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CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 71-5

MINERALOGICAL INVESTIGATION OF A SAMPLE OF NICKEL ORE FROM A DEPOSIT LOCATED EAST OF BRIDESVILLE, BRITISH COLUMBIA ON BEHALF OF ARCTIC GOLD AND SILVER MINES LIMITED

by

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MINERAL SCIENCES DIVISION

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COPY NO. 1

JANUARY 14, 1971

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SUMMARY OF RESULTS

Mineralogical studies made on a sample of nickel ore from the Old Nick nickel property, located east of Bridesville, British Columbia, on behalf of Arctic Gold and Silver Mines Limited, show that the ore is composed essentially of a serpentinized mafic rock, in which are disseminated small amounts of iron oxides and nickel-iron sulphides. The nickel is present largely as pentlandite; small amounts of mackinawite and traces of valleriite account for the remainder. Other minerals identified in the ore include pyrrhotite, magnetite, chromite, goethite, marcasite, molybdenite, ilmenite, hematite, pyrite, chalcopyrite, olivine (forsterite), amphibole, serpentine, calcite, asbestos, dolomite, and feldspar.

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INTRODUCTION

A sample of nickel ore from the Old Nick nickel property, located just east of Bridesville, British Columbia, was received from Mr. G. Mathieu of the Mineral Processing Division on October 21, 1970. Mr. Mathieu requested that the sample of the ore be examined to identify the minerals present, and to determine their grain sizes and textural relationships. The ore had originally been submitted to the Mines Branch by Mr. E. Livgard, Managing Director, Arctic Gold and Silver Mines Limited, 1300 Marine Bldg., 355 Burrard Street, Vancouver 1, B.C.

SAMPLE

The sample, as received, consisted of 21 small hand specimens, each one to two inches in diameter, as well as about 250 grams of minus ten-mesh head sample. The hand specimens were composed essentially of serpentine, olivine, and amphibole, in addition to much smaller amounts of carbonate minerals and feldspar; one of the hand specimens contained a few thin bands of fibrous asbestos. Visible mineralization in the hand specimens was very sparse and consisted of sulphides and iron oxides. The ore was reported by Mr. Mathieu to contain 0.30 per cent nickel.

METHOD OF INVESTIGATION

The hand specimens were examined under the ore microscope, and those showing the greatest amount of mineralization were used in preparing polished sections. A number of thin sections were also prepared from less mineralized hand specimens. The polished sections were examined microscopically under the ore microscope to identify the metallic minerals and to determine their grain sizes and textural relationships; the thin sections were examined petrographically to identify the gangue minerals. In addition, the head sample was screened and the 100 to 200- and the 200 to 325-mesh sizes were removed and separated into sink and float products by means of heavy liquids. Polished sections were prepared from the sink products and examined microscopically to permit a comparison of the ore minerals in the head sample with those in the hand specimens. The minerals in the ore were identified by the combined methods of microscopy, X-ray diffraction analyses and electron microprobe analysis. X-ray diffraction analyses, when required, were made by Mr. E.J. Murray of the Crystal Structure Group. Electron microprobe analyses were made on the mackinawite and valleriite to substantiate their identification, and most of the other minerals were analyzed to determine if they contained trace amounts of nickel.

RESULTS OF INVESTIGATION

General Mineralogy of the Ore

Based on the microscopical examination of the head sample, which is more representative of the ore than the hand specimens, the principal ore mineral* is pyrrhotite, followed by successively smaller amounts of magnetite, chromite, and pentlandite. Small to trace amounts of mackinawite, marcasite, valleriite, molybdenite, goethite, ilmenite, hematite, pyrite, and chalcopyrite account for the remainder of the ore minerals. The presence of pyrite, chalcopyrite, molybdenite, ilmenite, and hematite was confirmed only in the polished sections of the head sample, where each mineral accounts for only a few individual grains. These minerals will not be discussed further in this report.

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

Textures of the Ore Minerals

The ore minerals in the hand specimens tend to occur in two basic forms: those associated with the fibrous amphibole are typically elongate or acicular, whereas those associated with the serpentine and olivine are more equidimensional.

