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MINERALOGICAL INVESTIGATION OF A SAMPLE OF NICKEL-COPPER ORE FROM THE NICOPOR PROPERTY OF ZENMAC METAL MINES LIMITED, SCHREIBER, ONTARIO

by

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MINERAL SCIENCES DIVISION

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SUMMARY OF RESULTS

Mineralogical studies made on a sample of nickel-copper ore from the Nicopor property of Zenmac Metal Mines Limited, located near Schreiber, Ontario, show that the ore consists essentially of small masses and grains of iron oxides and sulphide minerals, disseminated in a largely siliceous matrix. Copper occurs almost entirely as chalcopyrite, with only minute amounts present in the form of chalcocite and digenite. Nickel is present as a constituent of a number of sulphide minerals, largely as violarite and pyrrhotite and to a minor extent as heazlewoodite, pentlandite, and smythite (?). Trace amounts of a platinum-palladium-nickel bismuthotelluride, and of molybdenite are also present in the ore. Other minerals identified include pyrite, marcasite, magnetite, hematite, ilmenite, goethite, sphene, quartz, feldspar, mica, amphibole and chlorite.

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INTRODUCTION

A sample of nickel-copper ore from the Nicopor property located near Schreiber, Ontario, was received from Mr. A. Wall of the Mineral Processing Division on June 15, 1970. Mr. Wall requested that the sample be examined to identify the minerals in the ore and to determine their grain sizes and textural relationships. The ore had originally been submitted to the Mines Branch by Mr. P.S. Broadhurst, General Manager, Zenmac Metal Mines Limited, P.O. Box 189, Schreiber, Ontario.

SAMPLE

The sample, as received, consisted of seven small hand specimens, one to two inches in diameter, and about 150 grams of head sample crushed to minus ten mesh. The hand specimens were composed of siliceous gangue minerals in which were disseminated small masses and grains of sulphides and smaller amounts of iron oxides. The ore was reported to contain 1.07 per cent copper and 1.75 per cent nickel*.

METHOD OF INVESTIGATION

The seven small hand specimens were sliced into wafers, one quarter of an inch in thickness. Polished sections were prepared from eleven of these wafers and examined microscopically to identify the ore minerals and to determine their grain sizes and textural relationships. In addition, the head sample was screened and the 65 to 150-, and 150 to 270-mesh sizes were removed and separated into sink and float products by

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*Analytical Chemistry Subdivision, Internal Report MS-AC 70-577.

means of heavy liquids. Polished sections were prepared from the sink products and examined microscopically to permit a comparison of the minerals in the head sample with those in the hand specimens. The gangue minerals were identified by X-ray diffractometer analyses of the float products, and by microscopical examination of oil immersion mounts of these products. The X-ray diffractometer analyses were made by Mr. E.J. Murray of the Crystal Structure Group. Electron microprobe analyses were made on a number of the ore minerals to determine their compositions while others were examined to determine if they contained any nickel.

RESULTS OF INVESTIGATION

General Mineralogy of the Ore

Based on the microscopical examination of the sections of the head sample, which is more representative of the ore than the hand specimens, the principal ore minerals* are pyrrhotite, pyrite, and magnetite; chalcopyrite and violarite are present in much smaller amounts. In addition, the head sample contains very small to trace amounts of heazlewoodite, pentlandite, chalcocite, digenite, hematite, ilmenite, goethite, sphene, molybdenite, and marcasite. The heazlewoodite, pentlandite, chalcocite, digenite, hematite, and goethite were observed only in the head sample, which indicates that the hand specimens are not completely representative of the ore.

The gangue minerals are dominated by quartz and felspar, with chlorite, amphibole, and mica present in much smaller amounts.

Detailed Mineralogy of the Ore

Pyrrhotite and Smythite (?)

Pyrrhotite, in addition to being one of the three principal ore minerals, is also the dominant nickel-bearing mineral in the ore. However,

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*The term "ore minerals" as used in this report, does not necessarily have an economic connotation.

its nickel content in relationship to the other nickel sulphides is quite low. Enclosed within the pyrrhotite are very small exsolution particles (Figure 1) of a mineral with a somewhat higher nickel content and a composition that approximates $(Fe,Ni)_{3.3}S_{4.0}$. This mineral is probably symthite (ideally Fe_3S_4), but this tentative diagnosis could not be confirmed by X-ray diffraction analysis because of the fine grain size. The results of electron microprobe analyses of the two minerals are shown in Table 1.

