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A STUDY OF MANGANESE ORE DEPOSITS, LAS BELA, WEST PAKISTAN

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INTRODUCTION

Manganese deposits in Pakistan have been reported from Las Bela, Hazara, Kohat, Azad Kashmir and Nushki. Deposits of Las Bela and Hazara are comparatively larger than other occurrences.

In Las Bela, the manganese ore bodies chiefly consists of oxide minerals with minor quantities of silicate and carbonate minerals. They are invariably associated with greenstones and frequently with calcareous and ferruginous shales. Greenstones are characterized by the presence of plagioclase sodic felspares, chlorites, sphene and epidote. The effusive phase of the greenstones is represented by submarine pillow lavas.

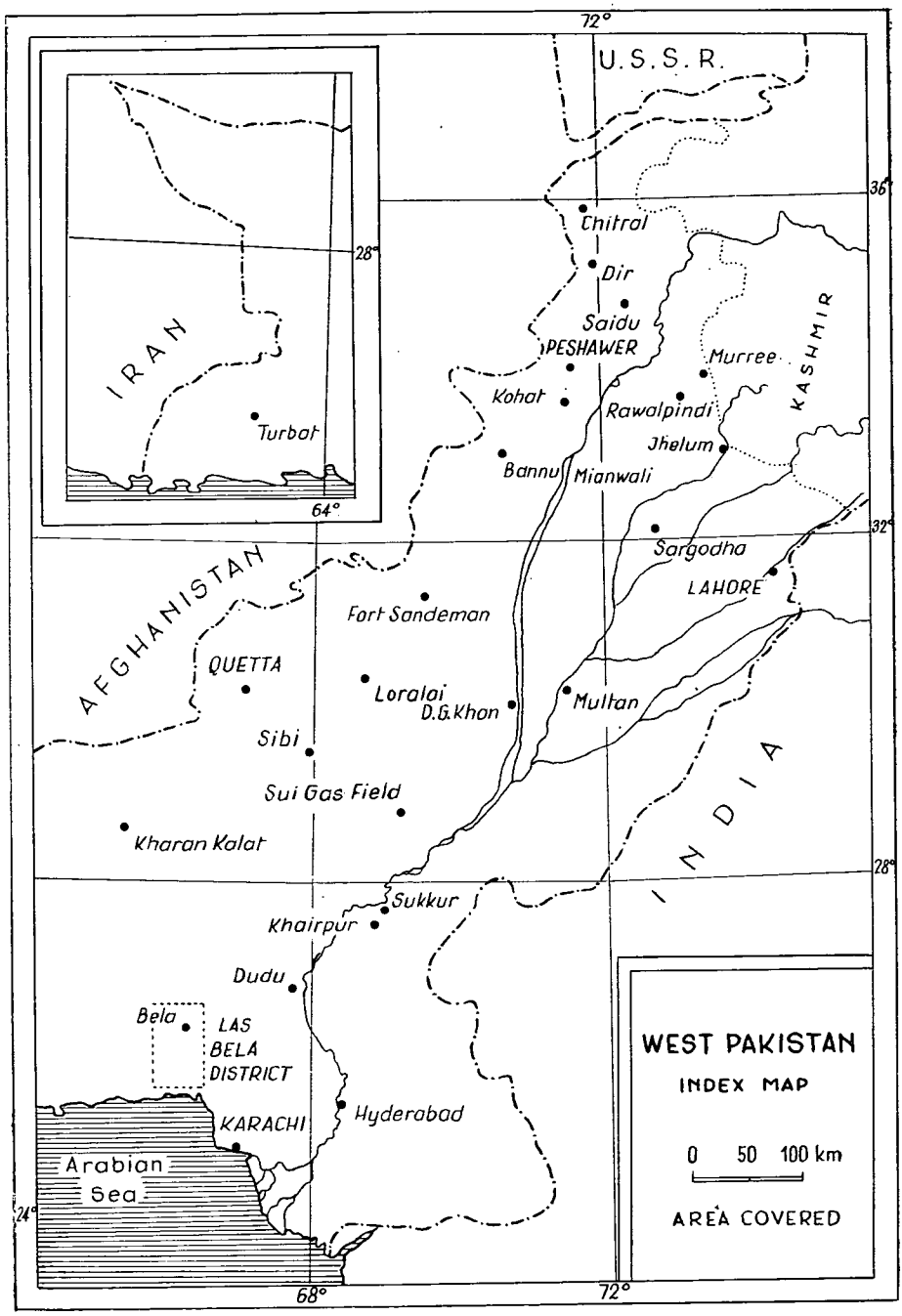
Most of the important ore bodies are located at the contact of pillow lava and red shales. Manganese ore bodies are in the form of lenticular beds except for Siro and Sanjro where manganese minerals are emplaced mainly along cracks, fractures and other such structural features [MASTER, 1956, 60]. This paper includes a brief description of three typical deposits of the area (Siro, Sanjro and Khairiri). An attempt has been also made to evaluate the ores and explain the origin of the deposits.

