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MINERALOGICAL INVESTIGATION OF A TITANIFEROUS IRON ORE FROM TITAN IRON MINES LIMITED, NORTHERN ONTARIO

by

D. OWENS

MINERAL SCIENCES DIVISION

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SUMMARY OF RESULTS

Mineralogical studies of a sample of iron ore from Titan Iron Mines Limited, in the Temagami district of Ontario have been completed. The results show that the ore is composed largely of feldspar and granular magnetite intimately intergrown with what appears to be ulvöspinel. Also present are appreciable quantities of ilmenite, which occur as inclusions in gangue and as inclusions and intergrowths with the magnetite-ulvöspinel. The ore also contains a small amount of hercynite as fine-grained inclusions in the magnetite and to a lesser degree in the ilmenite, as well as a small quantity of hematite, goethite, anatase(?) chalcopyrite, pyrite and pyrrhotite, and traces of bornite and violarite. The gangue minerals, in addition to plagioclase feldspar, include relatively coarse grains of olivine and pyroxene, and small amounts of apatite, chlorite, amphibole, biotite and graphite.

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INTRODUCTION

A sample of an iron ore was received from Mr. D. Raicevic of the Mineral Processing Division on May 1, 1968. The sample was reported to be from a deposit in Angus and Flett Townships in the Temagami Mining District of northern Ontario, and had originally been submitted to the Mines Branch by Mr. Arthur S. Bayne, Consulting Engineer, Suite 407, 80 Richmond Street, West, Toronto 1, Ontario. Mr. Raicevic requested that the sample be examined to identify the minerals in the ore and to determine their textural relationships.

The sample, as received, consisted of 7 small hand specimens, and about 100 grams of head sample crushed to minus 10 mesh.

METHOD OF INVESTIGATION

One polished section was prepared from each of the hand specimens and examined under the ore microscope to determine the identity and textures of the metallic minerals. In addition, three thin sections were prepared from the hand specimens and examined to identify the gangue minerals. Polished sections were also made of the 65 to 200 -mesh sizes of the head sample so as to permit a comparison of the minerals in the head sample with those in the hand samples. The minerals in the ore were identified by X-ray diffraction and microscopical studies.

RESULTS OF INVESTIGATION

General Mineralogy

The ore consists largely of granular magnetite and plagioclase feldspar, with an appreciable amount of ilmenite. Most, but apparently not all, of the magnetite, consists of a fine-grained intimate intergrowth of magnetite itself, and a titanium-bearing mineral that could not be positively identified, but which is probably ulvöspinel.

Also present in the ore are small amounts of hematite, geothite, hercynite ($FeAl_2O_4$), chalcopyrite, pyrite, anatase (?), bornite, pyrrhotite, violarite and an unknown phase.

The gange, in addition to the feldspar, consists of olivine and pyroxene, as well as very small amounts of biotite, amphibole, apatite, chlorite and graphite.

Detailed Mineralogy of the Ore

Magnetite

As noted above, the magnetite occurs largely in an intimate intergrowth with another mineral (Figures 1 and 2), which could not be positively identified, but which, for reasons given below, will be referred to as ulvöspinel (?). This intergrowth occurs mainly as granular aggregates (Figure 3) and individual grains in gangue and in combination with ilmenite grains in gangue (Figure 4). The grains of the magnetite-ulvöspinel (?) intergrowth range in size from about 0.14 to 1.5 millimetres. (The word "size" as used in this report refers to the greatest dimension of the mineral grain being described).

The mineral intimately intergrown with the magnetite is too fine-grained to permit its isolation for chemical or X-ray diffraction analysis. X-ray diffraction patterns of the mixture show only magnetite lines, which means that the second phase must have a diffraction pattern very similar to magnetite, or that it is amorphous, which is less likely. Electron-probe microanalysis of polished sections shows that the intergrowth has substantial titanium content, but was not able to discriminate between the two minerals because of the fine grain size. Optically, the second mineral appears to be isotropic. All these properties are consistent with the mineral being ulvöspinel (Fe_2TiO_4) or a member of the magnetite-ulvöspinel solid-solution series. For this reason, the mineral will henceforth be referred to as ulvöspinel (?) in this report.

