CHAPTER II

REGIONAL GEOLOGY AND STRATIGRAPHY

INTRODUCTION:

A thick sedimentary sequence of rocks occurring in a crescent shaped intracratonic Chhattisgarh basin of central Indian craton occupies an area of nearly 33,000 km² and covers a large part of southeastern Madhya Pradesh (Parts of Raipur, Durg, Rajnandgaon, Bilaspur, Bastar and Raigarh districts) and adjoining part of Sambalpur district of Orissa. This sedimentary sequence has been named as Chhattisgarh Supergroup (Schnitzer, 1971).
The Chhattisgarh basin like all other Purana basins of India is surrounded by mobile belts and grabens (Fig. 2). The northern margin of the basin having a thrust contact with Proterozoic mobile belt (Dutt, 1964). In general low to medium grade metamorphics and associated matavolcanics constitute the basement for the Chhattisgarh Supergroup, which vary from place to place. The margins of the basin (except southern and southeastern parts) show structural disturbances like faulting and intense folding (Murti 1987). In general Chhattisgarh sediments are not covered by any other younger rocks except few outliers of Gondwana Supergroup represented by Talchir and Barakar Formations in the eastern part of the basin in Raigarh district.

The following paragraphs deal with the regional geological setting, stratigraphy, regional correlation and age of Chhattisgarh Supergroup, and stratigraphy of the study area.

REGIONAL GEOLOGICAL SETTING

Geology of the basement rocks

The basement rocks of Chhattisgarh Supergroup as hitherto mentioned range in age from Archaean to Middle Proterozoic. Along the southwestern margin of the basin, rocks of Bailadila Group and intrusive granites and andesites are exposed. A few inliers of the Banded Iron Formation and schist...
Fig. 2 Tectonic framework of Purana basins in the Central Indian Craton. C. Chhattisgarh, A. Ampani, I. Indravati, K. Keskal, N. Nawagarh, Khariar, S. Sukma. (After Ramakrishnan, 1987).
are also recorded around Lohara.

The southern margin of Chhattisgarh basin unconformably overlies the Kanker Granites, which is represented by granites, gneisses and migmatites. Along the southeastern margin of the basin metasedimentary, metavolcanic sequences locally known as Sonakhan beds are exposed. They are essentially composed of highly crushed and steeply dipping quartzites, conglomerates, slates, hornfelses, felsites and gneisses.

Rocks belonging to Chilpi Group and Dongargarh Supergroup (Sarkar et al. 1981) outcrop and underlie along the northern and western margins of the basin respectively. The Chilpis in this area are represented by phyllites, slates, mica schists, tuffaceous quartzites, coarse feldspathic grits and conglomerates. The Bijli rhyolites, Pitepani andesites and Dongargarh granites constituting the Dongargarh Supergroup (Sarkar et al., 1981) occur along the western margin of the basin.

The rocks forming the basement for the Chhattisgarh Supergroup can be correlated on the basis of chronological data or on their relative stratigraphic positions. The geology of the basement compiled from various sources is presented in Table-II to elucidate the tectonic setting of the Chhattisgarh basin. It is clear from the above referred Table-II, that Khairagarh Group of rocks are the youngest amongst the basement, and thus it is inferred that the commencement of sedimentation in the Chhattisgarh basin might have started
Table-11: The relative position of basement rocks surrounding the Chhattisgarh Basin.

