

Significance of iron ore resources of Pur-Banera Belt in the economics of Bhilwara District

Pooja Sharma^{#1}, Arun Kumar Shandilya^{*2}, Neeraj Srivastava^{#3}

Research Scholar^{#1}, Associate Professor (Retd.)^{*2}, Researcher (Geology & Environment)^{#3}
Department of Geology, Govt. Dungar College, Maharaja Ganga Singh University, Bikaner, Rajasthan^{#1 and *2}

Abstract — The district Bhilwara economically depends upon textile industry, insulation bricks and large scale mining of sandstone, soap stone, iron ore and other minerals like feldspar, quartz, China clay, etc., out of which the role of iron ore mine is economically important.

In year 2016-17 the Gross district domestic product value is 32361.71 crore rupees in which the contribution of iron ore sale value is 728.65 crore rupees. It is clear that the contribution of iron ore in gross district domestic product is 2.25%.

The district has huge deposits of low grade sponge iron ore. M/S Jindal Saw Ltd. with their innovative ideas and international exposure have thought of upgrading iron ore, from 25% Fe to about 65% Fe by way of magnetic separation and other beneficiation methods as the ore is mostly magnetite along with magnetite quartzite.

The total mineable reserves of iron ore (Magnetite) in Bhilwara 51.71 million tonnes and the present the rate of production of ROM ore have around 50 lac tonnes per annum but after proposed exploration the proposed rate of production will be around 70 lac tonnes helped 600-900 people employ. A numbers of schools, private as well as Government have run in the district. Market, Carpentry, Blacksmithy and vehicle repair shops have come up giving employment to a large number of persons. Thus the mining have benefit about 2,500 persons in the area.

Keywords — Significance of Iron Ore, Pur-Banera Belt, Reserve/Resources and Production

I. Introduction

Bhilwara is a small town in the Mewar region of Rajasthan, India. It is located almost in the centre of Rajasthan state covering an area of 10,455 sq. kms. It is bounded by latitudes 25°01' to 25°58' and longitudes 74°01' to 75°28' and it is surrounded by other district, on the north by Ajmer District, on the east by Bundi District, on the south by Chittaurgarh District, and on the west by Rajsamand District.

There are 12 Tehsils in the district: Bhilwara, Banera, Mandal, Mandalgarh, Beejoliya, Kotri, Shahpura, Jahazpura, Raipur, Asind, Hurda, and Sahara. The sex ratio of Bhilwara district 973 is significantly higher than the State sex ratio 928.

The temperature of the Bhilwara district varies substantially from day to night and from season to season. The maximum and minimum temperatures of the region are 46° C in extreme summer and mean and maximum temperatures being lowest at 22.2° C and 7.3° C in extreme winter respectively. January is the coldest month. The period from middle of March to June is one of the continuous rises in temperature; and June is the hottest month normally. There is drop in temperature due to onset of monsoon and rises again in the month of September.

The district Bhilwara is famous for textiles in the Indian state of Rajasthan. The major industry is textiles, with more than 850 manufacturing units in the town. The main textile product is synthetic fabric used in trousers.

Bhilwara is the only centre in the country producing insulation bricks. There are about 33 units in district. In the mining sector there is large scale mining of sandstone, soap stone feldspar, quartz, mica, china clay, granite etc. in which the mica mining has played a very important role in development of economic and social condition of Bhilwara.

The recent and most important development in Bhilwara is the recognition of the district as major metallic mineral i.e. Iron Ore, Lead & Zinc producing hub. Hindustan Zinc Ltd. owned mining at village Agucha where in Asia's largest deposit of Zinc, Lead and Silver has mined. The district has huge deposits of low grade sponge iron ore, which were simply ignored by the industry giants so far. The M/S Jindal Saw Ltd. of Bhilwara district recognized the potential and with guidance of "Geological Survey of India" developed a huge iron ore mining and beneficiation plant in the district. Now the district has become a magnet for all major steel companies of the country. It has put the state of Rajasthan on the map of steel industries.

Other than that the Steel Authority of India Limited plans to invest around Rs. 800 crore to develop Bhilwara iron ore mine in Rajasthan and they plan to produce 5 million tonne per annum iron ore and set up a pellet plant with 2 million tonne per annum capacity at the site.

