and ageing temperatures, and even this is seen to depend on the silver concentration, as in the case of the peak value of resistivity.

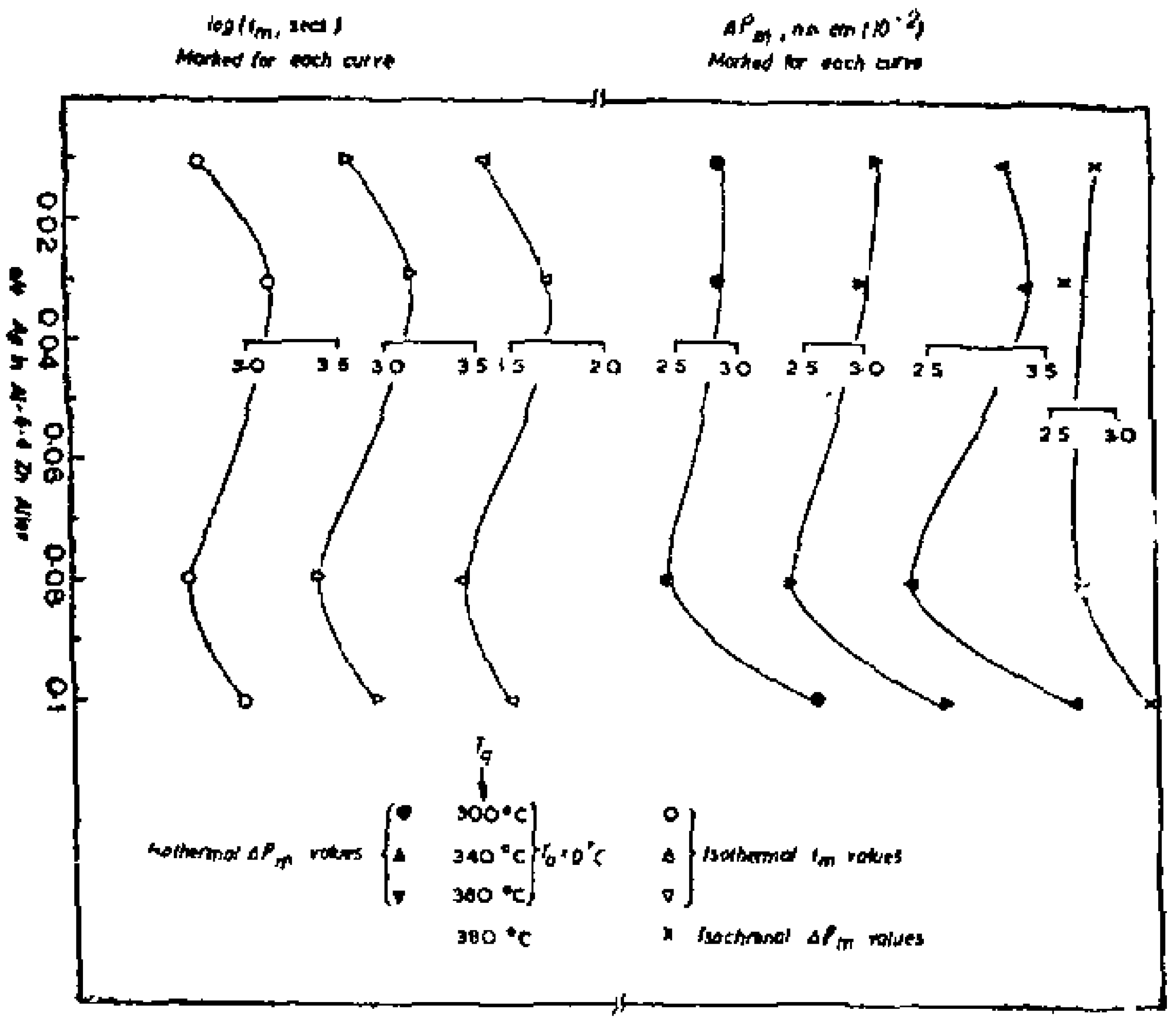

FIG. 5. Isothermal and isochronal ageing data against the silver concentration in the Al-Zn alloy.

CONCLUSIONS

The influence of silver on the clustering process in Al-Zn alloys is dependent on both T_q and T_a and also on the silver concentration. Al-Zn-Ag alloys provide an interesting case for studying the pre-precipitation processes in quenched alloys.

