Sedimentlogy of Quaternary Deposits of Paleo-Domain of Narmada in Harda_Bharouche Section Narmada Rift Valley, Central India

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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. In Harda _Bharouche section 180 sediment samples collected from Quaternary sediments, were analysed and their statistical parameters are studied which. Revealed the presence of three domains of quaternary deposits in Narmada valley in Central India.***

Keywords: Quaternary deposit, Paeo domain, NT1, NT2, NT3, Glacial Fluvio-glacial linear trench

1. 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 1300 kms length across the middle of Indian subcontinent before entering Gulf of Cambay in the Arabian sea near Baroda in Gujarat state. It enters the fertile alluvial plain and passes through the gorge of about 19 kms long consisting 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 valley has maximum width of about 32 kms.

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 it is exposed the repeated post erisional and depositional activities and subjected to anisotropic and asymmetric tectonic dislocation which has culminated diversified morphogenetic units and region which further undergone to process of tectonic evolution and chiseling of terrain by dynamic erosional and depositional activity resulting in and reshaping the terrain into various morphogenetic units and land form element, configuration of drainage, topography, physiographic, erosional platform, planation surfaces, denudation ridges, structural units linear valleys, strike hills, valley gapes, escarpments and river terraces. The cumulative dynamics of structural deformation, rinsing and sinking platform of Narmada has also manifested concealed cyclic mechanism of tectonics and geothermic activity hydrological activity, seismicity, neosiesmic events and in surface manifestation. In addition the valley gapes and valley trenches provided ideal sites for sedimentation for formation of quaternary platform, pediment, pediplain, peniplain and river terraces.

The Narmada flows along tectonically active NSF which forms a fault controlled basin of a huge thickness of Tertiary and Quaternary sediments. The thick blanket of Quaternary sediments occurs in the central part of valley in Jabalpur –Harda section and in Gurudeshwar –Bharouche section in lower of valley; where as in the other part in Harda –Mandleshwar section thin and isolated caps and strips of quaternary sediments are noticed on rock cut terraces and rock benches of country rocks. In Mandleshwar-Barwani, Dhadgaon- Tilakwarda the quaternary deposits are shallow to moderate in thickness and thin out to wards east. The isolated locus of accumulation and sedimentation along the entire length of 1300 kms of Narmada is controlled by the tectonics and structural frame work and sinking and uplift of fault bounded blocks and lineaments. It is well illustrated by neoseismic signatures and imprints on quaternary deposits and landscapes in the valley. The critical analysis of landscape profile evolution of drainage, quaternary terraces, river morphology and analysis of bore hole data of basement configuration of rock and quaternary deposits revealed that Jabalpur-Harda section valley segment suffered mega dislocation and sink to level of about 1150 m as compared to the adjoining blocks and created and has formed open rock basin and platform of quaternary sedimentation. This section display complete record of quaternary deposits of glacial, fluvio- glacial and fluvial sediments in increasing antiquity from the base. The study of bore data of ETO, CGWB, and GSI indicates and average thickness of quaternary deposits of about 435 m. The quaternary deposits bear well preserved imprints of neotectonisam indicating that the Sonata lineament zone seismically is active and has direct bearing on quaternary landscape of rift valley. The Harda –Mandleshwar section predominenently portrays the sequence of cyclic and noncyclical rock cut terraces and rock cut platform and benches which are time equivalent to the quaternary terraces of central and lower Narmada valley Khan et.al (2014). In Mandleshwar-Barwani the quaternary sediment are of moderate to shallow in thickness which are incised along with the country rock by cyclic structural dislocation and tectonic activity along ENE WSW lineament fabrics and dynamic incision of stream. It is well documented in quaternary terraces and composite erosional terraces; rock cut terraces caped by quaternary sediments, river profile and channel morphology. The morphogenetic expression of the section revealed uplift of block.

The Gurudeshwar-Bharouche embodies the thickest quaternary deposits which represents complete sequence from the base glacial fluvio-galcial fluvial, lacustrine and mud deposits. This segment is about 90 km in length and forms the southern margin of the N–S 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 rift trench. 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 bore hole data of ONGC, CGWB, GSI of deep geology in the basin have revealed occurrence of Deccan Trap at depths of 6000 m followed by an Achaean basement (Roy, 1990) Khan et.al (2002). 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 Khan et.al (2002).

The quaternary landscape has been chiseled in to step sequence of terraces (NT1 –NT3) which are both paired and none paired in nature and are time equivalent to the terraces of central sector of Narmada. Plate No _1 & 2

2. Previous work

In Narmada valley in last three decade lot of work has been done by different worker telefocus to their specialisation and expertize on different aspects of quaternary deposits. The work was in pieace meal and restricted in selected sector of valley. Lot of data has been generated on Narmada Valley Quaternary deposits during last 150 years. The different workers have studied the subject separately in the line of theirspecializations Roy, A.K. (1971), but the work was in pieace meal and restricted in selected sector there has been very little coordinated approach towards understanding and building up the Quaternary sedimentlogical history of the valley.

The sedimentology aspects of quaternary deposits have been attempted in Narmada valley in recent years Khan et. al (2016), Khan et.al. (2016), The Quaternary lithostratigraphy and sedimentological aspects were studied and in the Narmada valley (Khan 1984, Khan &Benarjee 1984, Khan & Rahate 1990-91-90 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 complete sequence of Quaternary deposits from lower Pleistocene to Holocene (Khan & Sonakia (1992). Khan, et.al (1912), Khan (2012) et.al Khan (in press), Khan (in press), .The results of sedimentological studies Khan (2015), quartz grain morphology, Khan (2014), quartz grain morphology, Palesole Khan (2014) Quaternary column 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 (1991). Ash bed Khan & Maria (2012) Khan & Maria (1912) Heavy mineral assemblage Khan (2016) tephra stratigraphy, Khan et.al (1991)Acharya, S.K. and Basu, P.K. (1993) Khan etal (2014) Khan et.al.(2015) Ash fall and its impects (2015) Khan et.al (2016) magnetostratigraphy, and bio-stratigraphy and correlation of sediment columns intra valley wise, inter valley wise and on unified Quaternary Platform Khan et.al (2012) focusing on hominid localities of China have been studied on quaternary platform which have given new insight on the age of the Narmada *Homo erectus.*

3. Present Work

The Narmada valley forms an ENE-WSW lineament and Quaternary deposits in it are confined to trough like basin, with profound asymmetry in northern and southern valley walls. The Narmada valley in Peninsular India negotiates along a prominent lineament with profound geomorphological and geological asymmetry between the northern and southern valley walls, giving it a tectonic significance. The Quaternary deposits of the Narmada valley represent the thickest deposits in peninsular India representing different domain of sediments deposited in distinct environment of glacial, fluvioglacial and fluvial. The various aspects of Quaternary deposits and their quarries are well described in faulted and sinking platform under structural riparian rift trench however digonestics and concealed strata remained silent and unrevealed as such hidden miseries of Narmada valley needs attention.

In the present work an attempt has been made for the first time to study sedimentological aspects of quaternary deposits of Narmada with an objective to build- up and conceive the dynamics of Quaternary sedimentation & tectonics of t middle & lower Narmada valley. (Plate No _1)

4. Area of study

The area of study is located in Harda _ Bharouche section of Narmada basin in lower Narmada. 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 Quaternary landscape in Harda – Bharouch Section represents stepped sequence of river terraces (NT1_NT3) where Harda _Barwani section 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 (1993) 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.

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 Unc hHeran, Aswan, Men rivers constitute minor basins which are tectonically segmented & ecologically integrated as in built part of main rift System. (Plate No 1)

The area 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 and 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.

