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# **Note on the Different Alkali Feldspar Generations from a Druse from La Paz (Canelones, Uruguay)**

By *Irene Michaelis de Sáenz* (Montevideo)\*)

With 8 figures in the text

## **Abstract**

The druse feldspars from La Paz (Canelones, Uruguay) are an example of genetic feldspar relations at rather low temperature. They were originated and/or affected by the following processes: Syncrystallization in the range of partial alkali feldspar miscibility, unmixing, epitaxial overgrowth, substitution of one feldspar by another by alkali ion diffusion, corrosion and complete replacement of former minerals, massive crystallization of a microcrystalline saccharoid mass, reordering and recrystallization, the latter affecting the type of twinning. Five different albite generations are identified. Simple explanations of epitaxial overgrowth and interpretation of the phase-temperature relations cannot be applied.

## **Zusammenfassung**

Als Beispiel der Mannigfaltigkeit der verschiedenen Vorgänge, die zur Entstehung der Drusenfeldspatphasen beitragen können, wurden die Feldspäte einer Druse aus La Paz (Canelones, Uruguay) untersucht. Es ergab sich, dass folgende Prozesse zur Entstehung der jetzigen Phasen beitrugen: Synkristallisation im Bereich der teilweisen Mischbarkeit, Entmischung, orientierte Überwachsung (Epitaxie), Ersetzung eines Feldspats durch einen anderen mit Aufrechterhaltung des Al/Si-Gerüsts durch Alkali-Ionen-Austausch; vollständige Korrosion und Ersetzung anderer Minerale durch Feldspat; plötzliche Kristallisation eines unregelmässigen feinkörnigen Feldspatkristallaggregats, diffusiver Si/Al-Ordnungsprozess und Rekristallisation mit Änderung der Zwillingsbeziehungen. Es wurden fünf verschiedene Feldspatgenerationen erkannt. Vereinfachte Erklärungen für die orientierte Überwachsung und genetische Deutungen, die auf Feldspatphasen-Temperatur-Beziehungen begründet sind, sind in diesem Fall nicht anwendbar.

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## INTRODUCTION

The genesis of alkali feldspar phases under pneumatolytic and hydrothermal conditions depends in a complicated manner on numerous varying factors. (Compare M. DE SÁENZ, 1967, the following paper.) It should be noted that excessive simplification of the temperature-phase relations may result in misleading conclusions. In the samples from La Paz (Canelones, Uruguay) originally metastable phases crystallized, while ordering, unmixing and recrystallization occurred later on as usual. Due to a considerable change in the Na/K relation of the fluid phase or hydrothermal solution, substitution and albitic overgrowth of idiomorphic albite on orthoclase is accompanied by a local substitutional process so that the rather simplified explanation of KERN and GINDT (1958) cannot apply. Another interesting fact is the occurrence of irregularly albite-twinned microcline, very similar to the one described by BARTH (1959) which certainly lost its crosshatched twinning by recrystallization under the influence of the solution which also deposited the secondary albite crystals.

## OCCURRENCE AND PARAGENESIS. MICROSCOPIC DETERMINATIONS

The samples used in the present study were kindly put at our disposal by Mr. W. Caggiano, who collected them from a pegmatitic druse, located 2 km from La Paz (Canelones, Uruguay). The place is at present no longer accessible.

The walls of the druse consist of a rock with pegmatitic homeoblastic texture and is mainly formed of orthoclase, albite, quartz and siderophyllite. A granophyric quartz-albite mass fills the spaces between the idiomorphic quartz and feldspar crystals of the rock (fig. 1, 2 and 3). The albite is mostly twinned after the albite law with rather coarse crystal individuals. It is not perfectly fresh. Granophyric albite is much fresher and its optic axial angle is somewhat larger (see fig. 3). Here only the determinations carried out on sample P-5 are reproduced but numerous other determinations gave similar results. Carlsbad twinning is not found in the other samples. Orthoclase presents micropertthitic unmixing as film-perthite. It contains abundant haematite lamellae which can be clearly seen with dark field illumination. The pink colour of the potassium feldspar is due to these inclusions, as well as to the rather high iron content indicated by the bulk analysis of these feldspars.