GENERAL GEOLOGY

Reconnaissance geological mapping of the Las Bela region has been done by Hunting Corporation. The lithology and succession, known to us, is of generalized nature and requires revision and mapping on a large scale.

The part of the region covered in this study, is a complex of several rock types, including intrusives of different ages and a sequence of sedimentary rocks containing extrusive volcanics. The Pab range borders the alluvial plain of Las Bela to the east. The main feature consists of Cretaceous shales and limestones, being penetrated and intruded by rocks of intermediate to ultrabasic composition. The nature of relationship of pillow lava and shales give sufficient evidence that the extrusion of lava occurred at various intervals, thus forming a sequence of alternating layers of pillow lavas and sedimentary rocks. This alternating sequence is penetrated by sills and dykes of various composition (mainly doleritic and diabasic).

Apart from volcanics, larger concordant greenstone bodies of intrusive nature, represent a later stage of igneous activity. At their contact with shales there is no visual marked change in the mineralogy and other physical characteristics, an evidence of low temperature of the magma at the time of intrusion. At places, where intrusions are in contact with pillow lavas, xenoliths, engulfed in greenstones are observed.


72°
U.S.S.R.
36°
Chitral
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Saidu
PESHAWER
Murree
KASHMIR
Kohat
Rawalpindi
Jhelum
Bannu
Mianwali
IRAN
Turbat
28°
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32°
Sargodha
LAHORE
AFGHANISTAN
Fort Sandeman
QUETTA
Loralai
D.G.Khan
Multan
Sibi
Sui Gas Field
Kharan Kalat
INDIA
28°
Sukkur
Khairpur
Dudu
Bela
LAS
BELA
DISTRICT
KARACHI
Hyderabad
Arabian
Sea
24°
68°
72°
WEST PAKISTAN
INDEX MAP
0 50 100 km
AREA COVERED

Fig. 1.

The sills and dykes at various localities seems to be a surfacial representation of intrusive bodies. The paragenetic relationship of the rock types and lithological association is typical of an Euogeosyncline at an early stage of orogeny.

Generally, the ore bodies are bounded and traversed by comparatively minor faults, but they de not give evidence that the manganese mineralization is in any case related to them. Slickensides and striations with shining surfaces show that the ore bodies have suffered post depositional diastrophism.

MANGANESE DEPOSITS

In Las Bela, the manganese ore minerals bearing bodies range from mere showings to deposits containing many thousand tons of high grade manganese ore to make them worth exploitation on commercial scale. Manganese has been reported from many localities. The following localities are important from mineralogical and economic point of view.

