ISSN NO. 2320-5407

*Journal homepage: http://www.journalijar.com*

*INTERNATIONAL JOURNAL OF ADVANCED RESEARCH*

**RESEARCH ARTICLE**

# Quaternary Tectonics & Sedimentation in Narmada Rift Valley, With Special Reference to Garudeshwar and Bharuch Section Gujarat State India

**Dr.A.A.Khan**
Ex. Director Geological Survey of India
,Director Rajeev Gandhi Proudyuogiki Mahavdhyalaya Bhopal-4620042 M.P India
Dr Maria Aziz
Medical Scientist
Rajeev Gandhi Ayurvedic College & Hospital Bhopal- 462004M.P. India
-

## *Manuscript Info*

***Manuscript History:***

Received: 11 January 2015
Final Accepted: 25 February 2015
Published Online: March 2015

***Key words:***

***Corresponding Author**

**Dr.A..A.Khan**
**Dr.Maria Aziz**

## *Abstract*

The Narmada river originates at Amarkantak at an elevation of about 1057 m above m.s.l.it descends across the rugged and mountainous tract through deep and steep gorges in straight sinuous to meandering pattern over a distance of 1280 km across the middle of the Indian sub-continent to join the Gulf of Cambay in Arabian sea in Gujarat state. It negotiates in sinuous to meandering pattern, at places it has conspicuous straight segment controlled by E-W lineament. It is bound by Vindhyachal in the north and Satpura range to the south; the area in between these two upland linear trench is found to be ideal area for study of Quaternary sedimentation as witnessed by the presence of multicyclic sequence of Quaternary terraces in Jabalpur- Baruche section. These terraces represent the former levels of valley floors formed by cumulative erosional and depositional activities of the river system.

In the area of study in lower Narmada between Grudeshwar and Baruche is occupied by thick Quaternary deposits of about 800 m which represent various domain of sedimentation. Based on sedimentlogical characters, depositional environments, erosional processes and their relation with depositional activity revealed that it comprised of four domains of sediments viz glacial, fluvio-glacial fluvial and tidal flats. The lower most unit (Boulder bed) is, of glacial origin, followed by the boulder conglomerate of glacio-fluvial and subsequently by fluvial of paleo- domain of Narmada and tidal flats. The top four formations Ankleshwar, Tilakwarda & Bharuch and Aliabat are designated as ($NT_o$-$NT_3$). Boulder conglomerate is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 180 of the Narmada alluvium was deposited in two distinct aggradations episode with a distinct, well defined break in sedimentation in rift system. The dissection of the quaternary blanket resulted in to two terraces ($NT_3$-$NT_2$), after break in sedimentation. The sediments of this aggradations episode constitute three lithostratigraphy units viz Ankhleshwar, Tilakwarda and Bharuch formation. The sediments of the alluvial phase are underlain by a boulder bed of glacio-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age.

The Quaternary blanket of in lower Narmada valley provides evidences of significant changes in channel kinetics of Paleo domain and present day domain of Narmada related with eustatic & sea-level fluctuation. The Quaternary deposits contained in the western asymmetric trench consist of sediments of various domains viz glacial, fluvio-glacial, fluvial, lacustrine and tidal flats later influenced by incursion of marine transgression and regression on tectonically active platform. It is evidenced by bore hole data and subsurface statistical analysis of sediments, quartz grain morphology of sediments, pale sole geometry and configuration of quaternary deposits in western segments of Narmada rift valley and SONATA TECTONIC ZONE.
The Quaternary deposits and river terraces (NT1to NT3) entrapped in tectonic zone with rock cut equivalence and scars are positive significant imprints of euestatic change / climatic changes in the during the sedimentation. The alluvial fan in between Tilakwarda and Rajpipla within the loop of Narmada Chamyal (2002) is mono illustration of morphogenetic process associated with neotectonic event. The disposition of Quaternary blanket, fan deposit and other quaternary land forms are controlled and restricted by SONATA LINEAMENT towards north. The fan deposits as claimed are not persistent in conformity of piedmont sedimentation, further it is devoid of torrential stream net work which firmly rules out to be endogenetic fan deposits. It appears to be older quaternary deposits of Narmada which has moved from basement and has been pasted along SONATA LINEAMENT.



## INTRODUCTION

The Narmada river originates from the Amarkantak plateau of Satpura Ranges in Rewa at an elevation of about 1057 m (220 40’ -810 45’) flows westerly course for about 1280 kms length across the middle of Indian subcontinent before entering Gulf of Cambay in the Arabian sea in Gujarat state. It enters the alluvial plain and passes through the deep gorge of Marble rocks near Jabalpur. It then takes westerly turn through the alluvial tract, situated between the Satpura and Vindhyan hills. The river course of Narmada conspicuously straight and is controlled by ENE_WSW to E_W lineament, is bounded by Vindhyan in the north and Satpura in the south. The average with of the valley is about 32 kms.

In the area of study in lower Narmada between Grudeshwar and Bharuch Quaternary belt of Narmada basin covers an area of about 4500 sq. km, is occupied by thick Quaternary deposits of which is about 800 m thick and represent various domain of sedimentation. It is found to be ideal locus of Quaternary sedimentation in western India as witnessed by multi-cyclic sequence of Quaternary terraces in the valley. The general elevation of Narmada alluvial plain varies between 00.00 to 65.00 m in lower Narmada and 65.00 to to 95.00 m in upper Narmada valley above the sea level. The general gradient of this plain in this stretch is about 1m /km towards west

The lower Narmada valley is exposed to the repeated post erosional & depositional activities and subjected to anisotropic and asymmetric tectonic dislocation which has culminated diversified manifestation, which further undergone to process of tectonic evolution and chiseling of rift valley by dynamic erosional and depositional activity resulting in reshaping of the terrain into various multi morphogenetic illustration and reorganization of units and land form element, sequential and renewed configuration of drainage, topography, physiography, plantation surfaces, denudation ridges, structural linear valleys, strike hills, valley gapes, escarpments and river terraces. The cumulative concealed dynamics and structural deformation of rinsing and sinking platform of Narmada, hidden cyclic mechanism of tectonics, geothermic, seismicity and neotectonics has illustrated various signatures and imprints on landscape in the valley. In addition the valley gapes and valley trenches provided ideal sites for sedimentation for formation of quaternary platform, pediment, pediplain, peniplain and river terraces.

### Review of Litrature

Splishbury (1833) was first to initiate the paleontological studied of Quaternary deposits of Narmada valley. Princep

(1834) described the Splishbury collection, which now forms the part of fossil collection in British museum. Theo bold (1860) (1881) was first to study the Quaternary deposits of Narmada in Hoshangabad and surrounding area. He referred the quaternary deposits of Narmada of Pleistocene age. He divided these deposits in lower and upper Groups and reported an axe from reddish clays of the Upper Group. In the following year Late (1881) he recorded a human cranium (transported), which was identified as Homo sapien supposed to have come from conglomerate bed

of Lower Group. Unfortunately the cranium specimen was lost in the museum of the Asiatic society of Bengal, hence the find remained inconsequential. Pilgrim (1905) reported various stone implements and considered the deposits to be Pleistocene age. De Terra and De Cardian (1936), De Terra and Petterson (1939) correlated these deposits with the Pleistocene of Northern India. Broadly they agreed to the classification of Narmada in to lower and upper as opined by Theobold (1860). The Homo Sapien cranium, which Theobold thought, came from the conglomerate bed, according to them it could have come from a younger deposit. They collected many Paleolithic tools, and stone implements but they were unsuccessful in coming across any mammalian fossil. Based on fossil assemblage and stone implements they compared the Quaternary of Narmada with those of Middle Pleistocene of North Western India characterized by fauna Elephas antiques (mammalian). Hour (1963) and Khatri (1966) studied various palaentological aspects of Quaternary deposits of Narmada valley. Triparti (1968) compared and correlated the Quaternary deposits of Godavari Valley with the sediments of Narmada Alluvium, on the basis of fossil assemblage and stone implements. According to him the Narmada fauna was equivalent to older alluvium fauna of Indo-Gangetic plain and slightly older than that of Kurnool cave deposits. Gupta (1974) studied geological and geomorphologic aspects of parts of Narmada valley. Biswas and Dassarma. Badam (1981) and Dasssarma (1979) studied the fossil assemblage of Quaternary strata of Narmada valley. Khan (1984) carried out detailed, geological, geomorphological and sedimentological studies and identified three prominent terraces in the central sector of the Narmada. The alluvial, deposits of the Narmada valley represent the thickest quaternary deposits in peninsular India. (Sonakia 1984), recovered skull cap Homo eructus from quaternary deposits of Narmada. The boulder bed which yielded Hominid fossil first time reported for the first to be of glacial & fluvio-glacial origin (Khan & Sonakia 1992). Beside occurrences of association of ash beds with fossileferous boulder conglomerate (Khan & Rahate 1991) indicates some of the volcanic source. It appears that close to the completion of cycle of deposition of the boulder bed there was powerful volcanic eruption and subsequent settling of the ash. The occurrences of association of two marked horizons at different levels further reveal the cyclic eruption and settling of volcanic matrix during sedimentation.

In recent years occurrences of volcanic ash beds in association with the quaternary sediments has been reported from different river basins of western, central, eastern and southern India. The first report on occurrence of Quaternary volcanic ash in India was by Williams and Royee (1982) subsequently similar occurrences were reported by several workers In Narmada the two horizons were identified one above the boulder conglomerate and other in the younger deposit khan (1992).

The complete account of Quaternary lithostratigraphy has been up dated in the Narmada valley (Khan 1984, Khan et.al 1984, Khan et.al 1990-91 Khan & Sonakia 1992, Khan & *et al* 1991, Rahate & Khan 1985, Khan *et al.* 1991, Khan 1991, Khan *et al.* 1992, Yadav & Khan 1996. The Narmada valley embodied almost whole of the Quaternary deposits time span from the lower Pleistocene to Holocene (Khan & Sonakia (1992). Khan (1912), Khan (2012), Khan ( in press) , Khan ( in press),.The results of sedimentological studies Khan ( 2014), quartz grain morphology, Khan ( 2014) paleo sole study of type Quaternary column section in Hominid locality in central sector of Narmada revealed the presence of complete sequence of quaternary sediments in Narmada rock basin viz glacial, fluvio-glacial and fluvial domain whereas the boulder conglomerate which has yielded human skull is of fluvio-glacial origin from Khan & Sonakia (1992) The results of analysis of sedimentary structures Khan ( in Press) Quartz grain morphology of sediment column, Khan ( in Press) Quartz grain morphology of different pale- sole, , Khan ( 2014) heavy mineral assemblage Khan ( in Press) tephra stratigraphy, , Khan et.al (1991 ) Khan & Maria (1912) magneto-stratigraphy, and bio-stratigraphy and correlation of sediment columns intra valley wise , inter valley wise and on unified Quaternary thrown new light on the age of the Narmada Homo erectus. Discoveries of volcanic ash beds and palaeomagnetic reversal in these Platform Khan et.al (2012) Khan (2013) focusing on hominid localities of Chinathe Quaternary deposits of Narmada have been correlated on Quaternary platform of China the first timeassisted in fixing the chronologic position of the skull. Fresh data on the age of the Narmada

*Homo erectus* are also available by additional finds of fossil mammals and a detailed taxonomic study along with a thorough review of some families of mammals.

**Area of study**

The area of study is located in the western extremity of Narmada basin in lower Narmada valley at the mouth of Gulf of Cambay. It is bounded by latitude 21 30 to 22 31 North 72 50 to 74 15 East in parts of Bharuch of Gujarat state. The area is main segment of tectonic disconformities; it encompasses two crustal provinces of Central India Shield, namely, the Northern Crustal Province (NCP) and the Southern Crustal Province SCP (Acharyya and Roy, 1998; Roy, 1988).

The area is situated at terminus point of basin which forms a oval depression which elongated and starched E-W direction ad truncated by crossed structural lineaments trending NW –SE, NE-SW direction. The quaternary blanket exposed to post deposition activity which subsequently chiseled by cumulative geostatic ad climatic changes resulting into various terraces, pre-quaternary and quaternary surfaces and landform elements of various domain and plantation surface. In the area Narmada channel course is both obstructed & guided and controlled by the cross lineament trending transverse to strongly dominated ENE-WSW to E-W SONATA LINEAMENT resulting in the channel dynamics to suddenly open out which at short range became sluggish as evident by the landscape manifestation of the area. The Garudeshwar and Bharuch section Narmada, descends in sinuous to meandering pattern, it is strongly influenced and guided by the SONATA lineament the major geofracture known as the Narmada-Son fault, which causes the river to flow westwards, opposite to the regional slope. The Narmada basin in the area consists of various sub- basins like Madhumati,Orsang Unch Heran,Aswan,Men rivers constitute minor basins which are tectonically segmented & ecologically integrated as in built part of main rift System. (Plate No 1)

**2. Tectonic set up of lower Narmada Rift Valley**

The Narmada River in its traverse across Indian Peninsular traversing the different geological domain from Archean to Quaternary along the length of 1280 kms debouching into Gulf Of Cambay in Gujarat state has embedded with two prominent Quaternary blankets in the valley one in Jabalpur –Harda section and another in Gurudeshwar –Bharuch section. Besides Harda –Barwani section is represented by rock cut terraces. It flows along the ENE–WSW-trending Narmada–Son Fault (NSF), a well-known and conspicuous tectonic element. (Biswas, 1987). A major part of the course of the Narmada River falls within the rocky area comprising Late Cretaceous–Eocene basaltic lava flows belonging to the Deccan Trap formation .The Narmada negotiate its course in sinuous to meandering channel pattern and its course is controlled by the fault and lineament and cross fractures .It forms in its course water falls, gorges rapids, nick points and with steep fall Khan et.al. (2014) & (Rajaguru et al. (1995).