The grains of magnetite-ulvöspinel (?) contain numerous lath-shaped and irregular inclusions of ilmenite (Figures 2 and 6). The irregularly shaped inclusions are mostly from a few to 200 microns in size, while the lath-shaped inclusions vary from 5 to 20 microns in width and from about 25 to 300 microns in length. In addition, the magnetite-ulvöspinel (?) contains fairly numerous spindle-shaped, oriented, inclusions of hercynite spinel ($FeAl_2O_4$), inclusions of gangue, and a few inclusions and veinlets of hematite and goethite. The hercynite inclusions rarely exceed a maximum length of 35 microns, while the gangue, hematite and goethite inclusions range from about 40 to 800 microns in size. The few hematite and goethite veinlets that cut the magnetite-ulvöspinel (?) are from 10 to

60 microns wide. A few grains of pyrite and chalcopyrite occur as inclusions in the magnetite-ulvöspinel (?), but these are generally few in number and only a few microns in size. Where the grains of magnetite-ulvöspinel (?) occur in a massive granular texture, they are separated by interstitial gangue (Figure 6).

Some of the magnetite shows no apparent intimate intergrowth with ulvöspinel (?) (Figure 7). In these occurrences the magnetite either forms a core bordered by ilmenite (Figure 5), or it forms a relatively coarse granular intergrowth with grains of ilmenite (Figure 8). Similarly to the intergrown grains, these grains of magnetite commonly contain inclusions of the other minerals, including both lath-shaped and irregular grains of ilmenite (Figure 5) and spindle-shaped inclusions of hercynite (Figure 7), which are of a similar size range as those in the intergrowth. In some of these magnetite grains the ulvöspinel (?) appears as a very thin border 1 to 3 microns in width, on both sides of the hercynite inclusions. In these cases, the magnetite also contains another unknown phase. It is white in colour and is found in a parallel arrangement with some of the hercynite inclusions in the magnetite. A few of these grains were also found in the magnetite-ulvöspinel (?), but due to their extremely small size, which does not exceed 3 microns, they could not be identified. In a few instances the magnetite and ilmenite are partially replaced by what is tentatively identified as anatase(?).The areas are very small and are not larger than 30 microns in size.

