CHAPTER I

INTRODUCTION

1.1 INTRODUCTION:

Joda-Palsa area is situated in Keonjhar district of Orissa, India, that includes a variety of metasediments, which includes iron formation (Jones, 1954), adjoining shales and phyllites, older sandstone, older granite and associated rocks. The rock formations of this area occur in the Archaean Complex of north-eastern part of Indian Peninsula (Pascoe, 1950, p. 196), should now be considered as Proterozoic, that has invited the attention of a number of eminent geologists in the past FERMOR (1921), JONES (1922).
1927, 1934), Parsons (1922), Krishnan (1928, 1936, 1957), Percival (1931), Dunn (1935, 1937, 1941), Dunn & Dey (1942) and Percival & Spencer (1940). This area has a very rich potential of iron and manganese, that has assumed economic importance; this has attracted a large number of working mines which, however, were established without much detailed geological work in the area.

This area is well known as the main producer of iron ore in the country and lies within the iron ore belt of Bihar and Orissa, that extends from Gua (22°13'N : 85°23'E) upto Cheliatoka (21°44'N : 85°09'E) in the western zone and turns back to Noasundi (22°09'N : 85°23'E) with a wide closure around Malangatoli (21°49'N : 85°19'E). This entire region is known as the "Horse Shoe" (Jones, 1934) (Fig. 1.1). Inspite of many opencast mines operating in this belt since a long time, certain potential areas remain still unexploited. The area of investigation has already produced enough of good quality iron and manganese ores and the mines are being worked by M/s. Serajuddin & Co., Orissa Mining Corporation Ltd., Tata Iron and Steel Co. Ltd., M/s. B.D. Patnaik & Sons, M/s. Rungta Mines, Mr. N.H. Ram, Mr. S. Lal, Mr. H.D. Pandya, Mr. A. Ray & B. Ray & Co., Kalinga Mining Corporation, Mr. S.C. Padhi, Mr. R.S. B. Deo, Mr. K.C. Pradhan, Mr. N.S. Deb, Mr. L.N.B. Deo, Mr. K.C. Thapper and Mr. H.B. Rahman.
The present area of investigation was mapped by earlier workers (KRISHNAN, 1928; JONES, 1934; DUNN, 1940; SPENCER & PERCIVAL, 1940) and the map was in 1 : 53,360 scale naturally without much of details. The only enlarged map was published by PRASAD RAO et al (1964) (4cm = 1km scale). Recently, Geological Survey of India, Orissa circle has broadly mapped some parts of the region on a 2" = 1 mile (1 : 31,680) scale, but the present area of investigation has not been taken up for detailed mapping so far. This area belongs to a part of the eastern limb of "Horse Shoe" of JONES (1934), that (this area) extends from south of Satkutnia pahar (21°56'N : 85°23'E) in the south west to Kamarpur (21°56'N : 85°28'E) in the south east, in the toposheet No. 73 G/5 to east of Rolda (22°01'N : 85°23'E) in the north west to north of Churlia pahar (22°02'N : 85°28'E) in the north east in the toposheet No. 73 F/8. The ore bodies occur in association with the iron formations and adjacent rocks at different places.

In the following pages certain points, not of immediate consequence to the study of geology of the region, are appended here; this is only to acquaint any future worker about the conditions in the terrain, so that difficulties to be encountered by him are lessened.
1.2 LOCATION AND ACCESSIBILITY:

The area covering about 100 sq.kms(approx.36 sq. miles) in the 'ore district' of Keonjhar is important from the point of view of both iron and manganese ores. The location is already described above(Fig. 1.1). The important localities in the area are Joda, Banspani, Jajang, Jolohuri, Joruri, Bamebari, Palsa, Kurband, Bichakhani, Tiring pahar, Dal pahar, Banspani pahar, Satkutnia pahar, Gurubera and Chamakpur. The terrain is hilly and is partly covered by thick forests. The accessibility of the terrain is rather poor. Joda (22°01'N : 85°26'E) is connected with Keonjhargarh (21°37'N : 85°35'E) by bus route and the rest part is negotiable either by foot or by jeep or truck on an un-metalled road.

