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Plate perthite, a new perthitic intergrowth in microcline single crystals, a recrystallization product

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Auszug

Eine neue Art perthitischer Verwachsung wurde in Mikroklinen von fünf verschiedenen Lokalitäten gefunden. Sie wurde nur in solchen Mikroklin-Bereichen gefunden, die als unverzwillingte, relativ große Einkristall-Bereiche in Erscheinung treten. Die Orientierungsbeziehungen wurden röntgenographisch gemessen (Tab. 2). Sie sind derart, daß die Al/Si-Verteilung in den $AlSi_3O_8$-Gerüsten von Wirt und Gast „topologisch kohärent" ist. Die in Dünnschliffen beobachtbare morphologisch charakteristische Verwachsungsart wird beschrieben. Wegen des plattigen — nahezu (001) parallelen — Charakters der Albiteinlagerungen (Tab. 1) wird eine Bezeichnung „Platten-Perthit" vorgeschlagen. Die Bildungsweise dieses Platten-Perthites wird diskutiert.

Abstract

A new type of perthitic intergrowth has been discovered in microcline from five different localities. It was only found in those parts of the microcline which occur as relatively large untwinned monocrystalline areas. The orientation relations were measured by x-rays (Table 2). They are such that the Al/Si distribution in the $AlSi_3O_8$ framework of the host and guest is "topologically coherent". The characteristic morphological intergrowth as seen in thin sections is described. The name "plate perthite" is proposed because of the plate-like nature of the inclusions of albite, which are nearly parallel to (001) (Table 1). The mode of formation of the plate perthite is discussed.

In the course of an investigation of the albite/microcline orientation relations in microcline-perthites (LAVES and SOLDATOS, 1962) an unusual perthitic intergrowth was found several times where the micro-

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cline was developed as a single crystal or where it consisted of broad lamellae or areas of single-crystal character. This intergrowth has a characteristic appearance in thin sections and exhibits lattice orientations which differ from the more usual ones in a rather well definable way. The special name "plate-perthite" is proposed for this kind of intergrowth, to distinguish it from the other kinds of intergrowth for which names such as "vein, film, string, patch perthites" are in common use (ANDERSEN, 1928).

Optical appearance

1. In (001) sections the plate albite appears as irregular "cloudy" areas which do not extinguish completely but only change their interference colour when the thin section is rotated between crossed nicols, thus indicating the existence of thin platy inclusions approximately parallel to (001).

2. In (010) sections lamellae are visible with relatively sharp boundaries against the microcline (Figures 1 and 2). The extension

Fig. 1. Microphotograph of specimen S 478 (cf. Fig. 3), Eaganville, Ontario. Section parallel to (010); crossed nicols; 48 ×. Plate albite is visible parallel to the cleavage traces of (001). Vein albite (thick) and film albite (thin) are also visible nearly vertical, and parallel to the c-axis direction. The albite appears white.

of the plates appears approximately parallel to the trace of (001). Table 1 gives some details.

3. In sections ⊥ to the *a* axis these lamellae also show relatively sharp boundaries against the microcline, but somewhat more inclined to the trace of (001). This is shown in Figures 3 and 4 and in Table 1.

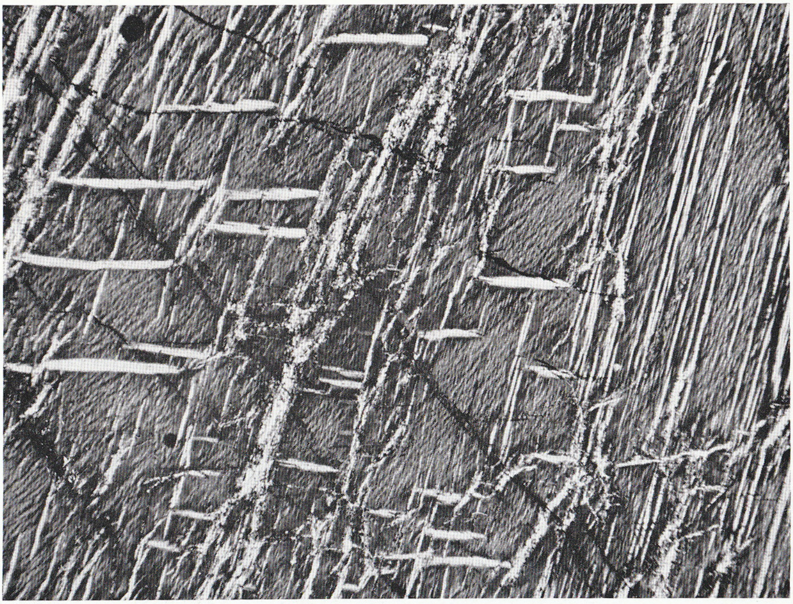

Fig. 2. Microphotograph of specimen S 1277, Yxsjveberg, Sweden. Section parallel to (010); crossed nicols; 50 ×. Plate albite is visible parallel to the horizontal traces of (001). Two generations of perthitic albite (thick and thin) are also visible. Their direction, nearly vertical, approaches the *c*-axis direction. The albite appears white

