Note on the determination of the optic axial angle of a crystal in thin-section by the Mallard-Becke method.

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MALLARD'S original method[1] was based on the measurement of the linear distance, as determined by an eyepiece-micrometer, between the optic axes in a section of the crystal at right angles to the acute bisectrix viewed in convergent light.

Professor F. Becke improved on this method by utilizing sections which were not at right angles to the acute bisectrix, but in which both optic axes were visible in the field. He projected both axes by means of an Abbe camera lucida on to a revolving drawing-table, and by means of the Mallard equation plotted the axes on a stereographic projection and thus obtained the optic axial angle, the angles of course being corrected for refraction to the true angles in the crystal section. Professor Becke[2] subsequently, by utilizing the Biot-Fresnel law, formulated a graphic method of obtaining the optic axial angle from a section in which only one axis was visible.

As a controversy has arisen between Professor Becke and Dr. F. E. Wright as to the correct method of obtaining the position of the second axis, and as the method the author proposes seems to avoid the debatable point, a brief résumé is given below.

[1] E. Mallard, Bull. Soc. minéralog. de France, 1882, vol. v, pp. 77–87.

[2] F. Becke, Min. Petr. Mitt. (Tschermak), 1905, vol. xxiv, pp. 1–34. See also J. W. Evans, Mineralogical Magazine, 1907, vol. xiv, pp. 230–234 and 276–281.

Professor Becke's method is as follows (fig. 1):—

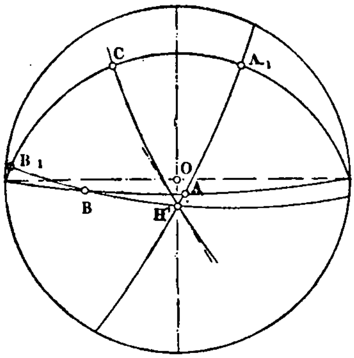

FIG. 1. Beck's method.

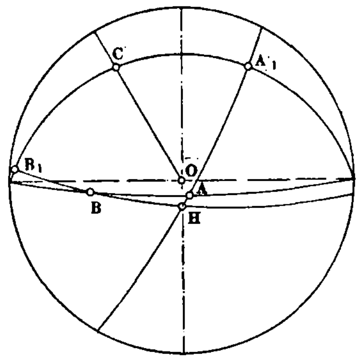

FIG. 2. Wright's method.

The visible isogyre is first drawn when it forms a straight line in an east and west direction, thus determining the optic axial plane. The section is then turned through any convenient angle, say 30° to 45°, and the drawing-table is revolved the same amount in the same direction. The new position of the isogyre is then drawn. The intersection of the two traces of the isogyre gives the position of the visible optic axis A. Any convenient point H on the second position of the isogyre is taken and with A is transferred, duly corrected for refraction, to a stereographic projection. A great circle through A on an east and west diameter is drawn, thus marking the optic axial plane, and on which consequently the second optic axis must lie. A great circle HAA_1 is drawn through H and A. Another great circle A_1CB_1, of which H is the pole, is drawn cutting HAA_1 in A_1. The plane of vibration through H is then given by a great circle tangent at H to a straight line parallel to the second position of the plane of vibration through the lower nicol. This intersects the great circle A_1CB_1 in C. On this great circle A_1CB_1 an arc CB_1 is set off equal to the arc CA_1. A great circle HBB_1 is then drawn cutting the great circle which marks the optic axial plane in B. By virtue of the Biot-Fresnel law, the optic axial angle 2V is then read directly by the arc AB.

Dr. Wright, in his recent book on 'The Methods of Petrographic-Microscopic Research',[1] takes exception to Professor Becke's method of

[1] F. E. Wright, Carnegie Institution of Washington, 1911, Publ. No. 158, pp. 158-160.

finding the plane of vibration through the point *H*, and is of opinion that it is more correctly represented by the great circle passing through *H* and the intersection *C* of the polar great circle with the trace of the principal plane of the lower nicol (fig. 2).

