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STUDY OF GEOMORPHOLOGY, FLUVIAL PROCESSES AND QUATERNARY TECTONICS IN THE AREA AROUND NARMADA AND TAPTI RIVER IN PARTS OF BROACH AND SURAT DISTRICTS .GUJARAT

(Progress Report for field season 1973-74)

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ABSTRACT

An area of 2,000 sq.km was covered with 300 sq.km between Broach and Alia bet in Narmada valley (forming parts of Broach district falling in toposheet NGs. 46C/10 and M) and 1,700 sq.km between Ukai and Kadia bet in Tapti valley (foiling parts of Surat district and falling in toposheet Kos. 46G/3, 4, 7, 8, 11, 12 and 46G/12, 15 and 16).

Between Broach and Alia bet Narmada forms a sixth order basin with a stream density of 0.9 km per sq.km. The braided channel continues upto Bharabhut where it splits in to two distributaries encircling Alia bet, the deltaic island. the braided portion, river has changed its course several times thereby changing the position of braid bars and islands. The Alia bet has grown in size from 19 x 2.0 sq.km in 1894 to 25.0 x 19.0 sq.km in 1968-69. This growth is resulted by intensive bank cutting and accretion of sediments at the peripheries of island at the times of floods. The flood- plains are of composite nature characterised by a terraced landscape with two distinct terrace levels and both aggragadational and degiadational features. Topographic features like two terrace levels, anasto-motic streams, stream captures, convexities in the longitudinal profiles of river bed and terraces and structural features like rectangular and angulate drainage, tilted terrace vloaks and occurrence of Broach earthquake in March, 1970 collectively indicate that the area has been undergoing a dynamic rejuvenation and is still tectonically unstable.

Tapti also flows through an almost, E-W series of parallel fissures in Cambay graben. This E-W trend is southern extension of

Narmada trend. Tapti has incised its channel into Deccan Traps and Ttertiary sediments before entering the alluvial zone.

From Ukai to Kadia bet it forms a seventh order basin with a stream density of 1.4 km per sq.km. The single channel flows of Tapti and its tributaries have laid down a composite flood plain which is broader in north than south of Tapti. The channel flows through straight, meandering and braided patterns before entering in to deltaic zone. The meanders are asymmetrical and incompletely developed. Flood plain is having a terraced landscape with both depositional and erosional features. Upper terrace is persistant as compared to lower terrace. Daltaic island, Kadia bet, has been growing in size at the expense of adjacent banks. The topographic and structural features found in the area collectively indicate that the area has been undergoing a dynamic rejuvenation and the uplift is taking place till present times.

STUDY OF GEOMORPHOLOGY, FLUVIAL PROCESSES AND QUATERNARY TECTONICS IN THE AREA AROUND (WEST OF BROACH) IN PARTS OP BROACH DIST., AND AROUND TAPTI IN PARTS OF SURATT DISTRICT OF GUJARAT.

(Progress Report for Field Season 1973-74)

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I. INTRODUCTION

Under a long form programme of study of geomorphology, fluvial processes, and Quaternary tectonics in the area between Sabarmati and Tapti river (Background report by Y.G.K. Murty and N.Bedi, January'73) in Gujarat the work was continued during field Season 1973-74 also. Two areas around Narmada and Tapti were studied in persuance of item No.4,code CM/16 shown on page No. 327 of the Annexure of proposals for annual programme of G.S.I. for 1973-74.

1) Narmada area: The area around Narmada between Kavagem and Broach-Ankleshwar was covered during Field Season 1972-73, therefore during this, field season an area of about 300 sq.km bound by latitude 21°25' to 21°45' , and longitude 72°45' to 73°00' , downstream to Broach-Ankleshwar up to Hansot-Aliabet Bharbhut was studied on aerial photos and by field work. Western portions of,

Aliabot and surroundings were studied on serial photos only. Area covered forms parts of Broach, Ankleshwar, Dabej and Hansot thaluks of Broaoh district falling in toposheet Nos. 46C/10 and 46C/14.

2)Tapti area: Free Ukai to Dumas-Kadia bet-Maziza, an area of about 1,700 sq.km bound by lat. 21˚05' to 21°20’ and long. 72°38’ to 73°37’ on both sides of Tapti river was covered. For morphometric analysis the whole Tapti basin downstream to Ukai was considered. It forms parts of Vyara, Mandvi, Bardoli, Kamrej and Chourasi taluks of SuraA district falling in toposheet Nos. 46G/3,

7, 8, 11, 12 and 46C/12, 15, 16. Area upstream to Ukai could not be studied as it is submerged under wservoir water of Ukai dam. Similarly the whole Tapti channel between Ukai and Kakarapar is under reservoir water of Kakarapar barrage, therefore channel features in this part also could not be studied,

A broad approach to study included thorough scanning of toposheet and aerial photos to acquinee an idea about salient fluvial-morphologica1 and tectonic features. Field work was later carried out on the basic of above.

As the area around Tapti is characterised by a rolling topography in contarst to surroundings of Narmada, the correlation between the two areas with respect to structural disposition could not be done. Therefore, a general study of morphology and tectonics of Deccan Trap terrain south of Tapti in Dangs district falling in toposheet No. 46H/9, 10 was also undertaken.

Field work was carried out under the guidance of S/Shri J Narayana Murthy and A.S.Ramiengar, Directors, G.S.I. In Bangs district, studies wore conducted in association with S/Shri B.K. Mohanty, Geologist and A.K. Ray, Asstt. Geologist G.S.I.

COMMUNICATION: Both the areas can be reached from Ahmedabad by road as well as railway route. National highway No. 8, connecting Bombay-Baroda-Delhi passes through the areas. Broad gauge routes of Western Railway connecting Bombay-Baroda-Delhi and Ahmedabad-Baroda-Delhi also passes through the areas. Hansot and Dahej are cennected to district headquarter Broach by state highways. Most of the villages in these talukas are connected by fair weather roads.

Apart from Surat, other main towns on the banks of Tapti are Mandvi. Kalod, Kamrej, Kathor and Dumas. Surat is 21 km west of National. Highway No.6 which passes through Kathor and Kathodra. All the taluka headquaters are

connected to surat by State highways and at the same time several other motorable roads rediata these towns towards villages. Surat-Bhusawal highway as well as broad gauge route of Tapti-valley Railway (Western Railway) pass through Bardoli Vyara and Songadh.

In the downstream stretches of both Narmada and Tapti ferry service is also there to cross the rivers.

Climate: Western parts of Broach experience a dry-hot climate from October to May and from June to September westerlies bring in rains. Temperature rises upto 106°P during summer conths of May and June and goes down to 45°F during winter months, especially in January. Average dizumal variation in temperature is 36°F (during November it goes upto 40˚F also) .July is the month having maximum rain with 98% of annual rainfall coming during June to September. Average rainfall of Broach district is 36.7". Rainfall increases from West to east as seen from the following avenge rainfalls of these towns:-

Hansot (Western most) =31.45"

Ankleshwar (middle one)=36.88".

Rajpipla (Fastern most)- 37.70"

From October to December, heavy due formation takes place. The relative humidity varies from 20% during November to March, to 90% during monsoon months. Area is swept by easterly and northerly Survace winds during Novembers-December and January-February respectively. Whereas southerlies low over the area during March to May giving place to westerlies during June to September which set in monsoon.

Surat district experiences four types of weathers viz., i) Winters during November to February, ii) Summer from March to Hay, iii) Monsoon (during Juno to September and iv) October being a tranaition month.

Winter is characterised bv clear sky, "light westerly sea braase in the afternoon and cole nights when the minimum temperature falls even up to 40°F during January. April and may have the highest temperature rising upto 114°F. Diumal variation of temperature is maximum, 30˚F during winter months and least, 10°F during July and. August. Average annual rainfall of Surat district is 57 Period between: June and October gets 98% of total rainfall with July being the month of maximum rain fall. The precipitation measures from west to east and north to south, Olpad being in extreme north-west gets 35.66” of rainfall compared to Dharampur in south-east, which gets 94.87” of rainftall, Relative humidity varies from 10% during winters, to 85% in rainy season.

Torrentical rainfalls associated with depression often cause severe floods both in Narmada and Tapti, inflicting heavy losses to communication, standing crops and inhabitations.

HISTORICAL SKETCH OF NAVIGATION IN NARMADA AND TAPTI

It is worthwhile to give it bried account of navigable conditions which prevailed in Narmada and Tapti during past as they throw some light on the rate of silting and fluvial processes of these rivers.