Table 1. *Values of the average plate directions relative to the trace of the (001) cleavage*

Specimen No.	In (010) sections (cf. Fig. 1 und 2) —"ϱ"	In sections perpendicular to the *a* axis (cf. Fig. 3 and 4) — "ω"
S 478	+ 1° to + 9° (up to 25° in rare cases)	17° to 21° (up to 24° in rare cases)
S 477	— 1° to + 6°	28° to 30°
S 486	+ 3° to + 7°	14° to 16°
S 436	+ 2° to + 5°	15° to 16°
S 1277	+ 2° to + 6°	not measured

It is important to note that the plate albite, in contrast to the vein albite, is not twinned and that it always has the same optical orientation within a microcline single-crystal area (Fig. 4).

It may well be that the intergrowth described above is identical to that described by WARREN (1915, p. 131) and by GOLDICH and KINSER (1939, p. 418) but these authors do not give descriptions in

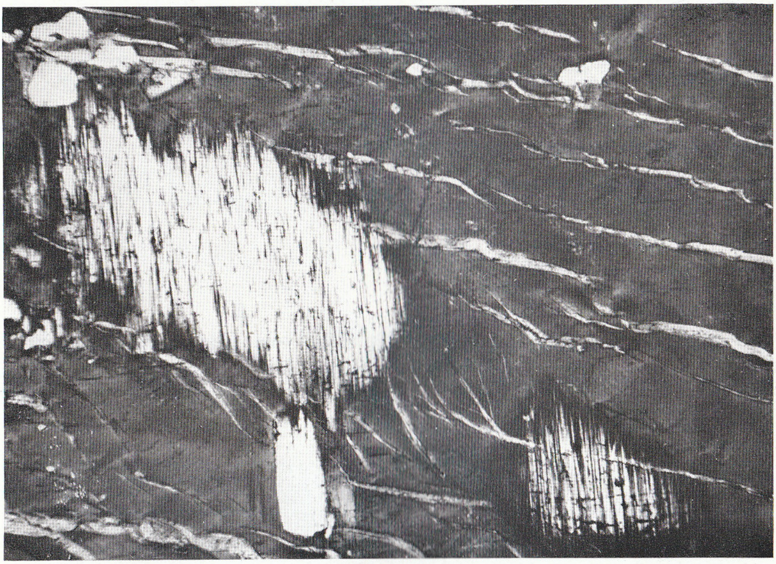

Fig. 3. Microphotograph of specimen S 478 (cf. Fig. 1). Section perpendicular to the a axis, crossed nicols, 44 ×. The trace of (010) is the direction of the twin lamellae in areas of vein albite (white); the perpendicular direction of the (001) cleavage trace is also faintly visible. The plate albite appears here as grey bands in a nearly horizontal direction. Note the angle: plate direction/(001) cleavage $\approx 20°$. The darkness of the haloes around the areas of the light vein perthite is a consequence of the difference of extinction direction compared to the extinction direction of the microcline single crystal. In these regions the process of microcline replacing vein albite and redepositing it as plate albite is not complete. X-ray photographs of such halo material without visible albite showed them to still contain appreciable amounts of submicroscopic "unexpelled" vein albite material which may cause the observed difference of extinction directions in the main microcline material and the halo regions

sufficient detail to allow a conclusion of identity. It is true, however, that GOLDICH and KINSER consider their intergrowth as "new" enough to give it a special name to discriminate it from names given by ANDERSEN (1928). Considering a (010) section they write (p. 419): "Although spindles measuring about 0.1 mm in length and being distinctly larger than the albite films appear to be related to the direction (001), but actually the direction of the blebs intersects the trace of (001) at an angle of about 12°. Although rare and as yet unnamed, this type of albite development is probably deserving of the rank of a textural variety." No name was proposed, however.