1.3 CLIMATE:

The entire rainfall of the region is by south east monsoon between June and October every year, but occasional winter showers take place in January and February. The temperature in summer rises to 44°C in May/June, but in winter it is quite cold and the temperature between December-February falls down to as low as 20°C.
1.4 FLORA AND FAUNA:

This region comes under Baitarani Reserve forest. The flora constitutes Sal (*Shorea robusta*), Piasal (*Pterocarpus marsupium*), Sisu (*Dalbergia latifolia*), Assan (*Terminalia tomentosa*), Kendu (*Bhatia frondosa*) and many other deciduous trees with heavy undergrowth of bushy plants that make post monsoon field work both difficult and risky, as it hides the exposures as well as wild animals. The flat hill tops are covered by tiger grass (*Asparagus*). Wild animals move freely in the region, even in day time. The author has come across many elephants, wolves, bears, deer, snakes etc. and occasionally tigers. The area is regularly haunted by elephants and bears.

1.5 GEOMORPHOLOGY:

Geomorphologically, the area can broadly be divided into two parts by the Baitarani river flowing north. The western half consists of mostly parallel hill ranges (barring a few), whereas the eastern half has low hill ranges of irregular physiographic trend. The different rock units of western half are volcanics, tuffs, lower shales, banded iron formations and upper shales, whose trend roughly conforms to the trend of the hill ranges, whereas the rock units of eastern half are mostly
sandstones and granites exhibiting no such control.

The different lithologic units have given rise to rugged topography in the area. Prominences in the topography are Satkutnia pahar (2303'), Kurband (2250'), Tiring pahar (2250'), Dal pahar (2390'), Langalota pahar (1911'), Jilling pahar (1974'), Banspani pahar (2250'), Surjat parbat (2232'), Bhaliathori pahar (1998'), Churia pahar (1978') and Kalaparhat (2320') (Fig. 1.7). The base height is near around 1550'. The hills are almost flat topped and are mantled by laterite. Deep valleys with moderate slopes less than 25° (Fig. 1.3) exist between the ridges. The hills and ridges are usually due to more resistant iron formation. The physiographic discontinuity of hills is observed to be essentially due to faulting.

An attempt has been made to exhibit the broad geomorphic characters in Fig. 1.7, by a hand drawn terrain elevation in the pattern of digital terrain tapes. It will be seen later (p.117) that the ore bodies are mostly confined to these flat hills rather than the more conical ones - a good geomorphological guide for ore search.

The physiography of this region shows 'negative
land forms' (THORNbury, 1969) (Fig. 1.4).

This region is a part of the catchment area of Baitarani river. Most of the streams from Kurband, Bansbari,
Banspani and Joda region within the drainage basin flow in an easterly direction which converge either at Dolka nala or at Kundra nala, the feeders of Baitaranl river (Fig. 1.8). The drainage pattern is controlled by regional structures and presents higher stream order (SPARKS, 1963, p. 119) (Fig. 1.8). First order streams showing a trellis pattern exist in the region and together with higher order streams they produce dendritic type of drainage that is a characteristic feature of complexly folded region (LOBEK, 1959, p. 69) (Fig. 1.8).

The lithology and structure more or less control the geomorphic configuration of the region that is evidenced from the following:

1. Banded iron formation, being more resistant to weathering, stands out as prominent ridges in contrast to valleys exposing shales (mostly they are covered by mantle soil).
2. The hill tops with laterite cappings are mostly flat and smooth, but valleys, in contrast, are 'V' shaped because of vertical corrosion in shale.
3. The resistant rock produced higher slopes than the soft rocks.
4. Faults have played a major role in carving
the geomorphic features of the area, which is reflected by escarpment in the transverse sections during the run of the rocks (where Baitarani river, Dolka nala and Kundra nala flow and which are inferred to be not joint controlled.

