CHAPTER : 2

GEOLOGY

2.1 GEOLOGY OF THE CHHATTISGARH BASIN:

The Chhattisgarh basin is located within the Central Indian Precambrian Shield. This shield comprises two cratonic blocks: the northern Bundelkhand block and the southern Bastar block. The craton is bounded to the northeast by Mahanadi Graben, to the southwest by Godavari Graben, to the northwest by Satpura mobile belt and to the southeast by Eastern Ghat mobile belt (Ramkrishnan, 1990) (Fig. 2.1). Deccan Trap flood basalts overlie the Precambrians of Bastar craton to its west.

Chhattisgarh Supergroup of rocks and equivalents are the latest episode of Precambrian supracrustal platformal deposits in the Bastar craton occurring along its eastern margin. The sedimentation in Chhattisgarh basin, was initiated with formation of proto-basins in the eastern margin during the Lower Riphean Period (Das and D'Suza, 1990) probably in response to tectonic activity in NNE-SSW trending Eastern Ghat mobile belt in the east and the NNW-SSE trending Sonakhan greenstone belt in the west (Das et al., 1992). Chhattisgarh Supergroup of rocks in the Bastar craton are found to occur in five different basins viz.: the main Chhattisgarh basin, the Khariar basin, the Ampani basin, the Inoravati basin and the Sabari basin (Fig. 2.1).
Fig. 2.1 Central Indian craton showing Chhattisgarh basin and its surrounding tectonic frameworks (after Ramakrishnan, 1990).

The Chhattisgarh basin covers an area of about 33,000 Sq.Km. with a maximum length of about 300Km. along ENE-WSW direction and a maximum width of about 150Km in south central part (Das et al, 1992). It is a crescent shaped basin within the Central Indian Craton and can be subdivided into two sub basins by the NNW-SSE trending Sonakhan high, viz: Hirri and Baradwar. The Hirri sub basin, referred to as the main basin in the west, having semi circular to elliptical outcrop pattern, while the other small Baradwar sub basin is of sub elliptical shape. The oldest rock formations of the Chhattisgarh basin (Singhora Group) are preserved in two apparently separated embryonic basins- one in Singhora area lying east of Sonakhan wedge, and the other in Barapahar area, NW of Sambalpur (Orissa) having a NE-SW basin axis, situated along the southern margin of eastern part of Chhattisgarh basin.

The entire Stratigraphic succession of Chhattisgarh basin is divided into three groups. The lowermost Singhora Group consisting of four formations of arenite, argillite and carbonate sequence. The middle Chandarpur Group, lying unconformably over the Singhora Group comprises mostly of arenite lithounit, divisible into three formations which grades conformably into Raipur Group at the top consisting of argillite-carbonate suite subdivided into six formations (Fig. 2.2, Table-2.1).
TABLE 2.1: STRATIGRAPHIC SUCCESSION OF CHHATTISGARH BASIN
(After Das et al, 1992)

<table>
<thead>
<tr>
<th>Intrusives</th>
<th>Dolerite dykes</th>
</tr>
</thead>
<tbody>
<tr>
<td>R A P U R</td>
<td>Purple shale with dolomite, dolomitic</td>
</tr>
<tr>
<td>Mantari Formation (70m)</td>
<td>limestone and gypsum</td>
</tr>
<tr>
<td>Hirri Formation (70m+)</td>
<td>Grey dolomite, argillaceous dolomite</td>
</tr>
<tr>
<td>Bilha member</td>
<td>Purple dolomitic argillite</td>
</tr>
<tr>
<td>Tareenga Dagauri member</td>
<td>Green clay, chert and shale intercalation</td>
</tr>
<tr>
<td>Kusmi member</td>
<td>Pink to purple calcareous shale</td>
</tr>
<tr>
<td>Nipania member</td>
<td>Purple and green beaded limestone, purple</td>
</tr>
<tr>
<td>Purple and green beaded limestone</td>
<td></td>
</tr>
<tr>
<td>Grey dolomite, argillaceous dolomite</td>
<td></td>
</tr>
<tr>
<td>Chandil Pendri/Deodongar member</td>
<td></td>
</tr>
<tr>
<td>Gunderhi Andha/Dotoparh member in the middle</td>
<td></td>
</tr>
<tr>
<td>Bagbura member</td>
<td>Predominantly pink, purple and grey shale</td>
</tr>
<tr>
<td>Kasdi member</td>
<td>with limestone intercalations/arenite/buff to green shale member in the middle.</td>
</tr>
<tr>
<td>Charnurla Ranidhar member</td>
<td>Purple limestone (Phosphatic)</td>
</tr>
<tr>
<td>Sirpur member</td>
<td>Cherty limestone and dolomite</td>
</tr>
<tr>
<td></td>
<td>(Phosphatic at places).</td>
</tr>
<tr>
<td></td>
<td>Chert and clay intercalation.</td>
</tr>
<tr>
<td>Kasapathar</td>
<td>Glaucnatic white to pinkish quartz arenite</td>
</tr>
<tr>
<td>Chhapradith</td>
<td>Purple, green, grey and balck shale with siltstone/quartz arenite with shale intercalation.</td>
</tr>
<tr>
<td>Lohardih</td>
<td>Ferruginous purple arkose and gritty wacke arenite with shale partings and conglomerate at the base.</td>
</tr>
<tr>
<td>Chhupali Formation (300m ?)</td>
<td>Stromatolitic limestone and dolomite, variegated shale with minor beaded limestone chert and siltstone intercalations.</td>
</tr>
<tr>
<td>Bhalukona Formation (20m +)</td>
<td>Quartz arenite/siltstone and minor shale</td>
</tr>
<tr>
<td>Sarasipali Formation (60m)</td>
<td>Variegated shale with siltstone and minor limestone</td>
</tr>
<tr>
<td>Rehatikhol Formation (20m+)</td>
<td>Feldspatic arenite. Arkosic arenite metrate at the base.</td>
</tr>
</tbody>
</table>

