Chapter II

GEOLOGY OF THE AREA

From the preceding chapter it would be seen that, with the exception of Kedar Narain (1961), no other investigator carried out studies on modern lines in the area under review. Their work had, in general, an economic bias and they covered vast areas in their preliminary regional studies. Consequently, they simply described a few lithological types of the region and did not pay much attention to the stratigraphic sequence, differentiation of various lithological units, and the geological structure. An attempt has, accordingly, been made here to establish the stratigraphic sequence of the area, as it has an important bearing on its structure.

As the area is highly folded, extensive use has been made of the top and bottom criteria, in working out the stratigraphic sequence. The study of cross-laminations, flute casts, ripple marks, bedding and cleavage relationship etc., has yielded exceedingly gratifying results. Throughout this work Shrock's (1942) 'Scouring in Layered Rocks' was consequently a veritable bible to the author. Billings' (1960) excellent work on structural geology was also extensively used.

Kedar Narain (1961) has suggested an unconformity between the 'Parsoi Formation' and the overlying succession of the 'Bijawar Series' mainly comprising limestones
and banded-haematite-quartzites. No reason or justification was given by Narain for suggesting an unconformity between the two formations, on the other hand, demonstrated that, apparently, there is no reason to suggest an unconformity between these two formations. Instead, it appears that there is regular change of facies from south to north. The argillaceous sediments give way successively to calcareous and ferruginous-arenaceous sediments as one proceeds upwards in the succession. Such changes are a common feature in any basin of deposition, and need not be interpreted as unconformity or even a break in sedimentation.

Stratigraphic Nomenclature

Pending the standardisation of the Indian Stratigraphic Nomenclature, the code recommended by the American Commission on Stratigraphic Nomenclature (1961), is used informally for classifying the rocks of the study area. In the absence of any fossil or data on radiometric age, the only basis available to classify these rocks is into rock-stratigraphic units. The rocks of the investigated area comprise two distinct lithological assemblages, each being mappable laterally on a scale 1:25000, as mapping on a scale of this order is essential for establishing a 'formation' (Code, 1961, Article 6d, p.650). The underlying assemblage is composed essentially of interbedded phyllites and argillaceous sandstones, which have undergone,
in general, a low grade metamorphism. This sequence of rock assemblages is characterised by the lithological homogeneity and well preserved sedimentary structures. The overlying assemblage is mainly of limestones, and banded-haematite-quartzites and brecciated quartzites. Thus, these two lithological units possess the requisite qualifications of a 'formation' (Code, 1961, Article 6, p.650). Following these recommendations (Code, 1961, Article 10e, p.652), names are suggested here for these two formations after the localities where the best outcrops occur. The available literature about the adjacent areas in the Son Valley suggests that the best exposures of the lower formation are seen near the Parsoi village (Mathur, 1950). The upper formation, on the other hand, is best exposed in Tatapahar in the Siddhi district of Madhya Pradesh (Garalapuri, 1965), which lies about 30 km west of the present area. According to Article 10 of the code (1961, p.652) "When geographic names (see remark h) are applied to such informal units as oil sands, coal beds, mineralized zones, and informal members (see Articles 4f and 8a), the unit term should not be capitalized", and 'geographic names should not be combined with the term 'formation' in informal nomenclature. A lithologic term is, therefore, used instead of 'formation', after the geographic name for the rock units exposed. The underlying formation is mainly composed of phyllites and the overlying formation is mainly composed of quartzites. Therefore,
the lower formation has been designated as 'Parsoi phyllite' and the upper one as 'Tatapahar quartzite'. For these two formations Kedar Narain (1961) had suggested the names, the 'Parsoi Formation' and the 'Bijawar Series' respectively.

As stated earlier, previous workers (see chapter I) had assigned these rocks to the 'Bijawar System'. The 'Bijawar System' of the type area comprises basal quartzites (locally conglomeratic), hornstone breccia, siliceous limestone, which are succeeded upward by ferruginous sandstone, banded-haematite jasper and dioritic trap (Pascoe, 1950, p. 286-287). This compares favourably with the upper formation i.e., 'Tatapahar quartzite' of the area studied, where also these rock types occur extensively in a same sequence. Moreover, lava flows in both the areas have yielded ages of 2.4 b.y. (Crawford, 1969) and it may be reasonable to presume that these simultaneous igneous activities took place in different parts of the same geosyncline, i.e. the Bijawar and the area under review were parts of the same geosyncline. This may justify their correlation, albeit with reservation.