Detailed Mineralogy of the Ore

Nickel-bearing Minerals

Three nickel-bearing minerals were identified in the ore: pentlandite, mackinswite and valleriite, with the pentlandite greatly predominating. Routine electron microprobe analyses were made on all the other ore and gangue minerals to determine if any of them contained trace amounts of nickel. The results were negative in all cases, except for some of the pyrrhotite.

The pentlandite $(Ni, Fe, Co)_9S_8$ is present essentially as inclusions in pyrrhotite (Figures 1 and 2) and to a lesser extent in magnetite and chromite (Figures 3 and 4). Minute amounts of pentlandite also occur as combined grains with pyrrhotite of magnetite in the gangue. The pentlandite grains vary from about 5 to 400 microns in size*; those present in the magnetite and chromite have a maximum size of about 100 microns. The majority of the pentlandite grains are between 15 and 100 microns, with an estimated average size of about 30 to 40 microns. A large proportion of the pentlandite that occurs as inclusions in the pyrrhotite is rimmed and penetrated by thin bands of magnetite (Figures 2 and 5). This characteristic is also true of some of the pentlandite inclusions in chromite.

The pentlandite is riddled with inclusions, the majority of which consist of mackinawite (Fe, Ni, Co)S (Figure 6), some of magnetite, and a few of pyrrhotite. Almost every grain of pentlandite contains at least a

*The word "size" as used in this report, refers to the greatest dimension of the mineral grains being described.

a few of these very small and irregularly shaped grains of mackinawite The mackinawite inclusions vary from 2 to about 35 microns in size, with the majority smaller than 5 microns. Inclusions of other minerals in the pentlandite are of the same order of size. Nearly all of the mackinawite occurs in the pentlandite; the few exceptions are a number of inclusions in magnetite and pyrrhotite, but the amount is insignificant. The composition of the mackinawite, determined from electron microprobe analysis of two of the largest grains, is shown in Table 1.

TABLE 1

Electron Microprobe Analysis of Mackinawite

Element	Wt %
Fe	57.95
Ni	5.66
Co	0.66
S	35.23
Total	99.50

Valleriite is present in the sample in trace amounts. Its normal composition is given as $(CuFeS_2) \cdot 1.5(Mg,Al(OH)_2)$. All of the grains of valleriite are very small, and range from about 5 to 35 microns in size. Two types of valleriite appear to be present in the ore. The first is a nickel-copper variety occurring as a few inclusions in magnetite and pyrrhotite. The nickel content of the valleriite, based on electron microprobe studies, is slightly less than four per cent; the existence of a nickel-bearing valleriite has not been reported previously. The second type of valleriite consists of very minor disseminations in gangue. These appear to be simply an iron-rich variety, because neither nickel nor copper was detected.

Pyrrhotite

Pyrrhotite [$Fe_{1-x}S$], the principal ore mineral in the sample, occurs almost entirely as disseminated grains in gangue (Figures 1, 2, 5 and 7), with only minor amounts present as inclusions in the other ore minerals (magnetite, chromite, pentlandite). The pyrrhotite varies from a few microns in size to slightly less than one millimetre. Some pyrrhotite is also present in combinations with either, or both, magnetite and pentlandite. The pyrrhotite contains fairly numerous inclusions of pentlandite and magnetite with fewer inclusions of gangue, chromite, mackinawite, and marcasite. This is the only occurrence of marcasite in the ore. These inclusions vary from a few to about 400 microns in size; most, however, are smaller than 150 microns. Attempts to determine the type or types of pyrrhotite in the ore were inconclusive, since electron microprobe analysis of a number of areas of the pyrrhotite gave results indicating the hexagonal type, whereas etch tests with HI were more indicative of the monoclinic type of pyrrhotite.

Electron microprobe studies on the pyrrhotite to determine if it contained trace amounts of nickel were essentially negative. However, a few areas of pyrrhotite were found to contain barely detectable nickel (less than 0.1 per cent).