<table>
<thead>
<tr>
<th>Proterozoic</th>
<th>Late</th>
<th>Archaean</th>
<th>Middle</th>
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<tbody>
<tr>
<td>Early</td>
<td>Dongargarh Group (1686 m.y.(^1))</td>
<td>Nandgaon Group (2200 m.y.(^1))</td>
<td>Amgaon Group (2500 m.y.(^1))</td>
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<tr>
<td></td>
<td>Mangikhuta Fm.</td>
<td>Karutola Fm.</td>
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<td></td>
<td>Khairaghar Group</td>
<td>Sitagota Fm.</td>
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<tr>
<td></td>
<td>(Granite 2465(\pm)22 m.y.(^3))</td>
<td>Bortalao Fm./Chilpi Gr. (^2)</td>
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<tr>
<td></td>
<td>(Rhyolite 2462(\pm)25 m.y.(^3))</td>
<td>Sonakhan beds.(^2)</td>
<td></td>
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<tr>
<td></td>
<td>Dongargarh Group (2200 m.y.(^1))</td>
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<tr>
<td></td>
<td>Kanker Granites</td>
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<td></td>
<td>Bailadila Group = Iron Ore Group (3200 m.y.(^4))</td>
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<td></td>
<td>Unclassified granites and gneisses (?)</td>
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after the culmination of Khairagarh Orogeny, i.e. about 1686 m.y. (Sarkar et al. 1981) ago.

Geology of Chhattisgarh Supergroup

The knowledge about the stratigraphy, sedimentation history and lithologic variations of the Chhattisgarh Supergroup is still fragmentary, in spite of the fact that it has been worked since quite long. Several workers such as Pascoe (1963), Dutt (1964), Schnitzer (1971) and Murti (1987) have worked in different parts of the basin and have contributed towards the geology of the Chhattisgarh Supergroup. However yet no complete and compiled geological map of the Chhattisgarh Supergroup is available. Latest field investigations by the geologists of Geological Survey of India (Record GSI 1989) have opened avenues of correlating and compiling the basin geology in a better way.

On the basis of available literature and the present work in the area around Lohara, stratigraphy of the Chhattisgarh basin is compiled and presented in Table III.

The Chhattisgarh Supergroup of rocks are divided into two Groups viz; lower : mainly arenaceous Chandarpur Group and an upper : calcareous and argillaceous Raipur Group, separated by an erosional unconformity (Murti, 1987).

Chandarpur Group :

The sandstones of Chandarpur Group rest unconformably over the Archacena to Early Middle Proterozoic rocks and are well
<table>
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<th>Case</th>
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Table: Comparative stratigraphic scheme of Chotiyagram Subgroup.
developed along the southern margin right from east to west. The maximum thickness is attained in the Bara Pahar and Phuljar hills in the eastern part of Chhattisgarh basin, where it becomes about 1650 m. thick (Pascoe, 1963). However in other parts of the basin its thickness seldom increases 450 m. and goes down to a few meters in the northern part. Murti (1987) divided Chandarpur Group into three Formations, namely (i) Lohardih, (ii) Chaporadih, and (iii) Kansa Pathar/Kondkera Formations in successive order.

(i) Lohardih Formation:

Lohardih Formation consists of a thin basal conglomerate unit, and arkosic-subarkosic sandstones occasionally containing lenses of conglomerates.

(a) Basal Conglomerate:

A thin horizon of basal conglomerates is reported at the base of Chandarpur Group throughout the southern margin. These are generally poorly sorted, non-stratified polymictic conglomerates, containing angular to subangular pebbles of granites and vein quartz embedded in siliceous matrix. Basal conglomerates grade upward into arkosic to subarkosic sandstones.

(b) Sandstones:

The sandstones conformably overlying the conglomerates are arkosic-subarkosic in nature. These sandstones are wh...
pink coloured thick bedded massive coarse grained composed of subangular to subrounded grains of quartz and feldspars. Sedimentary structures like ripple marks, cross bedding and animal borings etc. are frequently seen within these sandstones (Murti, 1987; Khan and Mukherjee, 1990).

(c) Conglomerate lenses in sandstones:

Lenses of oligomictic conglomerates measuring upto 50 m. in thickness have been reported by Murti (1987), occurring within the arkosic sandstones of Lohardih Formation in the central part of the basin. He interpreted these conglomerates as storm deposits in beach environments.

(2) Chaporadih Formation:

The medium to fine grained, greenish to reddish brown, thinly laminated micaceous sandstones conformably overlie the arkosic sandstones of Lohardih Formation. They make up a persistent horizon about 15 m. thick in the central part of the basin (Murti, 1987). These sandstones are characterised by the presence of authigenic glauconite pellets and micaceous sheen. The sedimentary structures like micro cross laminations, lenticular bedding, desiccation cracks and clay galls are quite common in these sandstones.