Unconformity

Archacan and Lower Proterozoic Basin
2.2 GEOLOGY OF THE KULHAN NALA BASIN:

The investigated basin is occupied by rocks belonging to the Chhattisgarh Supergroup. Stratigraphically the study area comprises of the oldest Gunderdehi formation overlain by Chandi formation belonging to Raipur Group of the Chhattisgarh Supergroup. The Gunderdehi formation comprises a lensoid outcrop of arenite member occurring to the southwestern boundary, and the shale member roughly occupying the southern part of the basin. The overlying Chandi formation comprises limestone lithology divided into a lower Pendri member and an upper Nipania member, both showing prolific growth of stromatolites. All these formations are by and large covered by thick laterite capping and/or soil mantle. The geological setting of the Kulhan nala basin (Table -2.2) has been framed on the basis of previous work (Dutt, 1964; Murti, 1987; Das et al., 1992) and the detailed field investigations carried out by the present author (Fig. 2.3).

2.2.1 Gunderdehi Formation:

Pink, purple shale and its arenite (sandstone) intercalations are only the exposed lithological units of this formation.

2.2.1.1 Shale member:

Shales though occupy the southern and southeastern portion of the basin, the absence of outcrops poses considerable difficulty in deciphering the geology of...
Fig. 2.3 GEOLGICAL MAP OF KULHAN NALA BASIN

- Nipania Member
- Chand Formation
- Pendri Member
- Shale
- Gunderdahl Formation
- Sandstone
- Inferred Boundary
- Bedding Joint

Scale
0 5 km
Plate No.1: Closely spaced joints in pink purple shale in Mahanadi Main Canal section 1 Km NE of Kukra village.

Plate No.2: Shale exposures in Mahanadi Main Canal, 1Km. NE of Kukra village. This type of joints impart secondary permeability to the rock.
Plate No. 3: Pink, splintary shale exposed in bala cutting near Piparhatta village showing prominent set of joints parallel to the bedding.

Plate No. 4: This well section shows complete weathering profile comprising altered shale at the base followed upwards by lithomargic clay 'Chhui' and laterite.
area. Only a few isolated outcrops of shales are observed in a largely soil covered terrain. The pink, purple shale is exposed along the Mahanadi Main Canal Section from Dhamni to Beldar Seoni. Small exposures of shales are also found in the Kulhan nala section. The other localities are Sakari, Murra, Dhansuli, Bureni, Kukra, Digari, Kotrabhata and Piparhatta (Plate No. 1, 2 & 3).

Megascopically it is commonly purple coloured, with minor greenish grey, buff, and dark brown coloured associates. They are laminated, compact, very fine to medium grained, thickly bedded, calcareous and effervesce readily with acid (dil. HCl). It is impermeable in nature and weathers into thin pencil like splinters. Slaty clevage and closely spaced joints make the rock extremely fragile (Plate No. 1&2). The purple colour can be ascribed to the presence of considerable amount of ferrigenous matter. The shales are generally capped by a blanket of lateritic regolith, followed by a thin bed of yellow clay locally known as "Chhuii" (Plate No. 4). This mantle may have been formed due to the weathering of calcareous shales and leaching out of the carbonate (Plate No.4). Towards the top, purple shales become arenaceous and carry bands of ferrigenous sandstone.