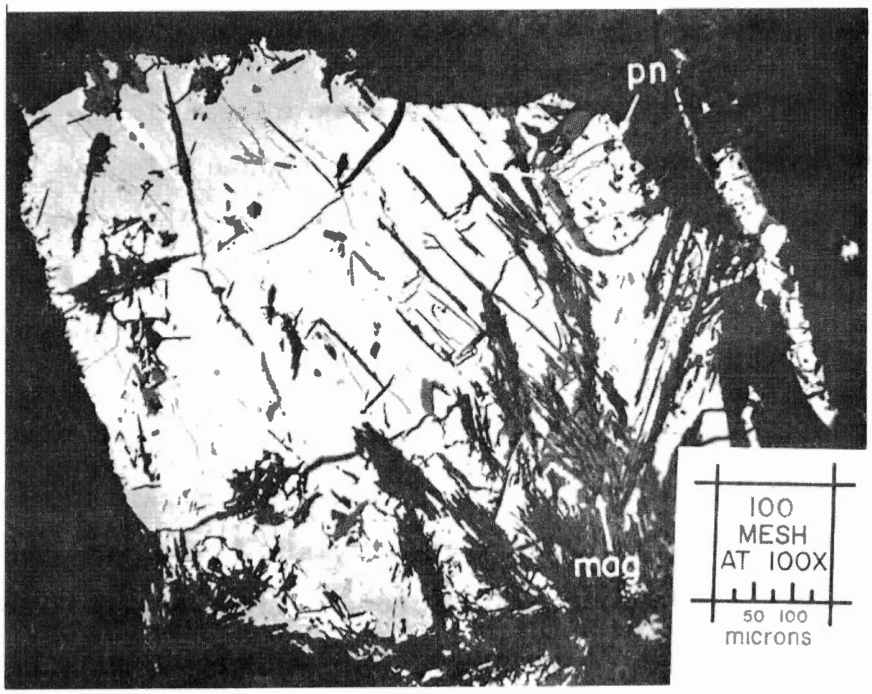

Figure 1. Photomicrograph of a polished section showing a large grain of pyrrhotite (light grey) in gangue (black). The pyrrhotite contains inclusions of pentlandite (pn) and gangue, and is penetrated by magnetite (mag) which also rims a few of the pentlandite grains.

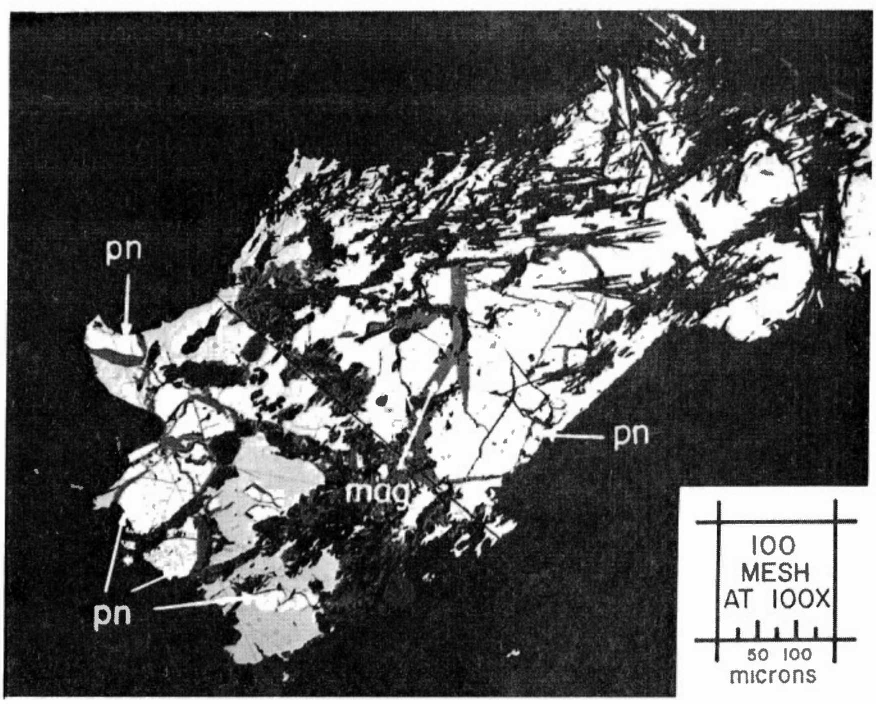

Figure 2. Photomicrograph of a polished section showing pyrrhotite (light grey) in gangue (black). The pyrrhotite is penetrated by gangue and contains inclusions of magnetite (mag) and pentlandite (pn). The pentlandite is bordered and penetrated by magnetite.