(3) Kansa Pathar/Kondkera Formation:

The Kansa Pathar/Kondkera sandstones conformably overlie the Chaporadih Formation and represent a lateral...
variation (Murti, 1987), those are differentiated by their colour.

Kansa Pathar Formation:

These sandstones are white in colour, massive, coarse to medium grained, quartzarenites seldom containing grains of detrital glauconites. Sedimentary structures like cross bedding and ripple marks are frequently present. Ripples are characterized with rounded crest.

Kondkera Formation:

The Kondkera sandstones are reddish to brownish in colour, thick bedded, massive and compact, orthoquartzitic in nature, having cross bedding and ripple marks as common sedimentary structures.

Raipur Group:

The argillaceous-calcareous sediments of Raipur Group unconformably overlying the Chandarpur Group sandstones, have been divided into four Formations, viz. Charmuria, Gunderdehi, Chandi, and Tarenga Formations. The Khairagarh sandstones occurring in between Gunderdehi and Chandi as reported earlier by Dutt (1964) from the western part of the basin, have not been recorded by Murti (1987) in the central part of the basin. Moreover, recent field investigations in the northwestern part...
of the basin by Das et al. (1989) have revealed two more Formations overlying the Tarenga Formation.

(1) Charmuria Formation:

The Charmuria Formation consists of grey flaggy limestones with a basal clay unit, which is named as Sirpur Member (Murti op. cit.), these clays are white to buff coloured, thinly laminated, containing chert bands. These grade upward into overlying cream to buff coloured, thinly laminated cherty limestones which is pyritiferous and occasionally phosphatic. The colour of these limestones changes upward becoming grey to black.

These limestones have been correlated with the Sarangarh limestones of Schnitzer (1975).

(2) Gunderdehi Formation:

The limestones of Charmuria Formation are conformably overlain by purple coloured shales named as Gunderdehi Formation. This Formation in general is represented by pink to purple shales, with a grey shaly unit in between, named as Dotopar Member (Murti, 1987). Gunderdehi shales are medium to very fine grained, thinly laminated, tuffaceous, calcareous shales breaking into splinters and characterized by the presence of authigenic glauconites. Sedimentary structures
like ripple marks, mud cracks, sole marks and intraformational shale-pebble conglomerates are present. Schnitzer (1969) named these shales as Scorinarayan shales. Dotopar Member is composed of fine grained and thinly laminated friable and calcareous grey shales. Presence of barite nodules and chlorite is reported by Murti (1972) from these shales.

The variation in colour of Gunderdehi shales (red-purple to grey) clearly indicates that the basin experienced fluctuations between oxidizing and reducing environmental conditions. However the greater part of Gunderdehi Formation represents purple shales, which implies that humid and warm climates prevailed in the region during the development of major part of Gunderdehi shales. Apparently quiet conditions of deposition as indicated by the thin laminations were periodically interrupted by high energy storm conditions as evidenced from the presence of intraformational shale-pebble conglomerates. The presence of authigenic barites, chlorites and glauconites has been interpreted as alteration product of volcanic ash in marine environments (Murti, 1987).

(3) Khairagarh Sandstones:

A sandstone unit in between Gunderdehi and Chandi Formations has been reported by Dutt (1964) in the western part of the basin, however it is generally absent in central part of the basin (Murti, 1980; Schnitzer, 1969) or occurs in the form of lenticular bands. These sandstones are coarse grained, gritty
and sub-arkosic in nature, containing authigenic glauconites. Dutt (1964) suggested that an easterly thinning of these sandstone outcrops is either due to original deposition, or to overlap of younger formations. The beds having a dip of $5 - 10^\circ$ northwards.

The presence of coarse grained sub-arkosic sandstones in calcareous, argillaceous Raipur Group indicates changes in tectonic pattern. These changes are local as is evidenced by limited occurrence of Khairagarh sandstones. Subarkosic nature indicates quick burial and little reworking. Current bedded structures indicates high energy conditions.