The Rashtriya Ispat Nigam Limited plans to initially invest Rs. 2,500 crore to set up a

beneficiation unit and a 2 million tonne pellet plant in Bhilwara for value addition of the ore before using it at the Vizag steel plant.

II. Geology of Pur-Banera Belt

Geologically Bhilwara Supergroup occupies major part of the district. The Vindhyan Supergroup represented by sandstone, shale and limestone is exposed in southeastern part of the district along the great boundary fault. The Gogunda Group is exposed in extreme north-western part of the district and the Kumbhalgarh Group occupies small area in south-western part of the district, both belonging to Delhi Supergroup. The Aravalli Supergroup exposed in western part of the district is represented by Davoda Group.

In the Bhilwara Supergroup of Iron Ore deposits are part of the Pur-Banera belt of the district, explored by GSI in the year 1969-70. The outcrops of iron ore body are available in Tiranga hill, Tiranga-Samodi, Dhulkhera (North) and (South) hills Suras hill, Samodi-Dhedwas.

Predominantly chemogenic rocks with bands of clastics, occurring from south of Banera to Samodi in west, for over a distance of 80 km in a 3 km to 12 km wide belt, have been assigned to the Pur-Banera Group. It comprises conglomerate, garnetiferous mica-schist, calc-schist, amphibolite schist, calc-gneiss, dolomitic marble, calc-silicate marble, hematite quartzite, magnetite quartzite, banded magnetite chert, and carbonate rocks with associated sulphide mineralization (Table 1). The grade of metamorphism is up to amphibolite facies. Pur-Banera Group rocks unconformably overlie the rocks of Mangalwar Complex. The Pur-Banera Group has been subdivided into five Formations, Pur, Pansal, Rewara, Tiranga, and Samodi, all formations are found within the study area and the Pur & Pansal Formations are considered as same formation by some authors, are described below.

A. Pur Formation

The Pur formation unconformably overlies the Potla formation of the Mangalwar Complex and is overlain by the Rewara formation. The type section is exposed between Pur and Samodi. The Pur formation forms the base of the Pur Banera group and occurs, intermittently, all around the Pur-Banera Synform. Pur formation extending from 5 km NE of Jasma in south to Mandal in the north along Western limb while Rasmi in the east to Banera, along Eastern limb. This formation named after the Pur-village in Bhilwara district, comprises conglomerate and quartzite. The basal quartzite of the Pur formation is massive to schistose in nature and contains a fair amount of actinolite and tremolite and shows gradational relationship with overlying calcareous matasediments. A band Conglomerate is seen SE of study area and very ferruginous quartzite is exposed in south of the study area, near Pur village. The

pebbles comprise vein quartz and quartzite of ellipsoidal shape and of various sizes maximum being 36 x 2 cm the pebble are highly stretched and deformed (Shrivastava, 1970). Pebbles are set in a fine grained matrix which commonly consists of sand size particles and it is cemented by silica & iron oxides.

Quartzite is fine grained metamorphic rock composed chiefly of grains of quartz with subordinate amount of mica, feldspars and iron oxides (Hematite and Magnetite etc.) which result from the impurities of the original sandstone during metamorphism. Quartzite shows sharp contact with overlying mica schist of Rewara formation.

B. Pansal Formation

Pansal formation is equivalent to Pur formation; it is considered by some authors. It is overlying the Potla, formation of Mangalwar Complex. It comprises conglomerate, quartzite and marble, occurring near Pansal and Arjiya and extending for about 6 km and over width of 1 km.

The rocks of this formation were earlier considered as the part of the Aravalli System by Gupta (1934). Quartzite contains a fairly-large amount of actinolite and tremolite and grades into calc-silicate-bearing marble, at places.

C. Rewara Formation

The Pur formation is followed by Rewara formation. The rocks of Rewara formation are extending from 3.5 km east of wari in the south to Banera in the north for over a distance of 80 km in a width of about 1 km to 10 km. It comprises calc-silicate marble, calc-schist, calc-gneiss, quartzite, mica schist and amphibolites schist.

Calc gneiss occurs as thick bands in the study area and found to be associated with quartzite and banded magnetite and hematite quartzite. The Calc gneiss is well banded and show compositional banding with parallel quartz vein.