NAVIGATION IN NARMADA : Breech has been one of the seats of trade between Indian and Western Asian markets (Periplus, A.D.75). Broach was connected to southern Arabia and Egypt by as a routes through which large quantities of Indian produce were exported. Ships also used to ply between Broach and Malabar, Geylon etc. In the seventeenth centaury, ships sailed to Java and Sumatra also. A traveller Mandelslo visited Broach in 1638 and wrote "Vessels from Surat, Broach and Cambay leave Gujarat in January and February for Persian Gulf and return in Later duo to silting the stretch between Narmada's mouth and Broach became unnavigable therefore shipping was curtailed.

NAVIGATION IN TAPTI: In 1876, navigation in Tapti was confined to the last twenty miles (32 km.) . The Dumas channel was the deepest and generally used by ships. In 1774 the ships of considerable size could go as far as up to Surat. Ships of 144 t0 180 tone used to go upto Surat in 1865. Afterwarde the channel has been getting filled up by silt and sand due to heavy glooda, as about 13 floods of tremendous severity have been recorded within the period of 1727 to 1876 and 18 severge floods have been recorded during the period from 1876 to 1970

.

These days a small Port has been established near Magdala on the left bank of Tapti and downstream to Surat. Here vessels of lesser capacities another during high tides and unload the cargoes.

PREVIOUS WORK: In the Memoir of G.S.I., Vol.6, part 3 on the Geology of Taptee and Narmada Valleys" W.T. Blandford has described the older alluvium and salient geomorphic features of the area, Later in A namual of Geology" Vol.11 and III, E.M.Paecoe gave an account of Geology of Narmada and Tap tee Valleys under the alluvial plains of Gujarat. O.N.G.C.has worked out a detailed stratigraphic sequence of the area between Broach and Surat. G.S.I has also conducted systematic mapping in parts of Breach district bringing oat certain conspicuous tectonic features Work carried out by G,S.I. and O.N,G.C. in connection with Broach earthquake of March, 1970 highlighted the general tectonic disposition of the area. During field season 1973-73, the author worked in the Upper reaches of Narmada basin in Gujarat in connection with the study of Jovial Morphology, processes and Quaternary tectonics.

II. NARMADA AREA

GEOLOGICAL SETTING: Details of the geological set up and formations of Narmada rift have been discussed if the progress report for field sea son 1972-73, in which moot of the Narmada area in Gujarat has been covered. However a composite stratigraphic sequence is given below:

Helocene	Sub-Re cent	Alluvium, blown sand I and soil etc, I
	Recent	Older allutium |Necgene

Quaternary)	Pleistocene	Agate Cogloaerate I (Ratanpur) I
Tertiary	Pliocene	Sandstone and clay stone (Broach)
	Miocene	Sandstone (Jhagadia, Ferruginous sandstone and conglomerate (Babaguru)
	Oligocene	Shale (Ankleshwar)
	Eocene	Black shale(Gambay)
	Palaeocene	Vagad Khor/Olpad formation.
Late Cretaceous to Eocene		Deccan Traps — Late Mesozoic to earlier Palaeogene
Middle to Upper Cretaceous		Bagh veds ——Mesozoic
	-Unconformity -	
Pre-Cambrian	- Metamorphics	- Proterozoic

Narmada rift in Gujarat forms a separate with in the Gambay graben Initial line of weakness along Narmada existed since Pre-Gondwana period and during Deccan Trap eruptions fracturing was intensified which continued till Post-Deccan Trap period. Due to this fracturing +ve and -ve zone a were created in which sedimentation took place pari-passu with tectonic movements till late Plaistocene . Older alluvium was deposited by Narmada and its tributaries during Quaternary and Holocene periods. Since then both endoganic

processes, like tectonic movements, and exogenic prosses like aggradation and degradation have been operating and causing the evolution of landscape. Majority of the geomorphic forms found in the area are manirestations of endogenic and exogenic processes.

III. GEOMORPHOLOGY AND FLUVIAL PROVESSES

From west of Broach Narmada flood plain approaches the coastal plain. Near Hansot it merges into tidal mud flats and beyond Hansot-Bharbhut line deltaic or esturinge zone of Narmada starts. Alia-bet occupies the deltaic ares, Namada flood plain is wide en on both side and is characterised by ciulticyclio terraced landscape developed by the various endogenic and exogenic agenciea. Narmada with its single channel flow has got Bhukti-Bhadar river, flowing in from north, as the only important tributary in the region. Geomorphology and the fluvial characteristics are discussed under the following.

1) MORPHOMETRIC ANALYSIS:

The degree of dissection in this part is comparatively less as compared to the upstream region, Horton's analysis of the drainage net work was carried out on toposheet Nos. 46C/10 and 14 m scale 1:63,360, In this part also Narmada forms a 6th order basin, itself being 6th order stroan, Morphometric details are given as below:-

Stream Order ,	No. of stream	Bifuroation ratio	Channel length	Total area	Representative Stream
-R-	-N-	-rb-	-L-(km)	-Ad-	
1	221	4.3	238.40		
2	51	5.6	112.80		
	9	9.0	58.40	445 sq.km.	

	1	1.0	24.00	
5	-	-	-	
6	1	-	11.20	Narmada
Total	288	Average rb upto 6th order=3.4	L 444.80	

The above details give the following relation also:-

Order	Average length of stream. - L - (km.)	Length Ratio re = L2/L1
1	1.08	
2	2.20	2.0
3	6.50	2.9
4	24.00	3.7
5		
6	11.20	

The plots of stream orders against their number and lenghts on a semilogarithmic paper are straight lines which confirm to the Horton's analysis of a standard basin (Plate -II). The average value of bifurcation ratio is 3.4 which is again within the standard limits of 2 to 4 obtained by Strahler.

Denisty and Texture

Average distance between two Adjacent channels will be 445/444 .PG

or 1.0 km.

Length of overlaid flow is half of the average distance between two streams or 0.5 km,

1.0 km of average distance between two streams indicates a low degree of distraction or an open texture.

2) CHANNEL FORM AND PROCESSES:-

Narmada and its trivutaries exhibit sinuoua, braided .and meandering channel pattern, Quantitative details in reject of Narmada channel are given below:-

l) Narmada Channel:- The length between Gora and shuklatirth is occupied by sinuous or straight and meandering channels. At Shulkatirth (14 km, Nr. valley, upstream. of Broach) braided channel starts and goes up to Bharbhn where it splits in to two major distributaries surrounding Alia bet before joining the Gulf of Cambay.

Between Broach and Bharbhut a straight down galley length of Nr km is traversed by 21.5 km of braided channel thereby having the timing. - down valley ratio equal to 1.13 (This ratio for total braided Nr Shukathirth to Bharbhut is 1.23), Ratio between undivided Nr. width and the sun of total widths of all Nr. is 1.3.

In Centreat to thre fairly stabilised islands between Shuklatirth and Broach, the island bars between Broach and Bharbhut are not 80 much stabilised. This has been inferred from the comparision of maps of the area prepared during 1894 (l" - 4 sailer), in 1947-48 Nr. and recent aerial photographs (1;30,000 and Nr.) has been shifted at certain places while at die place new channel has been farmed it the cost of

abandoning the old one. In figd of plats No. III (Degree-sheet 46C) are shown five island bars with two villages; Nr. located an the big is island. Fig, II of the same plate (Toposheet 1947-48) .shown variation in the number as well as size of these islands, Area of big island seems to have been reduced considerably and e.t the same time two villages located on it have been shifted to the left bank, From the aerial photos and field work it was however, found, fig. III of Plate III, that the configuration of these islands/bars has been further altered, The southern most sinusoidal anabranch, north of Sakarpur Bhata has completely been avandoned and two narrow and shallow channels left its place which regain dry mostly but get water during high floods. Two bars have been wiped out as the present channel was engraved into one of these, West of it the overall channel has been widened. Villages of Tapti and Bhanturia were wiped out, Koyali- Dhanturia was resettled further south in 1967 where as Tapti was completely scourged out in 1968, Present left bank runs through the southern extremity of Tapti village (Plate No„ z) ,

A new bar of 2,5 km length has been formed further The big island has grown in size from Nr. The enlargement and stabilization of islands indicates the occurrence of high floods with considerable lead and sufficiently pyodeablc or low threshold ture of banks, the bank cutting is reserve on both sides comparatively.it is more in south than in north. Greater incision and shifts in the channel are perhaps due to-a sudden increase in gradient, downstream of Broach as the ratio of gradients for 12 km upstream of Broach and 12 km downstream is 2,4.

ii) Longitudinal profile of Narmada channel between Broach and Bharbhut:

longitudinal profine (plate Nr. stows complete Nr) was drawn with respect of winter water level in channel. Nr. of the considered points were determined by substracting respective sedition thickness from the bank top Nr. at that point.

