

# **CHAPTER II**

## **GEOLOGY AND**

## **GEOMORPHOLOGY**

## GEOLOGY AND GEOMORPHOLOGY

## REGIONAL GEOLOGICAL SETTING

The area under investigation forms a coastal tract of Ratnagiri district. The entire coastal tract under investigation is occupied by the Deccan Volcanics, represented mainly by the basalts. The Deccan Trap basalt is a thick pile of volcanic lava flows of Cretaceous Miocene age (Krishnan, 1967). These lava flows have been classified as aa, pahoehoe, and simple and compound types (Adyalkar, 1984). The basaltic rocks are of tholeiitic type. According to Mitchell and Widdowson (1991), these basalts from the area belong to Ambenali Formation of Wai Subgroup. The regional geological setting of the area investigated has been shown in Fig.2.1.

In the area, owing to the tropical and subtropical climatic conditions, these tholeiitic basalts have been subjected to insitu lateritisation to form ferruginous lateritic cappings such an insitu lateritic cappings outcrops has been observed at Vengani (Plate I, Photo 1). Varadarajan and Nair (1978) suggested that the reactivation along earlier faults have affected laterites and Quaternary sediments. The lateritic profiles have been presented by Sriram and Jena (1980). Karunakaran and Sinha-Roy (1981) have suggested that the lateritisation could have been active at least from Upper Cretaceous period onwards. Ramam (1981) is of the opinion that the planar surfaces at different places

