A simple graphic method for determining extinction-angles in sections of biaxial crystals.

By H. G. Smith, A.R.C.S., B.Sc., F.G.S.

Demonstrator of Geology, Imperial College of Science and Technology.

[Read November 14, 1911.]

THE relationship between the optic axes and the vibration-directions in a section of a biaxial crystal was enunciated by Biot[1] in 1819, and may be stated as follows: The vibration-directions in any section of a biaxial crystal are given by the bisectors of the angles between the optic axes as projected on the plane of section.

Dr. Fletcher[2] and Mr. Harker[3] have elaborated the idea, but there appears to be room for a simpler presentment, more adapted to the needs of students, which does not involve the use of the optical indicatrix or the spherical projection.

Largely because of its excellent cleavages, barytes was selected as a suitable mineral for experiment, and the following account relates: (1) to the actual experimental determination of the extinction-angles in a pyramidal section of that mineral; and (2) to the graphic method for obtaining the extinction-angles in such a section.

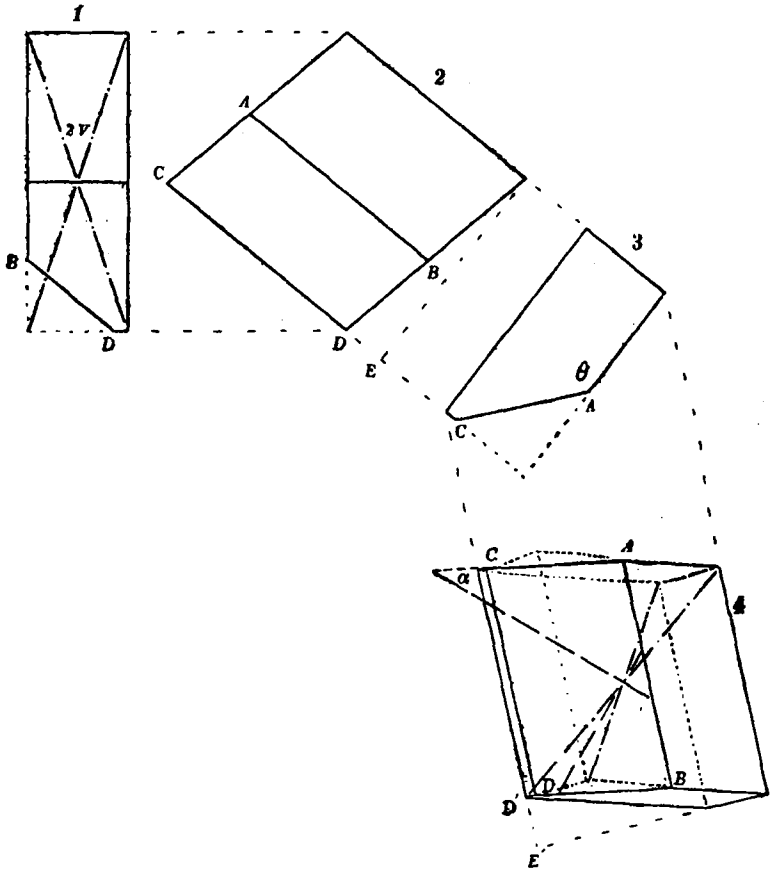
Experimental Determination.—Barytes cleaves into fragments bounded by faces of the prism and basal pinakoid. One of the rectangular edges of such a fragment was ground away so as to produce a pyramid face (*ABCD* in the figures) lying in the zone [110,001]. The inclination of this face to the basal pinakoid (the angle θ) was measured, and the fragment cemented, prepared face downwards, on a microscope-slip. Subsequent grinding produced a section showing two directions of cleavage, the inclination of which depends on the value of θ. One set of

[1] J. B. Biot, 'Sur les lois générales de la double réfraction et de la polarisation dans les corps régulièrement cristallisés,' Mém. Acad. Royale des Sci., Institut de France, 1820, vol. iii (année 1818), pp. 177–384.

[2] L. Fletcher, 'The optical indicatrix and the transmission of light in crystals,' Mineralogical Magazine, 1891, vol. ix, pp. 278–288 (see p. 341).