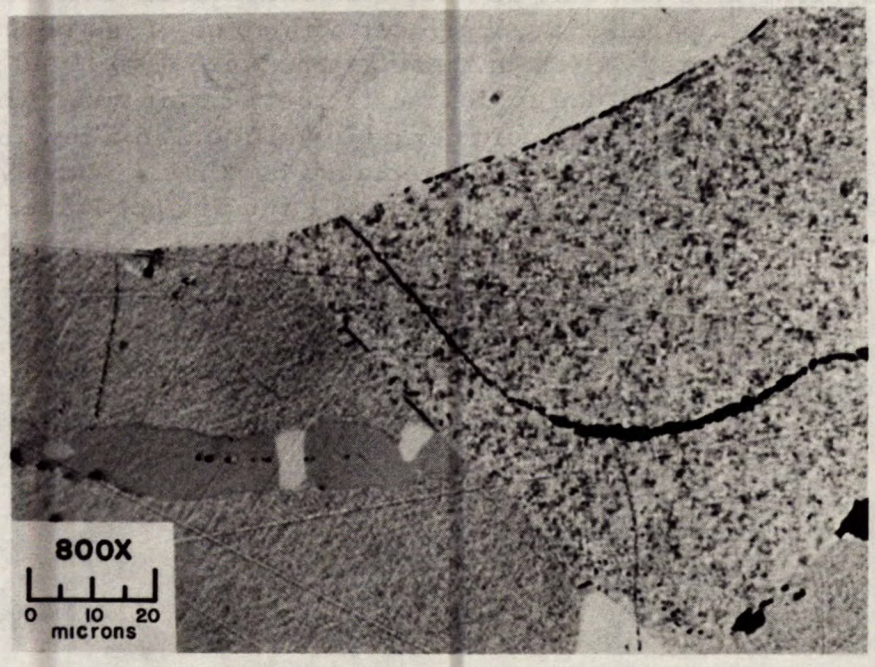

Figure 1. Photomicrograph (in oil immersion) of a polished section showing a patchy intergrowth of magnetite (grey) and ulvöspinel (?) (medium grey) on the right side, and a more uniform mixture of the two minerals on the left of the picture (light grey). An area of ilmenite (white) is shown in the upper left portion of the photomicrograph and as inclusions (white and medium grey) in the magnetite-ulvöspinel (?) mixture.

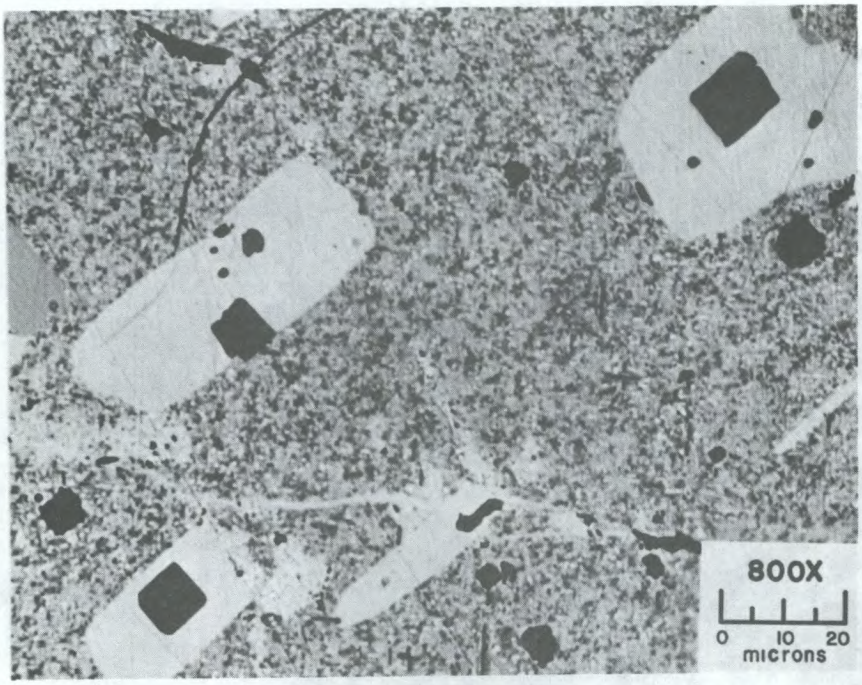

Figure 2. Photomicrograph (in oil immersion) of a polished section showing an intimate mixture of magnetite (greyish white) and ulvöspinel (?) (medium grey). This matrix contains stubby laths of ilmenite (white) and spindle-shaped inclusions of hercynite (black). Both the ilmenite and matrix also contain cubic inclusions of hercynite (black).