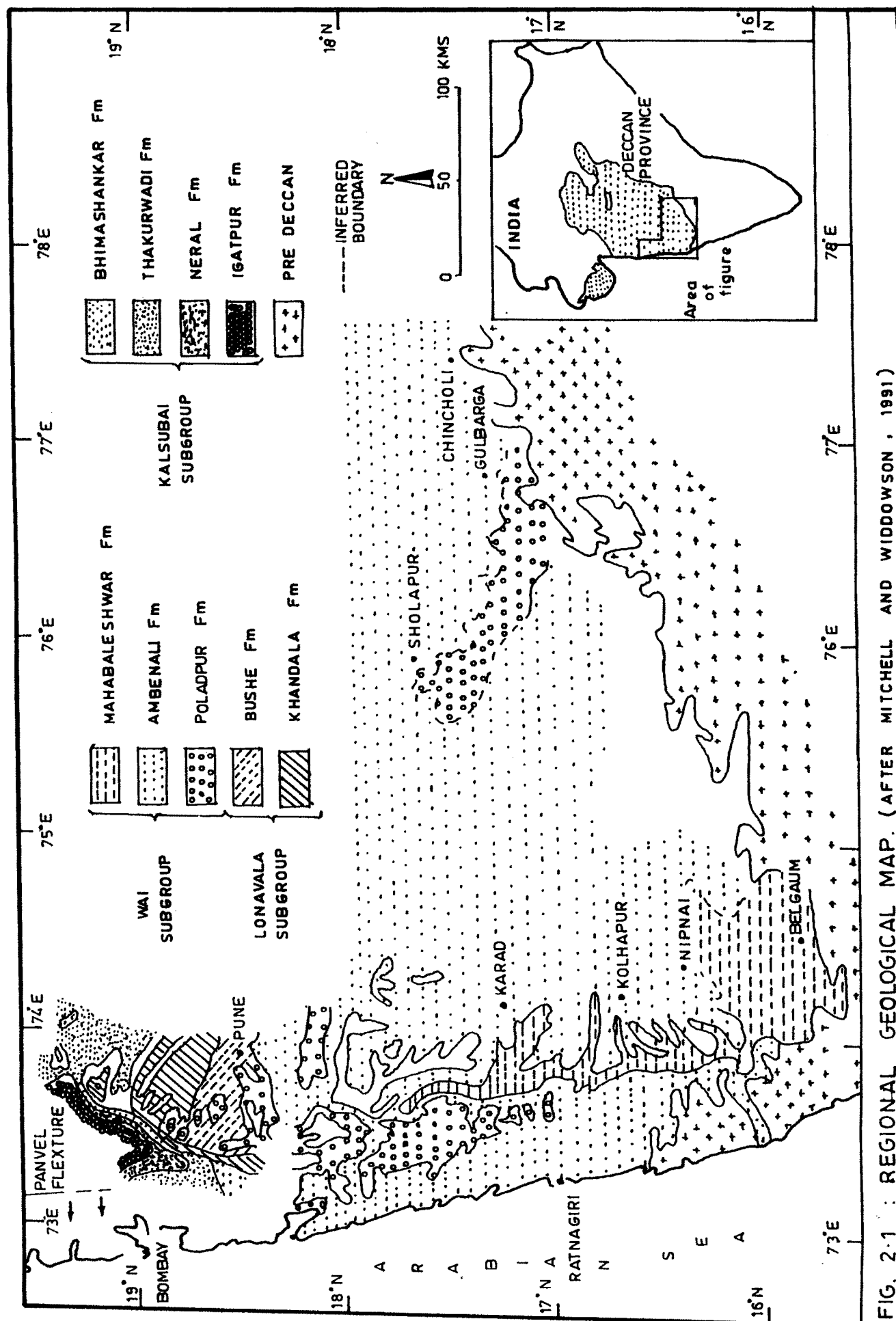


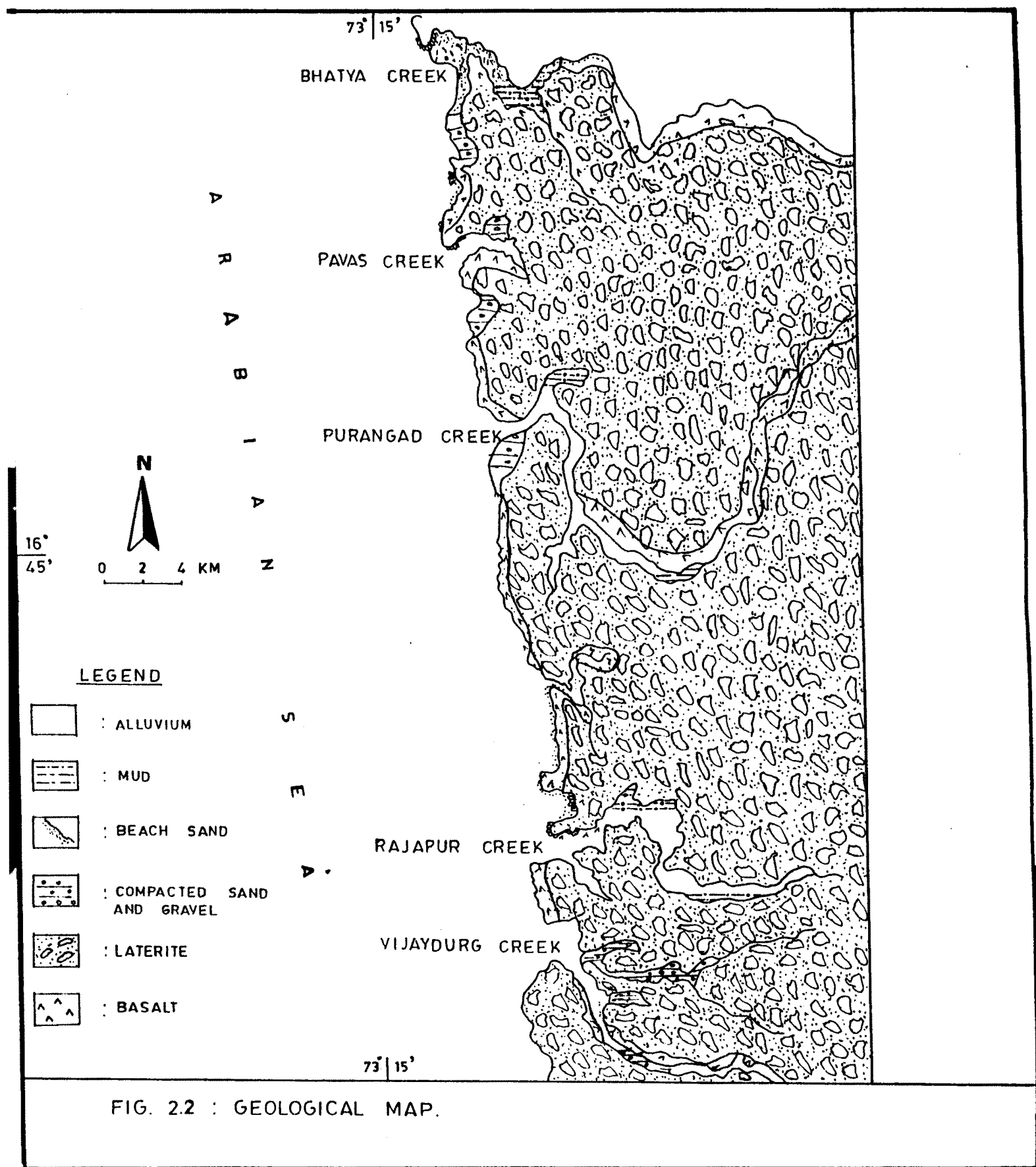
FIG. 2.1 : REGIONAL GEOLOGICAL MAP. (AFTER MITCHELL AND WIDDOWSON, 1991)

