

## NOTES AND NEWS

## EXPLANATION OF STRAIN AND ORIENTATION EFFECTS IN PERTHITES

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Laves (1952, p. 562), Coombs (1954) and others have noted that the compositions of the two phases of a perthite, determined from  $(\bar{2}01)$  spacings, are sometimes impossible: for example values have been obtained indicating minus ten per cent  $\text{NaAlSi}_3\text{O}_8$  in the potassium-rich phase and more than one hundred per cent in the sodium-rich phase. Laves pointed out that there must be serious distortions of the Si, Al-O framework, but so far no detailed explanation has been put forward. It is the purpose of this note to show that the anomalous results can be explained semi-quantitatively if the volume of a perthite unit remains constant even when the lattice is distorted to enable it to maintain continuity with the other component. In addition an explanation of the position of the perthite composition plane is given.

The major contact plane of orthoclase micro-perthites can be seen in a microscope to lie near  $(\bar{6}01)$ , making an angle of about  $73^\circ$  to the trace of the (001) cleavage in an (010) section. Because the schiller plane in crypto-perthites is also near  $(\bar{6}01)$  it is quite certain that the contact plane of the exsolved component and its host is the same for both crypto- and micro-perthites. The shape of the exsolved units varies from regular discs with the minor axis normal to the  $(\bar{6}01)$  plane to somewhat irregular units. Laves (1952, Fig. 16) has shown from  $x$ -ray photographs of an orthoclase crypto-perthite that the lattice rows coincide for two directions near [106] and [301], the former direction lying in the plane  $(\bar{6}01)$ . The author has confirmed this for several cryptoperthites and has also shown that the repeat distances along [106], but not [301], agree in length. Examination of many  $b$ -axis oscillation photographs of cryptoperthites has shown that the  $b$ -axes of the monoclinic potassium-rich component and of the pericline-twinned sodium-rich unit are parallel and of equal length: in addition, the reciprocal lengths  $1/b^*$  of the  $b^*$  axes of the albite-twinned sodium-rich phases are also equal to the monoclinic  $b$ -repeat. Consequently the  $(\bar{6}01)$  lattice planes of the two components in the cryptoperthites are identical if the deviation from monoclinic symmetry of the Na-rich phase is neglected. The small deviation that occurs is in opposite directions for the two components of either an albite or a pericline twin so that the average deviation is zero.

If the volume of a perthite unit is independent of distortion, the direction normal to the  $(\bar{6}01)$  plane must undergo readjustment to take account of the change in area at the  $(\bar{6}01)$  plane. Because all three axes expand from Na-feldspar to K-feldspar, the spacing of the  $(\bar{6}01)$  planes

must expand even more in a perthite when the  $(\bar{6}01)$  plane is common to both. From the cell dimension data listed in Table 1, it may be seen that the cell volumes vary comparatively little with the Si, Al ordering. Because orthoclase is thought to be partly ordered, the most suitable comparison is between its cell dimensions and those of an albite part-way between high and low-albite. The  $a$ -axis expands 5.1%, the  $b$ -axis 1.2%, the  $c$ -axis 0.9% and the volume 8.1% in going from the Na- to the K-feldspar. Consequently in a perthite with identical composition plane and no change of the volume of each unit, the spacing of the  $(\bar{6}01)$  planes should differ by 8.1%, a value considerably greater than the expansion for the isolated phases. The Bowen and Tuttle (1950) method for estimating composition utilizes change in the  $(\bar{2}01)$  spacing. As the  $(\bar{2}01)$  and  $(\bar{6}01)$  planes lie at an angle of  $24^\circ$ , the spacing expansion for the  $(\bar{2}01)$  planes should be approximately  $8.1 \cos 24^\circ = 7.4\%$ . For isolated units the spacing expansion for the  $(\bar{2}01)$  planes is 4.5% in going from the Na-feldspar to the K-feldspar. Consequently, the measured compositional gap should be about  $7.4/4.5 = 1.64$  times too large, if the assumption mentioned here holds true. Values observed by Laves and Coombs for the exsolved phases of certain cryptoperthites indicate compositional gaps of 120%. Correcting by 1.64 gives a value of 73% which turns out to be quite reasonable. By examination of many analyzed specimens to see if they were homogeneous or unmixed, MacKenzie and Smith (1955, 1956) found that the immiscibility gap for orthoclase perthites was about 85%, and for sanidine perthites about 40%. The specimens examined by Coombs and Laves would be expected to show an immiscibility gap similar to that for orthoclase perthites but perhaps somewhat less because of incomplete transformation from a sanidine perthite to an orthoclase perthite. The predicted value of 73%, therefore, is quite reasonable, showing that the volume is independent of distortion, at least to a first approximation.

