steel end pieces had deformed. No residual deformation was measured on the granite specimen. It is concluded that under these environmental conditions granite is not appreciably plastic.

In one extension test at 150°C with water, the marble specimen separated in the middle. On disassembly, it was found that dendritic growths of native copper completely covered the fractured face. No particular importance was attached to this since the environment was unknown. The pressure fluid—benzine—leaked in at some stage of the proceedings after the rupture of the marble. Some small euhedral calcite crystals were found deposited on the *outside* of the jacket.

In all cases, the grains of the marble deformed the steel cups with which they were in contact. The steel retains a perfect replica of the deformed surface of the marble.

Summary of Experimental Results

The principal effect of increasing the temperature from room temperature to 150°C is to decrease the strength of marble by an amount averaging about 40 per cent. This lowering of strength varies for the different orientations in such a way as to imply that resistance to translation on $\{01\bar{1}2\}$ is decreased more than is resistance to twinning. This is qualitatively confirmed by preliminary single-crystal experiments. The hypothesis of homogeneous deformation by translation and twinning on $\{01\bar{1}2\}$ presented in Parts I, II, III has now been tested by the same procedures on the 150°C data and is found consistent with observations.

No evidence for recrystallization flow was observed. The presence of water diminished the strength at 150°C in the same proportion as at room temperature. A test of 7 hours duration in water disclosed no evidence of psuedoviscous flow as would be expected if recrystallization were occurring.

The evidence from the physical measurements thus indicates that the mechanism of deformation at 150°C, both dry and in the presence of water, is similar to that previously suggested (Parts I, II, and III) for deformation at room temperature.

FABRIC OF DEFORMED MARBLE

Material for Study

The material used for study of fabrics developed by deformation at 150°C consists of sections cut from seven deformed cylinders (Table 4).

TABLE 4.—SPECIMENS SUBJECTED TO FABRIC ANALYSIS†

Cylinder number	Cylinder axis*	Type of deformation	Per cent strain	Conditions of experiment
306	T (R)	Compression	18	Dry
321	T (R)	Compression	20	0.49% water
255	3 (Q)	Compression	19	0.52% water
260	3 (Q)	Compression	19	0.42% water; slow test
176	T (R)	Extension	12	In water
252	3 (Q)	Extension	20	Dry
287	*d*	Extension	20	Dry

* Probable correlation with *P*, *Q*, and *R* cylinders of an earlier series of experiments (Griggs, 1940; Knopf, 1949) is noted in brackets (*cf.* Part III, p. 888).

† All specimens deformed at 10,000 atm. confining pressure.

General Microscopic Character of Fabric

The fabric of these Yule marble specimens deformed at 150°C is generally very similar to that of specimens of the same orientation deformed a like amount at room temperature. Intragranular deformation, principally made evident by the profuse development of $\{01\bar{1}2\}$ lamellae, is predominant in this material, as in that deformed at room temperature. The degree of development of lamellae is not significantly different from that in corresponding specimens deformed at room temperature. The most conspicuous difference in the thin sections is that the grains in the 150°C material are not separated as much as in the room-temperature material. In the latter, regardless of the care taken in impregnation and cutting of the thin sections, grains are commonly separated at the grain boundaries, whereas, in the 150°C material, the grain boundaries are usually sharp and well defined with no evidence of separation of adjacent grains. This is perhaps correlated with the coherence of the material after removal from the pressure chamber. Specimens deformed 20 per cent at room temperature are weak, can be broken between the fingers, and are friable at fractured surfaces. The 150°C specimens are apparently much stronger.