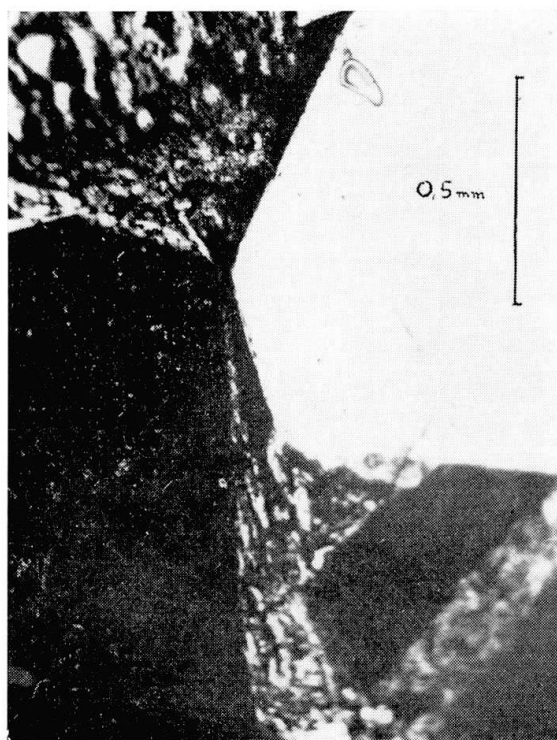


Fig. 1.

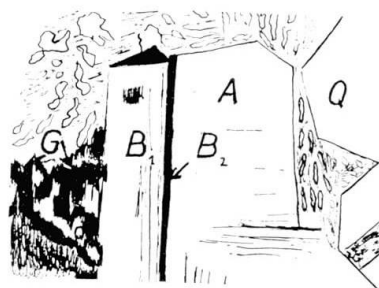


Fig. 2.

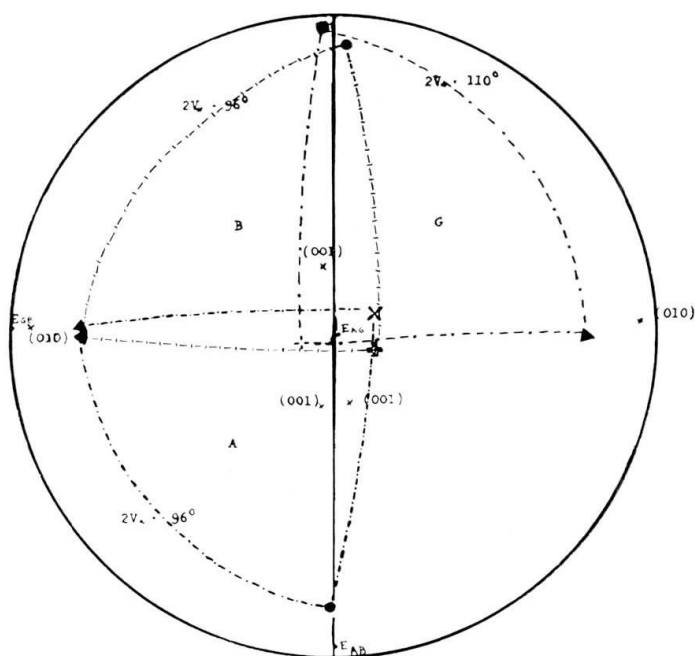


Fig. 3.

Fig. 1, 2 and 3. Photo, sketch and stereographic projection of sample P-5. Primary albite twinned after the Carlsbad and albite law. The albite law individuals are  $B_1 - B_2$ , A and  $B_2$  are related by the Carlsbad law.  $B_2$  is only a thin film between A and  $B_1$  so that observed with a low-power objective it seems as if A were related to  $B_1$  by a twinning axis  $E_{AB}$ . The whole crystal appears black on the photo, its details being given in the drawing. The albite crystal as well as an idiomorphic quartz crystal (white in fig. 1) are surrounded by a granophyric albite-quartz association. (Compare DRESCHER-KADEN 1948). The granophyric albite has the orientation G (see fig. 2 and 3) which is parallel to that of  $B_2$  although the optical properties are somewhat different. No corrosion signs are seen on the primitive albite nor on the quartz so that it must be assumed that the granophyric mass crystallized later, simultaneously between the primary crystals.