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USE OF LINEATION IN THE DETERMINATION OF FOLDS

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ABSTRACT

Lineation, as represented by the parallel arrangement of elongate quartz grains in quartzite, has been relied upon to interpret the folded nature of the rocks of Closepet-Satnur area in Bangalore District, South India. The maximum elongation of quartz grains is due to rotation around the fold axis *b* of the fold. Since the lineation is N-S, the rocks of Closepet-Satnur area must have undergone folding with fold axis striking N-S. The folded nature is confirmed by Petrofabric analyses.

THE AREA INVESTIGATED

FOLDS in rock formations are identified in the field if they are on a mesoscopic scale. If they are on a megascopic scale, that is, when folds are regional with limbs thrown apart for several miles, reliance is placed on converging and diverging dips of the beds and on the orderly repetition of the beds as revealed after mapping. The difficulty of identifying the folded structure of a regional kind arises when the beds dip in the same direction, as in an overfold or an isoclinal fold, and when the repetition of the beds is inconstant, because of the variation in composition within a single sedimentary bed. Such a difficulty was met with by the author in the Closepet-Satnur area in the southern part of Bangalore District, Southern India, where the granites, gneisses, granulites, and quartzites occur in a series of alternations with a general northerly trend and an easterly dip. The width of the exposures along their dip is about 8 miles; the outcrops for a distance of 20 miles along their strike were only mapped (Suryanarayana, 1960). This map covering an area of 160 sq.mls. reveals that the granites are bordered on either side by gneisses and quartzites; and, to the south, various types of charnockites interbanded with quartzite, ferruginous quartzite, and sillimanite gneisses, repeat when traversed along their dip. These observations led the author to conclude that the rocks of Closepet-Satnur area are flexed on a regional scale to an isoclinal fold. The author could adduce no other evidence for such an interpretation than for reiterating this point by drawing profile sections to show how the beds would repeat, if they are folded.

The Nature of the Linear Fabric Examined

When evidences of folding are absent, recourse must be had to some indirect method of assessing a folded structure. If lineations are present in rocks, they afford a clue as to whether rocks are folded or not. Most of the workers in the field of structural geology have, following Sander (1948, 1950), recognised the fact that lineation parallels the fold axis which is taken as *b*. Cloos (1957) has excellently summarised the views of a host of workers in this regard and discusses how lineation maintains consistent parallelism to the fold axis, though there may be several exceptions. It is thus to be noted that major and minor structures (lineation being regarded as minor structure) tend to be associated quite often, and if one is detected, the presence of the other is inferred with a reasonable degree of accuracy.

The rocks of Closepet-Satnur area characteristically exhibit planar structure, bedding, and foliation. Lineation is lacking. Cloos (1957), surveying the world literature on lineation, lists 15 types of lineations, *viz.*, striae on slickensides; fold axis; flow lines; stretching; elongate pebbles and ovoids; wrinkles; intersection of planes; linear parallelism of minerals and components; mineral clusters; pencil structure; rodding; pressure shadows; blebs and gas bubbles; parallelism of chlieren; boudinage. None is detected in the Closepet-Satnur rocks, except the one due to the linear parallelism of the elongate minerals; and this was recognised under the microscope in the quartzite collected at the eastern boundary of the Satnur granulites. The linear parallelism is therefore microscopic. The quartz grains in the quartzite are flattened in the *ab* plane—the S-Plane—with their greatest elongation parallel to the strike of the beds, which is generally N–S in the region.

When sections of Satnur quartzite were under examination for petrofabric study, quartz grains appeared elongate along both *a* and *b* axes of the fabric. The axis of maximum shortening is however along *c*. Hence to determine the greatest dimension, three sections of the Satnur quartzite, parallel to the planes *ac*, *bc*, and *ab* were taken. The measurements of length and breadth on five randomly selected grains in these three sections are given in Table I.

The values for B *c* in *ac* and *bc* sections are the lowest suggesting that the maximum shortening is along *c* which, therefore, becomes the axis of maximum compressive stress. The range of values along *c* axis is at the minimum indicating that the shortest dimension of the quartz grain has a uniformly low value. This contrasts with higher ranges for dimension along *a* and *b*.

The values for L *b* in *bc* and *ab* sections are the highest for the grain length indicating that the greatest dimension of the quartz grains parallels *b*. *a* parallels L in one case (*ac* section) and B in another (*ab* section); hence the grain has an intermediate value along the *a* axis.

