A METHOD FOR ESTIMATING THE FINISHING BIREFRINGENCE COLOR OF A CRYSTAL OF RANDOM ORIENTATION IN A THIN SECTION

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Due to the variability in thickness of the balsam layer, direct measurements of the thickness of a thin section with micrometers are unreliable. The interference figure does not give a sufficiently accurate indication of the orientation to enable one to estimate what the interference color of the finished thin section, consisting of a single crystal or of extremely coarse rock, should be. Therefore, the following method for estimating the birefringence color for standard thickness has been used.

Designating by t the thickness of the mineral in mm., by n_2 the index of refraction of the slow ray and by n_1 the index of refraction of the fast ray for a particular orientation, the retardation Δ is expressed by the equation

$$\Delta = t\ (n_2 - n_1).$$

This straight line relation can be expressed graphically by plotting the birefringence $(n_2 - n_1)$ for the given orientation with t as abscissa and Δ as ordinate. The slope of the straight line is $\operatorname{ctg} \alpha = \frac{\Delta_1 - \Delta_2}{t_1 - t_2} = \frac{\Delta}{t} = (n_2 - n_1)$.

Graphs of this kind are known as interference color charts, since the retardation is either given in the actual interference colors, or is indicated in writing.

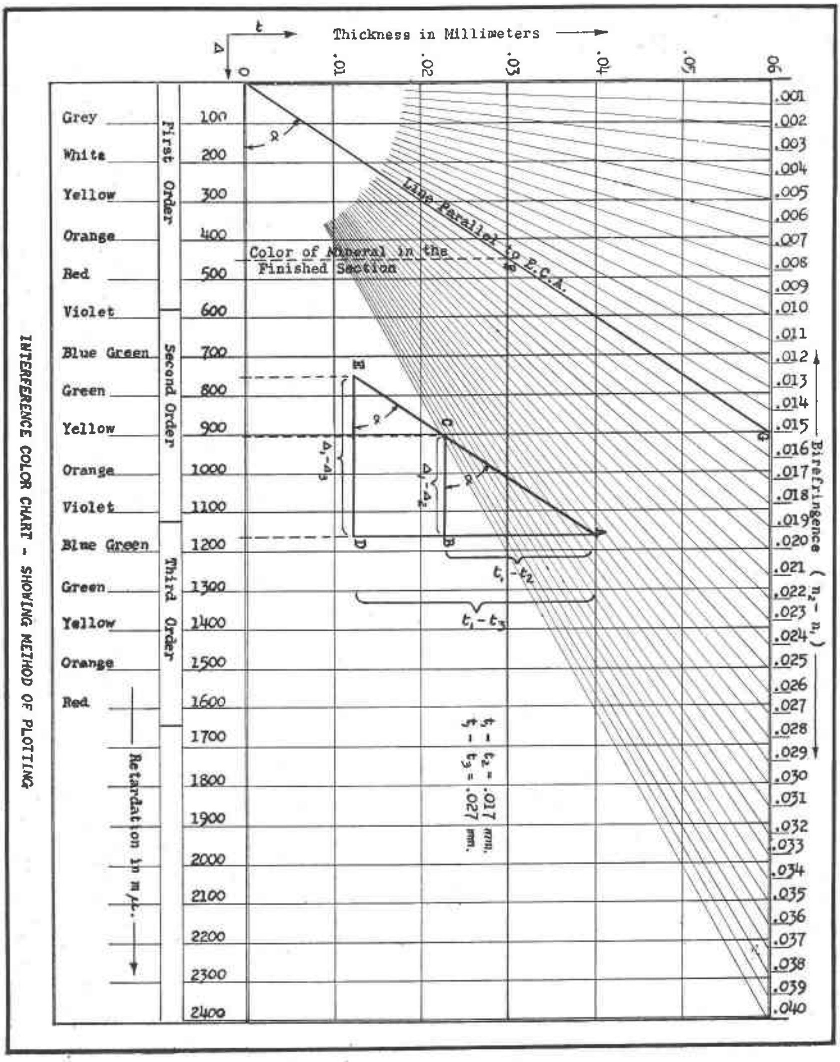
The method described here makes use of the fact that the value of ctg α is independent of the actual thickness of the mineral and depends only upon the difference $(t_1 - t_2)$ and the corresponding $(\Delta_1 - \Delta_2)$. For the determination of ctg α, one finds, therefore, t_1 and the corresponding Δ_1 for any thickness. Then one grinds the mineral a little thinner and finds the values of t_2 and Δ_2. It is now easy to plot or calculate $(n_2 - n_1)$ $= \frac{\Delta_1 - \Delta_2}{t_1 - t_2} = \operatorname{ctg} \alpha$ and to find the birefringence line corresponding to this value $(n_2 - n_1)$ on the interference color chart. The point of intersection of this line with the horizontal line for the thickness 0.03 mm. shows the retardation or birefringence color that this particular crystal should have in the finished section.

