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LATE QUATERNARY STRATIGRAPHY OF CENTRAL NARMADA VALLEY, MADHYA PRADESH : RESPONSE TO TECTONICS AND BASIN MORPHOLOGY

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ABSTRACT

The nature of basin and tectonic activities in the Central Narmada Valley has resulted in the deposition of various lithological units during the Quaternary Period. The basinal highs and lows and repercussion of neotectonics have been responsible in the lateral shifting of the river Narmada, and deposition of sediments more through the lateral accretion. This has resulted in the observed variations in the disposition of different lithounits, which has led earlier workers to propose different statigraphic classifications for Quaternary deposits of Narmada Valley.

INTRODUCTION

The Central Narmada valley preserves thick deposits of the Quaternary period. The tectonic behavior of the Central Narmada valley is largely responsible for the accumulation of thick deposits. These deposits have received considerable attention from paleontologists and geologists. They have yielded rich collection of vertebrate fossil fauna. The valley, in general, and Quaternay deposits, in particular, received further attention since the finding of hominid (*Homo erectus narmadiensis*) partial skull from Hathnora (Sonakia, 198). The assemblage of fossil fauna were employed by the earlier workers as an important tool to propose relative stratigraphy (De Terra and Paterson, 1939; Khatri, 1961; Badam, 1979) (Table 1).

The Quaternary stratigraphy of the Narmada valley was proposed by Theobald (1860). He divided the deposits into Lower and Upper groups and dated them

Table 1: Composite Stratigraphy of Central Narmada Valley

Relative age		Theobald (1860)		De Terra & Paterson (1939)	Khatri (1966)	Supekar (1968)	Badam (1979)
HOLOCENE					Yellow silty + Modern soil		
PLEISTOCENE — UPPER	Late						
	Middle				Yellow cross-bedded sand		
	Early			Younger alluvium	Cemented gravel	(1)	(2)
PLEISTOCENE — MIDDLE	Late						
	Middle			Older alluvium			
	Early				Red clay / Boulder conglomerate		
PLEISTOCENE — LOWER							
PLIOCENE		Upper Group	Black cotton soil irregular beds of sand & conglomerate				
		Lower Group	Red yellow clay & Boulder conglomerate				

(1) Black cotton soil
Yellow brown kankerised silt
Sandy brown kankerised silt
Sandy pebbly gravel
Red brown concretionary silt
Boulder coglomerate

(2) Dark brown consolidated silt and gravel
Yellow brown calcreted silt, sand & gravel
Reddish brown calcareous silt
Cemented boulder gravel

to Pliocene period. This stratigraphy continued to be recognised till De Terra and Paterson (1939) proposed a new classification and dated the deposits as Middle Pleistocene. The deposits were divided into Older and Younger alluvium (De Terra and Paterson, 1939). The Older alluvium comprised the Lower and Upper groups. The Lower group included basal conglomerate and Lower red concretionary clay, whereas Upper group included upper gravels and upper pink concretionary clay. The Younger alluvium consisted of black cotton soil. Khatri (1966) juxtaposed red clay and boulder conglomerate followed by cross-bedded sand, yellow silt and modern soil, in ascending order and dated them from Middle Pleistocene to Holocene. Subsequently, Supekar (1968) made minor revision to the proposed stratigraphy by placing boulder conglomerate below the red clay and dating the deposits to Upper Pleistocene. Badam (1979) accepted the stratigraphy proposed by Supekar with revision in the age. On the basis of the presence of *Hexaprotodon*, Badam (1979) assigned Middle Pleistocene to early Upper Pleistocene age to these deposits. Detailed morphological studies of the species of *Hexaprotodon*, reported from the Narmada valley, suggested that the species, namely *H. palaeindicus* and *H. namadicus*, are sexual diamorphics and hence cannot be treated as index fossils to assign relative dates to the sediments (Salahuddin, 1988).

