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MINERALOGICAL EXAMINATION OF A TITANIFEROUS IRON ORE FROM LAKE ST. JOHN, QUEBEC, SUBMITTED BY TITANIUM PRODUCTS CORPORATION

by

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MINERAL SCIENCES DIVISION

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SUMMARY OF RESULTS

Mineralogical studies made on a titaniferous iron ore from Lake St. John, Quebec, show that the ore is composed mainly of magnetite and ilmenite. The magnetite is largely massive and contains inclusions of ilmenite, spinel, graphite, goethite, gangue and an unknown mineral. The ilmenite is present as small masses and inclusions in magnetite. A few grains of pyrrhotite in gangue are also present.

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INTRODUCTION

Four small hand specimens of a titaniferous iron ore from the Titanium Products Corporation were received from D. Raicevic of the Mineral Processing Division on May 16, 1966. Mr. Raicevic reported that the ore was from a deposit at St. Charles, Bourget Twp, Lake St. John, Quebec, and requested that the ore be examined to determine the mineral constituents and their associations.

METHOD OF INVESTIGATION

The specimens as received were each about one inch in diameter. They were composed largely of black metallic minerals, slightly weathered and highly magnetic, which were identified as magnetite and ilmenite.

Two polished sections were prepared from three of the fragments, while the fourth was crushed to -65 mesh and separated into sink and float sub-fractions by means of a heavy liquid with a specific gravity of 3.30. One polished section was prepared from the sink sub-fraction. The minerals found in the ore were identified by microscopical and X-ray diffraction studies.

RESULTS OF INVESTIGATION

General Mineralogy

The ore consists mainly of magnetite and ilmenite. The magnetite is massive, and contains inclusions of ilmenite, spinel, gangue, graphite and goethite, veinlets of goethite and gangue, and minute particles of a white metallic mineral that could not be identified. The ilmenite is present as small masses and inclusions in the magnetite, and it contains a few inclusions of spinel, graphite, gangue and goethite, and veinlets of goethite. The gangue, which is composed of apatite, amphibole, mica, olivine and a mineral that could not be identified, contains a few grains of magnetite, pyrrhotite and goethite.

Detailed Mineralogy

Magnetite

The great majority of the magnetite is present in a massive form, and generally constitutes the matrix in which the other minerals occur. In addition, a small amount was observed as small inclusions in gangue, varying between 2 and 200 microns in diameter.

The magnetite is heavily fractured, and contains innumerable inclusions of ilmenite and spinel, and fewer inclusions of gangue, graphite, goethite and the white unidentified mineral (Figures 1, 2, 3, 4 and 5). These inclusions vary in size from a few microns to about 5 millimetres. The few veinlets of gangue and goethite in the magnetite vary in width from 5 to 40 microns. In a few places the magnetite has been partially replaced by maghemite along fractures and grain boundaries (Figure 6).

Ilmenite

Ilmenite occurs in the ore in a number of forms. The majority is found as small to large irregular bodies in the magnetite (Figure 1), which vary in size from about 50 microns to 5 millimetres. In addition, numerous thin lamellar inclusions of ilmenite are oriented along the octahedral planes of some of the magnetite grains (Figures 2 and 3). These inclusions vary in width from 2 to about 65 microns, but most are less than 15 microns wide. The third occurrence of ilmenite is as minute irregular grains in the magnetite (Figure 4) which in many, but not all, instances form complete borders about spinel inclusions in the magnetite. These ilmenite inclusions are usually smaller than 10 microns. The coarse ilmenite grains and small masses occasionally contain inclusions of spinel, graphite and gangue, and inclusions and veinlets of goethite. The spinel inclusions are in the form of both thin lamellar grains generally only a few microns wide and rounded to irregular grains varying from about 5 to 50 microns in size. The graphite inclusions occur as trails of minute grains, 2 to 10 microns in size, across the ilmenite. The goethite inclusions consist of grains, 5 to 35 microns in diameter, while the veinlets of goethite vary from 5 to 30 microns in width. The gangue veinlets are of the same order as the goethite, while the inclusions range from about 10 microns to about 1 millimetre in diameter.