The Quaternary landscape in Jabalpur- Harda Section and Gurudeshwar _Bharuch Section represents stepped sequence of river terraces (NT1_NT3) where Harda _Barwani sction is represented by rock cut terraces and rock benches with thin cap of Quaternary sediments at places . The Harda _Barwani Section embodies prominent landscape of rock cut terraces, rock sheets which indicate cyclic rejuvenation of river due to uplift in watershed region of Narmada in Quaternary times. The fluvial terrace (NT_2) is conspicuous landscape and persistently developed along the valley, has divergent relative disposition and cyclic in nature and has paired equivalent. The inter relations of fluvial terrace and rock cut terraces, their relative disposition , divergence and convergence of older and younger terraces across the length of Narmada indicate mega linear tectonic dislocation across Peninsular India Khan ( 2014). Ravishankar (1991) regards the Narmada–Son Fault as a part of the composite tectonically controlled zone in the middle of the Indian plate and termed it as the SONATA zone. Other synonyms used in literature to describe this zone include Narmada–Son Lineament (Choubey, 1971), Central Indian Shear (CIS) (Jain et al., 1995) and Central Indian Tectonic Zone (CITZ) (Radhakrishna and Ramakrishna, 1988; Acharyya and Roy, 2000). Geophysical studies in the central part of this zone reveal that this zone is of intense deep-seated faulting (Reddy et al., 1995). The zone witnessed large-scale tectono thermal events associated with large granitic intrusions around 2.5– 2.2 and 1.5–0.9 Ga (Acharyya and Roy, 2000). It was again reactivated during the Deccan volcanic eruption during Late Cretaceous–Paleocene (Agarwal et al., 1995). Profuse occurrence of E–W-trending dykes suggest that the zone formed the main centre of eruptive activity (Bhattacharji et al., 1996).The entire zone is presently characterized by high gravity anomalies, high-temperature gradient and heat flow and anomalous geothermal regime (Ravishankar, 1991) suggesting that the zone is thermo mechanically and seismically vulnerable in the framework of contemporary tectonism (Bhattacharji et al., 1996). The westward extension of this zone into the lower Narmada valley exhibits a less complex structural setting. Data on the NSF in this part is mainly the result of extensive geophysical surveys for commercial exploitation of petroleum reserves in the subsurface. ( Plate No 1,3 & 4 )

In the lower Narmada, it is expressed as a single deep-seated fault (NSF) confirmed by the deep seismic sounding studies (Kaila et al., 1981). Seismic reflection studies have firmly established that the NSF is a normal fault in the subsurface and becomes markedly reverse near the surface (Roy, 1990). Reactivation of the fault in Late Cretaceous led to the formation of a depositional basin in which marine Bagh beds were deposited (Biswas, 1987). The NSF remained tectonically active since then with continuous subsidence of the northern block, designated as the Broach block, which accommodated6–7-km thick Cenozoic sediments (Biswas, 1987). The total displacement along the NSF exceeds 1 km within the Cenozoic section (Roy, 1990). However, the movements along this fault have not been unidirectional throughout. The general tendency of the basin to subside has been punctuated by phases of structural and tectonic inversion (Roy, 1990). The N–S-directed compressive stresses during the Early Quaternary, folded the Tertiary sediments into a broad syncline, the Bharuch syncline, in the rapidly subsiding northern block (Roy, 1990). The Bharuch syncline extends from the NSF to the Mahi river in the north. The E–W trending axis of this syncline lies to the north of the Narmada river. corresponding anticlinal structures are found in the Tertiary rocks exposed in the southern up thrown block. Historical and instrumental records indicate that the compressive stresses still continue to accumulate along the NSF due to continued northward movement of the Indian plate. This is evidenced by the fault solution studies of the earthquakes at Bharuch (23 March 1970) and Jabalpur (22 May 1997), which suggest a thrusting movement (Gupta et al., 1972, 1997; Chandra, 1977; Acharyya et al., 1998). However, the underlying cause of the seismicity in the NSF zone is not yet understood (Quittmeyer and Jacob, 1979) extending Gujarat alluvial plains. A significant feature of the lower Narmada valley is the deposition of a huge thickness of Tertiary and Quaternary sediments in a fault controlled basin. To the south of the ENE–WSW-trending Narmada–Son Fault (NSF), the Tertiary rocks and basaltic flows of Deccan Trap Formation occur on the surface while to the north they lie in the subsurface and are overlain by Quaternary sediments. However, the overlying Quaternary sediments having a maximum thickness of 800 m (Maurya et al., 1995) .The correlation of subsurface data of CGWB and other agencies on Quaternary Platform Khan (2012) and Khan (2014) indicate presence of glacial fluvio-glacial deposits at the base of rock basin. Drill data from some of the deepest wells in the basin have revealed occurrence of Deccan Trap at depths of 6000 m followed by an Archaean basement (Roy, 1990). The Tertiary sediments, outcropping to the south of the NSF, represent the full sequence from Eocene to Pliocene overlying the Deccan Trap and show extensive deformation in the form of several ENE–WSW-trending anticline highs and ENE–WSW and E–W-trending reverse faults. Profuse occurrences of E–W-trending dykes suggest that the zone formed the main centre of eruptive activity (Bhattacharji et al., 1996). The entire zone is presently characterized by high gravity anomalies, high-temperature gradient and heat flow and anomalous geothermal regime (Ravishankar, 1991) suggesting that the zone is thermo mechanically and seismically vulnerable in the framework of contemporary tectonism (Bhattacharji et al., 1996). The westward extension of this zone into the lower Narmada valley exhibits a less complex structural setting. In the lower Narmada basin, it is expressed as a single deep-seated fault (NSF) confirmed by the Deep Seismic Sounding studies (Kaila et al., 1981). Seismic reflection studies have firmly established that the NSF is a normal fault in the subsurface and becomes markedly reverse near the surface (Roy, 1990). Reactivation of the fault in Late Cretaceous led to the formation of a depositional basin in which marine Bagh beds were deposited (Biswas, 1987). The NSF remained tectonically active since then with continuous subsidence of the northern block, designated as the Bharuch block, which accommodated 6–7-km thick Cenozoic sediments (Biswas, 1987). The total displacement along the NSF exceeds 1 km within the Cenozoic section (Roy, 1990). However, the movements along this fault have not been unidirectional throughout. The general tendency of the basin to subside has been punctuated by phases of structural and tectonic inversion (Roy, 1990). The N–S-directed compressive stresses during the Early Quaternary, folded the Tertiary sediments into a broad syncline, the Bharouch syncline, in the rapidly subsiding northern block (Roy, 1990). The Bharuch syncline extends from the NSF to the Mahi river in the north. The E–W trending axis of this syncline lies to the north of the Narmada river. Corresponding anticline structures are found in the Tertiary rocks exposed in the southern up thrown block. (Historical and instrumental records indicate that the compressive stresses still continue to accumulate along the NSF due to continued northward movement of the Indian plate. This is evidenced by the fault solution studies of the earthquakes at Bharuch roach (23 March 1970) and Jabalpur (22 May 1997), which suggest a thrusting movement (Gupta et al., 1972, 1997; Chandra, 1977; Acharyya et al., 1998). However, the underlying cause of the seismicity in the NSF zone is not yet understood (Quittmeyer and Jacob, 1979).

The Quaternary blanket of Narmada in lower Narmada provides evidence for significant changes in channel kinetics of Paleo domain and present day domain of Narmada related with eustatic & sea-level fluctuation. The Quaternary deposits contained in the western asymmetric trench consist of sediments of various domains viz glacial, fluvio-glacial, fluvial, lacustrine and tidal flats influenced by incursion of marine transgression and regression on tectonically active platform. It is evidenced by bore hole data and subsurface statistical analysis of sediments, quartz grain morphology of sediments, pale sole geometry and configuration of quaternary deposits in western segments of Narmada rift valley and SONATA TECTONIC ZONE. (Plate No 2)

**Quaternary deposits & Sedimentation**

The area of study is occupied by Quaternary blanket of about 800 m which represent different domain of sedimentation. Based on sedimentlogical characters, depositional environments, and erosional processes and their correlation with depositional erosional activity revealed that it comprised of four distinct domains of sediments viz glacial, fluvio-glacial fluvial / lacutrine and tidal flats. The lower most units (Boulder bed) is of glacial origin, the boulder conglomerate which seprates glacial and fluvial deposit is persistent horizon and is of of glacio-fluvial (Khan *el. al* 1991) fluvial terraces are of paleo- domain of Narmada and tidal flats over top the fluvial deposits and confined along the coast line on the margin of gulf of Cambay.The top three formations Ankleshwar, Tilakwarda , Bharuch, and Aliabat are designated as ($NTo$-$NT_3$) represent thick and multiple sequences of Quaternary sediments. ( Table No 1)

Based on study of statistical parameters of sediment their deviation and breaks in vertical stratigrphic column between 00.00 to 260 m below the ground level indicate that the sediments consist of three domains viz glacial, fluvio-glacial and fluvial.( Khan et.al in press). The study of these concealed sediments, their sedimentary environments and sedimentation and correlation both in vertical and horizontal columns indicates that the lower most units, Boulder bed (20 to 260 m. below ground level ) is of glacial origin, whereas the fossiliferous bed Boulder conglomerate (260 to 278m. above m.s.l.) is fluvio-glacial and top three formations in increasing antiquity are of fluvial origin. Boulder bed, Boulder Conglomerate, Ankleshwar, Tilakwarda Bharuch & Aliabat ( 65 to 90 m. above m.s.l.) are fluvial origin and represent the complete sequence of Quaternary sedimentation in Central India (Khan *el al* 1991). The Aliabet formation comprises of sediments of active channel deposit where as the older hree Ankleshwar, Tilakwarda Bharuch formation are related to older flood plains deposits of paleo-domain of Narmada and are grouped under older alluvium. Boulder conglomerate of fluvio-glacial origin is assigned an independent formational status based on distinct lithology and fossil assemblage. Boulder conglomerate is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 180 of the Narmada alluvium was deposited in two distinct aggradations episode with a distinct and well defined break in sedimentation in rift system. The dissection of the quaternary blanket resulted two terraces ($NT_3$-$NT_2$), after break in sedimentation. The sediments of this aggradations episode constitute tour lithostratigraphy units Ankleswar and Bharuch & Aliabat formation. The sediments of the alluvial phase are underlain by a boulder bed of glacio-fluvial origin. Thus, the boulder conglomerate, the basal unit of alluvium marks disconformities between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age (Khan 1992). The stratigraphic succession of Quaternary deposits is described is given in (Table No. 1, 2) (Plate No 1, 3 & 4 )

The stratigraphic succession of Quaternary sediments in lower Narmada valley comprise of four distinct groups of deposits viz. glacial, fluvio- glacial and fluvial ad tidal flats ; their age, litho constituents, environments of deposition and associated geomorphic elements are given in table (Table No 2 ).

**Glacial/Fluvio-glacial deposit**

The glacial and fluvio-glacial deposits of Narmada unconformable overly the Vindhyan and Deccan Trap rocks. The sediments consist of a heterogeneous assemblage of sub-angular to angular, sub-rounded, unsorted, unstratified rock fragments ranging from boulders to small pebbles, predominantly of quartzite, gneiss, sandstone, basalt, jasper, chart, gneiss, sandstone, basalt, chart, altered feldspar, ferruginous nodules, in a matrix of very coarse to very fine-sand, silt and clay. These clastics are highly angular, generally poorly sorted and, imbricated in fine matrix. The fine sediments comprise of reddish grayish and greenish sand with appreciable amount of mica flaks, altered feldspar, brick-red and buff silt, greenish-brown silt and clay, and greenish, reddish and dark maroon hard and plastic clay. These fine sediments contain fairly good amount of ferruginous material, quartz, mica flakes and altered feldspar grain. Though these sediments are similar in composition to the other deposits of Narmada but exhibit entirely different sedimentary pattern, sediment characters and mineral composition. These rock clastics are largely angular, very poorly sorted and demonstrate isotropic pattern in the valley. The sediments of glacial domain of Narmada were deposited in glacial environments during Pleistocene time. These deposits are concealed under boulder conglomerate in the valley.

**Fluvio-glacial deposits (Boulder Conglomerate)**

The conglomerate bed which constituted the fossiliferous horizon of Narmada is sandwiched between older fluvial sediment of paleo -domain and the glacio-fluvial boulder bed. This conglomerate bed is a very persistent horizon indicating a distinct phase of sedimentation in the valley. It is exposed in the bluff/scrap of Narmada around at the base of terraces $NT_2$ (Khan, 1984). The measured exposed thickness of the boulder conglomerate in western sector of Narmada is about 16.5 m and average thickness is 12.00 m.

The boulder conglomerate predominantly consists of sub-rounded to well rounded boulder, cobble and pebble of quartzite, gneiss, sandstone, basalt, agate, jasper, chart, chalcedony tightly cemented in a matrix of sand and silt. The finer sediments include different grade of sand and silt, brown and maroon in color often laminated and cross laminated. The skull cap of early man *Homo erectus* is recovered from boulder conglomerate (Sonakia, 1984)

It consists of three sub-litho units; each sub-unit characterized by distinct rock fragment shape, size, lithological abundance and allied sediment characters. The sub-units are composed of variable assemblage of quartzite, gneiss, basalt, sandstone, agate, jasper, chalcedony, chart, sand and silt (Khan1992) These sub-litho units display facies variation in the valley and upper units grades into gritty sandstone upstream of Tilakwarda.. The rock clastics of boulder conglomerate are tightly cemented in deep brown and maroon sand, silt and clay. The finer clastics display sedimentary feature like lamination, cross-bedding load structure, small ripples and, cut and fill feature. The cross-bedded units are often truncated by a pebbly layer at the top. The average measured thickness of these sub-units is about 2m.

The boulder conglomerate is of middle Pleistocene age equivalent to Siwalik boulder conglomerate (India), Trini bed of Java (Indonesia) and boulder conglomerate of Tapti (Khan.1982) These deposits have yielded skull cap of early man, *Homo erectus* Narmadensis along with other mammalian fossils Sonakia, (1984). (Khan 1991) has identified and recorded Ash bed of Quaternary age associated with these deposits around Timrawan upstream of Hathnora is of Aeolian nature and perhaps indicates volcanic activity during middle Pleistocene time

.

**Fluvial deposit (paleo domain of Narmada)**

The Fluvial deposit of conformably overlies the boulder conglomerate and represents the flood-plain fancies of palaeo -domain of Narmada. The sediments facies predominantly consist of clay silt and sand, calc nodules and calc matrix. The sediments are horizontal disposed and exhibit upward fining sequence typical of fluviatile deposits. The Fluvial deposit of paleo-domain of Narmada can be divided into three formations based on lithology, sediment assemblage, shape and size of rock clastics, relative disposition and diagnostic sedimentary characteristics. These formations are, viz. where as the older three Ankleshwar, Tilakwarda Bharuch formation Aliabat are related to older flood plains deposits of paleo-do-main of Narmada respectively. These formations represent the sediments of the palaeodomain of Narmada deposited in channel and flood plain environments during Upper Pleistocene times Khan & Sonakia (1992).

