Vanadiferous Iron Ore Deposits in Manchuria

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I. Introduction

The vanadiferous iron ore deposits of magmatic differentiation are mainly distributed in the northern part of Cheng-te, and ores are classified into three types: ilmenite-magnetite, rutile-magnetite and apatite-ilmenite-magnetite ores.

Total reserves of all the deposits is estimated to be 4 million tons, and 3.8 million tons of which is concentrated in the environs of Ta-miao about 35 km north from Cheng-te.

Table 1. List of Vanadiferous Iron Ore Deposits in Manchuria.

No.	Province	Name of Mine	Location	Chemical Composition			Reserves (Million tons)
				Fe	V	TiO_2	
1	Je-ho	Chi-chia-tzu	35km NNW from Cheng-te railway station.	40–57	0.05–0.30	12–15	2.0
2	〃	Erh-tao-ho-tzu	35km NNW 〃	40–57	0.05–0.30	12–15	
3	〃	Tieh-ma-tu-kou	45km NW 〃	45–50	0.1—0.3	10–12	0.18
4	〃	Ta-ta-shan	3km NW from Tieh-ma-tu-kuo	–	–	–	small
5	〃	Hei-shan	30km NNW from Cheng-te Railway station.	40–57	0.2—0.4	10–15	1.6
6	Chin-chou	Kitamura	60km N from Chao-yang railway station.	–	–	–	0.2

II. Country Rocks

The deposits in lenticular and/or massive forms occur in gabbro which intruded into the so-called "Huang-ku-tun formation" being composed of gneiss and crystalline schist. The gabbro can be classified into two kinds, melanocratic and leucocratic, and the latter is intruded by the melanocratic gabbro and hornblendite which sometimes changes to chlorite schist or hornblende schist.

The leucocratic gabbro sometimes shows gneissose structure and is exposed in a large area. It usually consists of a small amount of pyroxenes and hornblende with smaller amount of magnetite, ilmenite, chlorite, apatite, rutile and pyrite as accessary minerals. Although the iron ore deposits usually occur in the melanocratic gabbro and hornblende schist or chlorite schist, both of them are derived from the former. In the Ta-miao district, they are always in coarse-grained hornblendite containing many spots of aggregate of chlorite and diopside.

Rock-forming minerals of the melanocratic gabbro are same as those of the leucocratic gabbro and only difference between them is a quantity of mafic minerals in each rock. The melanocratic gabbro is, moreover, often impregnated with small grains of magnetite.

III. Deposits

From the viewpoint of a combination of ore minerals, the ore deposits could be classified into three types:

(1) Ilmenite-bearing magnetite deposit;
(2) Rutile-bearing magnetite deposit;
(3) Apatite-bearing ilmenite magnetite deposit.

The Chi-cha-tzu deposits in the northern part of the Ta-miao mine, the Kitamura mine, and the Hei-shan mine belong to (1), the Erh-tao-ho-tzu deposit in the southern part of the Ta-miao mine belongs to (2) and the Tieh-ma-tu-kou mine belongs to (3). Ores produced from the (1)-type deposits contain small quantities of rutile, and in spite of type difference, ores usually contain 0.05–0.40% vanadium.

The boundary between ore bodies and country rocks is comparatively distinct when ore bodies occur in the leucocratic gabbro. However, ore bodies change gradually to country rocks when the country rocks are rich in mafic minerals.

A. Chi-chia-tzu Deposits in Ta-miao Mine

There are thirty-four lenticular or vein-shaped ore bodies in the melanocratic and leucocratic gabbro, and sixteen of them are longer than 20 m in length. The maximum width of the largest ore body here is 42 m (18 m average) and can be traced 180 m along its strike. Moreover, the middle part of its outcrop shoots out more than 15 m vertically from the slope of the mountain.

Scale of ore deposits in the leucocratic gabbro is generally larger and quality of their ores are superior than those of ore deposits in the melanocratic gabbro.

B. The Erh-tao-ho-tzu Deposit in the Ta-miao Mine

There are six ore bodies running east to west, on the northern bank of the Erh-tao-ho-tzu-hsi-kou river. All ore bodies are in the melanocratic gabbro and three of them are longer than 100 m in length. They have a tendency to decrease their width at about 20 m beneath the surface. The Ta-miao mine had been mined to make vanadium steel and titanium white from the magnetic concentrated ore during World War II.

C. The Tieh-ma-tu-kou Mine

The mine is located on a spur, east of Tien-ma-tu-kou, 45 km northwest from Cheng-te city, and eight ore bodies are observed in the horblendite. The ores are rich in apatite and contain 45–50% Fe, 0.1–0.3% V, and 10–12% TiO_2, and reserves are calculated to be 180 thousand tons.

The Manchurian Match Company's plan to open this mine to produce phosphorus to avoid the inconvenience of using sulphur for matches in the latter stage of World War II could not be realized because of long distance transportation to their factory.

D. The Hei-shan Mine

This mine is located about 8 km east from the Ta-miao mine, and more than twenty ore bodies are found in the leucocratic gabbro or chlorite schist that occurs in the former, over an area 2.0 km long, 1.5 km wide. The ore bodies reach the maximum length of about 100 m and width of about 20 m, but are poor in underground extension like those of the Ta-miao mine. Reserves are estimated to be 1.6 million tons of ore; 40–57% Fe, 0.2–0.4% V, and 10–15% TiO_2.

E. The Kitamura Mine

Sometime in 1945, the vanadiferous magnetite deposit was discovered in gabbroic mass, 60 km north of the Chao-yang railway station on the Chin-ku line, and was named the Kitamura mine after the family name of the mining license applicant. There are numerous iron ore outcrops scattered over an area of 4×4 sq k, but none of them represents a part of large-scale ore body. The result of magnetic prospecting also indicated that there would be no ample hope for discovering large-scale ore bodies.

IV. Ores

A. Ilmenite-magnetits Ore

This is a steel-greyish, coarse-grained, massive magnetite ore usually found at the Chi-chia-tzu and the Hei-shan mines. Microscopic observations show the typical "Widmannstatten Figur" of minute ilmenite layers after etching the ore with conc. HCl for one or two minutes. There are also very small quantity of euhedral ilmenite which can be observed along the interstices of magnetite crystals. As accessary minerals, there are small amounts of hematite, hornblende, plagioclase, quartz, kaolinite, chlorite, apatite and rutile in the ore.

Chemical compositions other than the essential elements shown on Table 1, of the ores from Ta-miao and Hei-shan mines are as follows:

Ta-miao ore: 2.22% SiO_2 5.71% Al_2O_3 0.046% P 0.091% S 0.182 % Mn.

Hei-shan ore: 5.48% SiO_2 0.017% P 0.091% S 0.184% Mn 0.49% Cr_2O_3

A concentration of 65% Fe was produced by magnetic separation, in which vanadium was also concentrated. However, the iron content of tailings could not be lowered less than 28%.

B. Rutile-magnetite Ore

This is brownish black massive ore produced from the Erh-tao-ho-tzu deposit. Rutile occurs as interstitial matter along cleavages of magnetite or as minute granular grains in magnetite crystals. It is also found as fine euhedral crystals in chlorite.

Ore, of course, mainly consists of magnetite, of which rhombohedral cleavages are filled up by aggregates of chlorite crystals.

C. Apatite-ilmenite-magnetite Ore

This is a fine-grained blackish ore with a large amount of apatite and a few spinel and titanite. Chlorite occurs along cleavages or partings of magnetite crystals.

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