Discussion

One startling revelation of this study is the lengthening of the grain along *b* which is not usually the case in the deformation ellipsoids.

The ellipsoidal axial ratio $a : b : c$ is 3·76 : 7·40 : 0·45 for the quartz grains in the Satnur quartzite; *b* has the highest magnitude. In the transformation of a sphere to an ellipsoid, the strain is regarded as biaxial in ideal cases, with greatest lengthening along *a* maximum shortening along *c* and with *b* having a mean value equal to the diameter of the original sphere; thus for a biaxial strain $B = A + C/2$, $\theta = 45°$ holds good. But the most important strain is triaxial, because of the participation of all the three axes in the deformation, with B becoming greater than the diameter of the original sphere, but still having its magnitude between $A + C/2$ and A, such that $A > B > C$ and $B > A + C/2$, $\theta > 45°$ are maintained.

But the quartz grains of the Satnur quartzite present a special case of a triaxial ellipsoid where *b* is having the greatest magnitude such that $B > A > C$. B surpasses the value of A. Sander expounds that continuous stretching is possible by rotation about fold axis *b* during folding such that

TABLE I

Showing length and breadth measurements on quartz grains

Grain dimension and the fabric axis to which they are parallel	Values of measurement (in mm) on five grains					Average
			ac plane			
L ‖ *a*	3·20	2·80	1·80	4·80	2·70	3·06
B ‖ *c*	0·55	0·60	0·40	0·55	0·47	0·51
			bc plane			
L ‖ *b*	7·50	10·70	5·40	5·10	7·00	7·14
B ‖ *c*	0·36	0·32	0·40	0·40	0·50	0·39
			ab plane			
L ‖ *b*	7·70	7·70	6·80	6·80	7·30	7·66
B ‖ *a*	3·20	4·70	4·00	2·77	7·70	4·46

L = Length; B = Breadth; *a*, *b*, *c* = Fabric coordinate axes.
Mean of the two values of *a* = 3·76; of *b* = 7·40; and of *c* = 0·45.
Ratio *a* : *b* : *c* = 3·76 : 7·40 : 0·45.

lineation parallels *b*. The possibility of B becoming greater than A is likened to the rolling out of a dough-like substance between two boards, where the defection of relative movement is normal to the extension of the material. Sander (quoted by Fairbairn, 1949) adheres to this view in elucidation of tengthening parallel to the rotation axis *b*. In accordance with this analogy, elongation can occur due to plastic flow; and conditions for plastic flow can occur only at great depths (Fairbairn, 1949). Hence, in explanation of grain elongation in Satnur quartzite, it can be said that elongation developed at great depths by intergranular rotation, where confining pressures are high to allow for plastic flow. This rotation accompanied folding, and lineation thereby developed parallel to the rotation axis *b*, the fold axis. The lineation is N–S in Satnur quartzite and hence the fold axis is N–S. The Satnur rocks are thus folded.

Incidentally, petrofabric diagrams of quartz-axes orientation for all the three sections, *ac*, *bc*, and *ab* were prepared. They are reproduced here as Diagrams 1, 2 and 3. The quartz-axes were plotted adopting the usual universal stage procedure. All the three diagrams are similar in having maxima near the fabric axis *a* and having a partial *ac* girdle. It only means that diagrams for any other two planes can be obtained by rotation of any one diagram. For example, Diagram 1 can be rotated on either *a* or *c* to get the diagrams 2 and 3 respectively, without resorting to plotting of the quartz-axes from sections parallel to *bc* and *ab* planes.

The fact to be noted is that in all the three diagrams the point maxima lie near *a* indicating the parallelism of most of the quartz-axes to *a* and perpendicular to the grain elongation, suggesting that *a* is the direction of tectonic transport and *ac* the deformation plane. The *ac* girdle indicates some amount of bending or rotation about *b* which can be taken as the fold axis.

CONCLUSION

1. The discovery in the Satnur quartzite of the lengthening of the quartz grains along *b* the fold axis, and rotation about *b* is corroborated by the petrofabric diagrams also where the partial *ac* girdle indicates rotation about the girdle axis *b'*.

2. The Closepet-Satnur rocks are folded with the fold axis striking N.S., as revealed by the linear parallelism of elongate quartz grains; and since such lengthening of the flattened grains is possible at great depths, the rocks of this area must have been subjected to a type of metamorphism corresponding to the granulite facies (Granulites are known to

have flat lenticles of quartz. Knopf and Ingerson, 1938; p. 1[illegible]). The presence of sillimanite needles in the quartzite and the occurrence of separate bands of sillimanite gneisses and chornockites in the area confirm this view.