It would follow that the equivalents of the underlying 'Parsoi phyllite' are not exposed in the Bijawar type area. It is, therefore, propose to tentatively refer to these formations in the area under review to the 'Bijawar System' till such time as a firm and reliable basis of correlation is proposed and is found acceptable.
For the reasons mentioned earlier, the usage of the term 'System' is improper, as it is a Time-Stratigraphic unit. Instead, a suitable 'group' name, which is higher in rank than a 'formation' is called for. It is tentatively suggested that rocks higher in rank may here be referred to informally as the 'Bijawar group', thereby retaining the geographic name 'Bijawar' given by the earlier workers. The suggested stratigraphic sequence of the Parsoi area is given in Table I.

General Characters

The 'Bijawar group' of rocks, as pointed out earlier, occurs as a number of parallel ridges striking in an east-west direction. The regional dip of this group of rocks is from 60°S to 70°S; a lower value of dip locally in this area is taken to be a result of a plunge of the fold axes. The contact of the 'Parsoi phyllite' with the superjacent limestones and banded-haematite-quartzites of the 'Tatapanhar quartzite' is always conformable. Broadly speaking the lower formation is exceedingly monotonous in character, also perhaps in thickness, over a vast extent of the area. They are composed of an apparently homogeneous complex of interbedded sedimentary units. However, different strata often show variations in the proportion of sandstone and phyllite. This, together with the internal sedimentary structures, permitted the recognition of subformational members in the 'Parsoi phyllite'. Also, lithologies are always gradational. All the rocks types have been subjected to low grade
metamorphism and are uniformly folded, and in general, the deformation is severe. On the other hand, massive, 'competent beds show very little contortion when compared to the schists and phyllites. At some places, the phyllites have developed good sets of cleavages. The Parsoi phyllites appear to be divisible into: a lower member, dominantly of phyllites and are very fine-grained and of an upper member comprising thin alternate bands of argillites and metamorphosed sandstones or siltstones. The 'Parsoi phyllite' is thus a mass of argillaceous rocks, occupying a large part of the area under investigation. The overlying 'Tatapahar quartzite' covers a considerably small area. The predominant rock types of this formation are banded-haematite-quartzites, banded-haematite-jasper-quartzites and brecciated quartzites. The carbonate rocks, which form the lower part of the upper formation, occur in subordinate amounts, and are but rarely present. Thus, the upper formation comprises mostly ferruginous rocks.

Lithology and Field relations

Phyllites, Schists and thick-bedded Sandstones:

Phyllites and schists (plate I, Fig.1) constitute the bottom most rock-unit in the underlying formation. Although the phyllites are generally brown, beds of red, dark grey, purple and greyish white colours are not rare. Typical exposures of dark grey or black slate are found near the
TABLE I

SUGGESTED STRATIGRAPHIC SEQUENCE OF THE PARSOI AREA

<table>
<thead>
<tr>
<th>Vindhyan System</th>
<th>Semri Series</th>
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<tr>
<td></td>
<td>(Semri Series)</td>
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<tr>
<td></td>
<td>(Kajrahat Limestone)</td>
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<tr>
<td></td>
<td>(Bleaching Shales)</td>
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<tr>
<td></td>
<td>(Basal Quartzites)</td>
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<td></td>
<td>(Basal Conglomerates)</td>
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<tr>
<td></td>
<td>Unconformity</td>
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<tr>
<td></td>
<td>Faulted at some places</td>
</tr>
<tr>
<td>Flows &amp; Intrusives</td>
<td>(Metabasites, dolerite dykes, epidiorites and quartz veins)</td>
</tr>
<tr>
<td></td>
<td>(Brecciated quartzites with iron ores, Banded-haematite-quartzite and Banded-haematite-jasper-quartzite at places)</td>
</tr>
<tr>
<td></td>
<td>(Crystalline limestone and Marble)</td>
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<tr>
<td>Bijawar group (formerly 'Transition Series')</td>
<td>(Banded argillite with thin intercalations of meta-sandstones, Thick-bedded sandstones)</td>
</tr>
<tr>
<td></td>
<td>(Phyllite, quartz-mica schist and occasionally black slate)</td>
</tr>
<tr>
<td>Basement unknown</td>
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Khenjuar village and its adjacent localities. Bedding laminae in these rocks are scarcely recognised, and are subordinate to the cleavage at certain places. Occasionally a few sedimentary structures are preserved in these beds.