The author proposes to avoid this contentious point by the following simple method (fig. 3):—

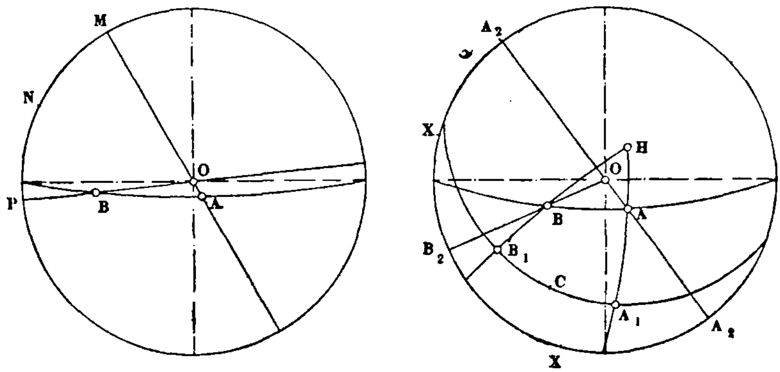

FIG. 3. FIG. 4.
Author's method.

Instead of taking a point *H* on the isogyre the centre of the field *O* is used. A straight line is drawn from *O* through the first optic axis *A*, cutting the circumference of the stereographic circle in *M*. The position of extinction *N* is then marked on the circumference of the same circle. From *N* an arc *NP* is set off equal to *MN*. *P* is then joined to *O* by a straight line and produced if necessary to cut the great circle marking the optic axial plane in *B*. The point *B* will then be the second optic axis.

The advantages that this method would appear to give are the following:—

(1) All doubt is removed as to the correct plane of vibration through *H*.

(2) Greater ease and accuracy in graphic construction as—

(*a*) *O* may be determined with far greater certainty than a point on a more or less clear isogyre.

(*b*) Only one great circle is necessary to be drawn, the remaining lines being straight.

(*c*) The line of extinction can be found with considerable accuracy in convergent or parallel light, the latter being no doubt the better.

The method proposed is of no service when the axial plane lies on a diameter, as the line of extinction will then be coincident with it.

It frequently happens that, when the optic axial angle of a thin-section or cleavage-flake of a crystal is required, an optic axis is a little way beyond the field, thus rendering the determination by the Mallard-Becke method impossible. In such a case it is possible to make a fairly good determination by combining Professor Becke's method of obtaining the second optic axis with the method proposed above by the writer (fig. 4). As in Professor Becke's method the optic axial plane is found by placing the isogyre horizontally in an east and west direction. The point H is then fixed precisely as before, and in addition the position of extinction is noted. All these data are transferred, duly corrected for refraction, to a stereographic projection. On this stereographic projection the point C on the great circle polar to H and the position of extinction X on the base circle are marked. Now if A and B be the positions of the optic axes, it is clear, by virtue of the Biot-Fresnel law, that OX will bisect the angle BOA (internally or externally), and also, if B_1 and A_1 be the points where great circles HB and HA cut the great circle polar to H, that $CB_1 = CA_1$. We now proceed to find the points A and B by trial and error. Set off on the base circle a series of equal arcs XA_2, XB_2, and on the polar great circle a series of equal arcs CA_1, CB_1. Trial and error will then determine with a reasonable amount of accuracy which values of A_2, B_2, A_1, and B_1 are to be taken so as to fulfil the necessary condition that OB_2 and HB_1 intersect at B, while OA_2 and HA_1 intersect at A. The procedure need not necessarily be a long one, as inspection of the field gives a rough idea of where the optic axis A is situated.

It is not suggested that the method can compare in accuracy with the case in which one optic axis is visible, but it is claimed that fairly reasonable accuracy may be obtained if no other method can be used. The diagram (fig. 4) is that for a cleavage-flake of labradorite. 2V was found equal to 69°. By using a very wide angle condenser, and thus rendering both axes visible, 2V was determined as 71°.