The cycle 2 and 3 of Schnitzer (1969) are represented by Karuid I and II limestones and shales and Akaltara and Lilagar limestones and shales respectively. These units are not reported by Dutt (1964) and Murti (1987) from the western or central part of the basin respectively.

Karuid I limestones are dark coloured and flaggy in nature, about 150 m thick and overly conformably the Sarangarh-Seorinarayan cycle, while the shales of the Karuid II cycle consist intercalations of siliceous limestones and are characterised by ripple marks.

The Akaltara and Lilagar limestones and sandstones placed in cycle-3 by Schnitzer (1969), are characterized by
stromatolitic limestones and shales, with a basal sandstone unit occurring below Akaltara limestones.

(4) Chandi Formation:

The Chandi Formation of Murti (1980) is equivalent to Raipur Formation of Dutt (1964) and includes Bhatapara and Nandini dolomites and limestones of cycle 4a of Schnitzer (1969, Table-III). This Formation overlies Gunderdehi shales with a gradational contact. Prolific growth of stromatolites makes this Formation an important key horizon for biostratigraphic correlation. This formation has been subdivided into three Members, viz; Newari, Pendri and Nipania in the ascending order.

(a) Newari Member:

The limestones of Newari member are pink coloured, stromatolitic, and conformably overlie the Gunderdehi shales or Khairagarh sandstones. Dolomitization along joints is occasionally seen within these limestones.

(b) Pendri Member:

The pink to purple limestones of Newari member, becomes greyish and fine grained upward and have been grouped under Pendri member. Grey shales are commonly associated with these limestones. These are characterised by branching columnar stromatolites. This member corresponds to Bhatapara limestones of Schnitzer (1969).
(c) Nipania Member:

This member constitutes purple mottled limestones intercalated with purple shales, which corresponds to Nandini limestones of Schnitzer (1969). Sedimentary structures like stromatolites, stylolites and desiccation cracks are commonly present. Nipania Member grades upward into Tarenga Formation.

The overall calcareous nature of Chandi Formation indicates higher rates of chemical weathering in the provenance, subsequently restricted supply of clastics and warm temperature. SH-V type stromatolites near the contact of Gunderdehi indicate open intertidal setup, and occasional branching LLH type support the protected intertidal setup. Uniform luxuriant widespread growth of stromatolites in Chandi indicates stable environments of their deposition (Murti, 1987).

The intercalation of purple and gray shales in Nipania and Pendri is an evidence of the fluctuation of the basin between oxidizing and reducing environments. The dolomitization of Chandi limestones is considered as secondary by Shukla et al. (1970), while Adyalkar and Dube (1978) proposed both early and late diagenetic dolomitization. Murti (1987) also observed both diagenetic and epigenetic dolomitization of limestones of Chandi, and proposed in-situ source of magnesium. The uniform thick sequence of carbonates of Chandi reveals an intertidal setup with gradual sinking of basin (Murti, 1987).
(5) **Tarenga Formation** :

Tarenga Formation (100 m) overlies Nipania Member of Chandi Formation and is represented by pink shales with interbedded chert. Shales laterally change to clays at places, which contain glauconite. Tarenga Formation corresponds to Patharia-Umariya cycle of Schnitzer (1969). Das et al. (1989) have reported occurrence of bedded reddish brown argillaceous dolomites in the northwestern part of basin and have correlated it with Tarenga Formation.

Tarenga shales are probably a result of terrigenous supply in the basin, and development of oxidising conditions as indicated by their colour. The clays (montmorillonite) and cherts of Tarenga according to Murty (1987) were formed by the alteration of volcanic ashes in marine environment. Das et al. (1989) suggested arid to semi-arid, oxidising, tidal flat environmental conditions for this formation.

