in glassy fragments, indicating superheating of the glass and disequilibrium between crystals and glass.

The character of the glassy material in the Luna 16 sample is virtually identical to that observed in Apollo specimens (e.g., [7]) and almost certainly reflects origin by meteorite impact. The preponderance of impact-produced glasses over shocked rock and mineral fragments is likewise consistent with observations on the returned Apollo samples.

Some glass fragments in the Luna 16 sample also exhibit quenching and devitrification textures similar to those reported in Apollo material (e.g., [2, 3, 4]). The textures suggest that crystal growth took place both during rapid cooling in the liquid state (quenching) and in the solid state (devitrification).

The more strongly colored yellow-brown to dark brown fragments display elongate, highly birefringent crystals and microlites, probably pyroxene, as well as parallel and dendritic growths of quench opaques (e.g., [3, 17]). In some fragments, quenching has proceeded to the point where the fragment is largely crystalline and may display an intersertal texture [14]. It is not clear whether such textures have been produced by rapid cooling of a primary magma or by quenching of an impact-produced melt of basaltic composition.

The colorless to pale green glasses with plagioclase-rich compositions [7] are generally less crystallized. Where present, crystallization has apparently taken place in the solid state and is strongly controlled by the shape of the fragments. The most common devitrification effect is the development of radiating or spherulitic textures of plagioclase crystals (fig. 2).

3. Conclusions

The Luna 16 soil particles exhibit distinctive shock metamorphic effects, uniquely produced by meteorite impact and virtually identical to those observed in other lunar samples. Distinctive rock and mineral deformation effects are observed in only 1–2 per cent of the fragments, a result consistent with studies of the Apollo samples. However, shock-produced glasses and glassy breccias constitute 70–80 per cent of the fragments studied. The generally high shock level of material in the regolith on Mare Fecunditatis is consistent with continuous meteorite impact [6] and suggests that the reworking and overturning of the surface fragmental layer indicated for the Apollo sites [1, 5, 11] is also occurring on Mare Fecunditatis.

The strong evidence for the formation of a fragmental layer at the Luna 16 site by repetitive meteorite impact strengthens the view that this process operates generally over the whole moon. The establishment of such general conclusions about lunar processes by examination of such a small amount of material emphasizes both the usefulness of petrographic methods and the unique character of the shock metamorphic effects themselves.

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