General shape of the profile in this section is concave upwards with a minor convexity between Han ho t and Bharbhut, The profile for 6 km length between Broach and pungam is lees steep (elegation fall of 1 m in 6 km) that the downstream stretch of 6 1m between Pungam and Koyali-Dhanturia elegation fall of 1,4 m in 6 km . After Koyali-Dhanturia the Nr. becomes gentler. Formation of this alight depression feuilitated the deposition of sediments in this portion h«ncj the formation of broad bore and islands. Generally the Nr. decreases stream, but

in a few sections patches of Nr. been observed both at surface and sub-surface. Since there is no apparent increase in grain size in the vicinity of convexity the latter appear to have been formed due-to tectonic causes, Similar convexities rave also been Nr. in the corresponding portions of alluvial terrace profit (Plate No. IV) and can be attributed to upwarping. Profiles of Narmada channel and its alluvial terreces converge downstream.

lit) Drainage patterns : Various drainage patterns developed in an Area substantiate the interpretation of geomorphology and understanding of land from evolution under the control of lithological and structural factors. Important drainage patterns ovserved on both sides of Narmada are given below:-

a)Recrangulate pattern: These are very conspicuous in their outline west of Bharbhut and south-west of Diva.

b)Off-set drainage North-east of Ankleshwar a stream flowing south to north shows left lateral off-set for a fiarly long distance before assuming its original direction of flow to north.

c) Anastomotic drainage: North of Shakarpur-bhata 0.75 km wide Narmada braid anabranche has been abandoned leaving two narrow channel sears in its place.

d)Captured and nearly developed drainage: Between Pungam and Haripura strew: with southerly flow into Amlaknadi has been captured near Shakarpur-Bhata and part of it now flows into a newly developed stream channel north of Shakarpur Bhata. Similarly a few more new streams hive developed north-west of Diva.

e)Yazoo stream ; Atatla Ahadi in south and three major streams in north flow

parallel to Narmada before joining it or some other stream, between Pungam and west of Haripura, Amla Ahadi exhibits a marked similarity in channel configuration to Narmada channel,

FLUVIAL MORPHOLOGY AND ASSOCIATED DEPOSITS:

Narmada has forced a single channel composite flood plain by the combination of fluvial aggradational and degiedationalprocesses. During flood periods in the months- of July September, when water crosses bankful stage and spreads overbank. 30 Movement of water is controlled by local f gradient and other impediments, Nr. results where load increases and gradient decreases. Increase in velocity causes scour. Flood plain features found are described Nr.

a)Stream channel features,

b)Covered flood plain features.

c) Alluvial traces

d) Deltaic and associated features

a) Stream channel features:

1) Braid bars and islands Sand bars are progressively deposited throught the channel, however, except a few big ones, every year floods change their position Sand bars grow into islands with progressive enalrgement and stabilisation West of Kukarwara-Shakarpur Bhata there are four send bars and one island of nr. diamond to lens shape disposed in an Nr. pattern along the river channel. They constitute alternate layers of sand and silt. But for their central portions they get submerged during high floods. Central part of the island is partly vegetated and is being cultivated during dry periods. Extension of younger vegetal growth towards downstream portions of island indicate that bars and islands grow in size due to accretion of sediments at the lateral and downstream peripheries. Material removed from the adjacent banks is deposited at the island peripheries by reflecting waves.

ii) Channel sears/Abandoned channels: North of Shakarpur Bhata a major anabranch of Narmada has completely been abandoned and in its place three channel scare are left. These are vide and 1.5 to 2.0 m deep channels

which retain water at the ends near their confluence with main-Narmada channel.

They however got filled w during floods and very high tides. The interchannel acar areas are covered by sand and dultivated during dry periods.

iii) Soour Routes : West of koyali-Dhanturia, near the bank the are several shallow longitudinal depressions interagersed ,with

sandy mutngopka. Both depressions Land humlocks are oriented in to N70°E- directions. Depressions have been formed due to -scouring during flood times, hence called scour routes, These are 2 to 3 m wide and 1 to 2 m deep.

iv) Back cut-off: Both bonks are subjected to intensive bank cutting Removal of material takes place by sloughing as well as scooping and stumping. Sloughing takes place where bank material is non-cohesive and of low threshold nature. Scooping is cone by water eddies at the bottom of bank soarp and due to this removal of bottom support upper haging column alumns down. (Photo No.4) Due to sluicing longitudinal crevasses art created at the bank tops which further facilitate the slumping.

y) Sand Splays:On the south of Narmada the. flood plain consists several heaps of sand and occasionally coarse debris scattered all along the bank, These are called sand splays and are deposited by flood waters.

b) Covered flood plain features:

i) Natural -leuees; These are prismatic bodies of sediments developed mostly on the right northern) bank due to spreading of sediments by -Overbank floods. From Broach to Bharbhut and beyknd they gently (2° to 3°) slope away from Narmada. The apex lies at the height of 5 to 10 m, above water level and bordering the terrace scarp. At the break of slope small streams run parallel to Narmada before joining it. Levees are exposed of mainly sandy silt and silty clays. the southern bank due to low are which is frequently flooded levees are not very prominent.

ii)Old meander scrolls: Though at present the river does not show any typical meander but from the parallel semicircular outline of

certain features like upper terrace, course of Ahlakhadi and alternate light and dark tones observed on aerial photos it seems that Narmada was having a curved channel during past flowing through Pungam area between north of sajod and Shakarpur-Bhata is characterised by these light and dark toned semicircular sands along which several parallel lines of Palm trees have grown. These particular bands are old meander scrolls. This particular zone is intensively oultivated.

iii)Bank swamps: In the area west of Haripura, there are a few small water polls with grassy vegetations and connected by narrow channels which get flooded during rains. These pools and channels are remnants of floods.

1) Alluvial Terraces :

Area is characterised by two distinct levels of alluvial terraces in south and only one terrace in north. The two terraces are reffered to as lower terrace (T1) and Upper Texture (T2) or Ankleshwar Terrace. Since altitudes of these terrace levels are different on both sides,, they are non- paired, or non—cyclic type terraces.

i) Lower Terrace (T1) : This is found only southern side of liver where it continues upto Hen sot and then marges into tidal flats. Its longitudinal profile is concave upwards with a little convexity between Nr. and Hansot. Surface elevation falls from 10 m, near Bharbhata to 7.5 m west of Nr. The thickness above current flood plain varies from 3.5 m near Bharbhata to 2 m near Nr. Decree of Nr. of the terrace to is very low due to a Nr sandy-silt cover, At the top there is a 1.0 to 20 m thick humic soil cover which is followed by non-strotified sandy silt. The Nr cover Nr medium to fine Nr. soil with plenty of tree roots and is intensively utilised for cultivation and grwoing Nr silt contains fine

mica flakes, white quartz grains and tiny pebbles of Deccan-Trap. Proportion of sand decreases downstream.

ii) Upper (T2) or Anklwshwar Terrace: This is found on both sides of Narmada. On northern side it forms the river bank scarp and continues beyond Bharbhat. In south it stands out prominently above lower terrace forming a scarp and continues upto south west of Aabheta where it merges with tidal flats. Elevation of surface on northern side, falls from 10,0 m near. Broach to 8.0 m west of Bharbhat. Fall in elevation on southern side is from 15. 5 m near Anklwshwar to 10.0 in near Ambheta. Variation in thickness on northern side is from 10.0 near Broach to 5 m near Bharbhat while an southern side - it is from 7.0 m near Anklwshwar to 1.5 m near Ambheta. Longitudinal profile of left bank terrace shows two concavities and two convexities indicating upwarping and tilting of terrace blocks.

The-terrace surface on both sides is undulating and rolling. At the scarp margin it is dissected by several transverse gullies. At places there are randomely oriented gullies also which have rendered the area uncultivable. Aw ay from the scarp where the top is covered by chernozem it is cultivated! Mostly the terrace comprises brownish sandy to silty pedocal. except near Hansot where it contains fine brownish silt with lime-caliche. At place there are plenty of criss-cross lime veins, 1 to 4 cm thick, and concentration of lime caliche in certain zones. These zones have undergone intensive leaching. The CaCo3 content of pedocal varies from 17.0% to 52% as compared to 10% CaCo3 content of fresh sediments. Four samples of pedocal have been given for c14 dating.

d) Deltaic and associated features;

West of Bharbhat, Narmada enters its delta area; The channel splits into two distributaries encircling Aliabet, which jutaposes gulf of Cambay. on both banks of river there are marhses and mud flats. Deltaic area of Narmada can also be cabled an esturine area as:

i)most of the Allabet gets submerged during high tides and completely
submerged during floods;

ii)high tide waters extend upstream upto Broach and even beyond;

iii)marshes and mud Plats occur on both banks and Alia bet.

Aliabet is pear shaped island with its broacer side towards seq Its top is characterised by extensive marshes and mud flats orisscrossed by tidal channels. Central portion has been stabilised as there is a fairly good growth of bushes and grass. These features get submerged during high tides and floods. Aliabet has been growing in size at a fairly rapid rate. Following variations in size have been found from various old and new naps.