(6) **Kodwa Formation** :

In the western part of the basin (Nandini-Bemetra Section) two more Formations i.e. Kodwa and Dotu have been reported by Das et al. (1989). The Kodwa Formation (70 m) conformably overlies the Tarenga Formation with a gradational contact. This Formation is represented by argillaceous grey dolomite/dark grey dolomite and black shales. Das et al. (1989) have correlated this Formation with Hirri-Kharkhena cycle of Schnitzer (1969).
The grey dolomites of Kodwa Formation show luxuriant growth of stromatolites. The stromatolitic columns are separated by black chert at many places. Presence of intraformational conglomerates within this formation indicates conditions of high energy tidal currents (Das et al. 1989).

(7) Dotu Formation:

The Kodwa Formation grades upward into Dotu Formation, which is composed of reddish brown shales interbanded with argillaceous dolomitic limestones and chert (Das et al. 1989). The lower part of this formation is mainly gypsum bearing as revealed by bore-wells. This Formation is correlated with Maniari shales of Schnitzer (op. cit.).

Gypsum occurs in cyclic periodicities with thickness of the individual band varying from less than 5 mm to 40cms, as distinct beds, as well as stringers or veins. The colour varies from white to honey coloured with different varieties like selenite, alabaster and satin spar. The cumulative thickness of gypsum band is about 6 m. (Das et al. 1989).

REGIONAL CORRELATION AND AGE OF CHHATTISGARH SUPERGROUP

In Peninsular India, extensive development of Proterozoic basins is seen, which overly low to medium grade metamorphics and are surrounded by mobile belts. These basins are Cuddapah-Kurnool, Vindhyans, Godavari-Pranhita Rift Basin, Bhima, Kaladgi, Indravati, Chhattisgarh, Kolhan and others.
basins of Jeypore-Bastar region.

These Proterozoic basins are characterized by the presence of orthoquartzites (often glauconitic), shales and limestones/dolomites sequences representing characters of shallow marine sedimentation. In spite of several attempts their intrabasinal correlation and sequential order in Proterozoics has not been fully attained. Earlier workers such as Ball (1877) and King (1885) have correlated Chhattisgarh sediments with Vindhyans on the basis of occurrence of porcellanites and glauconitic beds, while Blanford (1969-70) considered them coeval to Penganga of the Pranhita-Godavari Valley.

In the following paragraphs the geochronological data and stromatolitic assemblages available in the literature, are reviewed and on these basis an attempt is made to correlate sediments of Chhattisgarh basin with other basins (Fig. 3).

The occurrence of stromatolitic assemblages, Gymnosolen, Jurusania, Anaberia, Conophyton, Kussiella, Inzeria etc. characteristic of Early Riphean age i.e. 1600 ± 50 m.y. to 1300 ± 50 m.y. in Cuddapah basin lead Gururaja and Chandra (1987) to infer an Early Riphean to Late Riphean age for these sediments (i.e. 1600-900 m.y.). While Rb-Sr dating of basic lavas has revealed that base of Cuddapah system is not younger than 1555 m.y. and is as old as 1700
The image contains a diagram representing geological strata and sedimentary sequences. It appears to be a part of a page discussing the Chhattisgarh Supergroup and its equivalent sedimentary sequences. The diagram includes various rock formations and their depths, with labels indicating different geological units such as sandstones, quartzites, and cherty to flocation limestones. The text and labels are related to the geological formations and their stratigraphic positions.
m.y. (Crawford and Compston, 1973). Aswathnarayan (1962) has also inferred an age of about 1600 m.y. for Cuddapahs.

The stromatolites (Collenia columnaris, Conophyton cylindericus) reported from Kajrahat Limestones of Lower Vindhyans belong to Early Riphean (Kumar, 1976; Raha, 1987), while microbiota reported from limestone members of Sirbu shales have resemblance to Middle to Late Riphean assemblages (Kumar, 1976; Raha, 1987). Thus on these grounds it is inferred that Vindhyan sedimentation continued from 1600 m.y. to 900 m.y. The geochronological data also indicate a rough estimate of 1400-900 m.y. (Soni et al., 1987) for the Vindhyan sedimentation. Therefore, it is most likely that sedimentation in Vindhyan and Cuddapah basins started nearly concomitantly.