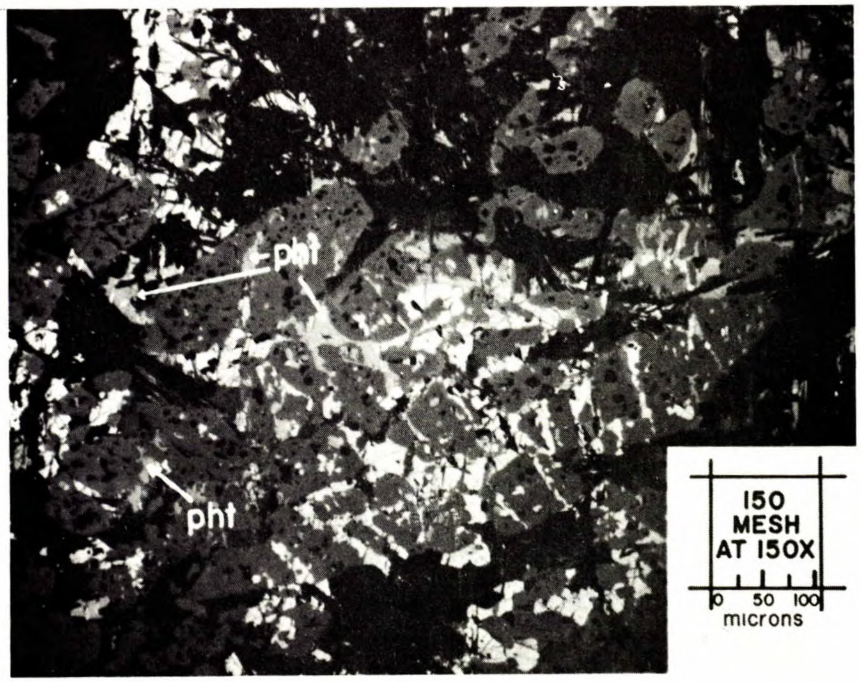

Figure 3. Photomicrograph of a polished section showing a cluster of chromit grains (medium grey) in gangue (black). Numerous inclusions of pentlandite (white) and a few grains of pyrrhotite (pht) are present in the chromite.

Figure 4. Photomicrograph of a polished section showing grains of chromite (dark grey) with inclusions and rims of magnetite (medium grey), associated with pentlandite (white) and some pyrrhotite (pht) in gangue (black).