Further, the two-fold stratigraphy was reorganised into three-fold stratigraphy (Biswas and Dassarma, 1981). The deposits were divided into Narmada lower, Narmada middle and Narmada upper, with each unit separated from the other by a disconformity. The Narmada lower deposits included red boulder bed, deep red gritty layer and deep red clay (often mottled); the Narmada middle deposits included boulder bed, yellow, red and grey grit and sand, and pinkish clay and sand with calcretes; and Narmada upper deposits comprise grey sand with calcretes, pedocal layer and black cotton soil. Based on the fossil mammal assemblage, the Narmada lower and Narmada middle deposits are dated as Upper Pleistocene, whereas Narmada upper deposits are dated as Early Pleistocene. Biswas (1989) designated Narmada lower as Narsinghpur Formation, Narmada middle as Devakachar Formation and Narmada upper as Jhalon formation (Table 2). He further assigned changes in the age of these formations, based on the findings of *Equus hemionus khur* and *Elephas namadicus*. The Narsinghpur Formation is dated from Middle Pleistocene to Late Pleistocene, Devakachar Formation to Late Pleistocene and Jhalon Formation to Early Holocene (Biswas, 1989).

Table 2: Three-fold classification of Quaternary sediments of Central Narmada valley (after Biswas, 1989)

Period	Formation	Lithology
Early Holocene	Jhalon	Grey clay and silt, grey sand and grit, grey pebble bed
	~~ disconformity ~~~~	
Late Pleistocene	Devakachar	Pinkish clay and silt, grit sand-upper part yellow, lower part grey, grey pebble bed
	~~ disconformity ~~~~	
Middle to Late Pleistocene	Narsinghpur (not entirely exposed)	Deep red clay and silt often mottled, deep red sand and grit
	~~ disconformity ~~~~	
	basement not clear	

NARMADA-SON LINEAMENT VIS-A-VIS NARMADA RIVER VALLEY

It would be equally important to review the geological history of the lineament before discussing the issues related to the stratigraphy of exposed Quaternary sediments.

The Narmada-Son lineament is an ancient tectonic feature and has been dated as Precambrian (Choubey, 1971). The lineament is bounded in the north by Vindhyan rocks and in the south by Purana Group of rocks. The lineament, also termed SONATA (Sone-Narmada-Tapti Lineament), is 1600 km long and 150-200 km wide (Ravi Shanker, 1991). Structural and geological studies suggest division of the lineament into longitudinal fault-bound blocks caused by lateral and vertical movement of cross/transverse faults (Ravi Shanker *et al.*, 1989). The lineament governs largely the course of river Narmada. The lineament preserves the evidences of active rifting in Late Archaean-Early Proterozoic times (2600-2400 Ma), thereby establishing the antiquity of the lineament to the geological past (Nair *et al.*, 1990). It is, therefore, not surprising to visualise the sedimentation in the lineament since the geologically early times. The deep bore hole logs (300m below the surface, courtesy Central Ground Water Board, Bhopal) at various places in the valley further corroborate the hypothesis. Seismic activities, recorded from various parts of Narmada valley, range in magnitude as much as 6.3 on the Richter scale (Brahmam, 1990). The earthquakes of 1863, 1938 and 1967 are further indicative of reactivation of deep buried lineament and/or faults in the valley. The recent earthquake (1970) in western India suggests the fault plane striking parallel to the Narmada-Son lineament (Gupta *et al.*, 1972).

GEOMORPHIC INVESTIGATIONS AND STRATIGRAPHY

In pursuit of evoking fresh thinking on the stratigraphy of the Narmada valley, it was imperative to visit the litho-sections, studied by earlier geologists. Emphasis is laid on the sections reported between Devakachar and Barmanghat (fig.1) as a large fossil faunal assemblage is known from this part of the valley and employed in the stratigraphic classification and dating.

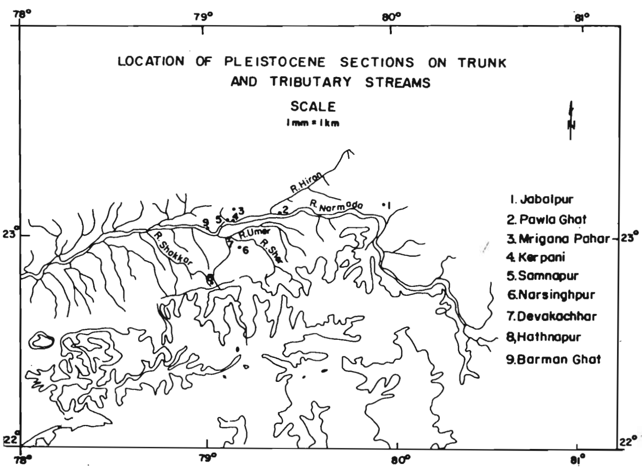

Fig. 1. Location map of some important localities of Pleistocene deposits situated on trunk river Narmada and its major tributaries.

