An interferometric examination of synthetic mica.

(With Plate X.)

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Introduction.

A RECENT report[1] has appeared describing a process developed in Germany for the production of a crystal described as synthetic mica. The details are given for a process used at Ostheim and reference is also made to a Siemens–Halske technique. Through the courtesy of Mr. Kendall of Metropolitan-Vickers we have secured a few small samples of the Siemens–Halske material. This is reported to be a fluor-phlogopite with the chemical composition $KMg_3AlSi_3O_{10}F_2$ and free from water of constitution. Claims made by the manufacturers stated that the synthetic material exhibits the cleavage characteristics of natural mica.

The few samples we have obtained have areas somewhat less than a square centimetre and we have selected thin cleavage flakes and submitted them to interferometric examination with the multiple-beam technique. Since we have already studied 25 natural micas (see preceding paper), the main purpose of this note is to report upon both how closely the synthetic material mimics the natural mineral and upon any differences. For this purpose use has been made of multiple-beam Fizeau fringes using a mercury-arc source, with both filtered and mixed radiations. Although described as a phlogopite the material is quite colour-free (presumably due to the absence of iron), highly transparent, and visually resembling a high-grade muscovite rather than the mineral phlogopite.

Experimental.

(*a*) *Surface topography.*—Thin flakes (*circa* 1/100 mm. thick) were cleaved off, the mechanical act of cleavage closely resembling that of the

[1] A. E. Link, Investigation of a synthetic mica process, Ostheim, Germany. Combined Intelligence Objective Sub-committee, no. 22, xxii–11, London (H.M. Stationery Office), 1945. [M.A. 10–108.]

natural micas. The thin sheets were silvered on one side and matched close against a high-grade silvered optical flat. The Fizeau fringes so formed for a cleavage surface closely resemble the typical fringes given by a natural mica, examples being shown in pl. X, figs. 1–3 (green mercury-line source). The smooth continuity of the fringes (fig. 1) is typical of mica and the cleavage steps quite characteristic. There is, however, a notable distinction in some regions. In practically every natural mica examined the value of the cleavage step remains constant to within the limit of observation along the length of the step, i.e. the surfaces above and below the step are 'parallel'. On the synthetic crystal, however, adjacent surfaces on either side of some cleavage lines are inclined to each other. In one case, for example, the angle of slope is $2\frac{1}{2}$ minutes of arc. Interferometrically this is a considerable angle, since a slope of only 1/250th of this amount can readily be detected even over only a 1 mm. length of crystal. The implications of this difference will be discussed later.

(*b*) *Doubly silvered film.*—The thin films were examined by silvering both sides and viewing the Fizeau fringes formed *within* the body of the crystal. Typical examples taken with monochromatic radiation are shown in pl. X, figs. 4–6.

Interpretation.

When these interferograms are compared with those of the natural mineral micas illustrated in the previous communication, four features emerge:

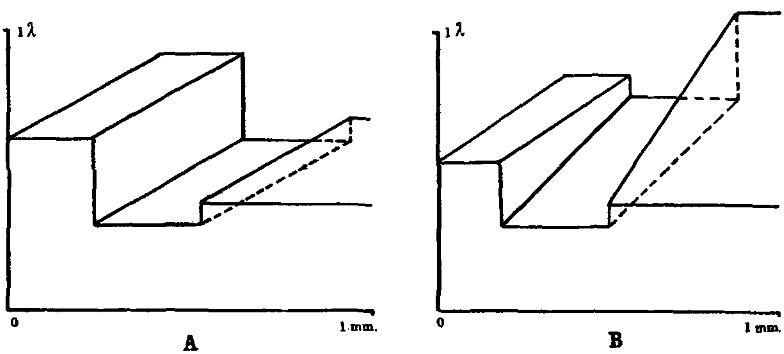
(1) The synthetic material clearly has a polycrystalline nature, whilst the natural micas tend to grow in large plates.

(2) The synthetic material shows comparatively few enclosed bubbles or gas pockets and in this respect is greatly superior to the natural phlogopite.

(3) Whilst natural mica cleaves in 'parallel' steps, such that a sheet is built up of regions which are of different thickness yet have strictly parallel faces, there are, on the other hand, frequent 'wedge' fringes in the synthetic sheet. An exaggerated schematic diagram illustrating the effect is shown in text-fig. 1. In this diagram the buckling and distortion of the sheet is disregarded. *A* shows the parallel-sided cleavage of the natural mica; and *B* the 'wedge' formation of the synthetic material, with gross exaggeration of the wedge angles which are only of the order of a few minutes of arc at most. This type of structure accounts for the observations made on both singly and doubly silvered specimens.

There seems no doubt that this illustrates a marked distinction between the natural and synthetic materials. All the evidence so far found shows that large natural mica crystals grow in strictly *parallel* sheets. The synthetic material appears to consist of a conglomeration of crystals which are *almost* but not quite parallel in many regions. The deviation from parallelism varies considerably from region to region.

(4) *Birefringence fringe doubling.*—Phlogopites do not show birefringence doubling of fringes, and indeed this is what we have found over



TEXT-FIG. 1. Diagram of cleavage surfaces. A, natural mica; B, synthetic mica.

practically the whole of the synthetic material. On one sample, however, there was a region which cleaved to give uniform tint areas over an appreciable area, a characteristic shown usually by the muscovites. In this local region the synthetic material showed a birefringence effect of the muscovite type, and, locally, either some intermediate crystal type has formed or some kind of twinning exists. Only a small fraction of the total area examined showed this complexity.