The pyrrhotite occurs essentially as aggregates of grains and as individual grains disseminated in the gangue (Figure 2). The aggregates range up to one centimetre in size, whereas the individual grains are largely from 25 microns to about 1.2 millimetres. (The word "size" as used in this report, refers to the greatest dimension of the mineral grains being described.) The pyrrhotite also occurs in combination with either chalcopyrite, magnetite, or pyrite in gangue, and is frequently present in intimate association with violarite (Figure 3). Small amounts of pyrrhotite also occur as inclusions in pyrite, chalcopyrite, violarite, and magnetite (Figure 4). These inclusions range from about 10 to 300 microns in size. The pyrrhotite itself, contains inclusions composed mainly of gangue, but also of violarite, chalcopyrite, magnetite, pyrite, and smythite (?) (Figures 1, 2 and 3), as well as veinlets of gangue and, to a lesser extent, of chalcopyrite. The inclusions in the pyrrhotite range from about 10 to 600 microns in size, while the veinlets are from about 5 to 100 microns in width.

TABLE 1

Electron Microprobe Analyses of Pyrrhotite and Smythite (?)*

Element	Pyrrhotite Wt.%	Smythite (?) Wt.%
Ni	0.64	1.67
Fe	60.10	56.84
S	39.16	41.11
Totals	99.90	99.62

*The above results are based on the averages from at least three separate analyses.

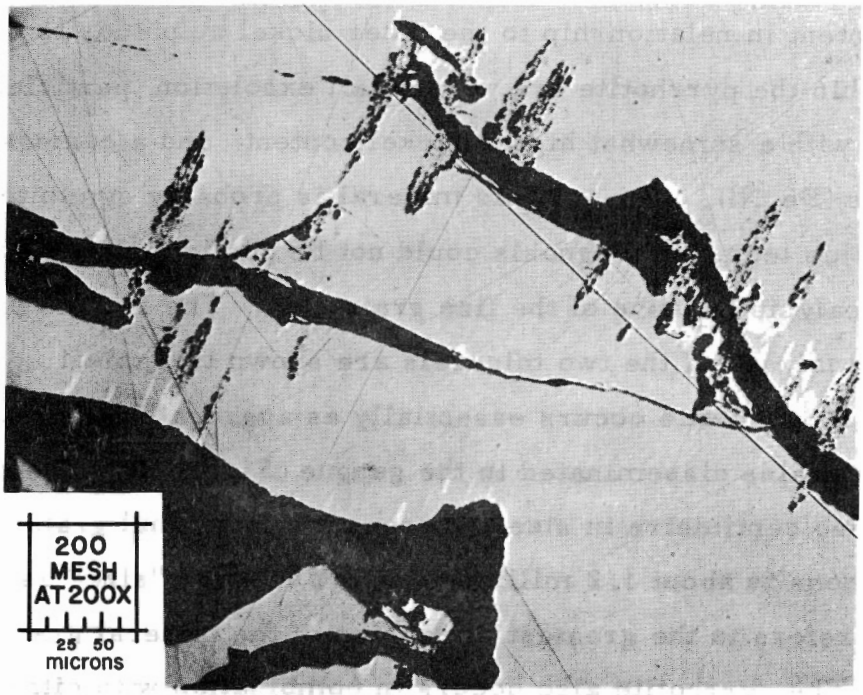

Figure 1. Photomicrograph (in oil immersion) of a polished section showing exsolutions of smythite (?) (white) associated with violarite (pitted, medium grey) in pyrrhotite (light grey).

