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Sedimentology of Tertiary and Quaternary Gravel and Sand Beds of Dhalbhumgarh-Chakuliya-Baharagora Area, East Singhbhum District, India

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Abstract: ***Sedimentological study and related mapping on 1:50,000 scale covering an area of 300 Sq.km and toposheet no. 73 J/11 & 12, has been carried out in areas east and south-coast of Dhalbhumgarh (22◦30'22": 86◦33'20") around Chakuliya-Kerukocha-Baharagora, East Singhbhum district, Jharkhand. The studies are aimed at reconstructing the depositional environment of the gravelliferous Tertiary and Quaternary sediments of the area mapping of different morphological elements of the depositional system, indicating areas for search of palaeoplacers. The Tertiary and Quaternary gragels named as "Narsinghgarh Formation", occur unconformably overlying the unevenly eroded surface of Pre-Cambrian basement represented mainly by mica -quartz schist's & phyllites of Chaibasa formation and Singhbhum Granite towards south-east of the area, i.e. West & NW of Bahargora (22◦17':86◦43'). The gravel sequence has been differentiated into three district litho-assemblages Lower, Middle and Upper. The Lower litho-assemblage occurring as patchy outcrops is represented by hard, indurate, ferruginised, polymictic conglomerate and ferruginised pebbly gritty sand- stone. The coarse, massive conglomerate of Middle litho-assemblage occurs within a broad off linear zone almost parallel to the course of the Subarnarekha River. The Upper litho assemblage is composed of fine textured, matrix supported, polymictic gravel with clasts size ranging from pebble to granule. The maximum exposed thickness of the gravel bed is about 6-9 meters. Well preserved leaf impressions of Angiosperms within the iron shale partings at the top of the Middle litho-assemblage have been discovered from the gravel mound north of Dharampur (22◦18': 86◦44').***

Keywords: Tertiary and Quaternary Gravels, Dhalbhumgarh-Chakuliya-Baharagora area, East Singhbhum district, Narsinghgarh Formation, Subarnarekha River

I. INTRODUCTION

Sedimentological study of Tertiary and Quaternary Gravel and sand beds of Dhalbhumgarh-Chakuliya-Baharagora area, East Singhbhum district, was carried out covering an area of about 300 sq.kms on 1:50,000 scale (22◦13'- 22◦25'N, 86◦35' - 86◦45'E) in parts of Survey of India toposheet Nos. 73 J/11 & 12. The field investigation was started on 23rd December, 2019 and continued up to 25th February, 2020. In addition to mapping, 75 nos. of natural/excavated sections were logged for detailed sedimentological studies. A total of 52 nos. of geochemical samples were collected and sent for analysis or Gold etc., 10 samples from clay beds were also collected for clay mineral analysis. Besides 24 nos. of samples were processed for chemical analysis of Major oxides.

II. LOCATION AND ACCESSIBILITY

The area mapped forms the south eastern part of East Singhbhum district, to the east and north of the Subarnarekha River. It is bounded by the Subarnarekha River in the west, Jharkhand-Orissa border in the south, 86◦45' Longitude in the east and south-eastern Railway main line in the north. Chakuliya and Baharagora are important block office situated well within the area. The area can be reached from Jamshedpur, the district Headquarters by train or road. Chakuliya is also an important Railhead on the S.E Railway (Main Line). National Highway 33 passes through the area and joins N.H 6 near Baharagora. The area is well served by a network of the Fair-weather and metalled roads and state highways.

A. Climate

The area generally enjoys tropical climate. The winter season commences from Late November and lasts till the middle of March. The summer season starts by the end of March and continues up to June. The area generally experiences intermittent rains during the summer months and nights become very hot with the prevailing westerlies. The rainy season starts in the second week of June and continues till October. During winter, the minimum and maximum temperatures are 3◦C and 32◦C respectively. The maximum temperature during the summer may rise up to 47◦C. The average annual rainfall of the district is 1420mm.

B. Flora and Fauna

The area is fast depleting of its natural vegetation. Even the hilly regions bordering the gravelliferous terrain show open mixed jungles with fewer scattered trees within bushy intergrowth. The comparatively lesser elevated areas represented by rocky uplands and gravely mounds are generally covered by thorny bushes and some isolated dry deciduous trees. In the plains in and around villages and in the valleys along the channels, green grasses shrubs and trees are witnessed including some fruit yielding varieties which are purposely grown. The predominant forest tree is Sal (Shorea robusta). In addition to Sal the other trees are Asan (Terminalia elliptica), Indian rosewood (Dalbergia sissoo), Kendu (Diaspyras melanoxylon), Bel (Aegle marmelos), Tamarind (Tamarindus indica), and Mahua (Madhuca longifolia). Among the fruit yielding varieties Jack fruit (Artocarpus heterophyllus), Sajan (Moringa oleifera), Papaya (Corica Papaya), Bair (Ziziphus mauritiana), Mango (Mangifera Indica) and cashwunt are common. Cashwunt plantation is extensively being done especially on the ferruginised gravel surfaces which support its luxuriant growth. Elephant, Spotted deer, Sambhar etc. are the common herbivorous in the jungles of the hilly terrain. Among the carnivorous, bears, Hyenas, fox and Jackals are common. Tiger, Leopard and wolves are reported to be present. Among the reptiles, snakes both nonpoisonous and poisonous varieties including the Cobra are Quite abundant. Rodents like rats, mice, hares and striped squirrels along with a variety of birds are commonly observed.

III. GEOLOGICAL BACKGROUND

An extensive gravel bed occurs as cover sediments over a vast are on the north- ern flank of the Subarnarekha River a little east of Ghatshila to Dhalbhumgarh and Baharagora and further east and south-east continuing into the Medinipur district of West Bengal and Mayurbhanj district of Orissa, presumably beneath the laterite cover. (Dunn and Dey 1942) in their pioneering work, proposed the regional geology of Singhbhum and the contiguous areas for the first time, and recorded semi consolidated gravels, pebbly grits, sands and rare mottled clays as tertiary gravels beds. They reported the basal bed to be made up of coarse gravel, in places cemented to from ferruginous sandstone- grit showing profuse cross stratification. West of Subarnarekha to be fluviatile but the character of grit and sand according to them suggested rather estuarine deposits.

Since, the study of (Dunn and Dey 1942) these supposedly tertiary gravel- lactiferous horizons were not studied either from sedimentological point of view and palaeoplacers concentrations. The quartz-pebble-conglomerates worldwide have attracted the attention for possible local of palaeoplacers deposits. During field 2019, sedimentological study and related mapping of Tertiary-Quaternary gravel on 1:50,000 scales covering an area of about 300 sq.km was carried out around Dhalbhumgarh (East Singhbhum district).

IV. METHODOLOGY, OBJECTIVE & SCOPE

The primary objective of the present investigation was focused on the following aspects: i. To map the sedimentary facies of the depositional system ii. To reconstruct the depositional environment of the Tertiary/Quaternary gravel de- posits of the area. iii. To indicate areas for search of palaeoplacers deposits based on above analysis. The present work was carried out in continuation of the work done during field 2019. Based on the above objectives it was essential, first to carry out geological and geomorphological mapping to bring out the exact deposition and distribution pattern of the gravel beds. Detailed observation and recording of sedimentological features in suitable, available section was to be carried out representatively for the area covered. The sedimentary facies were therefore, to be worked out taking into consideration the observable attributes of sediments in terms of depositional process. Once the sedimentary facies model is worked out the next stage was prediction of areas of search of palaeoplacers concentration zones.

The methodology adopted for field investigation broadly included the following:

A. Geological and geomorphological mapping on 1:50,000 scale.
B. Litho logical logging of vertical sections as exposed by streams and rivers flowing through the areas and as exposed by the existing gravels quarries operating in the area.
C. Detailed observation of suitably selected vertical sections and recording of basics sedimentological data in terms of clast size, matrix-clast composition, shape (roundness &sphericity) of clasts, orientation of clasts, nature of packing, bedding characteristics, frame work type, stratification type, grading characteristics and other primary sedimentary structures.
D. Representative sampling from various litho logical units for palaeoplacers and laboratory studies
E. Cataloguing of data an applied aspects pertaining to natural resources, including surface and groundwater resources, land use pattern and environ- mental hazards.

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V. GEOMORPHOLOGY

The Dhalbhumgarh-Chakuliya-Bahargora area forms a part of the Subarnarekha valley, confined within a broad zone, trending roughly NW-SE and bounded by the hilly tracts of the Dalma and Dhanjori to the north-east and south-west respectively. The Dalma range is fringed on the south, by a series of comparatively low, broken ridges of the Dhalbhum Formation which forms the immediate north-eastern boundary of the valley and extends beyond the Jharkhand-West Bengal border continuing into the Midnapore district. The north-west, the hills come closer and the Subarnarekha meanders thought the narrow valley. However, the valley opens out towards south-east so that the entire terrain is characterized by flat plain which continues east of Chakuliya-Baharagora tract up to the coast.

The area exhibits varied topography. The intensive northern ridge of the Dalma range are of considerable prominence, attaining heights up to 427m.a.m.s.l. at Chandakuta Pahar (22◦34': 86◦39') and even more. Towards south, away from the northern ridge, there is a significant break-in-alone manifested by a narrow Pediments belt which further south gradually merges with and is overlain by the undulating alluvial plain of the Subarnarekha river slopping towards south or south- west. To the south-west of the Subarnarekha river reveals of slope occurs in the ground surface which finally culminates into mountain range of the Dhanjori, attending maximum elevation of the 564 meters at Chadri Buru- west of Singapore (22◦22'12" : 86◦32'30"). However, the outer plateau varies in elevation between 150 and 250 meters. The relief of the valley plain varies from 70 to 140 m above mean sea level with general slopes towards the Subarnarekha River which flows south easterly in the area almost along the southern boundary of the valley. The variation in the ground slopes exert definite control on the geomorphic expression of the area manifested by well dissected undulating and rolling plains, dotted with small residual low hills (Dungis) and entrenched deeply by the stream traversing it.