From the pegmatitic walls large idiomorphic crystals grow towards the center of the druse. "Orthoclase" crystals with monoclinic habit, between 1 and 40 cm long are found, usually in oriented intergrowth with quartz. The core of the large orthoclase crystals is a typical runite; some of the runitic quartz crystals penetrating the feldspar crystal emerging as groups of parallel idiomorphic, low-temperature quartz crystals; some of them are colourless and others are smoked. They reach a size of up to 40 cm. Beryl crystals also occur. They are rather altered and of a greenish-white colour. Some of them are also of considerable size. Siderophyllite with  $n_\beta = 1,69 \pm 0,005$ ,  $2V_\alpha = 17,5^\circ \pm 0,5^\circ$ , dispersion of the optic axes  $v > r$  and a powder diagram similar to that of biotite, is found in isolated crystals usually not larger than 2 cm. Albite is found as primary, rather poorly developed crystals together with orthoclase. Idiomorphic albite

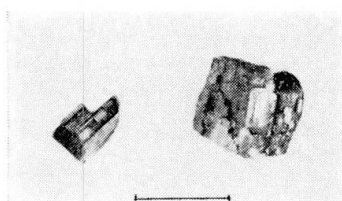


Fig. 4. Orthoclase crystals covered with idiomorphic crystals of epitaxial albite. A uniform albite layer covers the face (010). (Natural size.)

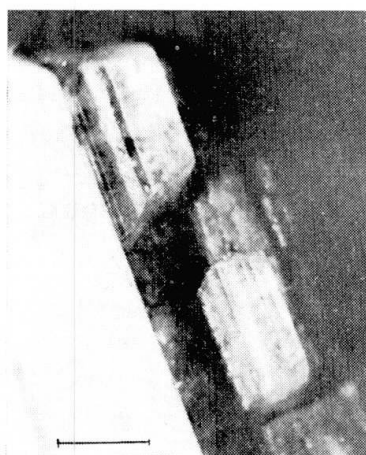


Fig. 5. Idiomorphic albite crystals with "staircase faces". The uniform albite layer on (010) with idiomorphic outlines towards (+a) is also visible. (5 mm on the photo = 1 mm.)

crystals with an uncommon habit, up to 5 mm in length, occur in epitaxial overgrowth on orthoclase (fig. 4 and 5). The whole group of idiomorphic crystals is covered with a thin layer of light brown iron oxides. On top of this layer a saccharoidal mass of microcrystalline albite is found, filling in cracks and hollow spaces, corroding the earlier minerals and the wall rock, especially orthoclase and quartz. This albite is finely twinned usually after the albite and pericline laws. Its extinction is not always uniform. The contour of these small albite crystals is very irre-

gular, even in places where no corrosion occurred. It is fresher, more finely twinned and has a larger 2V than the primary albite. Where it is in contact with other minerals it usually corrodes them. This is never the case with primary albite.

The severe corrosion of quartz crystals in this latest stage of albitization can be observed macroscopically as well as in thin sections of the rock. Substitution of orthoclase by albite is also evident in some places. Typical replacement features such as patch-perthite, chessboard albite etc. are found. In some places the impurities of orthoclase were expelled during substitution towards the interphase. They are found along the crystal border, the contact with microalbite in the perthitic crystals or cracks in the original crystal. It is interesting to observe that in some cases substitution was probably at first not complete, and inclusions accumulated along the perthitic albite films. Finally all the orthoclase was substituted by albite in some areas and the inclusions are now found along the directions formerly occupied by microalbite films in a rather uniform albite area. These inclusions are oriented in parallel direction with the microalbite of the non-substituted areas (fig. 6).

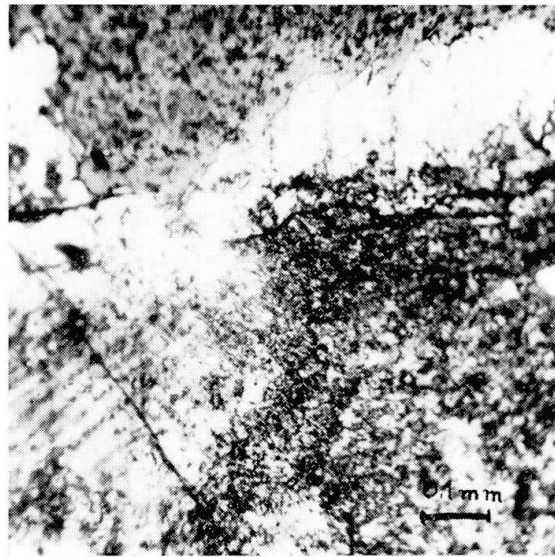


Fig. 6. Inclusions in albite formed by ion exchange from perthitic "orthoclase". The inclusions follow the direction of the original microcline-albite interphase. (Compare the text.)