Spinel

The spinel in the ore was found principally as inclusions in the magnetite and to a lesser degree as inclusions in the ilmenite. The spinel inclusions are of various shapes, the most common being in the form of minute spindle-shaped inclusions in magnetite (Figures 4 and 5). These inclusions vary from about 2 to 30 microns in size and some are completely bordered by ilmenite. Other spinel inclusions in the magnetite are thin lamellar ones oriented along the octahedral planes of the magnetite; still others take the form of irregular to almost cubic grains, some of which have the shape of a blunt cross. These inclusions range from about 5 to 60 microns in diameter. The spinel in the ilmenite consists of a few irregular inclusions of about the same size as those in magnetite, as well as a few lamellar inclusions with apparently random orientation. In a few instances the thin lamellar inclusions of spinel in the magnetite appear to have been partially replaced by ilmenite. X-ray diffraction studies made on the largest of the spinel grains, and on grains obtained from the sink sub-fraction, were identified as hercynite ($FeAl_2O_4$). It is assumed that the extremely fine-grained spindle-shaped inclusions of spinel in the magnetite are of the same composition, since their optical properties are similar.

Graphite

The graphite in the ore consists of a small number of grains occurring as inclusions in the magnetite and ilmenite. The inclusions in magnetite are irregular in form, and vary in size from about 10 to 350 microns, while those in the ilmenite are smaller, and vary from 2 to 10 microns in size.

Goethite

Goethite was found as both inclusions and veinlets in magnetite and ilmenite, and as inclusions in gangue. The inclusions in magnetite, ilmenite and gangue vary from about 5 to 350 microns, with all but a few less than 40 microns in diameter. The veinlets of goethite found in the magnetite and ilmenite vary in width between 5 to 40 microns.

Unidentified White Metallic Mineral

A mineral which could not be identified was found as minute inclusions in the magnetite (Figure 4). It is white in colour and isotropic, and was found in two forms. The predominant occurrence is as worm-like grains lying along one side of minute ilmenite grains. The second and much

less common occurrence is as thread-like grains lying parallel to lamellar ilmenite inclusions in the magnetite. The worm-like inclusions are only a few microns in size, while the thread-like inclusions have a width of 1 or 2 microns.

Gangue

The gangue minerals in the ore consist of apatite, olivine, amphibole, mica, and an unidentified mineral. The mineral that could not be identified was examined both microscopically and by X-ray diffraction methods. These reveal that the mineral is at least partially amorphous, and is fairly soft, translucent, and yellow to orange-brown in colour.

The gangue minerals vary widely in size and, while most of the gangue is present as small masses to fine grains in the ore (Figure 1), a number of veinlets of gangue were also observed (Figure 3). The small masses and grains range from 5 microns to 5 millimetres in size, while the few veinlets observed range from about 5 to 40 microns in width.

CONCLUSIONS

Examination of the ore suggests that great difficulty will probably be encountered in attempting to liberate the component minerals during beneficiation. Nearly all areas of the magnetite contain inclusions, which in general are extremely fine-grained, and, with the exception of the small masses and coarser grains of the ilmenite and gangue, it is to be expected that liberation of the inclusions in the magnetite will be impossible.

