——— (1964): Contribution à la mineraloge des arséniates calciques et calcomagnésian naturals, *Bull. Soc. franc. Minér. Crist.*, **87**, 169–211.

SABINA, ANN P., & TRAILL, R. J. (1960): Catalogue of *x*-ray diffraction pattern and specimen mounts on file at the Geological Survey of Canada. *Geol. Survey. Canada*, Paper, **60**–4.

TABLE 1. RESULTS OF IDENTIFICATION

Original label and R.O.M. Number	Determinations	Locality	Date of Acquisition
Wapplerite and picropharmacolite E 3756	Hoernesite and picropharmacolite	Freiberg, Saxony, Germany	1912
Haidingerite with pharmacolite M 6830	Picropharmacolite with pharmacolite	Hofmangang, Gottesgob Bohemia, Czecho-slovakia (Now Bozi Dar)	1913
Pharmacolite M 6831	Picropharmacolite and erythrite	Bieber Hesse, Germany	1913
Wapplerite and pharmacolite M 6836	Sainfeldite, weilite pharmacolite, picropharmacolite and erythrite	Bieber Hesse, Germany	1913
Hoernesite M 13690	Picropharmacolite	Joachimsthal, Bohemia, Czechoslovakia	1924
Pharmacolite M 23588	Pharmacolite	Ste. Marie Aux Mines, Alsace, France	1960
Pharmacolite M 23711	Pharmacolite and picropharmacolite	Gobes Gottes, Haut Rhine, France	1960
Picropharmacolite 23724	Picropharmacolite pharmacolite and arsenolite	Gobes Gottes, Haut Rhine, France	1960
Roesslerite on orpiment with realgar M 26067 M 26068	Hoernesite on orpiment with realgar	White Caps Mine, Manhattan Nye Co., Nevada	1964
Pharmacolite M 26164	Picropharmacolite pharmacolite and erythrite	Anton Mine, Heubachtal, Schwarzwald, Germany	1964
Pharmacolite M 26371	Weilite with pharmacolite	Wittichen, Baden, Germany	1964

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A NOTE ON THE TEXTURE OF PYRRHOTITE IN SOME ROCKS OF THE MUSKOX INTRUSION

KEIICHIRO KANEHIRA
Chiba University, Chiba, Japan

The Muskox intrusion is a layered mafic-ultramafic complex which occurs in the northwestern part of the Canadian Shield (Smith, 1962). A comprehensive study of this intrusion is underway by the members of the Geological Survey of Canada under the leadership of C. H. Smith.

A detailed study of the sulphides and native metals in the intrusion is being carried out by J. A. Chamberlain. In the course of his work, Chamberlain noted that many adjacent, interstitial pyrrhotite grains in the ultramafic rocks showed simultaneous extinction, and he suggested that a study of this phenomenon be undertaken. The texture appeared to have originated (1) as a result of interstitial crystal growth forming single large poikilitic crystals within the framework of the silicate minerals, or (2) as a result of separate pyrrhotite crystals having a common crystal orientation.

Rocks examined

The samples used in the present study were obtained from drill cores from the Muskox drilling project (Findlay & Smith, 1964). Three specimens of peridotite from the East hole (E1871′, E2160′, and E2220′) were arbitrarily selected for an examination of pyrrhotite texture. The chief primary constituents of the rocks examined are olivine and clinopyroxene, which to a large extent have altered to serpentine and magnetite (Chamberlain & Delabio, 1965). In addition, sulphides form 1 to 2 per cent (by weight) and chromite less than 1 per cent of the rocks. The principal sulphides, in decreasing order of abundance, are pyrrhotite, pentlandite and mackinawite. Pyrrhotite and pentlandite are almost certainly of primary origin, while mackinawite is believed to have formed at relatively low temperatures during serpentinization (Chamberlain *et al.*, 1965).

Texture of pyrrhotite

Sulphide minerals occur in clusters of separate grains that fill interstices between olivine crystals. A cluster is defined here by the fact that its component grains show parallel, or nearly parallel, extinction. The word grain, as used here, is restricted to mean an observed, discrete sulphide particle. Typical clusters consist of several sulphide grains which are not apparently interconnected. Most of the grains are composed of pyrrhotite with lesser amounts of pentlandite plus mackinawite and magnetite. Some of the grains are composed of pyrrhotite alone.

