NOTES ON CHROME GARNET, PYRRHOTITE AND TITANIFEROUS IRON ORE.

BY

B. J. HARRINGTON, B.A., PH.D.

NOTES ON CHROME GARNET, PYRRHOTITE AND TITANIFEROUS IRON ORE.

By B. J. Harrington, B.A., Ph.D.*

I. Chrome Garnet.

Garnet affords us an excellent example of the wide variation in composition exhibited by many mineral species. The variation is due to what is known as isomorphous replacement, or the replacement of one or more substances in a chemical compound by analogous substances without any essential change of form resulting therefrom.

If we take $R_3 R_2' Si_3 O_{12}$ as the general formula for garnet, the numerous analyses of the mineral which have been made tell us that R may be represented by calcium, magnesium, iron (in the ferrous state), manganese, &c., while R may be aluminium, iron (in the ferric state), or chromium. With all these differences in composition, the crystals of the mineral are always closely related or identical in form; but, as might be expected, the variations in specific gravity and colour are considerable.

In a paper on "Apatite and its associated Minerals," which I had the pleasure of reading before this Society about a year and a half ago, garnet was mentioned as one of the rarer constituents of the apatite-bearing veins; and its occurrence was again noticed in a report published by the Geological Survey last year. Of the varieties which have been observed the most common is probably a lime-alumina garnet; but the most interesting is a beautiful emerald-green variety which was discovered some time ago in the township of Wakefield, Quebec, and which has proved on analysis to be chromiferous. So far as I am aware there is no instance recorded in which the element chromium has hitherto been detected in any of the Laurentian minerals of Canada, although it is well known to be a constituent of serpentines and other minerals in succeeding formations. In order to ascertain whether the Wakefield garnet resembled the original ouvarovite or chrome-garnet, from Bissersk, in the Urals, a quantative analysis has recently been made, and the results are given under

* Read before the Natural History Society May 26th, 1880.

I. Under II is given Dr. Hunt's analysis of the chrome-garnet from Orford in the Eastern Townships, while, under III, is an analysis by Erdmann of the true ouvarovite:

	I. *	II.	III.
Silica	37.50	36.65	36.93
Alumina	18.65	17.50	5.68
Ferric oxide	1.07	.....	1.96
Ferrous oxide	.....	4.97	.....
Chromium sesquioxide	4.95	6.20	21.84
Lime	36.13	33.20	31.63
Magnesia	0.52	0.81	1.54
Cupric oxide	.....	.....	trace.
Loss on ignition	0.48	0.30	.....
	99.30	99.63	99.58

On comparing these analyses we see that while in the true ouvarovite, the predominant sesquioxide obtained on analysis is that of chromium, it is alumina in the garnet of Wakefield and Orford. Strictly speaking, therefore, the two last should be classed as lime-alumina rather than lime-chrome garnets.

The hardness of the Wakefield mineral is a little above 7 and the specific gravity 3.542. Before the blow-pipe it fuses between 4 and 5. Notwithstanding that it contains less chromium, the green in the specimens which I have seen is deeper than that of the Orford mineral and quite as deep as that of ouvarovite. The crystals are rhombic dodecahedrons with the faces often striated in the direction of the longer diagonal. In my specimens the well-defined crystals are mostly one-eighth of an inch or a little more in diameter; but one—unfortunately not entire—is nearly half an inch. On weathering, the crystals lose their glassy lustre, becoming dull and paler in colour. Among the minerals associated with the garnet are a green pyroxene, which is probably chromiferous, apatite, calcite, orthoclase, tourmaline and idocrase.

I am greatly indebted to Mr. J. G. Miller of East Templeton for the specimens which have enabled me to make the above analysis.

* The Atomic and quantivalent ratios are as follows:

	Atomic.	*Quantivalent.*		
Si	625×4	2500		2500
Al	362×3	1086		
Fe	013×3	39	1320	
Cr	065×3	195		2636
Ca	645×2	1290	1316	
Mg	013×2	26		

II. Pyrrhotite or Magnetic Iron Pyrites.

In 1875 a vein containing considerable quantities of copper pyrites was discovered near Polson's Lake, in Antigonish County, Nova Scotia. Loose masses of the ore had long before been found scattered over the surface, and although it was evident that they had not travelled far, a number of attempts to discover their source proved failures.

