TEXTURAL-MINERALOGICAL RELATIONSHIPS IN A POPULATION OF ANT SAMPLES:

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We have presented partial results of a mineral chemistry study of 87 lunar plutonic and granulitic fragments (ANT) from the Curator's collection (1). They occur in polymict breccias or as discrete particles collected from the regolith, and do not include any of the well-known lunar plutonic or granulitic rocks. They are considered here on the basis of each fragment's texture (Table 1). We assigned 80 of them to 13 textural groups on the basis of: (1) shapes of and contact relations between plagioclase and mafic silicates and (2) the grain size of the plagioclase. Clearly monomict fragments of igneous origin are distinguished by whether (IS) or not (I) they display conspicuous evidence of shock or crushing. It is not clear to what extent some of the smaller-sized, coarser-grained fragments (Ic, ISc) have undergone Apollonian metamorphism (2), which produced coarse (2-3 cm) granoblastic textures and equilibrated minerals over centimeters. Although all igneous fragments with plagioclase grains over 1 mm across are grouped together, there appears to be a continuum between rocks with plutonic textures and rocks with Apollonian granoblastic textures. The other fragments belong to the feldspathic granulitic impactite suite (3) and have distinctly smaller grain sizes (<0.5 mm). All members of this suite have granulitic matrices, produced by thermal metamorphism, on which their textural subclassification is based; many small samples contain mineral clasts and larger ones are likely to contain lithic clasts. In the granoblastic fragments (G) equant, anhedral plagioclase crystals with smooth boundaries meet in triple junctions of roughly 120°; generally smaller-grained mafic silicates occupy the boundaries and triple junctions between them and are not optically continuous. Large samples 78155 and 79215 belong to this class. Although most are probably polymict, the gross distribution of minerals in a few indicates relict coarse-grained textures. In the extreme case a rock is composed of a set of monomineralic mosaics. Poikiloblastic-textured fragments (P) also contain mosaic-textured plagioclase (chadacrysts), but the pyroxenes and very rarely olivines of neighboring grains are in optical continuity (oikocrysts). Large samples 77017 and 76230 belong to this class. These rocks are texturally and compositionally distinct from poikilitic rocks (e.g., 60315, 65015) that crystallized from impact melts (4). Textures of a few fragments (GP) range locally from granoblastic to poikiloblastic. Generally olivine is the dominant mafic silicate in granoblastic regions and pyroxenes in poikiloblastic regions.

There appear to be transitions between all the textures recognized in the ANT suite. They can be explained with respect to the inferred origins of the rocks. Plutonic rocks crystallized from the inferred initial lunar magma ocean or from magma bodies derived from the earliest crustal rocks. Sufficiently deep-seated plutonic rocks were texturally modified by the very prolonged annealing of Apollonian metamorphism. Shocked plutonic rocks and monomict breccias were respectively shocked and disaggregated during or after excavation. Crushed or mixed plutonic rocks that resided in early breccia sheets recrystallized to form the feldspathic granulitic impactites. The texture of a particular granulitic impactite depends on: (1) the texture of the protolith, the degree of (2) crushing or vitrification and (3) mixing that occurred during emplacement in the ejecta blanket, and (4) the thermal history of the ejecta

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blanket, which controlled (in a manner not presently understood) the nucleation history of the impactite (5).

Our data suggests that in the ANT suite there are relationships between a rock's texture and the composition and homogeneity of its silicates. Plagioclase compositions (Fig. 1) are restricted to An > 93.5 in the coarsest-grained (most primitive?) plutonic rocks (Ic, ISc). More sodic plagioclases are present in other textural groups. They are all inferred to be derivatives from the primary lunar plutonic rocks and the presence of relatively sodic plagioclase among them indicates that partial melting and fractional crystallization probably have played a role in the genesis of some. The olivines display no such relationship (Fig. 2). This is in part because of the relatively great range of Fe/(Fe+Mg) in the primary plutonic rocks, i.e., the existence of two subsuites: the Mg-rich plutonic rocks and the ferroan anorthosites (6). Fig. 3 depicts the standard deviation of plagioclase and olivine compositions within individual fragments as a function of textural class. Clearly the coarse-grained plutonic rocks have the most homogeneous mineral compositions; this reflects their monomict nature and the effects, in most, of Apollonian metamorphism. Among the granulitic impactites there is a predictable correlation between grain size and standard deviation; the largest standard deviations are found in the finest-grained varieties, in which there was the least time for equilibriation of matrix derived, in general, from polymict material. Furthermore, there is a weak tendency for plagioclase to be more homogeneous than olivine, probably reflecting the greater range of olivine compositions in the source rocks. The opposite relationship may characterize the plutonic rocks because a more complex substitution is required to homogenize the composition of plagioclase than to equilibrate Fe-Mg in olivine. Fig. 4 depicts the Wo content of low-Ca pyroxene as a function of textural class. If all the analyzed grains were of equal Fe/(Fe+Mg) and all coexisted with high-Ca pyroxene, and if none of the analyses were of composite low-Ca/high-Ca grains, the Wo contents would indicate the final temperatures of equilibration of the rocks and thus allow comparison of the thermal history of the different textural groups. The first two of these conditions were not met and the third cannot be substantiated. Nevertheless, some generalizations appear to be justified. Wo contents of under 2 1/2 mole % are almost wholly restricted to the coarse-grained plutonic rocks and the coarsest-grained feldspathic granulitic impactites, in which there was continued equilibration until relatively low temperatures were reached. In all the classes some grains with Wo contents of from 5 to 10% may be composite, but the high Wo contents of many must be real, for uninverted pigeonite is present in 77017 and 78155. Catastrophic cooling after excavation by meteoritic impact is the best explanation for the preservation of such high temperature pyroxene in some of these igneous and metamorphic rocks. In addition to the confounding factors listed above, the range of Wo contents of pyroxenes in each textural class reflects the effects of re-equilibration of pyroxene during cooling with or without quenching by impact excavation.