Microscopically, it is highly ferrigenous, illsorted, with about 20-30% of quartz and rest clayey matter. The compositional bands are indicated by alternate ferrigenous
Plate No. 5: Photomicrograph of Shale (Mid-Mix position)

Plate No. 6: A panoramic view showing exposures of sandstone near Kharkhari dih village.
Plate No. 7: Exposure of sandstone in a quarry near Ganaud.

Plate No. 8: Exposure of sandstone along a quarry face near Ganaud village. Presence of vertical joints seen towards the left imparts the rock a secondary permeability.
and less ferruginous laminations. The quartz grains show imbrications along the compositional bandings. Detrital quartz is highly angular. Micaceous grains occur as minor constituents (Plate No. 5).

2.2.1.2 Arenite member:

The entire thickness of the shale is marked with minor intercalations of arenaceous bands i.e. of ferruginous sandstones occurring as arcuate-shaped outcrops. Scattered outcrops are noticed along the high ground on either side of the Mahanadi Main Canal Section from Khola to Kusumkhuta. Small exposures of sandstone are also found near Banjari, Paunta, Ganaud, Birbira and 800m north of Bureni village.

Megascopically these are purple to maroon coloured, coarse grained rocks, commonly show horizontal bedding and current bedding. Abundant ferruginous matter imparts the rock a "rusty look" on weathering (Plate No. 6&7).

The closely-spaced joints facilitate easy quarrying into thin slabs. These arenites are lenticular and extend for a distance of few meter to as much as 20km along the strike and are upto 1.5km wide. The thickness varies from few cm. to 15 meters (Plate No.8). The sandstone is sub arkosic, containing about 20% of orthoclase feldspar. According to the earlier worker (Dutt, 1964) these arenites have been described as lenses of Khairagarh sandstone, but recent work (Das et al, 1992) has proved that the said arenite occurs in Gunderdehi shale as a separate unit and is not correlative with the arenite of Khairagarh area, which belongs to higher stratigraphic position and has been designated as 'Andha Arenite Member.'
Under the microscope, the sandstone is fairly coarse grained and ferruginous, composed of 60% quartz and 30% clasts. This can be a shale clast and 10% matrix. The cementing material is siliceous to ferruginous. Quartz grains are well rounded and uniform in size. They are highly indurated and show extensive wide overgrowth (Plate No.9). The rock may be compositionally classified between lithic wacke and quartz wacke.

2.2.2 Chandi Formation:

The Gunderdehi Formation is succeeded conformably by Chandi Formation with a gradational contact. This formation is characterised by prolific growth of stomatolites. The Chandi Formation in the basin under study, is represented by Pendri and Nipania members.

2.2.2.1 Pendri member:

The limestone belonging to Pendri member is grey in colour, stromatolitic, exposed on the left side of the road about 100m away from village Dondekhurd. Stomatolites are fairly large in size (8") with 12" diameter on cross section and are branched, with circular or elliptical on plan. The master joints have $S\ 80^\circ\ E-N\ 80^\circ\ W$ and $N\ 10^\circ W - S\ 10^\circ E$ trends, while smaller joints have $N\ 50^\circ E$, $S\ 40^\circ E$ and $N-S$ trends. Joints curve each stromatolitic column. Horizontal joints marked by clay indicate phases of deposition, but the colony is undisturbed.
Fig. 2.4

![Diagram of a quarry face showing layers of sedimentary rock and water table positions.]

Fig. 2.5 Schematic diagram of a quarry face at Palthri mine.

Key:
- Grey shale
- Grey limestone
- Shale Pocket
- Shaly limestone
- Original water table
- Present day water table
Plate No. 9: Photomicrograph showing extensive overgrowth in quartz. Locality: Banjari village (40x - X1 position).

Plate No. 10: Exposure of grey cement grade limestone (Zundal member) in Patchri mine. The quarrying necessitates pumping out of accumulated water, which has partly raised lowering of water table in the adjoining area.
In this locality, a small outcrop of thin sandstone, measuring 25m x 10m is exposed over the limestone (Fig. 2.4). It is reddish brown in colour and highly ferruginous in nature. This is the sandstone unit which is lateritised extensively over the entire study area. At most of the places, only laterite is preserved over the limestone, not the sandstone. In the land where laterite is totally eroded away, clayey soil exposed over limestone are found, which are presently being utilised for cultivation. At places, swallow holes are formed in limestones due to karstification, increasing the recharge.

The limestone exposed in Patthri mines near village Patthri is dolomitised, dark in colour, massive and is associated with minor intercalations of shales. The dolomitization process has produced secondary joints and cracks, which are filled with calcites. The mine covers an area of 500 x 500m and is 50m deep. It is producing high grade cement limestone. A sketch of the mine floor is given in Fig. 2.5 (Plate No.10).