Among the minerals associated with the copper pyrites are spathic iron ore, iron pyrites, pyrrhotite and more rarely native copper. Pyrrhotite, as is well known, frequently contains nickel, or both nickel and cobalt, replacing a portion of the iron, and much of the nickel of commerce has been derived from this source. On account of this fact it was deemed worth while to analyse the mineral from Polson's Lake. The specimen examined—for which I am indebted to Dr. Dawson—was paler in colour than ordinary pyrrhotite and had a very high lustre. It contained a good deal of spathic iron ore (or ankerite) which was difficult to separate completely from the pyrrhotite. An analysis gave the following results:

Iron	58.976
Copper	0.181
Manganese	traces.
Nickel	0.773
Cobalt	traces.
Sulphur	38.580
Calcium Carbonate	0.786
Magnesium Carbonate	0.216
	99.512

The carbonates must be due to a small quantity of intermixed gangue, and a little of the iron was no doubt also present as carbonate. The mineral was strongly attracted by the magnet.

It should be stated here that the late Professor Howe, of Windsor, Nova Scotia, detected nickel and cobalt several years ago in specimens of pyrrhotite from both Nova Scotia and New Brunswick.* Specimens from Cape Breton Island gave 0.50 per cent. of oxides of nickel and cobalt, the amount of metallic nickel being "at least 0.36 per cent." A specimen from Nictaux in Annapolis County, gave "nickel, with a little cobalt, 0.10 p.c.

* *Mineralogical Magazine*, April, 1877, p. 124.

while another from Geyser's Hill, Halifax County, gave a distinct reaction for nickel." Several samples of pyrrhotite from La Téte in New Brunswick were examined by Professor Howe, with the following results. "No attempt" he says "was made to separate the nickel and cobalt found, the metals were thrown down as oxides, and calculated as from protoxide of nickel."

No.	1	afforded	0.09	per cent.
"	2	"	0.36	"
"	3	"	0.80	"
"	4	"	0.40	"

Now in all the examples given, including the Polson's Lake pyrrhotite, the proportion of nickel is too small for profitable extraction, but the results of a single analysis are by no means sufficient to settle the matter. Concerning the quantity of pyrrhotite in the vein at Polson's Lake I have no information, but if an abundant constituent, then it would be wise to have a number of samples analysed. The pyrrhotite from some portions of the vein might perhaps contain a much larger proportion of nickel. It is probable also that some of the other constituents of the vein would be found on analysis to contain nickel.

I am told that some years ago a pyrrhotite containing 2.5 per cent. of nickel was profitably treated in Pennsylvania at a time when nickel was worth $1.50 per lb. Subsequently the price rose to $3.00 per lb., and in Litchfield County, Connecticut, an attempt was made to work a pyrrhotite containing, according to some authorities, about 0.75 p. c., but the results did not prove satisfactory. During the past few years the price of nickel has greatly declined, owing partly to the discovery of important deposits of nickel ores in New Caledonia. Exactly what the metal is worth in the United States at present I am not aware, but in England the price is only three shillings sterling per lb. A year ago it was four shillings to four and sixpence, while in 1874 it was eleven shillings.

The New Caledonia ores are said to be hydrated silicates of nickel, and to occur in serpentines associated with euphotides, diorites, amphibolites, &c. They are in fact found in rocks resembling the so-called metamorphic rocks of the Eastern Townships, many of which were long ago shown by Dr. Hunt to contain nickel.

That pyrrhotite is a common mineral in our Laurentian rocks is well known, and it is not unlikely that, as in Norway so here, deposits of both pyrrhotite and pyrite may yet be found, containing sufficient nickel for profitable extraction. A short time ago it was estimated that Norway annually supplied as much nickel as one-third of the yield of the whole world.*

III. Iron Ore from South Ham, P. Q.

Near the west shore of Lake Nicolet, in the first range of South Ham, there occurs a deposit of iron ore which is stated to be of considerable extent, and to occur in serpentine. A specimen recently examined was black in colour, and gave a black streak. It was readily attracted by the magnet, and had a specific gravity of 4.5. The following partial analysis shows the ore to be of interesting and unusual composition :

Metallic iron.....	44.69 p. c.
Chromium sesquioxide	8.31 "
Titanium dioxide.....	21.64 "

Such an ore would be of little value in the market at present, although it might be utilised by mixing with other ores. According to some authorities both chromium and titanium exert a beneficial influence upon the character of steel ; but in a number of cases steels, reported to contain one or other of these constituents have been shown to be entirely free from them.

---

* *Amer. Jour. of Mining*, Oct. 18th, 1879.