REFERENCES: (1) Bickel and Warner (1977) Lunar Sci. VIII, 112-114. (2) Stewart (1975) Lunar Sci. VI, 774-776. (3) Warner et al. (1977) Proc. LSC 8th, 2051-2066. (4) Simonds et al. (1973) Proc. LSC 4th, 613-632. (5) Bickel (1977) Proc. LSC 8th, 2007-2027. (6) Warner et al. (1976) Lunar Sci. VII, 915-917.

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Table 1: TEXTURAL CLASSIFICATION OF THE SAMPLE
("Plag" indicates diameter of plagioclase in mm)

Class; Grain size	Plag	Class; Grain size	Plag	Class; Grain size	Plag
Igneous (plutonic)		Granoblastic		Poikiloblastic	
-fine (If)	≤1.0	-fine (Gf)	<0.1	-fine (Pf)	<0.1
-coarse (Ic)	>1.0	-medium (Gm)	0.1-0.2	-medium (Pm)	0.1-0.2
		-coarse (Gc)	>0.2	-coarse (Pc)	>0.2
Shocked or Crushed Igneous (plutonic)		Composite: Granoblastic and Poikiloblastic			
-fine (ISf)	≤1.0	-fine (GPf)	<0.1		
-coarse (ISc)	>1.0	-medium (GPm)	0.1-0.2		
		-coarse (GPc)	>0.2		

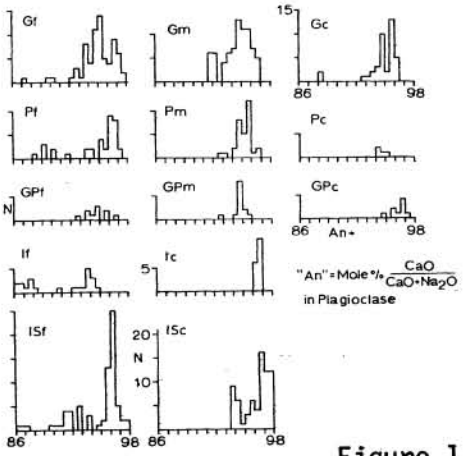

Figure 1.

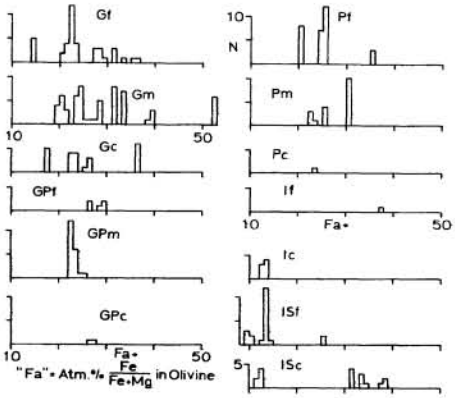

Figure 2.

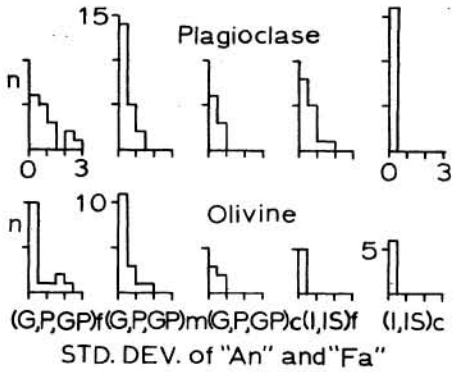

Figure 3.

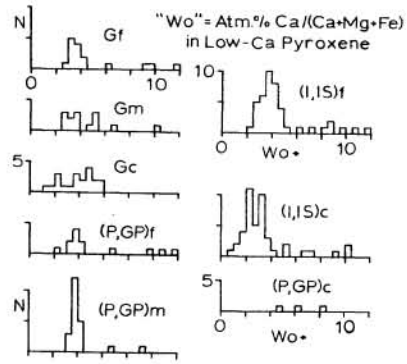

Figure 4.

FOR ALL FIGURES:
VERTICAL AXIS IS NUMBER OF CASES; SCALE IS 5 UNITS PER TIC MARK.