A. Drainage

The Subarnarekha River constitutes the chief drainage of the area. It flows in a meandering pattern from north-west to south-east through the area. In the lower reaches, to the south-west of Bahargora, it takes a sharp southerly swing and then abruptly turns to follow an almost easterly course, near the tr-junction of the Jharkhand, West Bengal and Orissa. The Subarnarekha exhibits typical braided pattern and is a perennial river with high monsoon discharges. However, the discharge during the lean periods is much less. The valley of the Subarnarekha in the upstream is not very wide but has bounded by steep banks. However, further downstream around Baharagora, the river bed is wide and shallow with extensive sand splay. The important northern tributaries of the Subarnarekha in the area are indurate Nala, Palpala Khal and Asanjora Khal. All these are almost sub-parallel in nature. The south-western tract is drained by Kodia Nala Which flows eastward through the Dhanjori Hills in a highly meandering from marking the boundary between Jharkhand and Orissa. It joins the Subarnarekha River about 6-7 km west of Baharagora. All these streams are ephemeral with very meager discharge, all short and narrow valleys with small catchments. The drainage pattern is dendritic to subdendritic with localized radial pattern over mounds, inselbergs and raised grounds.

B. Geomorphology of the Area

East of the Subarnarekha River (Fig: 1), except for some small inliers of the Precambrian rocks, the entire are is effectively covered with gravels, pebbly grits and ferruginised pebbly to gritty sandstone and younger valley fill sediments. The gravel beds form smooth, flat topped low, moundish terrain which has been subjected to extensive dissection, valley trenching and filling. Consequently, low level valley flats of younger sediments of variable thickness and width are interspersed with the mounds of gravel beds. The gravel bed is most conspicuously developed in the vast, undulating plain at about 110-120 m contour although isolated mounds as high as 130-140 m a.m.s.l have been observed in the area. The gravel beds with some facies variation continue up to the outer hills to the Dalma and the Dhanjori hills which form the boundary of the depositional basin to the north-east and south-west respectively. These gravelliferous horizons , however, are sharply marked off by a NW-SE trending wide and flat alluvial plain of the Subarnarekha valley at places forming distinct terraces at different levels at altitude and much lower than the gravel beds, representing present flood plains, older flood plain and older alluvial up- land. These extensive beds of gravels continue into the adjoining Medinipur district of West Bengal. West Bengal and also crossing the Subarnarekha to the south of the south of the Baharagora continue in Mayurbhanj district of Orissa. West of the Subarnarekha River (Dunn & Dey 1942) reported these gravel beds becoming much coarser covering low ridges and small plateau.

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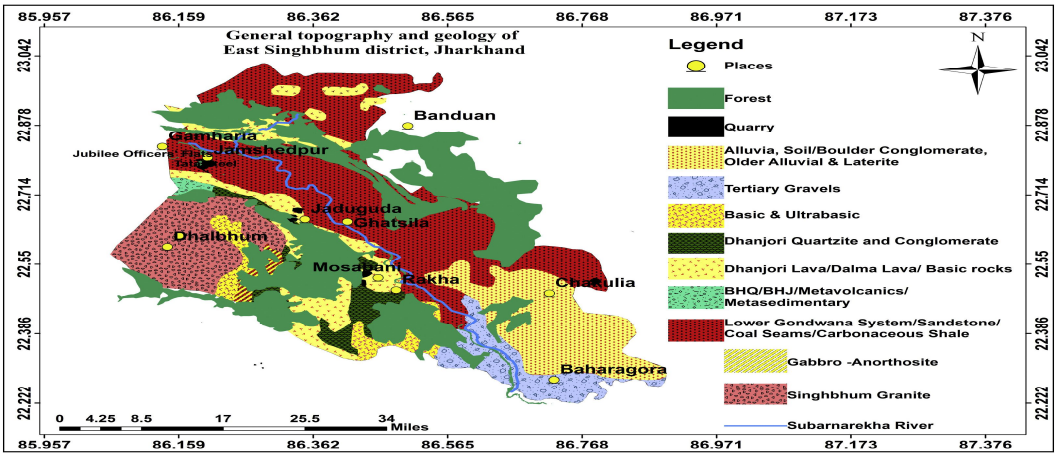


Figure: 1. Sedimentology of Tertiary and Quaternary Gravel and sand beds of Dhalbhumgarh-Chakuliya-Baharagora area, East Singhbhum district.

C. Morphostratigraphy

The major geomorphic units, identified in the area in order of diminishing antiquity are:

(i) The Rocky upland/inselbergs (ii) The Narsinghgarh Gravel surface (iii) The valley fill surface.

1) The "Rocky Upland" unit includes the hilly tracts of the Dalmas in North and the Dhanjori in the south which delimit the Subarnarekha valley, as well as numerous inselbergs hillocks and residual hills comprised of the Precambrian rocks. This unit occurs conspicuously in the southern part of the area to the west & NW of Baharagora. This unit is characterized by marked relief, intense dissection and absence of good soil cover and is manifested by a desolate rocky wasteland. One such very prominent isolated residual hill stands out at Sirbai Dungri (22◦21': 86◦39'). It rises to a height of about 70 m above the adjacent alluvial surface towards east and south east. On the western side, it forms a scarp face on the left bank of the Palpala Khal. The Rocky upland unit also includes residual hills and isolated mounds mainly of quartzite's and mica schists associated with quartz schists in the vicinity of Maheshpur, Jharia, Dharkuli, and Hijili. Also included in this are the several granitic and doleritic inselbergs north-west of Baharagora around Charakenara, Jharapahara etc. Which stand out as lines of low hills (dungris). The development of pediments is virtually absent or insignificant in the area. Occasion- ally, a narrow strip of pediment may be seen encoding or residual hills where it is represented by weathered mantel some-times exhibiting coprolites and laterite zones. This belt has been included in the Rocky upland unit since it does not constitute any significant and extensive land from unit.

2) It is an extensive and most conspicuous geomorphic unit on the northern flank of the Subarnarekha River and is represented by vast gravel plain. In general, the gravel surface forms highly undulating dissected, low moundish plain, the individual mound being separated by the intervening sediments. The gravel beds occur at different elevation ranging from 80m to 140 m above the mean sea level. Three district litho-assemblages (major facies) have been mapped within the gravels beds, viz. Lower, Middle and Upper litho-assemblages. However, they do not exhibit distinct geomorphic expression and hence have been compositely taken to form the Narsinghgarh Gravel Surface.

3) The Narsinghgarh Gravel Surface has undergone deep dissection and subsequent filling by the younger alluvial sediments comprising sand, silt and clay which form low level valley flats. These valley flats open out in the downstream direction and merge with the flood plains of the Subarnarekha River. This is clearly seen in the vicinity of Baharagora area towards the downstream of the Subarnarekha River where the alluvial plain is quite extensively developed. The Shyamsundarpur (22◦22' 45" - 86◦36' 30") in the area, a stepped sequence of the three distinct terrace surfaces is clearly discernable. The terrace system of the Subarnarekha is restricted within a narrow belt along the river. The terraces are confined to an average height of about 8-10 meters from the river bed level. They are comprised of disconnected, patchy and flat discrete steps. At most places however, the terraces are absent and the older surfaces are covered by the younger flood plain deposits. The valley flats of the streams dissecting the Narsinghgarh Gravel Surface often displayed two discrete steps or terraces-the higher one being an older surface which has been further dissected and the younger or the lower surface which is entrenched within the older surface. Many a time, it is not possible to differentiate the two surfaces on the map scale. The two surfaces, described below, therefore have been included in the valley fill Surface.

a) *Older Alluvial Plain:* The older alluvial plain forms an extensively developed moderately undulating flat topped alluvial upland above the present flood plain of the streams. It represents comparatively stable plain showing some sort of dissection and at places undulations. Soil profile is developed and consists of oxidized pale yellow, mottled silty clay with ferruginous concretion. At places it is marked by extensive presence of caliche along with the silt & clay often at shallow depths or even at surface.

b) *Younger Alluvial Plain:* The young alluvial surface is restricted to the areas wherever there are surface drainage features representing the flood plains. It forms a narrow strip flanking the important rivers of area. It is mainly developed along the banks of the Subarnarekha River and also in narrow strip along Sindura Nala, Palpale Khal and Asanjora Khal. At places this surface show a distinct height differences with the older alluvial surface. It is devoid of gully activity and soil formation has not taken place. This unit comprises the channel and the various associated morphological features. The surface is usually covered by grey to buff colored silty sand, sandy silt or clayey silt with minor ferruginous concretion at places.

VI. GEOLOGICAL ANALYSIS

A. Regional Geological Settings

Regionally, the area of study forms a part of the cratonic block of the Eastern Indian Shield and comprises the central valley of the Subarnarekha River.

The tertiary/quaternary gravelliferous sediment package unconformably rests over the differentially eroded basement comprising highly metamorphosed rocks of Chaibasa formation (Picture: 5) Precambrian (Proterozoic) age which is represented mainly by mica schist's, Quartz- Chlorite-Biotite schists and phyllites. The rocky floor is largely covered by the gravels but is exposed mainly along the Subarnarekha valley. The mica schist associated with quartz- schist's, north- west Bahargora consisting Kyanite quartz granulite and extending to Sirbai Kungri and the Biotite schists at Hijili, represent Indies of Chaibasa formation in the area. The gravels are flanked in the extreme north by the rocks of Dhalbhum formation comprising phyllites and quartzite's which constitute the outer ridges, fringing the Dalma hills on the southern side.

The southern base of Dalma is however represented by a sequence of chlorite schists and phyllites inter bedded with the basaltic flows. On the southwest the area is bounded by the Meta sediments, volcanic and volcanogenic rocks of the Dhanjori group represented mainly by quartzites, phyllites, Meta basalt with associated acid volcanic and mafics-ultramafics. However the area to the south and south east is flat or gently undulating open country with a cultivated thick soil mantle representing older alluvium overlying the Singhbhum Granite. The granites are generally massive, varying from fine grained to coarse porphyritic type with profuse intrusive, reticulating newer dolerities. These rocks are exposed in patches near east of Singhpura, Charakmara, Jharapahara etc. as isolated low hills (dungris).

Picture: 5. showing the contact relationship between the quartzite of Chaibasa formation and pebbly to cobble size oligomictic gravel of middle litho assemblage.

(Dunn 1929, 1940) and (Dunn and Dey 1942) proposed a stratigraphic sequence for both north and south Singhbhum and adjoining areas, which may be summarised as under:

North of the Shear Zone	South of the Shear Zone
Alluvium	Alluvium
Laterite	Laterite
Tertiary grits and gravels	Tertiary grits and gravels
Newer Dolerites	Newer Dolerites
Chhotanagpur Granite	Kolhan Series (Shale, Limestone, Sandstone, Conglomerate.)
Dalma Lava	Soda Granite

(Overlap)

Iron ore series	Iron ore stage	Phyllite Quartzite often Hematitic Phyllites, tuffs and basic igneous rocks.	Granophyre Biotite granite. Singhbhum Granite Dolorite.	(Maybe Pre-Dhonjori)
	Chaibasa stage	Mica-schist and hornblende schists, with quartz, granulite and quartz schist, tuffs and cherts.	Dhanjori Group. --Unconformity--	Lava and thin Phyllites quartzite-conglomerate --Unconformity--
			Iron ore stage	Phyllite and tuff with arkose conglomerate and quartzite. Phyllite tuff and basic igneous rocks.

