2.1 Introduction

The area records, a complicated geological history pregnant with geomorphological problems where facts are buried in erosion intervals marked by unconformities, the correct interpretation of which can often only be made by analogy and close study of buried landscapes and the existing morphology. The variety of geological formations of the area present numerous topographic expressions. The very formation of the area consists of a series of batholithic intrusions of granite into ancient sedimentary strata known as Dharwars. Granite and gneiss topography dominates most of landscape and widely differs in profile from the flat topped topography of the volcanic Rajmahal and Sangai river areas. The Dalma lawa flows present a different kind of landscape. Newer dolerites and dykes of the coalfields at Jharia, Bokoro, Karanpura, etc., also present a different kind of landscape. In short, this is a region of great inequalities having plateaux of different altitudes, hills and hillocks of varying elevations and intermontane valleys of varying depth and volume.

2.2 Geological Base

Previous workers have stressed the geological aspect of the country and a few of them have attempted a study of the region from the geomorphological standpoint. To Dunn, J.A. (1931) and to Dey, A.K. (1942) may be attributed the credit of having made references to and suggestions of geomorphological ideas which form the starting point of this study. The Manual of the Geology of India and Burma, Pascoe, E.H. (1950), provides an up-to-date knowledge of the geology of the area. Dunn, J.A. (1931) has outlined the physiography of Bihar, where he says, "some understanding of the causes underlying stream activity and land surface movement is essential." The first
A geomorphological article of some worth was attempted by Chatterjee, S.C. (1946), when he suggested that the Ranchi plateau was a rejuvenated peneplain. Chatterjee, S.P. (1940) contributed a paper on the, ‘Gneissic-topography of the Ranchi plateau’ in which on incomplete evidence he suggested the existence of four peneplains and states that the two middle peneplains, “are inclined position intersecting the other peneplains at various angles” (Bose, N.K.1940). N.K. Bose in a rejoinder pointed out that these terrace-like formation are not “depositional river terraces”, but are the result planation and subsequent headward erosion of the rivers on the plateau. S.C. Chatterjee has discussed the origin of some of the prominent features of Chhotanagpur as a whole in another paper. Since 1948 field work in different parts of Chhotanagpur has been done by the author often independently and sometimes accompanied by his teacher, S.C. Chatterjee and his students.

Stratigraphically, Chaibasa plain is composed of geologically ancient rocks of diverse origin, most of which has experienced intense pressures and metamorphism. Structurally, it forms a part of the Stable Deccan Shield which has generally remained unaffected by mountain building movements since practically the close of the Pre-Cambrian era. The later changes suffered by the shield have been mainly of the nature of normal and block faulting, resulting in the upliftment of some of its parts and sinking of others. Thus, development of tensional cracks, resulting in the subsidence of linear tracts forming basin-shaped depressions, took place in Upper Carboniferous times in Chaibasa plain as also in other parts of this old gneissic landmass. These depressions received depositions of fresh water and sub-areal sediments, which are now known as Gondwana plain deposits. The plain (both Chaibasa and Chhotanagpur) experienced successive uplifts in Mid-Miocene and Pleistocene times as a consequence of the Himalayan Orogeny.

The structural units are helpful in reconstructing the geological history of Chaibasa plain which has been sufficiently summarised by Dunn, J.A.
(1944) as follows: "A long period of erosion eventing out the irregularities of 
gneissic and granite in Pre-Cambrian land surface; an ice age in Upper 
Carboniferous; major trough faulting in the Permian times that brought into 
being the Kharkai valley when the Gondwana rocks were laid down in fresh 
water lakes; uplift in the hot desertic conditions of Triassic days when some 
fifteen meters of unprotected Gondwana sediments were stripped away and 
massive sandstone of Mahadeva series (Middle Gondwana) were formed; a 
volcanic outburst in the Jurassic; and minor faulting and tearing during Tertiary 
earth movements".

Thus, the area is characterized by 3 broad groups of rock, namely 
the Lower-Cambrian, Archaean and Basic Pre-Cambrian. These are as follows 
(Table II.1).

