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The optical characters of Antimonite.

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IN a paper communicated to this Society in March, 1903 [1], it was shown that antimonite is fairly transparent to radiations of long wave-length and that its behaviour between crossed nicols is consistent with orthorhombic symmetry. At the same time it was pointed out that it would be of interest to determine the wave-lengths of the radiations transmitted and the principal indices of refraction of antimonite for these radiations. On undertaking this investigation it was soon found that antimonite was quite sufficiently transparent to the rays at the extreme red end of the visible spectrum to enable visual observations to be made, and in a verbal communication to the Society on March 22, 1904, it was stated that the indices of refraction for red light were 4·129 for rays vibrating parallel to the axis Z and 3·873 for rays vibrating parallel to the axis X. These numbers were based on measurements made on a prism the faces of which were very indifferent. They can therefore only be regarded as rough approximations. Further, the exact wave-length of the radiation transmitted was unknown, an omission of some importance, as a few measurements made with a thermopile in the infra-red indicated that the dispersion in this region was very great. These preliminary results were, however, of sufficient

[1] Min. Mag., vol. xiii, p. 312.

interest to warrant an attempt to carry out a complete determination of the optical constants of antimonite with all the accuracy possible, and this investigation, though not quite finished, has now reached a stage when it seems desirable to put on record the results so far obtained.

The visible radiations transmitted by antimonite.—The first point to be determined was the wave-length of the visible radiations transmitted by antimonite. To effect this, one of Thorp's replicas of a Rowland grating having 14,504 lines to the inch was mounted on a spectrometer. Sunlight reflected from the silver surface of a heliostat mirror was focused on the slit by a quartz lens of 7 cm. diameter and 86 cm. focal length and the telescope was set on the line A of the solar spectrum. The slit was then entirely covered with a very thin cleavage-flake of antimonite. On now looking through the telescope it was found that the A line could still be distinctly seen, but that the more refrangible end of the spectrum was absolutely cut off just beyond A, while a considerable extension of the spectrum towards the infra-red had become visible. The antimonite was thus acting as one of the screens recently described by M. Štefánik[1], which have enabled him to see as far down the infra-red as ρ, σ and τ, and even under favourable circumstances to Φ, wave-length 1135.

On making these observations in a dark room, a faint line was observed in the region below A and by measurement was identified with Z of the infra-red solar spectrum, wave-length 823. The visible spectrum seen under these conditions extends somewhat beyond Z, but the illumination is too faint to permit of the identification of any more lines. It was thus established that a thin plate of antimonite transmits visible radiations extending from about 750 to about 850, and that in this region A and Z can be identified and used as standards.

Indices of refraction.—The principal indices of refraction were determined by the aid of two prisms prepared from a fine crystal of Japanese antimonite by Adam Hilger, Ltd.[2]

Prism I.—This prism was cut with its refracting edge parallel to the long axis, *Z*, of the crystal. One face was parallel to the cleavage-plane *b* (010), the other inclined to it at an angle of 7° 41′. Both faces had a very good polish and were sufficiently plane except quite close to the

[1] Compt. rend. Acad. Sci. Paris, 1905, vol. cxli, p. 585; 1906, cxlii, p. 986; cxliii, pp. 573 and 734.

[2] I desire here to record my appreciation of the great care and skill shown by the firm in working a very troublesome substance.

thin edge. One face gave a sharp reflected image of the slit, that afforded by the other was less satisfactory. When the prism was placed on the spectrometer and sunlight condensed on the slit by the above mentioned lens, two broad red images of the slit were seen in the telescope. These images were plane polarized, the vibrations in the most deviated image being parallel to the refracting edge of the prism, i. e. to the axis Z of the crystal. The lines A and Z could be detected in both spectra, though they were not very distinct. The prism was adjusted so that the cleavage-face was perpendicular to the axis of the collimator. In this position the light is incident perpendicular to a principal plane, and the values of two of the principal indices of refraction can be deduced from the relation $\mu = \frac{\sin(P + D)}{\sin P}$, where P is the angle of the prism and D the deviation observed.