The stratigraphic succession proposed by (Dunn 1940) and (Dunn & Dey 1942) has however been modified by later workers namely. (Sarkar and Saha 1962, 1977), (Sarkar and Deb 1971), (Banerjee 1975), (Mukhopadhyay 1976), (Bose and Chakravorty 1981), (Sarkar 1982), (Sing and Gupta 1984), (Gupta, Basu & Singh 1985), (Singh & Gupta 1986) and other.

B. Geology of the Area (Geology of the gravelliferous SEDIMENTS)

The extensive gravel bed Occurring over a vast area especially on the north- eastern flank of the Subarnarekha River has been made as Narsinghgarh formation, since its maximum thickness has been observed at Narsinghgarh near Dhalbhumgarh. The gravel bed rests over differentially eroded Precambrian rocks comprising schists and phyllites of Chaibasa Formation and, at places, Singhbhum granite towards south-east i.e. in the area around Bahargora. The bed rock, being highly undulating and irregular wide variation in the thickness of the gravels is observed from place to place. The maximum exposed thickness of the gravel recorded in the area is about 8 to 10 meters. The gravel package has been classified into three distinct, litho-assemblages (major facies) based on compositional and textural parameters. These litho- assemblages, namely the Lower, Middle and Upper litho- assemblages are marked by sharp erosional contacts. The gravelliferous horizons are sediments of variable thickness which have been differentiated into older alluvium and younger alluvium, based mainly on the degree of oxidation, morphological, lithological characters and pedogenesis. All the three gravel litho- assemblages have not been observed in a single section. The lower litho- assemblage is restricted only to some patchy occurrences. However pit and stream bank sections generally reveal the upper litho- assemblage underlain by the middle litho- assemblage. The middle litho- assemblage in some sections are unconformably under- lain by oxidized plastic silty clay, mottled, greyish yellow in colour and containing granules and at times interbedded fine pebble layers. The clay unit finally rests on unevenly eroded surface of the hard rocks.

The tentative stratigraphic sequence established in the area and the litho- logical details of the various litho-assemblages of the gravelliferous sediment units are summarised in the following table (Table-1).

Table- 1: tentative stratigraphic succession and lithological details of tertiary and quaternary sediments, Chakuliya-Kerukocha-Baharagora areas, east Singhbhum district, Jharkhand.

TENTATIVE GEOLOGIC AGE		STRATIGRAPHIC SEQUENCE	LITHOLOGICAL ASSEMBLAGES
1	2	3	4
Quaternary (Pleistocene to Recent)	Valley fills	Young Alluvium	Grey to grayish brown to buff colored silty sand, sandy silt and clayey silt, sometimes with minute ferruginous concretion.
		-----Erotional Unconformity-----	-----Erotional Unconformity-----
		Older Alluvium	Grayish yellow, mottled oxidized, silty clay containing calcareous and/or ferruginous concretion.
-----Erotional Unconformity-----		-----Erotional Unconformity-----	-----Erotional Unconformity-----
Tertiary	Narsinghgarh Formation	Upper Litho-assemblage (2.5 m)	Lateritised, fine textured gravel with profuse iron concretions and/or cherry red to reddish brown silty sand (Latasol) /duricrust/ hard pan. Loose to Semi consolidated highly oxidized fine textured, matrix supported, polymictic gravel with granule to pebble sized clast mostly of quartz.
		-----Sharp contact-----	-----Sharp contact-----
		Middle Litho-assemblage (10 m exposed)	Loose to semi consolidated, highly oxidized course massive matrix supported, oligomictic gravel with sub rounded to well round cobble to pebble size clasts predominantly of quartz.
		-----Erotional Unconformity-----	-----Erotional Unconformity-----
		Lower Litho-assemblage	Indurated, ferruginised, polymetic, matrix supported conglomeratic gravel/compact and indurated, ferruginous pebble to gritty sandstone with parallel & cross beddings.
-----Unconformity-----		-----Unconformity-----	-----Unconformity-----
			Yellow plastic silty clay with calcareous and ferruginous concentration with granular to fine pebbly quartz fragments at places.
-----Unconformity-----		-----Unconformity-----	-----Unconformity-----
Precambrian (Proterozoic)	Chaibasa Formation & Singhbhum granite. Hard rock basement.		Mica/quartz schist, phyllites, quartzite's, Kyanite-quartz-granulites, porphyritic granite, intrusive dolerite.

C. Lower litho-assemblage

The lower litho-assemblage is typically represented in the area by indurated ferruginised matrix supported, polymictic conglomeratic gravel at places grading into hard compact ferruginised pebbly to gritty sandstone, exhibiting very crude cross bedding. The clasts of the conglomerate range in size from coarse cobble to fine pebble and occasional boulders. The clasts are mainly of Quarts, while Quartzite, iron shale, ferruginous sand stone, ferruginous concretions, granite gneiss and rarely schists and basic rocks occur in subordinate amount. Clasts are generally angular to sub-angular to sub-rounded rarely rounded with poor sphericity and sorting. The matrix is arenaceous mostly coarse sandy in nature. The conglomeratic gravel is exposed as patchy outcrops near Birdanga and Dudhiyashol, surrounded by semi-consolidated gravel of the Middle litho-assemblage. While the gritty to pebbly crudely cross-bedded sandstone has been mapped as small patchy isolated mounds near Manidungri, Kharkashol, Chakadungri, NE of Khairbani, SE of Kalajharia etc. where it is surrounded by younger gravels of middle litho-assemblage and/or latasol. The maxi- mum thickness of lower litho-assemblage noted is 1.5+metres. The lower litho-assemblage does not form any distinct mappable geomorphic unit.

D. Middle litho-assemblage

The Middle litho-assemblage (Picture: 1) lies unconformably over the Lower litho- assemblage. It is characterized by loose to semi consolidated, coarse, massive, matrix supported oligomictic gravel. The clasts are sub-rounded to well rounded, ranging in size from granule to coarse cobble and rarely to boulder size.

Compositionally, the clasts are predominantly of quartz of various types viz. white, grey, smoky etc. and minor quartzite, ferruginous sandstone or iron shale. Sphericity is moderate and the quartz & quartzite clasts are commonly discoidal, ellipsoidal to flattish, elongated in shape while the ferruginous sandstone and iron shale clasts are bladed to tabular in shape, having poor sphericity and are angular to sub-angular. The clasts are unsorted and no apparent grading/stratification imbrications or pebble orientation is generally discernable. However, in some sections very crude stratification, grading and pebble orientation have been observed. The matrix ranges from argillaceous to arenaceous and is highly ferruginised/oxidized imparting cherry red to brownish red color to the gravel package. In deeper sections towards the bottom the matrix becomes more argillaceous i.e. clayey in nature and display yellow-grey cherry red mottling. The coarse massive gravel of the Middle litho-assemblage occurs within a broad off linear zone trending NW-SE almost parallel to the course of the Subarnarekha river, crossing the latter to the south of Bahargora and continuing further south towards Jamshola and beyond, in Orissa with a east and north east of this zone of coarser conglomeratic gravel, the Middle litho-assemblage is represented by comparatively fine textured gravel occurring extensively in Chakuliya- Baharagora area where it is represented by clast of quartz and quartzite usually smaller than medium pebble in size and is covered by a sheet of gravel of Upper litho-assemblage except for a few isolated patchy small exposures, which has been mapped around Dhalabera, NE of Bhandarshol, Benashol, Rangamatiya, NE Machadiha, NW of Mahulbera. The maximum exposed thickness of this unit is about 8-10 meters observed in some dug well sections near Amlagora Purnapani, Dhorshol. The middle litho-assemblage exhibits a distinctive geomorphic expression, characterized by flat topped extensive mounds or humps with propose gully or rill erosion on the flanks.

Picture: 1. showing pebbly size gravel of middle Litho assemblage capped by Latosol.

E. Upper litho-assemblage

The Upper litho-assemblage (Picture: 2) is represented by fine textured matrix supported, polymictic gravel. It is separated from the underlying Middle litho-assemblage by sharp contact. It occurs extensively as a cover, of varying thickness, over all the underlying gravelly litho- assemblage. It is composed of sub-angular to well-rounded clasts mainly of quartz and ferruginous concretions and bladed to clasts of ferruginous sandstone and iron shale, ranging in size from granule of pebble and a few cobble size floating clasts. Pea size ferruginous concretions are usually profuse towards the top. The matrix is composed of highly oxidized/ferruginised arenaceous to argillaceous material typically cherry red to deep reddish brown in color. Very commonly the quartz dominant sequence of Upper litho-assemblage is capped by compact and hard lithified, ferruginous sandstone and iron shale. At times, discontinuous, thin bends of iron shale/ferruginous sandstone occur within the Upper litho- assemblage at various levels. The thickness of such beds varies from about 10-15 cm to about a meter or even more. Very often, it occurs as thick, persistent beds, disjointed and blocky in nature consisting of bouldery chunks of ferruginous sandstone and iron shale's while at places it is thin and fragmentary in nature and contain angular, bladed to tabular clasts mainly of cobble to coarse pebble size. In some sections, for example NE of Dharampur several thin lenses of ferruginous sandstone and iron shale occur within the Upper litho-assemblage to form an alternating sequence of pebbly quartz layers and ferruginous shale and sandstone layers. Partial to complete lateretisation of the Upper litho- assemblage is very common. Intense lateretisation has been observed around Mural, Purnapani etc. Vertical/lateral variants of this unit like sandy gravel, gravelly sand or highly oxidized deep reddish brown silty sand (latasol) and variegated, grey-cherry red mottled clays looking similar to lithomarge have been frequently observed in the area

Picture: 2. showing erosional contact relationship between the upper litho- assemblage and the overlying quaternary alluvial sediments.

