The chemical analysis is given in Table 2. The most noticeable difference from normal apatite is the high content of Y_2O_3. The Y ion occupies the Ca position. *X*-ray fluorescence analysis also was used for determining Y. The small amount of SiO_2 may be caused by included quartz.

The formula derived from the analysis is

$$(Ca^{2+}_{773}Y^{3+}_{80}Ce^{3+}_{2}Fe^{3+}_{4}Al^{3+}_{6}Mn^{2+}_{2})_{867}P^{5+}_{568}O^{2-}_{2240}(F^{1-}_{148}Cl^{1-}_{3}OH^{1-}_{36})_{187}$$

or, simplified, $(Ca_{4.1}Y_{0.6})_{4.7}P_{3.0}O_{12.0}(F_{0.8}OH_{0.2})_{1.0}$ or even more simply $(Ca,Y)_{4.7}(PO_4)_3(F,OH)$. The molecular amounts of yttrian apatite and included quartz are 96.3 per cent and 3.7 per cent respectively. The totals of the recalculated univalent cations and anions of yttrian apatite are 4666 and 4667 respectively.

The above formula may be represented as $(Ca_{5-x}Y_{2/3x})(PO_4)_3(F,OH)$. When x=1, the formula is that of the present mineral and when x=5, the end member become yttroapatite.

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ETCHING OF SYNTHETIC FLUORPHLOGOPITE

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Introduction

Considerable work has been reported on the etch patterns produced on cleavage faces of natural muscovite and other types of micas. It seems that no etching work has been reported so far on synthetic mica. In

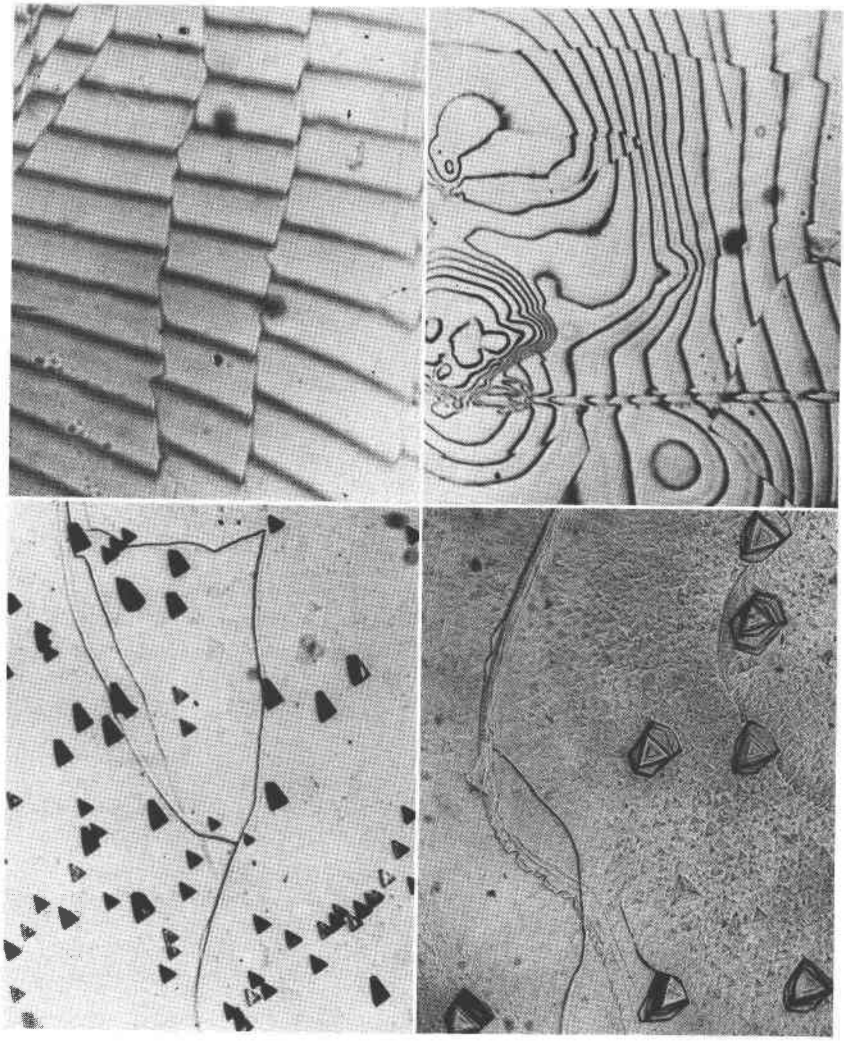


FIG. 1. (upper left) An interferogram on the cleavage face of synthetic phlogopite (×110)
FIG. 2. (upper right) An interferogram on the cleavage face of natural phlogopite (×110).
FIG. 3. (lower left) Etch pattern on synthetic phlogopite (×200).
FIG. 4. (lower right) Etch pattern on natural phlogopite (×175).

