

polarizers for the demonstration of interference figures using polished spheres of various crystals. He states that such a sphere held in the hand between the polarizers can be rotated and the student can "observe the position of the uniaxial or biaxial figure, and determine by experiment the effect of crystal orientation on the interference figure." Such experiments can be carried out with the *demonstration polariscope*. In addition thin plates can be placed on the rotating stage, and interference colors, extinction angles, twinning and other phenomena can be observed.

One of the chief virtues of the *demonstration polariscope* is that interference figures can be obtained on cleavage plates or on oriented sections of minerals. Between the stage and upper polarizer is a frame carrying a polished glass sphere 3 inches in diameter (a clear plastic sphere is equally suitable). The frame is mounted on tracks and can be pushed to the back of the instrument when not in use. With a properly oriented mineral slice and the sphere in position, an interference figure can be seen to completely fill the sphere as in Fig. 1.

The interference figures appear much the same as they would using a plate of the mineral of the same thickness with a microscope. For example, by using successively thicker cleavage plates of muscovite, one can see a sharpening of the isogyres and an increase in the number of isochromatic bands. By rotating a biaxial acute bisectrix figure to the  $45^\circ$  position, one can show how the optic sign is obtained with a quarter wave plate or red of the first order by placing these plates over the crystal section. Because the interference figure is seen on the surface of the sphere rather than in a plane, the emergence of both optic axes in a centered acute bisectrix figure can be seen at the same time in a crystal that has a  $2V$  as large as  $75^\circ$ .

#### UNUSUAL FORMS OF HALLOYSITE\*

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Kaolin type clay mineral is a common constituent of the clay of volcanic ash soils of advanced weathering stage. Electron micrographs of such clays usually show much of the kaolin to have the characteristic cylindrical form of halloysite described by Bates (1). X-ray diffraction patterns of the glycerol clay show basal spacings mainly between 7.2 and 7.4 Å, indicating that the form of kaolin is mainly metahalloysite, with only minor amounts of the 11 Å spacing of glycerol halloysite corresponding to hydrated halloysite.

In the course of an investigation of the clay fraction of a subsoil derived from volcanic ash at New Plymouth, it was found that the clay,

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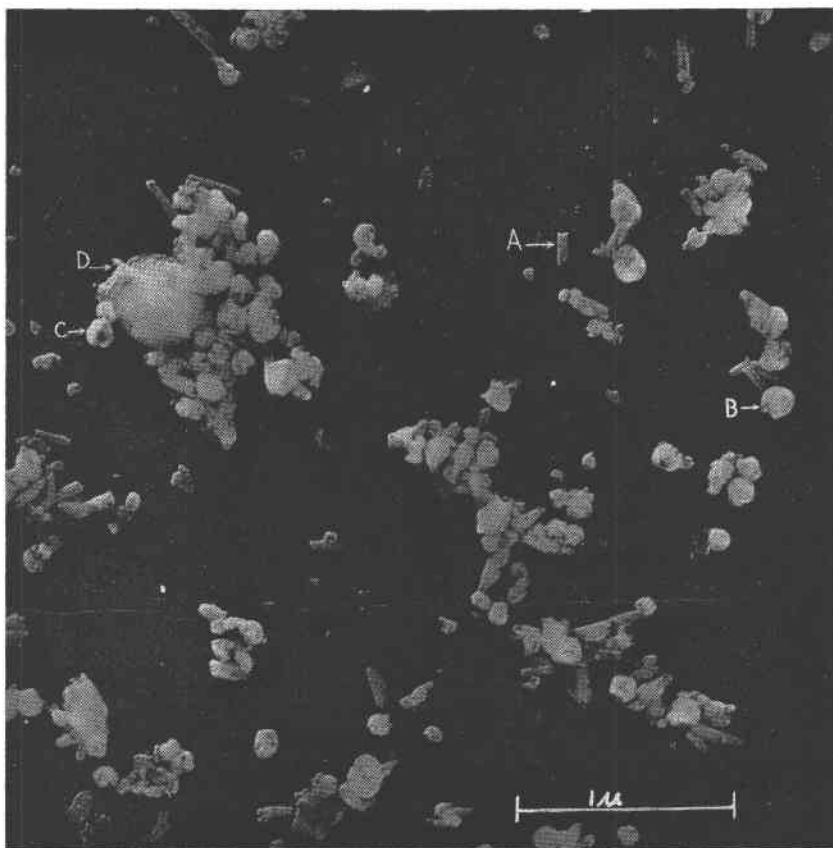