F. Lateretisation

The top of the Narsinghgarh gravel (Picture: 3) has been extensively lateritised (Picture: 4) forming a lateritised surface cover of varying thickness. In some cases, the gravel bed is capped by 20-50 cm thick lateritised duricrust/hard pan. Very often the gravel is covered by cherry red to reddish brown highly oxidized and ferruginised soil (Latasol), one meter or more in thickness which at times contains sporadic granular to small pebbly quartz. Sometimes the entire thickness of the Upper litho-assemblage is found to be lateritised showing well developed box work and pisolitic structures. The lateretisation process in the area apparently bears distinct relationship with heights. At higher altitudes above 130m contour level the lateretisation is more pronounced while lateretisation is partial and sporadic.

Picture: 3. showing the landscape of Lateritised Gravelliferous Surface of Upper Litho Assemblage of Narsinghgarh Formation.

Picture: 4. showing the landscape of Lateritised Gravelliferous Surface of Upper Litho Assemblage of Narsinghgarh Formation.

G. Older Alluvium

This morphostratigraphic unit has been mapped as the oldest exposed Quaternary de- posit in the area overlying the gravels and, at places, resting directly over the bed rock. These are distributed generally along the main streams occurring as valley fills showing inset relationship with the gravels. Such deposits also occur unconformably over the gravel beds. In general, it comprises oxidized, grayish yellow mottled silty clay containing calcareous and ferruginous concretions. This unit constitutes a gently undulating topography. Outcrops of this unit in the present area are observed as elongated patches usually in proximity of prominent streams, flanking them on either side. In the left bank scarp of the Subarnarekha River NW of Badahichu, East of Medhubera, Shyamsundarpur etc. this unit is exposed in sub-crop below a thick pile of younger alluvium.

H. Younger Alluvium

The younger alluvial sediments unconformably overlie the sediments of older alluvium. These are composed of unoxidised, unconsolidated grey to buff colored admixtures of sand silt, and minor clay in different proportions sometimes containing minute soft ferruginous concretions. The sediments in narrow strips mainly along the prominent rivers and streams. This compositor unit probably represents older flood plain deposits occurring mainly within active channels. Thick pile of younger alluvium occurs along Subarnarekha River which is flanked by 3-7m high banks mainly on the north-eastern side. Since the other streams draining the area are mainly seasonal or have very meager discharge, the younger alluvial unit is restricted to channel bars, point and lateral bars and thin minor over bank deposits.

The summarised informal morpho and litho-stratigraphic succession of the area is given table (Table-2) below:-

Table 2: Morpho-Lithostratigraphy of the area around Chakuliya-Kerukocha-Baharagora, east Singhbhum district, Jharkhand

TENTATIVE AGE	MORPHO-STRATIGRAPHY	LITHO-STRATIGRAPHY	LITHOLOGICAL DESCRIPTION	DEPOSITIONAL REGIME
1	2	3	4	5
Holocene to Present day.	Younger Alluvial plain.	Younger Alluvium.	Grey to grayish brown to buff colored silty sand, sandy silt and clayey silt, sometimes with minute ferruginous concretions.	Present day and plaeochannel, levees and flood basins deposition.
	----- Erotional Unconformity -----			
Pleistocene	Older Alluvial plain.	Older Alluvium	Grayish yellow, mottled, oxidized silty clay containing calcareous and/or ferruginous concretions.	Fluviatile depositional environments.

	----- Erotional Unconformity -----				
Tertiary	Narsinghgarh Surface (Gravelliferous Surface)	NARSHINGHGARH FORMATION	Upper Litho-Assemblage	Lateritised fine textured gravel with profuse iron concretion and/or cherry red to reddish brown silty sand (Latosol) / duricrust / hard pan.	Regional sheet flood deposition in alluvial pan environment.
				Loose to semi consolidated highly oxidized, fine textured matrix supported, polymictic gravel with granule to pebble sized classes mostly of quartz.	
			----- Sharp Contact -----		
			Middle Litho-Assemblages	Loose to semi consolidated, highly oxidized coarse massive matrix, supported, oligomictic gravel with sub rounded, to well rounded, coarse cobble to pebble size clasts predominantly of quartz.	Debris flood deposition in alluvial fan environment.
		----- Erotional Unconformity -----			
		Lower Litho-assemblage.		Indurated, ferruginised, polymictic, matrix supported conglomeratic gravel/compact and indurated, ferruginous pebbly to gritty sand stone with parallel & cross bedding.	Alluvial fan and associated traided stream system.
	----- UNCONFORMITY -----				
Precambrian (Proterozoic)	Rocky Upland.	Chaibasa Formation/ Singhbhum Granite.		Mica/Quartz Schist, Phyllites, quartzite, Kyanite-quartz-granulite/porphyritic granite and intrusive dolerite.	

VII. SEDIMENTOLOGY OF DHALBHUMGARH-CHAKULIYA-BAHARAGORA AREA

A. Textural and compositional analysis of sediments

The textural and compositional analysis of gravels has been carried out to reconstruct their depositional history. The study is based mainly on the clast size measurement and study of related sedimentological characteristics, such as determination of composition of sediments (clast and matrix), shape analysis of clasts in respect of roundness and sphericity, recognition of various types of orientation and packing of the different constituents etc. The study involves quantitative and/or qualitative evaluation of various attributes/variables of the sediments on the basis of their frequency distribution and correlation and interpretation of their significance.

A generalized comparative Qualitative evaluation of various textural at- tributes of the three litho-assemblages viz.; the Upper, Middle and Lower of the gravelliferous sediments is given in the following table (Table-3).

Table-3: qualitative details of various textural parameters of various litho-assemblages of the gravelliferous sediments around Chakuliya-Kerukocha-Baharagora, east Singhbhum district, Jharkhand.

--- GRAVELLIFEROUS LITHO-ASSEMBLAGES ---

TEXTURAL PARAMETERS	LOWER	MIDDLE	UPPER
1	2	3	4
1.CLAST SIZE	Fine pebbles to coarse Cobbles to occasional boulders.	Granular to coarse cobble, rare boulder.	Granule to pebble with a few floating cobbles.
2.ROUNDNESS	Angular to sub-angular to sub-rounded.	Sub-rounded to well rounded.	Sub-angular to well rounded.
3.SPHERICITY	Poor.	Moderate to poor.	Moderate to poor.
4.SHAPE	Varied (discoidal, and ellipsoidal).	Varied (discoidal, ellipsoidal, flattish, elongate bladed rarely spherical).	Varied (discoidal, bladed, and ellipsoidal).
5.SORTING	Poor.	Poor.	Poor.
6.GRADING	Absent.	At places normal to reverse grading desirable.	Occasional.
7.BEDDING	Ferruginous sandstone facies cross bedded absent in conglomeratic facies.	Crude bedding observed at places.	Rudimentary layering seen at places.
8.PACKING	Closest or rhombohedral.	Open or cubic.	Open or cubic.
9.PREFRERED ORIENTATION	By and large absent.	By and large absent.	By and large absent.
10.FABRIC	Isotropic.	Isotropic.	Isotropic.
11. IMBRICATION	Absent.	Absent.	Absent.
12.NATURE OF MATRIX	Arenaceous.	Argillaceous to Arenaceous.	Argillaceous to Arenaceous.
13.CLAST-MATRIX PROPORTION	Matrix>clast (Matrix Supported).	Matrix>clast (Matrix Supported).	Matrix>>clast (Matrix Supported).
14.OXIDATION OF MATRIX	Oxidized.	Highly Oxidized.	Highly Oxidized.
15. FERRUGINATION	Highly ferruginised.	Slightly Ferruginised.	Complete to partially lateritised.
16.COLOR OF MATRIX	Cherry red to deep reddish brown.	Cherry red to brownish red, becoming yellow mottled at depths.	Cherry red to deep reddish brown.

1) *Size Analysis of Sediment:* The clast analysis of the gravelliferous sediments pertains mainly to the Middle litho-assemblage at it is most conspicuously developed and well exposed in the various gravel quarries operating in the area. Clast size measurement has been done for clasts more than 10mm in size. The details of the various textural and com positional parameters and analysed are given in table-4 & 5. Size frequency distribution of the sediments in summarized in table (4).

Table 4 – overall percentage distribution of clasts in various size grades. Middle litho-assemblage of Narsinghgarh gravel formation:

LITHO-ASSEMBLAGE	PERSENTAGE DISTRIBUTION OF CLASTS IN VARIOUS SIZE GRADES					
	PEBBLE				COBBLE	
	- 20 Fine	- 30 Medium	- 40 Coarse	- 50 V.Coarse	- 60 Small	- 70 Large
MIDDLE LITHO ASSEBLAGE	-	15.39	56.34	23.42	3.95	0.88

Table 4 shows that the clasts range in size from medium pebble (-3 phi to -4 phi) to large cobble (-7 phi to -8phi). About 56.34% of clasts are in coarse pebble range (-4 phi to -5 phi), followed by 23.42% clasts in very coarse pebble range (-5 phi to 6 phi) this is supported by clasts of medium pebble range (-3 phi to -4 phi), while 3.95% clasts are of small cobble range (-6 phi to -7 phi) and only 0.88% clasts occur in large cobble range (-7 phi to -8 phi). The results also indicate that the gravel of the area are restricted within pebble and cobble range with no boulder size clasts and about 95.15% clasts are comprised of pebbles only. The gravels of the present area, in general, may thus be described as pebbly gravel. It is worthwhile to compare the results of the textural analysis of thin once with those of the Dhalbhumgarh area in the upstream. While the clasts of pebble size have increased from 75.14% in the upstream to 95.15% in the present area, the cobble size clasts show a decrease from 24.73% to 4.83% and boulders de- creased from 0.08% to nil. This comparative study clearly indicates a decrease in size from upstream to downstream direction i.e. from NW to SE along the Subarnarekha valley.

It exhibits a moderately wide size range varying from-3 phi to 8 phi and almost unsorted nature of sediments. The Histogram is more or less symmetrical marked by dominance (56.34%) of coarse pebbles (ranging between -4 phi and -5phi) and subordinate amount (23.42%) of very coarse pebbles (ranging between -5 phi and -6 phi). The frequency curve of the distribution is somewhat positively skewed indicating granitic variation towards the higher values of the sizes. This when compared to the histogram plotted from the data of proximal parts around Dhalbhumgarh suggest that the size range in the proximal part is wider in comparison to the present area, while sorting is slightly more pronounced in the present area in comparison to the proximal parts towards NW.