The area is beset with higher order drainage pattern and the hills on either side of the streams have attained almost equal heights and therefore, the topography of the area covered by rocks of "Iron Ore Group" seems to be a matured one (Lobek, 1929; Sparks, 1963; Thornbury, 1969; and Worcester, 1969).

1.6 GEOLOGICAL SETTING

The area of investigation represents the rocks of Precambrian formations, the age of which has been confirmed by radioactive age determination of Sarkar (1968).

Sarkar (op. cit) has provisionally classified the Precambrian formations into five groups by determining the closing age of different orogenic cycles (Table - 1.1).

The iron ore sediments of this region are included in Precambrian II by Sarkar (op. cit).
### TABLE - 1.1

<table>
<thead>
<tr>
<th>Precambrian V</th>
<th>(600-900 m.yrs.)</th>
<th>Chhatisgarh basin, Upper Vindhyan, Khairagarh, Malani, Monghyr (?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precambrian IV</td>
<td>(900-1600 m.yrs.)</td>
<td>Cuddapah, Lower Vindhyan, Satpura, Aravalli &amp; Delhi</td>
</tr>
<tr>
<td>Precambrian III</td>
<td>(1600-2500 m.yrs.)</td>
<td>Satpura &amp; Aravalli (in part), Amgaon, Eastern ghat(II)</td>
</tr>
<tr>
<td>Precambrian II</td>
<td>(2500-3000 m.yrs.)</td>
<td>Iron Ore, Dharwar, Banded gneissic Complex, Bundelkhand, Eastern ghat(I)</td>
</tr>
<tr>
<td>Precambrian I</td>
<td>(3000-3500 m.yrs.)</td>
<td>Older metamorphics (Bihar &amp; Orissa), Basement Complex (South India &amp; Rajasthan)</td>
</tr>
</tbody>
</table>

### 1.7 GEOLOGY OF THE "HORSE SHOE" AND DEVELOPMENT OF WORK WITHIN IT:

Several workers have made attempts to unravel different aspects of geology and mining of the region. As
is mentioned earlier, this is essentially because of the economic significance of the area.

In the fitness of things, therefore, a brief resume has been appended below, that brings forth a historic development of the nature of work done in the entire basin.

"The "Horse Shoe" of Jones (1934) is a low NNE plunging synclinorial basin, the western boundary of which is limited by Bolani-Kiriburi-Barsua-Khandadhar range and the eastern boundary is marked by Noamundi-Joda-Mahaparbat range with closure of both the boundaries represented by a series of hill ranges joining Kumritar, Mankarnachha and Malangatoli, lying to the south. The shape of the basin assumes a shape of "Horse Shoe" (Fig. 1.1). The "Horse Shoe" occupies a vast tract of forested areas of Keonjhar and Sundargarh districts of Orissa and Singhbhum district of Bihar and, as is said before (p. 2), it is the main producer of iron and manganese in the country.

The hill ranges of the "Horse Shoe" expose a thick pile of different sedimentary units of iron formation, belonging to the youngest "Iron Ore Group" of rocks of Precambrian times, of which the most prominent lithologic unit is represented by banded iron formation, locally known as banded hematite jasper/chert. The rocks are almost unmetamorphosed, that preserve a variety of primary
sedimentary structures.

The different litho-units exposed within the "Horse Shoe" are lower volcanic formation (bordering the limit of "Horse Shoe"), lower shale formation, banded iron formation and Kolhan group of sedimentaries with basal conglomerate followed upwards by sandstones.

JONES (1934) was the first to detaily survey the iron ore belt of Bihar and Orissa and delineated the different ore bodies along with a brief note on the geology of the belt (being primarily interested in the economic wealth of the belt). Other pioneers like FETHERSTON (1921), PARSONS (1922), JONES (1922, 1927), KRISHNAN (1927), PASCOE (1927) and PERCIVAL (1951) have published brief reports before the publication of memoir of JONES (1934). All the earlier workers have broadly mapped the area in 1:65,360 with not much details.