Bedhaghat (Jabalpur) (fig 2) : Before the entering the waterfalls at Bedhaghat River Narmada branches out on the right and takes a loop to rejoin the main river about 2 km downstream from the fall. The loop is an abandoned channel of the river and serves the purpose of spillway during the high discharge of river water. Thick Quaternary deposits are exposed along the spillway (fig. 3). The basal unit exposed is red clay (about 4m thick). It is compact and devoid of calcium carbonate of any form. It is overlain by thin deposit of medium to fine grained sand. Above it the red calcretised silty sand is present. The calcretes, nodular in form, are distributed all over the deposit. The top of this unit preserves the evidences of root casts, suggestive of the exposure of the bed to sub-aerial agencies. Overlying it is the cross-bedded sandy pebbly gravel. The channel gravels comprise clasts of basalt, most of which are weathered. Besides, clasts of schist and quartzire are also present. Very few clasts of dolomite, essentially of gravel size, are present in the deposit. The litho-unit gradually coarsens upwards and the clast size increases with predominance of dolomitic marble as a conspicuous clast component.

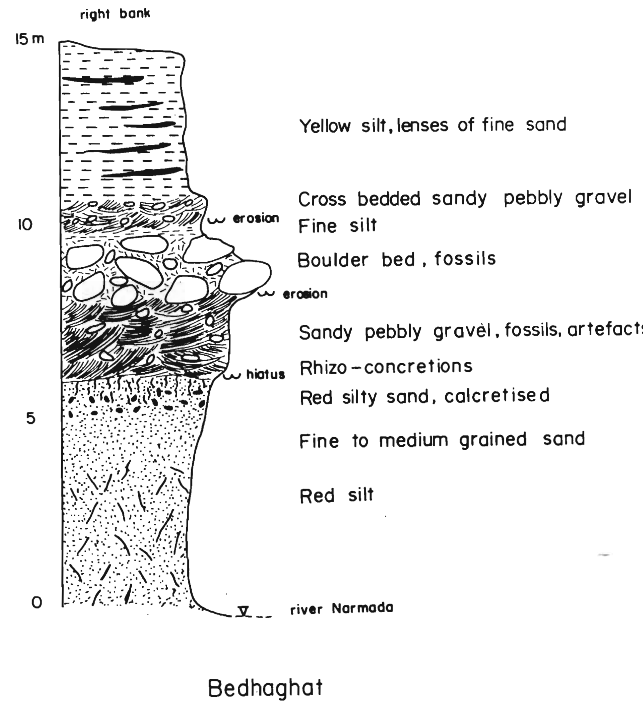

Fig. 2. Litho-column of Pleistocene alluvial deposit exposed on the right bank of river Narmada on a link-channel near Bedhaghat.

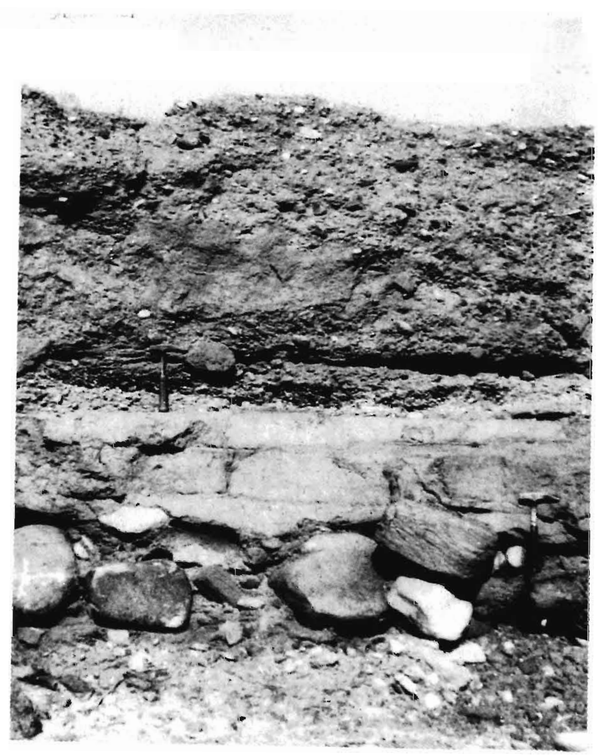

Fig. 3. An upper part of litho-column shown in Fig. 2. Note the fine silt embedded with boulders, now collapsed due to subsequent flush out of silt and overload. Overlying is the cross-bedded sandy pebbly gravel with lensoid bodies of medium-grained sand.