2) *Composition of Sediments:* Table-5 displays the clast composition with percentages vis-a-vis size frequency distribution in percentage of the Middle litho-assemblage. It is also depicted in PIE diagram as percentage clast composition. They show oligomictic nature of the gravel with 90.64% of the clast composed of Quartz only. The rest of 2.71% of Quartzite, 3.00% of Iron Shale, 1.94% of Ferruginous sandstone, 1.59% of Iron concretions and remaining 0.12% of other compositions including schists, phyllites, slate, etc. Such enrichment of quartz inches a higher degree of both mechanical and stability. Though composition-wise quartz, in general, constitutes, the bulk of clasts, accounting for about 90% of the clasts, its different varieties have been noticed in the area. White quartz is the most dominant type, however smoky and grey quartz are also significantly present constituting about 10% and 4% respectively of the total quartz clasts in the Middle litho-assemblage. The comparative order of abundance of different types of quartz clasts can be given as under, white quartz smoke quartz grey Quartz. Comparative study of clasts composition of the present area with that of the Dhalbhumgarh area indicates a more or less similar pattern, expect that there is an increase in percentage of iron shale's and ferruginous sandstone clasts which could have resulted from contribution of local provenances. It is also interesting to note that iron shale and ferruginous sandstone occur as partings and lenticular bands especially within the Upper litho-assemblage and even, at times, cap the Middle litho-assemblage. A broad correlation between the rock composition and clast size is also suggested. Thus the rocks like Phyllite, slate, iron shale etc. do not generally form large size clasts.

3) Roundness & Sphericity of clasts: The quartzite's and quartz clasts are generally sub-rounded to well rounded and occasionally sub-angular and are moderately spherical in shape, while the clasts of other composition, mainly iron shale and ferruginous sandstone, are sub-angular to angular and are generally bladed in shape. The comparative degree of roundness and sphericity as observed in the clasts of various compositions can be given in the follow order. Quartzite, Quartz Schist/Phyllite, Ferruginous Sandstone, Iron Shale. Roundness and Sphericity are positively correlated and each in turn appears to be a function of size. It has been observed that roundness and sphericity of the clasts of same composition increases with size. The larger clasts (coarse pebbles, cobbles etc.) Have greater roundness and sphericity compared to smaller size clasts (small pebbles and granules). The degree of roundness and sphericity of clasts and its relationship with size as observed in the area can be given as under: Cobbles, Very Coarse Pebbles, Coarse pebbles, Medium and fine pebble granules.
4) Orientation and Packing of Sediments: A preferred orientation of long axis of clasts is absent in the gravelliferous sediment. The orientation of the clasts in general is random and the fabric is thus isotropic. The packing arrangement in general is open or cubic in the upper and Middle litho- assemblages while the gravels of Lower litho-assemblage represent closest of rhombohedral packing. The gravel is usually unsorted, Grading or Stratification is absent in the lower litho- assemblage while occasionally the gravels of middle and Upper litho- assemblages display crude stratification with both normal and inverse grading. Indurated pebbly to gritty sandstone faces of lower litho-assemblage exhibit profuse cross bedding which is very crude to rudimentary in the facies of middle & Upper litho-assemblages.

B. Spatial variations

The lower litho-assemblage of Narsinghgarh formation is restricted in occurrence and has been mapped as a few small isolated and patchy outcrops, typically represented by hard compact ferruginised polymictic conglomerate grading into pebbly to gritty sandstone with profuse cross-bedding. The conglomerate/pebbly to gritty sandstone beds are, sometimes, underlain unconformably by yellow plastic silty clay with calcareous concretions as observed in a Nala section, North of Manidungri.

The Middle litho-assemblage typically represented by coarse massive oligomictic gravel, occurs within broad off-linear zone almost parallel to the present course of the Subarnarekha River. However, away from this zone towards east and north east in the present area, the Middle litho-assemblage is represented by comparatively finer oligomictic gravel. It occurs extensively in Chakulia-Baharagora area, usually under a thin cover of gravel Upper litho- assemblage expect for a few isolated patchy, small exposures. There is also a gradual decrease in clast size from NW-SE i.e. from proximal to distal part of the depositional basin.

The gravel of Upper litho-assemblage is composed of fine textured, matrix supported, polymictic gravel, occurring as sheet cover over the other litho- assemblages. Partial to complete lateretisation of this litho-assemblage is common. Vertical/lateral facies variants of this unit as sandy gravel, gravely sand, highly oxidized deep reddish down silty sand and variegated clay have been commonly observed.

C. Sedimentary structures

The Upper and Middle litho-assemblages display occasional crude stratification with both normal and inverse grading. In the lower-litho assemblage al- though, the main conglomeratic bed shows no definite grading or stratification, the pebbly to gritty sandstone contains stratified, cross-stratified low dipping beds as seen in a section near Manidungri. It preserves stacked cross-bedded sedimentation units, which are very crude and no reliable flow direction from these structures could be deduced.

D. Determination of clay minerals in sediment

The results of clay mineral analysis of 10 clay samples:

Quartz occurs as main constituent in all the samples. The significant occurrence of quartz indicates incomplete weathering and high degree of both chemically and mechanical stability as quartz is not only chemically, inert, it is also mechanically durable.

1) Kaolinite occurs in good amount in a number of samples. Presence of kaolinite characterized an acid, fresh water environment signifying presence of alkali feldspar in the source rock. It also indicated that the sediments are not very old since the increasing age kaolinite is replaced probably by Illite material.
2) Ittites form an important constituent in several samples. Illite are known as 'clay micas' and are developed by the alteration of micas, alkali feldspar, etc., under alkaline conditions. In the present area Illite may also be presumed to be the product of transformation of kaolinite with increasing age of sediments.
3) Montmorillonites are also present in some samples in trace amount. They are formed by the alteration of basic rocks or other silicates low in potassium, under alkaline conditions.

4) The oxides of iron, present in the samples through in small amount are Goethite, Hematite and Limonite. Presence of these imphes that from the source they are dispersed in a finely broken state and are mechanically transported and deposited with the finest clay fractions, thereby indicating nearby source exceptionally rich in iron which is confined by the significant occurrence of ferruginous laterite, hard pan etc. in the area.

E. Interpretation of Sedimentary Depositional Environment

The sedimentological studies of gravelliferous sediments carried out in Chakuliya- Kerukocha-Baharagora area, East Singhbhum district, Jharkhand leads to the following interpretations regarding the depositional environment:

1) The gravelliferous sediments of the area, specially the middle litho- assemblage can be classified as pebbly gravel (Folk, 1954).

2) The coarse grained nature of sediments with pre-dominance of pebble and cobble and subordinate amount of sand, poor sorting mode of occurrence, depositional characteristics etc. of the gravel sequence suggest its deposition broadly in an alluvial fan environment. Available evidences indicate alluvial fan deposit associated with braided river deposits built up by mountain stream where a steeper slope passes into a gentler slope spreading out and depositing their thick deposits down slope in the semi-confined valley between the Dalma and Dhanjori ranges indicating proximal past towards west. Chhotanagpur granite gneiss country appears to be the main provinance from where bulks of the material were probably derived. Rocks of Chaibasa formation of the Singhbhum Group which also forms the basement of the gravel deposits appear to be the local source of debris to some extent. However, there is apparent absence of contribution from Dalma and Dhanjori ranges except possibly some quartzite clasts from Dhanjori hills.

3) The patchy small occurrences of gravels of lower litho-assemblage the polymictic nature of the conglomeratic facies containing angular to sub- angular clasts imphes that at least some clasts are derived from nearby provinance and possibly it was deposited on the irregular surface of the basement. The lithological character and preserved crude sedimentary structures in the form of cross-bedding in pebbly to gritty sandy facies suggest that it is possibly a product of rapid fluctuations in the flow velocity typical of braided streams (Church 1972, Boothroyd and a Shaley, 1975, Williams and Rust 1969). Frequent lateral changes from gravelly/conglomeratic facies to pebbly-gritty sand- stone facies within a short distance reflect rapid changes in flow regime. Flows in gravelly braided streams are usually unsteady often flashy resulting in variable velocity, depth and grain size relationship. The compact and indurated nature of both the conglomeratic gravel and pebbly gritty sandstone indicate lithification and diagenesis to a considerable extent.

4) The coarse, massive, oligomictic gravel of Middle litho-assemblage occurs within a broad off-linear NW-SE zone almost parallel to the course of the Subarnarekha river, crossing the latter to the south of Bahargora and continues in Orissa with a somewhat decrease in overall size of clasts. To the east and north east of this coarse conglomeratic gravel the Middle litho-assemblage is represented by comparatively finer gravel, occurring extensively in Chakuliya- Baharagora area covered by a sheet of gravel of upper litho-assemblage except for a few isolated patchy small exposures. The deposition of this type of gravel is supported mainly by debris – flood deposit within the main channel and dispersed of conglomeratic sediments away from the main channel in a highly sediment charged fluvial system. The main cause for the deposition of a large amount of debris in alluvial fan regions is the decrease in depth and velocity of flow as a result of the increase in width due to the spreading of the flow from the apex of the fan (Bull, 1964).

5) The debris flow deposits of Middle litho-assemblage are poorly sorted occasionally showing both normal and inverse crude graded bedding. Pebbles are irregularly arranged and are without any preferred orientation. Grain size decreases while roundness increases from the proximal to distal part i.e. NW to SE of the area. Sphericity however more or less remains moderate throughout (Reinech and Singh, 1975) observed Maximum grain size and thickness of sediments decrease rapidly towards the base of an alluvial fan deposit. The roundness of coarse grains also increases with increasing distance from the apex. Sphericity shows no particular change within an alluvial fan (Blissenbach, 1954) roundness increases from the proximal to distal part i.e. NW to SE of the area. Sphericity however more or less remains moderate throughout (Reinech and Singh, 1975) observed that, maximum grain size and thickness of sediments decrease rapidly towards the base of an alluvial fan deposit. The roundness of coarse grains also increases with increasing distance from the apex. Sphericity shows to particular change within an alluvial fan (Blissenbach, 1954).

6) The extensive occurrence of fine textured, matrix supported, gravel of upper litho- assemblage occurring as sheet cover over the other litho- assemblages in the area represent sheet flood deposition, (Blissenbach 1954) suggested that flash flood deposits accumulate when a large amount of water charged with detrital sediments emerges from the mountains. It bands to spread out in sheets covering part of alluvial fan deposits. The polymictic nature of the sediment and presence of abundant floating clasts and

thin beds of ferruginous gritty sandstone and iron shale within the upper litho- assemblage similar to that of the lower litho-assemblage suggest reworking of sediment and probably some materials of the upper litho-assemblage have been derived from within the depositional basin itself.