The stromatolitic assemblages so far recorded from the Chandi Formation of Raipur Group (Tungussia, Baicalia, Colonella, Kussiella), and Jagdalpur Formation of Indravati Group (Conophyton, Colonella, Tungussia, Kussiellida) belong to Late Riphean to Vendian affinity (Ramakrishnan, 1987; Raha, 1987). Hence these two Formations have been considered coeval.

Another Proterozoic basin occurring in Karnataka-Andhra i.e. Bhima basin, although has not yet revealed any stromatolites, however has been correlated with the Charmuria Limestone Formation and Kanger Limestone Formation of Chhattisgarh and Indravati basins respectively, merely on ...
basis of lithological similarities (Schnitzer, 1969).

The radiometric age dating of authigenic glauconites of Chaporadih Sandstones has given K-Ar age of 700-750 m.y. (Kreuzer et al., 1977). Whereas age deduced on the basis of pole positions for pink shales of Gunderdehi is likely to be around 1250-1300 m.y. (Murti, 1987). In fact Chaporadihs are older than Gunderdehi shales, and the K-Ar age dating of glauconites from Chaporadih appears to be misleading. Nevertheless Murti (1987) has inferred that Chandarpurs must have been more than 1250-1300 m.y. old.

From the above discussion, it is concluded that unless more correct radiometric datings are not made available, it is very difficult to arrange them in a sequential order. Thus at present there is no alternative other than to follow the views of earlier workers (Dutt, 1964; Schnitzer, 1970; Kreuzer et al., 1977; Murti, 1987), regarding the equivalence of Chhattisgarh with Vindhyans, Kurnools, Bhima and Indravati sequences. This view is based on their lithological similarities, stromatolitic assemblages, and cyclic sedimentation.

**STRATIGRAPHY OF THE STUDY AREA**

The present area of investigation lies in the southwestern part of Chhattisgarh basin, and is covered by the rocks belonging to Chandarpur Group and Lower Raipur Group (Charmuria Formation). The geological map of the area is given.
Plate-I

A  Field photograph of an outcrop of polymictic conglomerates, occurring at the base of Lohardih Formation. Loc. 1 km. west of village Nalpani.

B  Field photograph showing trough type cross bedding in Lohardih sandstones. Loc. railway cutting, south of village Tarod.
Fig. 4 Geological map of Lohara, Durg distt. M.P.

Chaporadih Formation:

A unit of thinly bedded sandstones conformably overlying the arkosic sandstones of Lohardih is readily recognizable in several sections. These sandstones are characterized by their silty nature and ubiquitous development of authigenic glauconite pellets. These are reddish brown to light green in colour, composed of silt size quartz grains, and glauconite pellets, hence named as quartzarenites, sedimentary structures such as microcross laminations, lenticular bedding and desiccation cracks are frequently common (Plate II-A).

Kansa Pathar/Kondkera Formation:

The Kansa Pathar/Kondkera Formations conformably overlie the Chaporadih sandstones. These two Formations represent lateral facies variations and are supposed to be time equivalent (Murti 1987). The sandstones of Kansa Pathar are white siliceous cemented. While that of Kondkera are iron coated and ferruginous siliceous cemented. These are essentially quartzarenites, thick bedded, massive and cover most of the southern part of the study area. Cross bedding (Plate II-B), symmetrical and asymmetrical ripples are frequently preserved. The ripple index (4.3-10) indicates shallow marine conditions of their deposition (Plate IIIA).
Plate-II

A  Field photograph showing occurrence of thin bedded micaceous siltstones (Chaporadih Formation) underlying Kansa Pathar sandstones. Lenticular bedding is clearly visible in these sandstones. Loc. canal section, south of village Sanjari.

B  Field photograph showing large scale trough type cross bedding in Kondkera sandstones. Loc. village Tarod.
Raipur Group:

After the deposition of Chandarpur Group sandstones, the Chhattisgarh basin experienced a change in the environments which is evidenced from the fact that coarse clastics were no more available for deposition, instead fine silty material was derived, and finally culminated to give rise to intertidal-subtidal environments for deposition of thick limestones.

Charmuria Formation:

The Charmuria Limestone Formation has been vertically divided into four lithofacies (Mukherjee and Khan, 1989).