have cappings of laterites. It does not necessarily mean that there was an extensive residuum on entire surface which was formed earlier. He further concluded that the laterites could be formed selectively over some part of an extensive surface over some of the erosional remnants only. Ramam and Vaidyanadhan (1981) suggested that the laterites are formed due to residual chemical weathering resulting in neo-mineralisation. All along the coast, the calcareous sediments overlies the basaltic lava flows. These sediments are consolidated and unconsolidated in nature and exhibit horizontal laminations in vertical sections, wherever they are exposed and contain molluscan shell fragments in varying proportions. Development of tidal and mudflats has been recorded along the estuarine mouths.

#### Geology of the area

It is observed that in the area investigated are exposed mainly the basaltic lava flows, capped by laterites at various places and the Quaternary sediments exposed mainly along the coast. Lithological map of the area is presented in fig.2.2. The field and lithological characters of various litho units have been described in the following paragraphs.

Anon (1976) proposed the stratigraphic succession of the area, which was later modified by Siddiquie, et.al. (1976). It is given as below :



PERIOD		LITHOLOGY
Quaternary	: Subrecent to recent	Shore sands, dunes, soils, alluvium, etc.
Tertiary	: Miocene to pleistocene	Littoral concrete, laterites
Mesozoic	: upper cretaceous to lower Eocene	Deccan Trap Basalt

#### GEOMORPHOLOGY

The area investigated is the coastal tract that is developed mainly on the basalts of the Deccan Trap province. Along the coast, development of various geomorphic features have been observed. In the geomorphic analysis of the area, being a transitional environment, landforms developed due to marine and fluvial agencies have been identified and analysed in the context of its geomorphic evolution.

The area between Bhatya Creek and Vijaydurg Creek, in general is hilly with undulatory topography and prominent plateau tops. These hill ranges trend in and NNW-SSE direction. The area reveals sub-parallel and dendritic type of drainage pattern fig.2.3. The drainage map of all the basins of 5th orders have been given in figs.2.3 a,b,c,d,e,f,g and h. The area is dissected by Kajali river estuary to the north, Machakandi and Kodavli river estuaries in the central part of the area and Vaghotan river estuary in the



