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CONCERNING THE CONSTRUCTION OF THE OPTICAL ORIENTATION DIAGRAM OF ACID AND INTERMEDIATE PLAGIOCLASES BY A. S. MARFUNIN

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Abstract

The Marfunin diagram which plots α against γ in rectangular coordinates for acid and intermediate plagioclases is in error in the region where γ equals 0°. A corrected diagram is supplied.†

Introduction

Marfunin (1962) constructed his optical orientation diagram for acid and intermediate plagioclases (his Fig. 51) using data from the literature and from his own experiments. His Figure 50 represents these same data transferred into a rectangular coordinate system. Both diagrams, therefore, should be directly related. He describes the particular shapes of the composition isolines of Figure 50 in the region of $\alpha = 90°$ and $\gamma = 0°$ as follows:

> "curvature of isolines of composition (shown by arrows) at their intersection with coordinate axes is a consequence of the transposition from a stereographic projection to a rectangular coordinate system" (part of the caption to Figure 50).

†α, γ angles are Fedorow coordinates which correspond to $b^*\Lambda X$ and $b^*\Lambda Z$.

Comparison of Both Types of Diagrams

Figure 1 represents an enlarged part of Figure 50 in Marfunin's paper. A series of points has been placed systematically on the lines of the same chemical composition in the critical area. Table 1 lists the γ, α coordinates of these points. If these points are plotted back to the stereographic projection diagram, these sharply curved isolines in the critical area of the diagram should occur at an analogous position on the three-angle diagram (Fig. 2). Moreover, the shape of these isolines should correspond to the shape of the isolines on the stereographic diagram.

Figure 2(a) is an enlarged area of the three-angle diagram close to the $-\gamma$ end. Isolines of the same chemistry and structural state are dashed. Figure 2(b) shows the area around the $+\gamma$ axis in greater detail. The isolines are not plotted because the poor quality of printing of the original paper does not permit a photographic reproduction and reading.

If the reference points of Figure 1 are compared with transferred points of Figure 2, it can be seen that the points enclosed by dotted circles in Figure 1 are missing in Figure 2. All missing points are marked in Table 1 by asterisks. Considering the α, γ coordinates of these

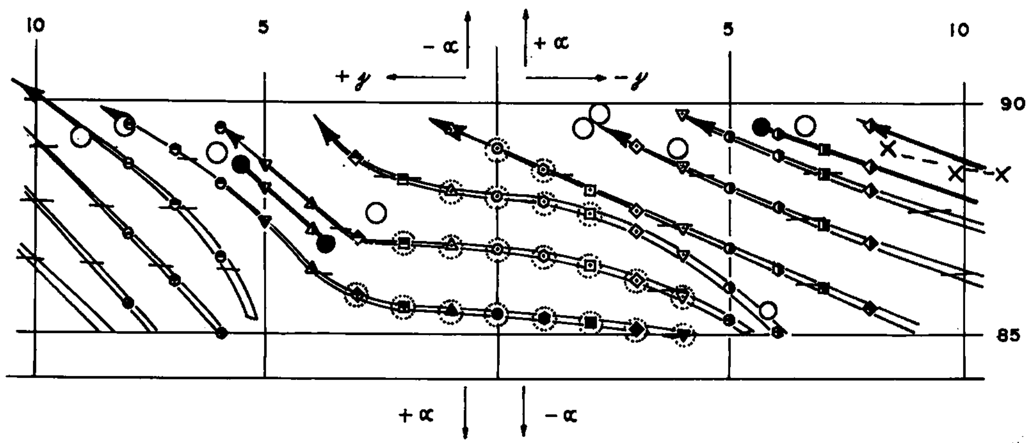


FIG. 1. Part of Marfunin's α, γ diagram. (Reference points on the arrows have been added.)

points (established with an accuracy $\pm$ 0.05° from Figure 1), it will be found that it is impossible to plot them on the stereographic projection because the values of these coordinates are too small to produce points by intersection. In other words, the points enclosed by dotted circles in Figure 1 do not have counterparts in the three-angle diagram of Figure 2. Therefore Marfunin's diagrams are not correctly related to each other.

