

NOTES AND NEWS

CHROMIAN ANTIGORITE FROM THE WOOD'S MINE,  
LANCASTER COUNTY, PENNSYLVANIA\*

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INTRODUCTION

The Wood's chromite mine in Little Britain Township, Lancaster County, Pennsylvania, is 2 miles southeast of Wrightsdale, and about 0.6 of a mile north of the Pennsylvania-Maryland State Line, within a large bend of Octoraro Creek. It is the largest of many mines in the State Line chromite district, and was in operation continually from about 1828 until 1868 and again between 1873 and 1880, producing more than 95,000 tons of high-grade ore. The Wood's deposit was the largest body of massive chromite ever found in North America, and before the Civil War it was the largest source of chromite in the world.

During active years the mine was also world-famous for its fine specimens of comparatively rare minerals, particularly of brucite, genthite, the chlorite k ammererite, and the antigorite variety williamsite. Although much of the dump material has been removed and the large dumps that remain have been combed frequently by mineral collectors, samples of most of the minerals for which the mine was justly famous can still be found. A lavender-colored mineral, collected in 1955 by Nancy C. Pearre and Allen V. Heyl from the dump south of the larger mine opening, is a hitherto undescribed chromian variety of antigorite.

GENERAL GEOLOGY

The Wood's deposit is in a belt of serpentinized ultramafic rocks about 30 miles long and averaging half a mile to a mile in width. The rocks trend eastward and northeastward parallel to the surrounding schists which they intrude. The Wood's mine is near the northern contact of the serpentine and schist; in the vicinity of the mine this contact dips steeply southward. The chromite occurs in irregular sack form (Sampson, 1942, pp. 124-125) and is commonly sheathed by a light yellowish-green serpentine, in some places associated with crosscutting veins of coarsely crystalline magnesite. The country rock near the mine is dark, massive serpentinized dunite that consists essentially of olivine and green antigorite with accessory chromite and magnetite (T. P. Thayer, 1956, oral communication); it characteristically weathers brown.

Numerous minerals, some of them rare, have been reported from the

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Wood's mine (Genth, 1875; Gordon, 1922; Beck, 1952). One of the commonest of these is the pink-to-lavender chrome chlorite, *kämmererite*, characteristically a close associate of the high-grade chromite deposits in the area. Foliated masses and large white crystals of *brucite*, and apple-green to yellowish-green incrustations of the nickel mineral *genthite*, were common associates with the ore. Other minerals from the mine include emerald green *zaraitite* and the chlorite *penninite*, white to brown *deweylite*, acicular crystals of *hydromagnesite*, and veins of chalklike *magnesite*; also *ripidolite*, *enstatite*, *aragonite*, *calcite*, *dolomite*, *chalcedony*, *drusy quartz*, and *jasper*. *Chalcocite*, *millerite*, *hematite*, *ilmenite*, *idocrase*, and *uvarovite* or green chromian *grossularite* have been found very rarely associated with the chromite.

Several varieties of serpentine are common on the mine dumps. These include the varieties *williamsite*, *picrolite*, and *marmolite*, and green *antigorite*. The lavender chromian *antigorite* here described bears a superficial resemblance, especially in color, to the more platy *kämmererite*, one of the minerals for which the mine was famous, and has probably been passed over by mineral collectors for that reason. Garrett (1853) mentions "fibrous *kämmererite*" at the Wood's and Line mines.

#### PURIFICATION OF CHROMIAN ANTIGORITE

Material was carefully prepared for the various studies in the following manner. A 120-gram sample of the chromian *antigorite* was crushed gently on a steel plate with a hand roller in order to break away the interstitial *dolomite* grains. The finer fraction ( $-100$ ) was screened off. The light-weight mineral, chromian *antigorite*, could not be removed satisfactorily by flotation with bromoform (specific gravity 2.8) because the contaminating mineral, *dolomite*, has approximately the same specific gravity as bromoform. Therefore, the fragments of chromian *antigorite* were selectively hand picked and ground to a powder from which the remaining magnetite grains were removed with a hand magnet, and then finally with a magnetized needle. Microscopic examination of the sample thus prepared showed no visible magnetite, but approximately one half of one per cent of *dolomite* was observed as impurity.