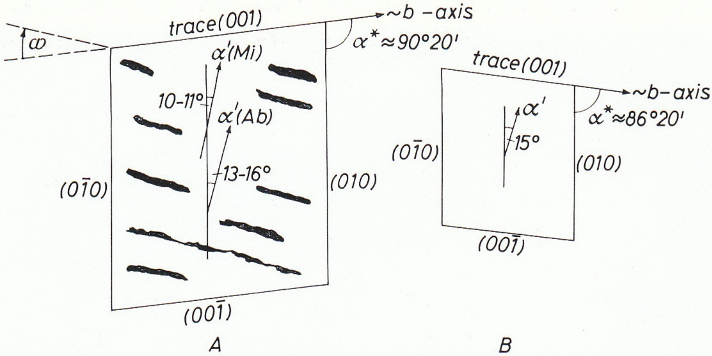

Fig. 4. A. Schematical drawing of the plate albite in a single crystal of microcline (the lattice angles α^* somewhat exaggerated) and with the measured extinction angles. The direction of view is the negative a-axis direction. B. For comparison the extinction angle in a section of albite $\perp$ to the a axis is drawn

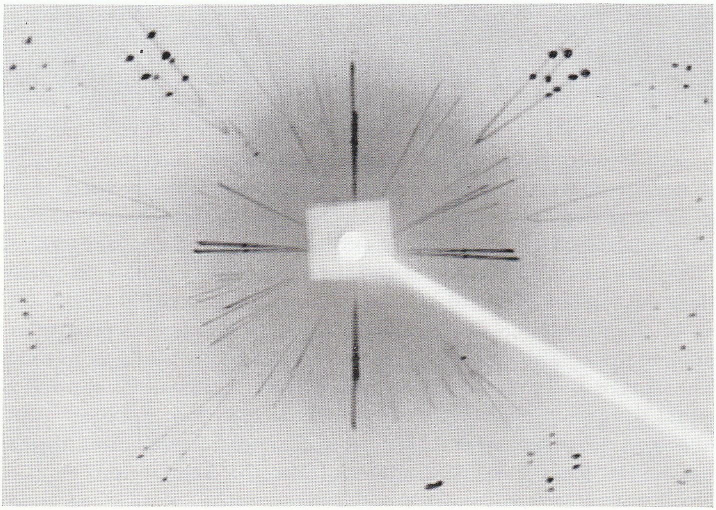

Fig. 5. Orientation photograph (Buerger precession method) without layer-line screen, $\mu = 10°$, Cu radiation, 40 kV, 15 mA, 2 hrs. with the average a axis = precession axis. The positive direction of the b^*-axes points to the right. The positive c^* directions point down. The direction of view is the negative a direction, and in the left-upper quadrant the conventional α^* angles are formed (microcline orientation after LAVES, 1951)

Orientation relations as revealed by x-ray methods

The plate albite has been found by us in five specimens from different localities. For x-ray photographs with the Buerger precession method the samples were cut from thin sections [(001), (010) or ⊥ *a*-axis]. They were always chosen in such a way that they contained both albite and microcline. The x-ray photographs were taken with the *a*, *b* and *c* axes as precession axis. Orientation photographs (see

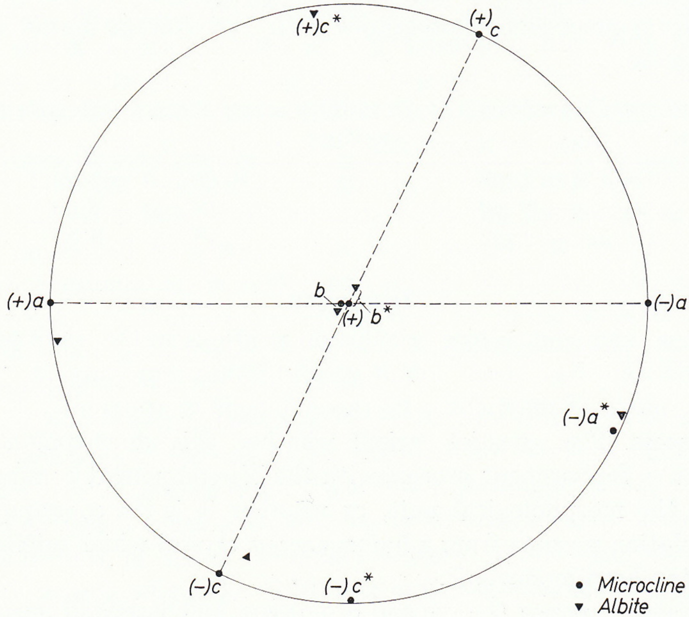

Fig. 6. The space relations of the values of Table 2 are roughly sketched in this stereographic projection in an exaggerated scale, i. e. the dots related to microcline are constructed rather exactly and the triangles related to albite are placed near the microcline dots in the right direction but with a distance enlarged by a factor of approximately 2.5

Buerger, 1944) are very sensitive for the characterization and measurement of orientation relations. Figure 5 shows such a characteristic photograph.