The younger alluvium is represented by sediments of active flood plain, point bar and sand bar facies of present domain of Narmada and consist of unconsolidated imprecated, stratified, polymodal sorted rock-gravel supported by very coarse to very fine-sand and is named as Aliabat formation. (Table No 2) (Plate No 1, 3 & 4)

## GEOMORPHOLOGY & QUATERNARY TERRACES

The Narmada in its traverse across Central Peninsular India in its last leg in lower Narmada valley before entering Gulf of Cambay, in Gurudeshhwar _ Tilkwara section it descends in sinuous to meandering pattern which is solely guided by ENE to WSW to E-W lineament and its sympathetic fractures. The landscap architect of valley has multithem manifestation of hidden mechanism of dynamics and Neotectonisam .In this segment Narmada has chiseled three terraces across its course breaking the monotony of land scape which are designated as NT1-NT3 besides its active flood plain. It downstream of Garudeshwar flows in a general WSW direction where it display meanders with wave lengths of 5–8 km .The Orsang, Aswan,Men and Bhuki are the major rivers joining the

Narmada from the north. The Karjan River, which drains a major part of the trappean uplands in the lower Narmada valley, meets the Narmada from the south. The other tributary is Madhumati River drains the western fringe of the trappean upland. In between the Karjan and Madhumati rivers there are several north flowing small streams meeting the Narmada at various points. The net work of drainage in the lower Narmada is structurally controlled and they are guided by neosiesmic ecology of pulsation variance as evident by neoseismic signatures on Quaternary landscape.

The presence of ravenous tracts in northern bank of Narmada with incised deep gullies of 20–25 m is manifestation of sudden dislocation of ground water regime and water table to deeper level due to subsidence of block along the lineament zone. The disposition of river terraces, entrenched meanders and alluvial cliff 15–30 m are suggestive of neotectonic activity in the area. The display of active Narmada channel configuration of terraces, meander scrolls, entrenched meander revealed misfit nature of Narmada in the area. The present channel of Narmada is strongly influenced by NSF and display persistent tendency to shift towards north due geotectonic activity along the fault. It also authenticates that there is significant up rise in the southern block of fault and subsidence of northern block which resulted into gliding and shift of Narmada to wards north.

The Quaternary blanket of Narmada display the stepped sequence of fluvial terraces breaking the monotony of topography , which from the prominent Quaternary landscape flanking Narmada valley, indicating the former levels of flood-plain or valley floor. These land forms have been formed by combined action of erosional and depositional process of stream up warping in the head ward ends and consequent eustatic and related climatic change in the post-Pleistocene time.

The Narmada terraces$NT_O$ to NT3), are both of cyclic and non cyclic nature. The NT0-NT1 are developed within the meandering loop of channel where as NT2 $NT_3$ are widely developed alon the flanks. In the upstream NT3 occurs as isolated caps and lenses along the margin of valley flanks which have divergent relative disposition. These land forms indicate vigorous and abrupt incision of valley floor due to relatively & repaid uplift of watershed area during Upper Pleistocene time. The NT1 to $NT_2$ are the major depositional terrace and have both convergent & divergent mutual disposition with other terraces. These terraces further downstream have matched equivalents along the valley flank, whereas in the up stream section the matched equivalents are rare. The conspicuous divergent relation of these terraces in the valley reveals successive uplift of catchments area and consequential incision of valley floor and adjustment of base level of Narmada during Upper Pleistocene time. The other land form elements of fluvial domain associated are point bar, sand bar, braided channel, meander scroll and cut of meander and paleo- channel which are braided in nature confined to present channel indicating sudden lose of bed slope due up lift of the area.

The terraces NT1 to NT3 of Gurudeshwar _ Bharuch section of lower Narmada valley are time equivalent to the three terraces NT1 to NT3 of Jabalpur _ Harda section central sector of Narmada and Khan (1982) (1984) (1992) Khan et.al (2014.The sequence of Narmada terraces is shown in the (Table No 3 )( Plate No 3 & 4)

The salient and diagnostic features and elements of these terraces are incorporated in the (Table No 5-10.) (Plate No 1,3 & 4)

**Quaternary Tectonics & Sedimentation**

The study of Narmada river terraces along the length of 1280 kms in between Jabalpur- Bharuch their correlation , relative disposition, their elevation and slope their critical and crucial sediment sequence in type area, drainage net work and its configuration , neo-seismic data imprints and signatures of modules of neo- deformation by compressive force, in relation to the movement of the Indian plate indicates that peninsular India has been undergoing high compressive stresses due to the sea-floor spreading in the Indian Ocean and locking up of the Indian plate with the Eurasian plate to the north (Subramanya, 1996). The study of Quaternary tectonics activity of Khandwa Sukta faults and Barwani faults Khan ( in press ) in the middle segment of valley , analysis of quaternary terraces of Tapti and their imprints of isoseismic events Khan (1984) in the confluence area of Tapti and Waghour, further authenticate the record that these N–S directed stresses have been accommodated by the under thrusting of the Indian plate below the Eurasian plate. The manifestation of this Phenomenon a part of these compressive stress is recorded along the NSF, a major E–W-trending crustal discontinuity in the central part of the Indian plate; further activities of significant magnitude are recorded from sea-level studies on the west coast and in the Himalaya located at the trailing and leading edges of the Indian plate during the Early Holocene respectively.

In Narmada Rift system taking as single ecological unit for Quaternary sedimentation & tectonics and presence of the Katni Formation in central sector with angiosperm flora suggests that sedimentation continued during Mio-Pliocene in localized lakes. The relative disposition of such lakes and subsequent deformation and structural dislocation on oscillating valley platform clubbed with rifting and faulting during Quaternary period has shifted the site of the lakes towards the present alluvium-covered area between Harda -Jabalpur, Garudeshwar and Bharuch as presumed: where as the present study of various aspects of Quaternary blanket in SONATA LINEAMENT ZONE reveled that quaternary sedimentation was a sequential and continuous process in rift valley system (Table No -3)from Mio-Pliocene Pleistocene time, has deposited complete sequence of glacial, fluvio-glacial lacustrine fluvial and tidal deposits with changing environments and climate in time & space . The present disposition of quaternary blankets in Son Narmada basin is due to post deposition Quaternary tectonics which is solely responsible for sedimentation, dislocation, faulting and shifting of different blocks and distorting ecology in rift system. The occurrence of Boulder bed and Boulder Conglomerate in Son Narmada Tapti and Purna with similar rock assemblages and suites of rock fabrics, heavy mineral assemblages, and quartz grain morphology in critical and crucial sections across the SONATA LINEAMENT ZONE strongly support tearing and rifting of quaternary blanket during late Pleistocene time. The presence of thick boulder bed in Harda inliers area, such as at Chandgarh and north east of Barwaha, boulder bed in confluence are of Tapti and waghur around Khadgaon in Tapti valley Khan et.al (1984) supports this assumption.

The Quaternary sedimentation incepting from glacial activity, followed by fluvio-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block faulting and segmental and linear displacement, dislocation, uplifting and isolated domal up- lift, Neogene rifting and Quaternary sedimentation, rift-bound Pliocene–Pleistocene rifting and volcanic activity specifically during glacial and fluvio-glacial phase are major component of the Quaternary period and tectonic processes of the Narmada Rift System. The Quaternary sedimentation was triggered by tectonic activities / up lift and climatic changes. The provenance for these sediments is the weathering products of eroding pre- Cambrian, meta-sediments, sedimentary and volcanic rocks along the watershed upland, rift escarpments and shoulders; faulted and uplifted blocks, volcanic fissure zones, and plateaus within and outside the rift. and SONAT lineament zone .The Narmada Rift System, bounded by adjacent plateaus rising 300–700 m above the rift floor, consists of number symmetrical and symmetrical faulted blocks, escarpment, rock cut terraces, rock floors and segments of relicts of half grabben. Although rift-related basins started to form during the late Oligocene to early Miocene times, the Narmada rifts were fully defined by middle to late Miocene time.
The Narmada rift system provided a unique setting for dynamic ecosystems that were characterized by rift up lift and subsidence which has created ideal loci of Quaternary sedimentation and environment for the accumulation of sediments, volcanic fabrics sediments, burial, digenesis, and preservation of organic remains. The rifts formed after widespread Quaternary sedimentation occurred and voluminous sediments in the rift basins accumulated by glacial activity consequential upon the lowering of temperature and climatic changes in water shed region. The Miocene -Pliocene–Pleistocene lake deposit of Katni on the eastern rift shoulder was created by faulting, topographic control or isostatic depression within the rift system. (Table No 4) (Plate No 2)

In Narmada Quaternary blanket posses abundant faunal remains in rift settings, including hominids Sonakia (1984), suggest that the Narmada Rift System created productive ecosystems during Pliocene–Pleistocene time. The volcanic rocks within the fossiliferous sediments provide temporal information for calibrating and sequencing hominid and other faunal evolution. The detailed geological sedimentological geochemical study of interbedded tephra ,Quartz grain morphology of sediments of quaternary strata and palo-sole of and geochronological studies Khan ( 2012 ), Khan (2013 ), Khan (2013) from the different localities for establishing accurate biostratigraphic and lithostratigraphic data, sedimentation rates, and paleo- environmental and tectonic histories of different sediment columns revealed that inspite of tectonic dislocation subsidence and oscillation and rinsing and sinking platform of sedimentation there is intake sequential deposits in the rock basin representing the sediments of glacial fluvio-glacial, fluvial lacustrine and tidal environment along the rift system. Interbedded volcanic rocks allow determination of the time of rifting, the beginning of sedimentation, sedimentation rates, and the transition from glacial, fluvio-glacial lacustrine to fluvial environments. The cyclic environmental transitions recorded in the sedimentary sequences of the rift basins are caused by tectonic activities, changes in relief, and climatic variations. The climatic changes in uplift, topographic and landscape features, coupled with block faulting, rinsing and sinking platform, created basins for the accumulations of thick lacustrine and fluvial sediments sequences with terrestrial and aquatic fossils. The sequential change in the sediment facies from finely bedded lacustrine deposits to fluvial sediments are commonly noted in the sedimentary sequences and reflect environmental and tectonic changes that can be temporally determined. Moreover, regional correlation based on the chemistry and geochronology of interbedded tephra has made it possible to establish accurate stratigraphic relations that are useful for paleo-environment reconstruction and evolutionary studies of fossil remains in the Narmada rift valley Khan et.al.

(2012). In addition regional tephra correlation is being used increasingly to link sites together which has established that similar tephra layers are known from other parts of rift valley, as well as from other basin and peninsular India Achariya,( 1998 ), Biswas, Khan (1992) Tiwari (1992) Khan et.al. (2012). There is a great potential for further correlation of tephra in the Rift System and marine sediments in the Arabian Sea. The Arabian Sea has a continuous record of deposition that extends to at least 7 million years. The Quaternary sediments interbedded with tephra with within the age range of the ODP Ocean Drilling Program 721/722 stratigraphic sections of the Arabian Sea are also present within the rift floor and the western rift margin of the region. The chemical and chronological correlations of ash beds within the rift sequences have been made with ashes described in marine sections. Detailed correlations based on orbitally calibrated time scales of paleo magnetic stratigraphy Rao (1997) within Quaternary sediments of rift deposits, it will provide ties to establish global climate changes based on the terrestrial and marine sediments of the rift system.

The Narmada Rift System consists of asymmetrical basin that has been evolved in different stages of tectonisam. The 100 -120 km-wide ad 1280 km long rift bounded by Satpura in south and Vindhyan in north constitutes conspicuous ENE-WSW to E-W rift basin zone is filled with Pliocene–Pleistocene sediments, whereas some of them contain Miocene sedimentary deposits. Most of the sedimentary sequences contain faunal and floral remains including hominid species.

Most of the basin-fill sediments were derived from topographically elevated rocks that are present both within and outside the rift basins. Lava flows and tephra are interbedded with the fossiliferous sediments classics sediments derived from the provinces of sediment mostly from crystalline basement volcanic, sedimentary, meta basic and sedimentary rocks, aided in the cementation and preservation of organic remains by providing secondary minerals released during alteration in a burial environment. Quick burial minimized the effect of pre -burial taphonomic processes. Moreover, chemical constituents released by alteration have provided critical temporal and spatial information without which the study of hominid evolution and paleo-environmental reconstruction in the Rift System would have been impossible.

The tephra layers associated with Quaternary deposits of Narmada Rift valley have under gone faulting, rifting, and dislocation during sedimentation. The impact of structural disturbances and\evidence of the effects of tectonics on fauna and flora are distinct and their signatures on dislocation and concealing of fossiliferous horizons are uncontrolled and ill defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of ***Homo eructs*** in Narmada rift from Hathnora Sonakia ( 1984) remained only discovery of hominid fossil in last two and half decade due inconsistency and concealed nature of fossiliferous horizon due faulting, dislocation and subsidence of Quaternary blanket of Narmada rift system as such researcher and scientist failed to add any further knowledge to hominid discovery in Narmada any further .