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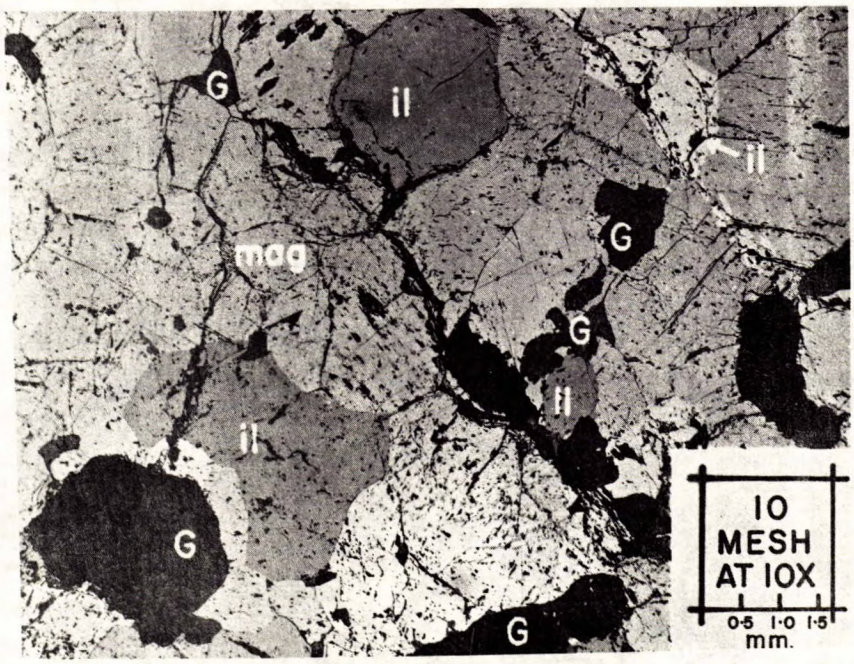

Figure 1. Photomicrograph of a polished section (under partially crossed nicols) showing massive, well fractured magnetite (mag) containing large to medium-sized inclusions of ilmenite (il) and gangue (G). The ilmenite shows as both white and medium grey, due to its anisotropism.

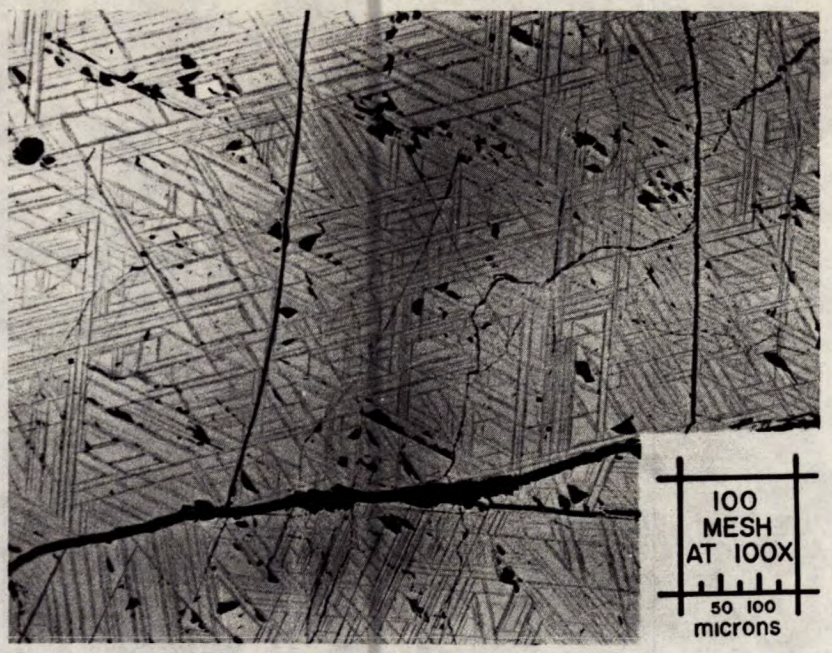

Figure 2. Photomicrograph of a polished section (in oil immersion) showing an area of magnetite (greyish white) containing numerous lamellar inclusions of ilmenite (medium grey) which are oriented along the octahedral planes of the magnetite. The two almost vertical black lines are gangue veinlets, while the horizontal black line and the other small black areas are a fracture and polishing pits, respectively.