JONES (op. cit) regarded the structure of the belt as a synclinorium pitching towards north with an overfolded western limb. BUNN (1940) accepted the above view. All these workers in Singhbhum and adjoining areas recognised three major groups of rocks as Gangpur Series, Iron Ore Series and Kolhans, and that there is a well marked thrust zone (Singhbhum copper belt thrust) that separates high grade metamorphic rocks in the north from the low grade
metamorphic rocks to the south. The iron ore belt belongs to southern part of the thrust zone. KRISHNAN (1927) carried out the most comprehensive geological work on the rocks of the area. Later works in the "Horse Shoe" include those of ACHARYA (1964, 1966, 1971, 1976); ACHARYA, AHMED & SARANGI (1969); ACHARYA, MOHANTY & SAHOO (1982); BANERJI (1964, 1974, 1977); BANERJI & ROY (1973); CHATTERJEE, PERRAJU, BANERJEE, NAG, BANERJEE & GHOSH (1964); CHATTERJEE & MUKHERJEE (1981); DUTTA & NANDY (1964); GHOSH, PRASAD & GHOSH (1963); IVENGAI & ALWAR (1965); MISRA, C. B. (1962); MISRA, A. (1969); MOHANTY, SINGH & ACHARYA (1930); MOHANTY, SINGH, DAS & ACHARYA (1990, 1982); MOHANTY & DAS (1991); MUKHERJEE (1961); MURTY & GHOSH (1971); MURTY & ACHARYA (1975); PANDA (1972); PRASAD RAO, MURTY & DEKSHITULU (1964); SAHA (1949, 1970); SARANGI (1963, 1972, 1975); SARANGI & ACHARYA (1979, 1972, 1975); SARKAR (1958, 1969); SARKAR & MOHAPATRA (1962); SARKAR & SAHA (1959, 1962, 1964, 1966, 1969, 1977); SARKAR & SAHU (1962); SARKAR, SAHA & MILLER (1967, 1969); and SUBRAMANYAM & MURTY (1975), of which SARANGI (op. cit.) has extensively worked in the closure zone of the "Horse Shoe", MURTY (op. cit.) has worked in a part of the western limb and central portion of the "Horse Shoe" and the present author is working on a part of the eastern limb of the "Horse Shoe" under the guidance of ACHARYA (op. cit.).
The different preproject works in iron formations and associated ores of the Post Graduate Department of Geology of Utkal University have been shown in Fig. 1.1.

1.8 Scope of the present work:

The present work is aimed at the elucidation of the structural geometry, establishment of the local stratigraphy and its correlation with that of the iron ore belt. The work is also extended to study the different controls of ore localisation and its genesis.

Detailed structural mapping was completed on a 4" = 1 mile (6.2cms = 1km or 1 : 15,940) scale covering an area of approximately 100 sq.kms. The hill tops and valleys, being mostly covered by laterite and alluvium respectively, hinder detailed structural work, but the nala (rivulet) sections, slopes and road-cuttings expose the different formations which provide clues for elucidation of structural geometry and the tectonic history of the region.

Stratigraphic studies were based upon regional structural geometry, supplemented by primary depositional features. Attempts have been made to study the history of sedimentation and condition of deposition of different lithologic units of the area. Endeavour is made to ascertain the diagenetic conditions of deposition.
In regard to the ore geology, the studies are extended to know its mineralogy and their textural relationship, and to ascertain the possible controls of ore localisation. Special emphasis has been given to separately describe the banded iron formation and sandstone of the area.

There are certain limitations to the scope of the present work, which are given below:

1. The structure and stratigraphy of the southern and western side of the present area of investigation have not been attempted, as it is included in the Post Graduate Department project works, being worked out by another researchers in the department. But discussions with them were constantly made, so that the continuity of geologic inferences is retained.