In the present work an attempt has been made for the first time to conduct detailed sedimentlogical studies in Harda_Bharouche section with an objective to build- up and conceive the sedimentological model with Environment of sedimentation in lower Narmada valley. About 210 sediment sample were collected from surface and subsurface quaternary deposits and from ongoing drilling project logs up to 180 m below the ground surface and carried out detailed statistical analysis in the laboratory which is presented here under. Plate No_2

5. The Statistical Computations

The statistical analysis of sediment sample of the area around Hathnora Narmada valley and particle size distribution curves were expressed on a Φ scale. Folk and Ward's (1957) graphical method was adopted to calculate mean size (Mz), sorting (σI), Skewness (SKI) and Kurtosis (KG). This method involves the measurement of several percentiles from cumulative curves (Φ5, Φ16, Φ25, Φ50, Φ75, Φ84 and Φ95). The formulae are as follows:

$$\Phi = -\log_2 G$$

where G = the grain size (mm) (i.e. sieve mesh opening)

Mean size

$$M_z = \frac{\Phi16 + \Phi50 + \Phi84}{3}$$

Sorting

$$\sigma_I = \frac{\Phi84 - \Phi16}{4} + \frac{\Phi95 - \Phi5}{6.6}$$

Skewness

$$SK_I = \frac{\Phi16 + \Phi84 - 2\,\Phi50}{2(\Phi84 - \Phi16)} + \frac{\Phi5 + \Phi95 - 2\,\Phi50}{2(\Phi95 - \Phi5)}$$

Kurtosis

$$K_G = \frac{\Phi95 - \Phi5}{2.44(\Phi75 - \Phi25)}$$

The computed textural parameters of sediments and their binary relation applied as tool in differentiating the various environments of Quaternary sedimentation in Moila R.J. et.al. (1968) the same key is used as tool to analyze and differentiate sediments of various domains in Narmada valley.

The study of statistical parameters of finer clastics of Quaternary terraces both in the stratigraphic sequence and down the current of Narmada and its tributaries is attempted to understand the nature of erosional and dispositional processes sedimentary pattern, behavior of transporting agencies, load characteristics and current capacity and energy condition, and cumulatively to decipher over all history of Quaternary sedimentation in Narmada valley. Besides detailed study of coarser clastics sediment of terraces above 16 mm of Narmada terraces has been attempted to under erosional and depositional history climatic variation, in, size variation and its relation to various level of energy condition, shape of rock fabric their relation to lithology and transporting media, palaeo-currents and provenances of sediment in Narmada Valley

In Harda – Barouche section 210 sediment samples were collected in stratigraphic columns of Narmada Valley down the current, from different domain of Narmada for detailed sedimentological studies in Jabalpur- Harda section in central sector of Narmada valley. These sediment samples were analyzed in the laboratory using ISI sieves with mesh 100, 50, 25, 15, 10, 8 and 6 mm scale size opening of these sieves were converted to corresponding phi scale from the weight percentage of various size grades, cumulative weight percentage were computed and cumulative curves were drawn and various graphical size parameter such as mean size, inclusive graphic standard deviation, inclusive graphic skewness and graphic kurtosis were computed using the formula of Folk and Ward (1957) which have reliability factor of 79 percent.

The statistical parameters and their interpretation in stratigraphic sequence succession wise as well down the currentis given below.

Statistical Parameters of the Sediments of Fluvial Terraces of Punasa Section Narmada Valley

Mean Size (MZ)

The average value of mean size of terrace NT1 is 2.615Ø (fine sand), and it ranges from 1.475Ø to 3.146Ø (medium sand to very fine sand). Average value of mean size of terrace NT2 is 1.885Ø (medium sand) and it varies from -0.432Ø to 2.351Ø (very coarse to fine sand). Average value of mean size of terrace NT3 is 1.820 (medium sand) and it ranges from -0.535Ø to 2.565Ø (very coarse to very fine sand).

The average and range values of mean sizes of terrace NT1 to NT3 revealed that the terrace chiefly consist of fine sand, whereas the terrace NT2 to NT3 pre-dominantly medium sand. The range values of mean size indicate that the younger terrace comprised of medium to fine sand, whereas the older very coarse to very fine sand. The association of sediments with various terraces NT1 to NT3 show progressive upward fines of sediments, typical of fluvitile environment and suggest constant decrease in load carrying capacity of the channel from early to late history of sedimentation. The variation in mean size as reveal by the relative range of sediments appears to be due to fluctuation in the energy condition of the channel during sedimentation.

Inclusive Graphic Standard Deviation (δ)

The average value of standard deviation for terrace NT1 is 0.295Ø (very well sorted) and it ranges from 0.232Ø to 0.410Ø (well sorted NT2 is 0.279Ø (very well sorted), it varies from 0.246Ø to 0.435Ø (well sorted to very well sorted). Average standard deviation for NT3 is 0.355Ø (well sorted) and varies from 0.258Ø to 0.435Ø (well sorted to very well sorted).

The average and relative range value of standard deviation of terrace NT1 to NT3 indicate that as a whole the sediments are well sorted to very sorted. The values of standard deviation decreases towards younger terraces NT3 to NT1 indicating improvement in sorting of sediments. This appears to be related to mean size, which decreasing antiquity and is inversely related with standard deviation, (Khan, 1985).

Inclusive Graphic Skewness (SKI)

The average value of skewness of terrace NT1 is +0.335Ø (very positive skewed), it varies from -0.450Ø to 0.560Ø (very negative skewed to very positive skewed), for terrace NT2 average value is +0.453Ø (very positive skewed) and it ranges from -.0652Ø to +0.622Ø (very negative skewed to very positive skewed), for terrace NT3 average value -0.255Ø (negative skewed), and it varies from 0.640Ø to 0.350Ø (positive skewed to very positive skewed).

The relative average value of skewness of terrace sediments indicates that the sediments of NT3 are negative skewed and NT2 and NT1 are positive skewed. The relative range of skewness suggest that the sediments are very negative to very positive skewed. The negative skewness suggests the higher energy environments, whereas the positive skewness low energy environment. As a whole relative average and range values of standard deviation revealed the strong tendency of the sediments to become positively skewed in increasing antiquity of terraces, thereby revealing decreasing in load carrying capacity of channel system towards the formation of younger terraces.

Inclusive Graphic Kurtosis (KG)

The average value of kurtosis of terrace NT1 is 0.310Ø (very platykurtic), it ranges between 0.215Ø to 0.416Ø (very platykurtic). Average value of kurtosis for terrace NT2 is 0.392Ø (very platykurtic), it varies from 0.230Ø to 0.547Ø (very platykurtic). Average value for terrace NT3 is 0.466Ø (very platykurtic) and it ranges from 0.345Ø to 0.554Ø (very platykurtic).