The present an integrated analysis of the stratigraphy of the Quaternary deposits of specifically of lower Narmada of Gurudwshwar _ Bharuch section and Jabalpur _ Harda of upper Narmada valley; is based on multiple criteria of morphostratigraphy, soil stratigraphy, tephra stratigraphy, lithological assemblage, biostratigraphy volcanic ash bed.y. Based on critical data analysis the stratetigraphy of quaternary deposit of Narmada Valley has been attempted for the first time. Based on analysis of multiple thematic data the stratigraphic classifications are summarized in (Table No -1,2, &4 ) Plate No 2)

## DISCUSSIONS

In Narmada Rift system taking as single ecological unit for Quaternary sedimentation and presence of the Katni Formation in central sector with angiosperm flora suggests that sedimentation continued during Mio-Pliocene in localized lakes. The relative disposition of such lakes and subsequent deformation and structural dislocation on oscillating valley platform clubbed with rifting and faulting during Quaternary period has shifted the site of the lakes towards the present alluvium-covered area between Harda -Jabalpur, Garudeshwar and

Bharuch as presumed: where as the present study of various aspects of Quaternary blanket in SONATA LINEAMENT ZONE reveled that quaternary sedimentation was a sequential and continuous process in rift valley system from Mio-Pliocene Pleistocene time, has deposited complete sequence of glacial, fluvio-glacial lacustrine fluvial and tidal deposits with changing environments and climate in time & space . The present disposition of quaternary blankets in Son Narmada basin is due to post deposition Quaternary tectonics which is solely responsible for sedimentation, dislocation, faulting and shifting of different blocks and distorting ecology in rift system. The occurrence of Boulder bed and Boulder Conglomerate in Son Narmada Tapti and Purna with similar rock assemblages and suites of rock fabrics, heavy mineral assemblages, and quartz grain morphology in critical and crucial sections across the SONATA LINEAMENT ZONE strongly support tearing and rifting of quaternary blanket during late Pleistocene time. The presence of thick boulder bed in Harda inliers area, such as at Chandgarh and north east of Barwaha, boulder bed in confluence are of Tapti and waghur around Khadgaon in Tapti valley Khan et.al (1984) Khan (1992), Khan (2012) Khan (2013) supports this assumption.
The Quaternary sedimentation incepting from glacial activity, followed by fluvio-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block faulting and segmental and linear displacement and islocation, uplifting and isolated domal up lift, Neogene rifting and Quaternary sedimentation and rift-bound Pliocene–Pleistocene rifting and volcanic activity specifically during glacial and fluvio-glacial phase are major component of the Quaternary period and tectonic processes of the Narmada Rift System. The Quaternary sedimentation was triggered by tectonic activities up lift and climatic changes. The provenance for these sediments is the weathering products of eroding pre- Cambrian, meta-sediments, sedimentary and volcanic rocks along the watershed upland, rift escarpments and shoulders; faulted and uplifted blocks, volcanic fissure zones, and plateaus within and outside the rift. The Narmada Rift System, bounded by adjacent plateaus rising 300–700 m above the rift floor, consists of number symmetrical and asymmetrical faulted blocks, escarpment, rock cut terraces, rock floors and segments of micro half grabben.Although rift-related basins started to form during the late Oligocene to early Miocene times, the Narmada Rifts were fully defined by middle to late Miocene time.

The Narmada rift system basins provided a unique setting for dynamic ecosystems that were characterized by Rift-related subsidence and coeval sedimentation also created an ideal loci of Quaternary sedimentation and environment for the accumulation of sediments volcanic fabrics sediments, burial, digenesis, and preservation of organic remains. Because rifts formed after widespread Quaternary sedimentation occurred and voluminous sediments in the rift basins were accumulated by glacial activity consequential upon the lowering of temperature and climatic changes in the region.

The Miocene -Pliocene–Pleistocene lake deposit of Katni on the eastern rift shoulder was created by faulting, topographic control, or isostatic depression similar to that of other Rift system.

The biotic & faunal remains in rift settings, including hominids Sonakia (1984), suggest that the Narmada Rift System created productive ecosystems during Pliocene–Pleistocene time. The volcanic rocks within the fossiliferous sediments provide temporal information for calibrating and sequencing hominid and other faunal evolution. The geological sedimentological geochemical study of sediments of interbedded tephra ,Quartz grain morphology of sediments of quaternary strata and palo-sole of and geochronological studies from the different localities for establishing accurate biostratigraphic and lithostratigraphic data, sedimentation rates, and paleo-environmental and tectonic histories of different sediment columns in area register sequential change in environment of sedimentation in increasing antiquity in the rock basin. Interbedded volcanic rocks allow determination of the time of rifting, the beginning of sedimentation of environment from glacial, fluvio-glacial lacustrine to fluvial environments. The cyclic environmental transition recorded in the sedimentary sequences of the rift basin is caused by tectonic activity, changes in relief, and climatic variations. The climatic changes in uplift, topographic and landscape features, coupled with block faulting , rinsing and sinking platform , created basins for the accumulations of thick sediments glacial,fluvio-glacial, lacustrine and fluvial sediments sequences with terrestrial and aquatic fossils. The sequential change in the sediment facies from finely bedded lacustrine deposits to fluvial sediments are commonly noted in the sedimentary sequences and reflect environmental and tectonic changes that can be temporally determined. Moreover, regional correlation based on the chemistry and geochronology of interbedded tephra has made it possible to establish accurate stratigraphic relations that are useful for paleo-environment reconstruction and evolutionary studies of fossil remains in the lower and upper Narmada valley.

There are evidences of the effects of tectonics on fauna and flora are distinct and its signatures on dislocation and concealing of fossiliferous horizons are uncontrolled and ill defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of ***Homo eructs*** in Narmada rift from Hathnora Sonakia ( 1984) remained only discovery of hominid fossil in last two and half decade due inconsistency concealed nature of fosilifrous horizon, due faulting, dislocation and subsidence of Quaternary blanket of Narmada as such researcher and scientist failed to add any further knowledge to hominid discovery.

The association of tephra layer with Hathnora formation of Narmada Khan (1992) and its chemical diagnostic keys used for correlation with quaternary sediments in rift system Khan et.al. (2012) both intra and inter valleys wise across the basin and continent and peninsular India Achariya, 1998 ), Biswas, Khan (1992) Khan et.al. (2012) Tiwari (1992) revealed the single source of ash matrix. There is a great potential for further correlation of tephra with environment of sedimentation in the Rift System and marine sediments in the Arabian Sea. The Arabian Sea has a continuous record of deposition that extends to at least 7 million years. The Quaternary sediments interbedded with tephra with within the age range of the ODP Ocean Drilling Program 721/722 stratigraphic sections of the Arabian Sea are also present within the rift floor and the western Narmada Rift margin of the region. The chemical and chronological correlations of ash beds within the rift sequences have been made with ashes described in marine sections. Detailed correlations based on orbitally calibrated time scales of paleo -magnetic stratigraphy Rao ( 1992) within Quaternary sediments of rift deposits will provide ties to establish global climate changes based on the terrestrial and marine sediments of the rift system.

The Boulder Bed and Boulder conglomerate which form the base of Quaternary sediments in the central sector of Narmada Valley are not exposed in the lower Narmada valley. These deposits are concealed under the sediments of lacustrine and fluvial deposits in the valley. The presence of these deposits is confirmed by study of bore hole data and logs of State and Federal agencies drilled in lower Narmada valley under various projects.

In the lower Narmada valley the river terracesNT-1 NT-2 which represents sediments of Bharuch and Tilakwarda formation date back to the Late Pleistocene. The sedimentation commenced with the deposition of the marine basal clays during the last interglacial high sea level at f125 ka, which is presumed to be about + 7 m as revealed by the study regression of the sea which led to the initiation of fluvial sedimentation. The fluvial sediments were deposited in to two phases with a sharp break marked by tectonic changes and related climatic changes. The sequences of sediments display imprints of compressive tectonic regimes of sedimentation. The southern margin of lower Narmada is marked by Narmada–Son Fault, the transformation of this geofracture in Tertiary to reverse fault in Quaternary is implicit in the seismic studies of the area (Roy, 1990).

The alluvial fan as calimed by Chamyal (2002) in between Tilakwarda and Rajpipla within the loop of Narmada is mono illustration of morphotectonic process associated with neotectonic event. The disposition of Quaternary blanket, and other land forms are controlled and restricted by SONATA LINEAMENT to wards north. The fan deposits as claimed is not persistent and not in conformity of piedmont sedimentation, further it is devoid of torrential stream net work which firmly rules out to be endogenetic fan deposits and appears to up lift cut & past mass of older quaternary deposits moved by tectonic activity along SONATA LINEAMENT.

The morphotectonic set up and drainage configurations of the Narmada in the area of study demonstrate strong influence of tectonics on development and evolution of drainage. The Narmada enters in the present area around Gurudeshwar, it descends in NW –SE direction cutting across NSA entering the quaternary tract. It further moves down stream of Tilakwarda swing towards west and suddenly become slow and sluggish resulting into sinuous to meandering channel pattern along the northern edge of upland and ultimately debouches in the Gulf of Cambay. The disposition and convergence of drainage net in conformity of disposition of quaternary landscape demonstrates an anomalous imprints and neosiesmic signatures on land escape which reveled persistent unstable & turmoil nature of basin which is well documented and illustrated in landscape architect of lower Narmada valley.

The tectonic uplift of the area during the Early and Late Holocene suggests inversion of an earlier subsidence of basin. Such inversion of the basin has been common in the Tertiary times and is well recorded in the sediments of that age (Roy, 1990). A symmetric convergence of the NT-1,NT-2 terraces , diagonal disposition of paired equivalent of terraces across the channel , divergent and linear disposition of cliff of NT-3 terrace in conformity of NSF, constant subsidence of basin indicate reactivation geotectonic activity along the SONATA LINEAMENT.

The displaced Late Pleistocene sediments across NSF in the Narmada and Orsang Heran and Madhumati & Karjan valleys, the NNW tilting of the (NT-1, NT-2), displacement and dislocation in sediments sequence, the anomalous topographic slope incised cliffs up to 25–30 m in the streams, in the area between NSF and the Narmada River, indicate unsynchronized neoseismic movements along the NSF during the Early Holocene. The displacement of sediments of NT-1 surface across the NSF indicates differential movement of about 35 m along the NSF during Early Holocene. The block between the Narmada and Karjan rivers bounded by the NSF and the two other cross-faults suffered subsidence leading to the formation of a series, linear and curvilinear cuts of on terraces and flood plains. The 5–8-m incised cliffs of the streams also suggest that this block escaped the uplift induced large scale incision going on simultaneously in other areas of the lower Narmada valley. The occurrence of ravines and association of deep gullies with the river terraces is morpho-tectonic manifestation caused by the sudden vertical movement and block adjustment which is displayed in sudden collapse of water table and ground water regime in the area to deeper level in conformity of tectonic harmony.

The strongest supporting evidence for the Early Holocene tectonic uplift of the area comes from the sea-level curves of the west coast of India which suggest a tectonic component of about 40 m at this time (Rao et al., 1996).

In the lower Narmada valley the river terrace NT-3 has occupied large area on the both bank of Narmada. It extends from Orsang river in the north east to Mahi river in the west from Baroda in the north to Bharouch –Aliabet in the southwest. In the southern bank of Narmada, it is developed around Ankleshwar and Rajpipla and further south. The average elevation of this surface is about 75 m above m.s.l , separated by both linear and curvilinear scarp. The average height of cliff. along the length of 90 kms between Bharuch and Tilakwarda is about 40 m which further up stream converge and abut against the NSF fault.

In the Narmada valley the river terraces NT-3, represent sediments of Ankleshwar formation. The fluvial sediments indicate deposition in single phases of fluvial sedimentation with a sharp break marked by tectonic changes and related climatic changes. The sequence of this formation is exposed in the cliff section, is marked by the major break in sedimentation as witnessed by the occurrence of persist pebble horizon at the base .This formation represent different sediment facies typical of fluvial environments .The sequence of sediments display imprints of compressive tectonic regimes on sedimentation.

In the lower Narmada valley the Mid–Late Holocene Quaternary valley deposits is the product of a Holocene high sea-level-induced deposition in a deeply incised valley trench is strongly influenced by NSF. A significant declining f tectonic uplift facilitated the encroachment of the sea into the valley and the creation of a depositional wedge, which extended up to the deep in land foothills. The 5–10-m exposed thickness of the valley-fill sediments reveals tide dominated estuarine deposition in the lower reaches and fluvial deposition upstream of the tide reach.

The pre-existing quaternary platform of NT-3 of Middle Pleistocene prior to induced sedimentation of tidal transgression was strongly influenced by tectonic impulses of NSF. The relative disposition of terraces NT-2 NT-3 cliff alluvial bluff and scarp, reveals that the present mouth of the Narmada river has retained roughly the originally funnel shape of the estuary formed during the Mid–Late Holocene. However, the size of the estuary is now considerably reduced in space and time with sedimentation and the compressive tectonic environment. The occurrence of NT-1 to NT-3, and Rock cut terraces in Narmada indicate dominance of vertical incision of former valley floor by reactivation of lineament and fault .The terrace disposition, their interrelation, relative pairing revealed constant decrease in stream kinetics and energy condition of channel towards late Holocene time. The disposition of landform and their relation with channel suggests that Holocene flood-plain processes and fluvial regime in the lower Narmada Rift Valley changed in response to decreasing rates of floodplain sediment accumulation and decelerating sea-level rise and that avulsion played a major role in flood-plain formation during the Holocene transgression.

The incursion and transgression of tides, present estuarine reach contains several islands, which are coeval with the terrace surface above the present tidal range. Hence, they are the products of estuarine processes of the Mid–Late Holocene and not those of the present day. Funnel shaped morphology and increasing tidal energy landward are characteristics of tide-dominated estuaries (Wright et al., 1973). Existing data suggest that the Mid–Late Holocene sea level has remained at the same level up to the present with minor fluctuations (Chappel and Shackleton, 1986. The Mid–Late Holocene sediments show tilting of 10–20 m which is more pronounced in the vicinity of the NSF suggesting that the incision and uplift of the valley-fill terraces well above the present day tidal limits is related to the continued differential uplift along NSF. Evidence of tectonic uplift has been reported from the coast also in the form of raised mudflats occurring 2–4 m above present sea level (Merh, 1993). Currently, the river occupies the northern margin of the Early Holocene channel belt and is clearly more sinuous. It exhibits a narrow channel with wide meanders inside wide belts of Mid–Late Holocene terraces NT-3) a typical pattern of unfit stream in the own system. (Dury, 1970)

The present an integrated analysis of the stratigraphy of the Quaternary deposits of the lower Narmada valley; Khan (2012), Khan (2014) is based on multiple criteria of morphostratigraphy, soil stratigraphy, tephra stratigraphy, lithological assemblage, biostratigraphy volcanic ash bed and polarity. Based on critical data analysis the stratetigraphy of quaternary deposit of Narmada Valley has been attempted for the first time .Based on analysis of multiple thematic data the stratigraphic classification are summarized in (Table No -1)

## Conclusions

The area of lower Narmada valley between Gurudeshwar-Bharuch is occupied by thick Quaternary deposits of about 800 m which represent various domain of sedimentation. Based on statistical parameters sedimentlogical characters, depositional environments revealed that it comprised of four distinct domains of sediments viz glacial, fluvio-glacial fluvial and tidal flats. The lower most units (Boulder bed) is or glacial origin, the boulder conglomerate of glacio-fluvial (Khan *el. al* 1991) and fluvial terraces are of fluvial paleo- domain of Narmada and tidal flats. The top three formations of paleo- fluvial domain of Narmada is represented by Ankleshwar , Tilakwarda and Bharuch formation. The Boulder conglomerate is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 180 of the Narmada alluvium was deposited in two distinct aggradations episode with a distinct and well defined break in sedimentation in rift system. The dissection of the quaternary blanket resulted two terraces ($NT_3$-$NT_2$), after break in sedimentation. The sediments of this aggradations episode constitute three lithostratigraphy units Ankleshwar , Tilakwarda and Bharuch & Alibat formation. The sediments of the alluvial phase are underlain by a boulder bed of glacio-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age (Khan 1992)
The Quaternary blanket of Narmada in Garudeshwar –Bharuch section has formed three terraces, besides its presented-day flood-plains, in the valley. These are designed($NT_O$ to NT3, $NT_O$ being the lowest terrace above the present-day course of the river, $NT_{1\,,}$ NT2 both are of cyclic and non cyclic nature. The $NT_3$ terrace occurs as elongated strip and isolated caps and lenses along the margin of valley flanks has divergent relative disposition. These land forms indicate vigorous and abrupt incision of valley floor due to relatively & repaid uplift of watershed area during Upper Pleistocene time. The NT1 NT2 are the major depositional terrace and have both convergent & divergent mutual disposition with other terrace. These terraces further downstream have matched equivalents along the valley flank, whereas in the up stream section the matched equivalents are rare. The conspicuous divergent relation of these terraces the valley reveals successive uplift of catchments area and consequential incision of valley floor and adjustment of base level of Narmada during Upper Pleistocene time. The other land form elements of fluvial domain associated are point bar, sand bar, braided channel, meander scroll and cut of meander and paleo- channel. These terraces NT1 to NT3 of western sector are time equivalent to the three terraces of central Narmada and represents three sequential Quaternary events in SNONATA LINEAMENT ZONE in Central India Khan (1982) (1984) (1992) Khan et.al (2014).