1. Crude orientation relations

In all five cases it was found that the positive *a*-, *b*- and *c*-axis directions of the microcline and the albite nearly coincide, if for albite the conventional orientation is chosen and for microcline the revised one by LAVES (1951). This means that both structures are related to each other in such a way that, as far as the Al/Si-distribution is concerned, a topological coherency exists.

2. Refined orientation relations

Differences in direction between corresponding microcline and albite axes have been found; these are listed in Table 2 and sketched in Fig. 6. Both components have $(10\bar{1})$ approximately in common (as taken from precession photographs with the average b axis as precession axis).

Table 2. *Orientation relations of the microcline and albite lattice axes in plate perthite*

$a \wedge a = 3°00'$	$a^* \wedge a^* = 2°10'$
$b \wedge b = 1°30'$	$b^* \wedge b^* = 3°00'$
$c \wedge c = 2°30'$	$c^* \wedge c^* = 3°10'$

Discussion

As the microcline-albite orientation relations in the plate perthite described here hav ebeen found several times, but only in "single-crystal" areas of microcline, its development is apparently a rather late process. The question arises whether this development took place as a replacement process with the Na component coming from outside the morphological unit, or whether it is the consequence of an exsolution process from a homogeneous crystal which might originally have been monoclinic.

In another paper (LAVES and SOLDATOS, 1962) several arguments are discussed which suggest that "vein" perthites originate by an exsolution process which takes place during the early stages, i. e. at a time when an originally Na-containing, K-rich feldspar was still truly monoclinic. It was further concluded that the development of "film" perthite and cryptoperthite also occurred by an exsolution process during later stages, when the truly monoclinic sanidine inverts to microcline by forming finely twinned domains, which increase in triclinicity as time proceeds.

Down to this stage the perthitic albite (be it vein perthite, film perthite or cryptoperthite) is oriented relative to the finely twinned microcline in a "monoclinic" way, i. e. b^* of the exsolved albite is parallel to b^* of the microcline twinned after albite law or/and parallel to b of the microcline twinned after pericline law (in the above-mentioned paper called exsolution type I)

Then follows a stage in which recrystallization plays an important rôle: The number of twin-domain boundaries diminishes with the tendency to form a single microcline crystal. One step in this process is the formation of more or less coarsely twinned domains with sharp boundaries, thus relieving the strain energy at the diffuse boundaries. Domains which are coarse enough to be cut out of thin sections for single-crystal photographs may be considered to possess already "single crystal" character. X-ray photographs of such material also reveal albite exsolved as cryptoperthite, but with orientations which are related no longer to the original monoclinic framework but rather to the microcline as a triclinic host. These relations are described in detail as Type II by LAVES and SOLDATOS (1962). (Intermediate cases between I and II have also been found and discussed). Thus, one has to assume that in such cases the single-crystal character has developed at temperatures high enough for the microcline to retain considerable amounts (up to $2^0/_0$) of Na feldspar in solid solution above the amount which can be held at lower temperatures. This amount is expelled later, be it in the course of cooling, by a further increase of triclinicity or by both.

Now, as far as boundary energy is concerned, these various orientation relations of the exsolution products are obviously not ideal in a single crystal of microcline. Therefore a thorough re- and „Sammel"-crystallization takes place leading to an arrangement of the albite in orientations of lesser boundary energy within the morphological perthite unit, where the Al/Si distribution is coherent in the microcline host and the albite guest.

Of course, such an orientation might possibly be produced by a later replacement process. However, one case was observed in which the above proposed rearrangement process was caught in action. Figure 3 shows clearly the vanishing of the vein perthite suggesting a growth of the plate perthite at the expense of the vein perthite.

At least in this last case the development of the plate perthite as a late consequence of exsolution and recrystallization without apparent change of the bulk composition appears to be the most probable explanation of the observations. Thus, we are inclined to generalize this observation and to believe that plate perthite is indicative of a late-stage exsolution process concurrently modified by recrystallization and rearrangement without a necessary change of the original bulk compostion.

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