The distribution of average values and relative range of kurtosis of terraces NT1 to NT3 reveal the pre-dominantly very platykurtic nature of sediments. The kurtosis values constantly decreases upwards, which indicate that the sediments were mainly derived from single source inferred to be from Vindhyan and Basaltic rocks, (Khan 1957) Plate No_3 & Table No 1

Statistical Parameters of the Sediments of Fluvial Terraces of Mandleshwar Section

Mean Size (MZ)

The average mean size for sediments of fluvial terraces of Narmada is 2.392 Ø (fine sand). It varies from -2.98 Ø to 3.10 Ø i.e. the sediment mainly comprises of very fine sand. The (MZ) in upper reaches upstream of Mandleshwar except little variation in the middle part of valley it progressively decrease down the stream. In between Mandleshwar and Barwaha it shows strong fluctuation whereas down the stream of Chamyala a significant steep fall in mean size is noticed. The fluctuation in this section seems to be related with lateral mixing of sediments. The conspicuous decrease in (MZ) down the steam of Barwaha appears to have related both with the steep change in the valley gradient and repeated reworking of sediments in the valley. The (MZ) show inverse relation with sorting in the valley, as the mean size decreases down the stream the sediments show significant.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation for sediment of terraces of fluvial domain is 0.388 Ø (will sorted) where as it varies from 0.327 Ø to 0.551 Ø i.e. the sediment of fluvial terraces are moderately sorted to very well sorted. In upper reaches upstream of Mandleshwar except the little variation the sorting values decrease down the stream which indicates improvement in sorting. In the Mandleshwar and Barwaha section it show strong fluctuation which is perhaps due to with lateral mixing of sediments, whereas down the stream of Barwaha the sediment show distinct and sharp improvement in sorting which is inversely related with the (MZ). The steep fall in the valley gradient down the stream of Thathikathur also has important bearing on these two parameters in the valley.

Inclusive Graphic Skewness (SKI)

The average value of skewness is 0.327 Ø.it indicates that sediments are very positive skewed. It varies from -0.553Ø to +0.551Ø i.e. the sediments are negative skewed to positive skewed. In the upper stream of Mandleshwar the sediment generally show little variation in skewness value and are negative skewed. In between the Mandleshwar and Barwahaskewness show atrong variation in values i.e. sediments are nearly symmetrical and are both negative and positive skewed, whereas down the stream of Barwaha there is steep increase in values of skewness and the sediment general the skewness values increases down the current indicating progressive increase of finer sediments in the lower part of valley, it seems to be due to with repeated reworking and rapid transport of sediments from thesource area during sedimentation.

Inclusive Graphic Kurtosis (KG)

The average value of kurtosis is --0.553Ø to +0.551Ø to +0.551Ø (Platykurtic). It varies from 0.525Ø to 1.521Ø i.e. sediments are leptokurtic to very platykurtic in nature. In upstream of Thathikathur, except little variation the overall value of kurtosis decreases down the stream i.e. the sediments become from leptokurtic to mesokurtic in nature. In Mandleshwar and Barwahasection inspite of fluctuation the value of kurtosis increase i.e. sediments show tendency to become leptokurtic, whereas down the stream of Mandleshwara the values of kurtosis sharply decreases and the sediment show strong tendency to become platykurtic in nature. In general the kurtosis except local variation between In tis section it show steady decrease in values i.e. the sediments show the tendency to become from leptokurtic to platykurtic in nature down the current in valley. Plate No_3 & Table No 2

Statistical Parameters of the Sediments of Fluvialterraces of- Khalghat-Barwani Section

Mean Size (MZ)

The averages mean size for sediments of fluvial terraces of Narmada valley is 1.199 Ø (medium sand). It varies from 1.522Ø to +1.989Ø i.e. the sediments pre-dominently medium to very coarse sand. In the upstream of Barwaha the (MZ) constantly decreases down the stream, perhaps due to steeper slope of the valley. In between Khalghat and Barwani it shows strong fluctuation, whereas down the stream of it significant and progressive decrease in (MZ) is noticed. The fluctuation in (MZ) between in this section appear to related with the lateral mixing of sediments brought by network of subsequent stream joining the central part valley at various places, whereas the decrease of (MZ) downstream is seem to be with due steep bad slope in the middle and lower segment of valley.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation of the sediments of fluvial terraces of Narmada is 1.359Ø (very poorly sorted). It varies from 0.521 Ø to 3.489 Ø i.e. the sediments are very poorly sorted to moderately sorted. In the upstream of Barwani the values of sorting sediments. In downstream it shows strong fluctuation, which seem to be due to lateral mixing of sediments in central part of valley. The downstream of Barwaha values of sorting progressively decreased depicting the sharp improvement in sorting of the sediment down the current of valley. This shows inverse relation of (δ) with (MZ) down the current i.e. as the sorting of sediments increases (MZ) decreases.

Inclusive Graphic Skewness (SKI)

The average value of skewness is +0.496Ø (very positive skewed). It varies from +0.22Ø to + 0.725 i.e. the sediments are positive skewed to very positive skewed. In the stream between Khalghat & Barwani section the values of skewness show relation i.e. the sediments are both coarse skewed and fine skewed. The downstream the sediment show constant increase in values of skewness which reveal the strong tendency of sediments to become fine skewed as the result of decrease in load carrying capacity of channel system during sedimentation perhaps due to loss in bed slope in the lower part of valley.

Inclusive Graphic Kurtosis (KG)

The average value of kurtosis is 0.799Ø (platykurtic). It varies from 0.320Ø to 1.210Ø i.e. the sedimemts are leptokurtic to very platykurtic in nature. In upstream of Barwani the values of kurtosis show strong fluctuation, whereas the down the stream there is marked decrease in the value of kurtosis i.e. the sediments show strong tendency to become platykurtic in nature down the current in valley. Plate No_3 & Table No_ 2, 3

Statistical Parameters of the Sediments of Fluvial Terraces of Barwaha Section

Mean Size (MZ)

The mean size of the sediments is 0.552Ø where as it values varies from 0.65Ø (coarse sand) to 2.75Ø (fine sand). The mean size of sediments corresponding to the different Quaternary surfaces NT1, NT2, NT3 range between 0.933Ø (moderately course grained) to 2.52Ø (fine sand) and 0.65Ø (coarse grained) to 2.75Ø (fine sand) respectively, which perhaps indicate up ward fining sequence of sediments and declining energy condition of stream system.

Sorting Index

It is the measure of sorting, which reflects the consistency in the energy level of depositing medium the average value is 1.45 Ø The sorting index of the sediments range from 0.62Ø to 2.167Ø i.e. moderately sorted to very well sort. The sorting index corresponding to NT1, NT2 & NT3 ranges from 0.5890Ø to 1.5780Ø, 1.058Ø to 1.691Ø and 1.589 to 2.167Ø. It that the sediments are moderately to well sorted. The comparatively poor sorting of the sediments corresponding to surface may be due to lateral mixing of the sediments brought by subsequent stream.

Skewness (SKI)

It denotes the symmetry of grain size frequency distribution. The symmetrical curves possess zero value, with excess fine material show positive value and those with excess coarse material have negative value. The average value is 0.62Ø to 2.167Ø where as values ranging from +0.308Ø to +1.721Ø. The sediments corresponding to NT1, NT2, NT3 +0.350Ø to 1.721Ø, +0.517Ø to 1.411Ø and +0.308Ø to 0.780Ø respectively. This indicates fluvial origin of sediment.

Kurtosis (KG)

It indicates peak of the curve. The lower values of Kurtosis (Platykurtic) points to a board peak, while high values of Kurtosis (Leptokurtic) denotes pronounced peak in the centre.

The average value of Kurtosis of the sediments is 0.885 Ø, where as it ranges between 0.626Ø (mesocratic) to 3.864Ø (Strongly leptokurtic). The Kurtosis values corresponding to NT1, NT2, NT3 surfaces ranges between 0.788Ø to 3.869Ø, 0.06Ø to 1.135Ø and 0.626Ø to 1.230Ø respectively. The above values suggest that the sediments are mesokurtic to strongly Leptokurtic in nature. The More than 50% of the samples corresponding to the surface are moderately to strongly leptokurtic and the rest are mesokurtic. About 20% of the samples corresponding to NT2 surface are Leptokurtic while rest are mesokurtic whereas 25% of the sample ofT3 surface are leptokurtic and rest are mesokurtic in nature.