Map/Aerial photo	Length	Width
i) Degree sheet (1894) 1";4 miles	19.0 km	1.20 to 2.0 km
ii) Toposheet (1947-48) 1":1 mile	21.0 km	4.0 to 10.0 km
iii) Aerial photos 1:30.000 & 1:50,000	25.6 km	5.0 to 19.0 km

Growth has been more in seaward direction as compared to the upstream portion. Enlargement in general can be attributed to the following factors:

i)In both distributaties water corrents swing laterally due to reflection taking place at the banks. This lateral swinging includes intensive bank cutting and the removed bank material is concomitantly deposited at the peripheries of Aliabet. Thus the size of Aliabet grwos and at the same time width of distributaries is also maintained.

ii)During floods Narmada brings huge load of sediments and deposits at hte of Aliabet in the form of a thin veneer every year. This may also contributes to the seawards extension of foreset beds.

iii) Water around Aliabet and in -the adjoining portions at gulf of Cambey mostly remains muddy and sedimentation is accelarated with settling of this suspended mud. Settling from suspension of mud in water might be due to the following reasons:

i)As Narmada water mixes with saline water of sea the finer clay particles flocculate and form aggregates whoh finally get settled,

ii) During high tides these partially settled clay aggregates get Stirred up and transported upstream with tidal waters. As the tide receeds the clay fraction gets spread over Aliabet and Nr. mud flats.

iv) Seaward grown or aliabet indicates tint possibly the rate of deposition of sediments by river is greater than the rate of removal by sea waves and currents which is due to the narrow expense of gulf of Cambay.

Mud flats or tidal mud flats: These are-found on both banks of Narmada, On northern bank they extend, west of Bharbhut, in narrow strips all along the bank whereas on southern side they are fairly wide and extend persistently from north of Gonpatpura to south-west of Ambheta and beyond. During high tides they are submerged under water and they comprise black fine silt and clay. When exposed, the

surface is characterised by tidal channel mud cracks and ripple luarka, North of Fardi prominent mud orika and ripple marks were found (photo No. 6) . Ripples with wave length of 2 to 3 cm were found oriented along N65°W - S65˚E. During dry periods green grass growns over vaste expanses of these mud flats.

CHAPTER IV

NEO - TEOTONICS

Narmada valley has been undergoing elroganic movements since Pre- Deccan Trap tiues when the formation of Narmada rift commenced. Deccan Trap eruptions marked a period of intensive tectonic activity- Post Deccan Trap period is characterised by faults trending in ENE-WSW (Narmada fault) and NNW-SSE(Laki fault) directions, Quaternary, tectomics commenced with the folding of youngest Tertiary sediments (Hear Jhagadia). Those folded foroations were later affected by NNW-SSE and NW-SE trending cross faults which must have been formed during Quaternary and Holocene times. Due to these movements the area has been undergoing an uninterrupted dynamic rejuvenation till redantly, During Quaternary and .Holocene periods not only fresh lineaments were formed but the old weal planes were also reactivated from time-to-time, This has been indicated by the following features observed in the area:-

l) Topographic features: Lower reaches of Kamada present excellent expression of subsurface movements' in topographic forms.

a)Two main levels of non-cyclic alluvial terraces indicate Nr. by river mainly due to uplift Topographic not unconformity between two terraces, valley cross profile (plate along with small bonches indicate lateral swinging of river which is again controlled by tectonic movements and load during floods.

b)Anastomotic stream channels, stream capture and development of new stream channels north of Haripura and Shakarpar Bhata indicate differential tilting of blocks.

c) Longitudinal profiles of Narmada and its two terraces on left bank show similar as well as dissimilar convexities between Ankleshwar and Hansot, which indicate differential upwaiping of terrace blocks. Similarly presece of a minor nickpoint in Narmada's longitudinal profile near Bharbhata calls for uplift calls as there is no hard rook barrier over there.

d) Complete convergence of longitudinal profiles of two terraces near Hansot as well as near convergence of these with Kamada's profile indicates a decrease in degree of ullift downstream.

2) Structural features:

a) Analysis of various drainage patterns like rectangular, angulate, anastomotic, etc. shove that they are controlled by sub-surface lineaments extending in almost E-W, ENE-WSW, NE-SW, NNE-SSW, NNW-SSE and NW-SE directions. These have been found affecting the youngest alluvium Also.

b) The trace of Kannada fault in ENE-WSW has been found extending up to

Sajod passing through north of Anklwshwar.

c) Tilted terrace blocks is another feature which indicate that the movements were taking place after the formation of these terraces. North of Sakarpur Bhata there is a very clear evidence of vertical movement which took place along a recently developed nala flowing in NNE direction . The eastern block has moved up with respect to western block, Existence of this nala was shown in toposheet prepared in 1947-48.

d) During the Broach earthquake on 23rd March, 1970, several fissures (3 to
30 m in length and 0.05 to0.90m in width) developed along a 21 km long belt
extending from Govalibet in east to Sajod in west. This fissure belt incidentally falls over the trace of Narmada fault. This is the conclusive proof of the tectonic instability of the area.

PART II.

TAPTI AREA

CHAPTER V

GEOLOGICAL SETTING

Tapti also flows along a fissure acme which is across Cam bay graben and at the same tine parallel to Narmaada trend This fissure has been found to be extending upto Kolhapur and beyond as suggested by the straight course of Tapti, River outs across Deccan Traps before emerging In to the west coast alluvial plain. It has incised deeply its channel into alluvium there by exposing underlying Deccan Traps and Sertiary sediments. A general stratigraphic sequence of rocks found in the area around Tapti is given below:

	Sub-Recent	Alluvium, blown sand, soil etc.	
Holocene	Recent	Older alluvium	Neogene
Quaternary			
	Pleistocene	Miliolite sandstone(?) and conglomerate.	
	Miocene	Gaj Series - Ferruginous sandstone	

Tertiary	Eocene	Nummulitic limestone	Palaeogene
	Palaeocene	Sub-nunmulitic Nr. shale Supra Trapean sediments partly lateritised with Bauxite at places.	
Late Cretaceous to early Eocene		Deccan Traps	Late Mesozoic to early Plaeogene.

Traps occur on both aides of Tapti. They are more prominent in north than towards south of the river. In the north, they occur In the form of E-W trending ridges with intervening valleys. These hills loose their altitude towards west and Mandvi Onwards they are concealed (Aider a thick cover of alluvium. Exposures are however found in the river channel of which the last cog is found near Bodhan beyond which river has cut into Tertiary sediments, lu south.'of Tapti Deccan Traps form a rolling topography where trap mounds are covered by alluvium.

Tertiary sediments are mostly found in the north-western part of the area, Supra-trappean sediments comprising basalt Nr. by ferruginous clay and in turn they are lateritised, also containing bauxite pockets, Nr. shale also overlies the Deccan Traps and occurs, along with Nr, in the form of disconnected lensoid end elongated hands north of Bodhan and near Banioli, Narth of Dodhin, Nr. limestone regts directly flyer Deccan Traps as veil as gypseous shale. This limestone is also not consistent, Fliocene ferruginous sandstone overlies limestone near Bodhan and further north it is found over gypseous shale. Post Miocene sediments are not exposed anywhere. Alluvium with blown

sand sail and kanker cover the Nr. Thickness of alluvium increases from east to west.

Formations of Tapti valley; The fissure along which Tapti has developed its channel seems to have been formed just after the Pre-Deccan Trap period, After flowing for a considerable distance in Malwa-Khandesh, Tapti cuts through western ghats before energing into Gujarat coastal plains. Airing its flow in this area mostly the course is unusually straight except in the later few km in coastal alluvium, at these Nr the immense thickness of alluvium bordered by wall like escarpment of Deccan Traps south of Tapti valley in southern Khandesh (near Jalgaon) are emphatically suggestive of faulting and Nr Tapti channel is almost at the junction of two prominent trends of Trap ridges found in the vicinity of coastal plain. North of Tapti this trend is E-W, where a toward a south it is almost N-S The E-W trend is parallel to the major Narmada rift trend and sinoe Tapti has also got the general direction of its course it can be said that Tapti fissure has also been developed by the same factors which founted the Narmada rift Some of the important reasons given are/follows:

a) According to Pasooe a general peninsular tilt was insinuated at the end of Deccan Trap period by compressive stresses causing Himalayan movements which gave rise to E-W trending fractures and also reactivated the already existing ones. Tapti fissure seems to be cue of them.

b) Vredumburg propounded that the peninsula was affected by an anticlinal warp with a NNe-SSw axis before Deccan Trap eruptions took plaoe, During post-Deccan Trip period intense compressional forces operated from North giving rise to E-W fractures. Tapti

lineament thus can fce deemed as the southern extension of Narmada faulting,

c) Palaecniagnetic studies have shown that Indian sub-continent has been undergoing a northward translations movement at the same time accompanied by an anticlockwise rotation of about 25° to 30˚. These tranalational and rotational movements have given rise to fractures across western coast of India which indicate to have undergone distinct transcurrent movements. Mouths of Tapti and Mindhola river exhibit the features.