In microcline perthites, where the perthite is coarsely developed, there is good reason to believe that the compositions of the two phases are near  $Or_{95}$  and  $Or_2$ . Nevertheless the  $\bar{2}01$  spacings do not show the gross anom-

TABLE 1. CELL DIMENSIONS OF CERTAIN FELDSPARS

Name	Compo- sition	$a$ (Å)	$b$ (Å)	$c$ (Å)	$\alpha$	$\beta$	$\gamma$	V
low albite	$Or_0$	8.138	12.789	7.156	$94^\circ 20^1$	$116^\circ 34^1$	$87^\circ 39^1$	664.2
high albite	$Or_0$	8.149	12.880	7.106	$95^\circ 22^1$	$116^\circ 18^1$	$90^\circ 17^1$	666.7
orthoclase	$Or_{92}$	8.562	12.996	7.193	—	$116^\circ 01^1$	—	719.3
sanidine	$Or_{92}$	8.564	13.030	7.175	—	$116^\circ 00^1$	—	719.7

<sup>1</sup> Data from Cole, Sorüm and Kennard (1949) and Ferguson, Trill and Taylor (1958).

alies found for the orthoclase and sanidine perthites described previously. The cell dimensions of these microcline perthites are close to or identical with those for the isolated units (Goldsmith and Laves, in course of publication). In these coarse perthites, the units are many thousands of unit cells thick and the surface strain will have little effect on the center of the unit. It seems probable that as the perthitic units grow, the surfaces can no longer resist the forces tending to return the units to their normal geometry: the bonds at the surface will break and there will no longer be any continuity of the Si, Al-O framework across the boundary. Such a process would be encouraged by the movement of Si, Al atoms during ordering and by external shearing stress acting on the feldspar crystals. The result of this process would be a fine network of internal discontinuities, especially suitable for the migration of ions. Complete recrystallization of a feldspar, as suggested by Tuttle (1952), would be made easier by the existence of these discontinuities. The  $x$ -ray photographs of many microcline perthites show some disorientation—the largest,  $2\text{--}3^\circ$ , has been observed in charnockitic specimens kindly supplied by Howie (1955). Deviations from parallelism of the  $b$  and  $b^*$  axes of the K-rich and Na-rich components have been found to occur for some micropertthites in conformity with the findings of Laves and Soldatos (1961). These disorientations may be the result of readjustment when the perthitic units break contact. A detailed study of the cell dimensions of perthitic components would be well worth while, for it should reveal intermediate effects between the gross distortion in cryptopertthites and the lesser effects in microcline micro-pertthites.

Laves (1952) has postulated that the  $(\bar{6}01)$  plane is chosen as the contact plane in perthites because this leads to the smallest angular deviation between corresponding lattice rows. Actually the situation is more complex. As shown earlier, the largest difference in the axial lengths is for  $a$ , which changes about five times as much as for  $b$  and  $c$ . Consequently to get the smallest dilatational strain, the contact plane should be nearly perpendicular to the  $x$ -axis. In Fig. 1 (curve a) are the actual calculated values for directions in the (010) plane. It may be seen that the smallest percentage deviation occurs near the direction [106], which indeed is the trace of the schiller plane. It is a remarkable coincidence that the smallest angular deviation also occurs when the schiller plane is  $(\bar{6}01)$ . Curves (b) and (c) of Fig. 1. show the angular deviation between corresponding lattice directions, calculated for unstrained sodium and potassium feldspars. To obtain curve (b) it was assumed that the  $z$ -axes were parallel. It may be seen that the angular deviations are not symmetrical, with a maximum value of  $58'$  in one direction and  $104'$  in the other direction. By rotating one feldspar  $23'$  with respect to the other, the angular devia-