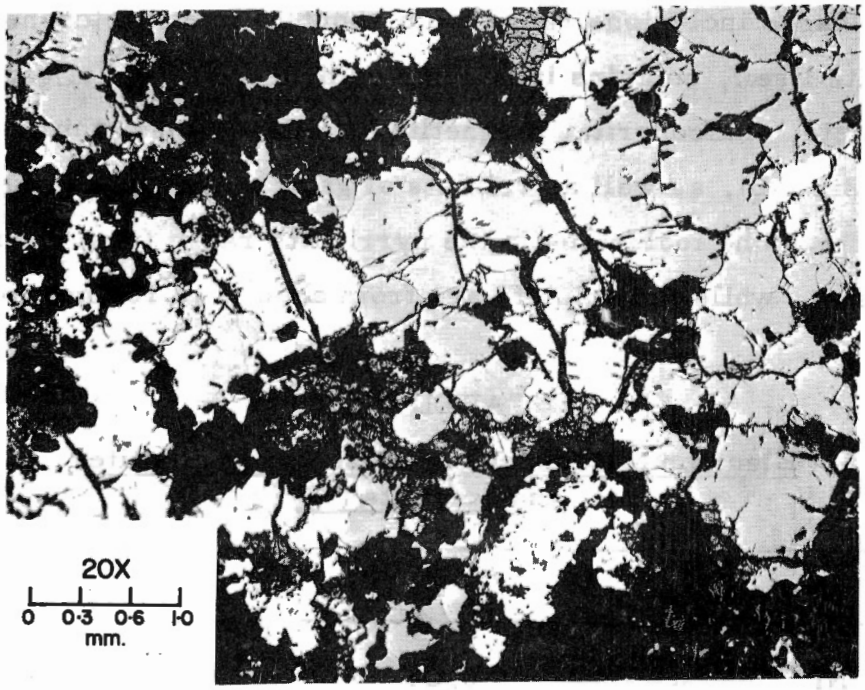

Figure 2. Photomicrograph of a polished section showing aggregates of pyrrhotite grains (light grey) in gangue (black). The pyrrhotite is cut by gangue veinlets and contains inclusions of gangue and pyrite (white).

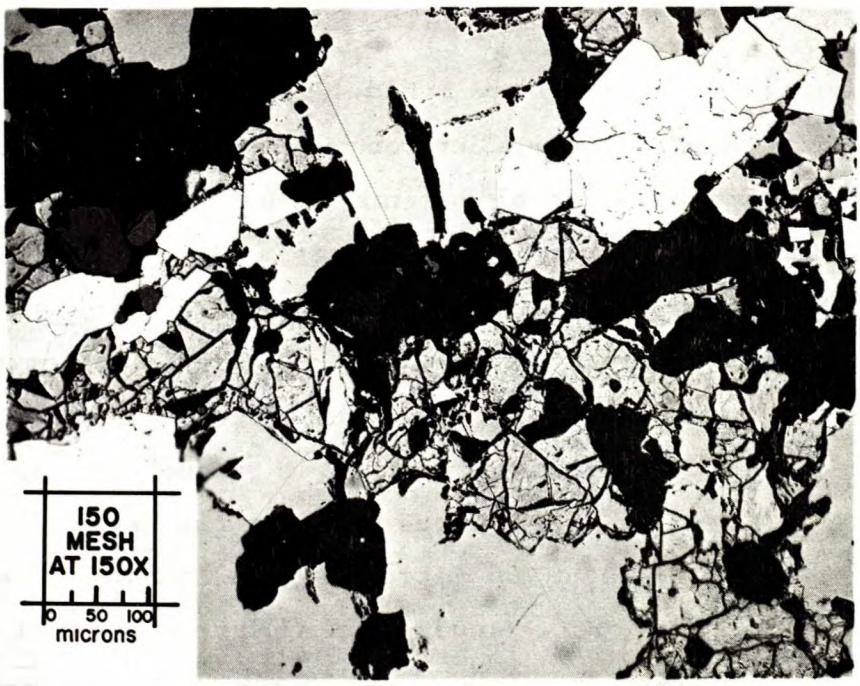

Figure 3. Photomicrograph of a polished section showing pyrrhotite (light grey) associated with fractured violarite (medium grey) and pyrite (white). Gangue (black) inclusions occur in the assemblage.