Fig. 4. A closer view of the boulders strewn over the gravels due to flushing out of silt and erosion.

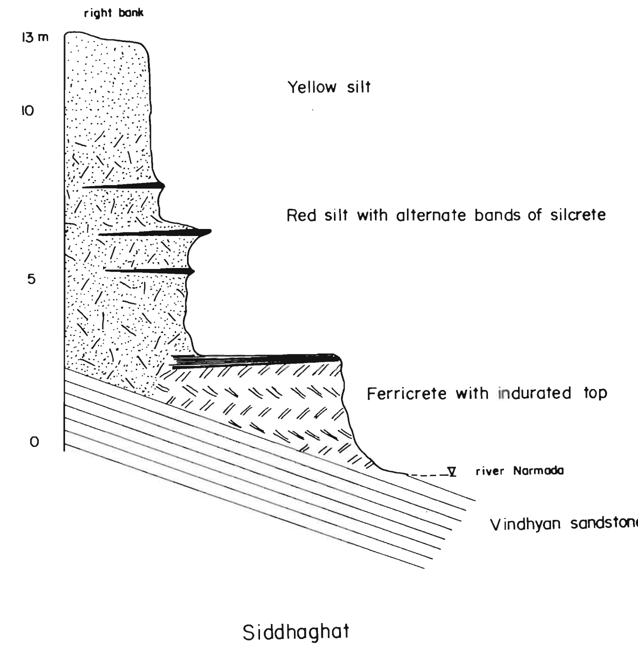

Fig. 5. Litho-column of Pleistocene alluvium and Tertiary (?) ferricrete exposed on the right bank of river Narmada at Siddhaghat.

Also, the increase in the size of the other clast component is noticed. The top of the unit is truncated by erosion. Deposits of boulders of dolomitic marble overlie the eroded surface (fig 4). The faunal material from this unit is taphonomically misfit and suggests the allochothonus nature of deposition of the fossil fauna (Badam *et al.* 1986). The boulders of dolomitic marble lack orientation and are matrix supported. Thin deposits of finely laminated silt cap the boulders.

Siddhaghat (fig. 5) : The Siddhaghat section is exposed near the village of this name at a distance of about 20 km downstream from Bedhaghat. The River Narmada cuts into a thick (20 m) alluvial deposit. It cuts through the ferricrete, which is at the base of the lithounit. The 3m thick ferricrete, indurated at the top (fig. 6), is the result of ferricretisation of the detrital material. The ferricretised detrital material rests over the outcrop of the Vindhyan Sandstone. The possibility of ferricretisation of the older surface could be during the absence of river at Siddhaghat in the geological past. Downstream from Siddhaghat, the sandy pebbly lithounit comprise pellets or pebbles of laterite as one of the clast component. It is suggestive of entrenching of ferricrete litho-unit in the geologically younger times. The ferricrete, possibly of Late Neogene Period, have been formed under semi-arid to sub-humid environmental conditions.

Mahadeo Piparia : The litho-unit at Mahadeo Piparia was studied by Supekar (1968). The section has red clay at the base, followed by boulder conglomerate. The conglomerate unit comprises clasts of Vindhyan sandstone and quartzite. The sandy pebbly unit overlying the conglomerate, consists of clasts of siliceous rocks (like chert, chalcedony, etc.), basalt and pellets of laterite. The basalt appears as clast component in the sediments from the sandy pebbly gravel unit onwards, despite the presence of basalt outcrops in the upstream near Mahadeo Piparia.

Pawlaghat (fig. 7) : The site is situated from 1.5 km upstream the confluence of river Hiran with Narmada. Here, too, red clay is exposed at the base and is overlain by unconsolidated sandy pebbly gravel consisting of abraded fossil fauna. A lense (4 x 0.6 m) of volcanic ash

Fig. 6. A closer view of indurated ferricrete (late Tertiary ?) exposed at Siddhaghat.

(tephra) occurs at the junction between unconsolidated sandy pebbly gravel and yellow silt (fig. 8). The tephra lense occurs as a lag deposit, as evident from the associated clast of the Vindhyan Sandstone.

