**PROVENANCE OF TERRA BRECCIAS.** H.G. Wilshire, U.S. Geological Survey, Menlo Park, Calif. 94025.

Samples returned from the lunar terra have a great variety of textures and a wide range of compositions. The textures are dominated by impact fragmentation and thermal metamorphism, but clues to the nature of the source rocks are found in varying degree in all the samples. The documented samples are divided into three groups on the basis of the information they yield about pre-excavation processes: (1) breccias with glassy to finely annealed matrices and clasts; (2) crystalline rocks in which pre-excavation texture is more-or-less intact; and (3) cataclastic breccias in which pre-brecciation textures are spottily preserved.

Rocks of the first group, the majority of returned samples, yield least direct information about their origin. These breccias have high matrix/clast ratios and the clasts are mostly fine-grained thermally metamorphosed fragmental rocks and fused materials. Many of the larger of these, however, contain a small percentage of hornfelses that are much coarser than the dominant clasts, and rocks with igneous textures, both volcanic and plutonic; they also contain large percentages of mineral debris in the 0.1 to 1mm and larger size range (Wilshire and Jackson, 1972). Much of the mineral debris in the Apollo 14 breccias is far too coarse to be derived from any lithic clasts other than the coarse hornfels and plutonic rocks. Moreover, the proportions of mineral species occurring as isolated clasts are in keeping with the feldspar-rich plutonic and coarse metamorphic rocks. These relations appear to be true of breccias from other terra sites as well but statistical data are not available.

At the opposite end of the spectrum is the small group of rocks whose pre-excavation crystalline textures have remained more-or-less intact. These are about equally divided among those with volcanic (e.g. 14053, 14310, 68415), plutonic (e.g. 15415, 69955, 78235), and coarse metamorphic (e.g. 78155, 76535, 72415) textures. The compositions of the plutonic and metamorphic rocks range from dunite through troctolite and norite to anorthosite, and may include Apollo 14-type K feldspar-quartz intergrowths as well (Wilshire and Jackson, 1972). Compositions of rocks with volcanic textures range from mare basalt-like through norite or troctolite to anorthositic. Fine-grained compositional equivalents of the K feldspar-quartz intergrowths also occur (e.g. 12013).

The third group, embracing cataclasites and little-modified derivatives, lies between the two extremes. It is probably the most important group because it has enough members to be statistically useful and it retains many direct signs of its source materials. The cataclasites are typically found as clasts in little-reworked breccias (Wilshire and others, 1973). Where pulverization and cataclastic flow have not been severe, the original very coarse grain size ($>$ 5mm, often $>$ 10mm) of many rocks is evident from relic lithic fragments and the dimensions of cataclastic flow structures in which mixing of pulverized mineral debris is not far advanced. Where cataclastic flow has been severe, the size of relic mineral debris frequently attests to coarse original grain size. Other signs of slow cooling history such as coarse exsolution lamellae in pyroxenes and coarse recrystallization textures are common.

A few of the cataclasites were derived from metamorphic rocks whose grain

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size is much larger than that of the typical metaclastic rocks, but the majority are clearly derived from a suite of coarse-grained plutonic igneous rocks. Cataclastic rocks derived from rocks with volcanic textures are rare. Basalt progenitors may occur in 14321 and in an Apollo 17 rock, but no rocks with volcanic texture form clasts in the simplest, least reworked Apollo 16 breccias. Inasmuch as the matrices of the least reworked breccias commonly have textures like those of volcanic rocks (see Warner and others, 1973), it appears that such rocks are largely formed by impact fusion of plutonic rocks. Typical fine-grained hornfelses are produced by less extreme fusion of the same source rocks whereas coarse hornfelses probably formed as pre-excavation events in a slow-cooling environment (see Gooley and others, 1973).

Considering the extreme average composition of the lunar terra (Turkevich, 1973), it would appear that igneous fractionation, followed by a lengthy post-consolidation history, in an environment not frequently plumbed by impact is required. The textures of the source rocks of many of the breccias is consistent with their formation in a plutonic environment, at depths perhaps greater than 5-10 km, from which they were excavated by large, basin-forming events. Formation of such large volumes of extreme differentiates by fractionation in shallow magma chambers and eruption at the surface does not seem possible in light of the high impact flux (Soderblom and Boyce, 1972) during late crustal history, nor are the rock textures consistent with this view.

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