TABLE I. γ, α COORDINATES OF REFERENCE POINTS

Symbol	γ	α	Symbol	γ	α	Symbol	γ	α
⊕	8	85.7	▲	1	85.5 *	▽	-4	-86.7
⊖	8	87.1	△	1	86.9 *	▽	-4	-87.3
⊖	8	88.7	△	1	88.1 *	▽	-4	-88.6
⊖	8	89.5	△	1	89.4	▽	-4	-88.8
●	7	86.1	●	0	±85.4 *	◐	-5	-85.3
●	7	87.8	⊙	0	±86.9 *	◐	-5	-86.0
●	7	88.9	⊙	0	±88.0 *	◐	-5	-86.9
●	6	85.0	⊙	0	±89.0 *	◐	-5	-88.1
●	6	86.7	⬢	-1	-85.3 *	◐	-5	-89.3
●	6	88.2	⊙	-1	-86.7 *	◐	-6	-85.1
●	6	89.4	⊙	-1	-87.9 *	◐	-6	-86.6
▼	5	87.4	⊙	-1	-88.6 *	◐	-6	-87.7
▼	5	88.1	■	-2	-85.3 *	◐	-6	-88.9
▼	5	88.6	⊡	-2	-86.5 *	◐	-6	-89.3
▲	4	86.4	⊡	-2	-87.6 *	◧	-7	-86.0
▲	4	87.2	⊡	-2	-88.1	◧	-7	-87.4
▲	4	87.8	◆	-3	-85.1 *	◧	-7	-88.5
◆	3	85.8 *	◇	-3	-86.1 *	◧	-7	-89.0
◆	3	87.1	◇	-3	-87.2	◆	-8	-85.6
◆	3	88.8	◇	-3	-87.7	◆	-8	-87.0
■	2	85.6 *	◇	-3	-89.1	◆	-8	-88.1
■	2	87.0 *	▼	-4	-85.0 *	◆	-8	-88.7
■	2	88.3	▽	-4	-85.8 *	◆	-8	-89.5

Two of Marfunin's migration curves are plotted into the α, β, γ system and rotated 20° to the east to get both migration curves continuously around γ (Fig. 3). As we go from the calcium-rich end-member to the sodic end, the absolute value of the γ coordinate systematically decreases to some minimum value and then increases to the albite end. The γ coordinate never reaches zero. This is true not only for low- and high-temperature curves, but also for the isolines of the structural states which are situated between two extremes. It can be concluded that at no point on the migration curves or between them does the γ coordinate equal zero. Therefore all points of Figure 1 having $\gamma = 0°$ are not possible. For this reason it is clear that the migration curves in the rectangular system α, γ must be discontinuous.

Figure 4 shows the high-temperature curve in the same representation as in Figure 3. Three points B, B′, B″ are considered on the migration curve. The spherical triangle AB″C is considered and the following relation for its sides can be written:

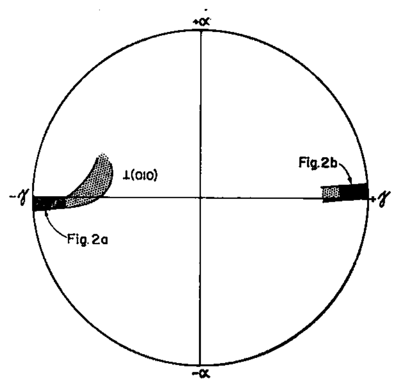
$$AC + \gamma'' \gg \alpha$$
$$90° + \gamma'' \gg 90° + x''$$
$$\gamma'' \gg x''$$

For the triangle AB′C an analogous relation can be written:

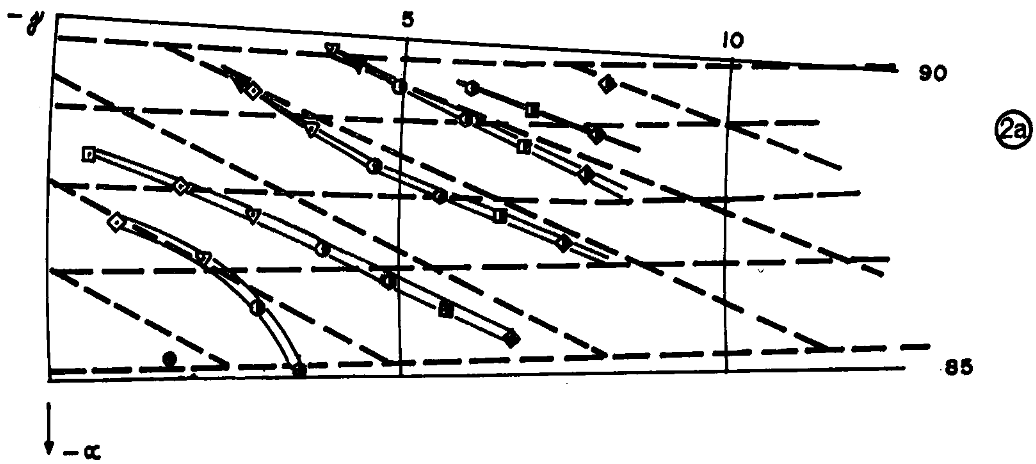
$$AC + \gamma' > \alpha'$$
$$\gamma' > \alpha'$$