FIG. 1. Electron micrograph of clay from subsoil derived from volcanic ash, New Plymouth, New Zealand: *A*. Normal tubular hydrated-halloysite particle. *B*. Hydrated halloysite particle in form of a distorted spherical shell. *C*. Hydrated halloysite particle in toroidal form. *D*. Amorphous mass of allophane present as a minor constituent of the clay.

which comprised 46 per cent of the subsoil, had the  $x$ -ray diffraction pattern of hydrated halloysite with an intense basal reflection of the glycerol clay at approximately 11 Å.

Figure 1 is an electron micrograph of this clay. About half the particles are normal tubular halloysite of average length about 0.2 micron. Most of the remainder are round particles ranging from 0.05 to 0.2 micron in diameter. Of these some appear to be hollow, rather distorted spherical shells, while others are apparently incomplete toroids as though formed from cylindrical halloysite particles rolled up so that their ends almost meet. The details of their structure are better seen in transparencies than in a print but nevertheless, the holes in the centres of some particles can be seen even in the print.

Particles with holes similar to those in the New Plymouth clay are shown in electronmicrographs by Davis *et al.* (3) of a sample stated to be serpentine. Serpentine is the magnesium analogue of kaolin and this particular serpentine contained mainly tubes and rods, but also a few particles having a "life-saver" appearance considered by those authors to be tubular particles seen in cross-section. In the case of the hydrated halloysite sample described here the holes apparent through many of the particles were at first thought to be due to tubes seen end-on but close examination appears to indicate that the holes are either centres of toroidal shaped particles or more transparent zones of incomplete spherical shells.

The clay of less than 2 micron equivalent diameter had a cation exchange capacity of 22 milliequivalents per 100 g.,  $\text{SiO}_2:\text{Al}_2\text{O}_3$  molecular ratio of 2.09,  $\text{Fe}_2\text{O}_3$  content of 5.1 per cent, and surface area by the *B E T* method of 137 sq. metres per gram.

Nomenclature used here for forms of halloysite is that of MacEwan (2).

#### REFERENCES

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2. MACEWAN, D. M. C. (1947), Halloysite nomenclature: *Mineral. Mag.*, **28**, 36-44.
3. DAVIS, D. W. et al. (1950), Electron micrographs of reference clay minerals: *Preliminary Report No. 6. American Petroleum Institute Project 49, Reference Clay Minerals.*

#### VAPOR PRESSURE GLYCOLATION OF ORIENTED CLAY MINERALS\*

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The process of increasing the (00*l*) spacings of expanded clay minerals to facilitate their identification was introduced by Bradley (1945), MacEwan (1946, 1948), and others. They demonstrated that numerous organic substances would enter the expanded clay lattices along the (001) plane between the 2.1 sheets, replacing the water. The organic molecule is generally larger than the water it replaces and the result is that the *d* spacings of the (00*l*) reflection series are increased. The resulting increase in *d* spacings is easily recognized, and the presence of expanded clays can be demonstrated even in complex clay mixtures.

It has been the practice in the past to use ethylene glycol as the organic liquid because it is cheap, easily obtainable, and water-soluble, and because the large molecules expand the (001) spacing to approximately 17 Å for pure montmorillonites with divalent cations. Samples were prepared by mixing the clays with liquid glycol.

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