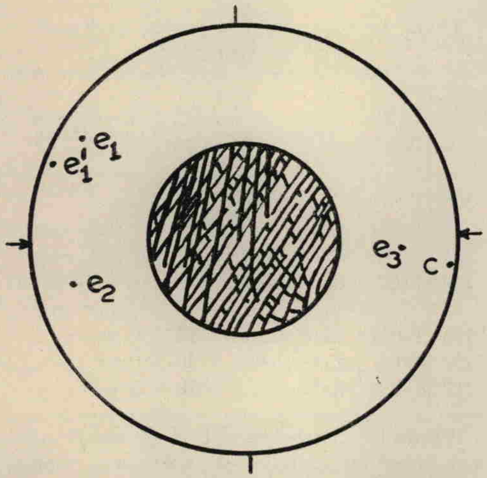

FIGURE 5.—ACUTELY INTERSECTING LAMELLAE e_1 AND e_1' IN A CALCITE GRAIN

Specimen 260. Continuous lines sloping down from right to left are traces of e_1. Heavier nearly vertical lines at left are e_1'. Discontinuous lines are e_2. Poles of e_1, e_1', e_2, and e_3 are shown in projection.

The next most obvious difference is that the lamellae are less distorted in the 150°C specimens. Local bending of lamellae at grain contacts and within the grains is considerably less evident in the 150°C specimens than in corresponding room-temperature specimens. This has an important consequence for the purposes of our study—the optical properties of highly deformed grains are much more easily determined on the universal stage as a result of the greater uniformity within the grains. In contrast to our previous experience with marble deformed at room temperature, cylinders of any orientation elongated or shortened by as much as 20 per cent at 150°C were found satisfactory for petrofabric analysis.

As in the case of deformation at room temperature, where orientation of cylinders in the stress field favors twinning on $\{01\bar{1}2\}$—*T* (*R*) cylinders in compression or *3* (*Q*) cylinders in extension—lamellar twinning on $\{01\bar{1}2\}$ is microscopically obvious in many grains; where the cylinder is unfavorably oriented for twinning, the majority of $\{01\bar{1}2\}$ lamellae appear as sharp lines with no obvious indication of twinned origin. In microsections cut from cylinders of this latter type a newly observed phenomenon is much more highly developed in the 150°C specimens. About 10 per cent of the grains show two sets of sharply defined lamellae intersecting at an anomalous angle of between 5° and 15°. In such a grain one set of lamellae (e_1 in Fig. 5) can be identified, by interfacial angles and by its relation to the *c* axis, as being parallel to one of the $\{01\bar{1}2\}$ planes of the crystal lattice. The other (e_1' in Fig. 5) necessarily is irrationally related to the same lattice. The pole e_1' invariably lies nearer the *c* axis than does the pole e_1; and in many grains e_1, e_1' and *c* are approximately cozonal. Two alternative interpretations are noted for future consideration as more data become available. Lamellae e_1' may possibly represent partings or twin lamellae inherited from the undeformed fabric and rotated through the crystal lattice to their present irrational position by translation gliding on other planes in the lattice (*e.g.*, one or both of the other $\{01\bar{1}2\}$ planes) during deformation. This possibility receives some support from the occasional occurrence of e_1' lamellae broad enough for a distinct optic orientation consistent with origin by twinning to be recognizable within the lamellae in question. But it is difficult to explain the generally rectilinear character of e_1' lamellae, or their lack of continuity across a given grain, in terms of such a mode of origin. Alternatively e_1' lamellae may perhaps have developed late in deformation by gliding on irrational surfaces inclined at low angles to an $\{01\bar{1}2\}$ plane, somewhat in the manner proposed by Fairbairn (1941) to account for lamellar structure in naturally deformed quartz. The latter possibility is supported by the observation that in rare cases e_1' offsets other lamellae, while in no case has e_1' been observed to be offset by other lamellae.

In several sections, just as in the case of marble deformed at room temperature, sparsely developed $\{02\bar{2}1\}$ lamellae (not recognizably twinned) appear in a minority of grains. The only other visible parting recorded is $\{10\bar{1}1\}$ cleavage.

Evidence of nonhomogeneous strain within a deformed cylinder was noted in some cases—