7) Vertical/lateral variants of upper litho-assemblage like the sandy gravel, highly oxidized deep reddish brown silty sand and variegated clay within a short distance indicate lateral as well as vertical changes in flow regime. According to (Reinech and Singh, 1975) the composition and nature of alluvial fan sediment is controlled mainly by the local source of debris rock and weathering processes.

8) Development of lateritic profile, thick ferruginous crust/hardpan mainly over the sediments of Upper litho-assemblage suggests prevalence of favourable climatic condition for lateretisation in the area for a considerable period of time.

9) The younger valley fills comprising the Quaternary sediments, represent the valley trenching and filling episode subsequent to the deposition, diagenesis and oxidation of gravel sequence.

VIII. BIOSTRATIGRAPHY

Well preserved leaf impressions of Angiosperms have been discovered for the first time from the gravel mound, north of Dharampur (22◦18’ 00”: 86◦44’ 44”), within the thin discontinuous layer of iron shale, capping the gravel mound constituting coarse massive gravel of the Middle litho-assemblage. The plant fossil displays well preserved leaf with prominent margins, acute apex and thick mid rib. Although angiosperms are known to continue to the present day, the mode of preservation, compaction and indurations is preserved, etc. suggests a long antiquity. A suspected crude hand axe (Palaeolithic tool) associated with the gravels of Middle litho-assemblage has been found occurring at a depth of about 1.00m from the ground level, in a pit section west of Haripur (22◦24’ 35”: 86◦39’ 20”). Some crude Microliths have also been found at the top of the gravel mounds at certain places such as near Tangashol (22◦25’ 30”: 86◦41’ 41”) and Sirbai (22◦20’ 10”: 86◦39’ 15”). The above evidences, coupled with very high degree of oxidation of the matrix of the gravelly sediments besides the development of well formed ferralithic duricrust are indicative of a long antiquity. Development of well formed lateritic profile involving the gravelliferous sediments of the Upper litho-assemblage further points out that favourable climate conditions for lateritisation prevailed in the area for a long period of time. It is therefore likely that the gravelly sediments may belong to Tertiary period. (Dunn and Dey, 1942) assigned a Tertiary age to these sediments suggesting that they are at least Pliocene and may be even Miocene, further adding that Miocene beds are known only a short distance to the south in Mayurbhanj in a similar position along the edge of the coastal plains. (Dunn and Dey: Geology of East Singhbhum 1942, Chapter XIII page 434).

IX. GEOCHEMICAL SAMPLING

Quartz-pebble-conglomerates worldwide have attracted the attention, for possible locales of palaeoplacers deposits, QPC are well known specially for their gold-uranium mineralization (e.g. Rand Conglomerate of South Africa and Jocobina of Brazil). The presence of extensive gravel beds close to quartz- pebble-conglomerate in nature, around Dhalbhumgarh-Chakuliya- Baharagora area, having highly ferruginous matrix and lateritised/latesolic cap are thus believed to be a promising zone for sampling for search for palaeoplacers specially Gold.

Also, the presence of basic-ultra basic rocks, acid volcanic besides Quartz- pebble- conglomerate in the adjoining Dhanjori basin which are reported to be gold bearing and also the occurrences of auriferous host rocks in the catchment of the Subarnarekha basin within the Dalma hills and the extant panning for gold at numerous places in the Subarnarekha river and its important tributaries have been considered as favorable factors for preliminary evaluation of economic potential of the area specially with reference to gold.

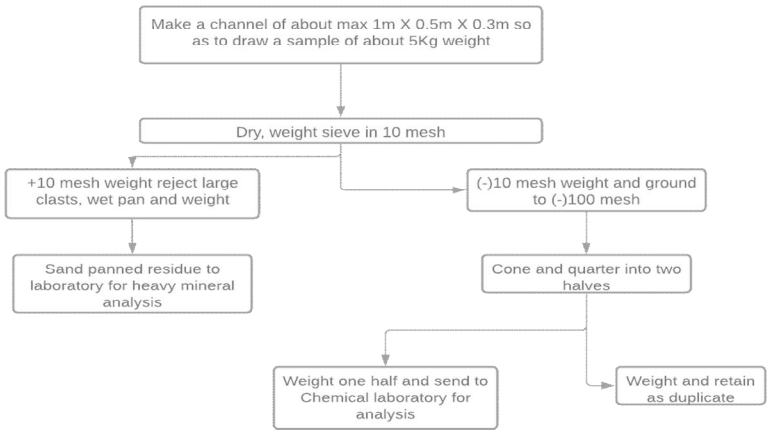
The lithological and textural characters and mode of deposition of the Lower litho- assemblage makes it sediment logically a suitable unit for concentration of palaeo placers. There appears to be limited sedimentological control for the palaeoplacers concentration in the debris flow type of deposits of the Middle litho-assemblage. Similarly economic gold concentration may not be expected in poorly sorted sheet flood deposition of the Upper litho-assemblage. How- ever, as the exposures of the Lower litho-assemblage are few and limited in the area, the other litho-assemblages have also been sampled, because local gold provenance may be an important criterion defining economic gold distribution (Bryan Krapex 1985), ventersdrop contact placer: a gold pyrite placer of stream and debris flow origins from the Archaean Witwatersrand Basin of South Africa. Sedimentology Vol. 32, P.223-234.

52 numbers of geochemical samples were collected for analysis of gold (Au), and associated radicals including Ag, Hg, As, Mo, Sb, and Bi & W.

The samples have been derived randomly covering entire area and represent all the three litho-assemblages of the gravel sequence. The sample, in general, comprises:

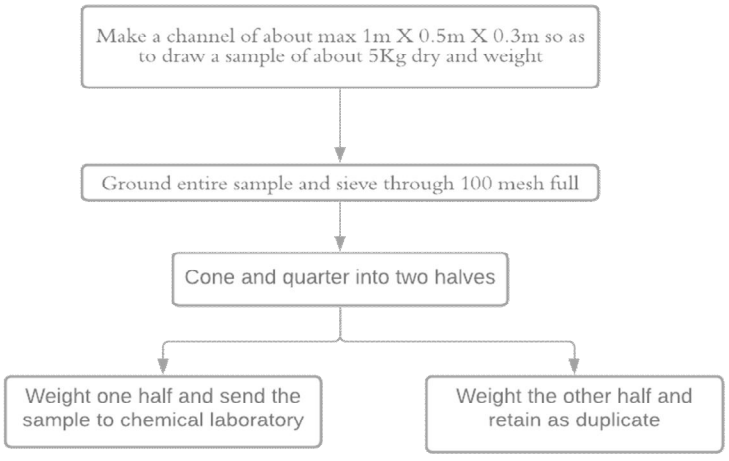
1) Matrix of various litho-assemblages of the gravel, collected mainly from the vertical sections at different levels and horizons.
2) Clasts of the gravel beds mainly different varieties (grey' smoky) of quartz.
3) Some River bed samples from the points of confluence of the streams.
4) Some samples of alluvium especially from river bank sections of vital rivers.

The scheme of sampling and processing of samples have been given in the flow charts I & II below –



Sample collection and processing for geochemical analysis of gold from Tertiary gravel beds (in case beds are loose)

Flowchart: 1.



Sample collection and processing for geochemical analysis of gold from Tertiary gravel beds (in case beds are consolidated)

Flowchart: 2.

X. RESULT

The results of chemical analysis of the samples & synthesis of the results indicate that the Au (Gold) content determined by AAS is less than 50ppb in all but 2 samples out of 52 samples analysed. The values in the 2 samples are just marginally high (60 ppb). Out of the 2 samples one sample is of highly ferruginised pebbly to gritty sandstone of the Lower litho-assemblage of Narsinghgarh Gravel Formation collected from Manidungri while the other sample represents highly lateritised indurated, fine textured gravel of upper litho- assemblage collected from a pit near Khairbani. These values do not practically imply any special economic significance.

Result of chemical analysis of 52 Gravel Samples for the determination of "Au" by AAS

Sl. No.	Sample No.	Au in ppb
1.	1/150/MRC/G.CHEM	<50
2.	2/151/ -do-	"
3.	3/152/ -do-	"
4.	4/153/ -do-	"
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A. Other economic resources

The economic resources of the area include various rock types which are extensively utilized as construction material resources. These are detailed below:

1) *Gravels:* In addition to the Dhalbhumgarh-Narsinghgarh area, the areas around Chakuliya and Baharagora are also extensively quarried for the gravels. Mainly they are in private ownership and are manually operated based on ‘pick and carry’, basis. Normally the coarse massive gravels of the Middle litho- assemblage are excavated which are in high demand as construction material as substitute for stone chips and also as ornamental stones in some modern buildings. Quarry pits normally 50m x 30m and some layer quarries up to 100m x 60m are existing having the depths of 8-10m, from which gravels are recovered. The matrix and clasts are separated. The clasts are further differentiated into several commercial grades depending largely upon the size of the clasts. The matrix is also locally used as forum for building construction and filling material for roads etc.
2) *Laterite:* Laterite, being hard and indurated and having the properly to resist denudation by the air and water much better than ordinary bricks, is a valuable material for building in the area. Chunks of laterite are dug-up and trimmed into square slabs or desired shapes for use as foundation slabs for pucca buildings and roads. It has been extensively used as floor slabs in the abandoned air strip of world war-II in the area south west of Chakuliya. Since the occurrence of laterite is restricted and highly scattered, its quarrying in the area is sporadic unorganized and revirement oriented. Its systematic exploitation has also limited scope.
3) *Quartzite and Dolerite:* In the area thick bands of massive quartzite and patchy outcrops of dolerite are frequent. They are being quarried on a very small scale in the area NW of Baharagora and are used as stone chips for construction work and road material. In view of the low demand because of local consumption only, no systematic exploitation has been done.

XI. APPLIED ASPECTS

A. Land Resources and its utilisation

Close correlation exist, between the landform, soil and the present land-use pattern in the area.

Gemorphologically, the land can be differentiated into the following categories.

1) The rugged rocky terrain and associated pediplain.
2) The undulating, dissected, moundish gravel plain.
3) The moderately dissected alluvial upland and flats.
4) The flat alluvial low land.

The rocky terrain and pediplain supporting the forest are under constant pressure of increasing population, greatly depleting its forest cover. The hill fringe area is almost bare. These are along with the pediplain are almost a wasteland covered by variable thickness of weathered mantle and regolith. The topography, scarcity of water, slope, etc. are all against its utilisation for agriculture and it thus remains an unproductive stony wasteland. A forestation is the only land use suitable for this surface.

The moundish gravel plain is under varied use; largely it is covered by shrubby and bushy vegetation. It supports good plantations mainly of Kendu Eucalyptus, Sal, Mahua, etc.