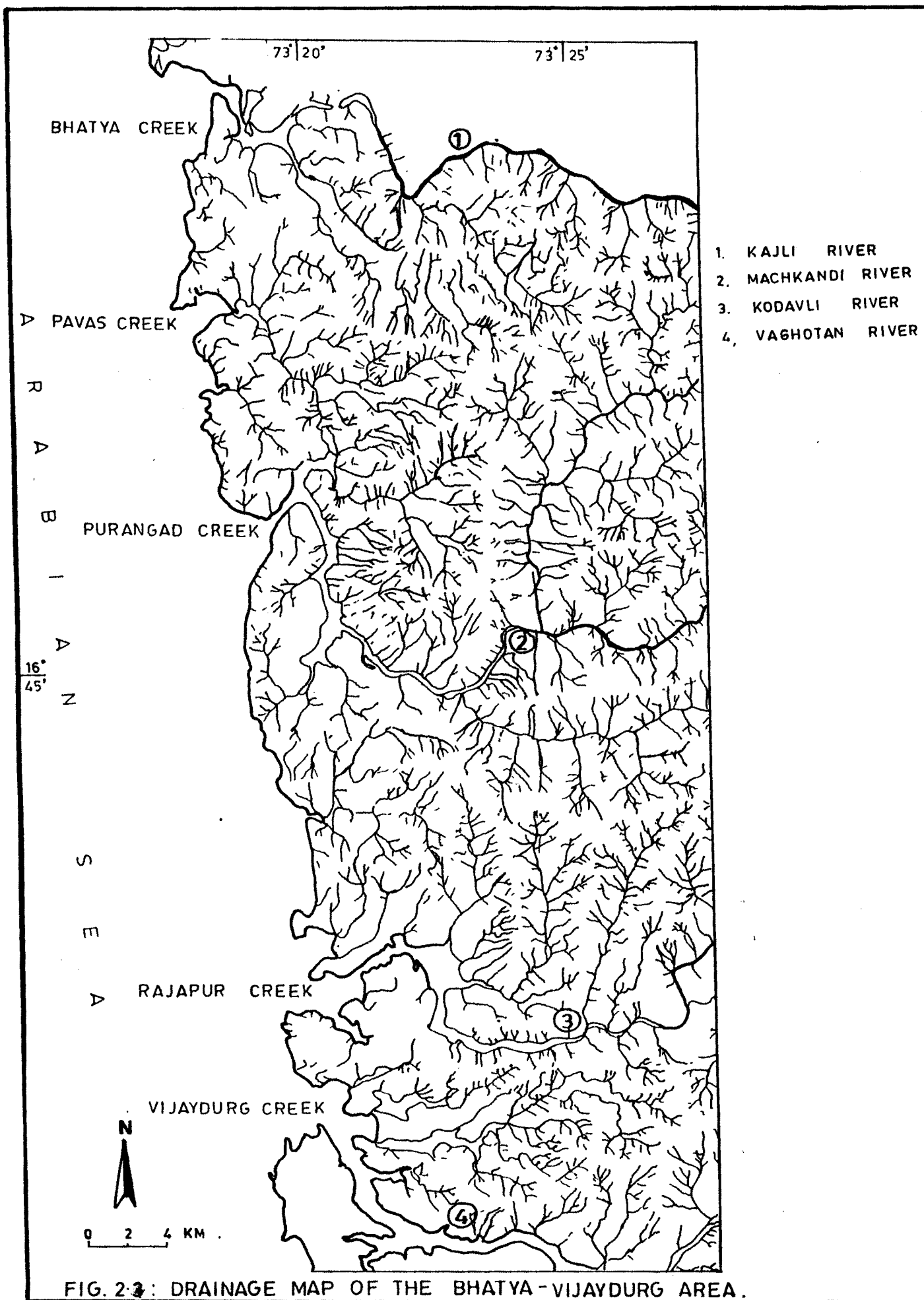


FIG. 2.3: DRAINAGE MAP OF THE BHATYA-VIJAYDURG AREA.