#### PHYSICAL AND OPTICAL PROPERTIES

Chromian *antigorite* from the Wood's mine occurs as an aggregate of lavender-colored, long, thin laths, some of which are more than two inches long. The slender laths are easily separated from one another. The laths are striated parallel to the elongation and are easily split into brittle columnar or needlelike rods. Cleavage is perfect in two directions parallel to the elongation of the crystals, but poor, frequently splintery,

transverse to the elongation. The structure is somewhat similar to that of the variety "picrolite." The hardness is slightly greater than 4. The luster is waxy. Thin fragments are translucent to transparent. Small fragments fuse with difficulty to white opaque beads. This chromian antigorite is not noticeably attacked by either cold or warm hydrochloric or dilute sulfuric acid.

The mineral is optically biaxial negative; the axial angle is  $58^\circ \pm 3^\circ$  and is constant in all grains observed. Dispersion of the axes is moderately strong,  $v > r$ ; the abnormal interference color is blue. The axial plane is parallel to the elongation {100}, and the acute bisectrix X is normal to the best cleavage {010}, assuming the mineral is orthorhombic. Extinction is parallel. The pleochroism is very weak; X and Y are pinkish lavender and Z is purplish lavender. The indices of refraction measured by the immersion method in white light are:  $\alpha = 1.567$ ,  $\beta = 1.577$ ,  $\gamma = 1.578$ ,  $B = 0.011$ . The indices and birefringence are somewhat higher than for antigorites described by Selfridge (1936), but some serpentines have even greater birefringence. The higher indices of refraction may be attributed to the presence of chromium.

The chromian antigorite sample was prepared for examination with the electron microscope by grinding lightly in distilled water, placing a droplet of the dispersed material on a collodion mount, and then drying in air. The electron micrograph (Fig. 1) shows thin angular plates and laths. The sample appears to be homogeneous. The electron microscope studies were made by Malcolm Ross, U. S. Geological Survey, who is making further studies of the mineral.

X-ray powder-diffraction studies by Fred A. Hildebrand, U. S. Geological Survey, show this lavender-colored mineral to be isostructural with antigorite.

#### CHEMICAL STUDIES

The chief constituents of the sample were determined by means of usual gravimetric procedures for silicate rocks. The presence of nickel made a triple precipitation of the  $R_2O_3$  group necessary. Nickel was then determined by the dimethylglyoxime method on the combined filtrates. In the determination of chromium the sample was fused with sodium carbonate-potassium nitrate, leached with water, and filtered, and the chromium determined by a colorimetric method on the filtrate. The total water was determined by the Penfield method using anhydrous sodium tungstate ( $Na_2WO_4$ ) as a flux. The analysis is given in Table 1.

Calculated on the basis of the structural formula the analysis yields:





FIG. 1. Electron photomicrograph showing lath-like structure of chromian antigorite from the Wood's mine, Lancaster County, Pennsylvania.

The chemical analysis shows a higher percentage (7 per cent) of  $\text{Al}_2\text{O}_3$  than for most antigorites; however, Bates and Mink (1950) gave a compilation of analyses in their discussion of the morphology and structure of the serpentine minerals in which some of the antigorites are shown to contain a notable amount of  $\text{Al}_2\text{O}_3$ . On the other hand, recent analyses of some antigorites by Hess and others (1952), Brindley and von Knorring (1954), and Nagy and Faust (1956) show low  $\text{Al}_2\text{O}_3$  content.