2.2.1 The Archaean System

The Archaean constitute the greater portion of the undulating area 
in the middle part of the Chaibasa plain. The Archaean represent the oldest rock 
formation in the study-area, constituting the basement on which all subsequent 
rock formation have been laid. These are exposed over proportionally larger 
areas than the others. This formation mainly consists of two rock groups: (i) The 
most ancient metamorphosed sedimentary rock system, i.e. the Dharwar systems, 
comprising schists, crystalline, limestones, marbles and calcsilicates, and (ii) 
widespread granite intrusives, gneisses, etc. Garnetiferous sillimanite, graphits, 
schists. These are located on the Suribasa (510m), Pampara (352m), Bhoyo-
Abru (255m) peneplains, Lli Gara (328m), Kharkai (241m) valleys, Hararango 
hill-complex (862m), Gutuhatu (568m), Lota Buru (626m) pahars in the 
northeast; Manoharpur peneplain (385m), Putung Buru (743m), Rong Buru 
(595m), Jiling Buru (724m) pahars, Petapeti gorge (520m), Ganmor scarp 
(620m), Sanjai (512m) valley in the northwest; Jhinkpani (460m), Jagmnathpur 
(512m) tablelands, Sirlingsia (458m), Satbhalya (416m), Jogi Buru (581m)
FIG. 2.1

CHAIBASA PLAIN
GEOLOGY

LOWER CAMBRIAN
PRE-CAMBRIAN
ARCH-EO-AN

22°15'N

85°45'E

DHANJORI AND DALAMA LAVA

KOLHAN SERIES

GRANITE, GNEISS

QUARTZITE, SHALES, MICA SCHIST, META-VOLCANIC

MICA SCHIST, PHYLLITE, QUARTZITE, ETS.

FIG. 2.1

10 5 1 0 1 0 2 0

Km
pahars, upper Roro Gara (480m), upper Lli Gara (540m), Kongera (450m)
valleys, Kasira

### Table II.I
Geological Formation in Chaibasa Plain

<table>
<thead>
<tr>
<th>Geological System</th>
<th>Formations</th>
<th>Series/Stages</th>
<th>Age (Million years B.P.)</th>
<th>Localities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td>Recent</td>
<td>Newer</td>
<td>Recent</td>
<td>Low-Lying area of plains and valley bottoms of Kharkai and its tributaries</td>
</tr>
<tr>
<td></td>
<td>Alluvium</td>
<td>Alluvium</td>
<td></td>
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<tr>
<td></td>
<td><strong>UNCONFORMITY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Older</td>
<td>Pleistocene (+1)</td>
<td>Out margins of riverine plains</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alluvium</td>
<td></td>
<td></td>
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<tr>
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<td>------------</td>
</tr>
<tr>
<td>Basic</td>
<td>Cuddapah</td>
<td>Iron Ore (400-600)</td>
<td>Lutu Buru, Chaou Buru</td>
<td>pahars, Kharkai valley; etc.</td>
</tr>
<tr>
<td>Pre-Cambrian</td>
<td>System</td>
<td>Series (Dhanjori Lava) ± 10</td>
<td>Chaibasa plain</td>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
<td><strong>UNCONFORMITY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late Archaean</td>
<td>Dharwar</td>
<td>Dhanjori (600-4500)</td>
<td>Maximum parts cover of the Chaibasa plain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Huronion)</td>
<td>Sandstone ± 10</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>UNCONFORMITY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Archaean</td>
<td>Peninsular Tron Ore (600-4500)</td>
<td>Upper Chaibasa plain and basement rocks in the Kharkai basin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gneiss</td>
<td>Series ± 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Cambrian</td>
<td>(Lewisian)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
gorge (517m) in the southeast and Deo gorge (512m), Lutu Buru pahar (862m), Konia (535m) valley in the southwestern valley part of the study-area.

The other Archaean rock-group comprising granites and gneisses are extensively found in the study-area. They vary from wellbanded gneisses to rocks consisting alternate quartz-felspathic and schistone bands, the later types grading into the magamatites (Dunn, J.A.1941). The granites rocks contain microcline, parathite, quartz, palageo, classic and biotite. The accessories include apatite and zircon.

Though there is no precise information regarding the origin of the above-mentioned Pre-Cambrian crystalline rocks, some geologists think that these rocks represent some of the oldest sediments of our planet, while others believe that heterogeneous magma of diverse character and composition. Originally exiting on our planet, was successively erupted into the earth's crust to form the rocks of this group after consolidation. Among these are intrusions of granite which under pressure have assumed a gneissic structure. The Pre-Cambrian crystalline rocks have also suffered considerable faulting, and intrusions of plutonic rocks. In almost all parts of Chaibasa plain, they weather into tors, and are called the “Dome gneiss”.

Associated with the Archean gneisses and schists are found some coarse-grained acidic differentiates of igneous rocks with are widely distributed in the Archean complex of Chaibasa plain. They occur mostly as veins and dykes, intersecting the older rocks, and sometimes as segregation patches in the body of the rock of which they are the differentiates. The acidic granite-pegmatites sometimes attain large dimensions and have found to contain many rare mineral deposits of economic importance, namely mica, ironstone, etc.