1. Siro Dhora
2. Sanjro Dhora
3. Jabli Dhora
4. Sukkan Dhora
5. Khairiri Nai
6. Giddar Dhora

The areas of manganese mineralization at Siro and Sanjro localities are larger as compared to other deposits, mentioned above, but the average Mn content is far lower. Manganese ore bodies are located mostly at the contact of pillow lavas and the overlying red shales, except for the locality (Sukkan Dhora) where red shales are underlain by serpentinites and volcanics are absent.

Previously, Siro and Sanjro Dhora areas have been investigated by a number of geologists. VREDENBERG and TIPPER were the first to report manganese from this area in 1904—05 [1909], W. N. KHAN, S. M. N. RIZVI and S. H. A. SHAH [1951] visited the areas. MASTER [1956, 1960] for the first time mapped Siro and Sanjro deposits on a large scale . The deposits were also sampled by digging trenches and channels. A complete summary of earlier work together with the preliminary conclusions reached on the investigation carried out by the author under the guidance of PROFESSOR VALIULLAH are contained in his Presidential Address to the Earth and Physical Sciences Section of the Scientific Society of Pakistan, Karachi Meeting, 1968.

Siro Dhora

Manganese mineralization has mainly emplaced along cracks and other such features in a dolerite sill [MASTER, 1956, 1960]. The sill is traversed by faults at many places with the result that its continuation is terminated at many places. The sill is intruded at the contact shales and pillow lavas. The shales acquire red colour near their contact with igneous bodies. Overlying the shales are red to whitish grey siliceous rocks and jasperoids. The siliceous rocks also contain impregnations of manganese oxide minerals and limonite.

Previously, the area has been investigated by the Geological Survey of Pakistan and the results of the channel samples MASTER [1956, 1960] gave an average of 5% Mn. The outer zone of the spheroids of sill and along cracks, contain a high percentage of manganese as a result of surfacial weathering but the enriched zone is very

thin as compared to the area of mineralization. However, at places near the contact of sill with shale, the mineralization is comparatively richer and such zones can be traced for considerable distance. This type of enriched zones at places attain a maximum thickness of 3 feet and a length of 50 feet, and consequently grade into barren sills. The ore is hard and highly siliceous.

Chemical analysis of a chip sample shows that it contain:

SiO_2	28.66%
MnO	23.81%
MnO_2	11.14%
Fe_2O_3	12.44%
Al_2O_3	0.52%
P_2O_5	0.068%
S	0.287%
CaO	5.05%

If mining is done on a small scale, supplemented by breaking into (3×3") pieces and sorting, a considerable enriched portion of commercial grade ore can be recovered.

With the collaboration of a local Mining Company and specifications supplied by a Japanese Firm. A 100 Kilograms ore (as representative sample) by mixing in various proportions of different grade and of course keeping in view the bulk of the ore lying at the mine head. The analytical report suggests that such ores can be utilised commercially.

Mineralogical studies with the help of X-ray diffraction technique and ore-microscope reveal the presence of braunite as the major constituent of the manganese minerals, usually associated with bixbyite (sitaparite), limonite and hematite, as iron minerals. The ores of Siro and Sanjro are much higher in iron content as compared to other deposits. The high content of calcium and silica is just by the presence of calcite and various forms of silica, as gangue. Calcite is commonly found to have replaced braunite. Pyrolusite is abundant in the outer zones of spheroids.

Sanjro Dhora

Sanjro deposit is located at 24 miles north of the town Bela, exposed at three isolated hillocks. Manganese mineralization rock association and minerals assemblage is nearly the same identical as to Siro Dhora deposit, except the zone of mineralization is thicker and high in Mn content. Apart from fracture and crack fillings and local replacement: certain polished sections of the ore show crude layering of manganese minerals.

BOGUE [1962] calculated a total of 21,500 long tons of which 7,100 long tons of ore contains 20—44% Mn on conservative basis. On breaking the ore into small fragments (4×4"), grade can be improved considerably. Nearly 200 tons of sorted ore lying at the mine head, partial analysis of a grab sample showed that it contains 40% Mn and 12% SiO_2.

