PRELIMINARY SURVEY AND CHEMICAL INVESTIGATIONS ON IRON ORES OF KHYBER AGENCY

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The authors have surveyed and chemically investigated the iron ores of Khyber Agency. Ore from Lashoora, a place eight miles from Jamrud, was found to be relatively rich in iron content but had a large percentage of silica (22.9% free and 8.5% combined) which makes it difficult to reduce. Attempts were made to reduce the silica content by washing, and gravity separation. The results are not very encouraging. The use of a magnet for concentrating the iron oxide particles has also failed. It is suggested that ore from greater depth be studied and the possibility of the production of ferrosilica examined.

Deposits of iron ore have been reported from time to time in the various regions of Khyber Agency, and some fantastic claims have been made about the quality and the extent of such deposits, but so far no systematic geological or mineralogical studies have been reported. The present investigations have been undertaken specially with the purpose of assessing the qualities of iron deposits in several areas in Khyber Agency. The difficulty of transport in the hilly areas and the non-availability of good quality metallurgical coke complicate the problem.

1. Survey

The areas surveyed are the following: (vide Fig. 1)

1. Lashoora, situated at about 8 miles from Jamrud 300° north-west and about four miles from Gudar 330° north-west.

2. Shilman, situated at about 10 miles north-east of Landikotal.

3. Jabba, situated at 10 miles from Jamrud in the direction of 290° south-west and $1\frac{1}{2}$ miles 33° north-west from Tanga.

4. Tanga, situated at 7 miles 21° south-west from Jamrud.

A. Lashoora

The colour of the rocks is black, grey and brown due to the intermixture of light and dark minerals. The rocks are folded and consist of shaly and slaty formations. The rocks are also crumpled and show signs of weathering and erosion. Quartzite bands are innumerable and occur in veins varying from $\frac{1}{4}''$ to 6'' in width.

An outcrop of hematite exists at about 1500 ft. altitude. The outcrop was 38 ft. in length, 8 to 10 ft. in width and 10 ft. in depth. The outcrop vanishes and again crops out at a distance of 200 ft. in the same continuity. It was varying in width from 2 to 3 feet and had a length of 25 ft. estimated after digging at certain intervals. The total outcrop of hematite exposed on the surface is about 50 ft.in length. The exact depth could not be measured due to lack of facilities of hard drilling; the maximum depth that could be

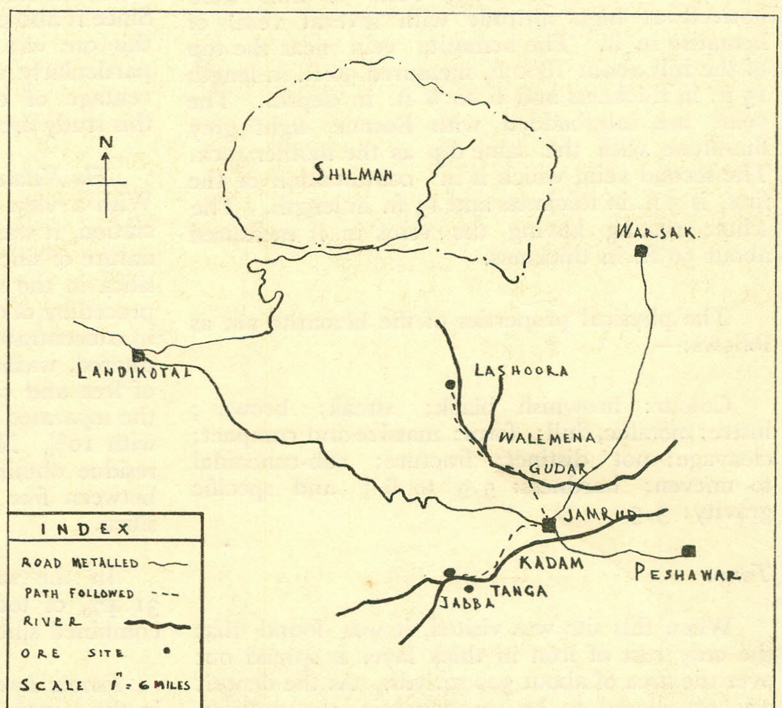

Fig. 1.—A part map of Khyber Agency.

measured was 10 to 12 ft. The physical properties of the mineral sample are as follows:

Colour: dark brown; streak: brown; lustre: metallic, dull; form: granular and compact; cleavage: not distinct; fracture: sub-conchoidal and uneven; hardness: 5.5 to 6; and specific gravity: 4.4.