Between the two 90° extinction positions, pyrrhotite shows distinct polarization colours: yellowish grey and bluish grey were observed alternately at the maximum illumination positions. These colours were noted on most pyrrhotite grains examined under the Leitz Panphot microscope of the metallogenic laboratory of the Geological Survey of Canada, and may show some variations with other instruments. When the polarization colour changes from bluish grey to yellowish grey in the clockwise rotation, the extinction position defines the vertical projection of the *c*-axis on the polished surface. Thus, under the ore microscope we can determine the bearing of this projection in each grain of pyrrhotite by measuring its extinction position. The techniques are described more fully by Kanehira (in press).

The intensity of the anisotropism depends on the angle between the *c*-axis of the pyrrhotite crystal and the polished surface. The surface parallel to the *c*-axis gives the strongest anisotropism; the surface normal to the *c*-axis gives an isotropic appearance; and the surface intermediate between above two extreme surfaces gives an intermediate anisotropism. Thus, the intensity of the anisotropism gives a useful parameter which can be used, qualitatively at least, to determine the plunge of the *c*-axis.

Sketches showing clusters of sulphide minerals in three specimens of peridotite are shown in Fig. 1. The polished surfaces from which these sketches were made are typified by the example shown in Fig. 2. The short lines in the sketches represent the bearings of the projections of pyrrhotite *c*-axis, as mentioned above. From the sketches it is clear that adjoining pyrrhotite grains are nearly simultaneously extinguished. The relative intensity of anisotropism among grains of a given cluster was observed to be almost identical, although no attempt is made to depict this in the figure.

Conductivity of pyrrhotite

In a series of conducting tests, an electric current was found to be transmitted, in many cases, from one pyrrhotite grain to others in the same cluster. Only rarely was it found possible to pass a current between grains belonging to different clusters. This suggests that pyrrhotite grains in the same clusters are, in fact, interconnected, while those of different clusters are usually not. Thus, it may be concluded that pyrrhotite with optical continuity is poikilitic in texture.

It is interesting to note that the poikilitic texture is repeated in the texture of the interstitial clinopyroxene in the rocks examined, a feature first observed by Smith (1962) in his original description of the geology of the intrusion.

Crystal size of pyrrhotite

The poikilitic habit of pyrrhotite in the samples studied indicates that the length of individual clusters as measured in polished section is representative of crystal size. The crystal sizes of the pyrrhotite so measured range from 5 to 8 mm. Similarly, the aggregate areas of sulphides in these

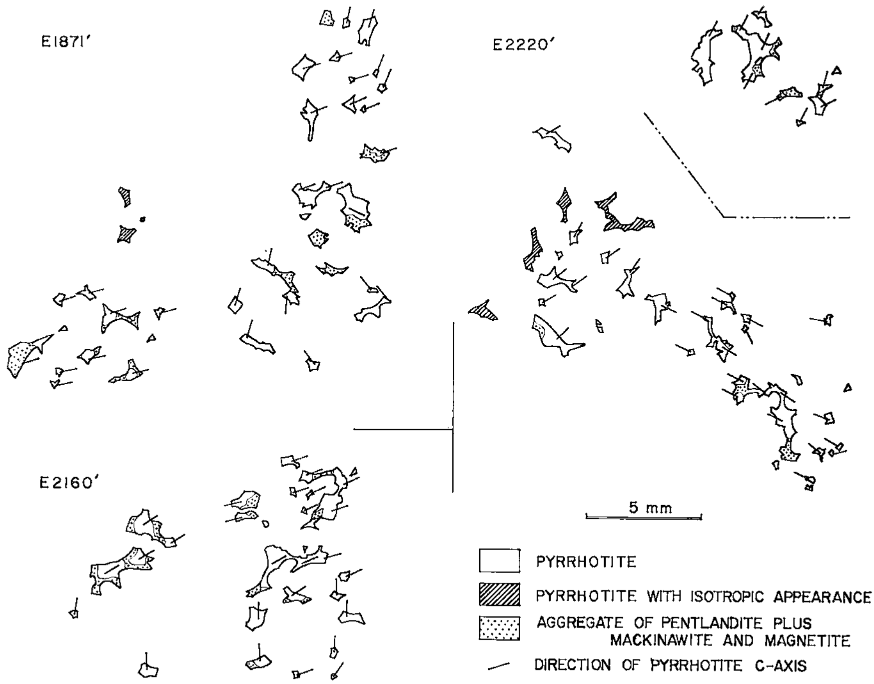

FIG. 1. Sketches showing sulphide clusters in three specimens (E1871′, E2160′, and E2220′) of peridotite.

same clusters must be a reflection of the volume of sulphides present. The average aggregate area of sulphides in the clusters is about 3 mm². Individual measurements are given in Table 1.