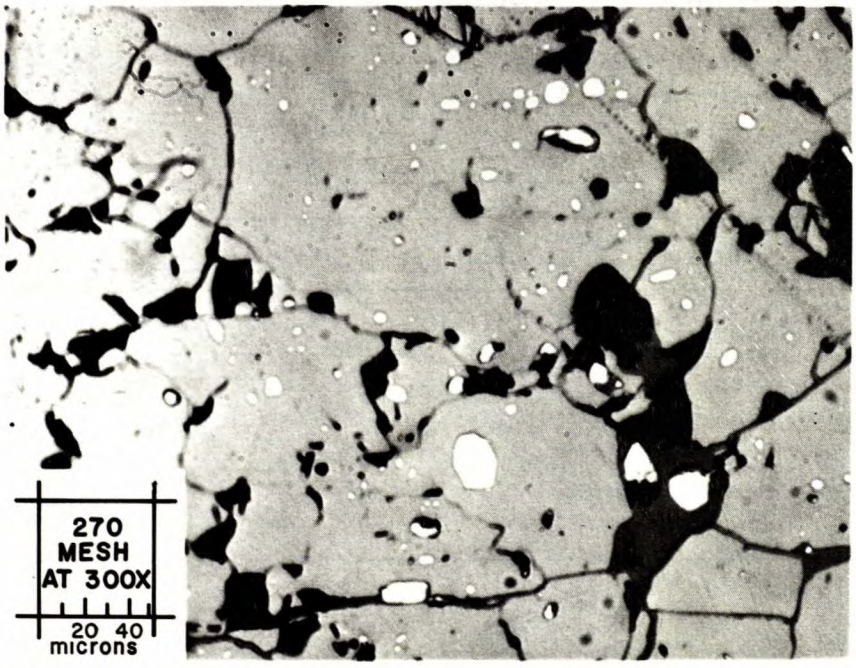

Figure 4. Photomicrograph of a polished section showing very small inclusions of pyrrhotite and chalcopyrite (both white) in magnetite (light grey). The few grey areas are inclusions of gangue and the black areas are polishing pits.

Violarite

Violarite is much less prevalant in the ore than pyrrhotite, although its nickel content is much higher. Electron microprobe analyses of various violarite grains show that its nickel contents varies from 24.2 to 30.7% and its iron content from 27.9 to 30.9%. The average composition of the violarite, based on a number of separate analyses, in given in Table 2.

The violarite occurs largely as heavily fractured aggregates of grains, frequently associated with pyrrhotite (Figure 3), sometimes with chalcopyrite (Figure 5), and as disseminations in gangue. Minute amounts of violarite are also present as inclusions in pyrite and magnetite. The violarite aggregates attain about 750 microns in size, but individual grains vary from about 5 to 200 microns; most of the violarite, however, is greater than 25 microns. The fractures in the violarite are often filled with other minerals. These are mainly of gangue and,to a much lesser extent, of chalcopyrite. The violarite, itself, contains few inclusions. When present, they consist of chalcopyrite, pyrite, pyrrhotite, magnetite,and gangue; these range in size from about 10 to 200 microns.

TABLE 2

Average Composition of Violarite

Element	Wt.%
Ni	26.7
Fe	27.9
Co	0.6
S	41.3
Total	96.5

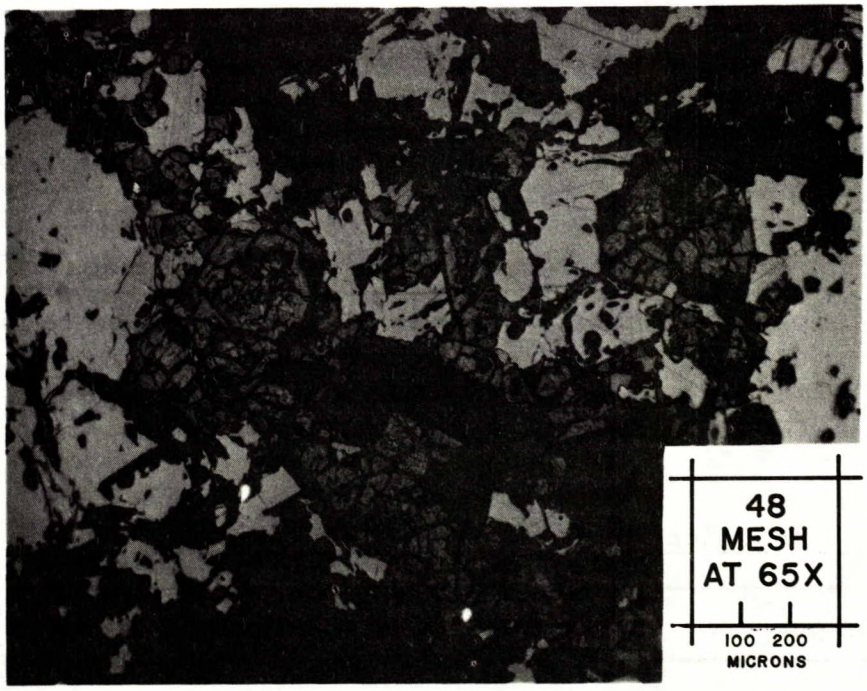

Figure 5. Photomicrograph of a polished section showing heavily fractured violarite (dark grey) associated with chalcopyrite (greyish white).