natural muscovite Patel and Tolansky (1957) have shown that two types of pits, (a) small widely distributed pits and (b) relatively large, localized, isolated pits, are produced by etching cleavages in hydrofluoric acid (HF) vapor. They have further shown that the individual, isolated pits on matched cleavages have perfect correspondence with regard to their position, size and shape. We have established that the etch pattern on natural phlogopite also consists of (a) small, widely distributed pits and (b) large, localized, isolated pits. However, the correspondence in the etch patterns on matched faces exists only with regard to the position and number of pits but not in regard to the shape and size. Pandya and Pandya (1959) have etched matched cleavages of natural muscovite, one in fused alkalies and the other in hydrofluoric acid and have discussed the correspondence of etch figures produced on them. In the present investigation we have tried to study the etch patterns produced on synthetic fluorphlogopite and compare them with those on natural phlogopite.

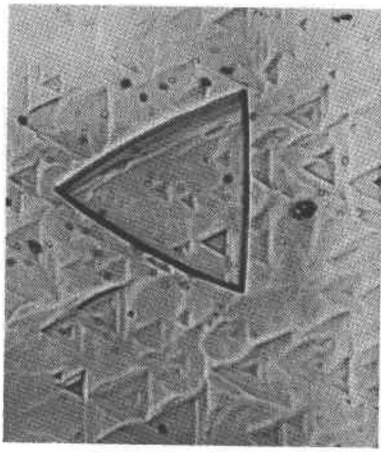
Experiments

For experimental purposes, fresh synthetic mica cleavages from our present stock were selected and subjected to a thorough microscopic examination by using phase contrast microscopy and multiple beam interferometry. Thus Fig. 1 represents a multiple beam interferogram on the cleavage face of synthetic phlogopite. It is very interesting to note from the nature of the fringes that the regions between the cleavage lines are quite flat. Figure 2 represents an interferogram taken on a cleavage face of a natural phlogopite. The fringes reveal that the cleavage surface is very uneven as compared with the cleavage face of synthetic mica (Fig. 1).

The selected cleavage faces were dipped in 40% hydrofluoric acid at room temperature for a known period of time. They were then taken out, thoroughly cleaned and examined microscopically after depositing thin films of silver upon them. Figure 3 shows the etch patterns produced on synthetic mica after 35 minutes of etching in hydrofluoric acid. Etch figures of various shapes and sizes are clearly seen. Figure 4 represents an etch pattern on natural phlogopite given here for comparison. The differences between the etch patterns on synthetic and natural phlogopite can be clearly seen by comparing Figs. 3 and 4. The essential differences are as follows:

Synthetic Phlogopite	Natural Phlogopite
1. Only individual, isolated pits are observed.	1. In addition to individual isolated pits, micropits are developed.
2. The individual, isolated pits are of different shapes and sizes.	2. The individual isolated pits are nearly of the same size and orientation.

Figure 5 represents an oil immersion photomicrograph of natural phlogopite in which the randomly distributed micropits are clearly seen. The absence of randomly distributed micropits in synthetic mica is clearly revealed in Fig. 6 which is an oil immersion photomicrograph in



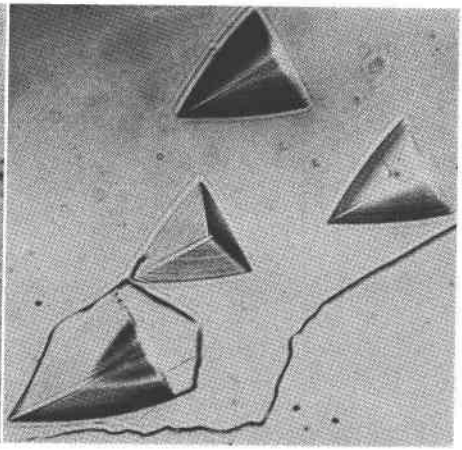
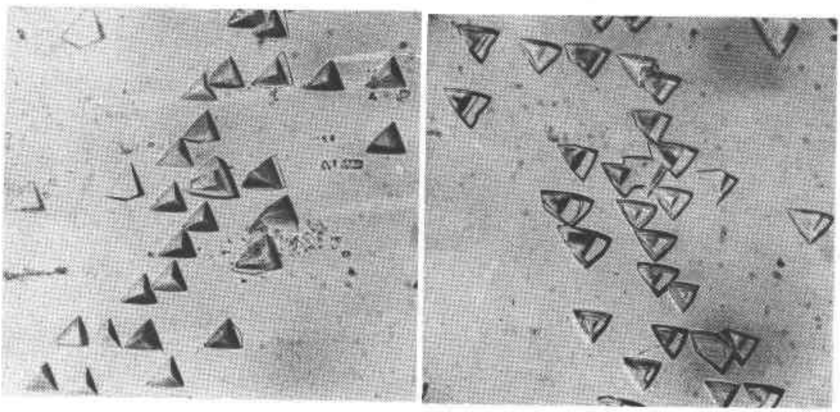