Mica schist is well developed foliated metamorphic rock composed of muscovite, garnet, biotite, plagioclase and quartz. Distribution of garnet is very irregular in mica schist. The mica schist is found to be associated with quartzite and gneisses.

Amphibolites are found in discontinuous thin bands in the area. It is contact with Quartzite and Calc-gneiss in the area. It is intruded by Quartz vein.

Gneiss (Quartzo feldspathic) is a metamorphic rock characterized by segregation of constituting minerals into layers or bands of contrasting composition, color and texture. It may show a variety of texture and structure but common is the gneissose structure. In study area gneiss showing highly weathered, loose and friable.

D. Tiranga Formation

The Banded Hematite quartzite and Banded Magnetite Quartzite occurring in the central

part of the Pur- Banera group has been assigned to the Tiranga formation. This formation is intermittently, seen along the two limbs of the Synform in a 500 m wide zone band between SE of Gurla to SE of Banera, for over 37 km. The formation conformably overlies the Rewara Formation and is overlain by the Samodi Quartzite.

In the type section of the Tiranga hill area, BMQ and BHQ intercalated with thin layers of biotite sericite schist and folded into an asymmetrical appressed Synform. These are intruded by pegmatite and quartz veins.

The BMQ and BHQ are exposed prominently as three bands along the crest of the Tiranga hill ridge. The inner most band forming the core of the Synform and is exposed on the Northern peak of the Tiranga hill and extends in the northerly direction through samodi, Dedwas, east of Dhulkhara, Bhanlikhera, Rangpura, Jaliya and west of Lampiya. The Western band possess through Gurla, Salampura, Dariba, Suras, west of Dhulkhera area, Jaliya, east of Devapura and Banera Reserve Forest. The average thickness of these bands varies from 3 m to 10 m except where it gets repeated by folding. BHQ and BMQ are folded in the study area. Siderite is brown in color while Hematite and Magnetite is black, brown and redish in color.

The mineralized magnetitic rock of the Pur-Banera belt is composed of three ubiquitous minerals, magnetite, garnet and quartz with varying proportions of amphibole and biotite. The banded magnetite quartzite is highly fractured and jointed and has alternate bands of magnetite and quartz-rich layers, the individual layers ranging from 1cm to 10 cm in thickness. Interlayered with these is 1 cm to 3 cm thick layers of fine-grained biotite and sericite with varying proportion of magnetite.

In the Tiranga Hill area, sulphide mineralization is confined to the biotite-sericite schist interlayered with banded magnetite quartzite. Galena, chalcopyrite, bornite, sphalerite, pyrrhotite and pyrite occur as dissemination in the biotite-sericite schist and as thin veins along fractures in the banded magnetite quartzite which forms the wall rocks. The mineralized zone of variable width (2 m to 60 m) is nearly 900 m long.

E. Samodi Formation

Clastic rocks with intercalatory marble and occurring between SE of Gurla in SE to Banera, for about 40 km over a width of 0.1 km to 1 km, have been assigned as the Samodi formation. It occupies the central part of the Pur-Banera Group and forms the core of the Synform. This formation comprises mainly quartzite with bands of calc-schist, mica schist and marble. The formation takes its name after the Samodi village in Bhilwara district where a type section of the formation is exposed.

The outcrops of Samodi quartzite are seen around Samodi, east of Suras and in the Banera

Reserve Forest. In the NE of Samodi, the rock contains intercalatory bands of garnetiferous mica schist. Towards Dhulkhera, the rock gradually grades into micaceous quartzite, quartz-mica schist and ultimately to mica schist. This rock is compact and massive with greenish-grey in color.

Lithological Description of Study Area:-

The study area is a 14.2 Km (Length) and 7.3 Km (Width) NE-SW hillocks passing through important landmarks like Samodi, Dhoolkhera, Mahuwakhurd and Lapiya. It falls in Survey of India Toposheet No. 45 K/11 and lies between following Latitudes and Longitudes: For Point A: 25°27'53"N 74°37'32"E, For Point B: 25°27'49"N 74°41'48"E, For Point C: 25°22'10"N, 74°36'26"E, For Point D: 25°22'10"N, 74°31'46"E (Fig 1). The general ground level is 450m and the height of hillocks above mean sea level upto 539m. The lithology of the study area is described below.