The thicknesses t_1 and t_2 can either be determined by micrometer measurements to .003 mm., or with the microscope by focusing the high power objective and reading on the fine adjustment screw the difference in heights. The retardation is determined by compensation with the quartz wedge and comparison of the colors on the chart. Care should be taken to have the slide clean and to take the measurements as nearly as possible at the same point. The errors introduced in t_1-t_2 by the micrometer measurements are due to the unequal pressure on the micrometer screw in the two individual measurements, and uncleanliness of the slide; the first of these can be eliminated by the use of a dial gauge. The factors which influence the microscope measurements are: first, the area of the slide in contact with the stage is comparatively large, and errors due to uncleanliness are more difficult to avoid; second, the high power objective must be focused upon a comparatively rough surface and the accuracy depends entirely upon the sensitivity of the observer's eye.

In order to illustrate how this method is applied, the following example is given: The section which consists of a single crystal of an unknown mineral, or a mineral at random orientation, is ground until it shows a clean blue interference color. The section is cleaned and at an easily determinable point the micrometer measurement is taken. This measurement reads $t_1=1.597$ mm. The compensation with the quartz wedge shows that the blue is of the third order and corresponds to a Δ_1 of 1150 mμ. Now the section is ground until the blue has changed to a bright yellow and the measurements are repeated, whereby t_2 is determined to be 1.580 mm. and the corresponding Δ_2 is 900 mμ. For the purpose of checking, another measurement is taken for bright green and gives $t_3=1.570$ mm. and $\Delta_3=750$ mμ. From these measurements we find $t_1-t_2=.017$ mm. $=AB$ (see Fig.); $t_1-t_3=.027$ mm. $=AD$; $\Delta_1-\Delta_2=250$ mμ $=CB$, and $\Delta_1-\Delta_3=400$ m$\mu=ED$, from which $\frac{\Delta_1-\Delta_2}{t_1-t_2}=\frac{.00025}{.017}=.00147$.

$\frac{\Delta_1-\Delta_3}{t_1-t_3}=\frac{.00040}{.027}=.00149$. According to these determinations the finishing birefringence color should be a deep orange of first order. It is still simpler to put a sheet of tracing paper over the interference color chart and plot the retardation Δ directly according to the colors of the chart—as shown in the illustration—and to use the vertical division of the chart for plotting $(t_1-t_2)=AB$ (see Fig.). After closing the triangle ABC by drawing the line CA we draw a line OG parallel to the long side CA through the origin of coordinates O, the intersection of which with the horizontal line for standard thickness (point F in the Fig.) indicates the finishing color.

Although due to the possible errors, especially in the determination of t_1-t_2, this method can be regarded only as an estimate of the finishing birefringence color, it is a valuable guide when dealing with single crystals at random orientation, or with an extremely coarse rock. In a series of measurements it has been found that the error in the estimated finishing thickness varies at an average within .008 mm., which corresponds in the case of quartz to a finishing color between straw yellow and white. If unfamiliar minerals occur in a fine-grained rock, one can apply this method in a similar manner, using the crystals of highest interference colors. The accuracy of this method decreases with increasing birefringence with respect to the values of Δ for the finishing color; the variation for the determination in thickness remains, however, within the same limits.



INTERFERENCE COLOR CHART - SHOWING METHOD OF PLOTTING