A NEW METHOD FOR MEASURING THE REFRACTIVE INDICES IN MICACEOUS MINERALS*

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ABSTRACT

A narrow strip of the mineral to be studied is cut and set vertically in a small cup containing a liquid of suitable refractive index; the whole is then placed on a temperature cell (heating stage) which is attached to a microscope and coupled to a thermostat and a refractometer. The refractive index of the mineral is measured by varying the temperature and consequently the refractive index of the liquid medium. The method outlined also permits measurement of the birefringence of chlorites.

The complete study of a mica sample is often necessary, either for purely scientific information or when its industrial utilization is contemplated. This study is facilitated by the fact that the members of the mica group have some characteristic properties in common. A similar statement can be made concerning the chlorites, though this group is less homogeneous and less well known.

Winchell (1925, 1933, 1935) has proposed a classification showing rather close relations between the chemical composition and some of the optic properties of micas (γ, α, and $\gamma - \alpha$). The measurement of the indices of refraction is necessary for knowing the position occupied by a mica in Winchell's classification. At the same time, these measurements give a fair idea of the chemical composition of the mica. It has been thought that, for both reasons, the publication of a new method for measuring α would be of interest.

PREVIOUS METHODS

The measurement of γ presents no great problem, since for the micas Z is always in the (001) plane. It can therefore be determined by the classical immersion method. The index normal to (001) is more difficult to measure.

Marie Louise Lindbergh (1946) has proposed a method which consists in introducing several cleavage flakes into a sirupy sodium silicate solution. In this medium, these fragments take up all possible orientations and one may be found having its (001) plane vertically disposed. Index α can thus be determined in the usual way.

Ferguson & Peacock (1943) have proposed another procedure. The index γ of the cleavage flake is measured and the lamella is then placed between the two hemispheres of a Fedorov universal stage in a liquid,

the index N of which is such that $\alpha < N < \gamma$. The preparation is then tilted about the optical direction Y, on the E.-W. axis, until the Becke line disappears. Knowing the angle of rotation necessary to bring this about, an equation permits the evaluation of α.

It has, however, seemed useful to devise a method allowing the measurement of α on a selected fragment without recourse to the Fedorov universal stage, since a number of laboratories do not yet possess this instrument. The proposed method is simple, rapid, and its degree of precision is good.

PROCEDURE

Using a razor blade, a narrow strip of mica 0.2 mm. or less in width is cut perpendicularly to (001). With the aid of a blowpipe, a pellet of
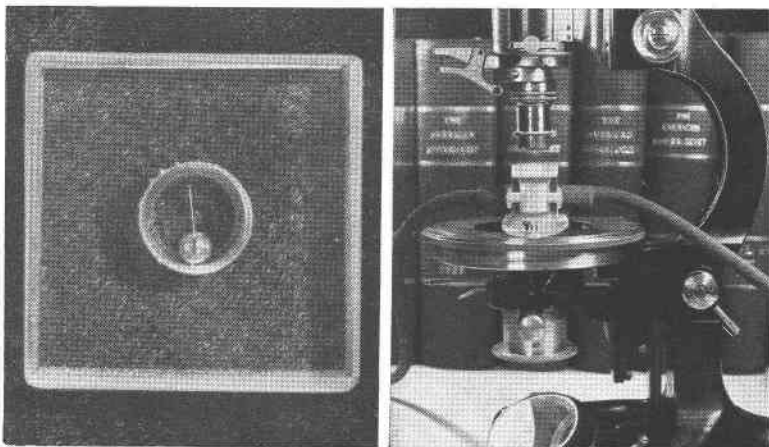

FIG. 1   FIG. 2

lead about 2 mm. in diameter is fused on a supporting block of plaster or metal in such a way that the pellet presents a flat base. This pellet is then detached and, again with the aid of a razor blade, a vertical nick is cut on its top. Using a needle, one end of the mica strip is introduced into the gap in the fused lead pellet in such a way that its plane of cleavage rests vertically, and following this the groove is closed with the aid of fine forceps. Because of the malleability of lead, a slight error can be easily corrected. These operations can be accurately and rapidly carried out under a binocular microscope.

The lead pellet is then introduced into a small cylindrical cavity bored in a glass block (Fig. 1). This cup is filled with a liquid of suitable index and the whole is placed on a temperature cell fixed to a microscope (Fig. 2); a drop of oil assures good contact and facilitates heat transfer. Details of the temperature cell are shown in Fig. 3.

The set-up for the measurement of the refractive index is of the current type, the heating stage being connected at one end to a thermostat and at the other end to an Abbe refractometer. To regulate the temperature, a Hoeppler Ultra-thermostat characterized by its great precision (0.02° C.) and by the speed of circulation of water (6 litres/min.) has been used by the author. The latter characteristic is of great value, since it assures perfect equality of temperature throughout the whole apparatus.
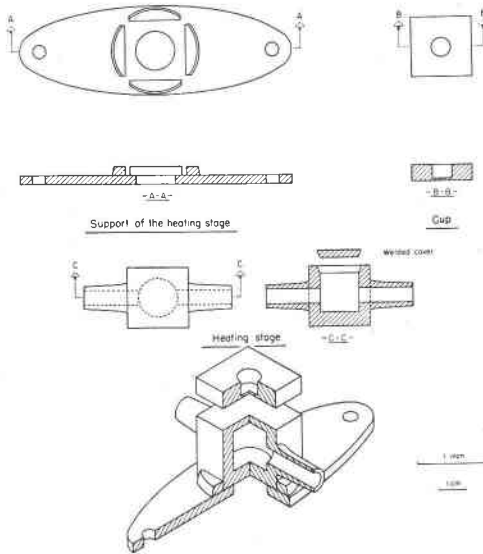

Fɪɢ. 3

The temperature of the water is varied till the Becke line disappears. At this point, the refractive index of the liquid is equal to that of the mica and it can be read on the refractometer drum.

The cup temperature has been checked with products of known melting points (beeswax and paraffin waxes), and found to be equal to that indicated by the refractometer and thermostat thermometers. To avoid differences in temperature between the various parts of the apparatus, it is necessary to vary the temperature slowly. The precision of the refractive index measurements made thus far is of the order of 0.002, but the use of a powerful monochromator would doubtless improve this.

Application and Limitations of the Method

Because of its principle, the method applies to all minerals possessing a perfect micaceous cleavage and having one of their indices in a direction normal to this cleavage. In the micas and most of the chlorites α is

the index normal to the cleavage; in some other chlorites it is γ and in these cases the method permits the measurement of the larger index. In a few minerals of the chlorite group, the direction of the index makes too large an angle with the normal to the plane of perfect cleavage, and in this instance the method does not apply. The flakes must be of sufficient size (a few millimeters is ample) and their optical orientation must be uniform.

Measurement of the Birefringence of Chlorites

The method provides a means of measuring directly the birefringence $\gamma - \alpha$ of oriented sections of chlorites. This birefringence is usually weak and seldom exceeds 0.010. Consequently, by placing the chlorite section at 45° from the cross-hairs and in a position of substraction, the retardation Γ can be measured by means of a Berek compensator. If the breadth d of the section has been previously determined with a micrometer, one has $\gamma - \alpha = \Gamma/d$.

The majority of chlorites have birefringence values within the range of the Berek compensator. Using a section 0.2 mm. wide, birefringence up to 0.012 can be measured, which is large enough for all practical purposes.

This method does not apply to the micas, at least when using the standard compensator, because their birefringence $\gamma - \alpha$ is too high.

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