NOTES ON CHROME GARNET, PYRRHOTITE AND TITANIFEROUS IRON ORE.

BY

B. J. HARRINGTON, B.A., PH.D.

NOTES ON CHROME GARNET, PYRRHOTITE AND TITANIFEROUS IRON ORE.

By B. J. Harrington, B.A., Ph.D.*

I. Chrome Garnet.

Garnet affords us an excellent example of the wide variation in composition exhibited by many mineral species. The variation is due to what is known as isomorphous replacement, or the replacement of one or more substances in a chemical compound by analogous substances without any essential change of form resulting therefrom.

If we take $R_3\ R_2\ Si_3\ O_{12}$ as the general formula for garnet, the numerous analyses of the mineral which have been made tell us that R may be represented by calcium, magnesium, iron (in the ferrous state), manganese, &c., while R may be aluminium, iron (in the ferric state), or chromium. With all these differences in composition, the crystals of the mineral are always closely related or identical in form; but, as might be expected, the variations in specific gravity and colour are considerable.

In a paper on "Apatite and its associated Minerals," which I had the pleasure of reading before this Society about a year and a half ago, garnet was mentioned as one of the rarer constituents of the apatite-bearing veins; and its occurrence was again noticed in a report published by the Geological Survey last year. Of the varieties which have been observed the most common is probably a lime-alumina garnet; but the most interesting is a beautiful emerald-green variety which was discovered some time ago in the township of Wakefield, Quebec, and which has proved on analysis to be chromiferous. So far as I am aware there is no instance recorded in which the element chromium has hitherto been detected in any of the Laurentian minerals of Canada, although it is well known to be a constituent of serpentines and other minerals in succeeding formations. In order to ascertain whether the Wakefield garnet resembled the original ouvarovite or chrôme-garnet, from Bissersk, in the Urals, a quantative analysis has recently been made, and the results are given under

* Read before the Natural History Society May 26th, 1880.

I. Under II is given Dr. Hunt's analysis of the chrome-garnet from Orford in the Eastern Townships, while, under III, is an analysis by Erdmann of the true ouvarovite:

	I. *	II.	III.
Silica	37.50	36.65	36.93
Alumina	18.65	17.50	5.68
Ferric oxide	1.07	.....	1.96
Ferrous oxide	.....	4.97	.....
Chromium sesquioxide.	4.95	6.20	21.84
Lime	36.13	33.20	31.63
Magnesia	0.52	0.81	1.54
Cupric oxide	.....	.....	trace.
Loss on ignition	0.48	0.30	.....
	99.30	99.63	99.58

On comparing these analyses we see that while in the true ouvarovite, the predominant sesquioxide obtained on analysis is that of chromium, it is alumina in the garnet of Wakefield and Orford. Strictly speaking, therefore, the two last should be classed as lime-alumina rather than lime-chrome garnets.

The hardness of the Wakefield mineral is a little above 7 and the specific gravity 3.542. Before the blow-pipe it fuses between 4 and 5. Notwithstanding that it contains less chromium, the green in the specimens which I have seen is deeper than that of the Orford mineral and quite as deep as that of ouvarovite. The crystals are rhombic dodecahedrons with the faces often striated in the direction of the longer diagonal. In my specimens the well-defined crystals are mostly one-eighth of an inch or a little more in diameter; but one—unfortunately not entire—is nearly half an inch. On weathering, the crystals lose their glassy lustre, becoming dull and paler in colour. Among the minerals associated with the garnet are a green pyroxene, which is probably chromiferous, apatite, calcite, orthoclase, tourmaline and idocrase.

I am greatly indebted to Mr. J. G. Miller of East Templeton for the specimens which have enabled me to make the above analysis.

* The Atomic and quantivalent ratios are as follows:

	Atomic.	*Quantivalent.*		
Si	625×4	2500		2500
Al	362×3	1086		
Fe	013×3	39	1320	
Cr	065×3	195		2636
Ca	645×2	1290		
Mg	013×2	26	1316	

II. Pyrrhotite or Magnetic Iron Pyrites.

In 1875 a vein containing considerable quantities of copper pyrites was discovered near Polson's Lake, in Antigonish County, Nova Scotia. Loose masses of the ore had long before been found scattered over the surface, and although it was evident that they had not travelled far, a number of attempts to discover their source proved failures.

