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Rock Fragments and Glasses Rich in K,REE,P in Apollo 12 Soils: Their Mineralogy and Origin

REPLY TO
ATTN OF:

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A yellow-brown glass characteristically rich in potassium, rare earth elements and phosphorous (designated KREEP) is an important rock type in the Apollo 12 soil. Within narrow limits these glass fragments have a common composition (SiO_2 48%, Al_2O_3 15%, FeO 11%, CaO 11%, MgO 8%, TiO_2 2%, K_2O 1.2%, P_2O_5 0.6% , and Na_2O 0.5% by weight). This unusual composition indicates that this glass was not derived by the melting of Apollo 11 or 12 basalts or soil and thus is probably not representative of indigenous mare material.

KREEP glass occurs in three morphologic forms: 1) ropy strands with internal flow texture, 2) blocky fragments, 3) matrix of breccia fragments composed of the mineral assemblage; hypersthene - plagioclase (An_{70-80}) - (K, Ba) feldspar - rare earth phosphate with clinopyroxene, olivine, ilmenite, troilite and iron as accessories. The ropy strands typically have many small fragments welded to their wrinkled or fluted surfaces; these fragments consist predominantly of the above minerals. The blocky glass fragments and breccias include fragments of the same mineral assemblage in various stages of partial melting. Shock metamorphism of the included feldspathic rock fragments and the presence of maskelynite and rounded ilmenite blebs in the glass fragments indicates that KREEP glass was formed by impact melting.

The KREEP component of the Apollo 12 soil also includes small fragments of unmelted feldspathic orthopyroxenites and gabbroic anorthosites, both containing abundant K-feldspar and REE phosphate. The close association of these rock types with the KREEP glass and the compositional resemblance to KREEP suggests that the fragments represent the original igneous parent material for the KREEP glass. The fragments are mineralogically and chemically more similar to Luny Rock 1 than Apollo 11 anorthosites.

Thin sections of the coarse fine fraction of soil samples 12032, 12037, and especially 12033 show that they contain significantly more KREEP glass than for the other soil samples. The compositions of KREEP glasses and of the average basaltic rocks can be used as end members for a simple two component mixing model explaining Apollo 12 soil and breccia compositions. The constant composition of KREEP glass and its enrichment in some soil samples suggests that a single impact event may have added this unique component to the Apollo 12 regolith.

Copernicus is the closest crater to the Apollo 12 site that penetrates mare material, and one of its rays passes close to the site. We therefore suggest that KREEP glasses and the associated orthopyroxenites in the Apollo 12 soil may have been derived from the Imbrian ejecta at Copernicus. This raises the interesting possibility that the Apollo 14 samples may contain considerable amounts of KREEP-like material.