The study of the sediment samples analyzed from the adjacent area (55F5, 6) reveals that the mean size of the sediments of the present day Narmada constantly decreases down the current whereas the sorting of sediment. The skewness show the tendency towards skewed positive and kurtosis indicates that the sediment of the domain become mesokurtic to Leptokurtic. Plate No_3 & Table No_ 2, 3, 4.

Statistical Parameters of the Sediments of Fluvialterraces of Punasa Barwaha-Barwani Section

The discussion is based on 20 sediments samples collected from the NT-1 NT-3 from the paleo-domain of the Narmada comprising Quaternary deposits in the middle lower segment of Narmada valley. The study of statistical parameters of finer clastics of Quaternary terraces in the stratigraphic sequence in Barwani section is attempted to understand of erosional and dispositional processes, sedimentary pattern, and behavior of transporting agencies, load characteristics, energy condition and current capacity to decipher over all history of Quaternary sedimentation in the lower segment of Narmada valley.

The discussion of grain size parameters is based on study of 30 sediment sample on the collected from the quaternary deposits of paleo domain and from the channel deposits. The results of Statistical parameters are tabulated in

Mean Size (MZ)

Average value of Mean size of sediment is NT-1 1.792Ø (medium sand), through it varies from 0.755Ø to 2.382Ø (medium to fine sand). The Average value of mean size of sediment of NT- 2 is 0.7555Ø (coarse sand), NT-2 A is 1.421Ø (medium sand), NT-2B 1.532Ø (medium sand), and at NT3 is 2.622Ø (Fine sand). The relative values of mean size of terraces along the length of about 60 km. revealed that there is sharp and progressive decrease in MZ of sediment in down current of Narmada river. The behavior of MZ also suggests that sediment broadly follows the river bed slope, pointing to exponential longitudinal profile. Thus decrease in the MZ in Narmada downstream is result of decreases in load carrying capacity and current velocity.

Inclusive Graphic Standard Deviation (d)

It is measure of sorting, which reflects the consistency in the energy level of the depositing medium, Average value of standard deviation for Narmada river sediment is 0.822Ø (moderately sorted) and it ranges from 0.728Ø to 0.318Ø (moderately sorted). The value of standard deviation NT2-A upstream is 0.728Ø (moderately sorted) at NT-B is 0.563Ø (moderately sorted), NT2-C 0.436Ø (well sorted) NT-3 in the downstream is 0.318Ø (very well sorted). The relative values of standard deviation at different localities along the Narmada river. Thus indicate the steady improvement in sorting of sediments downstream.

The down current improvement of sorting of sediments appears to be inversely related with mean size which decreases down the current.

Inclusive Graphic Skewness (SKI)

It denotes the symmetry of grain size frequency distribution, symmetrical curves passes zero value, with excess fine material show positive value and those with excess coarse material have negative value. The average value of skewness of NT-1 is -2.646Ø (skewed negative), where as it varies from 0.625Ø to +3.22Ø i.e. (skewed very negative to skewed positive). The value of skewness NT-2 is 0.625Ø, (Skewed very negative) NT-2 A is 0.415Ø (skewed very negative) at NT-2B is +0287Ø (skewed positive) and NT-3 in down stream section is +0.322Ø (skewed very positive).

The relative values of skewness of various localities along the Narmada rivers indicate that sediments have strong tendency towards skewed positive down stream i.e. the sediments become finer skewed. The increasing positive values of skewness down current indicate low energy environment of sedimentation in lower middle part of Narmada

Graphic Kurtosis (KG)

It indicates the peakness of the curve. The lower values of Kurtosis (platykurtic), points to a broad peak, while high values of Kurtosis (leptokurtic), denotes pronounced peak in the centre. The average value of Kurtosis of Narmada sediments of NT-1 is 0.683 (platykurtic), whereas it varies from 0.526Ø to 0.821Ø (platykurtic to very platykurtic). The value of kurtosis is un stream NT2 is 0.785Ø (platykurtic), NT2-A 0.821Ø (platykurtic) NT-2B 0.685Ø (platykurtic), at NT-C is 0.610Ø (veryplatykurtic), NT-3(down stream suction) 0.526Ø (very platykurtic).

The relative values of kurtosis of various localities along the Narmada reveal that despite of little variation the KG values decrease down stream and show strong tendency of sediment to become platy kurtic to very platykurtic.

Statistical Parameters of the Sediments of Fluvialterraces of Dhadgaon Section

Mean Size (MZ)
The mean size of the sediments shows a wide range values form 0.55Ø (coarse sand) to 2.65Ø (fine sand) . The mean size of sediments corresponding to the different Quaternary surfaces NT1, NT2 & NT3 range between 0.935Ø (moderately course grained) to 2.55Ø (fine sand) and 0.65Ø (coarse grained) to 2.76Ø (fine sand) respectively.

Sorting Index
It is the measure of sorting, which reflects the consistency in the energy level of depositing medium. The sorting index of the sediments range from 0.625Ø to 2.167Ø i.e. moderately sorted to very well sorted. The sorting index corresponding to NT1, NT2 & NT3 ranges from 0.5890Ø to 1.578Ø, 1.0582Ø to 1.691Ø and 1.586 to 2.165Ø. The values suggest that the sediments are moderately to well sorted. The comparatively poor sorting of the sediments corresponding to surface may be due to lateral mixing of the sediments brought by subsequent stream.

Skewness (SKI)
It denotes the symmetry of grain size frequency distribution. The symmetrical curves possess zero value, with excess fine material show positive value and those with excess coarse material have negative value.

The skewness of the different surface shows positive values ranging form +0.308Ø to +1.721Ø. The sediments corresponding to NT1, NT2, NT3 surfaces show skewness values ranging from +0.350Ø to 1.722Ø, +0.510Ø to 1.41Ø and +0.308Ø to 0.785Ø respectively.

This indicates fluviatile origin.

Kurtosis (KG)
It indicates peak of the curve. The lower values of Kurtosis (platykurtic) points to a board peak, while high values of Kurtosis (Leptokurtic) denotes pronounced peak in the centre.

The Kurtosis of the sediments analyzed ranges between +0.308Ø to +1.721Ø. (Strongly leptokurtic). The Kurtosis values corresponding to NT1, NT2, NT3 surfaces ranges between 0.785Ø to 3.865Ø, 0.065Ø to 1.135Ø and 0.626Ø to 1.230Ø respectively. The above values suggest that the sediments are mesokurtic to strongly Leptokurtic in nature. The More than 50% of the samples corresponding to the surface are moderately to strongly leptokurtic and the rest are mesokurtic. About 25% of the samples corresponding to NT2 surface are Leptokurtic while rest are mesokurtic whereas 22% of the sample of NT3 surface are leptokurtic and rest are mesokurtic in nature.

The study of the sediment samples analyzed from the adjacent area reveals that the mean size of the sediments of the present day Narmada constantly decreases down the current whereas the sorting of sediment. The skewness show the tendency towards skewed positive and kurtosis indicates that the sediment of the domain become mesokurtic to Leptokurtic. Plate No_3 & Table No_ 4

Statistical Parameters of the Sediments of Fluvial Terraces of Rajpipla Section

Mean Size (MZ)
The value of mean size of sediment of NT1 is 1.87Ø where as ranges from 1.132Ø to 2.85Ø indicates that sediments are mainly medium grained sand with occasional fine grained sand. The point bar sands are mainly fine grained. The sediments of lower section of Quaternary deposits are o medium grained sand which is relatively coarser grained sand and associated with silt and clay. The mean size of sediments of NT2 of older alluvium sequence of varies from 1.95Ø to 2.92Ø with an average of 2.52Ø while the mean size of sediments of NT3 older alluvium varies from 1.7Ø to 2.95Ø with an average of 2.600 indicating that sediments are mainly composed of fine grained sand with little silt and clay..

