On the determination of the optic axial angle and crystal-forms from observations by the Becke method in thin sections.

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SOME years ago the writer read a paper on the determination of the optic axial angle of a crystal by the Becke method.[1] This proposed method was to record the trace of the optic axial plane when horizontal, the position of one axis, and the extinction-direction. From these data and the established constants of the microscope, the position of the second optic axis may be found, as the extinction bisects the angle between the centre of the pole of the section and the two optic axes. Hence, the optic axial angle may be determined.

Considerable errors arise in these determinations owing to defects in the optical system of the microscope, and also to the inability to determine the exact position when the trace of the optic axial plane is parallel to the E–W. lines in the microscope. This inability is partly due to the imperfections in the convergent light image, and also to the fact that the trace of the optic axial plane is always curved in an orthographic or stereographic projection except where the axial plane is at right angles to the plane of projection.

The writer's suggestion now is to combine all the various observations made on different thin sections of varying orientation and thus see which observations are of the best value and incidentally obtain a complete reconstruction of the crystal. For the purpose of a trial, thin sections of a basalt from Orange Free State were selected, as these contained a large number of clean cut sections of olivine.

The following observations were made as far as possible on each crystal section of the olivine:

Position of the optic axial plane.
Position of an optic axis.

[1] H. Collingridge, Min. Mag., 1913, vol. 16, p. 348; 1914, vol. 17, p. 147.

Extinction.
Character of extinction.
Optic axial angle.
Thickness of slice.
Relative retardation.
Orientation of all traces of faces or cleavages.
Birefringence.

The mean index of refraction of the crystal has necessarily to be assumed or determined as closely as possible.

It may be noted here that the use of an oil-immersion objective and condenser for the convergent light observations tends to reduce errors due to imperfect knowledge of the refractive index of the crystal, and also allows of observation over a greater area.

It is necessary now to bring the separate observations of each crystal section together, and to do this a stereographic diagram on tracing-paper is made for each section, showing:

Optic axial plane.
Optic axis.
Extinction-direction.
Traces of cleavages and faces (marked by points on the circumference of the base circle at the extremities of the diameter marking the traces of the faces).

This diagram must now be rotated first round the E–W. diameter to bring the optic axial plane at right angles to the plane of the paper, and then round the N–S. diameter to bring the acute bisectrix to the centre. The traces of faces or cleavages will then be marked by single points, derived from one or other of the ends of the diameter parallel to the trace in the original diagram.

All the re-projected diagrams are now pricked through and combined on to one diagram (fig. 1). The great circles in this diagram are the equators of the crystal-faces (010), (001), (110), &c., being at 90° from the poles of these faces.[1] As there is now a common base-line (the optic axial plane) and a common point of reference (the bisectrix), the single points denoting the traces of one particular face or cleavage must fall (if correctly determined) on the great circle representing the equatorial projection of that face or cleavage.

[1] This method of projecting crystals has been used by J. Y. Buchanan, On the use of the globe in the study of crystallography. Phil. Mag., 1895, ser. 5, vol. 40, pp. 153–172.

Valuable aid is also given by adding to the diagram the projection of observations of sections of known orientation, such as those:

at right angles to an optic axis,
parallel to an optic axial plane,
at right angles to acute bisectrix.

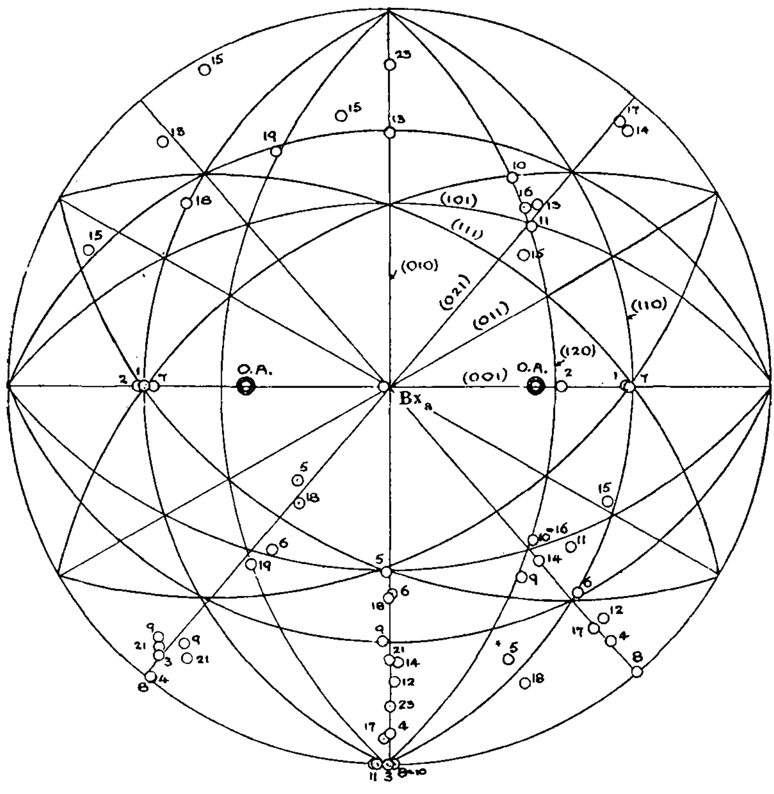

FIG. 1. Stereographic projection on (100) of the equators of the crystal-faces. The points 1–23 record the directions of traces of planes or cleavages measured in the sections.

The reconstruction of the crystal is made as follows:

(*a*) From observations 1, 2, and 7 the trace of (110) is drawn as a great circle inclined at 65° from the vertical diameter or trace of (010). It follows that $(110):(1\bar{1}0) = 50^\circ$.

(*b*) Calculated from (*a*), the trace of (120) is drawn inclined at 47° from the trace of (010).

(*c*) A diameter is now drawn to represent the trace of (021) by taking the best line through the plotted points. This diameter is inclined at 40° to the trace of (010).

(*d*) Calculated from (021), the trace of (011) is at 59° from the trace of (010).

(*e*) The equatorial projection (fig. 1) may now be re-drawn as the usual polar projection of the faces, and the crystal angles read directly. The following angles were obtained:

		Observed.		Calculated (Dana).
$(110):(1\bar{1}0)$	...	50°	...	49° 57′
$(120):(1\bar{2}0)$	...	86	...	85 56
$(101):(\bar{1}01)$	...	104	...	103 6
$(011):(010)$	...	59	...	59 37
$(021):(010)$	...	40	...	40 27
$(111):(1\bar{1}1)$	...	40	...	40 5

The other observations obtained in the several sections of the olivine crystals are given under the following serial numbers corresponding with the numbers plotted in fig. 1.

No.		2V.		$n_\gamma - n_\alpha$.	Orientation of section.
1	...	—	...	0·035	Parallel optic axial plane.
2	...	—	...	0·035	Ditto.
3	...	—	...	0·032	Nearly ⊥ acute bisectrix.
4	...	86°	...	0·039	—
5	...	84	...	0·036	—
6	...	85	...	0·039	—
7	...	—	...	0·036	Parallel optic axial plane.
8	...	—	...	0·034	Nearly ⊥ acute bisectrix.
9	...	—	...	0·038	—
10	...	—	...	—	⊥ optic axis.
11	...	—	...	—	Ditto.
12	...	82	...	0·039	—
13	...	83	...	0·039	—
14	...	84	...	0·038	—
15	...	84	...	0·036	—
16	...	—	...	—	⊥ optic axis.
17	...	—	...	0·034	Near optic axial plane.
18	...	84	...	0·039	—
19	...	—	...	—	⊥ optic axis.
Mean	...	84	...	0·0366	—