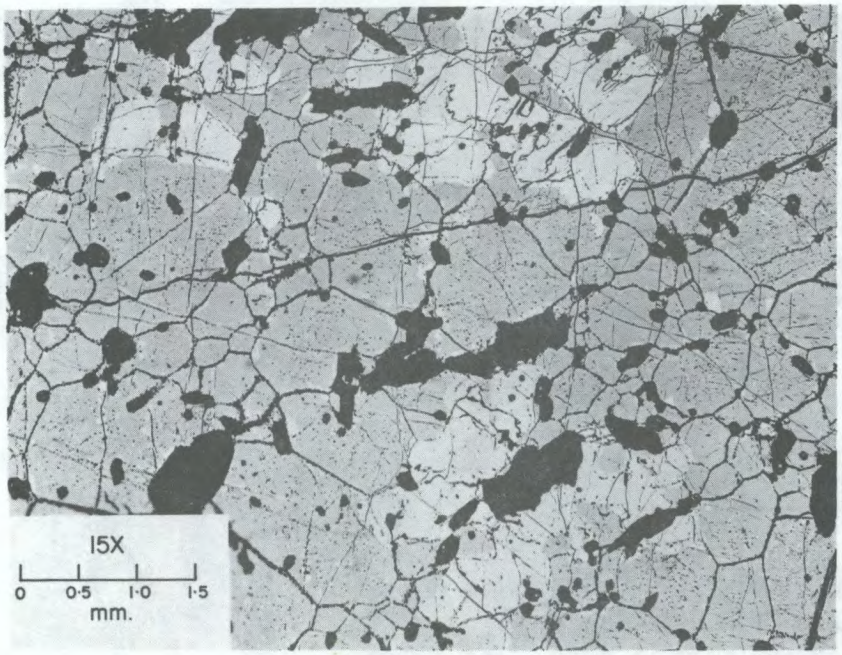

Figure 3. Photomicrograph of a polished section showing granular massive magnetite-ulvöspinel (?) (light grey) with coarse ilmenite (white). Finer grains of ilmenite can be seen along the edges of the magnetite-ulvöspinel (?) grains. The black areas are gangue.

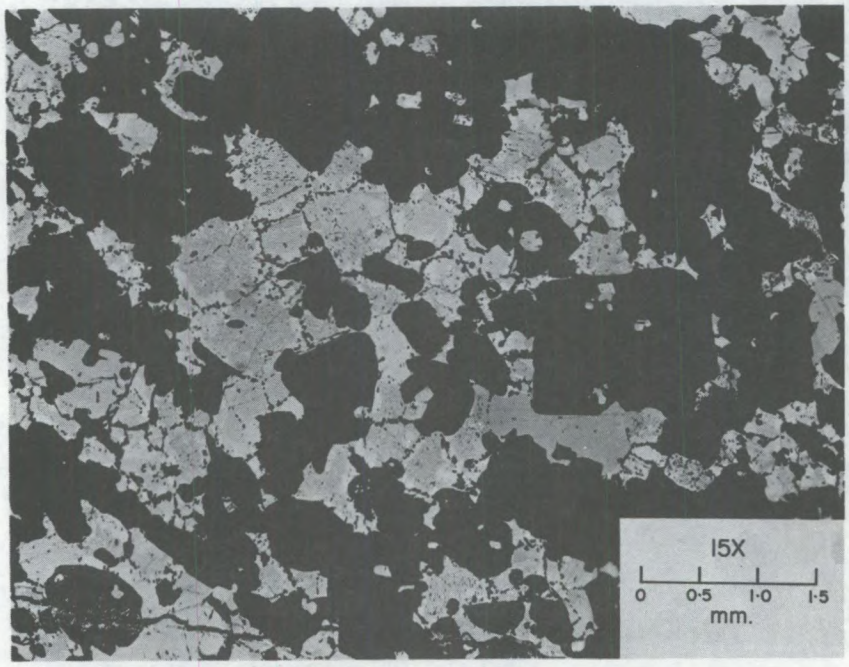

Figure 4. Photomicrograph of a polished section showing combined ilmenite (white and medium grey) with magnetite (light grey) in gangue (black).