Inclusive graphic standard deviation (d)
This is a measure of sorting which reflects the consistency in the energy level of the depositing medium. The upper sequence depicts inhomogenuity of sediments at places. The value of (d) in NT1, NT2, and NT3 sediments varies from 1.125Ø to 1.233 Ø where as it varies from 1.125 to 2.135. The sediments are moderately sorted to well sorted and sediments of lower sequence of quaternary deposits are moderately sorted. This suggests the homogenous nature of sediments transported & deposited under higher energy currents.

Inclusive graphic skewness (SK)
It denotes the symmetry of grain size frequency distribution. Symmetrical curve possess zero values while these with excess fine material show positive value and with excess coarse material show positive values and with excess coarse material negative values respectively. The sediments of older alluvium, younger alluvium and present day channel sediments in general have a tendency of slightly negative skewness. This indicates decline in energy condition of the channel system to wards late phases of sedimentation.

The average skewness values of NT1, NT2, and NT3 display is +0.308Ø which correspond to range values ranging from +0.350Ø to 1.723Ø, +0.510Ø to 1.415 Ø and +0.308Ø to 0.785Ø respectively. The sequence of quaternary sediments in this section depict association of heterogeneous matrix along the margin of valley and strong assorting which appears to be due to lateral mixing of sediments in the later stages of sedimentation .

Graphic Kurtosis (KG)
Graphic kurtosis indicates peakedness of the curve. Lower value of KG (Platy kurtic) point to a broad peak while high values of KG (Leptokurtic) marks a pronounced peak

The average value of kurtosis of terrace NT1 is 0.315 Ø (very platykurtic), it ranges between 0.213 Ø to 0.412 Ø (very platykurtic). Average value of kurtosis for terrace NT2 is 0.392Ø (very platykurtic), it varies from 0.233Ø to 0.545Ø (very platykurtic). Average value for terrace NT3 is 0.463Ø (very platykurtic) and it ranges from 0.345Ø to 0.535 Ø (very platykurtic). The value of KG in the lower and upper sequence is highly variable and sediments are from platykurtic to leptokurtic and very leptokurtic. The average value of KG in this sediment falls in the category of Leptokurtic. This value suggests fluctuations in the velocity of Narmada river during the sedimentation. Plate No_3 & Table No_ 5

Tatistical Parameters of the Sediments of Fluvialterraces of Tilakwarda _ Bharuch Section Narmada Valley

The under mentioned discussion of statistical parameters is based on the study of 25 sediment samples of fluvial terraces collected from Tilakwarda –Barouche section

Mean Size (MZ)
The average mean size for the sediments of fluvial terraces sediments of in this section is 0.2695 Ø (very coarse sand). It varies from -0.329 to 0.325Ø i.e. the sediments consist of very coarse sand to very fine sand. In this section except local variation around Tilakwarda (MZ) of sediment decrease down the current which appears to be related with the steep slope of valley.

Inclusive Graphic Standard Deviation (δ)
The average standard deviation of sediments of fluvial terraces sediments is 2.430 Ø (very poorly sorted). It varies from 0.521Ø to 3.272 Ø i.e. sediments in general are poorly sorted to moderately sorted Except little variation in sorting around Chandod the sorting of sediments show progressive and sharp improvement down the current.

Inclusive Graphic Skewness (SKI)
The average value of skewness is 0.188 Ø (positive skewed). It varies from -0.285 Ø to 0.248 Ø i.e. the sediments are negative skewed to positive skewed. In the down stream the skewness of sediments show strong fluctuation indicating that the sediments are both strongly fine skewed and coarse skewed. Down the stream of Tilakwarda significant increase in skewness value reveal the tendency of sediments to become fine skewed indicating decrease in transporting capacity of channel down the current in the valley.

Inclusive Graphic Kurtosis (KG)
The average value of kurtosis is 1.256 Ø (very leptokurtic). It varies from 0.546 Ø to 1.589 Ø (very leptokurtic to very platykurtic). The kurtosis value except variation upstream of Irni constantly decreases which indicate strong tendency of sediments to become platykurtic in nature down the current in the valley. Plate No_3 & Table No_ 6

6. Summary & Discussions

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- Barouche section. These terraces represent the former levels of valley floors formed by cumulative erosional and depositional activities of the river system.

The catchment area of the river, bordered by the Satpura and Vindhya Mountain Ranges, stretches over a territory of 98, 796 km2 (38, 145.3 sq mi). It is situated between longitudes 72°32' and 81°45' east and latitudes 21°20' to 23°45' north, on the northern edge of the Deccan Plateau. The catchment area encompasses important regions in Madhya Pradesh, Gujarat, and Maharashtra

The Narmada flows along tectonically active NSF which forms a fault controlled basin of a huge thickness of Tertiary and Quaternary sediments. The thick blanket of Quaternary sediments occurs in the central part of valley in Jabalpur –Harda section and in Harda– Bharouche section in lower of valley; where as in the other part in Harda –Mandleshwar section thin and isolated caps and strips of quaternary sediments are noticed on rock cut terraces and rock benches of country rocks. In Mandleshwar-Barwani, Dhadgaon- Tilakwarda the quaternary deposits are shallow to moderate in thickness and thin out to wards east. The isolated locus of accumulation and sedimentation along the entire length of 1300 kms of Narmada is controlled by the tectonics and structural frame work and sinking and uplift of fault bounded blocks and lineaments. It is well illustrated by neoseismic signatures and imprints on quaternary deposits and landscapes in the valley. The critical analysis of landscape profile evolution of drainage, quaternary terraces, river morphology and analysis of bore hole data of basement configuration of rock and quaternary deposits revealed that Harda-Bharouchevalley segment suffered mega cyclic incision as compared to the adjoining blocks and created and formed open rock basin and platform of quaternary sedimentation. The quaternary deposits bear well preserved imprints of neotectonisam indicating that the Sonata lineament zone seismically is active and has direct bearing on quaternary landscape of rift valley. The Harda –Mandleshwar section predominenently portrays the sequence of cyclic and noncyclical rock cut terraces and rock cut platform and benches which are time equivalent to the quaternary terraces of central and lower Narmada valley Khan et.al (2014). In Mandleshwar-Barwani the quaternary sediment are of moderate to shallow in thickness which are incised along with the country rock by cyclic structural dislocation and tectonic activity along ENE WSW lineament fabrics and dynamic incision of stream. It is well documented in quaternary terraces and composite erosional terraces; rock cut terraces caped by quaternary sediments, river profile and channel morphology. The morphogenetic expression of the section revealed uplift of block.

The 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.

In the area of study in lower Narmada between Gurudeshwar –Baruche section 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 units (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). 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 boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The boulder conglomerate is being of middle Pleistocene age.

The Quaternary blanket 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 asymmetric trench consist of sediments of various domains viz glacial, fluvio-glacial, fluvial, and lacustrine. 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. Khan et.al (2015), Khan et.al (2016)

In Harda _Bharouche section 180 sediment samples collected from Quaternary deposits of Narmada (NT1_NT3) they are analysed and their statistical parameters are studied in the type locality around Punasa, Mandleshwar, Khalghat, Barwaha, Barwaha-Barwani, Dhadgaon, Rajpipla, Tilakwarda and Bharouche sections.The NT1 as being the lowest terrace and NT3 is the oldest and highest terrace in Narmada valley. These terraces constitute complete sequence of sediments of fluvial domain measuring about 85 mts deposited in the Narmada during the different phases of sedimentation in Quaternary period.