CHAPTER VI

GEOMORPHOLOGY AND FLUVIAL PROCESSES

Upstream to Ukai the channel is under reservoir water of ukai Ihm. From Ukai to east of Bodhan Tapti flows over Deccan Traps and thereafter traversing over Tertiary rocks upto upstream of KamreJ, it flows into Gulf of Cambay through alluvial tract, On northern side the flood plain is bound by E-W trending Deccan trap ridges, from Ukai to Kanarapara, whereas towards south of Tapti, from Ukai to panohpipla, the flood plain is a flat country with variable width ranging from 15 to 19 km in north and 0-75 and 10 km in south.

A thorough analysis of the fluvial land forms indicates a terraced and undulating landscape. Though two levels of terraces have been found but only one of them is prominent and consistent. The multicyclic terrace landscape has been developed by both aggradational and degradational processes of single channel flow of Tapti. Due to dynamic rejuvenation of the area Tapti has got a well incised channel into rocks as well as alluvium.

Study of fluvial processes has been carried out under the following:

1) Morphometrio analysis

2) Channel form and processes

3) Morphometric features and associated fluvial sediments.

1) Morphometric analysis;

Morphometric analysis was carried out an drainage not work in area between Ukai and Dumas-Hazira, an toposheet Nos. 46G/3, 4, 7, 8, 11, 12 and 46C/12, 15 and 16 on scale 1:63,360. The area is bound by Nr 21°14' and 21˚28' and longitudes 72˚38' and 73˚37' Horton's analysis (ibid) shows Tapti as 7th order stream foiling a seventh order basin in this area. The morphemetric details are given below:

Stream order -R-	No. of streams -N-	Bifurcation Ratio -rb-	Channel length -L- (km)	Total area Ad	Representative Stream
1	3055	4.5	1914.40		
2	671	4.0	681.20		
3	166	4.5	349.60	2290 sq.km,	
4	37	3.3	184.80		
5	11	11.0	103.20		Ver River
6	1	1.0	11.20		
7	1	-	62.40		Tapti River
Total	3942	Average rb upto 6th order =4.7	EL=3306.80 km.		

Nr. 3306.80/2290.00 - 1.4 km of stream per sq.km of area. Average distance between two channels (Ad/EL) - 2290.0/3306.80 = 0.7 km. Length of overland flow (Ad/EL) =0.35 km.

The above details give the following relation's also.

Order	Average length of stream L - km	Length ratio L2/L1
1	0.62	
2	1.01	1.6
3	2.10	2.0
4	4.99	2.0
5	9.38	1.9
6	11.20	1.2
7	62.40	5.5

The plots of stream orders against their number and lenghts on semilogarithmic paper are straight line which confirm the Horton's analysis of a standard basin (PLATE - XI) . Bifurcation ratio of 4.7 is near to the standard value of round by Stratler. Denisty value of 1.4 is an average value for such a basin, however, the average distance of 0.7 km between two streams indicates a low degree of dissection. For an alluvial country this is an exception. In the op stream reaches, in Deccan Traps the decree of dissection is higher than the downstream alluvial area.

2) Channel form and Processes.

Tapti and its lower order tributaries have got well indeed channels exhibiting various types of drainage and channel Patterns. Quantitative detail

of Tapti channel are given below:

Tapti channel:

From Ukai to Dumas, tapti traverses a straight down valley distance of 96 km by 135 kin of channel length. Within this 135 km of channel it forms three major channel patterns - straight or sinuous, mearidering and braided. The last type merges into deltaic zone.

Straight or sinuous channel: From Ukai to Karjan the channel has got short straight stretches Upto Fanohpipla the channel is narrow (300 m) and almost straight. Prom Nr downstream it forms short straight runs taking obtuse turns except a curve, of 1.72 sinuosity, between Kakarapar and Mandvi. , k straight, valley length of "61 km is covered by 74 km of channel longth thereby attaining a sinuosity of 1.2 which is within the limits of sinuosity for straight channels. Width of channel varis between 500 and 600 m and at Vankla-Wareth-Kakazppar bend it is 1230 mi The length of individual straight runs varies from 5 to 6.5 km having length to width ratio between 4 and 6. There is a 3.0 km long stretch, between Pipria and Waroli, where Tapti has formed island.

Between Ukai and Kakarapar, the channel! is submerged under dam water, so the channel features in this diction could not be studied. Prom Kakarapar onwards, upto Bodhan, Tapti has cut its channel into traps however, the trap exposures in the present river channel are found upto waroli. The trap exposures ana interspersed with gravel and sand bars of flat, lobate and lensoid nature. Traps in the river bed occur in two forms viz; - i) low lying zones with rolling surface and ii) inolined trap straths out across the channel. The water line wanders vake from nearone vank to the other. In the flat zones river has cut its perennial as well subsidiary channels along joint planes as deep as upto 10 m.

near Wareth and Wankla. The inolined straths have been cut along N-S to NNE-SSW trending joints. The trap surfaces contain plenty of sigmoidal channel scars, rot and scoop holes.

Gravel and sand bars are found in the entire channel as well as on banks where there is a bend. These gravel bars along with traps form riffles proceeded by deeper pools in sand.

Near Pipria the river has developed braiding thereby forming two prominent islands. Near Wankla few braid bars have also been foiled. Beyond Wankla the channel again becomes straight.

b)Meandering channel: From Kholeshwar to Surat Tapti channel meanders into three asymmetrical loops with the following, meander geometry as measured co toposheet

i)straight down valley length = 25.0 km

ii)Meandering channel length = 42.0 km

iii)Ratio of (i) and (ii) = 1.7

iv)Width (w) of the channel varies between 0.32 and 1.12 km

v)Wave lengths (l) of meanders range between 5.0 and 10.0 km

vi)Amplitude (ii) , varies from 2.24 to 6.0 km .

vii)Ratio of ‘L’ to channel width 'W’ varies between 9 and 15.

viii)Radius of corvature varies from 1.6 to 3.2 km

ix)Ratio of ‘L’ to ‘r’ 3.1

x)Ratio of ‘L’ to ‘w’ varies between 5 and 7.

The sinuosity ratio of 1.7 indicates that in average the sinuosity is moderate, symmetric nature of meanders has caused variations in their amplitude and wave length, symmetric development of meanders and other. features indicates the variable credibility of venks which is in turn affected by three following factors:-

i)The variation in lithological opposition of banks from place to place

ii)Central of river meander -sand migration by local tectonic features.
iii)Check on bank erosion, hence on channel migration by artificial embankment and rip-rap aggregate.

Two cut of these meanders show typical meander flood plain features.

c) Braided Channel:From Surat downstream to Magdala, Tapti has got a braided

channel where it has formed one big island and several braid bars. The braid bars are composed of sand and are confined to band of the river. The 8.0 km of straight down valley length is traversed by 9.5 km of braided channel , (to both hanks there are narrow strips of tidal mud flat a juxtaposing low water level end whose width increases downstream.

d) Deltaic area: From downstream of Magdala, Tapti channel Nr. into two distributaries encircling Kadia-bet the delta island, this zone can also be called an esturing zone as the tidal waters often submerge this area and reach as up at ream Surat. Another peculiarity of esturine zone is that the 0,5 km wide river channel near Kagdala suddenly encompasses a width of 5.5 km forming the Kaila bet. At the north the raid flats turn into muddy depressions with intervening high off-shore send bars which are exposed when tide receeds.

Longitudial profile of Tapti river.

Major part of Tapti's channel is in Deccan Traps which makes it rough and at places the adjacent banks are even at different levels. Keeping in view this non-uniformity of channel longitudinal profiles for both sides have been drawn at the winter water leve1, The elevation

of various points vas determined by subtracting the respective bank thickness from the bank top elevations.

General shape of both profiles (Plate No,I) is cocuavs upwards, however, both have got two convexities, General gradient between Ukai and karjan, on left bank, and between Ukai and Dungraj on right bank is on steep side with an average elevation fall of 1.25 m per bug Prom these two points awards the profiles flatten with a prenounced concavity upwards. The left bank side profile exhibits a general convexity between west of Ghasiamara and Maohhi covering a distance of Nr. This is similar to the longitudinal profile of upper terrace in this Nr. The Nr is due to Deccan Trap mounds. Downstream to kadod the channel is characterised by accumulation of coarse gravel, Similarly two other convexities between Wareth and Un (l2 km) and Kamplspur and Bodhan (14 km) are due to Deccan Trap mounds.