A thick bedded sandstone, with interbedded thin phyllites, served as a marker horizon and proved to be by far the most important bed for deciphering a number of major folds in the southern part of the area. Typical exposures of this member can be observed in the newly constructed Chopan-Katni railway cutting (plate I, Figs. 2 & 3). Also, it can be traced right through Magardaha railway station up to Adarakudar village and at Karamsar and Jurra in the nala cuttings. Another band of thick sandstone is found near Sukra village, and this can be traced at Bakia and other places. However, its continuity is sometimes not seen on the surface because of soil cover. These beds are of fine to medium-grained quartz wacke sandstones, varying in colour from greyish black to brown and retaining most of their primary textural characters. Generally speaking, brown sandstones predominate over the other varieties. Greyish black sandstones are also prominent at certain places. The best exposures of the greyish black variety are noted near Magardaha railway cutting, and near Arangi and Kharar villages. Also, it is comparatively well developed in the southern part than in the northern part of the area.
Occasionally there are ripple marks, ripple-drift cross laminations, flute casts and load casts etc. on these beds.

**Thickness frequency distribution of sandstone and phyllite:**

The thickness of 206 beds of sandstone and phyllite (interbedded), were measured along the railway cutting, at the following localities: 1. section A - near Magardaha railway station, 2. section B - 45 meters east of Magardaha railway station, and section C - near Adarakudar village.

In all these sections the sandstones appear to be cyclic repetitions in varying thicknesses. It would be legitimate to point out that true rhythmic variations in thicknesses of sandstones and shales is not known from many recognised and well studied turbidite sequences, for example, the Puente Formation of California (Anderson and Koopmans, 1963, p. 837) or the flysch sediments studied by Sujkowski (1957, p. 549).

The sedimentary member studied comprises huge, cyclic repetition of sandstone and phyllite beds for several hundreds of meters, and is characterised as a whole by the great thickness of the sandstones than the phyllite beds.

The 206 beds of sandstone and phyllite measured were grouped into 2cm class intervals, and the frequencies cumulated and plotted on the logarithmic paper (Fig. 4). The total thickness of the above three sections is 60.73 meters. The thicknesses, plotted on the logarithmic paper, indicate log normal relations for they plot as straight lines. Similar
Fig. 4 - Logarithmic probability distribution of thicknesses of sedimentation units. Sandstone beds are shaded circles and open circles refer to intercalated shale (phyllite) beds.

Cumulative Percentages
log normal relations have been obtained from other turbidite sediments (Pettijohn, 1949; Bokman, 1953; McBride, 1962; and Dott, 1963). It can be seen from figure 4 that on the one hand, both the sandstone and phyllite beds decrease in thickness towards the east, and on the other, the thicker beds of both sandstones and phyllites deviate from log normal. Similar observations have been reported from the Martinsburg Formation of the eastern United States (McBride, 1962) and from the Cretaceous flysch sequence of the Patagonian Andes, southern Chile (Scott, 1966).

Banded Argillite:

A marked characteristic of this member is the regular thin bands which are alternately coloured black and grey, tan and sometimes even red (Plate II Fig. 1). The parallel banding of the different colours is due to interlamination of silty, argillaceous and ferruginous material. The stratification bands are often more than 1 cm thick and according to McKee and Weir (1953), the banded argillites may be considered as very thinly bedded. Some of the bands, particularly those which are greyish black in colour, range in thickness from 1 to 3 mm and they may be regarded as very thinly laminated. The other most striking feature of this unit is the ubiquity of internal bedding features like parallel laminations, ripple-drift-cross-laminations, convolute laminations etc. These internal sedimentary structures, in
an upward sequence, occur in a definite order. However, sedimentary structures are rare in the thick bedded sandstone member. The genetic significance of these structures is discussed later.