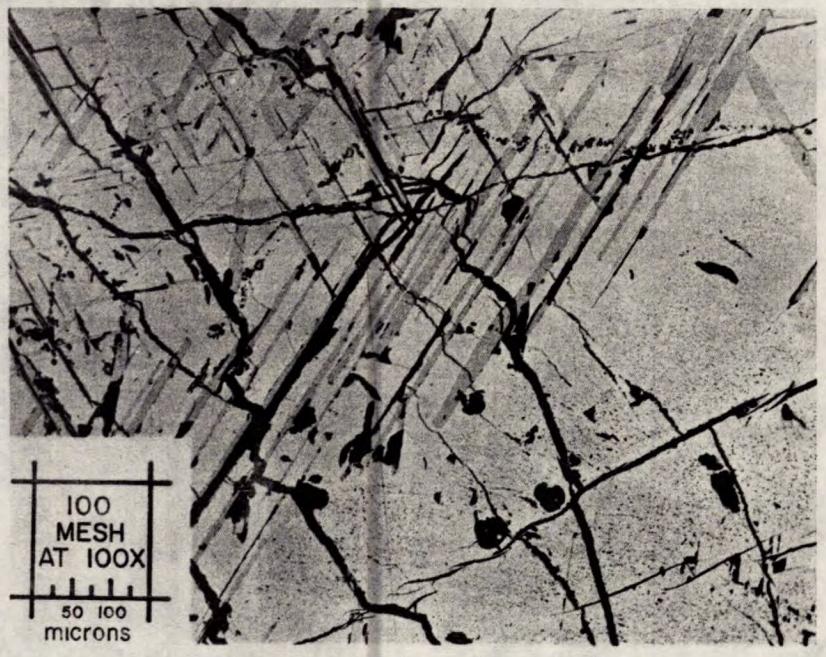

Figure 3. Photomicrograph of a polished section (in oil immersion) showing magnetite (greyish white) containing oriented lamellae of ilmenite (medium grey). The black veinlets represent both gangue and fractures, while the large irregular black areas are polishing pits. In the lower right corner of the photomicrograph are numerous small black dots which are spinel; an area similar to this is shown in Figure 4 at higher magnification.

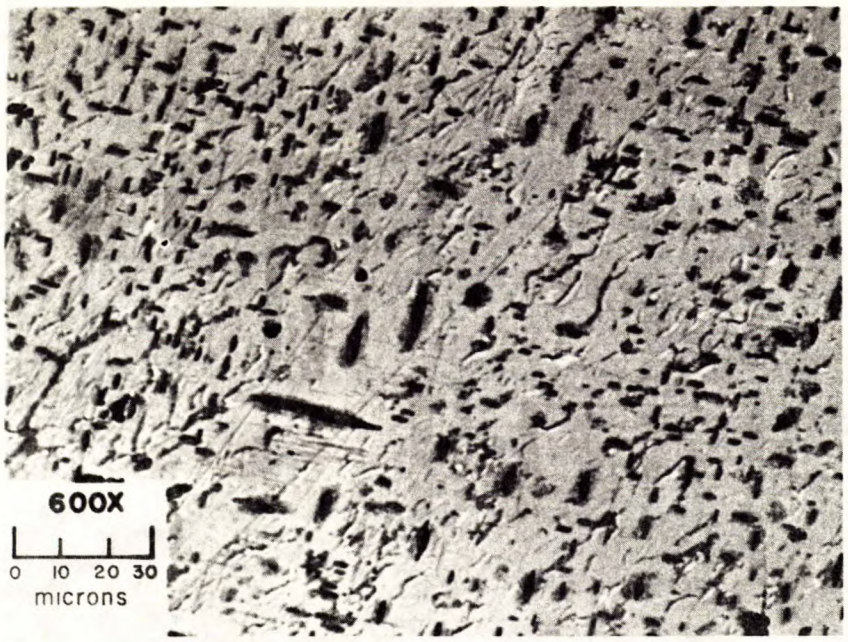

Figure 4. Photomicrograph of a polished section (in oil immersion) showing the host magnetite (greyish white) containing inclusions of spinel (black), ilmenite (medium grey) and the unknown white metallic mineral. The ilmenite forms complete rims about many of the spinel inclusions. The white metallic mineral forms a border along one side of some of the ilmenite inclusions. The spinel grains are aligned along two specific directions.