#### EPITAXIAL ALBITE OVERGROWTH

Oriented overgrowth of albite on orthoclase or microcline has often been described, especially in low-temperature feldspars of druses or cracks. KERN and GINDT (1958) discuss the structural relations of this

albite-microcline association. Their arguments, however, seem to be somewhat over simplified. LAVES (1952) already discussed the structural relations of albite to a monoclinic or pseudomonoclinic K-feldspar host in perthites, pointing out that twinning helps to adapt the triclinic albite to its host. The influence of twinning is certainly also of main importance in oriented feldspar overgrowths. Albite finds great difficulty in adapting itself to a single microcline crystal in "diperiodic" epitaxial association, on account of the angular differences of the lattices. Usually the overgrowth occurs in cases of crosshatched twinned microcline with four different crystal orientations and twinned albite with at least two different orientations. Both crystals are related to one another as if they were pseudomonoclinic. Such a crystal association should perhaps rather be called "pseudo-diperiodic" if this term is employed at all.

In our samples the microscopic determinations reveal that oriented overgrowth was accompanied by a very limited substitutional process. The outline of the ancient monoclinic orthoclase crystal is bounded by a thin layer of impurities probably due to alterations at the surface of the original crystal. Underneath this layer a 0,3 mm thick zone is found which grades from albite on the outside into microcline towards the center of the crystal. In this intermediate zone a variation in the refractive index ( $n'_\gamma$ ) on (001) from 1,523 to 1,527 was measured. The epitaxial idiomorphic crystals have a refractive index ( $n'_\gamma$ ) of 1,537. The optic axial angle for the intermediate zone varies between  $2V_\alpha = 70^\circ$  and  $2V_\alpha = 82^\circ$ , its value being  $113^\circ$  for the idiomorphic albite crystals. The epitaxial albite is pure low-temperature albite with a very low An content and presents no multiple twinning. This was also confirmed by spectrographic analysis and X-rays.

Simultaneously with albite outgrowth, recrystallization of the sub-microscopically or finely twinned microcline occurred. Microcline, twinned only after the albite-law with irregular contact faces is found near to the crystal surface (fig. 7 and 8). The albite-law twinning was probably maintained on account of the influence of the albite-twinned microalbite contained in the primary orthoclase.

Although in our samples contacts of single crystal areas of microcline with single crystal albite occur, they are connected by a zone of intermediate Na/K content.



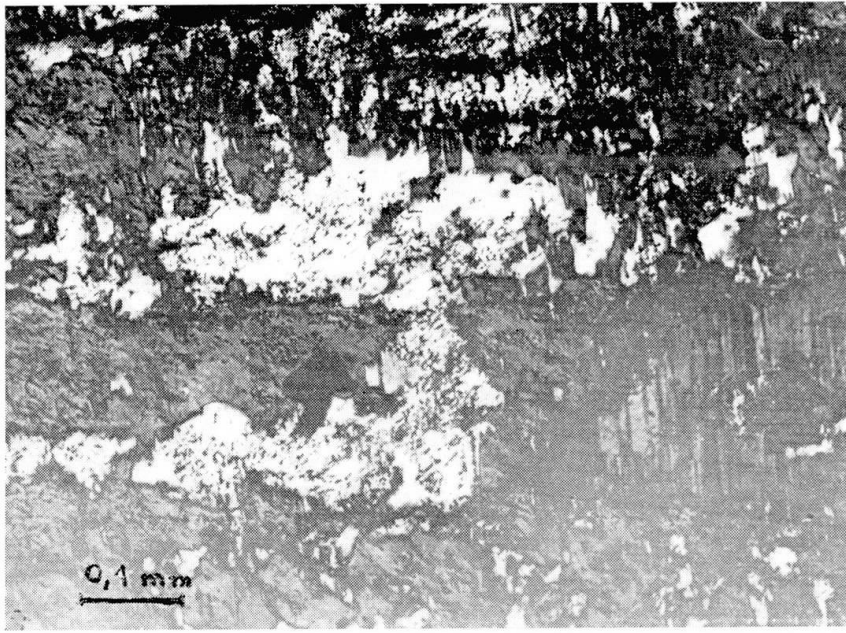


Fig. 7. Albite-twinned microalbite and irregular twins of microcline.