The mean values of the deviations were, for the line A 27° 26′ and 25° 4′ respectively, and for the line Z 26° 25′ and 24° 3′. Whence follow the values :—

μ_γ for line A = 4·303 ; for line Z = 4·193. Vibrations parallel axis Z.
μ_β ,, = 4·046 ; ,, = 3·919. ,, ,, ,, X.

Prism II.—The refracting edge of this prism was parallel to the cleavage and to the X axis of the crystal. One face of the prism was perpendicular to c (001) and therefore perpendicular to the cleavage, the second was inclined to the first at an angle of 9° 15′. Great difficulty was experienced in polishing the faces of this prism, and it was found necessary to cement the face perpendicular to the cleavage on to a plate of glass. Placed on the spectrometer, two widely separated red patches were seen, but the definition was not sufficiently good to enable the line A to be detected, much less the line Z. The telescope was therefore set on what was judged to be the central brightest portion of each patch corresponding roughly to the region about midway between A and Z. The mean deviations observed were 21° 4½′ and 30° 40½′ respectively, whence follow as above :—

μ_α = 3·141. Vibrations parallel axis Y.
μ_β = 3·993. ,, ,, ,, X.

Discussion of results.—The main source of error in the above observations is the uncertainty of the value of the prism-angle, any small inaccuracy in this determination having a great influence on the calculated value of μ, when such acute-angled prisms have to be employed. Thus an error of 1′ in the value of the angle of prism I alters the corresponding value of μ by 0·007. An error of the same magnitude in the determination of the deviation is less serious, changing the value of μ by 0·002. There is no particular difficulty in getting fair readings for the deviation of the line A, but, owing to its faintness, Z is much harder to observe. The nature of the reflections from the faces of prism I were such as to render the value of its angle uncertain by about 1′ of arc. The values of μ_β and μ_γ are therefore probably correct within $\pm$ 0·01. In the case of prism II the uncertainty is somewhat greater, and A and Z cannot be distinguished. A probable value of μ_α for the line A can, however, be deduced from the numbers quoted above on the assumption that the double refraction $\mu_\beta - \mu_\alpha$ is about the same for A as for the region midway between A and Z. Subtracting then 0·852 from 4·046 we get 3·194 as the value of μ_α for the line A.

The optical scheme of antimonite for red light of wave-length 760 is therefore as follows:—

Plane of the optic axis parallel to *a* (100). Acute bisectrix perpendicular to *c* (001). Double refraction strong, negative.

$$\mu_\alpha = 3{\cdot}194. \quad \mu_\beta = 4{\cdot}046. \quad \mu_\gamma = 4{\cdot}303. \quad \text{Whence } 2V = 25^\circ\ 45'.$$

In addition to exhibiting very strong double refraction, antimonite is remarkable as showing an extraordinarily high degree of dispersion in the region under consideration. Thus for β we have $\mu_A - \mu_Z = 0{\cdot}127$ and for γ we have $\mu_A - \mu_Z = 0{\cdot}110$. Carvallo's[1] measurements enable us to compare this dispersion with that of calcite, for which he found $\mu_{ord.}$ (760) = 1·6501 and $\mu_{ord.}$ (832) = 1·6477; difference = 0·0024. Thus the difference of the refractive indices in the case of antimonite is more than fifty times as great as in that of calcite.

Further, these results are of special interest in so much as they supplement the work of E. C. Müller[2], who by a study of the constants of elliptic polarization of the light reflected from fresh cleavage-surfaces of antimonite was enabled to draw the dispersion curves for the region extending from G to C.

In view of the information already gained it seems desirable that the investigation should be extended as far as possible into the infra-red region. Further, there seems ground for believing that with the aid of the experience now acquired, it may be possible to prepare

[1] Compt. rend. Acad. Sci. Paris, 1898, vol. cxxvi, p. 950.

[2] Neues Jahrb. Min., 1903, Beil.-Bd. xvii, pp. 187–251.

a prism cut across the cleavage with surfaces good enough to enable A and Z to be recognized.

Work in both these directions is now in progress, and it is hoped that it may be possible before long to communicate further results to the Society.

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