The average value of mean size (MZ) of terrace NT1 is 2.615Ø (fine sand), and it ranges from 1.475Ø to 3.146Ø (medium sand to very fine sand). Average value of mean size of terrace NT2 is 1.885Ø (medium sand) and it varies from -0.432Ø to 2.351Ø (very coarse to fine sand). Average value of mean size of terrace NT3 is 1.820 (medium sand) and it ranges from -0.535Ø to 2.565Ø (very coarse to very fine sand).The average and range values of mean sizes of terrace NT1 to NT3 revealed that the terrace chiefly consist of fine sand, whereas the terrace NT2 to NT3 pre-dominantly medium sand. The range values of mean size indicate that the younger terrace comprised of medium to fine sand, whereas the older very coarse to very fine sand. The association of sediments with various terraces NT1 to NT3 show progressive upward fines of sediments, typical of fluvitile environment and suggest constant decrease in load carrying capacity of the channel from early to late history of sedimentation. The variation in mean size as reveal by the relative range of sediments appears to be due to fluctuation in the energy condition of the channel during sedimentation.

The average value of standard deviation **(δ)** for terrace NT1 is 0.295Ø (very well sorted) and it ranges from 0.232Ø to 0.410Ø (well sorted NT2 is 0.279Ø (very well sorted), it varies from 0.246Ø to 0.435Ø (well sorted to very well sorted). Average standard deviation for NT3 is 0.355Ø (well sorted) and varies from 0.258Ø to 0.435Ø (well sorted to very well sorted).The average and relative range value of standard deviation of terrace NT1 to NT3 indicate that as a whole the sediments are well sorted to very sorted. The values of standard deviation decreases towards younger terraces NT3 to NT1 indicating improvement in sorting of sediments. This appears to be related to mean size, which decreasing antiquity and is inversely related with standard deviation, (Khan, 1985).

The average value of skewness (SKI) of terrace NT1 is +0.335Ø (very positive skewed), it varies from -0.450Ø to 0.560Ø (very negative skewed to very positive skewed), for terrace NT2 average value is +0.453Ø (very positive skewed) and it ranges from -.0652Ø to +0.622Ø (very negative skewed to very positive skewed), for terrace NT3 average value -0.255Ø (negative skewed), and it varies from 0.640Ø to 0.350Ø (positive skewed to very positive skewed). The relative average value of skewness of terrace sediments indicates that the sediments of NT3 are negative skewed and NT2 and NT1 are positive skewed. The relative range of skewness suggest that the sediments are very negative to very positive skewed. The negative skewness suggests the higher energy environments, whereas the positive skewness low energy environment. As a whole relative average and range values of standard deviation revealed the strong tendency of the sediments to become positively skewed in increasing antiquity of terraces, thereby revealing decreasing in load carrying capacity of channel system towards the formation of younger terraces.

The average value of Kurtosis (KG) of terrace NT1 is 0.310Ø (very platykurtic), it ranges between 0.215Ø to 0.416Ø (very platykurtic). Average value of kurtosis for terrace NT2 is 0.392Ø (very platykurtic), it varies from 0.230Ø to 0.547Ø (very platykurtic). Average value for terrace NT3 is 0.466Ø (very platykurtic) and it ranges from 0.345Ø to 0.554Ø (very platykurtic).The distribution of average values and relative range of kurtosis of terraces NT1 to NT3 reveal the pre-dominantly very platykurtic nature of sediments. The kurtosis values constantly decreases upwards, which indicate that the sediments were mainly derived from single source inferred to be from Vindhyan and Basaltic rocks, (Khan 1957)

The critical study of statistical of parameters their inter, intra and binary relation revealed that relative average and range values of mean size indicate that the younger terraces NT-1 to NT-3 predominantly consist of medium to fine sand and older terraces NT-2 to NT-3, very coarse to very fine sand. The mean size constantly decrease from NT-3 to NT-1 except little variation; which is indicative of constant decrease in load carrying capacity and current velocity of channel towards the late history of sedimentation. The variations in mean size suggest fluctuation in the energy condition of channel during sedimentation. The sediments of (NT3 to NT1) show improvement in sorting upward, the decreasing value of sorting coefficient towards younger terraces which may be related with, mean size of sediments, load carrying capacity of channel and static environment of sedimentation perhaps due to less turbulent nature of channel towards the latter phases of sedimentation in the valley. The sediments of older terraces viz. NT-2, NT2A, NT2B, – NT3-A are strongly negative skewed whereas the sediments of younger terraces are strongly positive skewed, the negative skewness is considered due to higher energy environment, whereas the positive of low energy environment. Average value of skewness progressively increases in decreasing antiquity, i.e. from older terraces NT3 to younger terrace NT-1 which reveal the strong tendency of sediments to become from negative skewed to positive skewed, thereby indicating steady decrease in energy condition of Narmada towards the latter stages of sedimentation. The sediments of older terraces viz. NT-3 and NT-2 display the higher values of Kurtosis, whereas the younger terraces NT-0 to NT-1 the lower values which reveal mesocratic to very platykurtic nature of the sediments respectively. The values decrease in increasing antiquity whereas the relative average values in older terraces reveals the sediments were primarily derived from more than the single source.