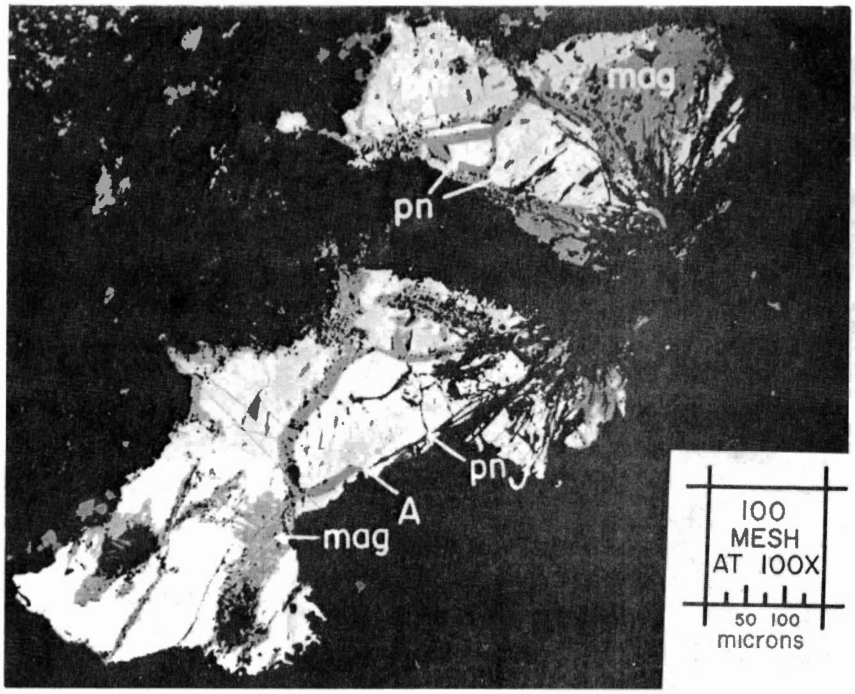

Figure 5. Photomicrograph of a polished section showing one of the typical associations between pyrrhotite (pht), pentlandite (pn) and magnetite (mag) in gangue (dark grey). It can be seen that the magnetite rims the pentlandite grains and forms inclusions in the pyrrhotite. The grain of pentlandite marked A, is shown in Figure 6 at a higher magnification.

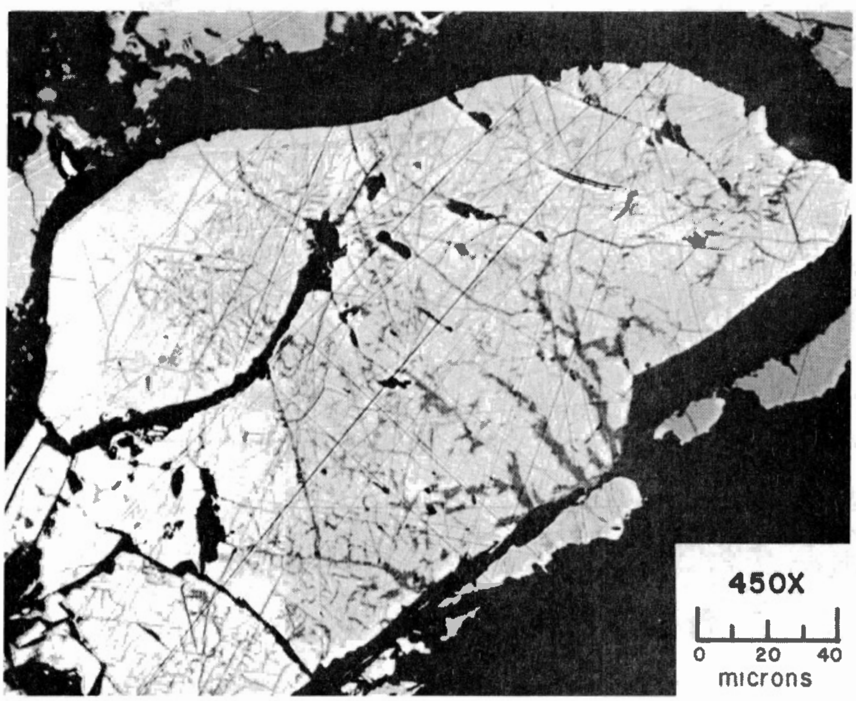

Figure 6. Photomicrograph (in oil immersion) of a polished section showing the grain of pentlandite marked A in Figure 5 at a higher magnification. This shows the typical occurrence of mackinawite (minute, medium grey inclusions) in the pentlandite.