The at gradient in the Upper reshes indicate large size of bed material and rough channel. This it confirmed be the Deccan Trap Nr and presence of straths giving rise to rapids, Scions of profile covering lower reaches between Kathor-Nr gentle and man an election fall of Nr.This signifies the presence of a smooth channel and Nr in sediment grain size downstream.

FLUVIAL MORPHOLOGY AND ASSOCIATED DEPOSITS:

Tapti has formed a single channel Nr meandering and covered flood plain exhibiting both degradation, Nr features described Nr. the following :

a)stream channel features

b)Meander belt features

c)Covered flood plains features

d)Alluvial terraces and

e)Deltaic or Esturine zone features.

STREAM CHANNEL FEATURES

1) Gravel, and sand bars. Downstream of Kakarapar the Nr contair Nr deposits in the fen of gravel and sand bars, Nr bars are generally elangai.sd Nr there axe, at certain places, irregular neaps also. Nr. reaches, between Kakarapar and Nr., the gravel bars fairly extensive and Nr. angular to rounded pebbles and boulders, less than 1 m to more than 2m in length, of Deccan Trap provenance.. Some of these bars have been grown into stabilised islands also as vest of Pipla. Gravel bars' as well as their constitutent pebbles and boulders Nr in size downstream. At the same Use bars become flatter and the variety of pebbles increases e.g. north-east of Ved-Nana the linear gravel ban Nr. both banks contain pebbles of traps, quarts, agate, chalcedony, etc. which are Nr. to rounded and vary in size from 1m to 1.5 cm.

Sand bare occur along with the gravel bars but their (Ave increases downstream. There are however two exceptions in upstream reaches which hive got fairly big extents. These high sand bars are confined to convex sides of the river bends near Wareth and Jakhla. The bends cause retardation in water velocity hence decrease its transporting power and provide favouravle for load deposition. The sand oar near Wareth is 300 x 100 m in size with a flat top which exhibits ripples in N10˚E – S10°W direction with wave length varying between Nr and 7 cm. Downstream the sand bars are confined to banks mainly and are with lobate tops. Sand grades into silt beyond Surat.

ii)Riffles and pools. These are found in the rough and rocky channel from Kakarapar to Bodhan. Due to irregular occurrence of

Deccan Traps in the channel the periodic spacing of 5 to 7 times channel width of riffles and pools is not found. Riffles or rapids are of two types i) riffles on rocky surface and ii) riffles on gravel surface. Ch trap surfaces the depth of riffles ranges between 0.5 and 1.0 m and water flows pretty fast on them in contrast to the riffles on gravel bars where the speed water is not very fast.

Pools always follow riffles. They contain 1.5 to 2.0 m deep water with sand and pebbles upto 1 cm length. Where the river hap cut fairly deep and extensive channel in Traps the pools persist for Longer distances.

iii)Bed rock features Pot holes, scoop holes and narrow channels.

Where water flows on trap surfaces with grater velocity pot holes and scoopholes have been formed lot holes are of sub-spherical to spherical in shape and range in diameter from a few cm to 1 m. Similarly narrow channels, a few cm to 1 m broad anu deep hove been sculptured in the rocky surfaces (Nr. Nos. 9 and 10)

All these features throw s light on the corrosive power of river. Airing flood times scouring and cavitation setin producing, small hollows of scoop holes in the rooky bed which are later developed into pot boles and narrow elragated channels with the help of voulders and pebbles in transport,

iv)Socur routes; East of Kakarapar and Kalva Tyara several abandoned 2 to 3 m wide, shallow channels are found, running parallel to river, over the bank. These are scour routes. They are developed by fast flowing flood water over the bank. When the flood receeds they are abandoned but get some water dtrring rains.

v)Islands and braid bars. Braid bars and islands are common feature of a braiding river and these arc found in Tapti also Apart from these, there are two islands forced near Dethli-Piprla in the straight channel c£ Tapti (Plate No. XI. Section Nos. 4 and 5). Out of these two the bigger one has developed earlier and is of lens shape. It is bound by a 13 m scarp on both sides with 4 m thick tarp in the lower portion and 9 m thick, soil above it. Island is fully stabilised as its top is thickly vegetated and partly cultivated also. Formation of this island seems to have been initiated during the earliest period of development of Tapti channel as top of the island is at the same level as that of adjacent bank and the river has cut equally deep into Deccan Traps of both sides. The smaller island is a big gravel bar which is under the processes of getting stabilised. It is at the upstream tip of the big island disposed en-echlon to the latter. Its top is covered by lensoid and lobate gravel and sand bars dotted with Deccan Trap protrudings at places. Due to intensive deposition the island has grown in size from (600 x 100) sq.m (in 1880-81 degree sheet) to (1300 x 500) .m (latest aerial .photos) ,Sandy patches support vegetation which increases downstream.

Braid bare are found from surat to Magdala along, with an island across Umra-Bhatha. The bars are lens shape and disposed along river - channel in an en-echlon pattern. Their shape and size however deep on changing due to floods. Tops are Nr. with slopes on both sides and have their of silt covering sand. Grass grows over some of these during dry periods. The island is disposed in almost NE-SE direction along the river. Its central portion is stabilised Its area is being enlarged by sand and silt depositions at the peripheries. Between 1948-

49 and present times the size of this island has increased ; from (3.0 x 1.2) sq.km to (3.5 x 1.4) sq.km.

vi) Bank cut offs: Throughout its course tapti has indulged in intensive bank cutting as the channel is bound by steep, almost vertical scarps. In the Upper reaches where the bank comprises hard rock and alluvium above it, bank cutting is accomplished partly by sloughing and Nr by disintegration bank retreating due to slumping is confined to bends, especially in meandering zone and lower reaches of channel. Bank downstream of KamraJ has been protected by rip-rap and embankment but where Nr. sloughing as well as slumping take place due to low threshold of bank. Magnitude bank cutting, oin downstream areas is ccnsiddrable and indicates rapid down- cutting as Nr. to planation. Bank retreating is more in meandering and braided zones.

Meander belt features :Meters in tapti have not fully developed. However,the presence of ewn a slight meandering is a. clear pointer towa-itis transition of river Nr vertical to horizontal plane. Meandering in Tapti starts from Nr and initiation of dominant role of river in planation is Nr by the flattening of longitudinal profile of river channel from this point onwards. Consequently Nr. of water causes lateral swinging which produces sculpturing of conreve bank and Nr on the convex bank. Some of the meander belt 'features observed are given below:-

1)Point bars: This is formed en the convex side of a meander. Due to lateral swinging and Nr movement of meanders of the material removed from concave bank is in turn deposited on the Nr. side giving Nr to a flat or undulating area known as point bar. .Two distinct point

bars have been located in the are4s north-west of Bherao-Kholeshwar and north-west of Katargan near Surat. Two distinct levels are seen in both cases.

a)Just above or juxtaposing the present channel las deposits.

b)Over the lower terrace level.

The former is narrower and Nr poorly-sorted mixture of ' fine gravel, sand and silt whereas the latter 1.3 fairly extensive and composed of fine grey silty soil which is intensively cultivated.

Meander scrolls: These are Nr outlines on point bars, as seen on aerial-photos, fanning automate arcuate hands of dark grey and light grey sediments. These mark sediment accretions while to be river is shifting away from the area in semicircular fashion. Due to cultivation their alternate high and low-zones have been obliterated. However, some symmetry can be seen from the coconut trees grown along these semicircular outlines.

Covered flood plain features

During over bank floods river spreads over a larger area which reduces its transporting power hence the excessive load is deposited there in the form of a fresh cover over previously deposited sediments. This new cover forms the covered flood plain features.

i) Natural-Nr.: These are developed on both banks of Tapti in the form of prismatic sediment bodies sloping away from river channel and are more precinent concave sides of river bends. In the meandering zones, on convex sides, they merge with point bars at lower level. Their apex in general lies 2.5 to 22.0 m above the present stream channel and the hypo ton use sieves 2° to 4° away from the bank, Due to this slope parallel streams have developed at the break of sloope and at the same

time zone flow down this slope also. On southern side there are so many streams which have got parallel courses very near to Tapti but finally flow away from it.