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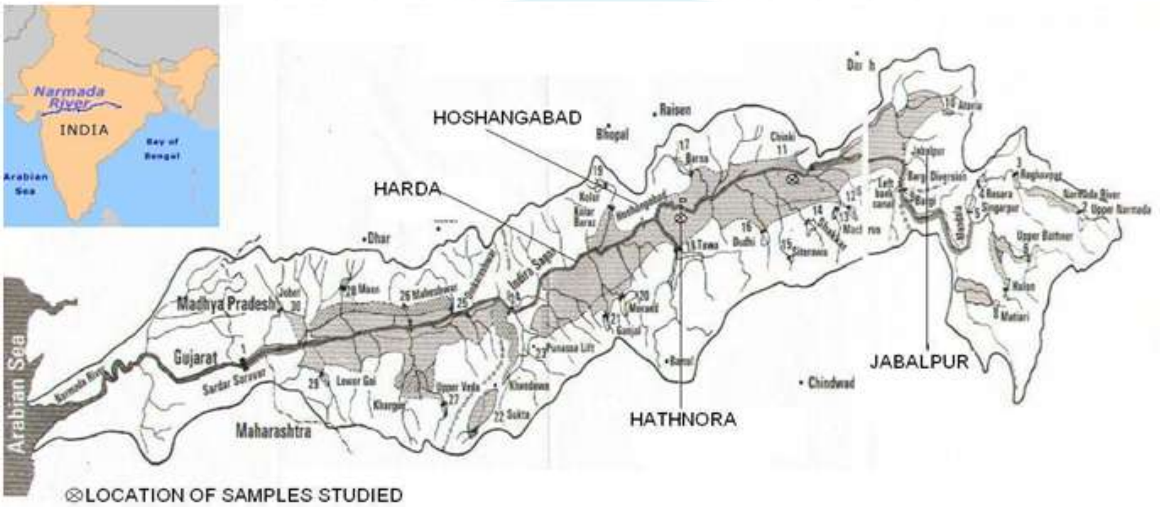
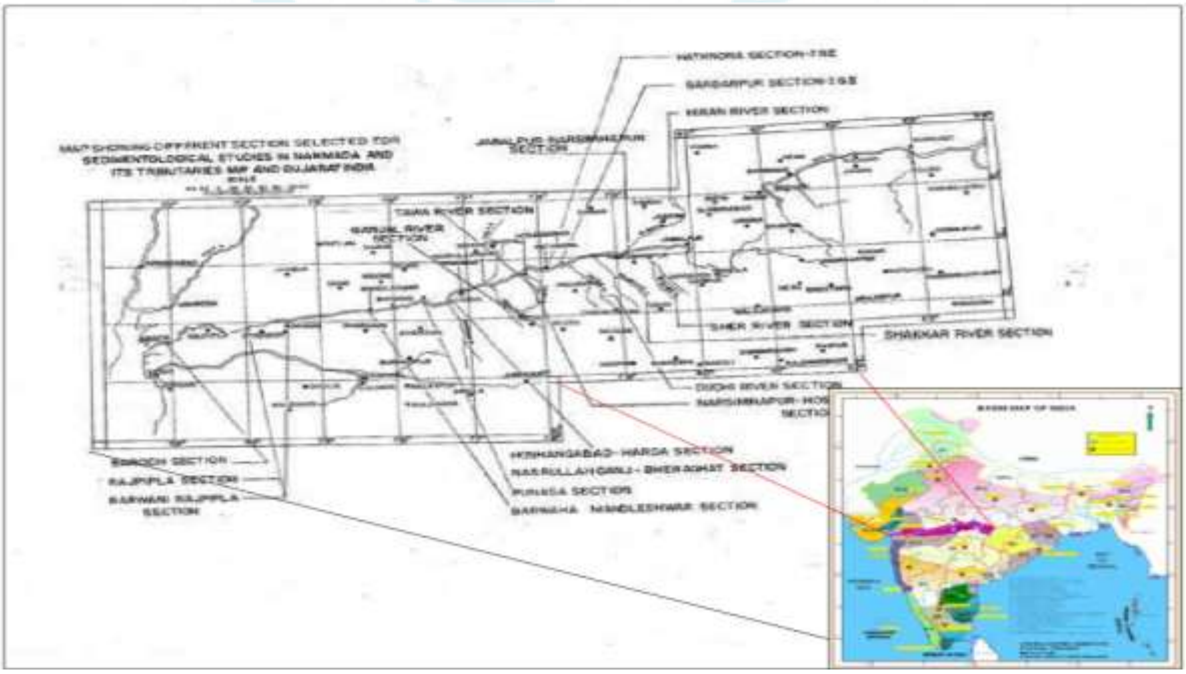


Plate No. 1



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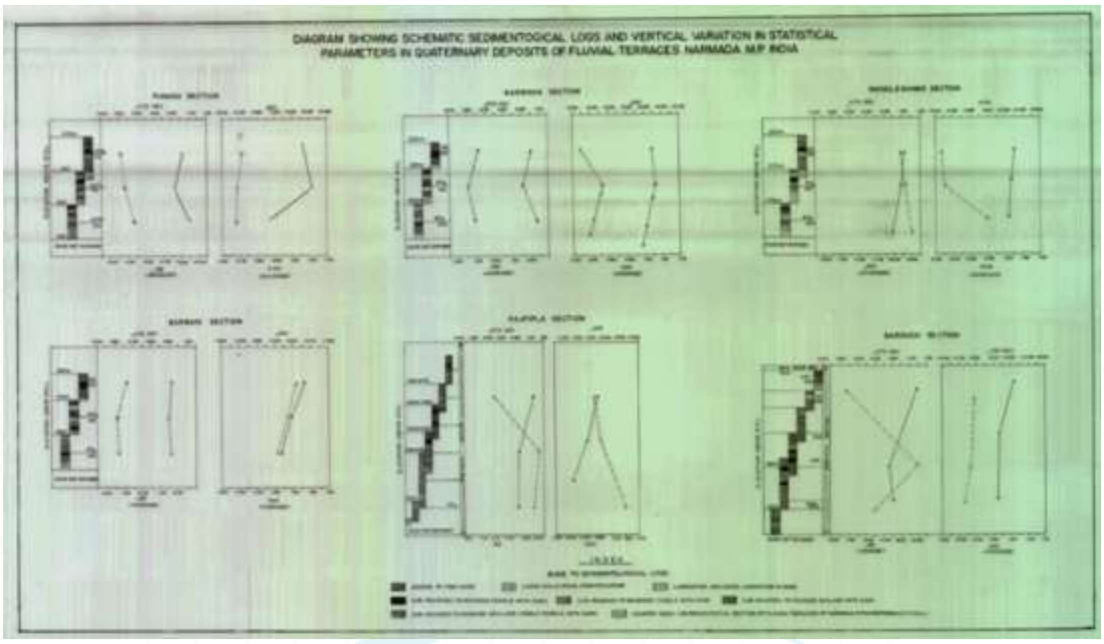

Plate No. 3

Table 1: Statistical Parameters of Fluvial Terraces of Narmada in Punasa Section

Terrace and its Designation	Mean Size (MZ)		Standard Deviation (D)		Skewness (SKI)		Kurtosis (KG)	
	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)
Narmada Terrace NT_1	2.615	1.475 to 3.146	0.295	0.232 to 0.410	0.335	-0.450 to 0.560	0.310	0.215 to 0.416
Narmada Terrace NT_2	1.885	-0.432 to 2.351	0.279	0.246 to 0.435	0.453	-0.652 to 0.622	0.392	0.23 to 0.547
Terrace NT_3	1.820	-0.535 to 2.565	0.355	0.258 to 0.435	-0.255	0.640 to 0.350	0.466	0.345 to 0.554

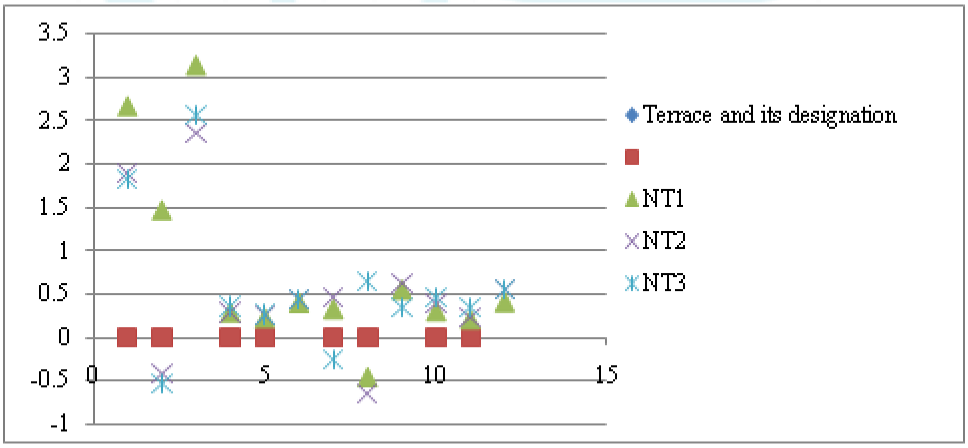

Table 2: Statistical Parameters of Fluvial Terraces of Narmada in Mandleshwar- Khalghat-Barwani Section

Terrace and its Designation	Mean Size (MZ)		Standard Deviation (D)		Skewness (SKI)		Kurtosis (KG)	
	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)
Narmada Terrace NT_1	1.792	0.755 to 2.382	0.822	0.728 to 0.318	-2.646	0.625 to 3.22	0.983	0.526 to 0.821
Narmada Terrace NT_2	0.755	1.421 to 2.532	0.728	0.625 to 0.885	0.625	0.325 to 0.28	0.785	0.525 to 0.910
Narmada Terrace NT_3	2.622	1.325 to 3.220	0.563	0.315 to 0.625	0.322	0.275 to 0.525	0.821	0.625 to 0.990