FIG. 5. (left) Oil immersion photograph of the etch pattern on natural phlogopite (×800).
FIG. 6. (right) Oil immersion photograph of the etch pattern on synthetic phlogopite (×800).

which only individual, isolated pits are seen. The absence of randomly distributed micropits on synthetic mica may be explained by postulating the absence of some imperfections in its crystal structure which on etching may lead to the occurrence of micropits. This appears reasonable since the synthetic mica is grown under controlled conditions.

In order to establish in synthetic mica the correlation of etch pits on matched faces, the latter were simultaneously etched in hydrofluoric acid for a period of 35 minutes. Thus Figs. 7 (a) and (b), represent the etch patterns on the matched faces. It may be noted that

1. Similar to natural phlogopite, synthetic phlogopite takes only 35 minutes to produce pits of nearly the same size which in natural muscovite takes 36 hours.



FIGS. 7(a) (left) and 7(b) (right) Etch patterns of matched faces in synthetic phlogopite (×420)

2. The number and positioning of the pits are such that they mirror image those on the oppositely matched face.
3. The pits are closely similar in shape.
4. Large numbers of pits are seen having some outer boundary.
5. The outer boundaries of the pits are not exactly of the same shape on the matched faces.
6. In many cases pits with an outer boundary coincide with a similar pit on the matched face, but there are pits without the boundary on one face coinciding with pits with the boundary on the matched face.

In order to investigate whether there is any correlation in the etch patterns on opposite sides of a thin mica flake, flakes .002–.003 cm thick

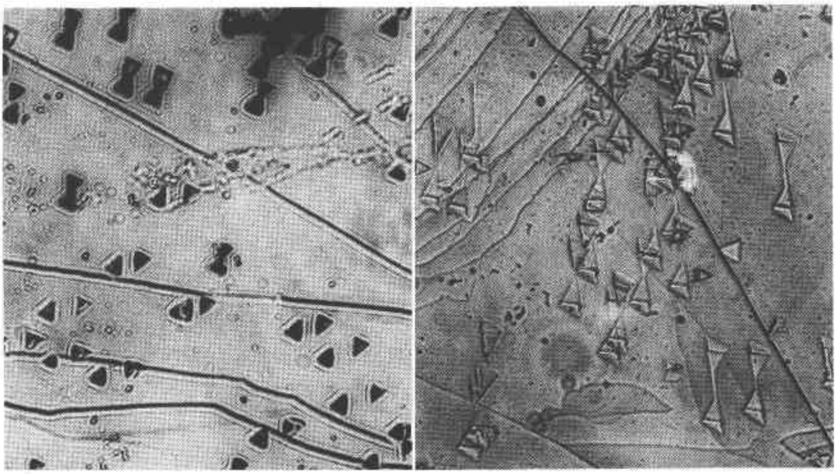
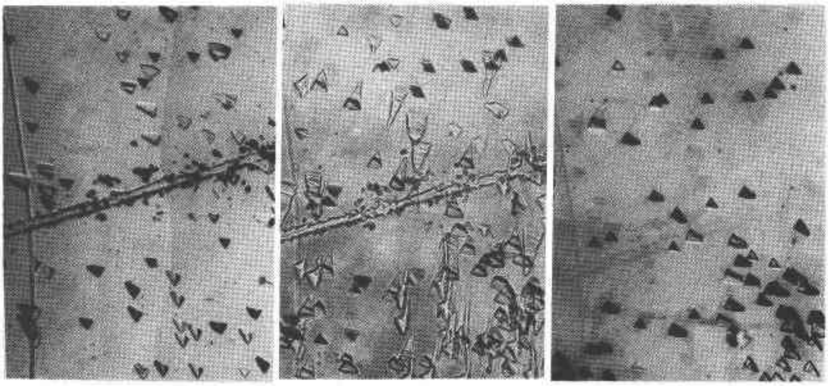