Devakachar: At the village Devakachar, the boulder conglomerate unit is absent. The red clay litho-unit is overlain by sandy pebbly gravel. A large collection of vertebrate fossil fauna has been made by the geologists from the sandy pebbly unit exposed at Devakachar along the river Umer. However, the assemblages from Devakachar and Talayyaghat (about 1 km downstream from Devakachar, on the river Sher), have proved taphonomically a misfit and allochothonous to the site of deposition (Badam *et al.*, 1986).

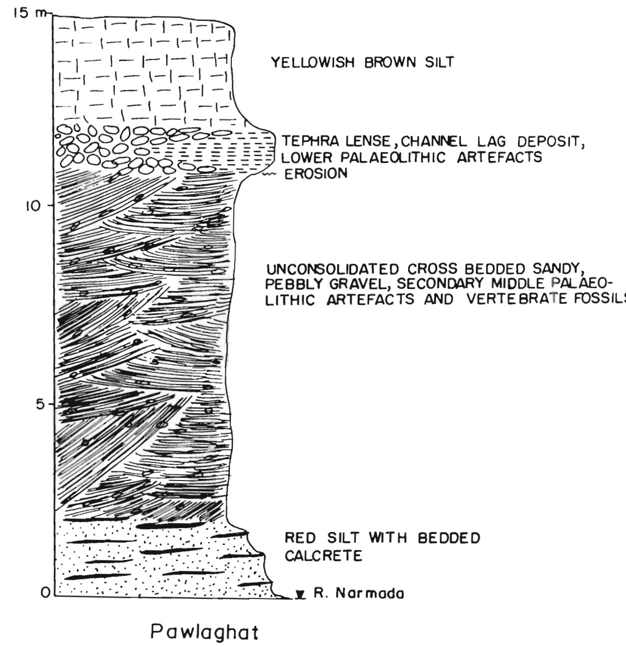

Fig. 7. Litho-column of Pleistocene alluvium exposed at Pawlaghat situated on the right bank of the river Narmada.

Samnapur (fig. 9) : South of village Samnapur, on the right bank of river Narmada, is the location of primary Middle Palaeolithic site, excavated by the team of geologists and archaeologists of Deccan College, Pune (Misra *et al.*, 1990). The stratigraphical column of the site is a composite one. The units of red clay and boulder conglomerate are exposed near the river Narmada and along the Richai nallah. The compact clay, formed as a result of the back swamp deposition, overlies the boulder conglomerate. A rubble horizon, comprising the stone artifacts and a few clasts, overlies the clay unit. The section is capped by the yellow silt horizon. The litho-units, namely clay and rubble horizons, are locally exposed at Samnapur only. Behind the archaeological site is a small tributary (Mutia nallah), which originates from near Mrigana Pahar and cuts through the rocks of the Gondwana Group. The Gondwana rocks are overlain by thin unconsolidated pebbly deposits bearing artefacts of Mesolithic Period. The presence of the artefacts of reasonably young geological period (early Holocene) and recent entrenchment of Mutia nallah, as evident from the geomorphic observations, suggests a geologically recent tectonic movement in the area.

Barmanghat (fig. 10) : The Quaternary deposits are exposed along both the banks of the river Narmada at Barmanghat. Essentially, a sandy pebbly gravel unit, with alternate layers of unconsolidated and consolidated sediments, are exposed on the right bank. Fine to medium grained cross-bedded sand occurs at certain intervals within the sandy pebbly unit. Concentration of

