OPTICAL NOTES ON SOME MINERALS FROM THE MAHOPAC IRON MINE, BREWSTER, NEW YORK

JOSEPH L. GILLSON, *The Massachusetts Institute of Technology.*

INTRODUCTION

In May, 1925, the writer, accompanied by several students, visited the dumps of the old Tilly Foster and Mahopac Iron Mines, near Brewster, New York. The mineralogy of the two mines seems to be very similar, although the material collected from the dump of the Mahopac mine did not contain examples of all of the minerals that have been reported from the Tilly Foster mine. Not having opportunity to carry the study further it seemed of value to describe the minerals that were collected since no tabulation of the minerals from the Mahopac Mine has ever been published. The importance of the study of these minerals is increased by the fact that the optical properties of most of the unusual varieties of the minerals from the similar Tilly Foster mine have not been recorded.

LOCATION OF THE MAHOPAC MINE

The Mahopac iron mine is located on the west side of Lake Mahopac and at the north end of a small lake called Kirk Lake, in Putnam County, New York. The mine is about seven miles southwest of the Tilly Foster mine. Its exact location is shown on the map of the West Point quadrangle published by the U. S. Geological Survey. It is near the east margin of the map on the road between Mahopac Falls and Kent Cliffs. All that is now visible of the mine is a small pond occupying the caved-in portion.

LITERATURE

Owing to the similarity in mineralogy of the Mahopac and Tilly Foster Mines, descriptions of the one are of interest in the study of the other. Several detailed descriptions of the geology and of the ore deposits of the two mines have been published. The latest of these, and one in which the older literature is summarized, is that of Colony[1] but in none of these reports is a detailed description given of the interesting mineralogy of the ore and its gangue.

The list of the minerals found at these mines, and reference to their published descriptions is given by Whitlock[2]. The only min-

[1] Colony, R. J.; The magnetite iron deposits of southeastern New York: *New York State Museum Bull.*, **249–250**, pp. 121–126 (1923).

eral cited by him as occurring at the Mahopac Mine is magnetite, although 28 minerals are listed from the Tilly Foster mine. Breidenbaugh[3] gave one of the first descriptions of these minerals. He described the mica, the chlorite, two varieties of serpentine, enstatite, actinolite, three varieties of chondrodite, pyrite, chalcopyrite, pyrrhotite, calcite, quartz, fluorite, and apatite. A year later J. D. Dana[4] described the serpentine pseudomorphs of the Tilly Foster mine. He said[5] that chondrodite, enstatite, hornblende, ripidolite, massive chlorite, dolomite, biotite, apatite and calcite, and two other species not yet determined occur changed to serpentine. In his preliminary remarks he gave interesting information in regard to mineral associations.

A little later E. S. Dana[6] published the results of a careful crystallographic study of the chondrodite from the same mine, and in another paper he[7] gave the results of an optical study to show that the mineral was monoclinic and not orthorhombic.

Analyses of the chondrodite from the Tilly Foster mine were given by Penfield and Howe[8] in their study of the humite group.

Other mention of the gangue minerals of the ore has been by name only. Ruttman[9] writing in 1887, listed the minerals from the Tilly Foster mine as follows: brucite, calcite, chondrodite (ruby colored crystals), dolomite, enstatite, epidote, fluorite, magnesite, magnetite, marcasite, molybdenite, muscovite, chlorite, pyrite, pyroxene, pyrrhotite, serpentine, talc and green garnet.

Koeberlin[10] who made a careful study of the geology of the district, found that the ore from the Tilly Foster mine contained

[2] Whitlock, H. P.; List of New York mineral localities: *New York State Museum Bull.*, **298**, pp. 68–71 (1903).

[3] Breidenbaugh, E. S.; On the minerals found at the Tilly Foster iron mines, N. Y.: *Amer. Jour. Sci.*, (3) **6**, pp. 207–13 (1873).

[4] Dana, J. D.; On serpentine pseudomorphs from the Tilly Foster iron mine: *Amer. Jour. Sci.*, (3) **8**, pp. 371–381, and 447–459 (1874).

[5] *Idem.* p. 457.

[6] Dana, E. S.; On the chondrodite from the Tilly Foster iron mine, Brewster, New York: *Amer. Jour. Sci.*, (3), **10**, pp. 89–103 (1875).

[7] Dana, E. S.; On the optical character of the chondrodite of the Tilly Foster mine, Brewster, New York: *Amer. Jour. Sci.*, (3), **11**, pp. 139–140 (1876).

[8] Penfield, S. L. and Howe, W. T. H.; On the chemical composition of chondrodite, humite and clinohumite: *Amer. Jour. Sci.*, (3), **47**, pp. 188–206 (1894).

