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SHOCK METAMORPHIC EFFECTS IN THE LUNA 16 SOIL SAMPLE FROM MARE FECUNDITATIS

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Shock metamorphic effects characteristic of meteorite impact and virtually identical to those observed in Apollo samples are common in fragments of the Luna 16 soil sample from Mare Fecunditatis. Two types of shock effects are present: (1) deformation and partial melting features in rock and mineral fragments (1–2 per cent of fragments); (2) heterogeneous glasses and glassy breccias produced by shock melting (70–80 per cent of fragments). Shock effects were observed in pyroxene (deformation twin lamellae; multiple planar shock lamellae; extreme mosaicism; partial isotropization); in plagioclase (planar shock lamellae; complete isotropization to form maskelynite); and in basalt fragments (plagioclase isotropization; selective partial melting). The glasses and glassy aggregates exhibit several characteristics of shock melting, especially: (1) diversity in chemical composition; (2) association with shocked mineral fragments and Ni-Fe spherules; (3) heterogeneous schlieren and incipient fusion of mineral inclusions. The shock metamorphic effects in Luna 16 soil and its similarity to Apollo material indicate that regolith formation by meteorite impact has occurred in Mare Fecunditatis and is a general process over the entire moon.

1. Introduction

Intensive studies of returned lunar samples have confirmed the theory that the bedrock on lunar maria is overlain by a fragmental layer (regolith) of varying thickness which has been produced by continuing meteorite bombardment [1]. The major evidence for this conclusion is the occurrence of distinctive shock metamorphic effects, uniquely indicative of meteorite impact, in returned samples of fragmental lunar material. Virtually identical suites of shock features, including unique mineral deformation structures and unusual heterogeneous glasses, have been observed in samples from the Apollo 11 [2–7], Apollo 12 [8–11], and Apollo 14 [12] missions.

The Russian Luna 16 automated probe landed on Mare Fecunditatis on September 20, 1970 and returned with 101 g of fine-fragmental material obtained by drilling 35 cm into the regolith. Preliminary examination of the sample [13] showed that it consisted of diverse fragments generally about 0.1 mm in size, including both basaltic and anorthositic rock fragments, 'cindery' and 'slaggy' aggregates of glass and rock fragments, and glass fragments and free-form glasses similar to material obtained from the Apollo 11 and 12 missions. The Luna 16 sample is relatively low in TiO_2 [13] and is thus chemically more similar to Apollo 12 material.

The purpose of this study was to examine the fragments for evidence of shock metamorphism in order to evaluate the role of meteorite impact in forming the lunar regolith at a new site relatively distant from the Apollo landing sites. The study was carried out as part of a consortium for mineralogy and petrology headed by J.A. Wood, Smithsonian Astrophysical Observatory (SAO).

The samples were obtained from SAO as fragments mounted on individually numbered polished thin sections, accompanied by index photographs giving each fragment a specific number (e.g., SAO 301,16). In the time available, four sections (301, 303, 315, and 318) containing about 1000 individual grains were examined