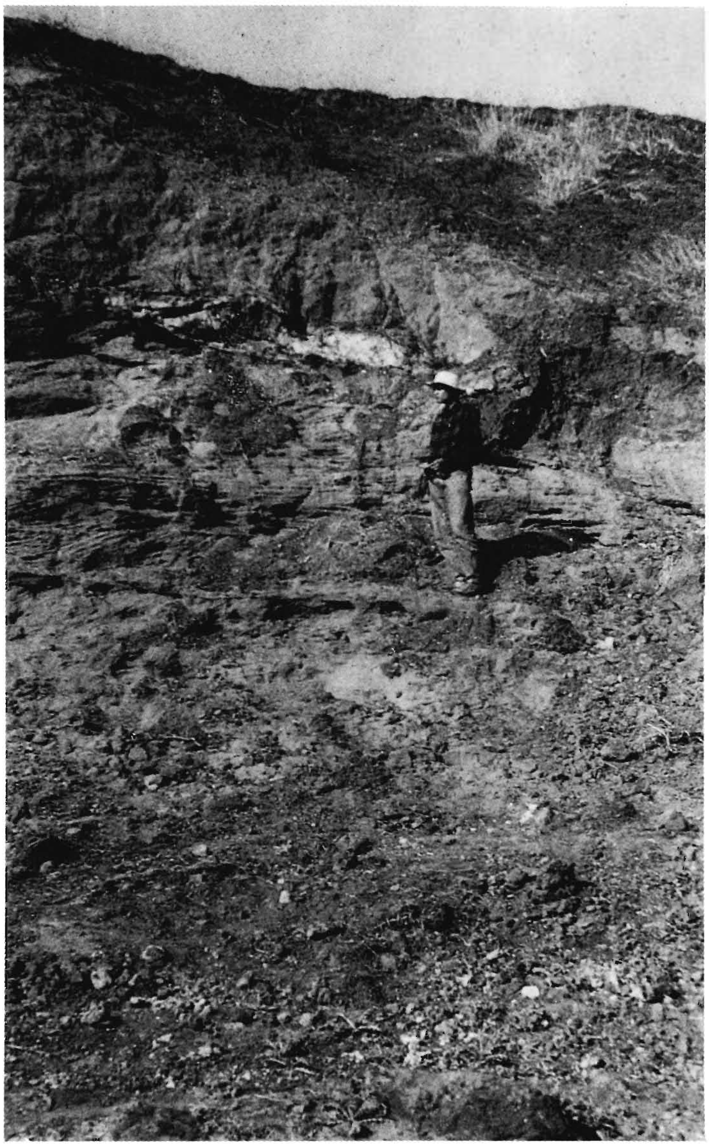

Fig. 8. A closer view of the lensoid body of volcanic ash (tephra lense) at the height of the head of the standing man. Other litho-units, sandy pebbly gravel and yellow silt are seen exposed below and above the tephra lense, respectively.

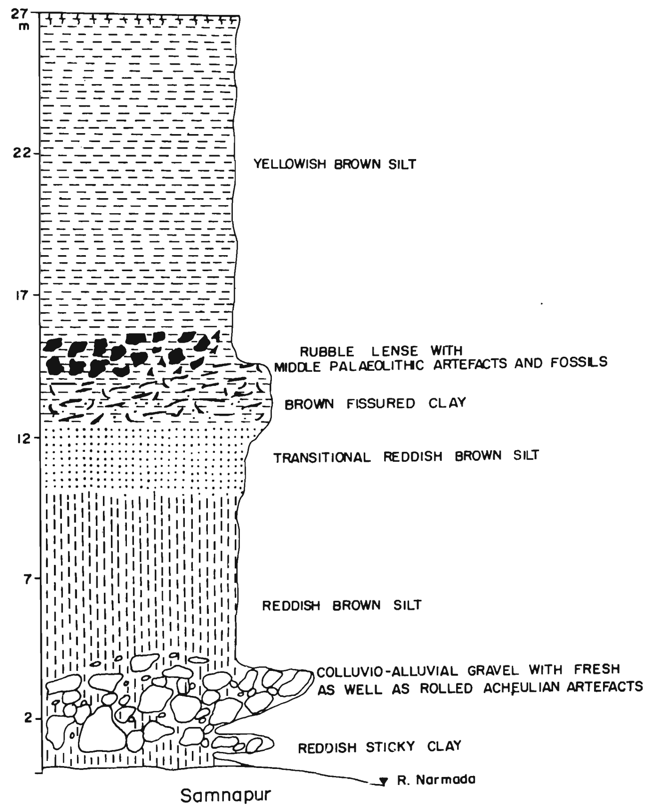

Fig. 9. Litho-column of Pleistocene alluvial deposits exposed at Samnapur on the Richai nala, a tributary of river Narmada. The autochothonus nature of palaeolithic artefacts has been the significance of the site.

molluscan shells within the sandy unit is represented as a thin layer (.30m). Overlying the sandy pebbly unit is the fine laminated yellow silt. A little upstream and diagonally opposite to the section is a thick deposit of boulders and cobbles. The coarse deposit, essentially of Vindhyan sandstone, is ungraded, clast supported and imbricated. The other clast components are basalt, green quartzite and siliceous rocks. The depositional nature of the sediments suggest high discharge conditions of the river Narmada.