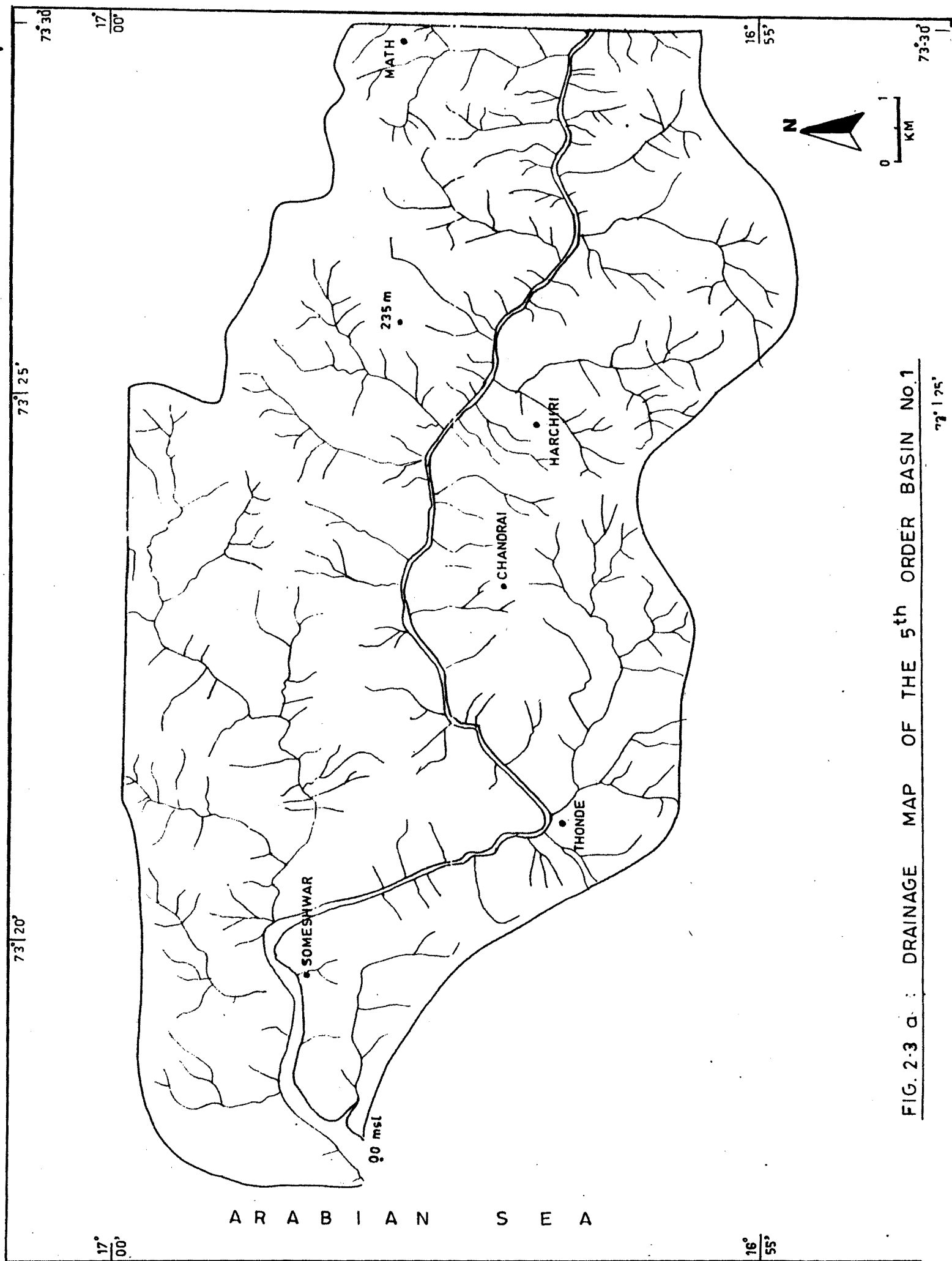


FIG. 2.3 a : DRAINAGE MAP OF THE 5<sup>th</sup> ORDER BASIN No.1

73° 1 25'



