

also to previous experiments<sup>6</sup> on the lowest temperatures attained by pumping liquid helium (0·71° on the 1932 scale), so we can state that the region of temperature hitherto available only with the elaborate apparatus of these earlier experiments is now accessible with the simple means described.

As the pierced membrane used in the above experiment offers an appreciable resistance to gas flow, we are now engaged on experiments to determine the size of membrane hole best suited to different conditions of heat influx to the apparatus. For this purpose the normal heating (that is, by gas conduction and radiation) to vessels less well insulated is simulated by enclosing an electrical heating coil in the helium vessel. These experiments have shown that a hole of 0·15 mm. diameter is too small unless the heat influx can be reduced below 1 millical./min. For example, a heat influx of 3·5 millical./min., which is roughly that occurring in our ordinary 30 c.c. vessel for demagnetization experiments, gives a temperature of 1·05° K. with a 0·15 mm. hole, while with a bigger hole it is again possible to reach below 0·8° K.

A complete account of these experiments will be given later.

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- <sup>1</sup> Rollin, B. V., and Simon, F., *Physica*, **6**, 219 (1939).  
<sup>2</sup> Blaisse, B. S., Cooke, A. H., and Hull, R. A., *Physica*, **6**, 231 (1939).  
<sup>3</sup> Kürti, N., and Simon, F., *Phil. Mag.*, **26**, 849 (1938).  
<sup>4</sup> Keesom, W. H., *Leiden Comm.*, Suppl. No. 71d (1932).  
<sup>5</sup> Schmidt, G., and Keesom, W. H., *Leiden Comm.*, No. 250c (1937).  
<sup>6</sup> Keesom, W. H., *Leiden Comm.*, No. 219a (1932).

#### Polymorphism of the Micas and Diffuse X-Ray Scattering of Layer Silicate Lattices

THE first significant work on the structures of the micas was that of Maugin<sup>1</sup>, who measured the units of structure and discussed types of isomorphous replacements. Pauling<sup>2</sup>, on the basis of his co-ordination theory, proposed general structures that were shown by Jackson and West<sup>3</sup> to be correct in some detail for muscovite. Maugin noted that the lattice dimension along the *c* axis of a biotite crystal was apparently one half that of muscovite, and he further observed diffuse scattering of X-rays from several crystal zones.

Muscovite contains close-knit layers approximating  $[(Al_2)AlSi_3O_{10}(OH)_2]^n$  in composition that are joined across the cleavage plane by potassium atoms having twelve-fold co-ordination. The unit of structure chosen by Jackson and West is crossed by two such layers related by a glide reflection plane, the crystal symmetry being monoclinic holohedral. Phlogopite results from replacing  $(Al_2)$  with octahedral co-ordination by  $(Mg_3)$ , which completely fills the octahedral positions; in biotite,  $(Al_2)$  is replaced by magnesium and iron.

Examination of many micas now brings to light a great variety of structure. Biotite, phlogopite, lepidomelane, zinnwaldite and lepidolite often have a single layer structure, the crystal symmetry being monoclinic hemihedral. A pseudo-hexagonal three-layer structure is also frequently found for lepidolites and zinnwaldites. Two-layer structures, similar to but not identical with that of muscovite, have been found for four of the fifty biotite-like samples examined. Several biotite samples were found in which the unit of structure apparently was crossed by six,

eight and ten layers. In the last case, the lattice periodicity is more than 100 Å. in a direction normal to the unique monoclinic axis, which introduces some question about the extent of an element in the crystal mosaic. Twenty samples of muscovite, including seven specimens associated with biotite or lepidolite (zoned crystals), all had a two-layer structure, and none showed diffuse reflections.

Many of the biotite-like samples give diffuse scattering of X-rays in  $[h_0k_0l]$  zones for which the *k* index is not a multiple of three. This is a result of random combinations of the various structures. Thus if some elements of the three-layer arrangement are replaced by a two-layer structure, the periodicity along the *c* axis will be destroyed for those planes with the *k* index other than a multiple of three, and reflections from such planes will be broadened. Random elements in the single-layer structure give rise to diffuse scattering but do not prevent close agreement between observed and calculated intensities. In structures of higher layer multiplicity, a few random elements make intensity calculations impossible by introducing an indeterminate phase shift, but do not necessarily lead to diffuse scattering as is shown by the layer minerals dickite, talc and pyrophyllite as well as by the micas.

The uniqueness of the muscovite structure is a result of its departure from the ideal arrangement proposed by Jackson and West. This departure, which is considerable, is shown by the relatively high intensities of reflections from  $(06l)$  with *l* odd, which should be absent for the ideal structure as they are for the biotites. Incomplete filling of the octahedral co-ordination positions in muscovite leads to distortion of the co-ordination and therefore of the layer. As a result, there is but one way in which the twelve-fold co-ordination of potassium between layers can be obtained. In the biotites, complete filling of the octahedral positions gives a regular arrangement within a layer and thus permits various combinations of layers. Even the two-layer biotite structures have  $(06l)$ , *l* odd, reflections absent.

The distinction between muscovites and biotites, from mineralogical data, has partially been recognized by Winchell<sup>4</sup>. Diffuse scattering of X-rays from the micas has features in common with the phenomena described by Preston<sup>5</sup> and Guinier<sup>6</sup> for alloys. Considerable time will elapse before detailed analyses of the many structures observed can be published.

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- <sup>1</sup> Maugin, C., *C.R.*, **185**, 228 (1927); **186**, 879, 1131 (1928).  
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<sup>3</sup> Jackson, W. W., and West, J., *Z. Krist.*, **76**, 211 (1930); **85**, 160 (1933).  
<sup>4</sup> Winchell, A. N., *Amer. J. Sci.*, **9**, 309, 415 (1925).  
<sup>5</sup> Preston, G. D., *Proc. Roy. Soc. (London)*, **A**, **166**, 872 (1938); *NATURE*, **142**, 570 (1938); *Phil. Mag.*, **26**, 855 (1938).  
<sup>6</sup> Guinier, A., *C.R.*, **206**, 1641, 1972 (1938); *NATURE*, **142**, 569 (1938).

#### Interrelation of Dissociation Energy, Internuclear Distance and Bond Order for Carbon-Carbon Linkages

Fox and Martin<sup>1</sup> have found that the heat of dissociation (*D* kgm.-cal.) for different carbon-carbon linkages (organic compounds, graphite, diamond) follows smooth curves when plotted against either internuclear distance (*r<sub>e</sub>* angstroms) or bond order *x*. When the assigned values of any pair of the three magnitudes *D*, *r<sub>e</sub>*, *x* are plotted against each other