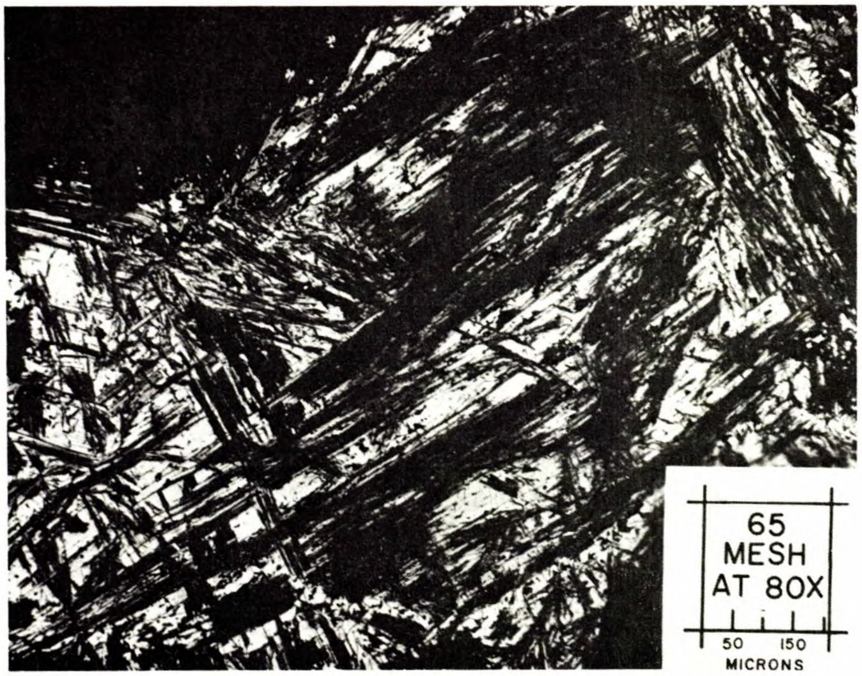

Figure 7. Photomicrograph of a polished section showing the typical texture of pyrrhotite (greyish white) associated with the acicular amphibole (dark grey).

Other Ore Minerals

The remaining ore minerals found in the polished sections of the hand specimens are magnetite (Fe_3O_4), chromite ($FeCr_2O_4$) and goethite (FeO.OH). The combined amounts of chromite and magnetite exceed that of pentlandite, but are less than pyrrhotite; the amount of goethite is insignificant.

The chromite and magnetite usually, but not always, occur in association with each other, as inclusions in, and rims about each other, and in intimate combination. The magnetite and chromite occur essentially as disseminations and clusters of grains in the gangue (Figures 3 and 4). These grains vary in size from two to about 450 microns. In contrast to the chromite, which rarely occurs as inclusions in the other ore minerals, magnetite is frequently associated with pentlandite and pyrrhotite. This association is marked by the presence of magnetite as complete or partial rims about pentlandite grains (Figures 1 and 5), as fracture fillings in pentlandite

(Figure 2) and as penetrations and inclusions is pyrrhotite (Figures 1, 2, and 5). The magnetite and chromite are sometimes riddled with inclusions of pentlandite, gangue, and pyrrhotite (Figures 3 and 4) and in other instances they are almost entirely devoid of inclusions. These inclusions are essentially smaller than 75 microns in size.

Gangue Minerals

The gangue minerals, which comprise the major portion of the ore, include serpentine, amphibole, olivine (forsterite), calcite, dolomite, feldspar, and asbestos. Serpentine is the major gangue mineral with successively smaller amounts of amphibole and olivine and from small to trace amounts of feldspar, calcite, dolomite, and asbestos. The matrix of the hand specimens consists of large areas of serpentine and olivine interspersed with clusters of acicular amphibole (Figure 8). Disseminated in this matrix are small amounts of fine-grained feldspar and somewhat coarser grains of calcite and dolomite. A few thin layers of asbestos fibres occur as veinlets cutting the gangue matrix. As mentioned earlier in this report, the olivine has been replaced to a large extent by serpentine (Figure 9).

CONCLUSIONS

Based on the mineralogical examinations of the ore sample, the following conclusions can be drawn:

Nickel is represented in the ore chiefly by pentlandite, to a much smaller extent by mackinawite, and only insignificantly by valleriite. The low nickel content of the mackinawite, which is present almost entirely as minute inclusions in the pentlandite, will inevitably reduce the grade of any pentlandite concentrate. In addition, much of the pentlandite will be difficult to liberate, from the other minerals with which it is associated, due to its small average particle size.