FIG. 8. (left) Synthetic phlogopite etch pattern taken in transmission showing the displacement in the pattern of two sides (×300).
FIG. 9 (right) Synthetic phlogopite etch pattern in transmission showing basal extensions (×350).

were cleaved and etched in hydrofluoric acid. Figure 8 is a photomicrograph taken in transmission of the etch patterns produced on both sides of a thin flake. Attention is drawn to the following features:

1. Instead of individual isolated pits, pairs of pits are observed.
2. Pits in each pair have similar shape and size but different orientations.
3. The etch patterns of the two sides can easily be recognized from the orientation of the etch pits, because pits of the same orientation belong to the etch pattern on the same face.
4. There is a high degree of correspondence in the etch patterns on the two sides.
5. The etch patterns of the two sides are relatively displaced.

Figure 9 represents etch patterns taken in transmission of some other thin flake of synthetic mica. In addition to the observations described



FIGS. 10(a) (left), 10(c) (right). Photographs taken in reflection of both sides of a thin silvered flake of synthetic phlogopite (×350).

FIG. 10(b) (center) Photograph taken in transmission of crystal used for Figs. 10(a) and (c) (×350)

above, it is interesting to note the following:

a. Unlike the pits observed in the above patterns these pits are asymmetric.
b. Many of the pits have basal extensions along a crystallographic direction.

The correspondence observed in Figs. 8 and 9 in the etch patterns on the two sides of thin mica flakes can be explained either by assuming (1) the existence of dislocation lines in the body of the crystal (Patel 1961) or (2) that slip might have occurred between the top and the bottom surfaces. If the second alternative is correct then the relative displacement in different pairs of the etch patterns on the two sides should be uniform and in the same direction throughout the whole region. Careful investigation of the etch patterns of Fig. 8 reveals that this is not so. The magnitude of the displacement is not the same in all the pairs and it is not in the same direction. This suggests that the linear defects may be inclined at various angles with the cleavage faces and hence may be lying in different crystallographic planes.

In order to study the nature of the basal extensions observed in Fig. 9 a piece of synthetic mica, .003 cm thick, after having been etched and photographed in transmission, was silvered on both faces. Photographs of these silvered faces were then taken separately. Thus Fig. 10 (b) shows the photomicrograph taken in transmission of a portion of the mica piece, whereas Figs. 10 (a) and (c) are photomicrographs of the two sides of the same part taken in reflection after silvering. Many of the pits in Figs. 10 (a) and (c) can be identified with those of Fig. 10 (b), the composite picture of Figs. 10 (a) and (c). It is surprising to note that in

Figs. 10 (a) and (c) the basal extensions observed in Fig. 10 (b) are not revealed at all. It was thought initially that the basal extensions of the pits may be similar to the wings associated with etch pits as observed on some natural Australian muscovite by Patel and Tolansky (1957), but it is quite clear from the above pictures that the basal extensions have nothing to do with the surface. They are due to something happening within the body of the crystal. It is therefore conjectured that they are the air wedges produced by the etchant in the body of the crystal.

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BLUE QUARTZ FROM THE WIND RIVER RANGE, WYOMING

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A granodiorite gneiss in the central Wind River Range, Wyoming contains numerous veins of blue, opalescent quartz (Parker, 1962) which owes its blue color to scattering of light by tiny needles of tourmaline. The color of blue quartz has been attributed to the presence of minute rutile needles by a number of authors (Goldschmidt, 1954; Holden, 1923; Lukesh, 1945; Watson and Beard, 1917.) Gordon (1946) attributes the blue color to "blue needles" which he identifies as trains of minute bubbles. Goldschmidt (1954) states that blue, rutile-bearing quartz is not to be confused with Cambrian and Ordovician blue quartzites of Norway which owe their color to fine, disseminated magnetite dust. Boyle (1953) notes the presence of graphite in certain black and gray quartz from Canada.

The fine needles in the Wind River Range blue quartz show straight extinction in thin section, and are length fast. Because no additional properties could be determined in thin section, ten grams of the quartz was dissolved in hydrofluoric acid with loss of the silica. The residue was washed with water to remove soluble fluorides, and the insoluble