[3] A. Harker, 'Extinction-angles in cleavage-flakes,' Mineralogical Magazine, 1893, vol. x, pp. 239–240.

cleavage-cracks is produced by the cleavages parallel to (110) and (001), and those of the other set by the cleavage parallel to the prism faces (1$\bar{1}$0) and ($\bar{1}$10) not lying in the zone [110,001]. As the latter were the sharper, they were chosen as the datum-line from which the extinctions were measured (the angle α in the accompanying diagram). The



vibration-directions were distinguished as 'fast' and 'slow' by means of a quartz-wedge.

The Graphic Method.—The principle of this method consists in obtaining an accurate orthographic projection on the plane of the section (fig. 4). For the construction of this it is necessary first to draw projections on (010) (fig. 1), on (001) (fig. 2), and on the zone-plane [110,001] (fig. 3).

As (010) is the optic axial plane, the optic axes are here inserted with the true inclination 2V ($= 37\frac{1}{2}°$ in barytes), and the dimensions of the rectangle are so chosen as to allow the optic axes to emerge from the corners (fig. 1). In the projection on the zone-plane, the true value of the measured angle θ is inserted (fig. 3). In fig. 2, the perpendicular from an acute corner of the rhomb on to the side CD gives the distance DE used in fig. 4, $D'E'$ being made equal to DE. The projection (fig. 4) on the artificially-prepared pyramidal face $ABCD$ is obtained by projecting at right angles to the trace of this face shown in fig. 3. Here CD and $D'E'$ appear in their true length, and these dimensions are taken from fig. 2. A line drawn from E' perpendicular to CD gives a third corner of the projected basal plane and the direction of the prism-edges, and the rest of the figure is easily constructed. The projected optic axes are inserted by joining the corners corresponding to those in fig. 1, and their angles are bisected. The bisectors should then be inclined to the traces of the prismatic cleavage (that parallel to $(1\bar{1}0)$ and $(\bar{1}10)$) at angles agreeing with the extinction-angles (a and $90°-a$) obtained experimentally.

The 'fast' and 'slow' vibration-directions may be distinguished by considering their situation with regard to the bisectrices; the bisector of the acute angle in most of the sections approximately coincides with what would be the projection of the acute bisectrix, and, barytes having a positive sign, this must be the 'slow' vibration-direction.

The results compared below include those obtained by the graphic method, the experimental determinations, and those calculated by a modification of Harker's method. The angles are given to the nearest quarter of a degree, and represent the inclination (a) of the 'fast' vibration-direction with the prismatic cleavage for different values of θ.

θ.	a Graphic Method.	a Observed.	a Calculated.
$108\frac{1}{2}°$	$13\frac{1}{2}°$	14°	$13\frac{3}{4}°$
121	$22\frac{1}{2}$	23	22
$134\frac{1}{4}$	$29\frac{3}{4}$	29	$29\frac{3}{4}$
$136\frac{1}{4}$	31	31	31
142	$32\frac{1}{2}$	32	$32\frac{3}{4}$
$150\frac{1}{4}$	$35\frac{1}{2}$	$35\frac{1}{2}$	$35\frac{3}{4}$

The graphic method herein described is capable of general application to biaxial crystals, wherever the crystallographic orientation of the section and the optic orientation of the crystal are known. Its principle consists in obtaining an orthographic projection on the plane of section,

and bisecting the optic axial angles so projected. At least three drawings are necessary:

(*a*) A projection on the optic axial plane, where the optic axes are inserted with the inclination 2V.

(*b*) A projection on the plane of the zone containing the prepared face and that from which its inclination is measured. Here the angle θ is inserted.

(*c*) A projection on the plane of section. This is obtained from (*b*) by projection at right angles to the trace of the prepared face.

In the case of barytes an additional projection—that on (001)—was necessary in order to obtain the dimension *DE*. With similar simple modifications to meet special cases, the method gives a view of the crystal in the required position; the bisectors of the projected optic axial angles then give the vibration-directions; and the inclinations of these with some datum-line give the extinction-angles.