2.2.2 The Lower Pre-Cambrian (Iron Ore Series)

The group of sedimentary and extrusive rocks, among which the iron ores occur, was originally designated by H.C. Jones the Iron ore series and certain adjacent more highly metamorphosed rocks were referred to as the “older
Plate II (A) A view of Archaean granite, gneisses in Kharkai river near Murkum, 1.0 km down stream from Satbhalya (416 m)

Plate II (B) A view of iron ore field on moderately sloping surface near Jhinkpani railway station about 2.5 km southeast of Siringsia market
metamorphic series” or “Older Dharwars”, while re-mapping portions of this type area in the Kolhan State and Keonjhar, Dunn, J.A. found that two formations has been included under the term Iron Ore Series. For the older to the two, the name Iron ore series is retained, and for the younger, Dunn, J.A. has proposed the name Kolhan series.

The sedimentary group is best knows and is perhaps best developed in the Bara Guira peneplain (485m) in the northeastern part of the study-area. It is representative of all grades from relatively unmetamorphosed to highly metamorphosed rocks. The associated basic lavas and intrusive rocks are now altered to epidiorites, hornblende-schists, etc. Within the Iorn Ore series, and more particularly. Within the hamatite-quartzites are the great Iron Ore deposits from which the series has derived its name.

2.2.3 The Basic Pre-Cambrian (Intrusive Rocks)

The Basic Pre-Cambrian rocks belong to two chief group: sedimentary rocks associated with lavas; intrusive basic igneous rocks and widespread granite. The sedimentary and basic igneous groups are found only near Dumria peneplain (495m) in the northeastern of the study-area where as the granite is dominant in an southeast direction across the core of Chaibasa plain.

The well-bedded quartzitess from steeply inclined ridges above the alluvium. They are usually accompanied by slates and phyllites. The Dharwars which formed the cover of the batholiths consists of slates, quartzites, phyllites add schists intruded by granite. Quartz-schists, mica-schists, hornblende-schists penetrated by inumerable intrusions of granite occupy dissected edge of the Chaibasa plain. The associated basic lavas and intrusive rocks are now altered to epidiorites, hornblende-schists, etc.

2.2.4 The Basic Pre-Cambrian (Effusive Rock)

The Chaibasa plain lie between the granitic plain and the micaschist plain in a triangular form. It is a extensive plain region of varying elevation of the south but turns a series of low broken ranges in the west. These are located
on the Chaou Burn (660m), Bal Burn (545m) pahars, upper Konia (565m) and Baitarni (450m) rivers in the southwestern part of the study-area.

In general structure, the anticline, is simple throughout except the almost closed dome known as the Pampara anticline. The Chaibasa geo-anticline contains the most intensity metamorphosed rocks of Chaibasa plain. It is in this western region, according to J.A. Dunn (1931), that the strike connection of the rock lying north and south of the main shear zone to the east is found establishing the correlation of the rocks to the north with the Iron Ore Series. The Kolhan Series is much younger in age than Iron-Ore Series. There is no certain identification of the age of the Kolhan Series and Newer Dolerites.

2.2.5 The Recent Alluvium

The younger alluvium is found in the low-lying areas of riverine plains and the valley bottoms of the area. The older alluvium, in contrast, occurs in narrow strips along the outer margins of the riverine plains. These are mostly confined to the lower riverine plains of the Kharkai and its tributaries.

2.3 Evolution of Landscape

Agents of denudation are constantly engaged in altering the surface features of the earth and in carving out different relief features as we see them today, such as valleys, plains, plateaus and uplands. These landforms result due to the interaction of the forces that act within the earth’s crust and those that act upon it. Infact, the surficial expression of landforms depends upon the nature and structure of rocks; climate and the time during which the agents of denudation have at work.

Physiographically, the Chaibasa plain forms a part of the ancient Indian Shield. It has been exposed for long ages to denudation and is once again heading towards peneplanation, as on several occasions in the geologic past. Its plain are relief type; they represent surviving remnants of hardir rock masses which have escaped weathering and removal. The rivers form broad valleys with
shallow channels as they flow over the gentle gradients of the plain, out are characterized by magnificent water falls as they descend the plain and by gorges and entrenched meanders further downstream.

The Chaibasa plain is composed of very old rocks which have been so intensely crushed, crumpled and injected with molten material from below that their mineral structure has been changed entirely, resulting in metamorphosis. The whole plain is studded with residual hills, projections above the surface of the plain. At several places, these residual hills are known as "Dorne gneisses", which represent a striking feature of the landscape. Their formation is due to exfoliation.