To some extent the gravelly area is under active cashew nut cultivation which sup- ports its luxuriant growth. Probably the ferralithic nature of the sediments is suitable for such cultivation. The forest department has undertaken plantation measures in some areas. Relatively higher, undulating and dissected alluvial upland containing ferruginous concretion and profuse kankar modules is unsuitable for good crops and yield very low produce. However, the gently undulating older alluvial plain occurring as valley flats supports the main agricultural activity in the area.

This surface is invariably used for paddy and rabbi cultivation. The extensive area south of Baharagora, covered by older alluvial unit is under varied agricultural usage and supports various crops including cash crops. However, better irrigation facilities are required to support multicropping practice.

The flat alluvial low lands constituting the flood plains are quite fertile and are used for paddy cultivation, especially for paddy seeding. They also support the brick manufacturing in the area.

B. Surface and Groundwater Resources

Except the Subarnarekha which is Perennial River with good discharge, other streams of the area including the Sindura Nala, Palpala Khal and Asanjora Khal, carry insignificant discharges or are dry. There is no surface water body of any significance other than small village pounds for local domestic use.

The area, in general possesses limited ground water potential. However, it varies from place to place due to the topographic factors, frequent lateral facies variation and wide variation in the thickness of the sediment due to highly uneven bedrock, topography. In the proximity of rocky terrain, in gravel beds over the bed rock highs and in the undulating alluvial upland, the ground water storage is poor and these are water scarcity areas. The aquifer zone is constituted by weathered mantle, fractured rocks, colluvial material etc. In such areas large diameter dug wells are preferred. However, in the vast undulating thickener gravel plains and in the intervening low level flats of younger valley-fills where bed rock is encountered at considerable depths, shallow tube wells yield moderate quantity of water.

C. Environmental Problems and Remedial Measures

The environmental problems broadly identified in this belt are:

1) Deforestation and soil Erosion: The most distressing environmental hazard in the area is deforestation for fuel and commercial purposes. The ever increasing impact of exponentially increasing population is leading to almost complete transformation of the landscape. The rocky terrain and the adjoining pediplain as well as the gravel mounds have been greatly depleted of its forest cover to the extent that host of the mounds and inselbergs are bare and rendered ruinous. Deforestation has accelerated soil erosion resulting in aggradations of drainage channels and rendering the adjoining fertile lands into Bad Lands.

2) Intense gulling and sheet wash erosion: Extensive head ward erosion by gulling and sheet wash is quite prominent in the gravely areas as well as, riverine tracts. The dissection around the gravel mound is partly due to the inherent geological setting. Once the thin cover of hard ferralithic top soil is removed, the gulling activities proceed at a much faster rate because of the loosely consolidated nature of the gravels. It results in removal of the matrix and spreading of the pebbles on the surface to generate wasteland. The agricultural lands (of the valley fills) in its vicinity are also rendered totally unfit due to the covering provided by the products of sheet wash erosion. In the riverine tracts, the alluvial belts flanking the streams on either bank are subjected to intense gully erosion. Gulling activity produces badly dissected and broken grounds. In some areas once the thin alluvium cover is removed, the underlying gravels are exposed, producing Bad Lands.

3) Impact of gravel/Stone Quarry: Incessant gravel and stone quarrying for constructional purposes and road metal is going on over vast area around Dhalbhumgarh, Chakuliya and Baharagora. The unplanned gravel quarrying mainly based on ‘pick and carry’ basis is posing serious environmental problems. It is destroying the landform by generating numerous large pits and depressions of various sizes after recovering the gravel. This not only renders the landscape useless and ugly but also poses a great safety threat to the inhabitants and cattle. Secondly, huge heaps and mounds of dumps of finer fragments and matrix of waste material, generated after the removal of clasts from the gravel, poses dust pollution problem causing health hazard specially during summers wind, More importantly, the finer tractions of the waste material is washed down and spread into the adjoining agricultural lands during the rains. Remedial measures to overcome these problems include planned and mechanized quarrying, disposal of quarry dumps, filling up of the quarry areas after operation and reclamation of bad land areas.

4) Inadequacy of water resource: Water is a major constraint in the area and is far below the requirement standards. It is the biggest limiting factor in the agricultural development of the area. Vast part of the area consists of dry agricultural land restricting the agricultural activities to single cropping due to inadequacy of water resources for agricultural purpose. This hardship is further highlighted during prolonged dry spells or monsoon failures. There is need for assessment and planning of the surface water resources for augmentation of surface water storage and exploitation and development of groundwater resources, to combat the inadequacy. The traditional practice of storing the seasonal overland flow by means of contour embankments has to be incubated.

5) Disruption of wild life habitats and migration of wild life.

XII. CONCLUSION

Study of the gravelliferous sediments in the area to the east and south-east of Dhalbhumgarh, around Chakuliya-Kerukocha-Baharagora, East Singhbhum district, Jharkhand, covering approximately 300 sq. Km, bounded by Latitudes 22◦13’00”– 22◦28’45” N and Longitudes 86◦35’00’: 86◦45’00”E, in parts of Survey of India toposheet 73 J/11 & 12, highlighted several characteristic features, which are summarised as under:

A. The gravel beds named as "Narsinghgarh Formation" rest unconformably over the differentially eroded basement of highly metamorphosed rocks rep- resented mainly by mica/quartz schists & phyllites of Chaibasa formation of Precambrian (Proterozoic) as. However, towards the south-east of the area around west and north-west of Baharagora the gravels are underlain by coarse, porphyritic Singhbhum Granite. All these rocks are also exposed on the surface as small isolated liners.

B. In the upstream direction of the Subarnarekha River, the gravel beds are confined within a broad NW-SE trending zone, bounded in the north-east by the ridges comprising rocks of Dhalbhum formation which forms the southern fringes of the Dalma range. In the south-west the gravels are delineated by the Dhanjori hills. However, the Subarnarekha River flanking the Dhanjori hills on the north-eastern side forms the boundary of the area of study. The gravel beds and their textural variants open out and spread over considerable area towards east and South-east, i.e. in downstream direction.

C. Extensive gravel bed occurs as cover sediments over a vast area on the northern flank of the Subarnarekha River. Confined usually between the elevation of about 80m and 140m above the mean sea level. The gravels occur mainly as dissected, flat topped low mounds separated from each other by intervening low level flats of younger (Quaternary) valley-fills, comprising sand, silt and clay of variable thickness. Such younger deposit also occurrence unconformably over the gravel beds.

D. The maximum exposed thickness of the gravel bed is about 8-10 meters, while it is reported to continue up to the depth of about 15-20 meters. Towards south-east a calcariferous mottled clay and silt sequence containing impersistent layers of granules of quartz intervenes between the Precambrian bed rocks and the overlying gravel bed with an angular erosional unconformity.

E. Gemorphologically the mapped area has been differentiated into three major morphostratigraphic units. In order of antiquity these are; i) The valley fills surface-comprising varying proportions of sand, silt and clay. It consist of, (a) Younger alluvial plain, and (b) Older alluvial Plain. ii) The Narsinghgarh Gravel Surface – Gravelliferous sequence. iii) The Rocky upland- Consisting of rock outcrops of various types, mainly mica/quartz achiest, phyllites and quartzite's of Chaibasa formation, Singhbhum Granite and dolerites. The rocky upland includes residual hills, inselbergs and narrow belt of pediment.

F. The gravel sequence has been differentiated into three district litho- assemblages (major facies) marked by erosional contacts viz., (i) Lower (ii) Middle and (iii) Upper. i) The Lower litho-assemblage has been mapped only at a few places in the area as detached, isolated outcrops. The Lower litho-assemblage is typically represented by matrix supported, indurated, ferruginised, polymictic conglomeratic gravel. Lateral facies variation from conglomerate to pebbly to gritty sandstone crudely cross bedded is common. The conglomeratic gravel is comprised of sub-angular to rounded clasts, predominantly of quartz and Subordinate quartzite, iron shale, granite, schist etc. It is highly ill-sorted and the clast size range from fine pebble to cobble and occasional boulder. The matrix is arenaceous mostly in coarse sand range.

G. The main gravel horizon i.e. the Middle litho-assemblage is characterized by loose to semi-consolidated, coarse massive matrix supported oligomictic gravel, comprising more than 90% (90.64%) clasts of quartz (white, grey and smoky). The clasts size range from medium cobble to large cobble with coarse to very coarse pebbles accounting for approximately 80%. The clasts are sub-rounded to well round with moderate sphericity, usually unsorted and occasionally display crude stratification with both normal and inverse grading. The matrix is arenaceous to argillaceous and show red color due to high degree of oxidation. The color is however yellow towards the bottom in deeper section.

H. The Upper litho-assemblage is composed of matrix supported, fine textured gravel with clasts ranging from pebble to granule. The clasts are polymictic in nature, composed mainly of sub-rounded quartz and ferruginous sand stone and iron shale. The clasts are highly unsorted and almost totally lacking in any form of stratification. The matrix is composed of highly oxidized and ferruginised arenaceous to argillaceous materials, typically cherry red to deep reddish brown is color, vertical/lateral variants of this unit such as sandy gravel, gravelly sand, or highly oxidized deep reddish brown silty sand and variegated clay have been commonly observed. 7. At most places the gravel bed is found to be ferruginised/lateritised at the top. Sometimes the lateritisation is partial while at places the entire thickness of the Upper litho-assemblage is found to be lateritised. The gravel bed is very extensively covered by 50 cm to 1m thick oxidized top soil (Latosol). In some cases, a 20-50 cm thick lateritic duricrust/hardpan is found to have formed over them.

I. The gravel surface is sharply marked-off by low level flats formed by younger (Quaternary) valley- fill sediments comprising sand, silt and clay of variable thickness. Such younger deposits also occur unconformably over the gravel beds, showing an inset relationship with the latter and are products of valley trenching and filling. In close proximity of the Subarnarekha river three levels of terraces representing the present flood plain, older flood plain, and older alluvial plain have been observed.

J. Detailed study of the Middle litho-assemblage indicates that the coarse massive gravel occurs within a broad off-liner zone, almost parallel to the coarse of the Subarnarekha river, crossing the latter to the south of Baharagora and continues in Orissa with a perceptible de- crease in overall size of clasts. To the east and northwest of this zone of coarse conglomeratic gravel, the

Middle litho-assemblage is represented by comparatively fine textured gravel, occurring extensively in Chakuliya-Bahargora area, covered by a sheet of gravels of the Upper litho-assemblage except for a few patchy, isolated, small exposures.

