# *A possible source of error in the determination of symmetry from optical extinction-angles.*

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[Read March 23, 1933.]

During an optical examination of many mesolite crystals with a view to a determination of their symmetry, the author was puzzled to find that whereas mesolite has generally been described as anorthic, on optical evidence, he could detect no trace of inclined extinction in the prism zone. A. Cavinato (1926)[1] and G. Cesàro (1909)[2] had already made similar observations. Further study revealed the probable causes of the discrepancies, and as these sources of error, and the precautions necessary for their avoidance, receive little or no mention in the principal text-books, an account of them might be of some use.

The monoclinic, pseudo-orthorhombic crystals of mesolite form prisms elongated along the *b*-axis and bounded by *r* (101), *R* ($\bar{1}$01), *o* (111), and *p* ($\bar{1}$11). There is general agreement on the optical behaviour of sections perpendicular to the *b*-axis, in which twinning on *a* (100) or *c* (001) is revealed. The discrepancies referred to are in the behaviour of natural and artificial plates parallel to the prism zone [010].

Since the optic axes are nearly perpendicular to the faces *r* and R, the natural prisms are not really suitable for examination. When lying perfectly at right angles to the microscope axis they give straight extinction, but the slightest inclination results in markedly inclined extinction. Small clean prisms were found to give straight extinction, but larger aggregates and parallel growths, which would not lie quite flat, gave extinction angles up to 12°. How this behaviour may constitute a source of error will be clear from fig. 1.

[1] A. Cavinato, Atti Soc. Ital. Sci. Nat., 1926, vol. 65, p. 104. [M.A. 4–319.]

[2] G. Cesàro. Bull. Acad. Roy. Belg., 1909, p. 435. The crystallographic orientation used for mesolite in this note is that proposed by Cesàro.

A much more important source of error, and one that does not always appear to have been fully recognized, was exemplified by a section cut approximately perpendicular to the $c$-axis. The two cut faces were practically parallel, but measurement showed that they were not quite in the prism-zone [010], being inclined about $2\frac{1}{2}°$ to it; this small deviation from the desired position sufficed to give rise to extinction phenomena which would have led to the crystals

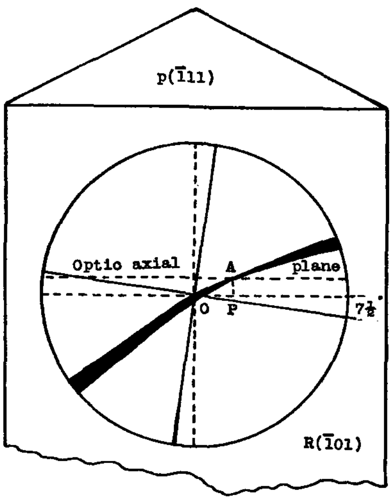


FIG. 1.

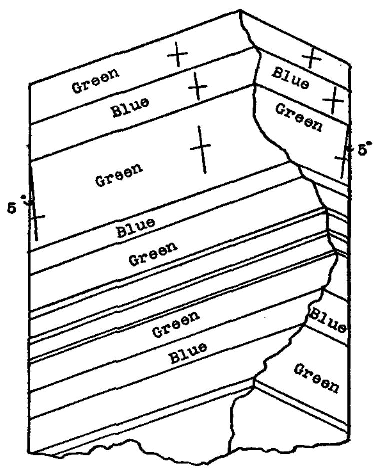


FIG. 2.

FIG. 1. Inclined extinction given by a mesolite crystal lying nearly on $R(\bar{1}01)$, but tilted 2° in the direction of $b(010)$. Optic axis $A$; $OP = 8°$, $AP = 2°$.

FIG. 2. Extinction phenomena shown by cut plate from a mesolite twin, inclined $2\frac{1}{2}°$ to $c(001)$ in the direction of $b(010)$. The main portion of the plate shows a light green interference-colour, traversed by blue bands.

being classed as anorthic but for a careful examination in convergent light. The plate (0·92 mm. thick) consisted of two portions in twin position, with a rather irregular boundary (fig. 2); the acute bisectrices of the two portions are inclined at some 15–20° to one another, and each is about 10° from the normal to the plate. In parallel light with the principal planes of the nicols perpendicular and parallel to the elongation of the crystal, extinction was not perfect in either portion of the twin, but the two portions matched; in the 45°-position, both portions showed a pale green interference-colour of the second order, traversed by bright blue bands parallel to the pyramid faces. In one member of the twin, the green field extinguished at about 5° to the elongation, the blue bands at about 4°, while the other member of the twin showed similar phenomena, the behaviour of the whole being symmetrical about the elongation (fig. 2).