Among the minerals associated with the copper pyrites are spathic iron ore, iron pyrites, pyrrhotite and more rarely native copper. Pyrrhotite, as is well known, frequently contains nickel, or both nickel and cobalt, replacing a portion of the iron, and much of the nickel of commerce has been derived from this source. On account of this fact it was deemed worth while to analyse the mineral from Polson's Lake. The specimen examined—for which I am indebted to Dr. Dawson—was paler in colour than ordinary pyrrhotite and had a very high lustre. It contained a good deal of spathic iron ore (or ankerite) which was difficult to separate completely from the pyrrhotite. An analysis gave the following results:

Iron	58.976
Copper	0.181
Manganese	traces.
Nickel	0.773
Cobalt	traces.
Sulphur	38.580
Calcium Carbonate	0.786
Magnesium Carbonate	0.216
	99.512

The carbonates must be due to a small quantity of intermixed gangue, and a little of the iron was no doubt also present as carbonate. The mineral was strongly attracted by the magnet.

It should be stated here that the late Professor Howe, of Windsor, Nova Scotia, detected nickel and cobalt several years ago in specimens of pyrrhotite from both Nova Scotia and New Brunswick.* Specimens from Cape Breton Island gave 0.50 per cent. of oxides of nickel and cobalt, the amount of metallic nickel being "at least 0.36 per cent." A specimen from Nictaux in Annapolis County, gave "nickel, with a little cobalt, 0.10 p.c.

* *Mineralogical Magazine*, April, 1877, p. 124.

while another from Geyser's Hill, Halifax County, gave a distinct reaction for nickel." Several samples of pyrrhotite from La Téte in New Brunswick were examined by Professor Howe, with the following results. "No attempt" he says "was made to separate the nickel and cobalt found, the metals were thrown down as oxides, and calculated as from protoxide of nickel."

No. 1	afforded	0.09	per cent.
" 2	"	0.36	"
" 3	"	0.80	"
" 4	"	0.40	"

Now in all the examples given, including the Polson's Lake pyrrhotite, the proportion of nickel is too small for profitable extraction, but the results of a single analysis are by no means sufficient to settle the matter. Concerning the quantity of pyrrhotite in the vein at Polson's Lake I have no information, but if an abundant constituent, then it would be wise to have a number of samples analysed. The pyrrhotite from some portions of the vein might perhaps contain a much larger proportion of nickel. It is probable also that some of the other constituents of the vein would be found on analysis to contain nickel.

I am told that some years ago a pyrrhotite containing 2.5 per cent. of nickel was profitably treated in Pennsylvania at a time when nickel was worth $1.50 per lb. Subsequently the price rose to $3.00 per lb., and in Litchfield County, Connecticut, an attempt was made to work a pyrrhotite containing, according to some authorities, about 0.75 p. c., but the results did not prove satisfactory. During the past few years the price of nickel has greatly declined, owing partly to the discovery of important deposits of nickel ores in New Caledonia. Exactly what the metal is worth in the United States at present I am not aware, but in England the price is only three shillings sterling per lb. A year ago it was four shillings to four and sixpence, while in 1874 it was eleven shillings.

The New Caledonia ores are said to be hydrated silicates of nickel, and to occur in serpentines associated with euphotides, diorites, amphibolites, &c. They are in fact found in rocks resembling the so-called metamorphic rocks of the Eastern Townships, many of which were long ago shown by Dr. Hunt to contain nickel.

That pyrrhotite is a common mineral in our Laurentian rocks is well known, and it is not unlikely that, as in Norway so here, deposits of both pyrrhotite and pyrite may yet be found, containing sufficient nickel for profitable extraction. A short time ago it was estimated that Norway annually supplied as much nickel as one-third of the yield of the whole world.*

III. Iron Ore from South Ham, P. Q.

Near the west shore of Lake Nicolet, in the first range of South Ham, there occurs a deposit of iron ore which is stated to be of considerable extent, and to occur in serpentine. A specimen recently examined was black in colour, and gave a black streak. It was readily attracted by the magnet, and had a specific gravity of 4.5. The following partial analysis shows the ore to be of interesting and unusual composition :

Metallic iron.....	44.69 p. c.
Chromium sesquioxide	8.31 "
Titanium dioxide.....	21.64 "

Such an ore would be of little value in the market at present, although it might be utilised by mixing with other ores. According to some authorities both chromium and titanium exert a beneficial influence upon the character of steel ; but in a number of cases steels, reported to contain one or other of these constituents have been shown to be entirely free from them.

---

* *Amer. Jour. of Mining*, Oct. 18th, 1879.