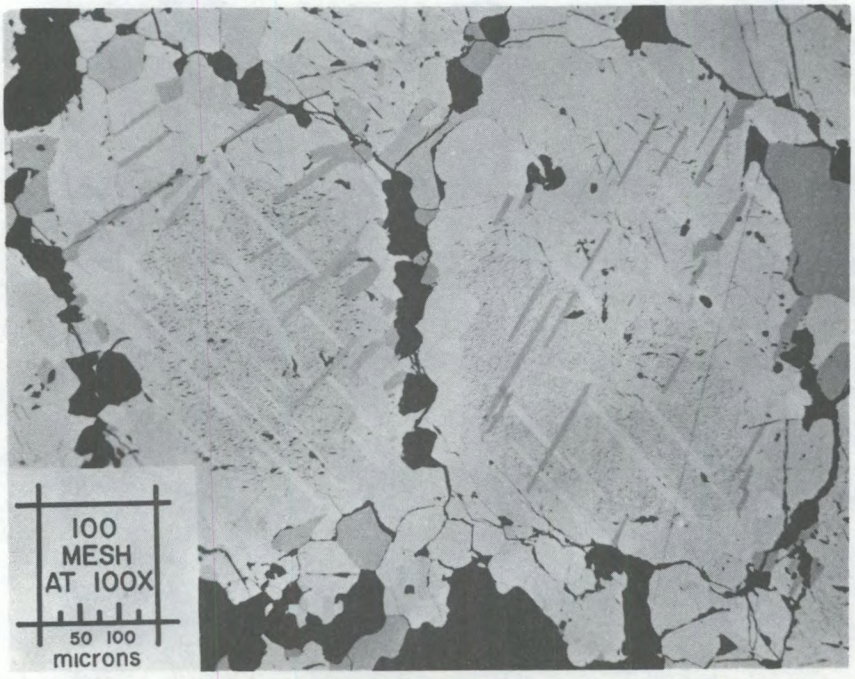

Figure 5. Photomicrograph (in oil immersion) of a polished section showing two grains whose centers consist of magnetite with very small hercynite inclusions (black), and which are rimmed by granular ilmenite (both white and medium grey). The magnetite is penetrated by laths of ilmenite. The black grains are interstitial gangue.

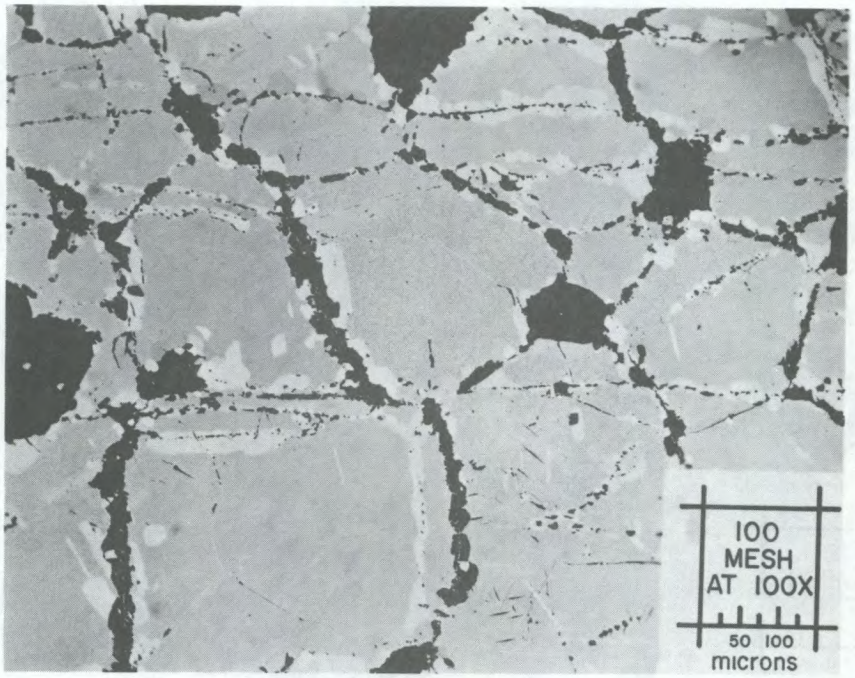

Figure 6. Photomicrograph (in oil immersion) of a polished section of an area in Figure 3 at a higher magnification. This shows the interstitial gangue (black) between grains of the magnetite-ulvöspinel (?) mixture (light grey) which contain numerous inclusions of ilmenite (white and medium grey) as well as a few spindle-shaped inclusions of hercynite (black).

