P.430

PETROLOGY OF MARE FECUNDITATIS. Petr Jakes, Lunar Science Institute; W. I. Ridley*, Arch M. Reid, Jeff Warner, Russell S. Harmon, Robin Brett, NASA Manned Spacecraft Center; and Roy W. Brown, Lockheed Electronics, Houston Texas

Two 0.025 gm samples of soil returned by the Luna 16 probe from Mare Fecunditatis have been investigated by optical and electron microprobe techniques. Analyses for major elements were made on 1020 minerals and 266 glasses. The two soils are from the near surface (horizon A) and from a depth of approximately 30 cm (horizon D). No significant differences between the soils were noted.

Particles in the soil are of four types: 1) mineral fragments, 2) glass, some containing mineral fragments and/or crystallites, 3) agglutinates and microbreccias, and 4) crystalline lithic fragments largely with ophitic to subophitic texture and consisting dominantly of plagioclase, clinopyroxene, ilmenite, olivine, rare ulvospinel, Ni-Fe, troilite. These fragments apparently represent the mare basalts indigeneous to the area.

The major minerals in the soil in order of decreasing abundance are, pyroxene 40%, feldspar 29%, oxides 19%, olivine 11%, metal + sulfide 1%.

Glasses. Average compositions of the major glass components are shown in Table 1. 23% of the glasses are Al-rich, Fe, Cr-poor basaltic glasses with lower Ca/Al ratio and higher Mg/Mg+Fe (.69) compared to the remaining glasses. These glasses have Ca/Al ratios almost identical to high-Al basaltic glasses from the Fra Mauro soil, and are considered to have a non-mare origin.

Two major non-mare types are recognized: 1) Basaltic glasses with 21-30 wt.% Al_2O_3. These comprise 22% of all analyzed glasses, and have the major element composition of feldspathic basalt or anorthositic gabbro. 2) Glasses with over 30 wt. % Al_2O_3. These comprise 1.3% of analyzed glasses and include gabbroic anorthosite and anorthosite compositions. Glasses with KREEP compositions are virtually absent in our sample of the Luna 16 soil. Two glasses have a granitic composition similar to the rare granitic glasses in the Fra Mauro, Apollo 11, and 12 soils. Remarkably low Na_2O is a characteristic feature of the granitic glasses.

Fe, Ti, Cr are higher, and Ca, Al lower in the majority of glasses, compared to those described above, and they are considered to be mare-derived. The mare glasses are divided into two groups (Table 1), a major group named Fecunditatis type A (70% of all glasses) with less than 5% TiO_2, and a minor group named Fecunditatis type B (7% of all glasses) with greater than 5% TiO_2. This latter group has up to 22 wt. % FeO and most closely resembles high-titania glasses from the Apollo 11 soil.

Type A glasses have a preferred composition (Table 1) that is distinctly different from other mare basaltic glass compositions. In particular they have less FeO, TiO_2, more Al_2O_3, and lower Ca/Al ratio (.76?) than other mare basalts. In most elemental abundances and ratios it is intermediate between other mare basalts and non-mare basalts.

Pyroxenes. Augite, sub-calcic augite and pigeonite are most abundant, and only 2 low-Ca pyroxenes may be orthopyroxenes. Ferro-augite and ferropigeonite are less abundant, pyroxferroite and ferrohedenbergite rare. Two pyroxene trends are observed in lithic fragments, although more may exist. One trend from augite cores, through low Ca ferro-augite to pyroxferroite rims, and a second trend from pigeonite cores through ferropigeonite to pyroxferroite rims. Pigeonites and augites contain significant Ti, Al, Cr as in Apollo 11 and 12 clinopyroxenes. Most pyroxenes plot along an Al:Ti = 2:1 line similar to Apollo 11 clinopyroxenes, although a few grains with low Al, Ti plot near to the Al:Ti = 4:1 line indicating some octahedral alumina.