The study of river terraces(NT-1, NT-2A, NT-2B, NT2C, NT3A, NT3B, NT3C, along the entire length of 1280 kms of Narmada Rift Valley between Jabalpur-Harda and Harda - Bharuch , their correlation disposition, sediment sequence comprehensive sedimentological columns in type area, drainage net work, Neo-seismic data of imprints and signatures of Neotectoisam & data base analysis of available models of neotectonic deformation of the Indian plate indicate that peninsular India has been undergoing high compressive stresses due to the sea-floor spreading in the Indian Ocean and locking up of the Indian plate with the Eurasian plate to the north (Subramanya, 1996). The study of neotectonic activity of Khandwa Sukta faults and Barwani faults Khan ( in press ) in the middle segment of valley , study ad analysis of quaternary terraces of Tapti and their imprints of neoseismic events TT-1 to TT-3 Khan (1984) in the confluence area of Tapti and Waghour further document and authenticate that these N–S directed stresses have been accommodated by the under thrusting of the Indian plate below the Eurasian plate. A part of these compressive stresses are accumulated along the NSF, a major E–W-trending crustal discontinuity in the central part of the Indian plate. The perceptible tectonic activity of significant magnitude during the Early Holocene has been reported from sea-level studies on the west coast and in the Himalaya located at the trailing and leading edges of the Indian plate respectively.

In Himalaya the study of tectonics of river terraces of Ganga complex revealed that Alaknanda consisting of six terraces ( AT-0 to AT-6), Bhagirathi five ( BT-1 to BT-5), Bhilangna four ( BHT-1 to BHT4), Mandakini three ( MT-1 to MT-3), Nandakini three ( NT-1 to NT-3), Pindar three ( PT-1 to PT-3), Madhmeshwar Ganga two ( MDT-1 to MDT-2), Bal Ganga, two ( BGT-1 to BG-2), and Patal Ganga one ( PGT-1 ) and Jamuna five terraces ( JT-1 to JT-5) Khan ( 1981) attributed six Quaternary phases of uplift in Himalaya ( Khan 1988) Khan ( 1992). Further termination of lacustrine sedimentation has been attributed to tectonic activity during the Early Holocene (Kotlia et al., 2000). This suggests a major tectonic phase in the tectonic history of the Indian plate, which is illustrated by imprints of neotectonisam in the along the NSF in the central part of the Indian plate. This suggests a renewed phase of extreme compression of the Indian plate, which led to tectonic inversion along the NSF in the lower Narmada valley. The significant increase in compressive stresses accumulating on an intra crustal fault like the NSF can transform and revert a previously subsiding basin into an uplifting one. Since the NSF has been characterized by a compressive stress regime throughout the Quaternary, we believe that such variations in the degree of compression, which can in turn be interpreted in terms of varying rates of plate movement, alone are responsible for the Late Pleistocene subsidence and the Holocene tectonic inversion in the Narmada Rift valley. The Jabalpur earthquake (1997), Uttarkashi Earthquake (1991) and Chamoli earthquake are manifestation of interplay of these plates.

The present Quaternary landscape of the lower Narmada valley which comprises of glacial deposit, fluvio glacial deposit and river terraces ( NT-1 to NT-3 ) and their correlation with rest of Narmada Rift valley between Jabalpur-Harda and Harda – Bharuch, with the terraces of type area suggest that it has evolved mainly due to tectonic activity along the SONATA LINEAMENT in a compressive stress regime. The sediments comprising these were deposits in a slowly subsiding basin during early Pleistocene middle Pleistocene and the Late Pleistocene. The Holocene period is marked by inversion, which had earlier suffered subsidence. The inversion of the basin is due to a significant increase in compressive stresses along the NSF during the Early Holocene, resulting in differential uplift of the lower Narmada valley. The continuation of the compressive stress regime due to ongoing northward movement of the Indian plate which is illustrated by imprints of noeotectonisam indicates that the NSF is a major candidate for future intraplate seismicity in the region.

The Quaternary deposits entrapped in tectonic zone in the lower Narmada Valley as claimed by Chamyal (2012 ) is alluvial fan as identified between Tilakwarda and Rajpipla within the loop of Narmada. It is mono illustration of morphogenetic process and morpho-tectonic manifestation associated with neotectonic event. The disposition of Quaternary blanket and other quaternary land forms are controlled and restricted by SONATA LINEAMENT. The convergence of fan deposits and its apex is not in persistence and in conformity of piedmont sedimentation further it is devoid of torrential stream net work and environment which firmly rule out to be endogenetic fan deposits. The present study of these deposits its disposition its composition indicates that these older deposits moved from basement and brought to the present position by tectonic activity along SONATA LINEAMENT.

The occurrence and relative disposition of terraces NT-1 to NT-3, and rock cut terraces in Narmada indicate dominance of vertical incision of former valley floor by reactivation of lineament and fault repeatedly throughout the history of sedimentation..The terrace disposition, their interrelation, relative pairing revealed constant decrease of stream kinetics and energy condition of channel towards late Holocene time.

The disposition of landform and their relation with channel suggests that Holocene flood-plain processes and fluvial regime in the Lower Narmada Rift Valley changed in response to decreasing rates of floodplain sediment accumulation and decelerating sea-level rise and that avulsion played a major role in flood-plain formation during the Holocene transgression.

TABLE- 2 MORPHOSTRATIGRAPHY OF THE NARMADA TERRACES

---------------------------------------------------------------------------------------------------------------

| Terrace | Nature of its Origin | Morphostatigraphy |
|---|---|---|
| NT_o | Depositional | Light grey to dark grey sand and silt |
| $NT_{-1}$ | Erosional / Depositional | Light grey to dark grey sand and silt with rock pebble<br>Sand and silt |
| $NT_{-2}A$ | Depositional | Grey & Brown sand and silt |
| $NT_{-2}B$ | Depositional | Yellow Brownish clay with silt |
| $NT_{-2}C$ | Erosional / Depositional | Yellow Brownish clay with silt with<br>Dark brown oxidized clay silt |
| $NT_{-3}A$ | Depositional | Dark brown, dark yellow clay silt<br>Brownish red clay and silt with Calc-matrix. |
| $NT_{-3}B$ | Erosional / Depositional | Dark brown, dark yellow clay silt<br>Brownish red clay and silt with Calc-matri |

TABLE NO 5 SALIENT FEATURES OF FLUVIAL TERRACES IN TYPE AREA IN NRMADA VALLEY
Locality: GARUDESHWAR

| | River bad | NTo | NT1 | NT2-A | NT2-B | NT2-C | NT3-A NT3-B NT3-C |
|---|---|---|---|---|---|---|---|
| Age | HOLOCENE | | | | | | |
| Elevation above MSL (m) | 90 | 95 | 200 | 210 | 220 | 225 | 230 Rock cut Terraces rock Scar |
| Geomorphic break (m) | 0.00 | 5.00 Alluvial Face | 10.00 Alluvial Bluff Section Steep Alluvial face | 20.00 Steep Alluvial fac Composite Rock Face | 40.00 Rock cut Terraces rock Scar Rock Face | 45.00 Rock cut Terraces rock Scar Rock Face Rock Face | 50.00 Rock cut Terraces rock Scar Rock Face Composit Rock Face |
| Elavation above RB (m) | 0.00 River bad Channel, Point Bar, Side Bar | 5.00 Rock Face and Alluvial Bluff | 10..00 Rock Face and Alluvial Bluff | 20..00 Alluvial Bluff Rock Face | 40.00 Rock Face | 46.00 Rock Face | 51.00 Rock cut Terraces rock Scar |
| Slope | ---------Towards west & SW-------- | | | --------Towards west and SW--------- | | ---------Towards west & SW---------- | |
| Nature of surface | --------Depositional , Cresent shape elongated ------ Errosional …………. | | | | Rock cyut terraces and Rock scar -------- Erosionall ---Lieanr scar line ----- | | |
| Cycle Sedimentation | Up ward fining cycle ---------------------- ----- -Polycycle ------------------------------ | | | | | Rock cut scars -- Section not not exposed--------- | |
| Orientation of W-Axes | | ENE-WSW to E-W | ENE-WSW to, E-W | ENE-WSW | ENE-WSW, NW-SE | E-W & NW-SE | ENE-WSW, NE-SW E-W |
| Plunge of L-Axes | | ------Towards west, South North West & West ------ | | --------Towards SW-------- | | Rock cut terraces and Scar | |
| Relative disposition | Convergent Divergent Divergent Divergent Divergent | | | | | | |
| Paired/Unpaired | Unpaired Paired Paired Paired unpaired Paired sharp Strand lines | | | | | | |
| Nature of scarp | ------Curvilinear---- Curvilinear --------- --------Linear------------------- --------Linear---------------------- ------ --------Linear--------------------------- --------Linear--------------------------- Rock cut scars ---- -----Erosional lines | | | | | | |
| Sedimentary feature | Braided Channel, Channel bar Point bar coalescence Channel bar, Side bar , Graded bedding , Cross bedding, Lamination, cross lamination | | | Terrace Section Scarp section Punasa Dam site Trench , Damsite Foundation Excavation ,Graded bedding , Cross bedding, Lamination, cross lamination & Cut and Fill features | | | |
| Terrace shape | --------- Cuspate------- ----------------------------- Rectangular-------------------------- Rock cut scar Sharp edge scar Isolated cap | | | | | | |
| Land use pattern | ------------------Barren -----------------Inhabitation and cultivation--------------------- Forest coverd area | | | | | | |
| Composition/Litho constituents arranged in probable order of abundance | River bad Braided Channel, Point Bar, Side Bar. With very coarse to very fine sand , silt & Clay<br>: Quartzite Gneiss, granite, quartzite, basalt, sandstone, limestone, Augate, Jaspar, schist, , slate, sand and silt.<br>NTo<br>: Gneiss,quartzite, gneiss,, basalt, ,granite, , sandstone limestone, phyllite, slate, shale, sand and silt .<br>NT1 Quartzite, gneiss, , basalt, granite sandstone, phyllite, , basic, schist shale sand and silt.<br>NT1-A Quartzite, granite, gneiss, meta basic sand stone, lime stone schist, basic, phyllite, slate, shale, sand silt and clay.<br>NT2-B. Rock cut scar<br>NT2-C Rock cut scar<br>NT3-A Rock cut scar<br>NT3-B : Rock cut scar Note : NT3-A , B Rock cut Scar , Strand lines , rock cut dissected nicks | | | | | | |
| | River bad | NTo | NT1 | NT2-A | NT2-B | NT2-C | NT-3 |

TABLE NO 6 - SALIENT FEATURES OF FLUVIAL TERRACES IN TYPE AREA OF IN NRMADA VALLEY Locality: TILAKWARDA

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Age | HOLOCENE | | | | | | |
| Elevation above MSL (m) | 85 | 90 | 96 | 110 | 115 | 120 | 130<br>Rock cut<br>Terraces<br>rock Scar |
| Geomorphic break (m) | 0.00 | 05.00<br>Alluvial Face | 11.00<br>Alluvial<br>Bluff<br>Section<br>Steep<br>Alluvial<br>face | 25.00<br>Steep<br>Alluvial fac<br>Composite<br>Rock Face | 30.00<br>Rock cut<br>Terraces<br>rock Scar<br>Rock Face | 35.00<br>Rock cut<br>Terraces<br>rock Scar<br>Rock Face<br>Rock Face | 45.00<br>Rock cut<br>Terraces<br>rock Scar<br>Rock Face<br>Composit<br>Rock Face |
| Elavation above RB (m) | 0.00<br>River bad<br>Channel,<br>Point Bar,<br>Side Bar | 08.00<br>Rock Face and<br>Alluvial Bluff | 15..00<br>Rock Face<br>and<br>Alluvial<br>Bluff | 20..00<br>Alluvial<br>Bluff Rock<br>Face | 25.00<br>Rock Face | 35.00<br>Rock Face | 45.00<br>Rock cut<br>Terraces<br>rock Scar |
| Slope | ---------Towards west & SW-------- | | --------Towards west and SW--------- | | ---------Towards west & SW--------- | | |
| Nature of surface | --------Depositional , Cresent shape elongated ------ Errosional …………. | | | Rock cyut terraces and Rock scar --------Erosionall --- Lieanr scar line ----- | | | |
| Cycle Sedimentation | Up ward fining cycle -------- -------------------- -Polycycle ------------------------------ | | | | Rock cut scars -- Section not not exposed--------- | | |
| Orientation of W-Axes | | ENE-WSW to E-W | ENE-WSW to, E-W | ENE-WSW, NW-SE | ENE-WSW, NW-SE | E-W & NW-SE | ENE-WSW, NE-SW E-W |
| Plunge of L-Axes | | ------Towards west, South North West & West ------ | | --------Towards SW-------- | | Rock cut terraces and Scar | |
| Relative disposition | Convergent Divergent Divergent Divergent Divergent | | | | | | |
| Paired/Unpaired | Unpaired Paired Paired Paired unpaired Paired sharp Strand lines | | | | | | |
| Nature of scarp | ------Curvilinear---- Curvilinear --------- --------Linear------------------- --------Linear--------------------------- --------Linear--------------------------- --------Linear--------------------------- Rock cut scars --------Erosional lines | | | | | | |
| Sedimentary feature | Braided Channel, Channel bar Point bar coalescence Channel bar, Side bar , Graded bedding , Cross bedding, Lamination, cross lamination | | | Terrace Section Scarp section Punasa Dam site Trench , Damsite Foundation Excavation ,Graded bedding , Cross bedding, Lamination, cross lamination & Cut and Fill features | | | |
| Terrace shape | --------- Cuspate------- ----------------------------- Rectangular--------------------------- Rock cut scar Sharp edge scar Isolated cap | | | | | | |
| Land use pattern | ------------------Barren -----------------Inhabitation and cultivation--------------------- Forest coverd area | | | | | | |
| Composition/Litho constituents arranged in probable order of abundance | River bad Braided Channel, Point Bar, Side Bar. With very coarse to very fine sand , silt & Clay<br>: Quartzite Gneiss, granite, quartzite, basalt, sandstone, limestone, Augate, Jaspar, schist, , slate, sand and silt.<br>NTo<br>: Gneiss,quartzite, gneiss,, basalt, ,granite, , sandstone limestone, phyllite, slate, shale, sand and silt .<br>NT1 Quartzite, gneiss, , basalt, granite sandstone, phyllite, , basic, schist shale sand and silt.<br>NT1-A Quartzite, granite, gneiss, meta basic sand stone, lime stone schist, basic, phyllite, slate, shale, sand silt and clay.<br>NT2-B. Rock cut scar<br>NT2-C Rock cut scar<br>NT3-A Not Developed<br>NT3-B Not Developed<br>NT3-C Not Developed | | | | | | |