The other isolated outcrops are present 1km NW of Pindraon inspection Banglow, small pockets of grey stromatolitic limestone are seen between Pauni and Mangsa, where a few grains of pyrite crystals are found scattered in this locality.

Megascopically they are fine grained associated with grey shale intercalations (Plate No. 11). The limestone is dolomitized. Occurrence of stylolites and calcite veins are
Plate No. 11: Gray shale intercalations in Pathri Mine. Presence of lensoid bodies of Gray shale, lacking joints, reduces storage capacities of the area.

Plate No. 12: Stylolite structure in Pendi member. Locality - Dondekala.
a common feature of this member (Plate No. 12 & 13). Karst features such as grike and clints (Plate No. 14) are also very common. Pendri member grades into the overlying Nipania member.

In thin section, it appears muddy with coarse micritic patches interspersed with round or convolute patches of micrite and sparite mixtures. Calcite vein is also observed (Plate No. 15). Patches with a good degree of dolomitization as evidenced by euhedral shapes of crystals are seen (Plate No. 15). At places, development of green diagenetic chlorite and patches of red micrite portions where more ferroin calcite is present are observed. Opaques such as pyrite occurring as euhedral crystals are also noticed. This may be classified as mudstone as per Dunham's (1962) classification. It shows "non fabric selective - sinuous fracture porosity."

2.2.2.2 Nipania member:

The limestones of this member are exposed to the west and south of Mandhar, which is of cement grade and is being mined for the cement plant located at Mandhar. Other exposures occur in Kulhan nala section, NE of Ninwa, Bhursada, 500m NE of Kirna, S 50°W of Bahesar, around Sontara, Dhansuli and Tarwa villages.

Megascopically this member consists of coarse to medium grained, purple limestone, with mottled appearance. Stromatolites and stylotites are the common features (Plate No. 17). Under karst features sinkholes are commonly observed (Plate No. 18 & 22).
Plate No. 13: Calcite veins and extensive jointing observed in Pendri member near Dondekala village.

Plate No. 14: Karst feature (Grike and Clint) in Pendri member, Near Dondekala village.
Plate No. 15: Photomicrograph of Pendri member showing calcite vein (40x -XL position)

Plate No. 16: Photomicrograph of Pendri member showing dolomitization, evidenced by euhedral form of the grains and ferroin calcite crystals. (40x-XL position)
Plate No. 17: Exposure of Nipania member—pink, purple stromatolitic limestone near milepost 11/7 on Raipur—Balodabazar Road.

Plate No. 18: Joint controlled solution structures near village Lakhana.
Microscopically, this limestone shows alternate micrite and sparite layers also alternating with layer of dolomite spars. It is clayey in nature and also shows diagenetic chlorite (Plate No. 19 & 20). Dolomite rhombs are euhedral in shape, which possibly contain calcite inclusions which make them cloudy. It also shows patches of micrites and sparite mixed matrix between the dolomite grains. As per Folk's (1962) classification this could be called as sparry limestone. The limestone shows "fabric-selective intercrystalline porosity" along the dolomite layers and "intergranular porosity" in layers where micritic laminations have been replaced by sparry calcite.

The shale-sandstone sequence overlying these limestone are of limited vertical extent but its gentle and undulating dip extends it over a large area. The shales are pale green, buff, grey and white in colour. They are commonly micaceous and sandy but towards the bottom they are highly calcareous and gradually pass into the lower stromatolitic limestone. The shales are conformably overlain by ferrigenous sandstone. The sandstone is thinly bedded and shaly at the bottom, but more ferrigenous and thickly bedded (10-60cm) towards the top.

2.2.3 Laterites:

Laterites occur as small cappings over the sandstone, shale and limestone and its contact with the underlying formation is always sharp. The lateritic capping over the sandstone is generally very hard. Over the shale it is soft.
Plate No.19: Photomicrograph of Nipania member showing anhedral Calcite crystals and opaque pyrite crystals (darktoned) (40x -XL position).

Plate No.20: Photomicrograph of Nipania member showing dolomitization evidenced by euhedral form of the grains (40x-XL position).
clayey and more ferrigenous, while over the limestone it
gradually passes into pisolitic ones with lesser amount of
clayey materials. It's thickness varies from 1-5 meter
(Plate No. 21).

2.2.4 Soil and Alluvium;

The alluvium is restricted to the course of Kulhan
nala and extends laterally for about 500m to 1km. on either
banks. It comprises gravel, sands and sandy clays varying in
thickness from 2-5meters. The cultivated areas are generally
covered by grey loamy soil measuring about a meter in
thickness.

** ** **
Plate No. 21: Laterite capping on Nipania member. Panoramic view taken from Baradera village.