CATACLASTIC PLUTONITES: POSSIBLE KEYS TO THE EVOLUTIONARY HISTORY OF THE EARLY MOON., P. M. Bell and H. K. Mao, Geophysical Laboratory, 2801 Upton St., N. W., Wash., D. C. 20008.

Dunite and cataclastic anorthosite from the Apollo 16 and 17 sites are among the most significant of the returned lunar rock types, because of their probable plutonic formation and because of a possible origin as early differentiates in the formation of the moon. Samples 72415 (dunite) and 64589, 61576 (anorthosites), are nearly monomineralic. The grain sizes range up to an inch in diameter having evidently survived excavation from great depths in the moon during the impacting of large lunar basins. Later thermal metamorphism has affected these rocks to a moderate extent, but much of their existence was shielded from deterioration in the lunar regolith. Vestiges of the former character of these rocks are apparent in textural features and in inclusions that have clearly responded chemically to conditions that are alien to those under which they originally formed. It is these textures, and included assemblages that provide convincing evidence of a past history in the lunar interior or mantle.

Dunite (72415). The dunite sample from Apollo 17 boulder #2 was extracted from a "blue-gray" anorthositic breccia (72435). The age has been confidently reported as 4.6 b.y., making it the oldest returned lunar rock. This age is deduced partly with reference to the rock's petrology, but it would not be entirely circular reasoning to note that later events have not clouded interpretation of the isotopic data (1).

The texture of coarse-grained olivine appears relatively undeformed. The rock also contains rosettes of a chromate-twopyroxene-plagioclase symplectite (2). At first glance the total assemblage seems to follow a low pressure crystallization sequence (3), but evidence obtained in the present study suggests that the rock formed under high pressures and temperatures. This evidence mainly includes the existence of microsymplectite assemblages (average 10 μm in diameter) totally included in large olivine crystals.

The microsymplectites have the bulk composition of garnet (approximately idealized: $(Ca_{1.9}Mg_{0.6}Fe_{0.5})(Cr_{1.3}Al_{0.7})Si_3O_{12}$). They may actually contain garnet, but usually consist of a eutectoid intergrowth of spinel and pyroxene with occasional plagioclase. Consistent with their history of formation at high pressure, the olivine host has kept their composition uniform. The rosettes mentioned above are not uniform in composition, but probably have the same origin. They may have reacted with surrounding pyroxene or plagioclase. The important conclusion is that the dunite formed at high pressure and contained garnet. This is the first substantial evidence for the existence of garnet in lunar rocks.

It is also likely that garnet existed in many other Apollo samples and that the rocks, or their phenocrysts, did not form at the moon's surface. Similar microsymplectites occur in nearly every olivine-bearing rock returned from the moon. The individual microsymplectite crystals are small (<1 μm in diameter), and not easily recognized or analyzed (i.e. 12018 (4)) but those that have been analyzed are now realized to be of garnet composition.

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Cataclastic Anorthosites (64589, 61576). These anorthosite samples were collected by rake, and consist essentially of shocked single crystals of anorthite. Their crystal size suggests that they have cooled at depth, although results of analyses of their abundant inclusions are not yet sufficiently complete to substantiate a high pressure origin. The coarse grained texture and narrow composition simply suggest a plutonic origin.

Discussion. The present discovery of relict high pressure assemblages after garnet in dunite and in other lunar rocks suggests that the popular notion that Apollo rocks have completely crystallized on the lunar surface is incorrect. It will be necessary to reexamine theories of the igneous history of the lunar surface in conjunction with previous data on the crystallization of phenocrysts (5).

Cataclastic anorthosites represent a related, but different, type of evidence of the character of early lunar crystallization that has not been obliterated by impact metamorphism in the regolith.

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