After providing a description of the geology and geological history of the area, it has been considered necessary to trace out the morphogenesis of the present landforms. Probably, the world 'morphogenesis' was used first by the Hungarian geomorphologists Pascoe(1950) to illustrate the morphological character of landforms as developed during various stages of the geomorphic cycle. Recognition of morphological phases of landforms is, therefore, largely based on a detailed study of the stratigraphic and structural sequence as also on the appreciation of present landforms in the study-area.

Thus, the following major phases can be conceived in the evolution of landscape in the area:

2.3.1 The Dhanwar Phase
2.3.2 The Mid-Palaeozoic Peneplanation
2.3.3 The Early-Carboniferous Rifing and the Gondwana Depositional Phase
2.3.4 The End-Mesozoic Peneplanation
2.3.5 The Miocene Upliftment
2.3.6 The Pliocene-Pleislocene Upliftment
2.3.7 The Present Phase
2.3.1 The Dharwar Phase

The Chaibasa plain is an ancient land-mass, which has perhaps never gone under sea and has been subjected to long period of protracted erosion. In Pre-Cambrian times, however, the area received depositions of sediments which were later folded and metamorphosed to from the Dharwar rocks. This movement probably took place during the Huronian times. The basement of the Chaibasa plain is composed of the Archaean crystallines, mainly granites and gneisses. These rocks were intruded as a series of bothaliths into the Dharwar rocks which have been largely removed. Though, the Kharkai river did not exist during this period, the drainage of the area flowed eastwards.

A series of east-west ranges extended over the central part of the plain in the Dharwar Phase. These ranges were of considerable elevation, but no exact estimate is possible in view of their great antiquity.

2.3.2 The Mid-Palaeozoic Peneplanation

A long period of quiescence from Pre-Cambrian (Dharwar) to Mid-Palaeozoic times reduced the area into a peneplain. This may be called as the Mid-Palaeozoic peneplanation (Fig. 2.2.1). The outer framework of Chaibasa plain is the product of subsequent structural growth over the denuded Pre-Cambrian (Dharwar) granite and gneissic floor. Top cover of the Archaean fold mountain has been completely removed away in the long interval of time. Thus, the significant tectonic-feature of Leda Buru pahar is the peneplained Archaean mountains.” The peneplained surface emerged only in the south, otherwise it is deeply buried by subsequent accumulation” (Singh, R.P., 1969).

2.2.3 The Early-Carboniferous Rifting and Gondwana Depositional Phase

Trough faulting, resulting in the formation of linear depressions and slight elevation of the adjoining parts in Early Carboniferous times heralded another phase in the area (Fig.2.2.2).
The plain was then occupied by a thick cover of icesheets, indicated by occurrence of hill beds in the area. The ice appears to have covered the irregular surface of Chaihasa plain and drifted towards the east. Movement of ice planed the hills and filled the valleys with debris, thereby obliterating the former lines of drainage. The ice melted in Permian times, thus, converting the linear depressions into a lake through which rivers, sometimes almost lost in stagnant water, wended their way eastward to the sea (Fox, C.S. 1930). Thus, a great era of continental deposition, the Gondwana era, was initiated in the down-faulted depressions of Chaihasa plain.

The total thickness of Gondwana sediments (middle and lower) in Chaibasa plain has been estimated to be about 3600m (Fox, C.S. 1930). Under the weight of the accumulating sediments, the crystalline surface must have sagged below. During the Early Triassic times, the climate became dry and by Mid-Triassic times hot desertic conditions prevailed which resulted in break in deposition. The break in marked by an unconformity at the base of the Mahadeva series. The actual lapses of time was not great, but the adverse condition put an end to the floral life the Lower Gondwana period. It appears that the Gondwana era in the Kharkai region come to an end at the close of the Triassic times.

Since the Jurassic time, normal erosion has it uninterrupted away over the Chaibasa plain. This has resulted in the removal of the Gondwana strata from over the greater part of the plain except the down-faulted troughs where they have been preserved from total erosion. In the faulted basin, the strata dip forwards the south. Their basal beds are not much disturbed and at their deepest lie roughly as 1500m blow the sea level. If these beds are continued northward in the air, they would pass over the top of the Hararango Buru pahar (862m) above sea level (Fox, C.S., 1930).