Khairiri

The ore body occupies a part of the terrace of Khairiri Nai (stream) and attains a height of 40 feet from the present stream bed.

Exposed at the slope of pillow lava, dipping at an angle of 18 degrees, the ore body has a lenticular form with distinct layering which pinches out in all directions.

The deposit is under and overlain by red to pinkish shales. Thickness of the deposit varies from few centimeters to 14 feet, in the centre. The exposed surface of the ore can be traced for 400 feet along dip slope, while the width varies from 50 to 100 feet. Field observations indicate that prior to the uplift of the area and subsequent deepening of the stream channel, nearly the lower half portion of the deposit was drowned below the groundwater level.

Water table seems to have played an important role in determining the mineralogy of the lower half portion of the deposit. On the basis of physical characteristics of the ores, the deposit can roughly be divided into two parts.

1. The upper part, which consists of hard, massive and cavernous or spongy ores.

2. The lower part, substantially consists of soft and powdery ore. This abrupt change in the appearance of ores is an striking feature of the deposits. There are local evidence to favour the idea that a part of the ore body has remained below the water table (formed by stream). The presence of stream bed sediments, silt and gravel covering the lower half of the deposit.

At the top end, the ore bed contains two thin lenses of chert and the contact between chert and ore bed is sharp.

Microscopic studies reveal that hard and massive ores, commonly exhibit colloidal banding, pisolites, concretions and other such features. The soft and powdery ores are dominantly composed of minute concretions, open space fillings with unoriented needle-like crystals of pyrolusite and alteration of primary minerals.

The deposit is separated by a thin bed of red shale containing abundant pods of manganese (mostly braunite). The thickness of the shale bed gradually increases downdip and with that the ore bed thins out. Replacement on a minor scale along the partings of red shales indicate that manganese bearing solutions have trickled downed along such partings. Other field evidences also indicate the outlet of hot solutions was very close to the proximity of the deposit. X-ray diffraction patterns prove that braunite is the major constituent, followed by pyrolusite, manganite, in order of abundance. Manganoan calcite is found in small veins usually accompanied by silica. Rhodochrosite was found only in one sample. Calcite and various forms of silica are common gangue minerals.

The distribution of manganese in the deposit is not uniform. However, a number of samples showed that the lower part of the bed is more siliceous and lower in manganese content than the upper manganese layer, overlying the thin bed of red shales. On the basis of numerous analysed samples representing different parts of ore bodies, sorted and low grade ores, it may be safely assumed that 7000 tons of high grade ore can be mined. Fifteen hundred tons of high grade ore has already been shipped to Japan from this mine.

MINERALOGY

Mineralogy was studied with the help of petrographic microscope, ore microscope and X-ray diffraction technique.

Polished and thin sections of ore samples were prepared. Micro samples of the minerals were scooped from the polished sections, using a diamond pointer under the microscope. Although, it was not always possible to obtain a pure mineral powder. The powder was mounted on a fine glass fibre. A number of samples were also tried with diamond-gelatine technique. Fe radiations (1.9373) were employed through-

out with Mn filter. Most of the patterns were taken on 11.7 cm. camera and few with 5.96 cm camera.

The manganese minerals can be grouped into:

1. Oxides *2.* Silicates *3.* Carbonates

Manganese oxide minerals are the most abundant and form bulk of the ore bodies. The silicate minerals are usually associated with oxides but in minor quantities. Carbonate minerals are scarce, represented by manganoan calcite and rhodochrosite was recognized only in one sample.

Oxides

Among oxides, braunite is the most abundant, followed by pyrolusite, manganite, bixbyite and hollandite in order of abundance.

Braunite

Braunite constitutes the major portion to the ore, it can usually be found, where the ore body is hard, without the effects of superficial weathering. A reddish brown silicate is commonly associated with it. It forms colloform banding, concretions, pisolites, pellets and pods of various dimensions. Braunite is associated with bixbyite at Siro and Sanjro Dhora. — Pyrolusite is the common alteration product of braunite.