Hathnapur (fig. 11) : The exposures of the Quaternary are along the right banks of Shakkar river. The boulder conglomerate deposit is the result of cut and fill within the Gondwana rocks. The highly consolidated deposit is poorly sorted and lacks imbrication. The predominance of locally available rock fragments as clast components suggests a fill depositional environment. Deep entrenchment by the river Shakkar has exposed the deposits.

DISCUSSION AND CONCLUSION

From the present study of the litho-sections, it has become clear that red clay and boulder conglomerate are the units exposed along the north bank of river Narmada. Also, the units are dominated by mono-rock type, derived from the Vindhyan hills. The units are located very near to the foot-hill of Vindhyan hills. The gravity contour study of the river Narmada indicates that it is tectonically controlled and is flowing along the southern fault of the rift (Brahmam, 1990). Close inter-relationship and temporal correlation between the structural and geomorphological evolution of the SONATA and Himalaya is suggested (Ravi Shanker, 1993). The tectonic pulsation in Himalaya, thus, would have been responsible in the uplift and subsidence of blocks in the lineament, causing deposition of coarser material from the uprising hills and basinal highs in close proximity.

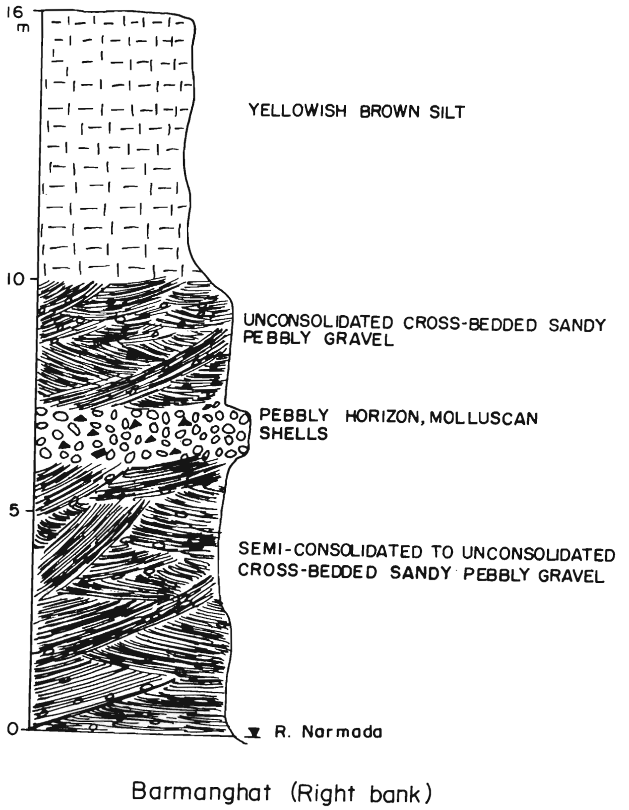

Fig. 10. Litho-column of the Pleistocene alluvial deposits exposed on the right bank of river Shakkar, a major tributary of river Narmada at Barmanghat.

