SOME NEW NICKEL MINERALS.

By Dr. Stephen H. Emmens.

I have, of late, had occasion to examine numerous samples of ores from the recently developed mining region known as the Sudbury District in the Province of Ontario, Canada, and in the course of such examination I have met with three nickeliferous minerals that appear to be distinct from any species hitherto described.

FOLGERITE.

This is found in the Worthington mine, on the Algoma Branch of the Canadian Pacific Railroad, about 30 miles southwest of Sudbury. The mineral deposit here opened up is of a character similar to that usually observed in the mines of the district; that is to say, it consists of a mixture of pyrrhotite and chalcopyrite, forming ore masses of approximately lenticular form and of varying magnitude, imbedded in a greenstone dyke traversing the Huronian rocks that constitute the chief geological features of the region.

The pyrrhotite is in itself nickeliferous to a greater or less degree in every mine of the district, but at the Worthington mine it is found to be associated with a distinct sulphide (Folgerite) carrying a very high percentage of nickel. This sulphide is spoken of by the local miners and newspapers as being *millerite*, but it differs widely from that species. Its chief characteristics are as follows:

Lustre.—Metallic.

Color.—Light bronze-yellow in mass, but almost tin-white when broken up into fine grains.

Specific Gravity.—No determination of the pure mineral has been made, but a fragment associated with adhering pyrrhotite showed a sp. gr. of 4.73.

Hardness.—3.5.

Streak.—Grayish black.

Form.—Massive, with a platy structure. No crystals have as yet been observed.

Fracture, Irregular.—When comminuted the large fragments preserve a platy form while the smaller particles are finely granular. Very brittle.

Heat Reaction.—When the powdered mineral is heated in a closed tube no sublimate is produced.

Solubility.—The mineral dissolves in nitric acid with separation of sulphur and a green solution.

Magnetism.—In large fragments the mineral is non-magnetic. In minute grains it is magnetic. The finely triturated powder is non-magnetic.

Microscopic Appearances—Under both lens and microscope the powdered mineral appears in the form of shining white grains of irregular form, very distinct from the shining spicules of a light brass-yellow color which constitute the powder of true millerite.

Chemical Analysis.—The specimens analysed were magnetically separated from the accompanying pyrrhotite and gave the following results:

	A	B	C
Nickel	35.20	31.45	29.78
Iron	33.70	31.01	26.89
Sulphur	31.10	37.54	43.33
	100.00	100.00	100.00

Specimen A consisted of platy fragments, each one of which was tested separately with the magnet. Specimens B and C were separated in the form of a coarse powder from the accompanying pyrrhotite, and probably still contained some adhering particles of that mineral. In the cases of B and C the analysis was conducted by first roasting the mineral and then fusing with potassium bisulphate, followed by solution, peroxidation, precipitation of the iron and electrolytic separation of the nickel, all with the usual precautions. In the case of A the raw mineral was dissolved in aqua regia. The sulphur was estimated by difference; and a check determination (by fusion of the raw mineral with sodium carbonate and nitrate and final precipitation as barium sulphate)

for sulphur only, in a fourth sample, gave 34 per cent. It may also be mentioned that specimen A came from the Worthington mine, and that B and C were sent to me with the statement that they came from a deposit at the northeast extremity of the Worthington greenstone dyke. This deposit is distant about 1½ miles from the Worthington mine and has recently been explored by the Emmens Metal Company; but when Mr. C. T. Mixer, the chemist of that company, paid a visit of inspection to the workings, the person in charge who had sent me the specimens in question could not point out the place whence he had taken them and could not show any further occurrence of the mineral *in situ*. It is probable, therefore, that A, B and C all came from the Worthington mine.

The formula corresponding with the above mentioned analyses is Ni Fe S_2, which corresponds to

Nickel	32.87
Iron	31.30
Sulphur	35.83
	100.00

This composition is between Ni S (*Millerite*) and Ni Fe_2 S_3 (*Pentlandite*). It is also distinct from that of the "ferriferous polydymite" found at the Vermilion mine, a little to the northeast of the Emmens Company's working, and described by Clarke & Catlett (*American Journal of Science, 1889, p. 372*), as containing 43.18 per cent of nickel, 15.47 per cent. of iron and 41.35 per cent. of sulphur, and as approximating, therefore, to the formula Ni_3 Fe S_5.

I have named this mineral *Folgerite* after Commodore W. M. Folger, the Chief of the Bureau of Ordnance in the U. S. Navy Department, in recognition of that distinguished officer's achievements in the utilization of nickel steel.

BLUEITE.

This mineral has for some time past puzzled the Sudbury miners, who have locally dubbed it "Jack's Tin." It is found in several mines of that district and notably at the working of the

Emmens Metal Company, where it is found associated with niccolite, gersdorffite, pyrrhotite and chalcopyrite in the outcrop of a quartz vein cutting the before mentioned greenstone dyke.

The following are the characteristics of the mineral:

Luster.—Metallic, somewhat silky.

Color.—Pale olive-gray, inclining to bronze.

Specific Gravity.—4.2.

Hardness.—3 to 3.5.

Streak.—Black.

Form, Massive.—No crystals have as yet been observed.

Fracture.—Sub-conchoidal, irregular. Brittle.

Heat Reaction.—When the powdered mineral is heated in a closed tube a sublimate of sulphur is produced.