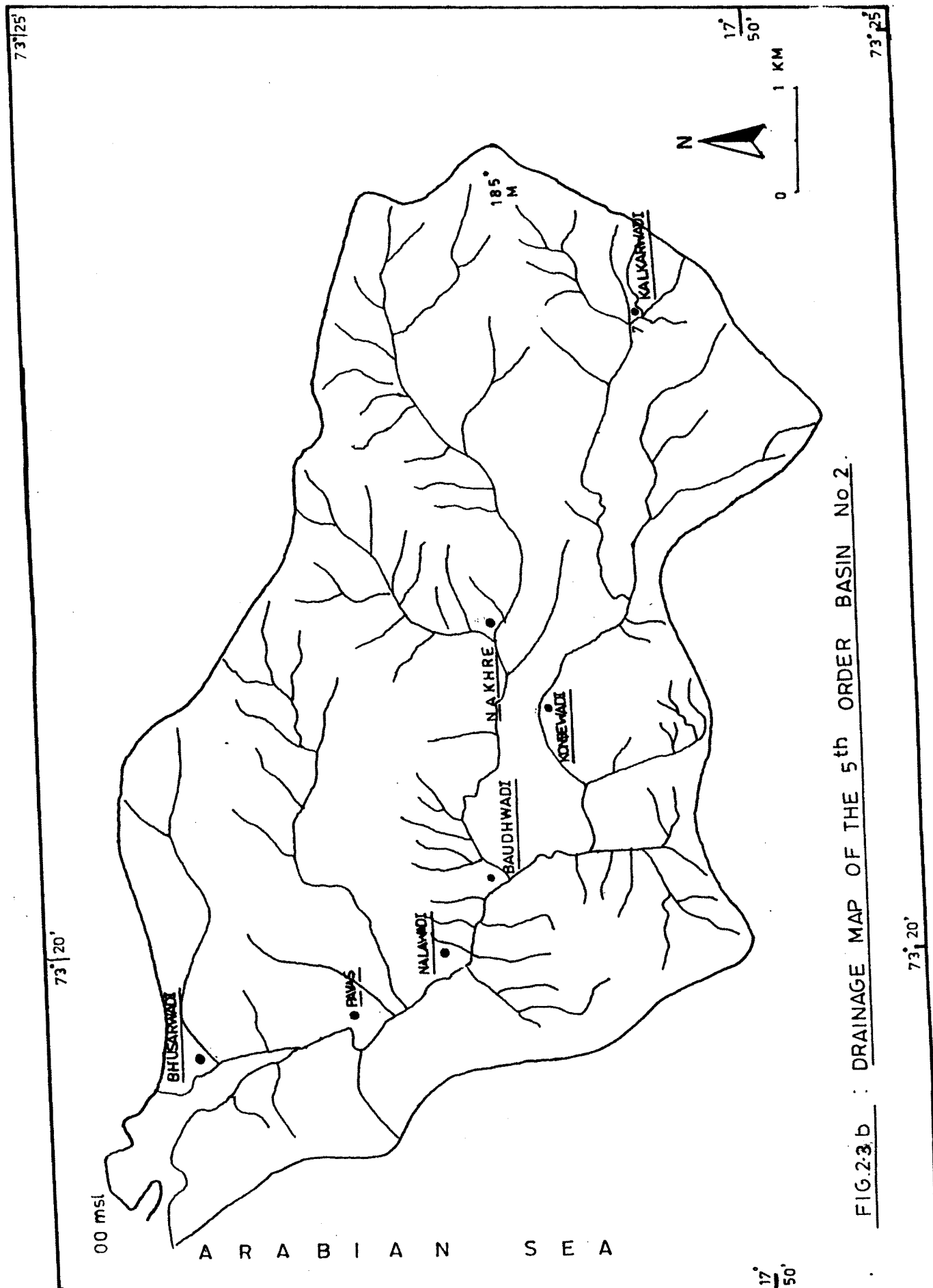


FIG.2.3.b : DRAINAGE MAP OF THE 5<sup>th</sup> ORDER BASIN No.2.