tions can be made symmetrical and thereby a minimum as shown in curve (c). Zero deviations occur for two directions, one about  $2^\circ$  from the trace of the schiller plane  $[10\bar{6}]$  and the other  $90^\circ$  away. Curve (d) shows the actual deviations measured by Laves for a cryptoperthite. The correspondence with curve (c) is very good, except that the deviations for all directions are about 50% greater than those for the isolated feldspars. This arises from the distortion described earlier.

One might ask whether the dilatational or the angular distortion governs the choice of  $(\bar{6}01)$  as the schiller plane. Although it seems likely that angular factors contribute to the strain, the dilatational effect must be paramount: otherwise the other plane with zero angular distortion could be a possible contact surface. Although the author is skeptical

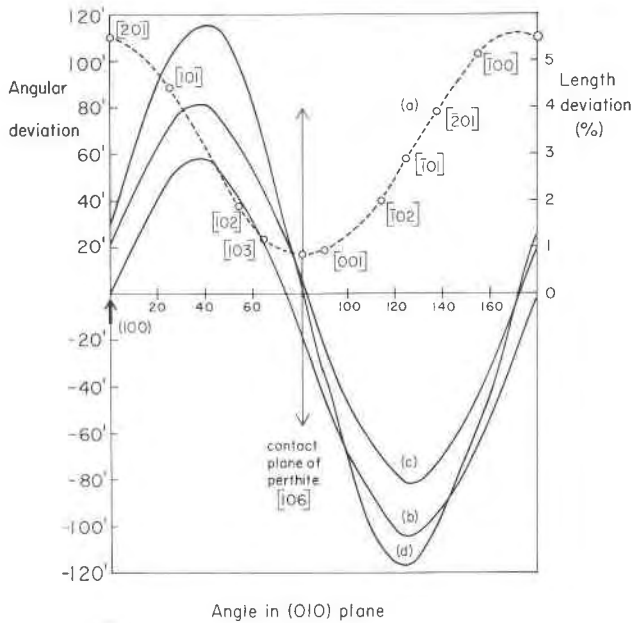


FIG. 1. Geometrical differences between K- and Na-feldspars. Curve (a) shows the deviation in repeat distance for several zone axes in the  $(h0l)$  plane. Curve (b) shows the angular deviation between corresponding lattice directions if the  $c$ -axis of the two feldspars are in contact. Curve (c) shows the angular deviation if one feldspar is rotated so that the maximum positive deviation equals the maximum negative deviation. Curve (d) contains the data measured by Laves (1952) for a natural cryptoperthite. Curves (a), (b) and (c) were calculated by using the orthoclase in Table 1 as a representative K-feldspar and an intermediate albite as the Na-component. For simplicity, the deviations of  $\alpha$  and  $\gamma$  from  $90^\circ$  were neglected: albite and pericline twinning cancel out the effects of the triclinic geometry, anyway.

about the validity of such simple considerations as those used here, he is nevertheless gratified to find how well they do explain phenomena that must really be based on very complex systems of chemical forces.

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INDEXED POWDER DIFFRACTION DATA FOR SCAPOLITE

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During a study of the similarities between natural scapolites and fibrous potassium lead silicates synthesized by Shell (1957), no indexed powder diffraction data for scapolite for comparison could be found in the literature nor in the  $x$ -ray powder data file. Recently, Eugster and Prostka (1960, p. 1859) published data on seven indexed peaks for two synthetic scapolites. However, it is felt that additional indexed data, particularly for natural scapolites, might be a desirable addition to the literature since future comparisons might be desired. This note thus presents indexed data for some 40 peaks for scapolites from Arendal, Norway and from Grenville, Quebec.