This would appear to indicate anorthic symmetry in the crystal, but an examination in convergent light showed that the phenomena

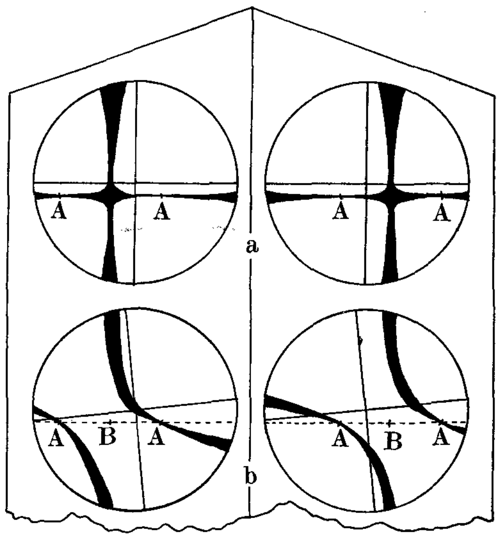


Fig. 3. Interference-figures shown in convergent light by a cut plate from a mesolite twin, inclined $2\frac{1}{2}°$ to $c(001)$ in the direction of $b(010)$. Optic axes $A$, $A$; bisectrix $B$.

(*a*) Nicols parallel and perpendicular to [010].

(*b*) Nicols at 5° to [010] and [100]; left half of the twin in extinction position.

are due solely to the plate being cut not quite perpendicular to the optic axial plane of the crystal. In both halves of the twin the optic axial plane was found to run slightly below the centre of the field, while the bisectrix was to the right of the centre in one half, to the left in the other. The blue bands proved to be due to regions with somewhat lower birefringence and smaller optic axial angle.

Figures 3 *a* and 3 *b* show how the apparently anomalous extinction phenomena arise. Since neither the optic axial plane nor the plane containing $\beta$ and $\gamma$ is quite perpendicular to the section, extinction is not perfect in the expected position with the principal planes of the nicols perpendicular and parallel to the elongation of the crystal, but on examination in convergent light and rotating a few degrees, we see one axial brush in the figure for one half of the twin sweep across the centre of the field—complete extinction; rotation in the other direction is necessary to produce the same result in the other half of the twin. The blue bands, with a somewhat different optic axial angle, naturally require a somewhat different rotation. Calculation, by the formula of L. Duparc and F. Pearce[1] gives for a cut plate inclined at $2\frac{1}{2}°$ to $\beta$ and $10°$ to $\gamma$, with $2V = 90°$, an extinction-angle of $4\frac{1}{2}°$ to the elongation, in good agreement with the observed value. The extinction-angle varies with the inclination of the plate and with the optic axial angle, being greater the more inclined the plate is to the optic axial plane, the more inclined it is to the bisectrix, and the greater the optic axial angle about that bisectrix which is nearly normal to the plate.

It has seemed desirable to go into some detail over these phenomena; partly because the behaviour of plates 'cut perpendicular to a bisectrix', but probably only approximately in the desired position, has appeared in the literature several times as evidence of the supposed anorthic symmetry of mesolite; and partly to call attention to the caution necessary in the optical study of natural[2] or artificial plates which are supposed to be perpendicular to a principal optic plane or axis of the crystal, a matter in which the text-books give no adequate warning of the possibilities of error. It seems to be frequently assumed that a displacement of the cut face by 1–2° from the desired position is of no importance, but this example of mesolite shows that such is not the case.

[1] L. Duparc and F. Pearce, Traité Techn. Min. Petr., Leipzig, 1907, part 1, p. 250.

[2] Vicinal faces, especially if somewhat irregularly developed, may at times cause a crystal laid on a slide to be 1 – 2° or more from the supposed position. Cleavage plates may also give false results if the cleavage face on which the plate is lying happens to be stepped to any extent.