Pyrolusite

Pyrolusite is generally considered as a '*supergene mineral*', and on the basis of textural relationship and the predominence of pyrolusite in the zone exposed to weathering below the 'drowned water table' and in cracks, provide sufficient evidence that pyrolusite is mostly supergene. Pyrolusite specimen are very soft and difficult to prepare a polished section. The pyrolusite section, thus prepared, consist of small pellets with contrasting concentrical bands of pyrolusite. Such specimens are intensively traversed by veinlets of calcite. Cracks are, generally, filled with unoriented needle-like crystals of pyrolusite and this texture suggest an open space filling.

Manganite

Manganite was indentified is ore specimen from Kairiri and Sukkan Dhoras in two specimens is found to be associated with hollandite and in some sections with reddish brown silicate. It exhibits a faint stratification in a number of samples. Hollandite associated with manganite seems to be primary or hypogene. It is very rare to find hollandite associated with manganite (D. F. HEWETT, personal communications). Bixbyite is also a primary mineral and shows a common association with braunite.

ORIGIN

The source and environments of deposition of the manganese deposits, whether considered as proper sedimentary or hydrothermal have been debated for the last 100 years. Extensive research is being done all over the world to determine the mode of origin and more exact knowledge is required for exploring new deposits of manganese in future. The complexity is created by the varying nature of manganese deposits all over the world.

However, volcanism as a possible source of manganese, for the deposits associated with volcanics, such deposits are frequently characterized by their bedded nature,

in the form of lenses or similar features. The idea was first seriously put forward by French geologists working in Morocco (1934), described some of the occurrences of manganese as '*Volcanogenic-Sedimentaire*'. Later this was applied by Germans as '*Exhalative-Sedimentaire*'. It is believed that hot solutions connected with volcanism, enriched in Mn, Si, Fe and certain trace elements on combining with sea water are oxidized and precipitated as sediments.

The manganese deposits of Las Bela range from hydrothermal to volcanogenic-sedimentary in origin. The source of manganese in either case was volcanism. Following volcanism, hot solutions carrying Mn mixed up with marine waters, MnO was oxidized by oxygen to higher states of oxidation and precipitated, whereas, at Siro Dhora and Sanjro Dhora took place mineralization mainly along fractured zones (hydrothermal). The above statement is based upon wast field observations, mineral assemblage, and chemical composition of the ores and minerals. The main features that brought us to this conclusion are:

1. Bedded nature of the deposits.
2. Sharp contact of the ore bodies and the enclosing rocks.
3. Most of the polished sections show, faintly stratified manganese oxide minerals or textures typical of precipitation from gel state (colloform banding, concretions etc.) and on these grounds it can be conveniently argued that deposition of manganese took place under quiet water conditions.
4. Absence of large discordant relationship of ores and the host rocks.
5. The most important evidence to support the relationship of Mn carrying solutions and pillow lavas, is the presence of numerous small veinlets of manganese that cut across the pillows underlying the deposits. The spheroids of lavas are stained with films of manganese along joints and fractures.

A number of samples were sent to D. F. HEWETT, for his expert opinion. His interpretations suggest that the persistent traces of layering in manganese oxide minerals lead to confirm the idea of deposition of manganese oxide minerals under quiet water (marine) conditions, following the extrusion of lavas.

It seems that the ores are not related to any particular period of eruption, but many, at intervals. True to the extent that such deposits show abnormal concentration of certain trace elements (W, Th, Ge, Pb, Cu, Zn, etc.) [HEWETT, 1966, STRAKHOV, 1968], as mentioned earlier. A number of samples were analysed with X-ray fluorescence and spectrographic methods.

The usual association of quartz, chert, calcite, manganoan calcite, barite and copper minerals identified in one locality, bring us further evidence.

It is also believed that the hydrotherms located at various centres near ore-deposits were fluctuating in their chemical composition.

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