[9] Ruttman, F. S.; Notes on the geology of the Tilly Foster ore body, Putnam Co., N. Y.: *Trans. Amer. Inst. Min. Eng.*, **15**, p. 89 (1887).

[10] Koeberlin, F. R.; The Brewster iron bearing district of New York: *Econ. Geology*, **4**, p. 740 (1909).

only magnetite, chondrodite, spinel and serpentine. These he had noted in one thin section.

Colony[11], the most recent writer, said:

> "None of the earlier students of this (the Tilly Foster) deposit seemed to attach any importance to the unusual minerals in the ore, such as chondrodite, ripidolite, brucite, serpentine, spinel, and allied types. The magnetite replaces a previously metamorphosed interbedded crystalline limestone; connected with the ore are still unreplaced remnants of colorless pyroxene, both monoclinic and orthorhombic, (essentially diopside and enstatite); an almost colorless olivine, chondrodite, light green spinel, phlogopite, clinochlore and serpentine."

Of the Mahopac Mine he[12] said:

> "Samples of material from the old dump carry chondrodite, clinohumite, clinochlore, phlogopitic colorless mica, carbonate, serpentine and magnetite."

Boydell[13] made a study of the splendid collection of serpentine pseudomorphs from the Tilly Foster mine in the Harvard Mineralogy collection, but his material has not been published.

Larsen[14] has given the optical data on a chondrodite from Brewster, N. Y.

The Minerals from the Mahopac Mine

Chondrodite. Two varieties of chondrodite were found among the specimens collected by the writer. Crystals in white marble have a deep golden brown color, while others associated with chlorite, amphibole and magnetite, have a deep red color, similar to that shown by some garnets, yet the optical properties of the two varieties are nearly identical. The red variety has a slightly smaller optic angle than the brown. According to Penfield and Howe[15] the garnet red crystals from the Tilly Foster mine contain 7.22% FeO while the brown crystals contain only 5.94% FeO.

The optical properties of the chondrodite were determined to be as follows:[16]

[11] Colony, R. J.; The magnetite iron deposits of southeastern New York: *New York State Museum Bull.*, **249–250**, pp. 122–123 (1923).

[12] Colony, R. J.; *op. cit.*, p. 125.

[13] Boydell, H. C.; Unpublished manuscript presented as a partial requirement in a course in the paragenesis of minerals, Harvard University, 1920.

[14] Larsen, E. S.; The microscopic determination of the non-opaque minerals· *U. S. Geol. Survey Bull.*, **679**, p. 57 (1921).

[15] Penfield, S. L. and Howe, W. T. H.; *op. cit.*, pp. 194-197.

[16] In all determinations of refractive indices here given the accuracy is ± .003.

$\alpha=1.643$ $\beta=1.655$ $\gamma=1.670$	2V=80°±5° (brown crystals). 2V=75°±5° (red crystals). $\rho > v$ moderate. Polysynthetic twinning common. Optic sign +.	Pleochroism strong: X=deep chrome yellow; Y=yellow; Z=light yellow.

These properties are very similar to those of a variety of chondrodite given by Larsen[17] but the refractive indices are higher than on the variety he studied from Brewster, N. Y.

OLIVINE. Although Colony was the first to mention the occurrence of olivine at these mines, it is in reality one of the most abundant minerals not only at the Mahopac mine, but also at the Tilly Foster. The mineral has a light green color on a fresh surface, but where weathered the color is yellow or yellow brown. The olivine is associated with amphibole, chondrodite, chlorite and magnetite.

The optical properties of the olivine are as follows:

$\alpha=1.673$ $\beta=1.688$ $\gamma=1.704$	2V near 90°. $\rho > v$ weak.	Optic sign, +(?).

These properties are not those of forsterite, the usual olivine found in contact metamorphosed limestones, but are rather those of a variety containing more iron.

SPINEL. Spinel is a very common mineral at the Mahopac mine, although most of the crystals are so small that they are found only during the microscopic study of the specimens. The spinel is black, or very dark green in color by reflected light, and when in euhedral crystals has the octahedral form common to that mineral.

It is a variety of pleonaste with an index of refraction of 1.759, and has a deep grass green color by transmitted light.

CHLORITE. Chlorite is commonly associated with the chondrodite, and the deep green color of the chlorite makes a striking contrast to the dark brown or red of the chondrodite.

The optical properties are as follows:

$\alpha=1.580$ $\beta=1.581$ $\gamma=1.590$	2V=0° to 12°. $v > \rho$ weak.	Optic sign, +. Pleochroism faint, X=faint green, Z=colorless.	Symmetrical extinction on polysynthetic twinning in sections containing X and Z, 3 degrees.

This is presumably the ripidolite mentioned by Colony.[18]

[17] Larsen, E. S., *Op. cit.*, p. 291.
[18] Colony, R. J.; *Op. cit.*, p. 123.