TABLE NO 7 SALIENT FEATURES OF FLUVIAL TERRACES IN TYPE AREA OF NRMADA VALLEY

Locality: CHANDOD

| | River bad | NTo | NT1 | NT2-A | NT2-B | NT2-C | N-T3 |
|---|---|---|---|---|---|---|---|
| Age | HOLOCENE | | | | | | |
| Elavation above MSL (m) | 80 | 85 | 95 | 100 | -- | -- | 110 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Geomorphic break (m) | 0.00 | 5.00 Alluvial Face | 15.00 Alluvial Bluff Section Steep Alluvial face | 20.00 Steep Alluvial fac Composite Rock Face | Not Developed | Not Developed | 30 .00 m Alluvial Bluff Section Steep Alluvial face - |
| Elavation above RB (m) | 0.00 River bad Channel, Point Bar, Side Bar | 10.00 Rock Face and Alluvial Bluff | 20..00 Rock Face and Alluvial Bluff | 25..00 Alluvial Bluff Rock Face | Not Developed | Not Developed | 30 .00 m Alluvial Bluff Section Steep Alluvial face -- |
| Slope | ---------Towards west & SW--------- | | --------Towards west and SW--------- | | ---------Towards west & SW--------- | | |
| Nature of surface | --------Depositional , Cresent shape elongated ------ Errosional …………. | | | Rock cyut terraces and Rock scar --------Erosionall --- Lieanr scar line ----- | | | |
| Cycle Sedimentation | Up ward fining cycle -------- ------------------- -Polycycle ------------------------------ | | | | Rock cut scars -- Section not not exposed--------- | | |
| Orientation of W-Axes | | ENE-WSW to E-W | ENE-WSW to, E-W | ENE-WSW, NW-SE | ENE-WSW, NW-SE | E-W & NW-SE | ENE-WSW, NE-SW E-W |
| Plunge of L-Axes | | ------Towards west, South North West & West ------ | | --------Towards SW-------- | | Rock cut terraces and Scar | |
| Relative disposition | Convergent Divergent Divergent Divergent Divergent | | | | | | |
| Paired/Unpaired | Unpaired Paired Paired Paired unpaired Paired sharp Strand lines | | | | | | |
| Nature of scarp | ------Curvilinear---- Curvilinear --------- --------Linear------------------- --------Linear---------------------------- --------Linear--------------------------- --------Linear--------------------------- Rock cut scars -------Erosional lines | | | | | | |
| Sedimentary feature | Braided Channel, Channel bar Point bar coalescence Channel bar, Side bar , Graded bedding , Cross bedding, Lamination, cross lamination | | | Terrace Section Scarp section Punasa Dam site Trench , Damsite Foundation Excavation ,Graded bedding , Cross bedding, Lamination, cross lamination & Cut and Fill features | | | |
| Terrace shape | --------- Cuspate------- ----------------------------- Rectangular--------------------------- Rock cut scar Sharp edge scar Isolated cap | | | | | | |
| Land use pattern | ------------------Barren -----------------Inhabitation and cultivation--------------------- Forest coverd area | | | | | | |
| Composition/Litho constituents arranged in probable order of abundance | River bad Braided Channel, Point Bar, Side Bar. With very coarse to very fine sand , silt & Clay<br>: Quartzite Gneiss, granite, quartzite, basalt, sandstone, limestone, Augate, Jaspar, schist, , slate, sand and silt.<br>NTo<br>: Gneiss,quartzite, gneiss,, basalt, ,granite, , sandstone limestone, phyllite, slate, shale, sand and silt .<br>NT1 Quartzite, gneiss, , basalt, granite sandstone, phyllite, , basic, schist shale sand and silt.<br>NT1-A Quartzite, granite, gneiss, meta basic sand stone, lime stone schist, basic, phyllite, slate, shale, sand silt and clay.<br>NT2-B. Rock cut scar<br>NT2-C Rock cut scar<br>NT3-A Not Developed -----------------------------<br>NT3-B Not Developed ----------------------------- | | | | | | |

TABLE NO 7 -SALIENT FEATURES OF FLUVIAL TERRACES IN TYPE AREA OF NRMADA VALLEY

Locality: RAJPIPLA

| | River bad | NTo | NT1 | NT2-A | NT2-B | NT2-C | NT3-A NT3-B NT-C |
|---|---|---|---|---|---|---|---|
| Age | HOLOCENE | | | | | | |
| Elavation above | 70 | 80 | 90 | 100 | -- | -- | NT3-A 115 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MSL (m) | | | | | | | |
| Geomorphic break (m) | 0.00 | 10.00 Alluvial Face | 20.00 Alluvial Bluff Section Steep Alluvial face | 30.00 Steep Alluvial fac Composite Rock Face | Not Developed ------ | Not Developed ------ | 45 .00 m Alluvial Bluff Section Steep Alluvial face ------ |
| Elavation above RB (m) | 0.00 River bad Channel, Point Bar, Side Bar | 10.00 Rock Face and Alluvial Bluff | 20..00 Rock Face and Alluvial Bluff | 30..00 Alluvial Bluff Rock Face | Not Developed | - Not Developed | 45 .00 m Alluvial Bluff Section Steep Alluvial face ------- |
| Slope | ---------Towards west & SW-------- | | --------Towards west and SW--------- | | ---------Towards west & SW--------- | | |
| Nature of surface | --------Depositional , Cresent shape elongated ------ Errosional ………… | | | Rock cyut terraces and Rock scar --------Erosionall --- Lieanr scar line ----- | | | |
| Cycle Sedimentation | Up ward fining cycle -------- -------------------- -Polycycle ------------------------------- | | | | Rock cut scars -- Section not not exposed--------- | | |
| Orientation of W-Axes | | ENE-WSW to E-W | ENE-WSW to, E-W | ENE-WSW, NW-SE | ENE-WSW, NW-SE | E-W & NW-SE | ENE-WSW, NE-SW E-W |
| Plunge of L-Axes | | ------Towards west, South North West & West ------ | | --------Towards SW-------- | | Rock cut terraces and Scar | |
| Relative disposition | Convergent Divergent Divergent Divergent Divergent | | | | | | |
| Paired/Unpaired | Unpaired Paired Paired Paired unpaired Paired sharp Strand lines | | | | | | |
| Nature of scarp | ------Curvilinear---- Curvilinear --------- --------Linear------------------- --------Linear---------------------- ------ --------Linear--------------------------- --------Linear--------------------------- Rock cut scars --------Erosional lines | | | | | | |
| Sedimentary feature | Braided Channel, Channel bar Point bar coalescence Channel bar, Side bar , Graded bedding , Cross bedding, Lamination, cross lamination | | | Terrace Section Scarp section Punasa Dam site Trench , Damsite Foundation Excavation ,Graded bedding , Cross bedding, Lamination, cross lamination & Cut and Fill features | | | |
| Terrace shape | --------- Cuspate------- ----------------------------- Rectangular-------------------------- Rock cut scar Sharp edge scar Isolated cap | | | | | | |
| Land use pattern | ------------------Barren -----------------Inhabitation and cultivation--------------------- Forest coverd area | | | | | | |
| Composition/Litho constituents arranged in probable order of abundance | River bad Braided Channel, Point Bar, Side Bar. With very coarse to very fine sand , silt & Clay<br><br>: Quartzite Gneiss, granite, quartzite, basalt, sandstone, limestone, Augate, Jaspar, schist, , slate, sand and silt.<br>NTo<br>: Gneiss,quartzite, gneiss,, basalt, ,granite, , sandstone limestone, phyllite, slate, shale, sand and silt .<br>NT1 Quartzite, gneiss, , basalt, granite sandstone, phyllite, , basic, schist shale sand and silt.<br>NT1-A Quartzite, granite, gneiss, meta basic sand stone, lime stone schist, basic, phyllite, slate, shale, sand silt and clay.<br>NT2-B. Not Developed NT2-C Not Developed ---------------------------------------------------------------------<br>NT3-A Not Developed NT3-B Not Developed --------------------------------------------------------------------- | | | | | | |

TABLE NO 8 -SALIENT FEATURES OF FLUVIAL TERRACES IN TYPE AREA OF NRMADA VALLEY

Locality: CONFLUENCE AREA OF MADHUMATI RIVER WITH NARMADA

| | River bad | NTo | NT1 | NT2-A | NT2-B | NT2-C | NT3-A NT3-B NT-C |
|---|---|---|---|---|---|---|---|
| Age | HOLOCENE | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Elevation above MSL (m) | 65 | 75 | 85 | 95.00 | -- | -- | NT3-A 100 |
| Geomorphic break (m) | 0.00 | 10.00 Alluvial Face | 20.00 Alluvial Bluff Section Steep Alluvial face | 30.00 Steep Alluvial fac Composite Rock Face | Not Developed | Not Developed | 35 .00 m Alluvial Bluff Section Steep Alluvial face ------ |
| Elavation above RB (m) | 0.00 River bad Channel, Point Bar, Side Bar | 10.00 Rock Face and Alluvial Bluff | 20..00 Rock Face and Alluvial Bluff | 30..00 Alluvial Bluff Rock Face | Not Developed | Not Developed | 35 .00 m Alluvial Bluff Section Steep Alluvial face ------- |
| Slope | ---------Towards west & SW-------- | | --------Towards west and SW--------- | | ---------Towards west & SW--------- | | |
| Nature of surface | --------Depositional , Cresent shape elongated ------ Errosional ………… | | | Rock cyut terraces and Rock scar --------Erosionall --- Lieanr scar line ----- | | | |
| Cycle Sedimentation | Up ward fining cycle -------- -------------------- -Polycycle ------------------------------- | | | | Rock cut scars -- Section not not exposed--------- | | |
| Orientation of W-Axes | | ENE-WSW to E-W | ENE-WSW to, E-W | ENE-WSW, NW-SE | ENE-WSW, NW-SE | E-W & NW-SE | ENE-WSW, NE-SW E-W |
| Plunge of L-Axes | | ------Towards west, South North West & West ------ | | --------Towards SW-------- | | Rock cut terraces and Scar | |
| Relative disposition | Convergent Divergent Divergent Divergent Divergent | | | | | | |
| Paired/Unpaired | Unpaired Paired Paired Paired unpaired Paired sharp Strand lines | | | | | | |
| Nature of scarp | ------Curvilinear---- Curvilinear --------- --------Linear------------------- --------Linear---------------------------- --------Linear---------------------------- --------Linear---------------------------- Rock cut scars --------Erosional lines | | | | | | |
| Sedimentary feature | Braided Channel, Channel bar Point bar coalescence Channel bar, Side bar , Graded bedding , Cross bedding, Lamination, cross lamination | | | Terrace Section Scarp section Punasa Dam site Trench , Damsite Foundation Excavation ,Graded bedding , Cross bedding, Lamination, cross lamination & Cut and Fill features | | | |
| Terrace shape | --------- Cuspate------- ----------------------------- Rectangular--------------------------- Rock cut scar Sharp edge scar Isolated cap | | | | | | |
| Land use pattern | ------------------Barren -----------------Inhabitation and cultivation--------------------- Forest coverd area | | | | | | |
| Composition/Litho constituents arranged in probable order of abundance | River bad Braided Channel, Point Bar, Side Bar. With very coarse to very fine sand , silt & Clay<br>: Quartzite Gneiss, granite, quartzite, basalt, sandstone, limestone, Augate, Jaspar, schist, , slate, sand and silt.<br>NTo<br>: Gneiss,quartzite, gneiss,, basalt, ,granite, , sandstone limestone, phyllite, slate, shale, sand and silt .<br>NT1 Quartzite, gneiss, , basalt, granite sandstone, phyllite, , basic, schist shale sand and silt.<br>NT1-A Quartzite, granite, gneiss, meta basic sand stone, lime stone schist, basic, phyllite, slate, shale, sand silt and clay.<br>NT-3 Alluvial Bluff Section Steep Alluvial face ----------------------------------------------------------------------<br>NT2-B. Not Developed NT2-C Not Developed ----------------------------------------------------------------------<br>NT3-A Not Developed NT3-B Not Developed ---------------------------------------------------------------------- | | | | | | |