2. The petrofabric work could not be attempted due to the extreme fineness of grains of jasper/chert in support of kinematic analysis.

1.9 METHODS OF STUDY:

The available map was enlarged to 1" = 1 mile scale (1 : 15,840) by pantograph, to plot sufficient structural details on the map. More than one year has been devoted
to field work from 1978 to 1982. About 30% of the area has mappable exposures and large tracks are either covered with thick soil or laterite. The attitude of different planar and linear structures has been measured directly in the field. The Landsat imageries and areal photographs were used for geological appraisal of the area with subsequent collection of ground truths. The areal photographs of the area belong to Map Sheet No. 373E, in scale 1" = 1 mile (1: 31,680) and photographs were taken by Air Survey of India Ltd., Dehradun, in February, 1951. The photographs belonging to the area are runs 8 to 13 and are arranged in the following manner and were made available for study by the Director, Geological Survey of India (North Circle), Orissa, Bhubaneswar.

<table>
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<tr>
<th>Run</th>
<th>Stereopair Nos.</th>
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<tr>
<td>13</td>
<td>5 to 11</td>
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<td>12</td>
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<td>10 to 23</td>
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<td>11 to 21</td>
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</table>

The photographs were first laid out into uncontrolled mosaic to attain an integrated picture of the entire area and a general reconnaissance of the geological and
physiographic set up was made. Important physiographic and cultural features of the area were annotated on alternate photographs with reference to relevant toposheets (73 G/5 and 73 F/8) in order to facilitate quick location and reference. Each stereopair photograph was then erratically scanned under a mirror stereoscope and all the plottable geological details and important physiographic features were marked on alternate photographs. Standard recognition elements, e.g. tone, texture, shape, size, pattern, association, drainage and land use were utilised to identify the geological details. This was done prior to the field work and took about a month's time.

More than 400 rock specimens were collected from the field, that were examined in hand specimens with the aid of a pocket lens and magnet. The thin sections of the specimens, numbering about 150 have been examined under the microscope and several polished sections have been studied under the microscope.

The Dhanjori sandstone exposed in the eastern part of the area is the store house of cross bedding, that has been utilised to determine the palaeocurrent direction. Further, the sandstone has been studied in detail regarding their sphericity, roundness, so as to infer about their deposition and environmental characters.
The area is a part of the iron ore belt of Bihar and Orissa and it has assumed importance because—

(1) the area is a part of the only 'Mining district' of the state in the sense that about 40 mining operations of 17 mining concerns are in progress, within an area of 100 sq. kms. The entire district has many working mines.

(2) the area has big potentialities of very high grade (63% to 69% of Fe) and medium grade (50% to 63% of Fe) iron ore and high grade (40% to 47% of Mn) manganese ore, which is being worked out by various mining organisations,

(3) all the ore deposits have been confined within a small region, named "Iron Ore Geosyncline" by JONES (op. cit.) and this region is the best producer and most important supplier of iron ore of the country. In spite of this, the structure of the "Iron Ore Geosyncline" is not yet out of controversy and more so the eastern limb to which the present area of investigation belongs, that represents the unmapped portion of the eastern limb. Further,
a grade-wise estimation of the deposit has not yet been made. All these are possibly due to the fact that there has been no need for these studies as iron ore is available in plenty wherever it is dug,

(4) the proposed sponge-iron plant near Palaspanga and Joda,

(5) the existing ferromanganese plant at Joda (22°01'N : 85°25'E).
A map showing the present area of investigation, part of the eastern limb of Horse Shoe (Jones, 1934).

Fig 1.1

R.P. Mohanty.
A MAP SHOWING THE ROUTE TO THE AREA OF INVESTIGATION, ALONG WITH DISTRIBUTION OF IRON ORE DEPOSITS OF BIHAR AND ORISSA.

PRESENT AREA OF INVESTIGATION

Fig.1-2.