relations in microcline and albite would be "parallel" whereas with the old setting they would be "anti-parallel" (or in "albite-twin-relation"). A new setting with

$$\alpha = 90°42, \quad \beta \approx 116°, \quad \gamma = 87°38$$

was therefore proposed (Laves, 1951b).

This proposal of "switching" has now been widely accepted (see *e.g.* Deer *et al.*, 1963, p. 15). However, it is not always realized that changing the old setting into the new one also necessitates a switching of the indicatrix into a position sketched in Fig. 2.

It may be thought that such arguments be a matter of semantics. However, a very practical purpose may sometimes be served by determining optically whether or not adjacent microcline and albite areas have a "coherent" $AlSi_3O_8$-framework. For example the plate-perthite intergrowth, a late stage microcline perthite development, may be mentioned (Laves and Soldatos, 1962).

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MECHANICAL TWINNING IN ACID PLAGIOCLASES

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After crystal-structural, physico-chemical, and petrological evidence had been adduced (Laves 1952a) to show that the high and low-temperature forms of $NaAlSi_3O_8$ differ as regards their Al/Si distribution, it was further shown (Laves 1952b) that the mechanical-twinning behavior of acid plagioclases furnishes additional evidence to confirm this conclusion.

Accepting the general correctness of Taylor's 1933 determination of the feldspar structure and by using only straightforward arguments concerning structure theory and twinning mechanisms, it was shown that acid plagioclases cannot twin mechanically unless their Al/Si distribution is sufficiently disordered, *i.e.* "topologically" monoclinic.

Earlier experiments of Mügge and Heide (1931) who did not succeed in experimentally producing mechanical twinning in albite (low) and the successful experiments of the writer (1952b) on analbite (which is disordered as regards Al/Si) are in good agreement with the proposed theory.

In a recent paper Vogel (1964, p. 624 and 625) questions the arguments of the writer. Referring to the paper by Laves (1952b) he writes:

"Laves (1952) advanced the theory that twinning could occur in plagioclase only where the Si/Al-O framework was nearly or exactly monoclinic. In albite or intermediate plagioclase only the disordered plagioclase approaches the monoclinic form. The results of the present study indicate that twinning can take place at any structural state and that the external scatter observed within a sample is due to twinning during this ordering process."

In so far as Vogel is referring to "growth twinning" or "annealing twinning" he may be right. If he is referring to "mechanical twinning" which was discussed in the note criticized (Laves, 1952b), he is certainly wrong.

A rather fuller version of the argument put forward in the 1952 note may be stated as follows: Consider a triclinic cell containing one Al and three Si sites. A distinction can be made between "acute" and "obtuse" cell corners. Assume the Al to be originally concentrated in an "acute" cell corner. By a deformation process similar to mechanical twinning the Al would be transferred to an obtuse cell corner. This would produce a "feldspar-like" material not identical structurally with the virgin crystal. This queer unstable feldspar-like material *would not be a twin*. To *become* a twin many (Al, Si)-O bonds would have to be broken and to be rearranged by a sort of reconstructive recrystallization, a process known to be very sluggish even at temperatures near the melting point (1100° C. and higher).

Among other things Vogel puts forward as certain evidence his Fig. 8 showing a Carlsbad twin in which albite-twin lamellae do not coincide with the Carlsbad-twin boundary. He states:

"Theoretically both of these twins have the (010) plane as the composition plane, however, the composition planes of the albite and Carlsbad twins in this grain are not parallel."

Two points must be mentioned concerning this observation. a) There is no theory capable of predicting the orientation (or orientations) of composition planes in twins. b) Most petrographers have noted that Carlsbad twinning is due to growth twinning and that the orientation of composition planes can be rather irregular and unexpected. Thus the present writer is not at all surprised at what is shown in Vogels Fig. 8 but altogether questions the conclusions drawn from it.

In this connection it may be mentioned that the writer (together with Irene M. de Sáenz, in a paper soon to be published) found that strange things may happen *after* twin formation: Many "Textbook" pericline growth twins of albite from the Swiss Alps and other localities have been investigated by single crystal x-ray techniques. In all cases it was found that the *macroscopical* composition plane is a "rhombic section" with σ approximately 20°. *Structurally* the material shows an orientation resembling that of a pericline twin but with (001) as the plane common to both parts of the "twin," *i.e.* with "σ"$=0$. Further it was found that the *structural* "twin" *orientation* is such that the "twinned" parts can be brought to superposition only by a rotation of 180° about an *irrational* direction lying in the (001) plane and deviating from [010] by amounts of approximately 30′ to 60′ varying from specimen to specimen. (The Buerger-precession method allows of an accuracy of $\pm 5'$ in such measurements).

Obviously the material "recrystallized" within geological times in such a way as to minimize the strain at the composition plane. Admittedly such relations can be determined by x-ray techniques allowing accuracies of approximately $\pm 5'$ but not by optical measurements as applied by Vogel in his investigation.

Another point must be mentioned in this connection. In the sentences quoted above, Vogel refers to "plagioclase" or to "albite or intermediate plagioclase." In my 1952b note, however, I restricted my arguments to such acid plagioclases which do not have a doubled c axis, as *e.g.* anorthite has. It was pointed out that the Al/Si arrangement in anorthite is such that mechanical twinning can occur under the conditions of Heide's and Mügge's experiments (1931). For intermediate plagioclases as, for instance, labradorite, available x-ray data do not suffice for a prediction whether or not mechanical twinning is possible in those possessing a maximum degree of order. However so long as they are in a sufficiently disordered (high-temperature) state they should be capable of mechanical twinning like that of the acid plagioclases. As nothing is known of the Al/Si distribution in intermediate plagioclases in an intermediate structural state, nothing can be predicted about their twinning behavior. On the other hand, experimental investigations of the mechanical-twinning behavior of such feldspars combined with investigations of the optical and x-ray properties of the untwinned and perhaps mechanically "twinned" areas may be helpful in obtaining qualitative information concerning the degree of order present in their Al/Si distribution.

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DEFORMATION TWINNING IN ORDERED PLAGIOCLASE

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The topic of deformation twinning in ordered plagioclase is a subject that deserves discussion because of the ubiquitous occurrence of plagioclase twinning and its potential as a petrogenic indicator. If plagioclase can twin regardless of structural state, and if this twinning can be dated with respect to the ordering history, plagioclase then becomes a very important tool in petrogenic interpretation. Thus the writers welcome Dr. Laves' (1965) discussion as an opportunity to review our own observations and conclusions with respect to the optical data.

In investigating plagioclase samples from a wide range of petrologic environments, ranging in composition from An_{30} to An_{90}, Vogel (1964) concluded that the scatter of optical orientation with respect to the twin elements indicated that plagioclase could twin mechanically regardless of the structural state. In review, this conclusion was based principally on the following observations (Vogel, 1964, p. 623):

1. There is negligible external optical-crystallographic scatter of deformation twins in plagioclase from volcanic samples and these plots fall on the disordered (high-temperature) migration curves. 2. Similarly, there is negligible external scatter of deformation twins in plagioclase from metamorphic samples and those plots fall on the ordered migration curve. 3. Samples that exhibit extreme external optical-crystallographic scatter of deformation twins are from coarse-grained, igneous-appearing rocks. This scatter commonly covers the area between the disordered and ordered migration curves. 4. When late-stage deformation twins can be recognized they exhibit negligible optical-crystallographic scatter and plot near the ordered migration curve.

Vogel's (1964) interpretation of these observations is that the external optical-crystallographic scatter of plagioclase twins from coarse-grained, igneous-appearing rocks is due to deformation twinning during the order-