Pentlandite and Heazlewoodite

Pentlandite and heazlewoodite, the two other nickel sulphides in the ore, occur only in the sections prepared from the head sample; neither of them was seen during the microscopical examination of the hand specimens. Only a few grains of pentlandite were observed in the head sample, and they were free in all instances.

Although more heazlewoodite than pentlandite is present in the head sample, the number of grains is quite small. Though some of the grains are free, most occur in combination with chalcocite and digenite.

Platinoid Bismuthotelluride

Two individual grains of a platinum-palladium-nickel bismuthotelluride were observed during the examination of the ore sample. One grain, 30 microns in size, occurs as an inclusion in pyrite, and the other grain, about 90 microns in size, occurs partly enclosed by chalcopyrite in gangue (Figure 6). Separate electron microprobe analyses were made on each grain to determine its composition. The results of these analyses are given in Table 3.

TABLE 3

Composition of the Platinoid Bismuthotellurides

Element	Grain in Pyrite	Grain in Chalcopyrite
	Wt.%	Wt.%
Pt	3.90	12.50
Pd	17.11	12.19
Ni	4.70	4.02
Bi	17.43	18.65
Te	56.47	52.71
Totals	99.61	100.07

Figure 6. Photomicrograph (in oil immersion) of a polished section showing a grain of the platinoid bismuthotelluride (white) partly enclosed by chalcopyrite (medium grey) in gangue (black). The dark grey grains are magnetide.

Chalcopyrite

Chalcopyrite and violarite occur in approximately the same proportions in the ore. Except for a few grains of chalcocite and digenite, which occur in combination with grains of heazlewoodite in the head sample, chalcopyrite is the only copper-bearing mineral present in the ore. The chalcopyrite occurs essentially as grains and small masses disseminated in gangue (Figure 7). These grains and small masses vary in size from a few microns to about 2.5 millimetres. Some chalcopyrite also occurs in association with violarite (Figure 5), as inclusions in pyrite, magnetite, and pyrrhotite; as veinlets in magnetite and fracture fillings in violarite; and as combinations with pyrrhotite and magnetite in gangue. The chalcopyrite inclusions vary from about 5 to 200 microns in size, while the veinlets are from 5 to 30 microns in width. The chalcopyrite contains few inclusions of pyrrhotite, violarite, gangue, magnetite, and pyrite. These inclusions range in size from about 5 to 180 microns.

Molybdenite

Only trace amounts of molybdenite are present in the ore. Although a number of free grains of molybdenite occur in the head sample, only one small grain was observed as an inclusion in gangue in a hand specimen.

Other Ore Minerals

Other ore minerals present in the sample include pyrite, magnetite, marcasite, hematite, ilmenite, goethite, and sphene. Of these, only pyrite and magnetite are present in significant quantities and, in fact, are two of the major ore minerals.

Pyrite

Most of the pyrite occurs in the ore as small masses and relatively coarse grains in the gangue. Though some of the pyrite is as large as 1.0 centimetres, the majority is from 25 microns to about 3.0 millimetres. Much smaller amounts of pyrite occur as inclusions in some of the other