**Crystalline Limestone and Marble:**

Crystalline limestones which crop out a kilometer north-east of Parsoi, and from there they spread out farther eastward to Arangi. Their relationship with the underlying 'Parsoi phyllite', as well as with the overlying banded-hematite-quartzites, is obscure, since they are completely lacking in bedding. However, their position can be located by means of major structures in the region. The rugged weathering surfaces of these limestones are of great help in recognizing them at some localities. Usually these limestones occur in lenticular masses, and are brownish white in colour though sometimes also red. Because of the selective distribution of colour in these rocks, one may attempt to generalise that the limestones that overlie the 'Parsoi phyllite' are brownish white in colour, but those associated with the traps are commonly reddish. Generally speaking, they range in composition from siliceous to ferruginous, and coarsely crystalline calcitic marble and occasionally to dolomite. Thus, the limestones occurring in Kunwar areas are siliceous, massive and crystalline; whereas those occurring at Chulia and to the west of Chulia are mostly ferruginous.
A calcite vein, about 0.2 km in length, occurs within the crystalline limestone, about three kilometers north of Parsoi (24°26'; 52°54'). The mineral is transparent, but near the exposed surfaces it is slightly iron stained along the cleavage planes. It is possible that calcite has been formed by the dissolution of the limestone and reprecipitation of pure calcium carbonate in cavities in the limestone.

At some places, particularly at Parsoi and Arangi villages, limestones are highly recrystallised, and hence coarse-grained, calcitic marble. Foliation may be noticed near Arangi and may be the result of the appearance of green actinolite.

Banded-Haematite-Quartzite, Banded-Haematite-Jasper-Quartzite, and Brecciated Quartzite:

Quartzites occur at several places in the area and are generally underlain directly by the upper most member of lower formation, though sometimes by the Crystalline limestones, as seen to the east of Kunwar, to the north of Parsoi, and near Arangi, and Kauria. Occasionally, also quartzites rest directly on argillites as at Chulia and Kaspani. Commonly they form the highest elevations in the area under investigation. These quartzite-capped ridges form convenient landmarks, which are very helpful in determining the major folds in the northern region of the area.
Banded-haematite-quartzite occurs at the base of the Brecciated quartzite, and is well seen at Chulia and Parsoi. Quartz and iron ore occur in alternating bands. Such rocks often exhibit well bedded structures. Generally speaking, these rocks are tightly folded at sharp angles. A typical specimen of Banded-haematite-and Jasper-quartzite with small step faulting is shown in fig.1 (plate. VII). The banded-haematite-quartzite is more haematitic near Chulia and Kunwar than at Parsoi. It is composed of grains of specular iron ore (haematite) and greyish brown quartzite, arranged in parallel layers. Quartzite layers range in thickness from a fraction of an inch to an inch. Limonite sometimes takes the place of haematite and imparts a brownish yellow tint to the rock. Banded-haematite-quartzite beds are imper- sistent, and cannot be traced for long distances along the strike direction. Hence it was not found possible to map them separately from the brecciated quartzite beds.

At Chulia this formation is partly represented by banded-haematite-jasper-quartzite, and other outcrops are invariably brecciated. They are composed of fragments of quartzite and jasper, generally angular to subangular in shape. The cementing material is secondary silica and iron oxide. Fragments of banded-haematite-quartzite also occur in the brecciated quartzite. It is probable that crushing has resulted in haematitic powder, which appears as the cementing material and also as fillings of the voids between
the crushed fragments. Cementation by haematite is predominant at certain places. This is seen particularly in the hills near Parsoi. In the Bijul section near Darti, relict bedding planes of banded-haematite-quartzite in the brecciated quartzite are seen even after its brecciation. However, from a distance the horizon appears to be a crushed and a craggy mass, forming chains of hillocks with an east-west disposition. Pure white quartzites, with occasional fragments of red jasper and haematite are seen in the nala bed north of Parsoi. When traced farther east, it is seen to grade crudely into brecciated quartzite.