Table 1 Geological Sequence of Pur-Banera Group

Super Group	Group	Formation	Lithology
	Recent	Recent	
	Intrusives		Amphibolite Dyke
Bhilwara Supergroup	Pur-Banera	Samodi Formation	Amphibolite Dyke intrusives, Mica Schist, Marble interband and Quartzite.
		Tiranga Formation	Sulphide bearing Hematite /Magnetite Quartzite.
		Rewara Formation	Calc-Schist, Calc-Gneiss, Calc-Silicate marble,Mica Schist, Amphibolitic Schist.
		Pansal Formation	Conglomerate/ Quartzite.
		Pur Formation	Conglomerate/ Quartzite.
	Mangalwar Complex	Potla Formation	Migmatite, Amphibolite, Garnetiferous Mica Schist.
		Suwana Formation	Amphibolite (Granitised); Mica Schist with Amphibolites, Calc-Silicate rock; Quartzite

1. Iron Formation: - This magnetite quartzite, hematite quartzite and carbonate rock interbedded with biotite garnet schist, calc schist and calc gneiss occur as a persistent horizon in the study area (Fig 2 and Fig 3). The magnetite quartzite consist of two individual bands separated by partings of biotite-sericite schist and are folded. The two prominent bands representing line of asymmetrical fold forming

a chain of hillocks are exposed from Tiranga in south to Dhulkhera in north and also from Suras in south to Dhulkhera in north.

The magnetite quartzite is cherty at places and fractures are filled by secondary silica. At places magnetite is hydrated on the surface and is occurring as goethite and limonite.

2. Calc Silicate/ Calc gneiss / Calc schist: -

This is the main rock formation outcropping in the study area, which occupies the non-mineralized zone of the hilly part of the study area. Compositional bedding is well observed in calc gneiss. It consists of Felspar and quartz constituting the white band while the dark bands have amphiboles, biotite, diopside and garnet.

3. Garnetiferous Mica Schist: - These are well exposed in the study area. The rock is grey and medium to coarse grained (Fig 4). It consists of biotite, muscovite, quartz and porphyroblasts of pink to reddish garnet which are generally fractured. Kyanite occurs sporadically.

4. Copper, Lead, Zinc and Sulphide Mineralization: - Exploration done by GSI for Copper, Lead and Zinc in Pur Banera belt established the presence of sulphide mineralization along the contact of magnetic rock with quartz- mica schist. However the exploration did not reveal any association of rich lead, zinc or copper mineralization.

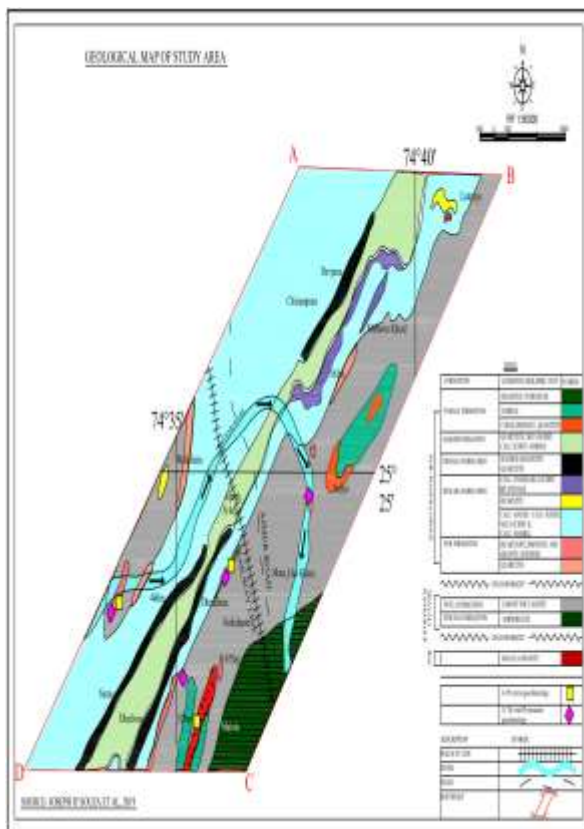


Fig. 1 Geological Map of Study Area



Fig. 2 Deposition of BHQ along with Quartz vein within Quartzite showing Tiranga Formation of Pur-Banera Group