B. Shilman

As the preliminary examination of the ore showed a poor percentage of iron mixed with a high percentage of alumina, silica, lime and magnesia, the detailed study of the ore has not been carried through.

Jabba

The topography is rugged and the dark massive limestone shows signs of weathering and denudation. Rocks are highly crumpled and shattered, mainly due to the action of heat and water. The massive limestone is shaly in nature and dark grey in colour.

Rusts and coatings of iron were found at several places, at some places appreciably thick but not of economic value. Huge rusts of iron were noticed at high altitude with several veins of hematite in it. The hematite vein near the top of the hill about 1800 ft. measured 30 ft. in length 15 ft. in thickness and 6 to 8 ft. in depth. The veins are interbedded with Eocene light grey limestone with the same dip as the mother rock. The second vein, which is in continuation of the first, is 5 ft. in thickness and 15 ft. in length. The whole rusting having the veins in it measured about 50 ft. in thickness.

The physical properties of the hematite are as follows:—

Colour: brownish black; streak: brown; lustre: metallic, dull; form: massive and compact; cleavage: not distinct; fracture: sub-concoidal to uneven; hardness: 5.5 to 6; and specific gravity: 3.3.

Tanga

When this site was visited, it was found that the only rust of iron in thick layer is spread out over the area of about 300 sq. yds. As the deposit was considered to be un-economic, the detailed study of Tanga ore has not been attempted.

2. Chemical Examination of the Ores

Samples collected from different places and even from the same area varied greatly in chemical composition, but some of the typical analyses are shown below:—

TABLE 1.—CHEMICAL ANALYSIS OF THE ORES.

Composition	Lashoora ore %	Shilman ore %	Jabba ore %
Loss on ignition	10.6	2.6	5.8
Silica	31.4	32.6	60.7
Iron oxide	51.4	23.9	31.1
Alumina	6.4	20.9	2.2
Lime	<0.1	9.2	—
Magnesia	<0.1	9.4	—

It will be evident from Table 1 that only the Lashoora ore is relatively rich in iron content. Since it also occurs in relatively abundant quantity, this ore was subjected to further detailed study particularly with reference to the very high percentage of objectionable silica. The results of this study are detailed below.

The Nature of Silica in the Lashoora Iron Ore.—With a view to examine the possibility of beneficiation, it was considered necessary to find out the nature of silica in the iron ore. First, the total silica in the sample was determined by the usual procedure of decomposing the finely ground sample in concentrated hydrochloric acid. The residue was filtered, washed and ignited. This gave the total of free and combined silica. In another sample, the separated silica was digested on the steam bath with 10% Na_2Co_3, filtered and washed. The residue obtained was free silica. The difference between free and total silica gave the combined silica.

In the sample under analysis, the total of 31.4% of total silica gave: Free silica, 22.9%; combined silica (by difference) 8.5%.

Ferrous Iron.—Ferrous iron was also determined in the sample to find out the possible existence of ferrous silicates by the following method.[1]

One gram of the finely powdered sample is decomposed in a current of carbon dioxide in a large platinum crucible with dilute sulphuric and hydrofluoric acids. When the decomposition is complete, the sample is taken in an excess of boric acid and promptly titrated with potassium permanganate (0.1 N).

Only a trace of ferrous iron is present in the iron ore.

3. Attempts at Beneficiating the Ore

The main objectionable impurity in the ore is the high percentage of silica (about 30%). If this could be reduced to the range of 10 to 12 percent, the ore would probably be easily reduced. The silica in the ore is partly combined (about 8.5%) and partly free silica (about 22.9%). While the combined portion cannot be separated by any physical process, efforts were made by some simple techniques to see whether the free silica could be separated or not.