PYROXENE. Only one pyroxene was found in the material collected by the writer. It occurs in cleavable masses associated with magnetite and mica, and except that the optic angle is large it has properties similar to diopside.

The properties are as follows:

$\alpha = 1.679$ $\beta = 1.691$ $\gamma = 1.705$	2V 80°±5°. $\rho > v$ weak.	Optic sign, +. Color, green. Cleavage, typical pyroxene.	Extinction angle, $c \wedge Z = 29°$. Not pleochroic, but green in thick grains.

MICA. A greenish mica occurs in sub-hedral crystals, reaching an inch in diameter, associated with pyroxene and magnetite. It has a pearly luster on the cleavage flakes, and a light greyish-green color. The color along a very pronounced gliding or parting plane (probably 102) is very dark green. The plates have a wavy structure as was noted by Breidenbaugh[19] on the mica from the Tilly Foster mine.

The optical properties are as follows:

$\alpha = 1.558$ $\beta = 1.595$ $\gamma = 1.595$	2V, nearly 0°. Optic sign, −.	Pleochroism, X = nearly colorless, Z = pale green in thick flakes.

These properties are nearer those of muscovite than of phlogopite, as the mineral was called by Colony.[20]

AMPHIBOLES. Two varieties of the amphibole group were found. One has unusual optical properties, although it resembles actinolite in the hand specimen. Cleavage faces of massive aggregates associated with magnetite have the color of actinolite but in the marble it occurs as small dark green crystals with corroded edges.

The properties of this green amphibole are as follows:

$\alpha = 1.634$ $\beta = 1.644$ $\gamma = 1.655$	2V = 85°. $v > \rho$ perceptible.	Optic sign, +. Cleavage, typical amphibole. Extinction angle $c \wedge Z = 24°$. $b = Y$.	Pleochroism, weak, X = slate grey, Y = yellow green, Z = blue green.

The other amphibole occurs in large cleavable masses, individual grains of which reach several inches in diameter. It is associat-

[19] Breidenbaugh, E. S.; *Op. cit.*, p. 208.

[20] Colony, R. J.; The magnetite iron deposits of southeastern, New York: *New York State Museum Bull.*, **249–250**, p. 125 (1923).

ed with tourmaline, apatite, quartz, and scapolite; minerals not found associated with the chondrodite, olivine, spinel and chlorite.

The optical properties are as follows:

$\alpha=1.651$	$2V=75°\pm5°$.	Optic sign, −.	Pleochroism, strong,
$\beta=1.659$	$\rho>v$ weak.	Cleavage, typical of	X = light yellow
$\gamma=1.674$	Extinction angle	amphibole.	green; Y = green; Z
	$c\wedge Z=22°$	Color, black.	= deep blue green

Scapolite. Scapolite occurs only with the black amphibole, and with quartz, tourmaline and apatite. It is a colorless, glassy variety and is moderately altered to an isotropic mineral having an index of refraction of about 1.48. The indices of refraction of the scapolite are: $\epsilon=1.542$ and $\omega=1.560$.

Tourmaline. Small black crystals of tourmaline occur with the black amphibole and in quartz; $\epsilon=1.632$; and $\omega=1.663$. The pleochroism is strong from a light cinnamon brown, with a tinge of red; to very dark green.

Apatite. Only microscopic crystals of apatite occur. The indices of refraction are 1.632 and 1.637.

Serpentines. Insufficient material was available to study these minerals and no properties can be given.

BOOK REVIEWS

GEOLOGICAL MAPS. The Determination of Structural Detail. Robert M. Chalmers. Oxford University Press, American Branch, *New York.* **1926**. vi+175 pp., with folder and numerous illustrations. Price 12s. 6d. net, postage extra. ($4.25.)

The subtitle expresses well the purpose of this book which has been written primarily for students. After a brief discussion of topography, the author treats in detail the effect of the inter-relationship of topography and structure upon the distribution of outcrops. Numerous problems on the determination of thickness of beds, strike, dip, direction and amount of throw and heave of faults, etc., are presented and solved mathematically. This feature of the book should make it especially valuable to beginning students in geology. All geological maps referred to are of British areas but the manner of treatment is such that this fact does not detract from the value of the book for American students.

Chas. W. Cook.

ROCKS AND ROCK MINERALS. Louis V. Pirsson, revised by Adolph Knopf. Second edition. 426 pages. $3.50 net. John Wiley & Sons, Inc., *New York.* **1926.**

The first edition of this excellent text on the megascopic determination of rocks appeared in 1908. In the second, the revised edition but minor changes can be noted. No single portion has received any notable contribution of new material. The cuts, figures and analyses are the same as in the previous text, but in places material