Nature of Brecciation:-

In this area brecciation seems to be the result of (a) chemical action (b) and tectonic activity.

The former one can be distinguished in the field by the absence of slickensides or association of visible faults. Moreover, it appears that the brecciation of the banded-haematite-quartzite is present only on the surface of the beds and not in the interior. Therefore, in this case, brecciation (Plate VII, Fig.3) was considered to be a result of intense weathering. Similar, brecciation is described from the Canga area by Dorr et al, (1952 p.286).

Locally, however, brecciation took place apparently by tectonic movement or faulting (Plate VII, Fig.2). Such
localities are noted for the occurrence of strong slickensiding, grooving, deformed fragments and sometimes a distinct association with visible faults cutting across these brecciated quartzites. Important areas for such tectonic activity are Kauria, Arangi, and other places.

**Basic Intrusives:**

Intrusives in the area can be divided into two groups, namely:

1. The unmetamorphosed north-south striking dykes.
2. Basic metamorphosed sills.

One of the longest dykes of the area cutting across the phyllites occurs along the Khairahi nala. It is approximately 3.8 kilometers in length. Other dykes are seen near Semerda, to the north of Khenjuar and are more or less parallel to this long dyke. All the dykes mentioned above occur only in the 'Parsoi phyllite'. They are all doleritic in composition. On the other hand, the sills are epidioritic in composition. The vast majority of them are fine-grained, though some are medium-grained in texture. However, almost all the dykes are narrow and inconspicuous and do not break into branches or offshoots. All the dykes, particularly the one near Semerda village, and with the exception of the dyke running along the Khairahi nala, weather into rounded boulders of various sizes, and sometimes show distinct exfoliation structure. Often their
continuity may be inferred in the field from the occurrence of these isolated bouldery fragments scattered on the surface. Chilling of rocks in the marginal zones of these dykes is not notable, with the exception of the long dyke occurring along the Khairahi nala.

Basic sills have been noticed near the south of Dob and the north of Pipra, as shown on the map (Fig.3a). They run in an east-west direction roughly parallel to the strike of the Parsoi sediments. They are also restricted to the 'Parsoi phyllite' and never occur in the Tatapahar quartzite. In contrast to the dolerite dykes, the sills are subjected to low grade metamorphism and petrographically they may be placed in the category of epidiorite or meta-dolerites.

**Basic Lava Flows:**

Basic lava flows have been noticed in their greatest development near Parsoi and Kunwar and extend up to Kauria village, almost 6 to 8 km in length, along the strike. Their mode of occurrence, the extensive presence of amygdules (plate VI, Fig.4), as well as the complete absence of igneous veinlets in the adjoining rocks whose junction with the lava is clear and normal, reveal that they are not dykes or sills but are subaerial lava flows. Strong folding in the area has induced distinct schistosity in these lava beds, sometimes they are completely altered into schistose rocks. The typical specimens
from the Parsoi and Kunwar areas are green in colour. The vesicles are filled with calcitic material.

**Agglomeratic Trap:**

An excellent exposure, nearly 200 meters long, of an agglomeratic trap (plate II, Figs. 2 & 3) is noticed near Kunwar. It occurs above the lava flow and below the purple shale, striking N 70°W to S 70°E with a dip of 70° towards the south. Its strike has a consistently parallel relationship with the strike of the purple shale. Basaltic fragments of varying sizes, with vesicular surfaces, are embedded in a homogeneous trap matrix. They are subspherical to elliptical in shape, range in size from 13 cm to one cm and are usually aligned in a direction varying from N30°W to N 70°E with a plunge ranging from 15° to 65° towards the southeast. It is possible that these subspherical and elliptical inclusions are volcanic bombs and lapilli, that became embedded in the subsequent lava flows. This is supported by the fact that some of them are highly vesicular, and apparently "lost their gases in explosive spurts" (Holmes, 1965, p. 303).