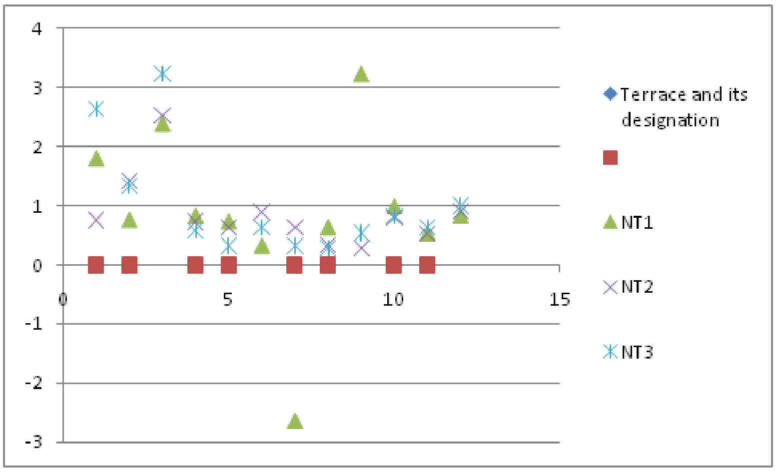

Table 3: Statistical Parameters of Fluvial Terraces of Narmada in Barwaha Section

Terrace and its Designation	Mean Size (MZ)		Standard Deviation (D)		Skewness (SKI)		Kurtosis (KG)	
	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)
Narmada Terrace NT_1, NT_2, NT_3	0.552Ø	0.65Ø to 2.75Ø	1.45 Ø	0.62Ø to 2.167Ø	+0.496Ø	0.62Ø to 2.167Ø +	0.885 Ø	0.626Ø to 3.864Ø

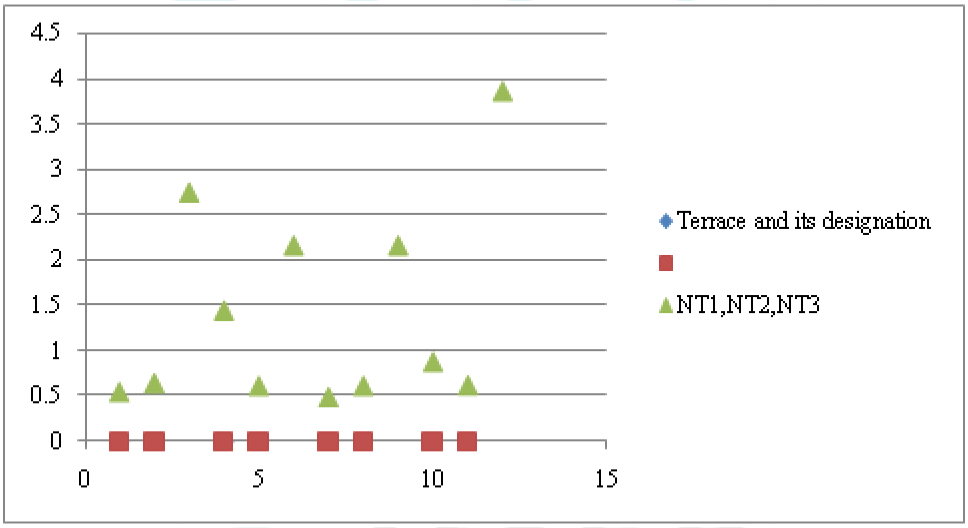

Table 4: Statistical Parameters of Fluvial Terraces of Narmada Dhadgaon Section

Terrace and its Designation	Mean Size (MZ)		Standard Deviation (D)		Skewness (SKI)		Kurtosis (KG)	
	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)
Narmada Terrace NT_1, NT_2, NT_3	0.55Ø	2.55Ø (fine sand) and 0.65Ø	0.822	0.625Ø to 2.167Ø	-2.646	+0.308Ø to +1.721Ø.	0.983	+0.308Ø to +1.721Ø.

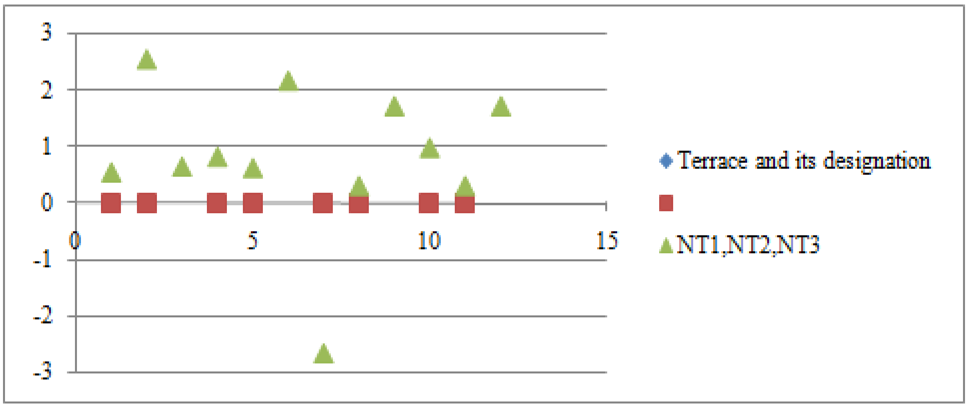

Table 5: Statistical Parameters of Fluvial Terraces of Narmada in Rajpipla Section

Terrace and its Designation	Mean Size (MZ)		Standard Deviation (D)		Skewness (SKI)		Kurtosis (KG)	
	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)
Narmada Terrace NT_1, NT_2, NT_3	1.87Ø	1.132Ø to 2.85Ø	0.310	1.125 to 2.135.	2.32	+0.510Ø to 1.415 Ø	0.181	0.213 Ø to 0.412 Ø

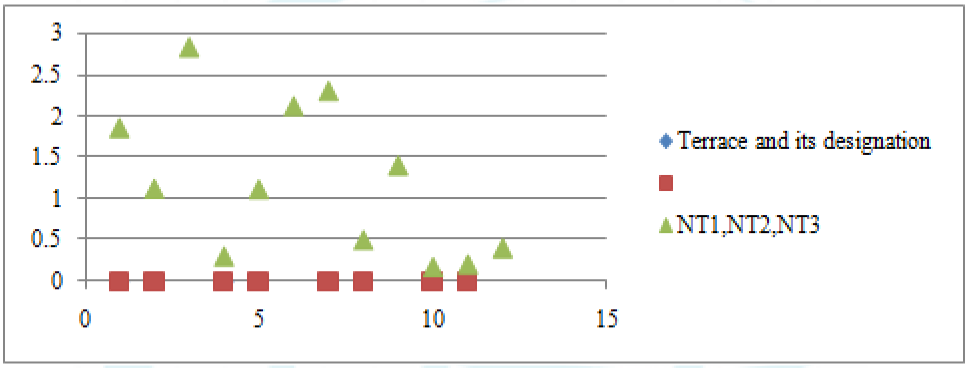

Table 6: Statistical Parameters of Fluvial Terraces of Narmada Bharouche Section

Terrace and its Designation	Mean Size (MZ)		Standard Deviation (D)		Skewness (SKI)		Kurtosis (KG)	
	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)	Average (Ø)	Range (Ø)
Narmada Terrace NT_1, NT_2, NT_3	0.2695 Ø	-0.329 to 0.325Ø	2.430 Ø	0.521Ø to 3.272 Ø.	0.188 Ø	-0.285 Ø to 0.248 Ø	1.256 Ø	0.546 Ø to 1.589 Ø