Disintegration of the silver film.

A notable difference between the natural and synthetic materials is shown by the fact that the cleaved surface of the synthetic crystal is chemically active and rapidly disintegrates the silver surface. On the other hand, on practically all the natural micas the silver surface remains stable over many months. (In rare instances local disintegration sets in over very small regions. This will be discussed elsewhere.)

The disintegration is shown in pl. X, figs. 7 and 8, which represent monochromatic Fizeau fringes of a doubly silvered slip of the synthetic material taken respectively one week and ten days after silver deposition.

It can be seen that over the whole surface area small nuclei act as disintegrating centres, and the silver is destroyed in circular patches spreading out from each nucleus. The successive stages of the break-up can be clearly followed in the interferograms. Such material can clearly not be used as a silvered mica condenser.

It is clear that the synthetic material is an imperfect crystal. The destruction of the silver is obviously chemical and may be due possibly to fluorinated centres, or some other chemically active constituents. We have occasionally witnessed the break-up of silver films when deposited on dirty surfaces, but such break-up is rarely as violent as that shown here. The cleavage face of the crystal was free from extraneous dirt and impurity, but may easily have contained unconverted particles of the constituent mother materials from which the crystal was made. The amount of silver involved in the large disk in fig. 8 is only 3×10^{-8} gram.

Summary.

(1) The synthetic material is highly transparent and contains few inclusions.

(2) Cleavage closely approximates to that of a natural mica, but differs in detail.

(3) The material appears to be largely polycrystalline consisting in parts of almost parallel plates.

(4) As distinct from the natural mica the synthetic material has numerous chemically active centres which attack silver.

(5) Most of the material shows no birefringence on the cleavage surfaces, but a local birefringent area has been found.

It may be concluded that the synthetic material is much more free from inclusions than natural phlogopite. In this respect it closely resembles a muscovite. Crystallographically, however, it is less perfectly formed than a natural mica, although the differences as listed above are not such as to make a serious distinction. In cleavage and structural characteristics, as in homogeneity, the synthetic material is inferior to a good grade of muscovite, but superior to a natural phlogopite.

Explanation of Plate X.

Synthetic mica (fluor-phlogopite).

Figs. 1–3. Fizeau fringes of single cleavage faces.

Fig. 1. Shows smooth continuity of fringes. This region resembles the surface of a muscovite. ×30.

Fig. 2. Typical cleavage step. ×30.

Fig. 3. Typical of natural mica, showing numerous cleavages, but some surface irregularity. In some cases the fringes separated by a cleavage get out of step, indicating a wedge. ×30.

Figs. 4–6. Fizeau fringes of doubly silvered sheets.

Fig. 4. The uniform tint areas resemble those of muscovites. In contradistinction to natural phlogopite there is a notable absence of inclusions. ×30.

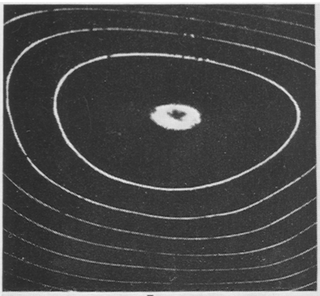
Fig. 5. Showing irregular internal wedges. ×30.

Fig. 6. Showing a section exhibiting wedge fringes, indicating the two faces of the mica sheet are not quite parallel. ×30.

Figs. 7 and 8. Fizeau fringes illustrating the chemical destruction and disintegration of the silver film on synthetic mica, increasing progressively with age.

Fig. 7. Surface after 7 days, originally as clear as in fig. 4. ×36.

Fig. 8. Same surface as in fig. 7 three days later. Surface breaks up by spread of circular rings of opacity. ×36.



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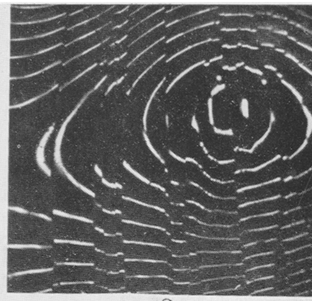

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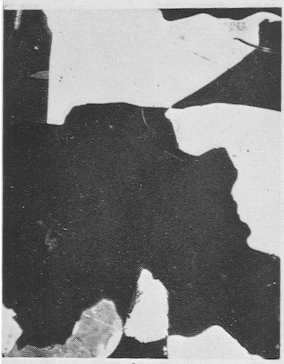

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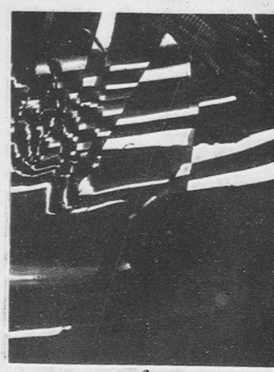

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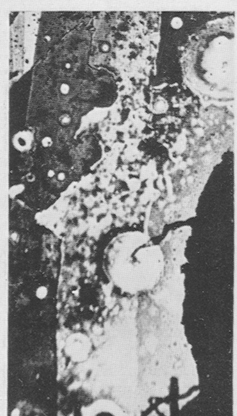

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