Fig. 3 Outcrops of Iron ore deposit showing Tiranga Formation of Pur-Banera Group



Fig. 4 Garnetiferous mica schist showing Rewara Formation of Pur-Banera Group

Structure Deposition of Ore Body

The strike of the rocks varies from N 25° E – S 25° W to N 55° E – S 55° W and dips vary from 65° to 80° towards SE. Bedding plan (S₀) is prominent in iron formation and calc gneiss is defined by compositional banding. Foliation plane (S₁) is prominent in garnetiferous mica-schist and calc schist within the study area. Asymmetrical drag folds are present in outcrops of iron formation forming a synclinal structure, especially in Tiranga Block (Fig 5). They are highly jointed and fractured also. The physical and chemical effects of weathering can be seen in the study area in granite gneiss and dolomitic rock of Rewara Formation. (Fig 6 and Fig 7).

Stretching lineation formed by shearing of rocks during asymmetrical deformation of a rock mass. The vertical and inclined axial planes of fold are found in the study area. The normal fault is found in the study area. (Fig 8).



Fig. 5 Close view of drag fold existing in between Quartzite rock of Tiranga Formation in Pur-Banera Group



Fig. 6 Effect of chemical and physical weathering on Granitic-Gneiss rock of Rewara Formation in Pur-Banera Group



Fig. 7 Signature of Chemical weathering exposed on dolomitic rock of Rewara Formation in Pur-Banera Group



Fig. 8 Banded Hematite Quartzite separated by a fault plane in Tiranga Formation of Pur-Banera Group

III. Reserve/Resources of iron ore in Bhilwara

In India the total resources (Reserve & Remaining Resources) of Hematite is 22486.96 million tonnes, out of that Rajasthan shares 38.40 million tonnes which is negligible in context of national quantity. But looking to total national resources of Magnetite which is 10789.15 million tonnes, Rajasthan contribute 616.91 million tonnes. Hence share of Rajasthan is only 5.88 % which is also too less. In year 2015-16 there were 297 leases of iron ore were prevailing in India, in which Rajasthan contributed 17 leases with 2235.09 Hectare area (Table- 3) and spread in its nine districts namely Alwar, Bhilwara, Bundi, Dausa, Jaipur, Jhunjhunu, Karauli, Sikar and Udaipur.

In the Bhilwara district reserves of iron ore based on the information available from the GSI report and also from the Surface Geological Plan and Transverse section drawn at 100 m interval, the reserves have been estimated. The specific gravity of in-situ iron ore has been worked out to be 4.00.

The reserved have been categorized as proved from hill top level to the surface ground level 460 MRL as the outcrops are available through out from the hill top to surface level along the slope in strike direction. Sub-surface drilling has established the presence at 40 to 50 m level below the surface and therefore Probable reserve has been taken up to 30 m below the proved reserve (460m to 430m MRL) and another 30 m depth (430m to 400 MRL) below probable reserve has been categorised as Possible reserve.

The concentration obtained from tests meet the requirements of the mining company and is found to be viable and therefore economic and Feasibility parameters are 1 and 1. The table 2 shows geological

reserve of iron ore in Tiranga, Tiranga-Samodi, Suras, Dhulkhera North, Dhulkhera South, and Samodi-Dhedwas Blocks. The highest percentage of iron ore (Magnetite) in Dhulkhera South, Samodi-Dhedwas Blocks, and the lowest percentage of iron ore (Magnetite) in Suras, Dhulkhera South Blocks.

According to mining by companies the mineable reserve of iron ore (Magnetite) in Bhilwara Proved 16.70 million tonnes, probable 14.26 million tonnes and possible 20.75 million tonnes. The total mineable reserves of iron ore (Magnetite) 51.71 million tonnes (Table 2).