TABLE NO 9 -SALIENT FEATURES OF FLUVIAL TERRACES IN TYPE AREA OF IN NRMADA VALLEY

Locality: BHAROUCH

| | River bad | NTo | NT1 | NT2-A | NT2-B | NT2-C | NT3-A NT3-B NT-C |
|---|---|---|---|---|---|---|---|
| Age | HOLOCENE | | | | | | |
| Elevation above | 60 | 70 | 80 | 90.00 | -- | -- | NT3-A 105 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MSL (m) | | | | | | | |
| Geomorphic break (m) | 0.00 | 10.00 Alluvial Face | 20.00 Alluvial Bluff Section Steep Alluvial face | 30.00 Steep Alluvial fac Composite Rock Face | Not Developed | Not Developed | 45 .00 m Alluvial Bluff Section Steep Alluvial face ------ |
| Elavation above RB (m) | 0.00 River bad Channel, Point Bar, Side Bar | 10.00 Rock Face and Alluvial Bluff | 20..00 Rock Face and Alluvial Bluff | 30..00 Alluvial Bluff Rock Face | Not Developed | Not Developed | 45 .00 m Alluvial Bluff Section Steep Alluvial face ------- |
| Slope | ---------Towards west & SW-------- | | --------Towards west and SW--------- | | ---------Towards west & SW--------- | | |
| Nature of surface | --------Depositional , Cresent shape elongated ------ Errosional ………… | | | Rock cyut terraces and Rock scar --------Erosionall --- Lieanr scar line ----- | | | |
| Cycle Sedimentation | Up ward fining cycle -------- -------------------- -Polycycle ------------------------------- | | | | Rock cut scars -- Section not not exposed--------- | | |
| Orientation of W-Axes | | ENE-WSW to E-W | ENE-WSW to, E-W | ENE-WSW, NW-SE | ENE-WSW, NW-SE | E-W & NW-SE | ENE-WSW, NE-SW E-W |
| Plunge of L-Axes | | ------Towards west, South North West & West ------ | | --------Towards SW-------- | | Rock cut terraces and Scar | |
| Relative disposition | Convergent Divergent Divergent Divergent Divergent | | | | | | |
| Paired/Unpaired | Unpaired Paired Paired Paired unpaired Paired sharp Strand lines | | | | | | |
| Nature of scarp | ------Curvilinear---- Curvilinear --------- --------Linear------------------- --------Linear---------------------------- --------Linear--------------------------- --------Linear--------------------------- Rock cut scars --------Erosional lines | | | | | | |
| Sedimentary feature | Braided Channel, Channel bar Point bar coalescence Channel bar, Side bar , Graded bedding , Cross bedding, Lamination, cross lamination | | | Terrace Section Scarp section Punasa Dam site Trench , Damsite Foundation Excavation ,Graded bedding , Cross bedding, Lamination, cross lamination & Cut and Fill features | | | |
| Terrace shape | --------- Cuspate------- ----------------------------- Rectangular-------------------------- Rock cut scar Sharp edge scar Isolated cap | | | | | | |
| Land use pattern | ------------------Barren -----------------Inhabitation and cultivation--------------------- Forest coverd area | | | | | | |
| Composition/Litho constituents arranged in probable order of abundance | River bad Braided Channel, Point Bar, Side Bar. With very coarse to very fine sand , silt & Clay<br>: Quartzite Gneiss, granite, quartzite, basalt, sandstone, limestone, Augate, Jaspar, schist, , slate, sand and silt.<br>NTo<br>: Gneiss,quartzite, gneiss,, basalt, ,granite, , sandstone limestone, phyllite, slate, shale, sand and silt .<br>NT1 Quartzite, gneiss, , basalt, granite sandstone, phyllite, , basic, schist shale sand and silt.<br>NT1-A Quartzite, granite, gneiss, meta basic sand stone, lime stone schist, basic, phyllite, slate, shale, sand silt and clay.<br>NT-3 Alluvial Bluff Section Steep Alluvial face ----------------------------------------------------------------------<br>NT2-B. Not Developed NT2-C Not Developed ----------------------------------------------------------------------<br>NT3-A Not Developed NT3-B Not Developed ----------------------------------------------------------------------- | | | | | | |

TABLE NO 10 -SALIENT FEATURES OF FLUVIAL TERRACES IN TYPE AREA OF NRMADA VALLEY
Locality: ALIABAT

| | River bad | NTo | NT1 | NT2-A | NT2-B | NT2-C | NT3-A NT3-B NT-C |
|---|---|---|---|---|---|---|---|
| Age | HOLOCENE | | | | | | |
| Elavation above MSL (m) | 25 | 35 | -- | -- | -- | -- | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Geomorphic break (m) | 0.00 | 10.00 Alluvial Face | Not Developed | Not Developed | Not Developed | Not Developed | Not Developed |
| Elevation above RB (m) | 0.00 River bad Channel, Point Bar, Side Bar | 10.00 Rock Face and Alluvial Bluff | Not Developed | Not Developed | Not Developed | Not Developed | Not Developed |
| Slope | ---------Towards west & SW-------- - | | --------Towards west and SW--------- | | ---------Towards west & SW--------- | | |
| Nature of surface | --------Depositional , Cresent shape elongated ------ Errosional …………. | | | Rock cyut terraces and Rock scar --------Erosionall --- Lieanr scar line ----- | | | |
| Cycle Sedimentation | Up ward fining cycle -------- -------------------- -Polycycle ------------------------------- | | | | Rock cut scars -- Section not not exposed--------- | | |
| Orientation of W-Axes | | ENE-WSW to E-W | ENE-WSW to, E-W | ENE-WSW, NW-SE | ENE-WSW, NW-SE | E-W & NW-SE | ENE-WSW, NE-SW E-W |
| Plunge of L-Axes | | ------Towards west, South North West & West ------ | | --------Towards SW-------- | | Rock cut terraces and Scar | |
| Relative disposition | Convergent Divergent Divergent Divergent Divergent | | | | | | |
| Paired/Unpaired | Unpaired Paired Paired Paired unpaired Paired sharp Strand lines | | | | | | |
| Nature of scarp | ------Curvilinear---- Curvilinear --------- --------Linear------------------- --------Linear---------------------- ------ --------Linear---------------------------- --------Linear---------------------------- Rock cut scars ---- -----Erosional lines | | | | | | |
| Sedimentary feature | Braided Channel, Channel bar Point bar coalescence Channel bar, Side bar , Graded bedding , Cross bedding, Lamination, cross lamination | | | Terrace Section Scarp section Punasa Dam site Trench , Damsite Foundation Excavation ,Graded bedding , Cross bedding, Lamination, cross lamination & Cut and Fill features | | | |
| Terrace shape | --------- Cuspate------- ----------------------------- Rectangular--------------------------- Rock cut scar Sharp edge scar Isolated cap | | | | | | |
| Land use pattern | ------------------Barren -----------------Inhabitation and cultivation--------------------- Forest coverd area | | | | | | |
| Composition/Litho constituents arranged in probable order of abundance | NTo : Quartzite Gneiss, granite, quartzite, basalt, sandstone, limestone, Augate, Jaspar, schist, , slate, sand and silt.<br>:<br>NT1 Not Developed<br>NT1-A NT-3 Not Developed ----------------------------------------------------------------------------------------------<br>NT2-B. Not Developed NT2-C Not Developed ----------------------------------------------------------------------<br>NT3-A Not Developed NT3-B Not Developed --------------------------------------------------------------------- - | | | | | | |

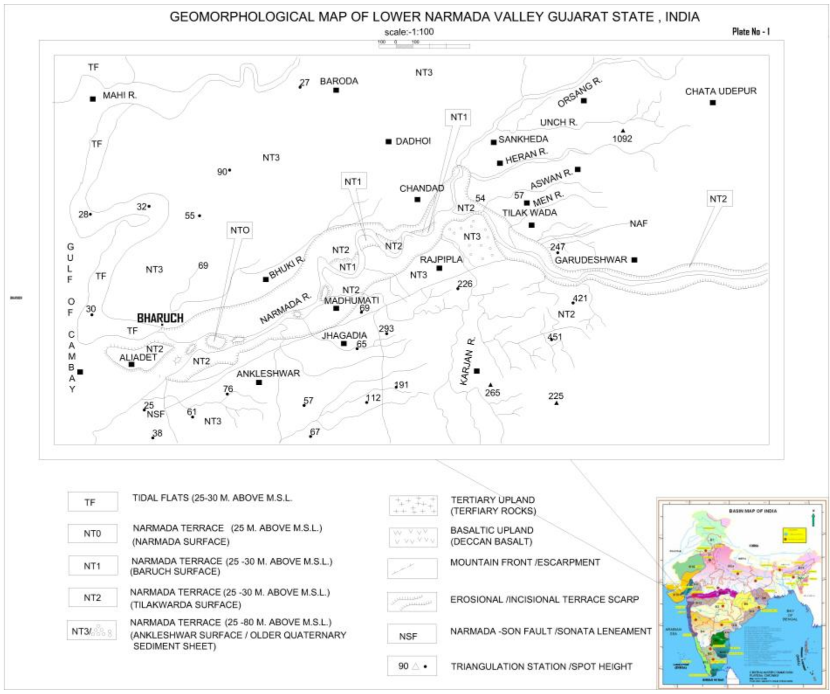

GEOMORPHOLOGICAL MAP OF LOWER NARMADA VALLEY GUJARAT STATE , INDIA
scale:-1:100
Plate No - I
BARODA
MAHI R.
CHATA UDEPUR
ORSANG R.
UNCH R.
DADHOI
SANKHEDA
HERAN R.
ASWAN R.
MEN R.
CHANDAD
TILAK WADA
NAF
RAJPIPLA
GARUDESHWAR
BHUKI R.
NARMADA R.
MADHUMATI
BHARUCH
JHAGADIA
KARJAN R.
ALIADET
ANKLESHWAR
NSF
GULF OF CAMBAY
TF
NT0
NT1
NT2
NT3
TIDAL FLATS (25-30 M. ABOVE M.S.L.
NARMADA TERRACE (25 M. ABOVE M.S.L.) (NARMADA SURFACE)
NARMADA TERRACE (25 -30 M. ABOVE M.S.L.) (BARUCH SURFACE)
NARMADA TERRACE (25 -30 M. ABOVE M.S.L.) (TILAKWARDA SURFACE)
NARMADA TERRACE (25 -80 M. ABOVE M.S.L.) (ANKLESHWAR SURFACE / OLDER QUATERNARY SEDIMENT SHEET)
TERTIARY UPLAND (TERFIARY ROCKS)
BASALTIC UPLAND (DECCAN BASALT)
MOUNTAIN FRONT /ESCARPMENT
EROSIONAL /INCISIONAL TERRACE SCARP
NARMADA -SON FAULT /SONATA LENEAMENT
TRIANGULATION STATION /SPOT HEIGHT

Plate No -3

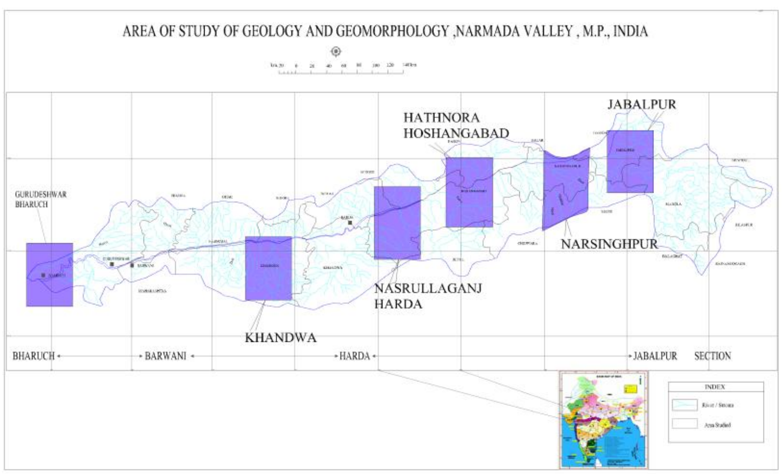

AREA OF STUDY OF GEOLOGY AND GEOMORPHOLOGY ,NARMADA VALLEY , M.P., INDIA
GURUDESHWAR
BHARUCH
KHANDWA
NASRULLAGANJ
HARDA
HATHNORA
HOSHANGABAD
NARSINGHPUR
JABALPUR
BHARUCH
BARWANI
HARDA
JABALPUR
SECTION
INDEX

Plate No - 4

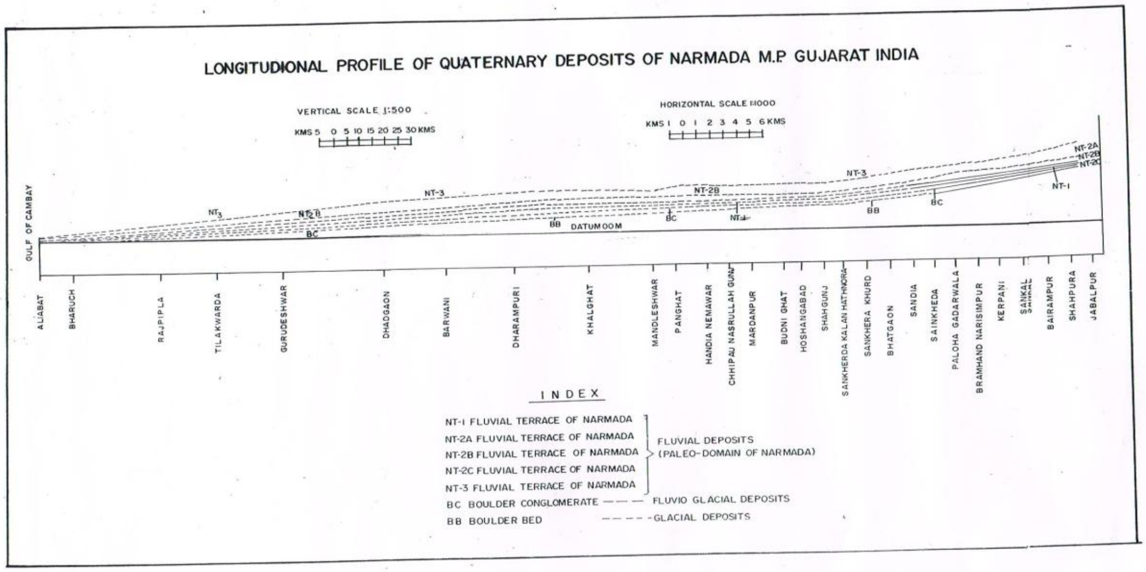
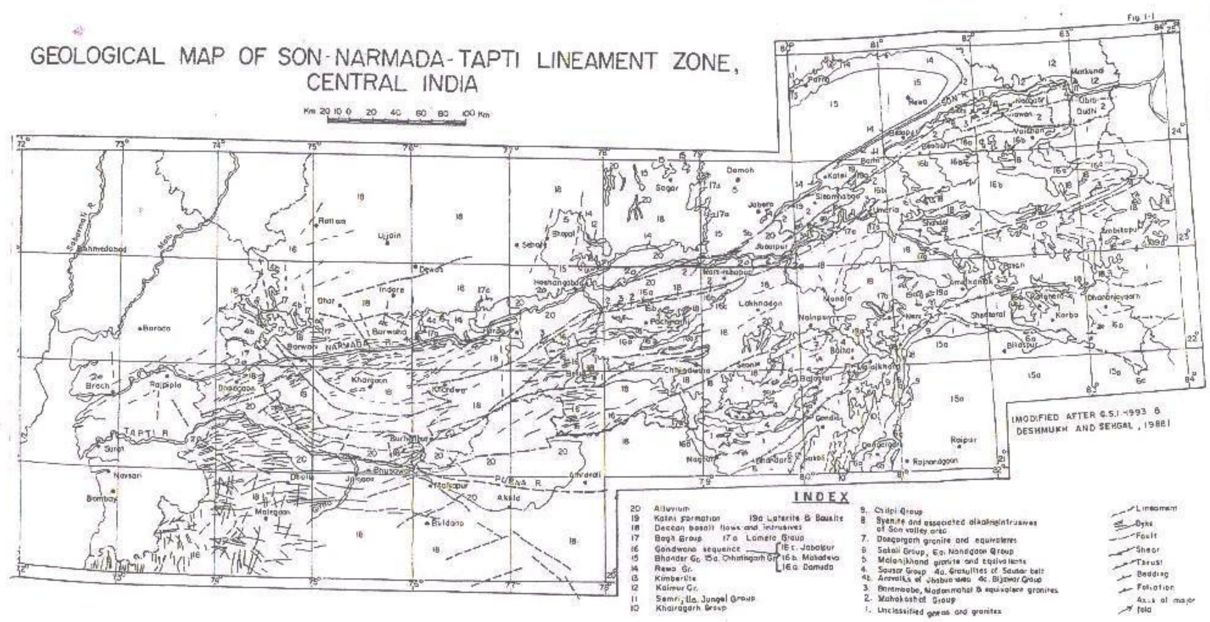



