We assume that the lamellae shown in Fig. 4 are twin lamellae produced by shock waves. This assumption is strongly supported by the fact that lamellar clinopyroxene coexists in two rock fragments with isotropic plagioclase (diaplectic glass). In addition, lamellar clinopyroxene shows heavy mosaicism as is known from both artificially and naturally shocked pyroxene (CARTER *et al.*, 1968).

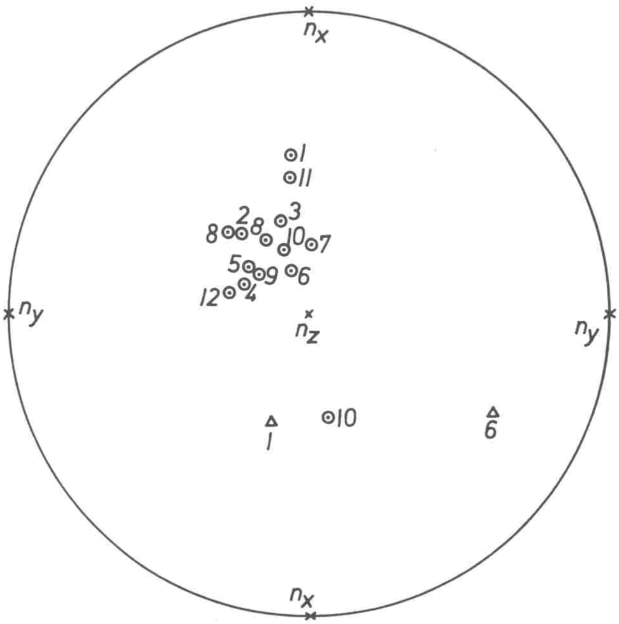

Fig. 5. Orientation of deformation structures in clinopyroxene. ⊙ Lamellae; △ Planar structures. Numbers refer to individual grains.

Clinopyroxene in paragenesis with diaplectic plagioclase glass has experienced shock pressures of at least $\simeq$300 kbar. However, the minimum peak pressure of shock which is required to produce the lamellae may be considerably below 300 kbar, because in one of the above mentioned rock fragments lamellar clinopyroxene also occurs in parts where the plagioclase is still birefringent.

(c) *Olivine*. Planar deformation structures have been found in olivine grains within a diaplectic plagioclase glass fragment, about 1 mm in dia. The source rock is probably gabbroic anorthosite. These planar structures, measured in 5 grains, appear mostly to be very thin lamellae which are parallel to {100}, {010}, {001} and {130}. Planar structures parallel to {130}, observed in 3 grains, are characteristic of dynamic deformation. They have been produced in shock experiments with olivine single crystals and olivine nodules (MÜLLER and HORNEMANN, 1968, 1969), but have not been obtained in static compression tests (RIECKER and ROONEY, 1966; RALEIGH, 1968). The same planar structures have also been observed in some chondritic meteorites (MÜLLER and HORNEMANN, 1969). Although planar structures parallel to {130} in single crystals can already form at dynamic pressures as low as $\simeq$50 kbar, coexistence with diaplectic plagioclase glass indicates that the olivine grains studied have been affected by shock pressures of at least 300 kbar.

X-ray photographs of single olivine grains from the investigated lunar glass fragment display elongated streaks demonstrating shock-induced mosaicism.

Glasses

Isotropic glasses in the lunar soil and breccias are of two different kinds which should not be confused. We distinguish between fused and diaplectic glasses. Fused glasses solidified from liquid melts. They can be recognized by several features, such as vesicles, schlieren and other flow structures, and partially fused mineral grains. Their shapes are determined by surface tension. Diaplectic glasses* are amorphous phases which were formed by shock waves in a subsolidus reaction. They probably originate from high pressure phases transformed to glass during pressure release (AHRENS and ROSENBERG, 1968; AHRENS *et al.*, 1969; ENGELHARDT and BERTSCH, 1969; STÖFFLER and ARNDT, 1969; ENGELHARDT *et al.*, 1970a).

Individual grains of diaplectic glasses have monomineralic chemical composition. All morphological characteristics of the molten state are lacking. Instead, the morphology of the previous crystalline state is sometimes preserved in features such as cleavage, twin boundaries, grain boundaries. The density and refractive index values are intermediate between those of the crystalline and the fused mineral.

Diaplectic quartz and feldspar glasses are known from terrestrial impact craters (see several papers in FRENCH and SHORT, 1968). The name maskelynite should be restricted to the diaplectic plagioclase glass of labradorite composition occurring in the Shergotty meteorite.

(a) *Diaplectic plagioclase and alkali feldspar glasses.* In the soil and breccias as well as in some crystalline rock fragments colorless and isotropic grains are observed which often show plane grain boundaries and cleavage but no indications of fusion such as vesicles or flow structures. A larger number of such isotropic fragments was selected by hand under the stereomicroscope from the fractions 1·0–0·5 mm and 0·25–0·5 mm of the samples 10084-106, 10085-25 and 10085-26. Sixteen grains were selected for refractive index determination. Since most of them contained inclusions of pyroxene and ilmenite only 6 grains were suitable for density measurement. Microprobe analyses of these selected grains yielded plagioclase compositions with An contents between 83 and 96 mole %.

The composition, density and refractive index values measured for each individual grain are listed in Table 2.† Figures 6 and 7 show refractive index and density versus the composition of these isotropic grains, and for comparison purposes refractive index and density of normal fused plagioclase glasses. As seen from both sets of data the values of normal glasses are lower than those of lunar isotropic grains of the same

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* The term "diaplectic glass" was proposed in 1966 for "amorphous phases produced by shock waves without melting", at the First Conference on Shock Metamorphism of Natural Materials held at Greenbelt, April 14–16, 1966 (ENGELHARDT and STÖFFLER, 1968. See also: ENGELHARDT *et al.*, 1967). Later CHAO (1967) proposed the term "thetomorphic" to describe "any glassy phase transformed by shock from the crystalline host mineral in the solid state".

† An-contents given in Table 1 and Fig. 1 in ENGELHARDT *et al.* (1970b) are too low due to an error in the conversion of wt. % to mole %.