Table 2 Category wise geological reserve of Iron Ore in Bhilwara

S. No.	Block	Proved 111 (tonnes)	Probable 122 (tonnes)	Possible 333 (tonnes)	Total (tonnes)	Reserves (tonnes) From 400m to 250m above MSL	Magnetite %	Fe%
1.	Tiranga Block	1,43,83,760	83,49,600	83,78,400	3,11,11,760	41900000	6.94 to 61.52	5 to 44.3
2.	Tiranga Samodi Block	--	--	2,02,768	2,02,768	5680000	10.03 to 53.08	7.22 to 38.22
3.	Suras Block	7,20,000	23,09,000	23,67,000	53,69,000	11850000	22.19 to 40.91	16.06 to 29.60
4.	Dhulkhera North Hill	26,48,000	25,97,000	28,68,000	81,13,000	14350000	21.28 to 76.42	15.4 to 55.3
5.	Dhulkhera South Hill	8,04,000	25,91,000	33,45,000	67,40,000	16760000	19.47 to 49.61	14.09 to 35.90
6.	Samodi Dhedwas Block	--	--	58,96,832	58,96,832	38130000	21.29 to 52.59	15.41 to 38.05
	Total	1,85,55,760	1,58,46,600	2,30,58,000	5,74,60,360	128670000	6.94 to 76.42	5 to 55.3
	Mineable Reserves (million tonnes)	16.70	14.26	20.75	51.71			

Source- DMG, Udaipur, Rajasthan

Table 3 Production of Iron ore in Rajasthan

Year	Leases (No.)	Area (in Hec.)	Production (Lac' Tonnes)	Sale value (Core' Rs.)	Revenue (Lac' Rs)	Employment (Nos.)
2015-16	17	2235.09	41.34	795.12	3084.67	992
2016-17	18	2240.10	35.63	743.82	3225.28	899

Source- DMG Udaipur, Rajasthan.

IV. Significance of iron ore production in Bhilwara economics

The significance of iron ore production in Bhilwara district in so many fields is described as under:

Indian iron ore production has more than doubled in last five years and has generated a handsome amount of foreign exchange. Indian iron ore production output for the years 2013-14, 2014-15 and 2015-16 stands at about 152.18 million tonnes, 129.32 million tonnes and 155.91 million tonnes respectively.

In Rajasthan the iron ore production in year 2015-16 was 41.34 lac tonnes, and because of those production 3084.67 lac rupees generated and these rupees helped 992 people employ. In the year 2016-17 the iron ore production was 35.63 lac tonnes, and because of those production 3225.28 lac rupees

generated and these rupees helped 899 people employ (Table 3).

In Bhilwara district of Rajasthan the production of iron ore (Magnetite) by mining companies and they shows for the present the rate of production of ROM ore have around 50 lac tonnes per annum but after proposed exploration the proposed rate of production will be around 70 lac tonnes to obtain 20 to 25 lac tonnes of concentrate of iron ore from the existing in these blocks i.e. Tiranga hill, Dhulkhera North Block, Dhulkhera South Block, Suras Block and Samodi Dhedwas as well as Dhedwas-Dhulkhera Blocks and employed 600-900 people of Bhilwara district. The mining companies are helping the local people of Bhilwara district in so many fields by the production of iron ore. i.e.

1) The area is moderately backward where majority of people depend on agriculture in semi-arid area. The agriculture depends mainly on rain, which is erratic and irregular. The mine area has provided job to some 600 workers directly employed for mining work earning Rs. 250/- to 450/- per day. Technical and other qualified people are earning much more than the above wage. Thus, the general economic statuses of local people have improved.

2) A number of school, private as well as of government have run near the mining area.

3) Market, Carpentry, black-smithy and vehicle repair shops have come up in the locality giving employment to a large number of persons. Thus the mining have benefit about 2,500 persons in the area.

4) The local people have given vocational training for working in the mine and allied work to enhance their skills for safe and systematic work.

5) Periodic medical checkup of all workers have conducted providing they free medical camps in nearby villages regularly to check the health of the people and provide free medical advice and facilities.

6) Local people have motivated for being more environment friendly and conscious for planting and nurturing trees in their local surroundings. For this purpose, every year some 2000 to 3000 saplings of plant including fruit bearing plants have distributed and persons having best records of survival of plants have rewarded every year.

7) Local schools and Panchayat Bhawan have provided with sanitation facilities including drinking water supply arrangements.

8) Scholarships have awarded to meritorious and needy students of nearby schools to encourage them to go for higher technical education.

9) Annual sports have arranged on Panchayat Level to promote sportsmanship.

10) Buildings of the local worship places within mine area and around mine area have renovated.

11) Business opportunity develops for the local people.

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