Most probably the entire Kharkai basin and adjoining area of Chaibasa plain on the west once overlain by Lower Gondwana rocks (Fox, C.S. 1934). In the Middle Triassic period, the Gondwana cover was exposed to arid
erosion which removed about 3000m of Lower Gondwana rocks from the region (Fox, C.S. 1934). As arid erosion is comparatively slow, it is not possible to suppose that the whole succession of Lower Gondwana strata, which had been accumulating there since the Upper Carboniferous time, was eroded away during the short break of the Middle Triassic period.

2.3.4 The End-Mesozoic Peneplanation

By End-Mesozoic times, the vestiges of Early-Carboniferous movement were obliterated and most of the Gondwana deposits, except those in faulted troughs were denuded away. This produced the End-Mesozoic peneplain (Fig.2.2.3). The drainage lines of Gondwana times were superimposed on the crystalline basement and the streams entrenched their course across sills and dykes of earlier ages.

2.3.5 The Miocene Upliftment

The Pre-Tertiary peneplanation was followed by out-pouring of lava which buried the drainage lines in the western part of Chotanagpur highlands (Fox, C.S., 1934). New rivers developed on the lava surface which flowed to the west.

Chaibasa plain continued to be a peneplain throughout the greater part of the Tertiary period. However, in Mid-Miocene times, the area of upper Chaibasa plain was uplifting by about 300m as a consequence of the Himalayan orogeny, (Fig.2.2.4). The Kharkai river whose western portion was buried under lava was once-again cut-off due to the development of a fault-scarp in the west. This uplift was in form of block movement with sharp, warping along the N-S. axis. It also created the eastern edge of the upper plain. At the sometime, a trough developed along the Kharkai valley.

2.3.6 The Pliocene-Pleistocene Upliftment

The End Pliocene times, the Chhotanagpur plain, including Chaibasa plain, were uplifted by another 200m which gave an elevation of about 600m-650m to the upper plain and 375m-400m to the lower plain (Fig.2.2.5)
Thus, Chaibasa plain today represents a good example of multicyclen relief were rivers have been rejuvenated again and again following each interruption in the progress of the cycle. Vertical movements in different parts of the plain region since the Late-Tertiary times have rejuvenated the rivers again and again, resulting in the development of falls and rapids at the edges of the uplifted blocks. It is, however, noted that the rapids of the Deo river, 20.0km above its junction which the Koro river is due to the presence of dykes across the bed of the river.

2.3.7 The Present Phase

The topography in the present phase, appears to be comparatively more dissected (Fig. 2.2.6). The Kharkai river over Chaibasa plain, in fact, show evidence of lateral plantation. The streams have also increased in length due to headward erosion during recent times. The progress of valley widening has narrowed the interfluves and destroyed the last surviving faces of the initial surface. The present surface has development after continuous denudation since the End-Tertiary uplift.

2.4 Summary and Conclusion

Geologically, Chaibasa plain is characterized by 3 broad groups of rocks, namely the Lower-Cambrian, Archaean and Basic Pre-Cambrian. The basement of Kharkai, Gara and Koro valleys are composed of crystalline rocks, mostly granites and gneisses, and Archaean era. Associated with the Archaean gneisses and schists are found some coarse-grained acidic differentiates of igneous rocks which are widely distributed in the Archaean complex of Chaibasa plain. The sedimentary group is best known and is perhaps best developed in the Potung Buru, Chaou Buru and Leda Buru pahars, etc. The Dharwars which formed the cover of the batholiths consists of slates, quartzites, phyllites and schists intruded by granite. The basic Pre-Cambrian-effusive rocks is a expensive plain region of varying elevation in the south but turns a series of low
broken ranges in the west. The Younger and Older Alluvium are mostly confined to the lower riverine plains of the Kharkai rivers.

The following sequence is noted in the evolution of landscape in the area: (i) Folding of Dharwar rocks during Huronian orogeny and intrusion of massive igneous masses during the Pre-Cambrian, (ii) A long period of quiescence from the Pre-Cambrian (Dharwar) to Mid-Palaeozoic times, reducing the area into peneplain, (iii) Trough faulting in the formation of linear depressions and slight elevation of the adjoining areas in Early-Carboniferous times, (iv) Development of the End-Mesozoic peneplain due to obliteration of the vestiges of the Early-Carboniferous movement and removal most of the Gondwana deposits, except in faulted troughs, (v) Upliftment of the western Chhotanagpur highlands, including upper Chaibasa plains, by about 300m in Mid-Miocene times and that of whole of Chhotanagpur highlands (including lower Chaibasa plain) by another 200m in Pliocene times, synchronizing with the Himalayan orogeny. This gave an elevation of about 900m-950m to the upper plain and 450m-600m to the lower plain.

2.5 References