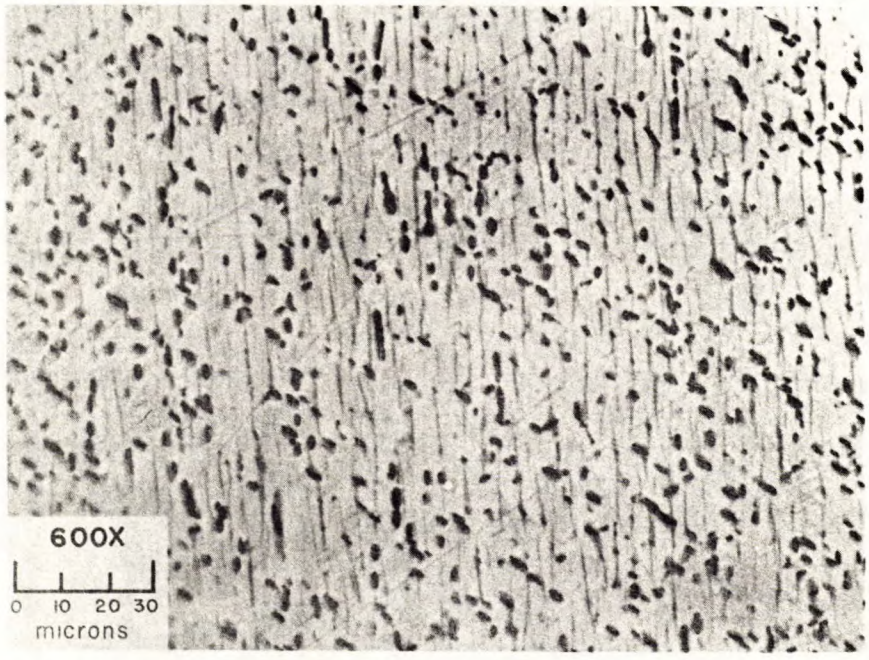

Figure 5. Photomicrograph of polished section (in oil immersion) showing magnetite (greyish white) containing oriented inclusions of spinel (black) and ilmenite (medium grey). Some of the spinel is rimmed with ilmenite.

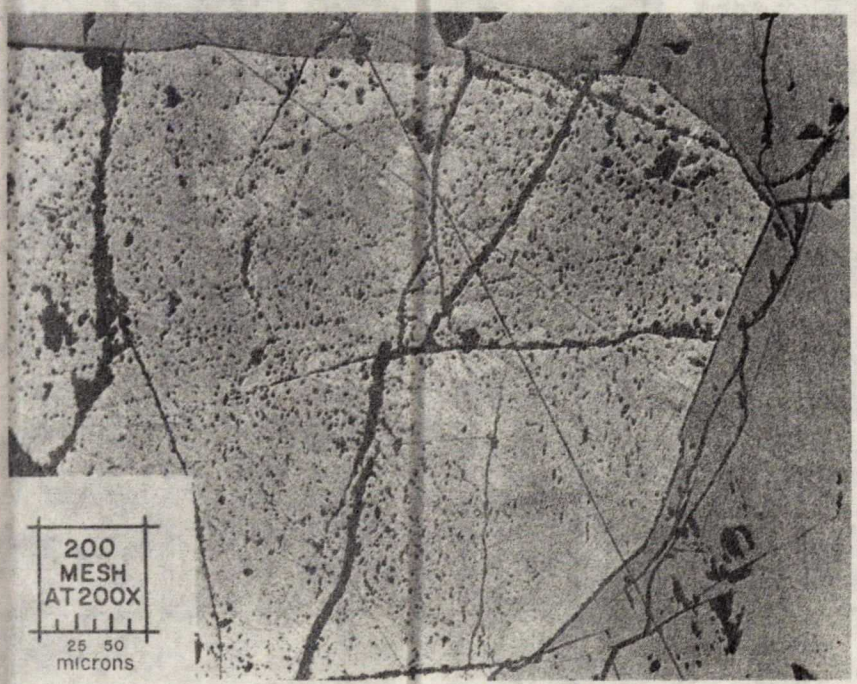

Figure 6. Photomicrograph of a polished section (in oil immersion) showing magnetite (medium grey) being replaced along its grain boundary and fractures by maghemite (white). The dark grey area is ilmenite. For purposes of contrast the minerals show one shade darker than in the other photomicrographs.