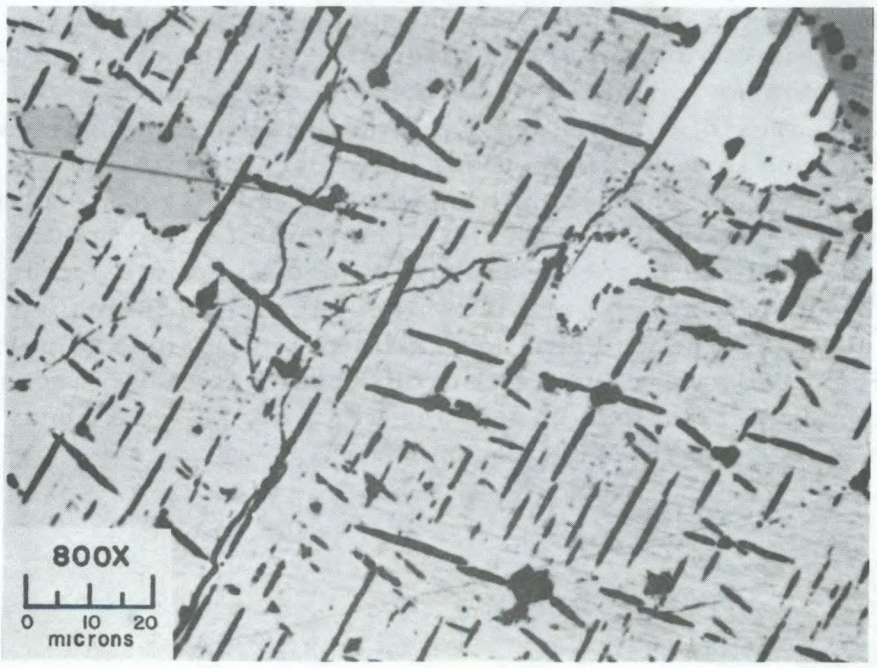

Figure 7. Photomicrograph (in oil immersion) of a polished section showing oriented spindle-shaped inclusions of hercynite (black) in magnetite (greyish white). A few inclusions of ilmenite (white and medium grey) are also shown.

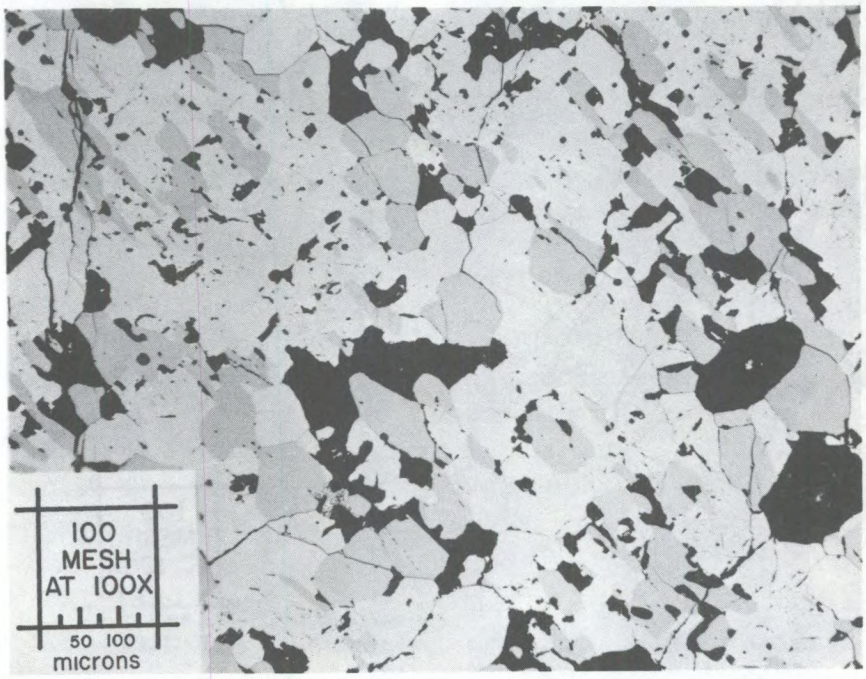

Figure 8. Photomicrograph (in oil immersion) of a polished section showing a granular aggregate of ilmenite (medium grey) and magnetite (white). The black areas are grains of gangue.