The lowest lithofacies, i.e. Lithofacies 'A' consists of siliceous clays of dirty white to yellow colour, which are massive to thinly laminated (Plate IIIB). The thickness of this facies varies between 2 to 5 m. This lithofacies unconformably overlies Kansa Pathar/Kondkera sandstones of Chandarpur Group and has been correlated with Sirpur clay Member of Murti (1987).

Lithofacies 'B' which is represented by white to buff coloured cherty limestones conformably overlies the lithofacies 'A'. These limestones are thin bedded (0.8 to 2 cm thick) and are well exposed in Kharkhara canal section near Sambalpur (Plate IV-A) but also found in dug wells and road cuttings at villages Andi, Raipura, Kapsi, Sory, etc.
Plate-III

A  Field photograph showing large scale symmetrical ripple marks developed in Kansa Pathar sandstones. Loc. near Ganjerdehi village.

B  Field photograph showing laminated nature of siliceous clays of lithofacies 'A'. Loc. Balod-Lohara Road, at 39th kilometerstone.
Nagri etc. Under hand specimen these limestones are fine grained, thickly laminated to thin bedded and break with a conchoidal fracture. These limestones generally contain pyrite nodules (1 to 8 cms in diameter) with their long axes parallel to bedding planes. Yellowish while chert bands (discontinuous) 3 to 7 cms thick are occasionally developed along the bedding planes, which are also thickly laminated.

Lithofacies 'B' is conformably overlain with a sharp contact by lithofacies 'C'. This lithofacies is represented by phosphorites and phosphatic siliceous clays. The phosphorites are white to pale white coloured, hard, compact and thinly laminated. The thickness of phosphorite unit varies from 0.5-1.0 m. Disseminated specks of pyrite and limonite are characteristically seen in these phosphorites. Occasional desiccation cracks and ripple marks are also present within these phosphorites. The phosphatic siliceous clays are lateral as well as vertical facies variation of phosphorites (Plate IV-B). Phosphatic siliceous clays are dirty white to buff in colour, soft and light in density (Plate V-A), evenly laminated and also contain pyrite nodules. Chert bands are often present within these phosphatic siliceous clays.

Minor warps and joints occasionally present within phosphorites are indicative of secondary deformational stresses. The thickness of this facies varies due to the
Plate-IV

A  Field photograph showing development of thin parallel continuous laminations in cherty limestones of lithofacies 'B', Loc. Kharkhara canal section near village Sambalpur.

B  Field photograph showing outcrops of phosphatic siliceous clays and phosphorites exposed in Kharkhara canal section near village Sambalpur. Note a sharp contact between underlying limestones of lithofacies 'B' and phosphatic facies 'C', demarcated by black line.
lenticular depositional pattern. The unit having a maximum outcrop width of nearly 8 kms and strike length of about 12 kms but not always phosphatic in nature.

Lithofacies 'D' is represented by grey, flaggy limestones and constitutes major part of Charmuria limestone Formation (Platey-B). The contact between lithofacies 'C' and 'D' is covered under thick soil, however borehole data at Kochera. and Papra villages reveal that the lithofacies 'D' is a result of offlap and thus directly and conformably overlies the lithofacies 'B' (Fig. 5).

The limestones of this facies are thinly laminated compact and become shaly in upper parts. This facies is well developed (350 m thick) and represents about 70% of the total thickness of Charmuria Formation.
5. Clay argillaceous limestones. 6. Alluvium/Laterite.

1.5: Schematic panel diagram showing lithofacies distribution in Lohara area. (Based on core well data). For A, B, C, D, E, F refer Fig. 4.
Plate-V

A  Field photograph showing close up view of phosphatic siliceous clays. Note that secondary oxidation has produced yellow colouration, while central part is left unattacked (white coloured). Also markedly seen are the animal borings (marked by arrow). Loc. Kharkhara canal section near village Sambalpur.

B  Field photograph showing thin bedded flaggy limestones of lithofacies 'D'. Loc. village Bhimkanhan.