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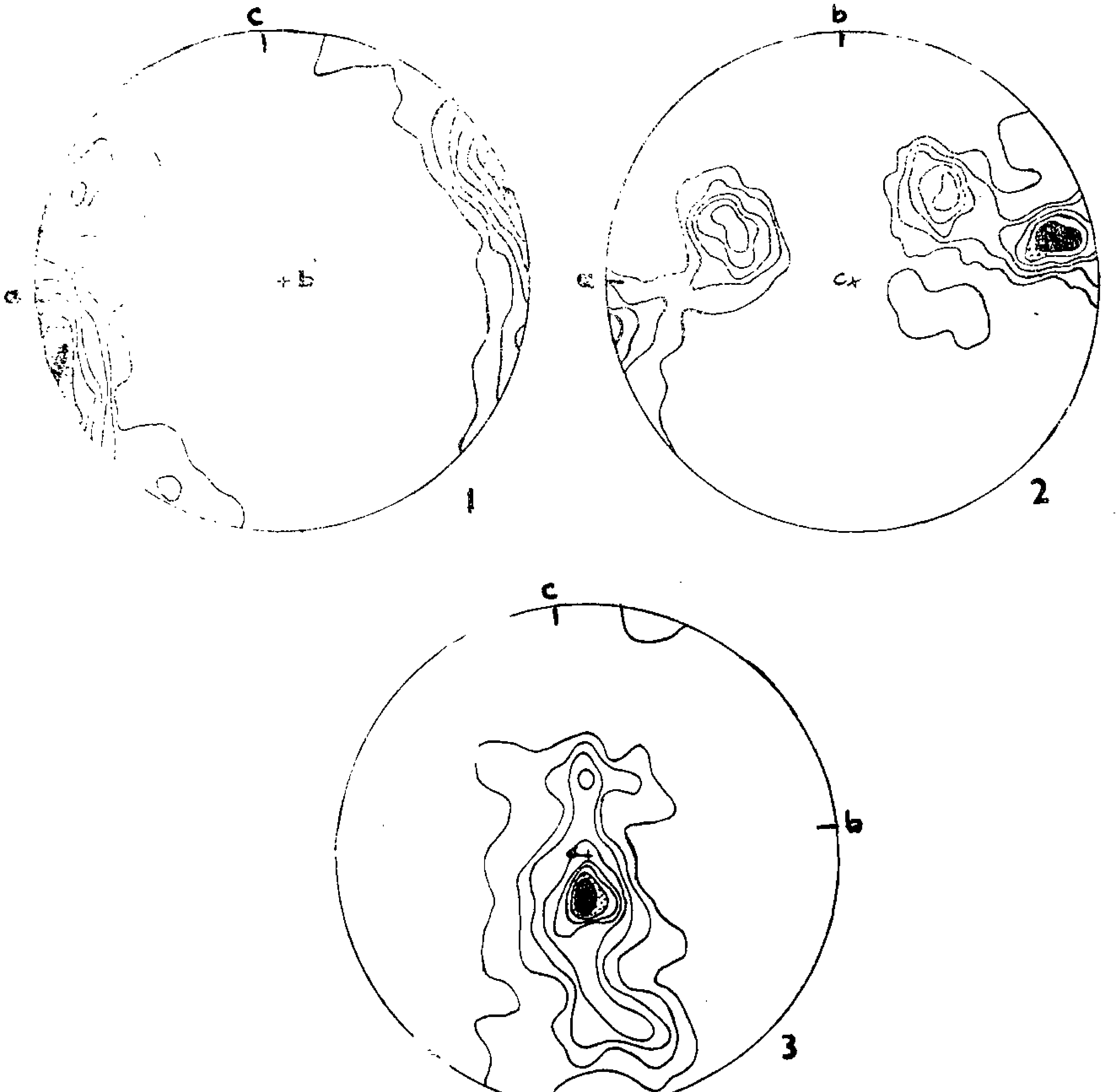

DIAGRAMS. 1–3. Each diagram represents plots of 300 quartz-axes. D. 1. Contours 13–11–9–7–5–3–1%. D. 2. Contours 15–13–11–9–7–5–3–1%. D. 3. Contours 13–11–9–7–5–3–1%.

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