Removal of Silica and Concentration of Ore by Simple Washing.[3]—Samples of 25 g. of one batch of powdered ore with 32.5% silica and 42.5% Fe_2O_3, passing through different B. S. sieves were washed successively 3 times with about 100 ml. of water each time and decanted after settling for about a minute. The results are given in Table 2.

TABLE 2

No. of experiment	Sample passing through B. S. mesh No.	% of recovered sample, dried at 105°C.	% of SiO_2 in the residue	% of Fe_2O_3 in the residue	% of reduction of silica	% of enrichment of Fe_2O_3
1	10	91.2	30.5	44.0	6.6	3.5
2	20	87.2	30.7	44.4	5.5	4.5
3	30	83.8	29.4	44.8	9.5	5.4
4	40	76.6	30.2	44.8	7.1	5.4
5	60	75.1	30.1	45.6	7.4	7.3
6	80	70.8	29.2	46.4	9.8	9.2
7	90	66.6	29.3	46.8	9.9	10.1
8	100	63.8	28.9	46.8	11.1	10.1
9	120	56.2	27.9	47.4	14.2	11.5
10	200	40.8	24.4	49.1	25.0	15.5

It is observed from the above that the recovery of the washed residue decreased with the fineness of the sample (*i.e.* higher mesh No.). The iron oxide content progressively increased and the silica percentage correspondingly decreased, but not to the desired limit.

A slightly different technique of washing was also tried by taking the powdered ore at the bottom of a long glass tube (120 cm. long and 5 cm. diameter) and overflowing the lighter particles by introducing water from the bottom (Fig. 2). The residue at the bottom did not show any better concentration of iron ore.

Gravity Separation.—As the specific gravity of hematite (5.2) is considerably higher than that of quartz silica (2.6), it was considered worth-while to try some kind of gravity separation. A liquid of specific gravity higher than the specific gravity of silica, would have been ideal, such as tetrabromoethene, methyl iodide etc.; but as these were not available, a concentrated solution of calcium chloride was prepared of sp. gr. 1.8. The powdered ore was shaken with this solution in a cylinder and allowed to settle. After partial settling, the top portion of liquid was decanted and the residue was washed free from calcium chloride and analysed. The concentration effect of this process was not found to be significantly higher than that of the simple washing method.

A horse-shoe magnet also did not attract

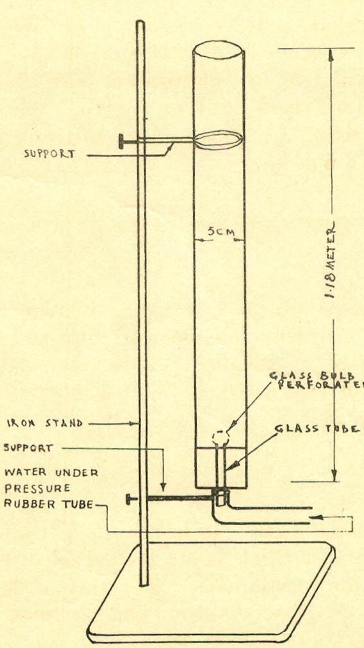

Fig. 2.—Gravity ore washer.

preferentially the iron oxide particles from the powdered ore.

Study under the Microscope.—The powdered sample of the ore under the microscope showed clearly the crystals of hematite and sand particles, although there were some large segregated particles of hematite, the majority of them in small particles were found intimately mixed with the sand particles. This fine admixture makes the physical separation of hematite and silica so difficult.

4. Conclusion and Lines for Further Study

The observations carried out by us indicate strongly against the possibility of reduction of iron ore found in Khyber Agency and the difficulty of beneficiation by the usual method of ore dressing. Further geological study is needed to find out if better quality iron ore is available at a greater depth from the surface. Samples collected and investigated by the authors were mostly from the surface.

It is also worth-while to study the possibility and economics of producing ferrosilicon from the ore—which appears suitable for the production of the alloy; a furnace to produce ferrosilicon requiring a much higher temperature than that required at the blast furnace—is at present not available in these Laboratories.

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