It is clear that, in general, the ratio $|\gamma|/|x|$ decreases as the migration curve approaches the intersection with the line AB. At that point the spherical triangle converts into line segment AB and α, γ and x are related by:

$$AC + \gamma = \alpha$$
$$90° + \gamma = 90° + x$$
$$\gamma = x$$



The line segment converts once again into a spherical triangle as the migration curve continues past the intersection of the line AB, and the relation between its sides are similar to those described previously. Two basic relations can then be written as follows: $\gamma \geqq x$ for γ positive and $\gamma \leqq x$ for γ negative, where x is the difference between α and 90°. Figure 5 shows this relation. If this graph is applied to Marfunin's two-angle diagram, it is clear why its reference points enclosed by dotted circles do not exist on the stereographic projection. They are situated in such a way that they do not fulfill the quoted conditions.



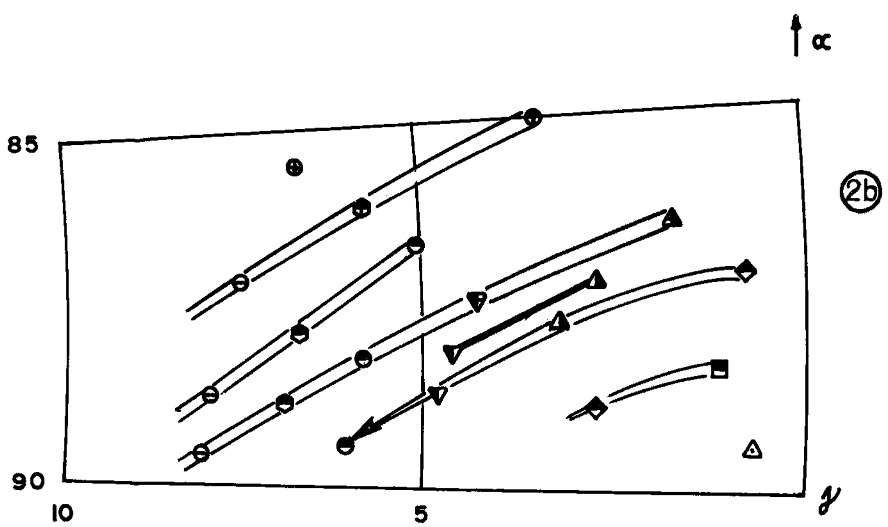


FIG. 2. (a) Part of Marfunin's three-angle diagram in the neighborhood of $-\gamma$. (Reference points and arrows are transferred from Figure 1.)

(b) Part of Marfunin's three-angle diagram in the neighborhood of $+\gamma$. (Reference points and arrows have been transferred from Figure 1.)

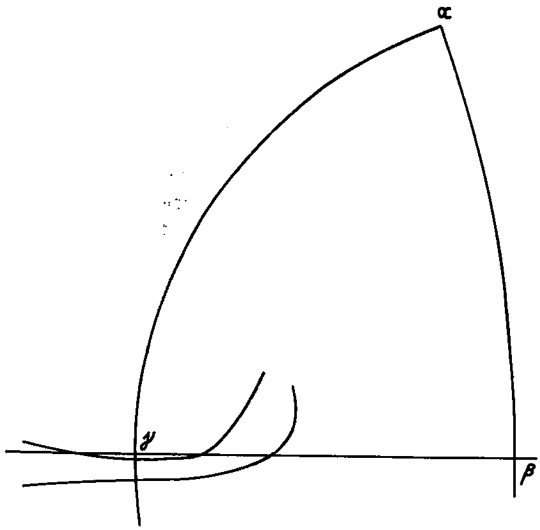


FIG. 3. Marfunin's migration curves in the α, β, γ system.

Figure 6 shows Marfunin's diagram with the application of these conditions. The arrows (lines of the same composition) are terminated at points 1, 2, 3 on the right side of the diagram. They should appear at the left part of the diagram at the points shown by the dotted lines. Instead, they are shifted upwards to the points 1′, 2′, 3′, showing an abrupt change in structural states by approximately 25% in favor of the ordered structure, which is not correct. It is obvious that the lines of the same chemical composition are not plotted correctly.