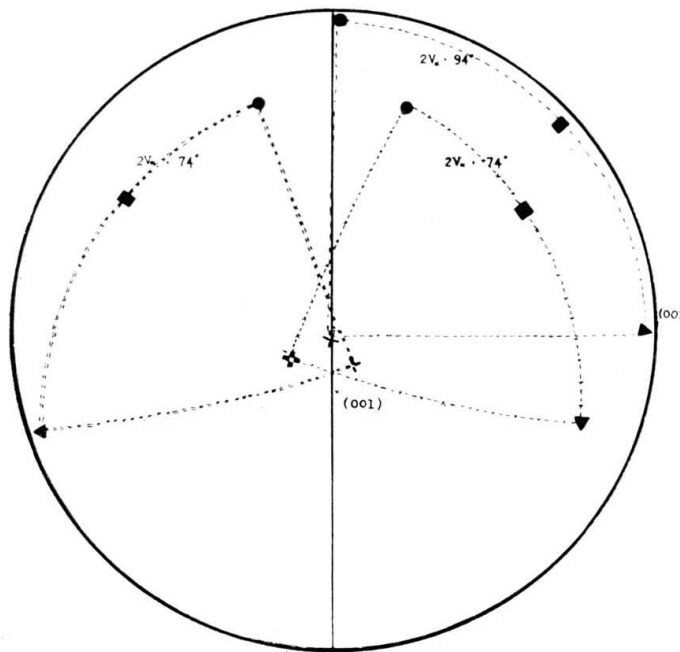


Fig. 8. Stereographic projection showing both orientations of microcline and one of the albite positions.



## GENESIS OF THE DIFFERENT FELDSPAR PHASES

Crystallization and later transformation of the feldspar phases of these samples occurred in pneumatolytic and hydrothermal environment. (Compare for definitions NIGGLI 1948.) The crystallization of the druse-wall must have occurred somewhat below 600°C, in the zone of partial alkali feldspar miscibility. Crystallization temperatures cannot be determined from the composition of these phases as it was considerably altered by subsequent diffusive processes. The large idiomorphic crystals also crystallized from fluid phase under low pressure conditions. They were originally monoclinic but ordered and recrystallized later. The Na/K relation in the solution must have increased considerably towards the end of this period as finally pure albite was deposited on the primary orthoclase crystals and partial albitization occurred in minor superficial areas. Recrystallization was intense towards the end of the crystal deposition. Crosshatched twinning disappeared in many places, an irregular albite-twinned microcline being left over.

Ordering progressed considerably in most crystals. In the final period of crystallization pneumatolytic conditions were replaced by hydrothermal ones. The concentration gradient was steep, probably due to rapid evaporation and cooling. Crystallization speed and low ion mobility did not permit the growth of idiomorphic ordered albite crystals. A saccharoidal microcrystalline albite mass was deposited and the highly corrosive hydrothermal albite solution attacked quartz and orthoclase replacing these minerals by albite. The fine crosshatched twinning of this albite suggests that it probably was originally monoclinic.

## FINAL CONSIDERATIONS

These samples seem to be an interesting example of the complicated processes which occur as feldspars crystallize from pneumatolytic or hydrothermal environments. It is only too evident that in none of these phases composition or structural state can be taken as a guide for the determination of crystallization temperature. Also the frequently described, apparently simple, epitaxial overgrowth of albite on orthoclase or microcline is in this case a combination of overgrowth with a substitution process, and is accompanied by recrystallization of the host feldspar. A more detailed study of the relation between ion mobility and progressive ordering of the solid phase is proceeding with the aim of confirming the viewpoint put forward in this paper.

*Acknowledgement.* The writer wishes to thank Mr. W. Caggiano for supplying the specimens for this study.

*Note:* This work was done in partial fulfillment of the thesis submitted for the degree of Dr. en Química of the University of Uruguay, Montevideo. The final conclusions are published in the same issue of this journal.

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