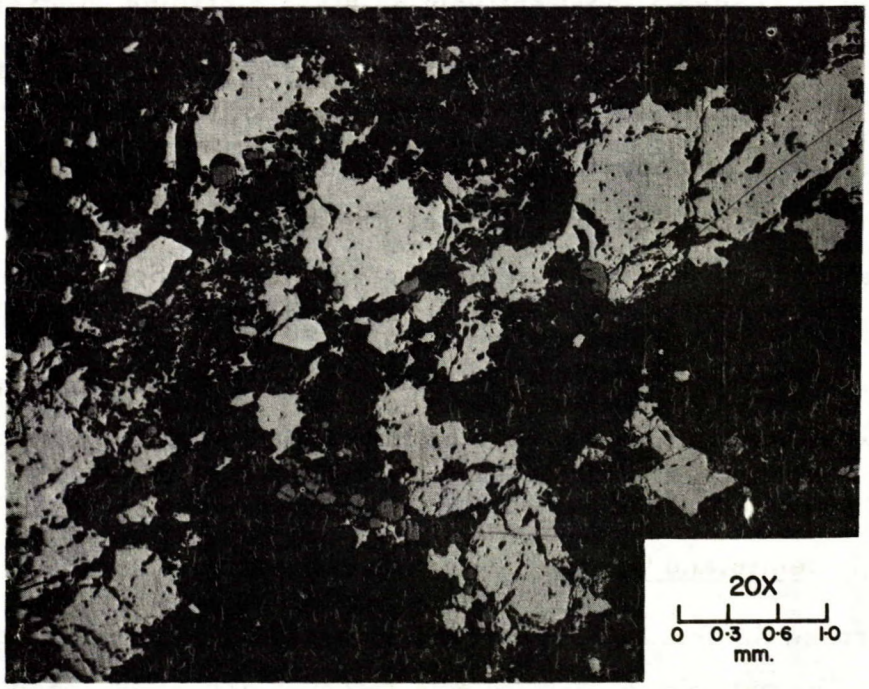

Figure 7. Photomicrograph of a polished section showing small masses and numerous grains of chalcopyrite (white) disseminated in gangue (dark grey). A few grains of magnetite (medium grey) are also shown.

ore minerals including pyrrhotite, magnetite, violarite, and chalcopyrite. These inclusions are from about 25 to 300 microns in size. The pyrite contains few inclusions. These are composed mainly of gangue and, to a much lesser extent, of chalcopyrite, pyrrhotite, magnetite, violarite, and marcasite. This is the only occurrence of marcasite in the ore. The inclusions in the pyrite vary from about five microns to more than one millimetre , although most of them are smaller than 160 microns.

Magnetite

Magnetite occurs almost entirely as disseminations, aggregates, and small masses in gangue. Much smaller amounts of magnetite are present as inclusions in pyrite, chalcopyrite, pyrrhotite, and violarite and in combinations with chalcopyrite and pyrrhotite. The grains of magnetite vary from about 15 to 180 microns in size; the aggregates and small masses are up to 0.1 and 1.0 centimetres in size, respectively. Some areas of the magnetite are relatively free of inclusions, while others are riddled (Figure 4). These inclusions are composed of gangue, chalcopyrite, pyrite, pyrrhotite, and violarite. The inclusions in the magnetite vary from about 5 to 450 microns in size.

Hematite, Ilmenite,and Goethite

Only trace amounts of each of these minerals occur in the ore. The presence of hematite and goethite was detected only in the head sample, where a few free grains of each mineral phase was found. Ilmenite also occurs in the head sample in a similar manner; however, a number of small grains are present in association with some magnetite grains in the hand specimens.

Sphene

A few small clusters of grains of sphene are present as inclusions in the gangue, all of which are smaller than 100 microns.

Gangue minerals

The gangue minerals are composed chiefly of quartz and feldspar. Smaller, but appreciable, amounts of chlorite, mica, and amphibole are also present.

CONCLUSIONS

The mineralogical investigation of the ore leads to the following conclusions:

(a) Copper is represented almost entirely by chalcopyrite, much of which is coarse-grained. However, some of the small chalcopyrite grains in the gangue, pyrrhotite, magnetite, and violarite will be difficult to liberate. The amount of copper occurring as digenite and chalcocite is practically insignificant.

(b) Nickel is present in the ore essentially as pyrrhotite and violarite. Although pyrrhotite is much more prevalant than violarite, its nickel content is very much lower. This means that either a low recovery or a low grade of nickel concentrate can be expected. The pyrrhotite also contains numerous small violarite inclusions which may give liberation problems.

The nickel represented by heazlewoodite and pentlandite is of a minor nature only, and should not play an important role in beneficiation.

(c) Platinum and palladium are present as a platinoid bismuthotelluride. Since only two grains were seen in the examination of the ore, no estimate of liberation can be given.