Ilmenite

The ilmenite in the ore occurs as individual grains and clusters in gangue (Figure 9), in combination with magnetite-ulvöspinel (?) in gangue (Figure 4) and as coarse to fine-grained inclusions in magnetite and magnetite-ulvöspinel (?) (Figures 2, 3, 5, 6 and 7). The ilmenite in gangue varies from about 5 microns to 1.4 millimetres, but most of the grains are greater than 50 microns in size. The grains in magnetite and magnetite ulvöspinel (?) are both irregular and lath-like in shape. The ilmenite also occurs as a granular intergrowth with magnetite (Figure 8) and sometimes contains inclusions of both cubic (Figure 2) and lath-like (Figure 10) inclusions of hercynite. In addition, the ilmenite contains a few inclusions of pyrite and chalcopyrite (Figure 9), varying in size from about 5 to 100 microns. The ilmenite also contains inclusions of gangue, which range from about 20 to 300 microns in size.

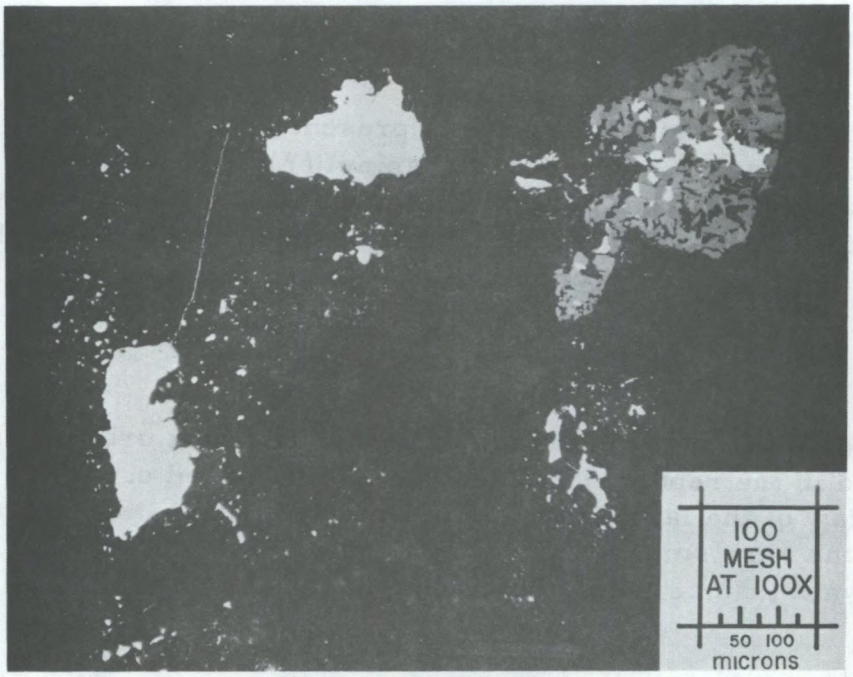

Figure 9. Photomicrograph (in oil immersion) of a polished section showing inclusions of chalcopyrite (white) in ilmenite (grey) and gangue (black).

Figure 10. Photomicrograph (in oil immersion) of a polished section showing ilmenite (white) with lath-shaped inclusions of hercynite (black). The other larger black areas are gangue.

Hematite

Only a small amount of hematite is present in the ore. It occurs as inclusions and veinlets in magnetite-ulvöspinel (?) and in gangue. The grains of hematite vary from 50 to 450 microns in size, while the veinlets vary in width from 10 to 60 microns. Most of the hematite is partly replaced by goethite; this is the only occurrence of goethite that was seen.

