	1.1	0.0
Aphanitic particles[1]	0.8	1.4	5.3	0.0
Cindery glass	3.9	5.6	0.0	3.4
Glass-bonded aggregates	13.2	18.2	4.2	1.7
Soil breccias	20.9	20.3	40.0	19.6
Mineral fragments	0.8	11.2	1.1	0.0
Others[2]	0.0	2.8	0.0	0.9
	100.0	100.1	100.2	100.0

1 This category includes devitrified glasses and very rapidly cooled (i.e., quenched) melts.
2 Particles that cannot be assigned to one of the other groups are placed in this category. Most are heavily shocked, unrecognizable fragments.

NONMARE LITHIC FRAGMENTS

Taylor, G. J. et al

Table 2. Average modal analyses(vol.%) of anorthositic (ANT) lithic fragments from Apollo and Luna soils. Numbers in parentheses represent one standard deviation of the mean. See text for our operational definition of ANT. An average of 125 points was counted on each particle.

	Apollo 11	Apollo 15	Apollo 16	Apollo 17	Luna 20
No. of particles	32	45	50	32	70
Mafic silicates	15.4(12)	9.5(10)	12.9(10)	27.9(11)	27.6(13)
Plagioclase	84.2(12)	90.3(10)	86.9(10)	71.4(11)	71.9(13)
Opaque phases	0.3	0.2	0.1	0.3	0.4
Metallic NiFe	0.1	0.0	0.1	0.3	0.1

Table 3. Average modal analyses (vol.%) of KREEP-enriched 1-2mm lithic fragments from Apollo 14, 15, 16, and 17 soils. RN, recrystallized noritic breccias; poik, poikilitic noritic fragments. An average of about 125 points was counted on each particle.

	Apollo 14	Apollo 15	Apollo 16		Apollo 17	
	RN	RN	RN	Poik	Poik	RN
No. of particles	45	48	14	49	15	43
Mafic silicates	45.9(11)	47.0(10)	44.4(7)	38.3(10)	47.5(8)	46.6(8)
Plagioclase	45.5(10)	48.9(10)	52.6(8)	59.3(10)	48.4(8)	49.5(6)
K-rich glass	4.8	0.8	1.0	0.8	1.4	1.2
Phosphate phases	1.1	0.3	0.3	0.2	0.4	0.3
Opaque phases	2.2	2.6	0.8	0.9	2.2	1.9
Metallic NiFe	0.3	0.1	0.8	0.5	0.1	0.4
Zircon	0.2	0.1	0.0	0.0	0.0	0.0
Silica	0.0	0.2	0.1	0.0	0.0	0.1

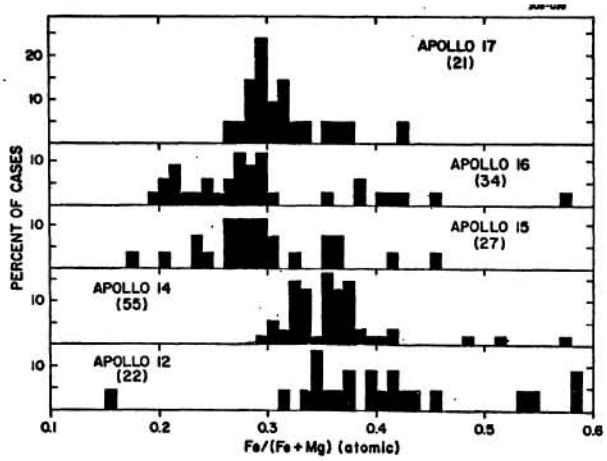

FIGURE 1. Histograms of Fe/(Fe+Mg) in 1-2mm KREEP-enriched lithic fragments; analyses obtained by defocussed-beam microprobe traverses.