PETROLOGY OF APOLLO 16 METAIGNEOUS ROCKS

D. Walker, J. Longhi, and J.F. Hays, Hoffman Lab, Harvard Univ., Cambridge, Mass. 02138

Included in the breccias of the Apollo 16 sample is a suite of leucocratic igneous rocks in various stages of disrepair. This suite is characterized mineralogically by abundant plagioclase and chemically by a relatively low Fe/Fe+Mg ratio compared to the major rock types present at other lunar landing sites. Petrographic and experimental petrology studies have not revealed any unambiguous primary liquids. If the chemical variation in the suite is controlled by crystal-liquid fractionation, the process can only have occurred in a limited range of oxygen partial pressures. The rocks we have studied are discussed in order of decreasing modal and normative plagioclase content. Electron probe analyses of glasses produced by fusion of rock powders in graphite capsules at 5kb are recorded in Table 1.

Anorthosite 60025,125W_1 is composed of about 97% plagioclase (95 mole% An) which shows evidence of granulation and shearing. Original grains as much as 1-3 mm are still recognizable. The most abundant ferromagnesian minerals are green augite (Wo43En38) and hypersthene (Wo03En45). These pyroxenes generally inhabit the granulated zones of plagioclase. The high modal plagioclase and suggestion of large relict grain size favor the interpretation that 60025 is a metamorphosed cumulate.

Feldspathic basalt 68415,139B_1 has a fine to medium grained subophitic texture dominated by equant and lath shaped anorthite. The large laths are unzoned with respect to Na (An96-98) but exhibit zonation in Fe/Fe+Mg from .22 in the cores to .46 on the rims. Needle-like laths in the mesostasis have values of .68 at an An content of 86. Olivine in the section has a very limited range of composition (Fa28-32 molar). Pigeonites cluster in composition about Wo14En62. The mesostasis contains rhyolitic glasses, ilmenite, native Fe and a red potassium feldspar. Native Fe is also included within plagioclase laths as spherules. Dry, high pressure melting experiments were undertaken to assess the possible implications of a 68415 magma. Corundum replaces plagioclase and spinel as the liquidus mineral above 15kb, making a partial melting origin at 300 km or deeper unlikely.

Xenoclastic basalt 60335,75E_1 has a matrix of material similar in texture and mineralogy to 68415. The olivine is slightly more magnesian (Fa18-20) and may be rimmed by orthopyroxene (En76 Wo5) which is in turn mantled by pigeonite. Islands of thermally metamorphosed breccia of texture akin to 60315 (but more feldspathic) are armored with polycrystalline plagioclase. Other features suggesting assimilation of material in the liquid are anhedral, inclusion-charged, An84 plagioclase cores overgrown by euhedral, clear, An96 mantles. Clearly 60335 does not represent

METAIGNEOUS ROCKS

Walker, D et al.

a magma composition.

Poikiloblastic olivine norite 60315,75W_1 appears to be a thermally metamorphosed, medium grained olivine norite. 2-3 mm orthopyroxene poikiloblasts with optically continuous clinopyroxene rims of indistinct outline contain myriad plagioclase and olivine inclusions. The zonation of the pyroxene poikiloblasts suggests crystallization from a magma but does not preclude solid state growth. The groundmass contains a few ½ mm anhedral single crystals of plagioclase which contrast with the very fine grained, polycrystalline surroundings. If these clasts were more abundant, the rock would be transitional to the xenoclasts of 60335. The groundmass also contains ¼ mm spherules of native iron. It is not possible to assess on the basis of the present texture and mineralogy whether 60315 was once a magma.

As noted by LSPET[1] the compositional variation of the Apollo 16 suite can be described to a first approximation by a calcic plagioclase component. If an igneous ancestry is assumed to be directly (or indirectly in the case of breccias) responsible for this chemical variation, then crystal-liquid fractionation processes must occur in the plagioclase liquidus field. The compositions of these rocks are plotted on the pseudo-ternary liquidus diagram[2] (analysis of 60315 is from LSPET). Figure A shows the liquidus relations inferred for sealed silica tube experiments in molybdenum capsules. The low iron content of the products shows that the oxygen fugacity was too low to be compatible with the natural examples. Figure B shows the liquidus relations inferred from controlled oxygen pressure experiments in iron tubes at an oxygen pressure ½ order of magnitude below the Fe/FeO buffer. It is evident that the spinel field has encroached on the region of interest. It is possible, then to bracket the oxygen pressures at which such a differentiation could occur.

[1]LSPET (1973), Science, v. 179, p.23.
[2]Walker et al. (1972) Proc. 3rd Lun. Sci. Conf., v. 1, p.797.

METAIGNEOUS ROCKS

Walker, D, et al.

TABLE 1

	60025,90	68415,82	60335,40	62295,48
SiO_2	44.4	45.3	46.6	45.3
TiO_2	.10	.35	.65	.80
Al_2O_3	35.0	28.7	24.8	20.8
Cr_2O_3	.04	.14	.15	.20
FeO	.66	3.69	4.08	5.99
MgO	.30	4.44	8.07	14.4
CaO	19.5	16.3	14.3	11.5
K_2O	.02	.12	.31	.14
Na_2O	.43	.50	.62	.40
Sum	100.4	99.5	99.6	99.5