Plate No - 2




Modified after GSI 1995

The area in Narmada Rift valley around Jabalpur, Hathnora, Hoshangabad, Nasrullahgunj, Harda ,Khandwa , Khargone, Barwani, Dhadgaon Tilakwarda & Bharuch studied in detailed by author from 1982 to 2014 & existing maps are modified .

## REFERENCES

Acharyya, S.K., Kayal, J.R., Roy, A., Chaturvedi, R.K., 1998. Jabalpur earth quake of May 22, 1997: constraint from a afters hockstudy, J.Geol.Soc. India 51,295-304.
Acharyya, S.K., Roy, A., 2000. Tectono thermal history of the central Indian tectoniczoneand reactivation of major faults/she arzones. J. Geol.Soc. India 55,239-256.
Agarwal, G.C., 1986. Structure and tectonic so fexposed Tertia ryroks between Narmada and Kimrivers in South Gujarat. J.Geol.Soc. India 27,531-542.
ANON (1983) Discovery of fossilized Human skull in Narmada valley Alluvium Hohangabad area, M.P., Geol. surv. India, C.R News.

BADAM.G.L. (1979) Pleistocene forms of India, Deccan college, Pune.

Bhattacharji, S., Chatterjee, N., Wampler, J.M., 1996. Zones of Narmada-Tapiri ftrea activation and Deccan vol vanism : geo-chronological and geochemical evidence. In: Deshmukh, S. S., Nair, K.K.K. (Eds.), Deccan Basalts. Gondwana Geological Society, Nagpur, pp. 329-340.
BISWAS AND DASSARMA, D.C. (1981) New species of tstegodon from Narmada valley, Prof. Field Conference on Neogene- Quaternary boundary in India (IGCP).Calcutta.

Chamyal, L.S., Khadkikar, A. S., Malik. J.N., Maurya, D.M., 1997. Sedimentology of the Narmada Alluviai Fan, Western India. Sediment. Goel.109,263-27.
Chamyal, L.S, Maurya , D.M. Bhandari Rachna Raj ,S (2002) late Quaternary geomorphic evolution of the the lower Narmada Valley , westrn India implication for neotectonic activity along the Narmada-Son Fault Geomorphology 46 (2002 ) 77-202

Chandra, U., 1977. Earth quakes of peninsular India:aseismotec-tonic study. Bull.Seismol. Soc. Am. 65,1387–1413.
Choubey, V.D., 1971. Narmada–Son Lineament, India. Nature 232,38–40.
DASSARM, D.C (1979) Some observation on the Quaternary and mammal assemblages of India. Geol. Surv. India, Misc.Publ.no.45 pp 279-287.

DE TERRA and DE CHARDIAN,t (1936) OBSERVATION ON THE UPPER Siwalik formation and later Pleistocene deposits in India Procd. Amer. Phil. Scie. v 76,no6 pp 719-722.

De TERRA, H. and PATERSON (1939). studies on the Ice age in India and associated human culture.Carn. Inst. Washington.

Gupta, H. K., Mohan, I., Narain, H., 1972. The Broach earth quake of March 23, 1970.Bull. Seismol. Soc. Am.62, 47–61.
Gupta, S.K. (1974) Geology and sedimentation of parts of Narmada Basin, Sehore and Hoshangabad districts, M.P., Geol. Surv. India, Progress Report.

Gupta, H.K., Chadha, R.K., Rao, M.N., Narayna, B.L., Mandal, P., Ravikumar, M., Kumar, N., 1997. The Japalbur earth quake of May 22,1997. J.Geol. Soc.India 50, 85–91
Gupta, S.K. (1974) Geology and sedimentation of parts of Narmada Basin, Sehore and Hoshangabad districts, M.P., Geol. Surv. India, Progress Report.

Jain, S.C., Nair, K.K.K., Yedekar, D.B., 1995. Geology of the Son–Narmada Tapili neamentzonein central India. Geoscientific studies of the Son–Narmada–Tapilineament zone. Project Cruman sonata. Geol. Surv. India-Spec.Publ.,vol.10,pp.1–154.
Kaila,K.L.,Krishna,V.G.,Mall,D.,1981.Crustalstructurealong Mehmadabad–BillimoraprofileintheCambaybasin, Indiafromdeepseismicsoundings.Tectonophysics76,99–130.
KHAN A.A AND A. SONAKIA (1992) Quaternary deposits of Narmada with special reference to the Hominid Fossils, Jour. Geol. Soci. Of India Vol. 39 No2, pp 147-154

KHAN, A. A, RAHATE,D.N, Fahim, & Banerjee, S.N.( 1991 ) Evaluation of Quaternary terrace of lower Narmada valley , Districts Sehore and Hoshangabad, Madhya Pradesh

KHAN, A.A (2014) Tectonic Evaluation Quaternary Sedimentation and Palioanthrological records in the Narmada Riff System (M.P.) in Central India

KHAN, A.A, RAHATE, D.N,, FAHIM, M. AND S. BANARJEE,S.N ( 1992) Evaluation of Geology and Geomorphology in Central Narmada Valley ( Districts Sehore and Hoshangabad, Madhya Pradesh ) Scientific Publishers, Jodhpur.

KHAN, A.A, Rahate, D.N. (1991) Volcanic Ash from Quaternary deposits of Narmada Valley Central India. Proceed, of 78th session of Indian Sci. Cong. Association. (Abstract) pt. III pp 28-29

KHAN, A.A. & Banerjee, S.N. (1984) Geology and Geomorphological studies in the parts of Narmada Basin, Sehore district of M.P. Un Pub. Report. Geol. Surv. India.

KHAN, A.A. & VATSA, U.S. (1987-88) Geoenvironmetal Appraisal of the area around Jabalpur City, Madhya Pradesh G.S.I.. Rec. Vol 122 pt-pp 163-64.

KHAN, A.A. (1984) Geological and Geomorphological studies around Tapti-Vagher confluence district Jalgaon, Maharashtra. Geol, Surv. India Rec. V.113 pt 6 pp 99-109.

KHAN, A.A. (1990 ) Geomorphology of Narmada Valley Of Jabalpur_ Handia Section Unpublished G.S.I Note.

KHAN,A.A.( 1991).Geological studies of Harda – Barwaha basin in parts of Dewas, Sehore, Hoshangabad and Khandwa districts with the Aid of Satellite imagery and Remote Sensing Techniques, Geol. Surv. Ind, Rec. Vol; 126 pt-6

Khan, A.A. Sultan Wajida & Aziz Maria (2013) Homo Erectus On Unified Quaternary platform In India And China A Correlation & Sequential Analysis Research Scopes .Vol. I issue -3 pp-43-56

Khan, A.A. & Aziz Maria (2013) Homo Erectus & Homo Sapien in Spectrum of Volcanic Ecology, Narmada Valley ( M.P.) India. Vol. I issue -3 pp-43-56

.

Khan, A.A. (2013) Quartz grain morphology & statistical analysis of Paleo soil of Hominid locality Hathnora Narmada valley India .Research Scapes Vol.II Issue IV April to June 2013

Khan , A.A. ( 2013) Quartz grain morphology of Quaternary sediments, Paleo soil & present soil of narmadaa valley India. Research Scapes Vol.II Issue IV April to June 2013

Khan,A.A. & Aziz, Maria (2014) Tectoniccs Evolution , Quaternary sedimentation and the Anthropological Records in Narmada Rift System (M.P.) Central India. Inter .Jour of Research in Techno Sciences VolI Issue I January (2014).

Khan A.A.( In press) A Critical Analysis of Imprints of Neotectonisam in Sukta sub -basin parts of district Khandwa (M.P.) India

KHATRI, A.P. (1980) The Pleistocene mammalian fosse of Narmada river Valley and their horizons. Asian perspective, v.-9pp 113-133.

Khatri, A.P. 1966. The Pleistocene ammalian fossi is of Narmada river valley and their horizon, *Asian Perspectives*, 9: 113-133.

Maurya, D.M., Raj,R., Chamyal,L.S., 2000. History of tectonic evolution of Gujarat alluvial plains, western India during Qua-ternary: a review. J. Geol.Soc. India55,343–366.

*PILIGRIM,G.E. ( 1905) Elephas antiques ( namadicus ) in Godavery Alluvium, Rec. GSI. V. 32 pt I p 215*.

PRINCEP, J.( 1932 ) Note on Jabalpur fossil bones. Jour.Asiatic Soci. Bengal, v.I, pp456-458.

----------------- Note on fossil bones discovered near Jabalpur. Jour. Asiatic Soc. Bengal.v. 2 pp 583-588

Quittmeyer, R.C., Jacob, K.H., 1979. Historical and modernseis-micity of Pakistan, Afghanistan, north western India and south-eastern Iran. Bull.Seismol.Soc.Am.69,773–823.
Radhakrishna, B.P., Ramakrishnan, M., 1998. Archaean–Protero-zoicboun dary in India. J.Geol.Soc.India32,263–278.

RAHATE.D.N.,KHAN A.A AND BANERJEE, S.N. ( 1985 ) Geomorphological and geological studies of Quaternary sediments in collaboration with project CRUMANSONATA IN PARTS OF Narmada valley, Sehore, hoshnagabad and Dewas districts, M.P. progress repost ( Unpublished ) Geo. Surv. Ind.

.

Ravi Shankar 1991. Thermal and crustal structure of SON ATA- a zone of mid continental rifting in Indian shield. *four. Geol. Soc. India.* 371301:211-220.

Ravi Shanker 1993. Structural and geomorphological evolution of "SONATA" rift zone in Central India in response to Himalayan uplift. *Jour. Palacontol. Soc. India,* 38: 17-30.

Reddy, P.R., Murthy, P.R.K., Rao, I.B.P., Khare, P., Kesava Rao, G., Mall, D.M., Koteshwara Rao, P.,Raju, S.,Sridhar, V.,Reddy, M.S., 1995. Seismi creflection fabric patternin Central India: preliminary results. Mem.J.Geol.Soc. India 31,537–544.
Roy, T.K., 1990. Structural styles in southern Cambay basin India an drole of Narmad age of racturein the formation of gianthydrocarb on accumulation. Bull. OilNat. GasComm. 27, 15–38.

SONAKIA,A ( 1984) The skull Cap of Early man and mammalian fauna from Narmada Valley alluvium, Hoshangabad are, Madhya Pradesh , India Rec .Geol. Surv. V.113 pt-6, pp.159-172

SPLISHBURY, C.G. (1883) Account of the bones discovered in beds of the Omar Nadi enear Narsighpur on Godaveri in valley Nerbuda. Jour. Asiatic Soc. Bangal , v 2, pp 388-395.

THEOBOLD, W (1860) On Tertiary and alluviumdeposits of the Central portion of Narmada Valley. Meom.GSI,vII, pp.279-298.

Tiwari, M.P. and Bhai. H.Y. (1992) (In press ) Quaternary stratigrphy of the Narmada valley.

TRIPATHI, C. (1968) The Pleistocene alluvial deposits of Central India .Rec. GSI.v 95 (2).

TRIPATHI, C. (1968) The Pleistocene alluvial deposits of Central India .Rec. GSI.v 95 (2).

Venkat Rao, K., chakraborty, S., Rao, K.J., Ramani, M.S.V., Marathe. S.D. & Borkar, B.T.1997: Magnetostratigraphy of Quaternary fluvail sediments and tephra of Narmada valley, Central India, Geol. Surv. Ind., Spl. Publ.No. 46,pp65-78.

YADAVA, N.L. AND KHAN, A.A. ( 1995 ) evaluation of Geology and structure of Eastern Harda- Barwah Basin, Madhya Pradesh using Remote Sensing Techniques with Field Checks. Jour.Ind.Soci. Remote Sensing ( Photonirvachak)

Williams, M.A.J.and Royce, K, 1982: Quaternary geology of the middle son valley, north central India,P implication for prehistoric Archaeology, Palaeogeography, Palaeoclimatology and palaeoecology, Vol. 38. pp. 139-162.

WILLIAM,M.A.J. AND CLARKE,M.F. 1995 Quaternary Geology and Prehistoric environment in Son and Belan valleys, North Central India , Geol..Soc. Ind. Mem .32, pp 282-308.l

Venkat Rao, K., chakraborty, S., Rao, K.J., Ramani, M.S.V., Marathe. S.D. & Borkar, B.T.1997: Magnetostratigraphy of Quaternary fluvail sediments and tephra of Narmada valley, Central India, Geol. Surv. Ind., Spl. Publ.No. 46,pp65-78.