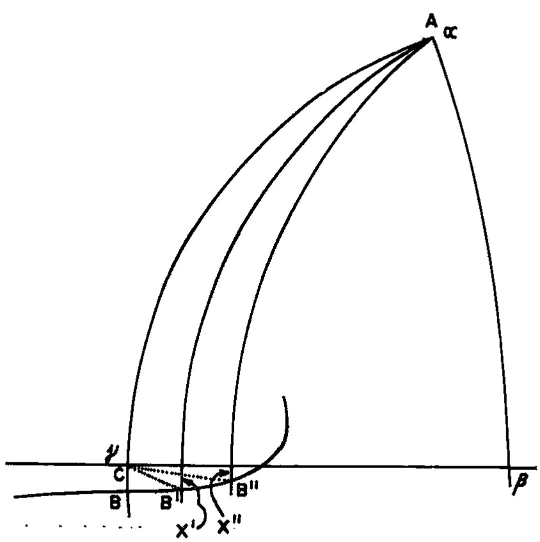


FIG. 4. Marfunin's high-temperature migration curve in the α, β, γ system with appointed B, B′, B″ points.

CONCLUSIONS

The following conclusions can be drawn from the foregoing discussion:

(1) a part of Marfunin's two-angle diagram is not correctly related to his three-angle diagram;

(2) the curvature of composition isolines is not a consequence of the transformation of the three-angle diagram to the two-angle diagram, but rather a consequence of a mistake in the basic geometry;

(3) compositional isolines are not in the correct location in the vicinity of the intersection of the coordinate axes;

(4) no measured point plotted into Cartesian α-γ system can fall into the "southern" quadrant outlined by the diagonal lines.

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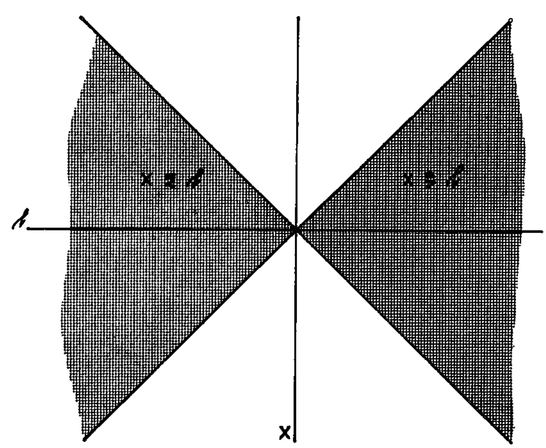

FIG. 5. Graph of relations $\gamma \geqq x$ (for $\gamma+$) and $\gamma \leqq x$ (for $\gamma-$).

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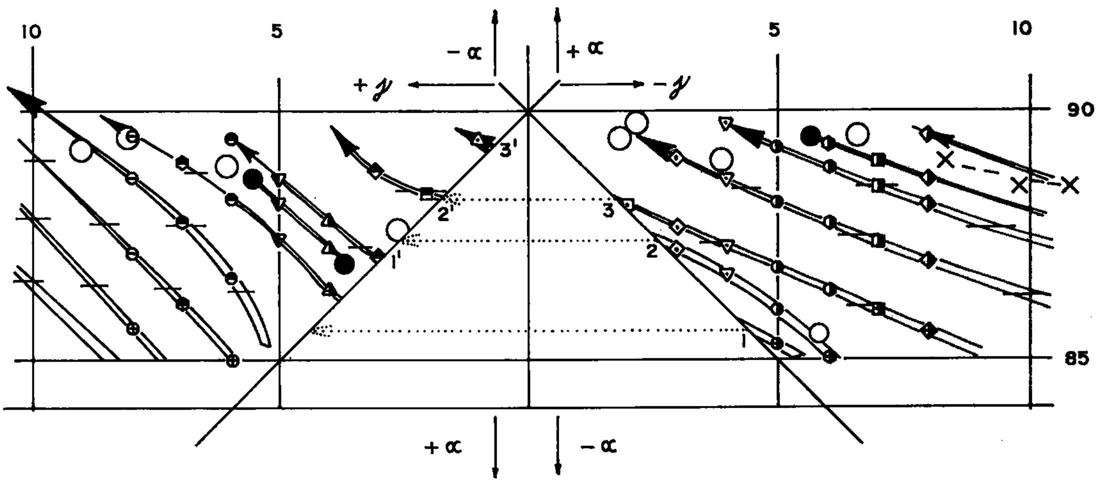

FIG. 6. Part of Marfunin's α, γ diagram with the mathematical relations applied.