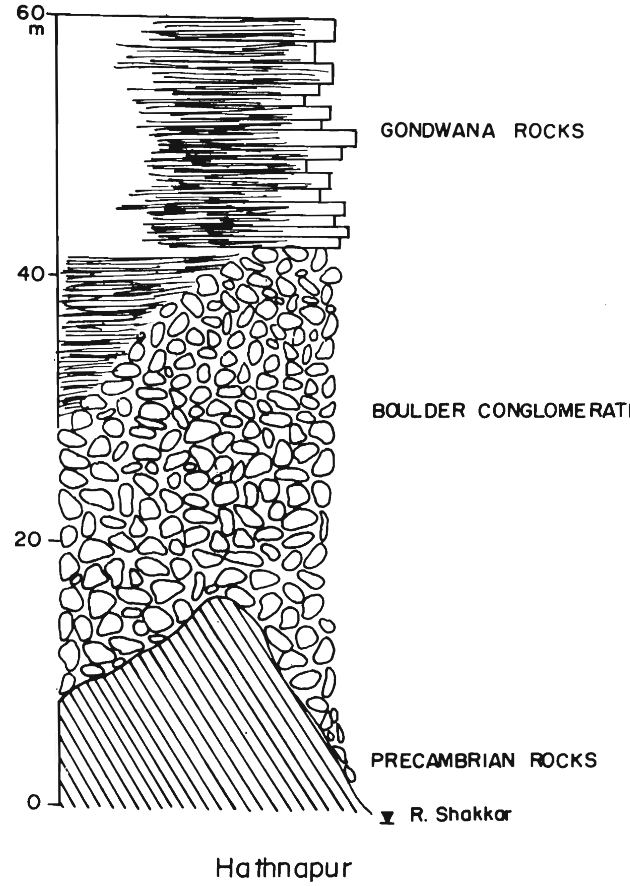

Fig. 11. Litho-column of the Pleistocene fill deposits on the right bank of river Shakkar, a major tributory of the river Narmada.

This could be further corroborated from the coarse wash depostis of Palaeocene and Lower Eocene lying unconformably over the Deccan Trap in the western end of the SONATA zone, which experienced 'tensional environment with rapidly subsiding basins' (Ravi Shanker, 1993). Besides, direct evidence of Late Cenozoic tectonic movement is ascertained from the fact that several faults which were normal in the older layer show reverse effect (Ravi Shanker, 1993).

The sandy pebbly unit is lithologically quite in contrast to the underlying units. The unit is heterogenous in composition and devoid of cobbles and boulders. Besides, definite evidences of fluvial depositional environment are identified like cross-bedding, etc. The incorporation of clast of the Deccan Trap, ferricreate, etc. suggest the integration of fluvial system in the valley. The finding of fossil assemblage from this deposit, though secondary in nature, helps in assigning the Late Pleistocene age to the deposit (Rajaguru *et al.*, 1994). The subsequent quiescence of Himalayan tectonics also resulted in bringing in the stability of the Narmada-Son lineament. As a result, the fluvial system achieved graded form and gradually got integrated to deposit a uniformly exposed sandy pebbly gravel all over the valley.

The uppermost unit, fine laminated silt, suggests the complete grading achieved by the river Narmada. This unit once again is exposed uniformly all over the valley which in turn suggests the establishment of fluvial system and its grading nature.

The presence of tephra lense, rubble horizon, and high discharge deposits are certain depositional features which, though local in nature, have significant importance. The presence of tephra lense within the Quaternary deposits poses perplexed questions. It is believed that tephra in the valley is an aerial fallout of the volcanic episodes in SE Asia (Korisettar *et al.*, 1989). Similarly, the precise cause of deposition of rubble at Samnapur is still unanswered. This localised feature is attributed to several reasons, e.g., deforestation of nearby hills, rejuvenation of fault within the nearby Bijawar outcrops, local washdown by Richai nallah. However, it is yet to be accepted that such localised features could be the result of variation in one fault block to another, as a response to tectonic pulsations.

It is, therefore, suggested that stratigraphy of the Central Narmada valley is controlled by the tectonic movements in the valley from time to time. In response to these tectonic pulsations, the basin configuration has constantly undergone modifications, which are reflected in the sedimentary deposits of the exposed Quaternary litho-units. The lateral shift of fluvial agency, caused by the modification in basinal configuration and/or tectonics, has resulted in the syn-deposition of varios litho-units over space and time. Perhaps, this fact remained unattended by the earlier geologists and therefore resulted in periodic revisions in the stratigraphy.

It can be said that among the exposed deposits of the Quaternary, there are three main litho-units, namely Red clay and Boulder Conglomerate, Sandy pebbly gravel and Yellow silt (Table 3). The other units are the result of local variations due to basin configuration and tectonic pulsation.

Table 3: Revised stratigraphy of exposed Quaternary Deposits

Litho-Units	Geomorphic event	Relative age
Yellowish silt, occassionally with defused calcium carbonate	Aggradational phase	Holocene to Terminal Pleistocene
~~ disconformity ~~~		
Sandy pebbly gravel with rolled vertebrate fossil fauna and stone artefacts	Integration of fluvial system, river grading	Late Pleistocene
~~ disconformity ~~~	tectonic activity	
Red clay with lenses of boulder conglomerate	Disintegrated fluvial system, lateral depositional process active	Late Middle Pliestocene

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