Hercynite

The description and occurrence of hercynite in the ore has already been discussed in the report. Its identification is based on X-ray diffraction analysis of a few of the largest grains in ilmenite. It has therefore been assumed that the very small grains which could not be checked by X-ray are also hercynite, since their occurrence in the ore is the same.

Sulphides

A number of grains of sulphide minerals occur in the ore. They consist essentially of chalcopyrite and pyrite, with lesser pyrrhotite. In addition, one grain of violarite and a few grains of bornite were also seen. These minerals occur primarily in the gangue and, with the exception of chalcopyrite and pyrite, none were seen in the metallic minerals. The grains vary in size from about 2 to 200 microns, but most are smaller than 60 microns.

Gangue Minerals

The gangue consists essentially of plagioclase feldspar, which contains medium to coarse grains of olivine and pyroxene (Figure 11). Small amounts of apatite, amphibole, biotite, chlorite and graphite were also noted. The amphibole and biotite form thin rims about the metallic minerals and the olivine grains. The chlorite consists of a few veinlets cutting the feldspar and metallic minerals. The graphite is distributed as small particles throughout the other gangue minerals.

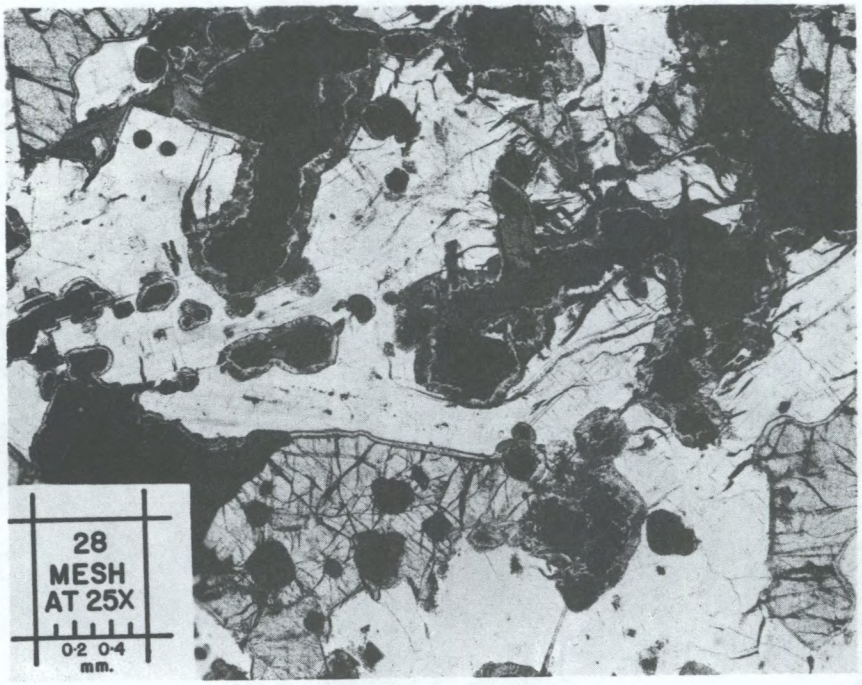

Figure 11. Photomicrograph of a thin section showing inclusions of magnetite and ilmenite (black) in a matrix of feldspar (white). The medium-grey fractured grains containing a few metallic inclusions are olivine. The olivine and the metallic minerals are rimmed by other gangue minerals.

CONCLUSIONS

The conclusions drawn from the mineralogical investigation are as follows: Firstly, the magnetite is largely intergrown with ulvöspinel (?), which cannot possibly be liberated. Secondly, the hercynite inclusions, as well as quite a few ilmenite inclusions, will also not be liberated from the magnetite. Thus the magnetite can be expected to retain some titanium, Thirdly, most of the ilmenite in the gangue can probably be liberated, as can the majority of the ilmenite in the magnetite and magnetite-ulvöspinel(?). It is likely, however, that it will retain some hercynite and gangue inclusions.

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