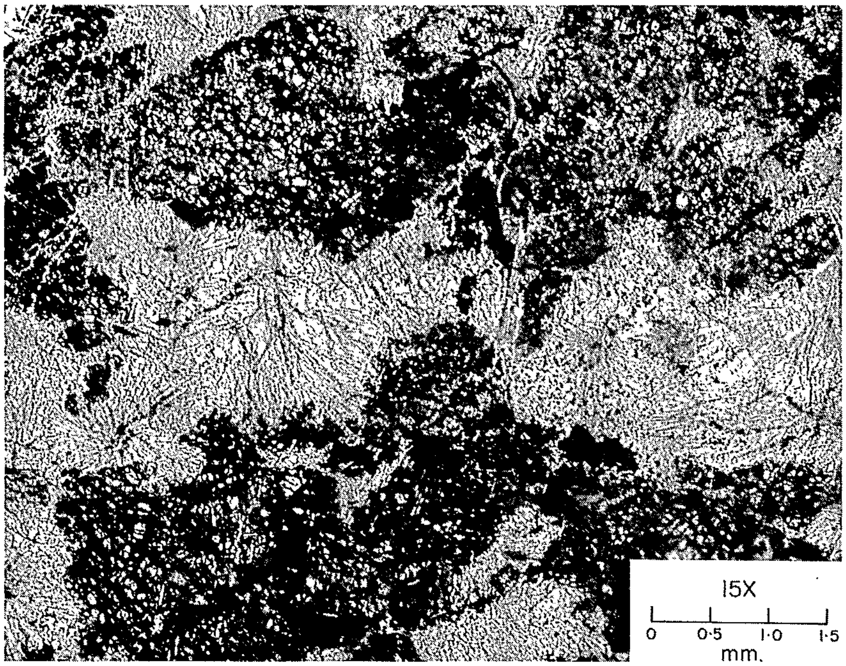

Figure 8. Photomicrograph of a thin section showing sheaf-like clusters of acicular amphibole (greyish white) interspersed with patches of serpentine and olivine (dark grey to black).

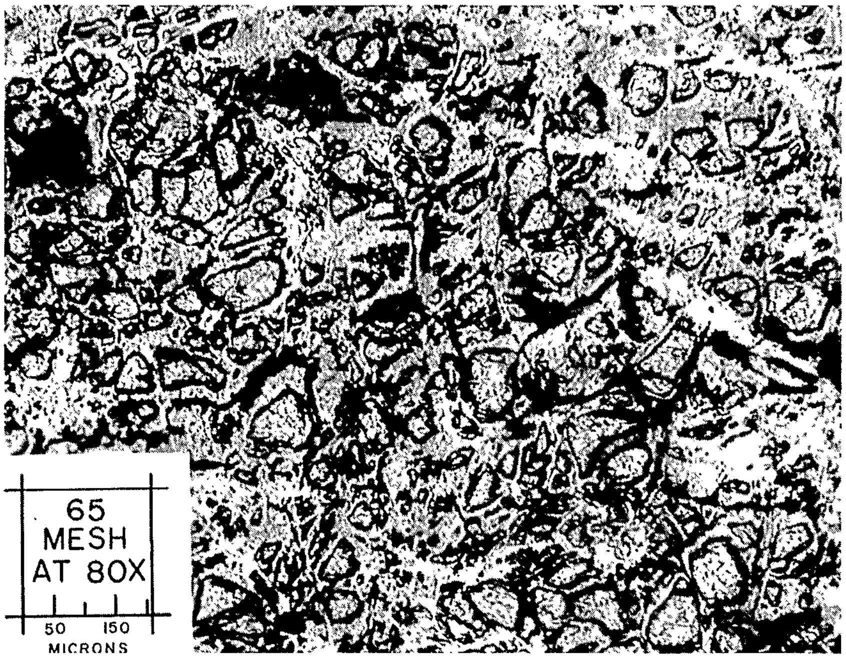

Figure 9. Photomicrograph of a thin section showing one of the areas of serpentine and olivine, at a higher magnification. Remnants of olivine grains (marked by a dark rim of higher relief) are shown in the serpentine matrix (greyish white). The field also shows a few inclusions of the opaque ore minerals (black) in the serpentine.