The authors have assumed that some of the magnesium in the mineral described above has been replaced by aluminum and chromium. Although the analysis agrees with some of the k ammererites, the morphology, physical properties,  $x$ -ray pattern, and the optical properties correspond closely to antigorite.

$X$ -ray fluorescence determinations by J. M. Axelrod, U. S. Geological Survey, show 4.3 per cent  $\text{Cr}_2\text{O}_3$ .

TABLE 1. CHEMICAL ANALYSIS OF CHROMIAN ANTIGORITE  
(Analyst: A. C. Vlisidis)

	Per Cent	Corrected <sup>1</sup>	Molecular ratios
SiO <sub>2</sub>	36.00	36.00	0.5991
Al <sub>2</sub> O <sub>3</sub>	7.51	7.51	.0737
Fe <sub>2</sub> O <sub>3</sub>	.56	.56	.0035
FeO	.45	.45	.0063
MgO	37.87	37.75 <sup>2</sup>	.9392
CaO <sup>3</sup>	.16	.00	
H <sub>2</sub> O <sup>-4</sup>	.24	.24	
H <sub>2</sub> O <sup>+</sup>	13.16	13.16	.7311
TiO <sub>2</sub>	.05	.05	.0006
Cr <sub>2</sub> O <sub>3</sub>	4.36	4.36	.0287
NiO	.35	.35	.0047
MnO	.01	.01	.0001
CO <sub>2</sub> <sup>5</sup>	.26	.00	
	100.98	100.44	
Sp. gr.	2.62		

<sup>1</sup> Analysis corrected for 0.54 per cent dolomite based on 0.16 per cent CaO.

<sup>2</sup> Corrected for 0.12 per cent MgO present as dolomite.

<sup>3</sup> Not included in formula because it is present as dolomite, an impurity.

<sup>4</sup> Not water of composition.

<sup>5</sup> CO<sub>2</sub> calculated.

Semiquantitative spectrographic analysis by Harry Bastron, U. S. Geological Survey, gave the following results:

Mg	Si	Al	Cr	Fe	Ca	Ni	Ti	V	Mn	Cu	B	Sc
M	M	X. <sup>+</sup>	X.	X. <sup>-</sup>	.X	.X	.OX	.OX	.OOX <sup>+</sup>	.OOX	.OOX <sup>-</sup>	.OOOX

Ag, Au, Hg, Ru, Rh, Pd, Ir, Pt, Mo, W, Re, Ge, Sn, Pb,  
Looked for but not found: As, Sb, Bi, Zn, Cd, Tl, In, Co, Ga, Ce, Y, Yb, La, Zr,  
Hf, Th, Nb, Ta, U, Be, Sr, Ba, K, P.

The minor-element content of this antigorite is consistent with the theory of Faust, Murata, and Fahey (1956), as to the relation of minor elements of the serpentines to their geologic origin, in that this serpentine derived from ultrabasic rock contains Ni, Cr, Sc, and probably a trace of Co in a concentration below the limit of detectability by this method.

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### MAGMATIC DIFFERENTIATION AT AMBOY CRATER, CALIFORNIA

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Amboy Crater, a recent group of nested cinder cones near Highway 66, approximately 75 miles east of Barstow, San Bernardino County, affords an excellent example of magmatic differentiation of basaltic magma. The general geology of the area will be described elsewhere (Parker, Calif. Div. Mines, to be published). The suite of rocks selected for this discussion are from the cones themselves. The surrounding flows are not suitable for such a study due to the uncertainty of their relative ages. The absolute age of none of these rocks is known, but the relative ages of those from the cones can be judged with a high degree of certainty. All of the samples are from nested cones built around a single, central conduit with the exception of No. 4 which comes from a short intracrater-flow which breached the older cones from which specimens Nos. 1, 2, and 3 were collected.

All of the specimens are olivine basalts. In general they are composed of a groundmass of glass, plagioclase, clinopyroxene, and magnetite with phenocrysts of olivine and plagioclase. Plagioclase phenocrysts are not