TABLE 1. AGGREGATE AREAS OF SULPHIDE GRAINS IN VARIOUS CLUSTERS

Specimen No.	Aggregate area in mm²
E1871′	4.6, 4.5, 4.5, 2.3, 0.8
E2160′	5.2, 5.2, 2.5, 2.5, 1.6
E2220′	3.0, 2.7, 2.3, 2.2

Some of the sulphides in the intrusion are believed by Chamberlain (personal communication) to have crystallized from an interprecipitate immiscible sulphide liquid during cooling of the Muskox magma. The poikilitic texture of pyrrhotite indicates slow cooling of the magma during the period of sulphide crystallization. It is suggested that the volume of sulphides in individual clusters, which can be approximated from the

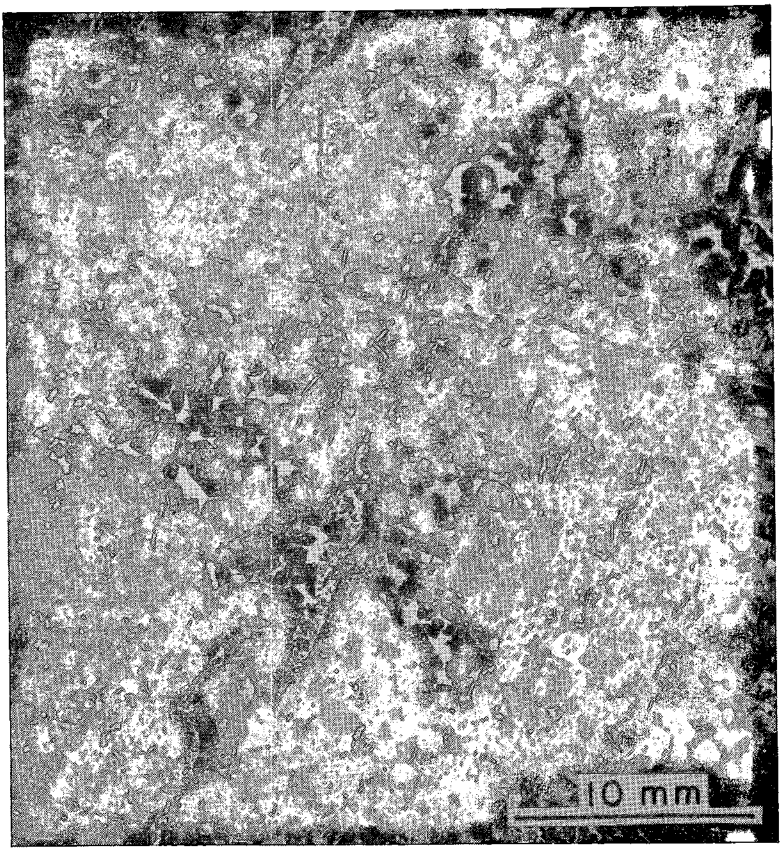

FIG. 2. Sulphides (white) filling interstices between serpentinized olivine crystals (dark grey). Left lower and right upper parts of the photograph are sketched in Figure 1 (E2220′).

aggregate areas of sulphide grains as mentioned, may be the expression of the volume of the immiscible sulphide droplets in the magma.

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References

Chamberlain, J. A., McLeod, C. R., Traill, R. J., & Lachance, G. R. (1965): Native metals in the Muskox intrusion. *Can. J. Earth Sci.*, **2**, 188–215.

Chamberlain, J. A. & Delabio, R. N. (1965): Mackinawite and valleriite in the Muskox intrusion. *Am. Min.*, **50**, 682–695.

Findlay, D. C. & Smith, C. H. (1964): The Muskox drilling project. *Geol. Surv. Canada*, Paper **64**–44.

Kanehira, K. (in press): Sulphide ores from the Coronation mine, Saskatchewan. *Geol. Surv. Canada, Bull.*

Smith, C. H. (1962): Notes on the Muskox intrusion, Coppermine River area, District of Mackenzie. *Geol. Surv. Canada*, Paper **61**–25.

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