The deposits comprise and Nr which become finer downsteam. The old levee deposits have Nr.

ii) Nr: These are the heaps of sand which get deposited, in the guilees across levees and channels along levees, during High floods. Sand splays indicate flood levels Nr every year, fall along Tapti they are found in gullies across banks Upstream to Kakarpar and Kala Vyara they are found are crying the longitudinal flood scones.

iii) Back swamps: Between Kanja and Bedkun-Dar a few elongated depressions

containing water are found of the slope break of natural levee. These can be called back Nr in which the floor water gets trapped. There are several small streams interconnecting them. The water at places' is stagnant and has caused growth of grass and other vegetation.

d) Alluvial Terraces:

Tapti has out two terrace levels. The upper terrace Nr cm both aides of river and is persistant and well preserved., The lower terrace level is Nr to the meandering zone only and coalesces with fresh point tare. Demarcation of these two terraces has been made on the basis of their Nr in altitude, degree of surface dissection and Nr the purpose of Nr they have been named as Nr. terrace (T1) and upper terrace (T2)

Lower Terrace (T1) : This occurs in a disconnected fashion and confined to the meandering zone in the north-west of Bherao-kholeshwar and Katargam. As both these areas arc intensively cultivated the scarp separating the terrace levels is not present howevwr, there are a few steps, less than cue meter high, in Bherao-

Kholoshwar area. The Nr elevation falls from nealy 20 m near Kholwshwar to 8 m near Katargam. Thickness varies from , 10 m to 5 m as we go downstream. The terrace is mostly flat with almost negligible degree of dissection. The one to two mater thick top layer is dark grey silty and sandy soil below which are found unstratified sand and gravel, Weathering has been very little and the grain size decreases downstream.

Upper Terrace (T2):This terrace is found on both banks of Tapti from Ukai to Dumas and Hazara. It is fairly persistent and well preserved. On the northern bank from Ukai to Bagaltoi Nr. against Deccan Traps and after that, merges with alluvial plain. In upto nr it, coalesces with rolling topography and beyond this Nr. alluvial plain. General elevation of the terrace top falls Nr, to 4 m near Duma3 where it merge a with tidal flats. longitudinal profile of both sides are too convexities between l) Mandvi and Pipria, ii) Bodhui and Kathor. Similarly profile of southern aide also shown two convexitoes between i) Jakhla and Dethli and ii) Dungra and Bheda first conversity, iii both cases, is due to Deccan Trap mound second being Nr., This has produced tilted terrace blocks as seen iron the Nr drainage found Nr sides, Longitudinal profiles of both terraces and liver Nr-go in downstream direction indicating drop in gradient Nr.

All through the torrr.ee stands above the river bed forcing a steep scarp except at a few places Nr has gently slope. Thickness of the scarp decreases from Nr.. near Dumas. From Kakarapar to Waroli the bottom 4 to 5 w of. scarp is Nr Traps. Top. of the terrace is undulating which is fairly dissected by shaped 3 to 12.m deep gullies oriented between and Nr Intensity of gullying increases westwards with the

thickness of alluvium sand and silt layers exposed in Nr. gullies indicate that they have been formed in an old alluvial fill.

This terrace Nr an unetratigied clayey, Nr vita lime caliche overling Deccan Traps and Tertiary sediments, There are even a few cm thick veins of calcareous crust also. The Nr content of pedocal ranges from 16.0% to 82.5% Whereas calcareous crust found Un has shown 81.0% concentration of CaCo3. In a section near Karjan, vertically disposed in the grey sandy soil Nr concretions were found. These tubes have got a void in the centre around which the caloareous material has been deposited. The diameters of the tubes very between 0.5 cm and 3,5 cm.

a) Deltaic or Esturine gone features:

West of Magdala Tapti enters its deltaic acne and splits in to two distributaries which have got their channels around Kadia bet, the deltaic insland. Whole of this zone, in fact, is an entuizy as it gets submerged during high tides and has got marshy tidal flats. In feature of this zone are Kadia bet and tidal flats.

1) Kadia bet: It is a north-south oriented mat shy island occupying the whole mouth of Tapti. It has been growing in its size as indicated by the following:

	Dimensions of Kadiabet	
	Length	Width
a) Toposheet (1994) 1” 4 miles	3.5 km	1.6 km
b) Toposheet (1948-49) l”;mile	4.3 km	2.75 km
c) Aerial -phktos 1:50,000 (latest)	6.0 km	4.00 km

This growth of Kadia bet has been facilitated by (i) excessive pediment deposit over its surface Tapti during high floods, (ii) the

sedimentation of mud and clay fractions during high tides and (iii) the shaltered nature of Tapti1 s mouth form Nr waves Nr due to which the rate of river sedimentation is greater than the rate of erosd.cn by sea waves and currents.

Along with increase in the size of kadia bet width of estuary has also been increasing due to intensive bank cutting by river North of Hazira river bank has receeded by 400 to 500 m since 1948-49 and at the same time Kadiabet has grown westwards Due to lateral swinging of waves by reflection the bank material sloughed at the northern part is deposited at the adjacent perifhery of Kadia bet.

Top of the Kadia bet is characterised by marshy as well as dry patches and several tidal scour routes. Dry patches carry growth of green grass. On the eastern aide of Kadia bet there are two send bars also.

ii) Tidal mud flats: These ate found in the form of-narrow muddy strips on both banks of Tapti, from its mouth to Surat. these are formed by tidal water, during high tides. Tidal water loaded with considerable quantity of flooedlated clayey material rises upstream and autmerges lower portions of both tanks for few hours. The clayey material settles down during the high tide period. On receding of tide the tidal water travels back depositing its fine load at the banks in the form of sticky mud. On drying, polygonal mud cracks appear at the surface When wet they become maikbes as found dwanstream of Magdala, south of Kawas - Bhatfcur and en Kadia bet. The flats constitute fine dark grey to black silty and clayey material.

CHAPTER VII

NEO - TECTONICS

Tapti course follows a aeries of almost B-W trending parallel fissures across Cambay basin. Trend of these fissures is parallel to Narmada trend. Formation of figures has been due to differential epeirogenic movements which started during pre-Deccan Trap period. During Tertiary and Quarternary periods not noly fresh linamenta were formed but the already existing ones were also reactivated. Area around Tapti has been experiencing an uninterrupted dynamic rejuvenation till present times as indicated by the following topographic and structural features:-

1)Topographic feature:

a)Two levels of non-cyclic alluvial terraces have been formed to deep entrenchment of river, right upto Deccan Traps below alluvium, due to transition in base level. At places valley-in-valley cross profiles indicate lateral swinging of river which is the result of Differential tectonic movements.

b)Development of new stream channels recently and stream capture west of pardi Dhoran indicate differential tilting of blocks.

c)Longitudinal profiles of Tapti as well as its terraces show convexities in the same stretch (between Dhagra and Bhada) which have been caused due to Nr.

d)The Nr convergence of Longitudinal profiles or Tapti and its terraces in downstream region and dissimilariteas in their slopes in upstream and downstream regions indicate differential uplift i.e. more in upstream region and vice-versa.

e)The symmetric nature of meanders is due to control of river course by subsurface lineaments.

f) Intensive gullying of terrace tops is another indicator of progressive rejuvenation of the area,

2)Structural features

a)Several instances of rectangular and angular drainage patterns are found on both sides of Tapti Occurrence of such patterns in alluvium indicatos the presence of subsurface lineaments which central the drainage, Nr of these linaments show that there are three main Nr extending in E-W, NE-SW to NNE-SSW end NNW-SSE to NW-SE. Out of these NNW-SSE to NW-SE set is youngest as it off-sets the former two sets at many places. These lineaments are found in all routes like Traps, Tertiaries and alluvium which indicates that they have developed during Nr Recent times This is one of the foremost evidences of tectonic instability of area during Quaternary and decent times,

b)Tilted terrace blocks were formed during Recent times only.

c)Width of Tapti basin in south is very less as compared to north, acne of the streams flow very close and parallel to Tapti course and then take turn to south. This indicates the presence Nr tilted blocks on both sides Nr with southern block higher than the northern but both tilting to south. This is another feature conforming presence of E-W fault along Tapti course .

d)As in the vicinity of Narmada, Deccan Traps north of Tapti are also Characterised by typical faulted Nr. Trend of alleys and ridges is almost parallel to Narmada. This changes to N-S direction south of Tapti. Tapti Nr flows through the junction of these, two trends.

e)Morphological studies of Deccan Trap area,, further south of Tapti in Dangs district also show that the area is being uplifted. Some of the important feature-observed are:

i)Deeply intrenched course of streeams like Puma, Khapii etc.

ii)Presently underfit nature of puma in some of its stretches.

iii)Occurrence of several straight and v-shaped deep gorges i.e. Barda river gorge which is Nr by fault Nr a exhibiting undirected triangular Nr cross wineglass Nr, slacken sides, etc.

iv) Absolutely undissected and partially dissected plateau tops and Nr.

f) As the records show Tapti valley has experienced several earthquake between 17th and 20th century which is one of the exclusive evidences of instability of the region.

