CHARACTERISTIC PATTERNS OF PLAGIOCLASE TWINNING

By

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Abstract

Patterns of plagioclase twinning show characteristic differences in the following groups of rocks:

rocks in greenschistfacies: simple Gorai A- and Gorai C-twins, all with (010) as composition plane;
rocks in almandine amphibolite facies: lamellar Gorai A-twins, acline or pericline law more frequent than albite law;
thermometamorphic rocks: lamellar Gorai A-twins, albite law more frequent than acline or pericline law;
magmatic rocks: lamellar Gorai A- with simple Gorai C-twins.

For a short characterization of the twinning pattern it is suggested to use not only the amount of Gorai C-twins, but also the (010) twin ratio.

The request to lecture on this subject reached me only on arrival in Oslo. It was decided that I should give the general statement, which was, however, already published in a preliminary note (Tobi (1961 a)). Yet, for the sake of completeness, a short review of the lecture may here be given.

The Gorai method

To show certain characteristic differences in the patterns of plagioclase twinning in magmatic vs. metamorphic rocks, Gorai (1951) brought the various twin laws into two groups claimed to be distinguishable without the universal stage. The usually lamellar albite, acline and pericline twins, alone or combined in the same crystal, were designated as A-twins, all other twins, alone or combined with A-twins,

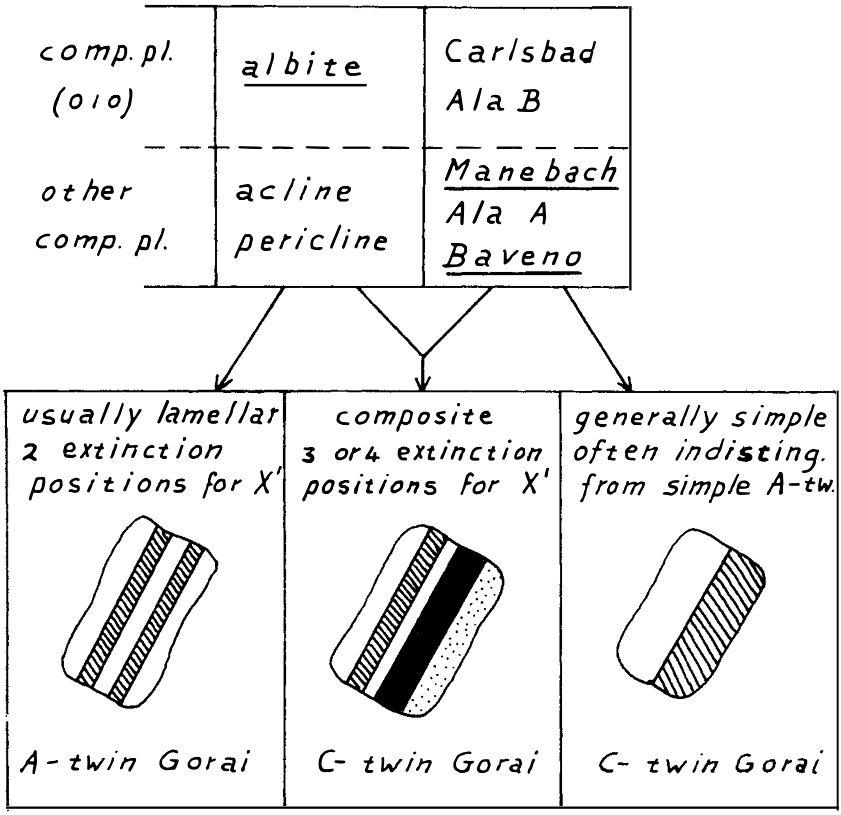

Figure 1. Diagram of the more important twin laws of plagioclase, indicating the Gorai distinction according to twin habit (vertical) and the additional distinction according to composition plane (horizontal) as proposed in the present paper. Normal laws with symmetrical extinctions with regard to the composition plane are underlined. Complex laws are omitted, since they usually occur in composite twins in which the corresponding normal and parallel laws are also represented.

as C-twins (figure 1). It appeared from his study that only magmatic rocks showed any appreciable amount of C-twins. This amount proved to be also dependent on the anorthite content, basic igneous rocks having more C-twins than acid rocks.

In the following the plagioclase twinning pattern of some major rock groups will be considered, and a refinement of the Gorai method will be proposed.

Albite grown in the greenschist facies

A special study was made of albite porphyroblasts occurring in low-grade metamorphic pelitic rocks of various parts of Europe. The twins are usually simple. The few lamellae present often end abruptly within the crystal, indicating growth twinning according to the morphological criteria of Vance (1961). Twins with composition planes other than (010) are absent. The distinction between Carlsbad and non-lamellar albite twinning is not easy, as the extinctions of the former are very nearly symmetrical in plagioclase of this composition. Even construction of the twin axis on a Wulff net is not unambiguous. With the universal stage they may be distinguished by making X of one individual parallel to the control axis. When, on turning on the control axis, the whole twin remains dark, it is an albite twin, when the other individual lights up, it is a Carlsbad twin. Fortunately, the existence of both laws is brought out clearly by the occasional presence of twins consisting of two large individuals with a narrow central lamella or wedge of other extinction in between. The two large individuals are usually twinned according to the complex albite-

Figure 2. Composite twinning in albite porphyroblast. The large individuals are twinned according to the albite-Carlsbad law. The wedge-shaped central lamella forms an albite twin with the left and a Carlsbad twin with the right individual. Note that the Carlsbad composition plane is less regular. The thin lamella at the upper end lies entirely inside the left individual. Crossed nicols, 50 ×.