Solubility.—The mineral dissolves readily in nitric acid without separation of sulphur and yields a yellow solution.

Magnetism.—The mineral is non-magnetic.

Microscopic Appearance.—Under the lens the powdered mineral appears to be composed of irregular grains of a dull gray color. Under the microscope the color appears a dull grayish black and the particles are seen to be finely granular without any crystalline form.

Chemical analysis.

Nickel	3.5
Iron	38.8
Sulphur (by difference)	52.3
Insoluble	5.4
	100.00

After deduction of the insoluble matter (gangue) the figures for the mineral become

Nickel	3.70
Iron	41.01
Sulphur	55.29
	100.00

The sulphur is probably too high, as, owing to the character of the gangue, a portion of this latter may have entered into solution.

The formula $Fe_{12}NiS_{26}$ (= (Fe, Ni) S_2 where Fe: Ni = 12 : 1) corresponds with the foregoing analysis, the figures of such formula being :

Nickel	3.76
Iron	42.96
Sulphur	53.28
	100.00

The considerable percentage of nickel (a very rare element in pyrite) and the easy solubility in nitric acid without separation of sulphur seem to preclude this mineral from being considered merely as a nickeliferous variety of pyrite or marcasite. I have named it *Blueite*, after Mr. Archibald Blue, late Secretary of the Royal Commission appointed to investigate the Mineral Resources of Ontario, and now Director of the Bureau of Mines of that Province.

WHARTONITE.

This mineral was brought to me by Mr. C. T. Mixer from a mine situated about seven miles northeast of Sudbury and about two miles from the Blezard mine, worked by the Dominion Mineral Company. It has been known locally as the Shepherd mine, and is of a character similar to the general mines of the district.

The following are the characteristics of the mineral :

Lustre.—Metallic.

Color.—Bronze-yellow.

Streak.—Black.

Form.—Cellular ; the cavities being lined with minute cubic crystals, and the intermediate substance being finely granular. This structure precludes the specific gravity and hardness from being determined with precision. A large piece showed a sp. gr. of 3.73 and a hardness of 4.

Fracture, Irregular.—Brittle.

Heat Reactions.—A sublimate of sulphur in a closed tube and fumes of SO_2 in an open tube. A sulphur flame is observed on heating a fragment held in forceps.

Solubility.—The mineral is soluble in HNO_3 with separation of sulphur and a greenish yellow solution.

Magnetism.—On comminution about 10 per cent. of the mineral is found to be magnetic.

Microscopic Appearance.—Under both lens and microscope the powdered mineral is seen to consist of grayish black grains of irregular form and finely granular structure, with occasional minute cubic crystals.

Chemical analysis :

Nickel	5.40
Iron	42.90
Sulphur	45.00
Insoluble	4.80
	98.10

After deduction of the gangue these figures give :

Nickel	5.79
Iron	45.98
Sulphur	48.23
	100.00

Separate determinations of iron and sulphur were made in the magnetic and non-magnetic constituents respectively with the following results :

	Mag.	Non-Mag.	
Iron	66.55	40.4	} plus a little gangue.
Sulphur	7.00	52.6	}

and a qualitative examination showed that the nickel was clearly with the non-magnetic portion.

The inference deducible from these observations is that the mineral is a mixture of a nickel-iron-disulphide with some magnetite ; and taking the proportion of this latter as being 10 per cent. we have for the composition of the other constituent :

Nickel	6.27
Iron	41.44
Sulphur	52.29
	100.00

This corresponds to the formula $Fe_7 Ni S_{16}$ or (Fe, Ni) S_2, in which Fe : Ni = 7 : 1, and of which the figures are :

Nickel	6.10
Iron	40.68
Sulphur	53.22
	100.00

It may be that this non-magnetic mineral is in part composed of pyrite, in which case the formula will require modification. The aggregate, however, is distinguished by its form and nickeliferous character from pyrite and marcasite.

I have named this mineral *Whartonite*, after Mr. Joseph Wharton of Camden, N. J., in recognition of that gentleman's eminence as the head of the nickel industry in America.

NICKEL AND NICKEL-IRON SULPHIDES IN GENERAL.

For the purpose of indicating the relations of all the known nickel and nickel-iron sulphides to each other, the following table may be found useful :

Name.	Percentage constitution.			Molecular constitution.			
	Ni.	Fe.	S.	Ni S.	Ni S_2.	Fe S.	Fe S_2.
Millerite	64.72	.....	35.28	1	..	..	..
Polydymite	59.47	.....	40.53	3	1	..	..
Beyrichite	57.90	.....	42.10	2	1	..	..
Ferriferous Polydymite	44.92	14.26	40.82	3	..	..	1
Folgerite	32.87	31.30	35.83	1	..	1	..
Pentlandite	22.03	41.95	36.02	1	..	2	..
Horbachite	11.24	42.81	45.95	1	1	1	1
Inverarite	10.44	49.72	39.84	1	..	4	1
Whartonite	6.10	40.68	53.22	..	1	..	7
Blueite	3.76	42.96	53.28	..	1	..	12

It remains to be added that the analyses of the new minerals herein described were made by Mr. C. T. Mixer, and that specimens of Folgerite, Blueite and Whartonite accompany this paper for exhibition to the meeting.