K. The size frequency distribution of the sediments of the Middle litho- assemblage points out unimodal distribution with a maximum of 56.34% clasts concentration in coarse pebble range (-4 phi to -5 phi), followed by 23.42% in very coarse pebble range pebble range (-5 phi to -6 phi), while only 4.83% of clasts occurs in cobble size. This when compiled with the size frequency distribution carried out in the proximal part i.e. upstream part of the depositional basins around Dhalbhumgarh indicates that the clast size gradually and consistently decreases from proximal to distal end i.e. from NW to SE. Further the size range in the proximal part is wider in comparison to the present area, signifying that sorting is somewhat more pronounced in the present area in comparison to the proximal part.

L. The percentage clast composition indicates more or less equal pro- portion of quartz clasts in the Middle litho-assemblage throughout the area including the proximal part around Dhalbhumgarh, which indicates higher degree of mechanical stability. However somewhat wider diversity in the com- position of the Middle litho-assemblage in comparison to the proximal part around Dhalbhumgarh is observed, which may be attributed to contributions from local provinces other than the main source area, towards the distal part.

M. The pebbles of the Middle litho-assemblage are, in general, irregularly arranged, poorly sorted, and are without any preferred orientation. Roundness of the clasts increases from NW-SE, however, sphericity more or less remains moderate throughout. Rudimentary stratification as well as graded bedding character is noticeable locally.

N. The sedimentological studies suggest deposition of the gravel sequence broadly in an alluvial fan environment with the initial sedimentation of the basal conglomeratic facies of Lower litho-assemblage on the irregular surface of the bed rock. Subsequently the de- position of pebble to gritty sand stone facies of the Lower litho-assemblage took place by graded stream system, producing well stacked sequence of vertically and laterally accreting channel bars. The coarse massive gravel of the Middle litho-assemblage is mainly debris- flood deposit within the main channel and dispersal of fanglomeratic sediments away from it in a highly sediment charged fluvial system. Finally the extensive occurrence of fine textured gravel of the Upper litho-assemblage represents regional sheet flood deposition. The younger valley-fills comprising the Quaternary sediments represent the valley trenching and filling subsequent to the deposition, diagenesis and oxidation and upliftment of the gravel sequence.

O. Well preserved leaf impression of Angiosperms within the partings iron shale at the top of the Middle litho-assemblage of the gravelliferous horizon has been discovered from the Gravel mound north of Dharampur (22◦18’00”: 86◦44’40”). A crude hand axe (Palaeolithic tool) associated with the coarse gravel of the Middle litho-assemblage has been found in a section near Haripur (22◦24’35”: 86◦39’20”). Besides, some crude Microliths have also been collected from the top of the gravel mounds near Tangashol (22◦25’30”: 86◦41’40”) and Sirbai (22◦20’10”: 86◦39’15”). All these evidences supported by the compaction, indurations, high degree of oxidation of sediments besides development of ferralithic duricrust/hard pan and well formed lateritic profile over the Upper litho-assemblage suggest a long antiquity, supporting by (Dunn & Dey 1942).

P. Results of chemical analysis of 52 no of samples show Au-content in all but two samples, to be less than 50 ppb. However, 2 samples representing the lateritised fine textured gravel of the Upper litho-assemblage and the ferruginised gritty to pebbly sand stone the Lower litho-assemblage show Au content of 60 ppb. Results of Chemical analysis of 70 samples collected from the proximal part of the depositional basin around Ghatshila-Dhalbhumgarh area indicated Au content in all the samples less than 50ppb. However, mercury and arsenic con- tents show certain anomalous values. The high values of Hg (70 to 320 ppb) show a rough linear alignment trending NW-SE & W-E between Janbani- Tangashol and Kuchakanali-Kochiyasoli respectively, and is roughly correlatable with the geophysical anomaly zone trending NW-SE along Gayraduba Nala Narsinghgarh and Dhalbhumgarh as reported by (Sh. L. K. Das, et. al., 1990). In the light of the above results, as far as gold is concerned there appears no promising chance of finding placer gold of economic significance in the gravels. However, an attempt can be made to search alluvial gold in the river bed sediments, since extensive planning for gold along the banks of the Subarnarekha River has been observed in the area. So far as the higher value of mercury is concerned, it is suggested that attention should be paid for further investigation for Hg, along the causative body in the area.

Q. The result of analysis of 10 number of clay samples indicate Quartz as the major constituents in all the samples. Kaolinite and Illite are significantly present. While Montmorillonites, Plagioclase, limonite, Goethite and Hematite occur in small amount or trace amount. The presence of quartz indicates incomplete weathering. The occurrence of Kaolinite characterize acid fresh water environment and signify presence of alkali feldspars while presence of Geothite, Hematite and Limonite point a nearly source exceptionally rich in iron.

R. The basic resources of the area are agricultural land and forest. The occurrence of extensive gravel beds also serves as an important resource. A section of the rural population is engaged in gravel quarrying and a large number of privately owned quarries are flourishing in the area around Dhalbhumgarh, Chakuliya and Baharagora. Matrix and clasts are separated and the clasts of different sizes, after being differentiated into several commercial grades, are supplied as construction material. In addition chunks of Laterite are worked out for use as foundation stones, while quartzite and dolerites are also quarried on small scale for stone chips for construction work and road material.

S. The land use practice is closely linked with the geomorphological setting of the area. The rocky terrain and associated pediplains are under forest cover. The gravelly surface is covered by shrubby and bushy vegetation and supports plantation mainly of Sal, Kendu, Eucalyptus, Mahua, Cashwunt, etc., While the alluvial plains are under active cultivation for paddy, rabbi and to some extent cash crops, south of Baharagora, Suitable steps for enhancement of vegetal cover, extension of agricultural activity and land management's measures, for example pasture development on pediment zone and remote gravel mounds are recommended.

T. The overall surface and ground water potential of the area is limited except in the vicinity of the Subarnarekha River which is a perennial river with good discharge. It is necessary to monitor and explore the surface and ground water resources for conjunctive use in the region.

U. The ever-increasing impact of increasing population is leading to almost complete transformation of the landscape. This causes disturbances of the ecological balance. De- forestation also accelerates soil erosion gulling and sheet wash erosion rendering fertile land into unproductive lands. A forestation, measures to check gully erosion and creation of effective green belts on the pediplains and gravel uplands by promoting, social forestry & horticulture etc. Without encroaching upon the agricultural land are recommended.

V. The unplanned gravel quarrying on large scale, mainly based on 'pick and quarry' basis is posing serious environmental hazard. It causes large scale degradation and generates huge dumps of waste material. An integrated programme of study for assessment of impact of quarrying, waste disposal, conservation and reclamation of degraded land is suggested.

XIII. ACKNOWLEDGMENT

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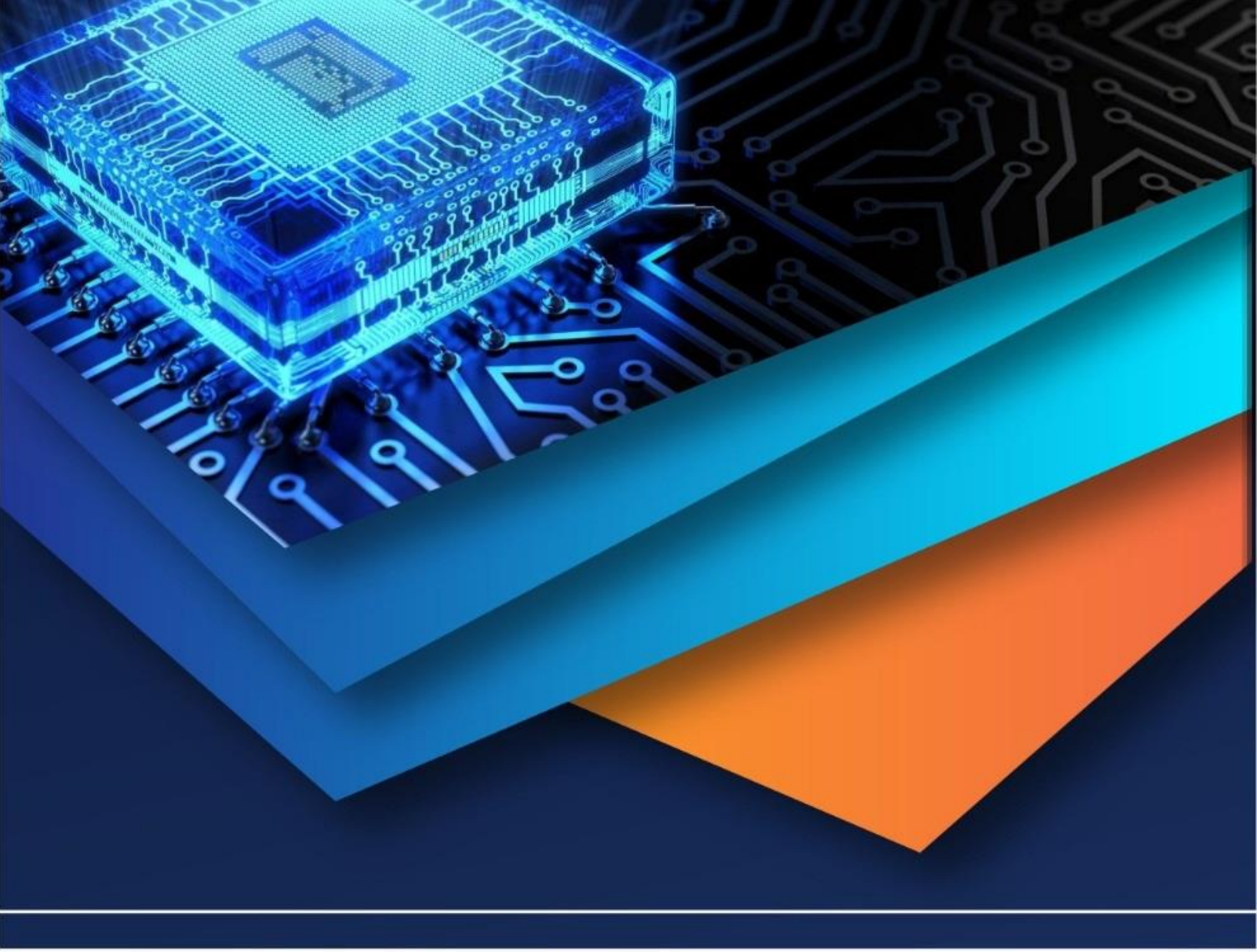

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