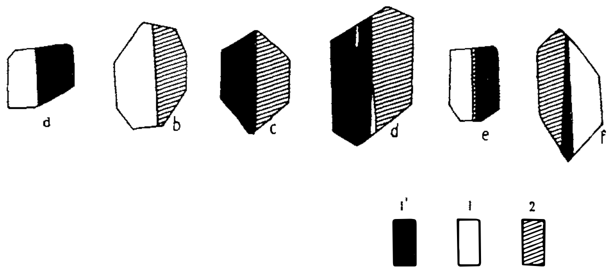

Figure 3. Characteristic twinning in albite porphyroblasts of the greenschist facies: 1–1′ : albite law; 1–2 : Carlsbad law; 1′–2 : albite-Carlsbad law. Usually a is the most frequent type, followed by *c* and *d*.

Carlsbad law, with almost equal extinction positions at the same side of the composition plane, while the central wedge forms an albite twin with one side and a Carlsbad twin with the other (Figures 2, 3). These composite twins are usually rarer than simple albite twins, but more frequent than simple Carlsbad twins. They were found in albite

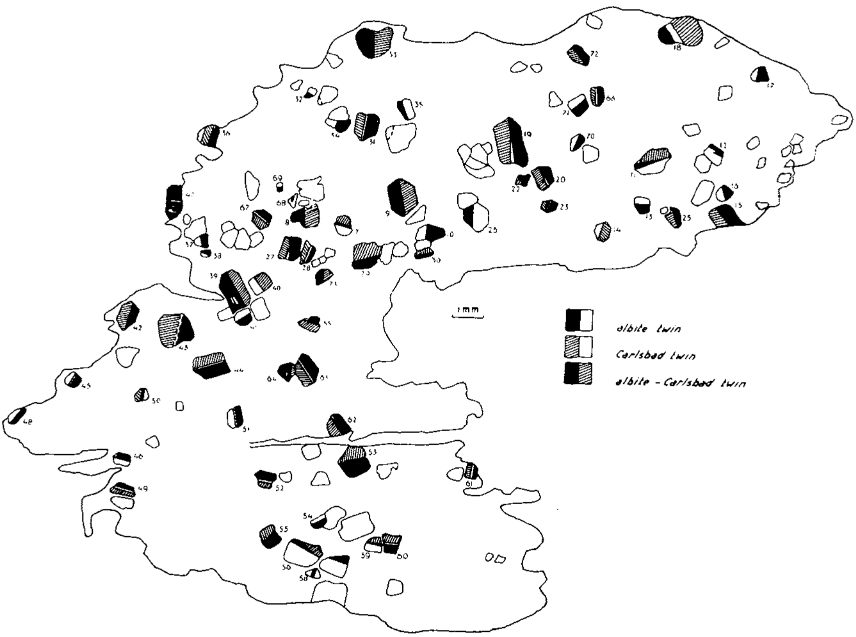

Figure 4. Diagram of thin section of a sericiteschist with albite porphyroblasts displaying an unusual amount of albite-Carlsbad twins. Belledonne Massif, France.

porphyroblasts of all regions studied. An example with a rather unusual abundance of these twins is shown in Figure 4. Clearly, such rocks do not follow the rule of Gorai, even where far less albite-Carlsbad twins are present.

The same pattern may be shown by non-porphyroblastic albite. Smaller crystals, however, are less frequently twinned, while it is often more difficult to prove their growth under greenschistfacies conditions.

Plagioclase grown in the almandine amphibolite facies

Twinning is here generally lamellar: all twins are A-twins in the sense of Gorai. A distinction between albite twins on one hand and acline or pericline twins on the other is possible in all sections normal to the composition plane. Fulfilment of one or more of the following conditions points to the acline or pericline twin:

1) positive elongation
2) distinctly asymmetrical extinction positions
3) very low birefringence in one or both individuals

Lamellar twins showing none of these properties are albite twins. These criteria are not valid for plagioclase with an anorthite content higher than about 70%, which, for all we know, is not formed in this metamorphic facies. More data on the rapid recognition of twin laws were given in another paper (Tobi (1961b)).

When the lamellar plagioclase twins of micaschists and amphibolites in this metamorphic facies are studied in this way, it appears that acline or pericline twins are generally more frequent than albite twins. The lamellae are usually glide twins according to the morphological criteria of Vance (1961). Perhaps pericline twins are more frequent than acline twins. The distinction is often not easy, and even impossible at 40% An, where the rhombic section coincides with (001). Usually both laws are present, they may even be found in the same crystal (Figure 5).