Plagioclase. Plagioclase compositions vary from An_{99} to An_{68}, but 60% are in the range An_{90}-An_{99}, and show less than 2 mole % An variation in individual grains. Fe varies from 0.18-1.8 wt. % and generally the most calcic plagioclases contain the lowest Fe. The plagioclases are quite distinct from the more sodic plagioclases in Apollo 11 high-K basalts but are undistinguishable from plagioclases in Apollo 11 low-K basalt and Apollo 12 basalts.

Opaque Minerals. The following minerals occur in the soil: ilmenite, Cr-Al ulvospinel, Ti-Al-Cr spinel, Fe-Ni and troilite. The majority of ilmenites lie within the compositional range of other mare ilmenites, but a few with greater than 2 wt. % MgO may indicate a higher Mg/Mg+Fe ratio in the melt on crystallization. Cr-Al ulvospinels range from Ulv_{57} Cr_{30} Hc_{13} to Ulv_{94} Cr_1 Hc_5 and generally fall in the range of Apollo 12 ulvospinels. The range in Ti-Al-Cr spinels is $FeCr_2O_4$ 40-34 mole %, $FeAl_2O_4$ 32-15 mole %, Fe_2TiO_4 29-47 mole %, and most resemble Apollo 11 spinels. The high Al_2O_3 contents of these spinels may reflect the high Al_2O_3 content of the Fecunditatis type A basalts.

Olivine. 75% of all analyzed olivines fall in the range Fo_{57}-Fo_{68}. Rare grains have Fo_{75} compositions. Only 8% of the grains are more fayalitic than Fo_{31}, the most iron-rich grain being of Fo_{11} composition. Zoning is not extensive, rarely exceeding 2 mole % Fo. Mn varies from 0.1-1.4 mole % tephroite and is lowest in Mg-rich olivines. Overall the olivines are more iron-rich than those in Apollo 11 and 12 basalts.

Discussion. If we assume that a preferred glass composition approaches the composition of a rock type, then Fecunditatis type A basalts are unlike Apollo 11, 12 basalts, although the Mg/Mg+Fe ratios are similar. If the latter reflects degree of partial melting from a uniform source composition, then the higher Al_2O_3, and lower FeO, MgO, TiO_2 and Cr_2O_3 in Fecunditatis type A basalts suggests their source region is unlike that of other mare basalts. Notably, some basaltic fragments with igneous textures indicate the earlier crystallization of plagioclase in Fecunditatis basalts, compared to Apollo 11 and 12 basalts. The intermediate chemistry of these basaltic glasses, between other mare basalts and non-mare glasses, indicates a source region that is more aluminous than that of the Apollo 11 and 12 basalts, but less aluminous than the source of non-mare rocks.

P.432

Luna 16: Composition of Glasses

	Granite	Anorthositic	Highland Basalt	Fecunditatis B Basalt	Fecunditatis A basalt	Weighted average
SiO_2	77.57	43.02 (2.79)	45.20 (1.68)	41.53 (2.36)	44.57 (2.64)	44.47
TiO_2	n.d.	.08 (.08)	.54 (.51)	7.00 (2.44)	2.62 (1.21)	2.45
Al_2O_3	10.76	35.34 (1.79)	25.28 (2.33)	11.94 (2.21)	15.92 (3.10)	17.91
Cr_2O_3		.02 (.03)	.11 (.06)	.22 (.07)	.23 (.07)	.20
FeO	1.42	1.06 (1.03)	6.49 (2.71)	18.15 (2.19)	14.43 (2.57)	12.81
MgO	n.d.	1.82 (2.03)	8.10 (2.19)	8.09 (2.00)	9.01 (1.87)	8.65
CaO	1.01	18.86 (1.54)	14.28 (1.49)	11.26 (1.54)	11.86 (1.54)	12.43
Na_2O	0.49	.37 (.42)	.23 (.18)	.38 (.16)	.32 (.16)	.27
K_2O	6.69	.05 (.15)	.07 (.11)	.14 (.08)	.09 (.08)	.09
CaO/Al_2O_3		.534	.565	.94	.745	
MgO/MgO+FeO		.493	.560	.308	.385	
No. analyzed	1	16	64	14	170	
Percentage of glass grains	0.4	1.3	21.6	7.2	69.9	

n.d. = not determined