All the above mentioned points Nr that the area has been undergoing a dynamic rejuvenate due to Nr the same time, the effect of Nr changes, of whatever Nr, can not be overlooked. It has been Nr in many parts of the world that about 6,000 year B.P the sea level was 2 to 3 m higher than the present sea level and since then it has- receeded Recent .work on raised beaches of Saurashtn is shown two ancient sea stands above the present sea, level.

i)+2 to -3 m above present sea level - 4500 to 6500 B,F, and

ii)+2 to -6 m above present sea level during late Pleistocene.

If the Nr level ha s receeded by 2 to 3 m around Saurashtra coast since 6500 year B.P then it must have had Nr effect on the tapti area also due Nr. However, raised beaches have not been Nr the coast between mouths of Tapti and Narmada but At the Nr, appearance of several sand bars there. Nr enlargement of two river mouth islands, Aliabet in Narmada and Kadiabet in Tapti, can be attributed to the Nr level. Thus the effects of Nr visible in the mouth area of Tapti whereas in the upstream region effects Nr movements are more clear.

CHAPTER VIII

CONCLUSIONS:

NARMADA AREA

1)Lower part of Narmada channel, between Broach end Aliebat is also controlled by a series of ENE-WSW trending closely spaced faults.

2)In this portion also single channel flow of Narmada. has laid down a composite flood plain with both Nr features,

3)In the sixth order basin of Narmada the drainage density in this part is 0.99 cm of stream Nr area.

4) Aliabet has grown in size due to heavy sedimentation and Nr Cambay.

5)Area has been experiencing an uninterrupted dynamic rejuvenation due to Nr movements which have been taking place Quaternary , and Nr times.

6)Area is still tectonically active as has been evidenced by Broach 'earthquake of March 1970,

TAPTI AREA

1)Tapti also follows a series of E-W to ENE-WSW trending fissures across -Cambay graben. This trend is perhaps a Nr of Narmada rift.

2)Occurrence of Tertiary sediments right at the western periphery of NrTraps indicates Nr. period.

3)The alluvium' covering Nr vas deposited during Kolocene and sub-Recent periods.

4)Tapti forms a 7th order basin in Nr density of 1.4km Vat, of stream lenght / sq. ian. of area.

5)By its single Nr flow Tapti has laid down a Nr flood plain exhibiting both depositional and degradational features,

6) The fluvial-morphological and structural features indicate the area has been undergoing a dynamic rejuvenation, due to Nr movement which have been taking place till present Nr. However, the effects of Nr level changes since past 6500 years are also visible in the river mouth area.

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X INDEX TO LOCALITIES

NARMADA AREA

Sl. No.	Name	lat.	Long.
1	Ambhete	21˚34’45"	72˚ 57’00"
2	Ankleshwar	21˚38’00"	72˚ "59’15"
3	Bharbhut	21˚40’00"	72˚ 50’45"
4	dboifchata	21˚40’15"	72˚ 58’20"
5	Bhorbhata Nabet	21˚41’00"	72˚ 59’45"
6	Boxda	21˚37’00"	72˚ 57’30"
7	Broaol	21˚41’45"	72°59’00"
8	Dasan	21˚41’00"	72˚ 54’00"
9	Diva	21˚39’00"	72˚ 58’15"
10	Divi	21˚ 39’15"	72˚ 59’15"
11	Hansot	21˚33’00"	72˚ 48’30"
12	Haripure	21˚36’ 30"	72˚ 55’00"
13	Koyli Dhantwira	21˚39’15"	72˚ 53’00"

14	Kukt	21˚40’45"	72˚ 56’00"
15	Matiad	21˚37’00"	72˚ 53’00"
16	Mehegan	21˚40’30"	72˚ 45’30"
if	notia	21˚30’30"	72˚ 51’30"
18	Nagal	21˚36’30"	72˚ 55’30"
19	Old Taria	21˚39’45"	72˚ 53’15"
20	Pungam	21˚36’00"	72˚56’00"
21	Sajod	21˚37’00"	72˚ 54’15"
22	Sakarpur	21˚38’45"	72˚55’15"
23	Sbera	21˚36’00"	72˚50’45"
24	Wadwa	21˚ 41’30"	72˚ 52’15"
25	Warwara	21˚41’00"	72˚ 54’30"
	TAPTI AREA		
1	Abrama	21˚ 16’45"	72˚ 54’45"
2	Amoli	21˚ 17’00"	72˚ 57’30"
3	Badi Chhawad	21˚ 16’15"	73˚ 13’45"

37	Maobhi	21˚ 17'00"	73˚ 03’45"
36	Mandvi	21˚ 15’00"	73˚ 18’ 00"
39	Motioter	2l°15,00 "	73˚ 21’45"
40	Niadra	21˚ 16’30"	73˚ 05’00"
41	Panchpipla	21˚ 15’15"	73˚27’30"
42	Vardi Dhoran	21˚ 18’ 45"	72˚ 58’00"
43	Phanpur	21˚ 15’00 "	73˚ 36’30"
44	Pipria	21˚ 14’ 45"	73˚ 08’ 45’"
45	Hajwad	21˚ 15’15"	73˚ 33’30"
46	Bander	21˚ 13’15"	72˚ 43’30"
47	Rudhwara	21˚ 13’00"	73˚ 07’45"
48	Sapura	21˚ 14’30"	73˚ 06’30"
49	Sigod	21˚ 11’45"	73˚ 13’15"
50	Siogpur	31˚ IB’ 00"	73˚ 31' 15"
51	Timba	21˚ 16’00"	73˚ 06’00"
52	Uchhrel	21˚ 12’30"	73˚ 12’00"
53	Ukai	21˚ 14’45"	73˚ 36’03"
54	Umareari	21˚ 13’30"	72˚ 12’15"
55	Un	21˚ i4’oo"	73˚ 14’00"
56	Vagnera	21˚ 16’00"	73˚ 29’ 00"
57	Vekur	21˚ 15’30"	73˚ 28’30"
58	Ved Nana	21˚ 14'30"	72˚ 49’15"
59	Walak	21˚ 15’15"	72˚ 54’45"
60	Wankla	21˚ 15’45"	73˚ 21’00"
61	Waraohha Mota	21˚ 14’30"	72˚ 53’00"

62	Ward	21˚ 10’00"	73˚ 08’00"
63	Wareth	21˚ 16’15"	73˚ 21’00"
64	Warjakhan	21˚ 15’00"	73˚ 17’30"
65	Waroli	21˚ 54’45"	73˚ 07’30"
66	Wasigam	21˚ 14’00"	73˚ 19’00"

4	Bagaltoi	21˚17’00"	73˚23’30"
5	Balaltirth	21˚ 16’45"	73˚ 25’45"
6	Bamni	21˚ 11’ 30"	73˚ 12’30"
7	Bedkua Dur	21˚ 15’30"	73˚ 24’00"
8	Bheda	21˚ 16’30"	72˚ 55’00"
9	Bhamlia	21˚ 12’15"	73˚ 11’00"
10	Bharao	21˚ 15’30"	72˚ 48’15"
11	Bodhan	21˚ 17’00"	73˚ 05’15"
12	Dethli	21˚ 14’00"	73˚ 07’30"
13	Dhawa	21˚ 17’15"	73˚ 02’30"
14	Dugaa	21˚06’15"	72˚ 42’15"
15	Dungra	21˚ 17’45"	73˚ 01’15"
16	Gewaohh	21˚ 15’15"	73˚ 09’45"
17	Ghalha	21˚ 17’45"	73˚ 02’15"
16	Ghasiamera	21˚ 16’30"	73˚ 25’15"
19	Hazira	21˚ 05’45"	72°38’45"
20	Jakhla	21˚14’30"	73˚16’15"
21	Jamapur	21°15’ 15"	73˚ 28’00"

22	Jarimora	21˚14’00"	73˚ 15’45"
23	Kakarapar New	21˚ 16’00"	73˚ 21’45"
24	Kakarapar Old	21˚ 16’00"	73˚ 22’15"
25	Kala Vyara	21˚ 16’15"	73˚ 24’00"
26	Kamlapur	21°13’30"	73˚ 11’00"
27	Kamrej	21˚ 17’00"	72˚ 58’ 15"
2’	Karjan	21˚13’30"	73˚ 00’30"
29	katargam	21˚ 13’30"	72˚ 50’00"
30	Kathor	21˚ 17’15"	72˚ 56’30"
31	kanja	21˚ 16’00"	73˚ 22’30"
32	Khanjroll	21˚ 13’45"	73˚ 09’45"
33	Khervara	21˚ 16’00"	73˚ 27’ 30"
34	Kholeshwar	21˚ 18’ 15"	72˚ 59’30"
35	Kholvvad	21˚ 16’45"	72˚ 57’00"
36	Kadod	21˚ 13’00"	73˚ 13’15"

PLATES 1 TO 11

Not Available