Plagioclase grown under thermo-metamorphic conditions

Here twinning is less frequent and generally lamellar (no Gorai C-twins), if the rock is not imbued with a melt, in which case the pattern may become magmatic. As a rule, albite twins are distinctly more

Figure 5. Plagioclase crystals with lamellar acline and pericline twinning in amphibolite of the almandine amphibolite facies. Below the centre of the photograph a crystal in extinction position shows a pericline "band" at a small angle to a few acline lamellae. Belledonne Massif, France. Crossed nicols, 70 ×.

frequent than acline or pericline twins. This rule appears to hold true not only for obvious cases such as hornfelses, but also for deeper-seated metamorphism at higher temperatures than indicated by the normal gradient (micaschists with andalusite instead of kyanite). Even part of the sillimanite-almandine subfacies, frequently influenced by "perimagmatic processes" (Fyfe. Turner & Verhoogen (1958) p. 230), shows this twin distribution.

Eventually, a statistical analysis of twinning might become an important tool in the study of types of metamorphism intermediate between Dalradian and thermal metamorphism.

Plagioclase in magmatic rocks

Plagioclase crystallized from a melt shows more varied patterns of twinning than plagioclase of metamorphic origin. Lamellar twins are of general occurrence, and, as was pointed out by Gorai, a fair amount of C-twins is usually present. In addition, we can say that twins with (010) as composition plane are distinctly more frequent than other twins. Indeed, the abundant occurrence of albite and Carlsbad twins is so well known that deviations from this general rule are easily over-

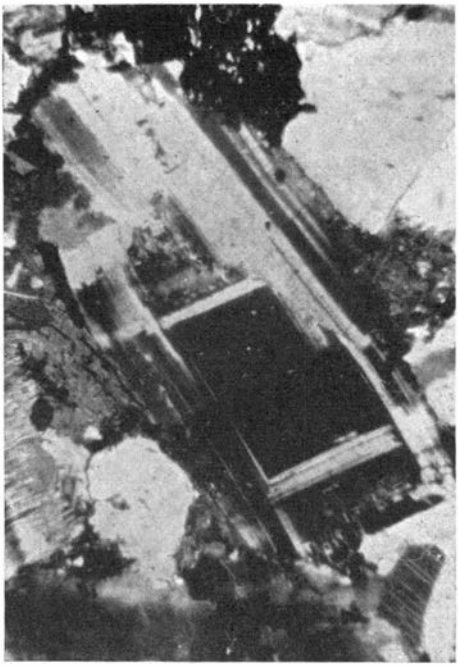

Figure 6. Lamellar albite twinning combined with a simple Ala A twin in plagioclase of a metamorphic trondhjemite, Tydal region, E. of Trondheim, Norway. The larger crystal shows also acline twins. Crossed nicols, 15 ×.

looked in routine microscopic petrography. As an example, the aberrant pattern of twinning in a metamorphic trondhjemite of the Tydal region, E. of Trondheim, may here be mentioned. In this rock the majority of twinned plagioclase crystals consist of albite lamellae combined with a transverse Ala A twin (Figure 6). A similar pattern was found in certain spilites in the Odemira region in Portugal.

The (010) *twin ratio*

To bring out more clearly the differences in twinning pattern outlined above, a refinement of the Gorai method would seem useful. The present author suggests that not only the relative amount of C-twins, but also the relative amount of twins with (010) as composition plane should be taken into consideration. This "(010) twin ratio" should be 1.00 for albite grown in the greenschistfacies, 0.75–1.00 for

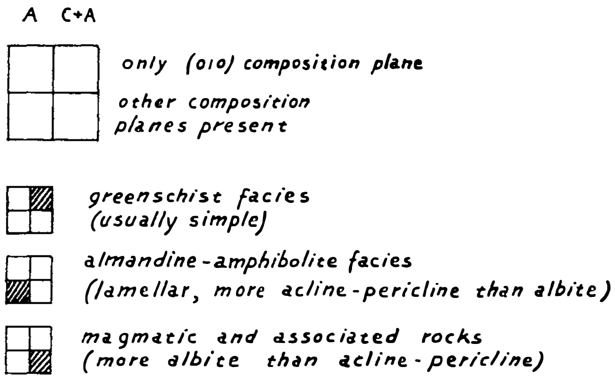

Figure 7. Diagrams showing qualitative differences in the plagioclase twinning pattern of some major rock groups. The presence or absence of C-twins and of composition planes other than (010) is indicated by shading of a quarter of the squares the significance of which is shown in the large square.

plagioclase of magmatic rocks and hornfelses, and smaller than 0.50 for plagioclase grown in the almandine amphibolite facies (fuller data in Tobi 1961 a).

It must be pointed out, however, that a cumbersome counting of all twins present is seldom necessary for classification of a thin section in one of the discussed main groups: the differences are often qualitative rather than quantitative. Albite of the greenschistfacies should not show a single composition plane with positive elongation, plagioclase of the almandine amphibolite facies should not show a single twin with more than two extinction positions. This qualitative aspect is illustrated in Figure 7.

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