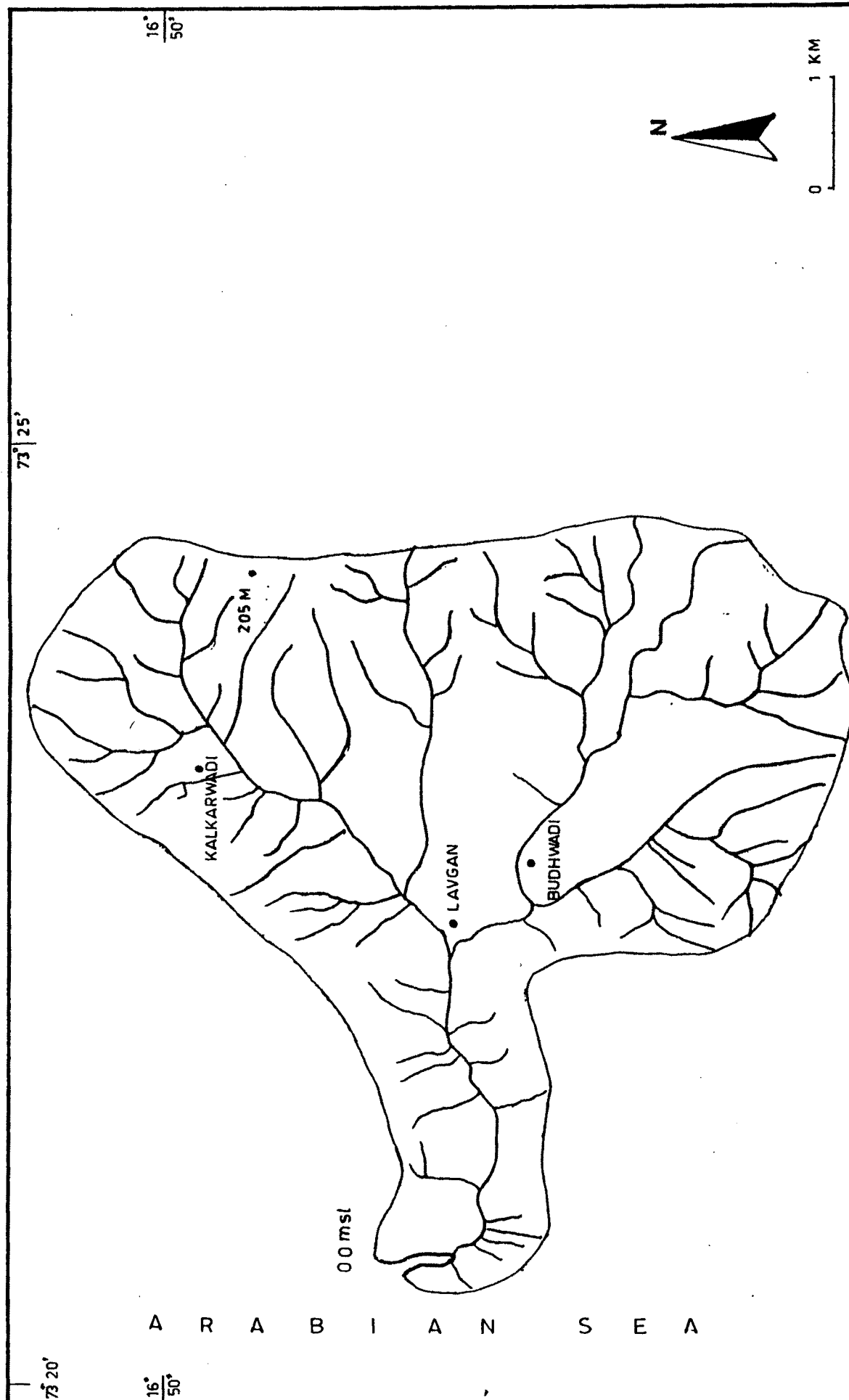
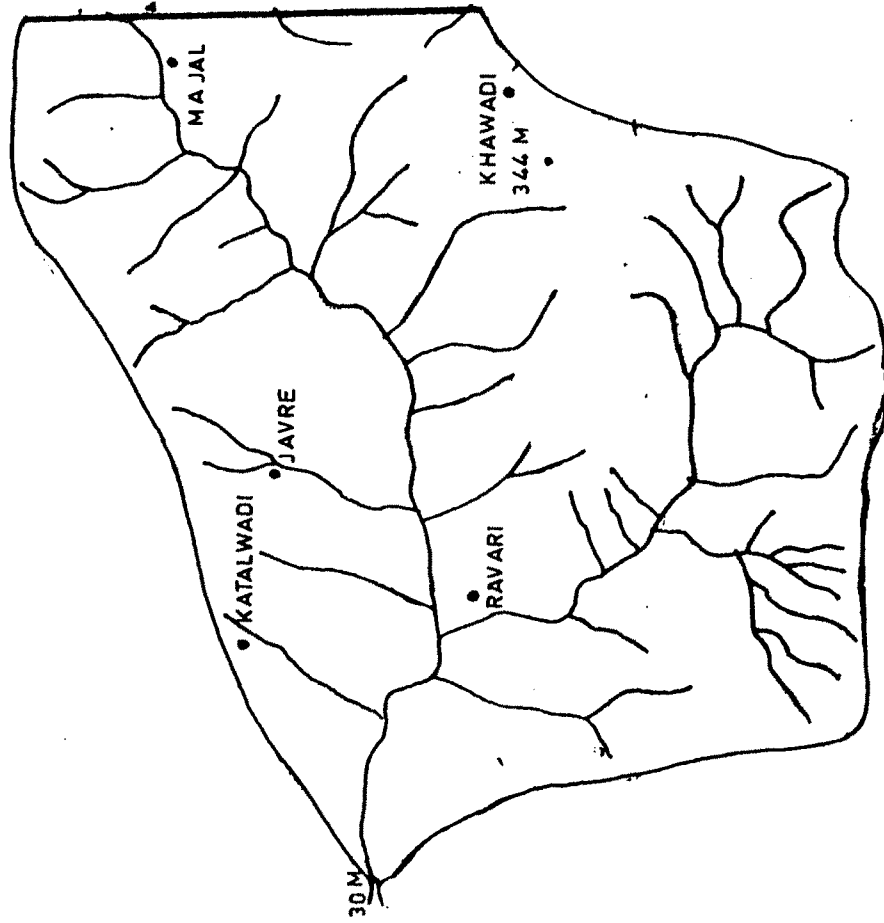


FIG. 23 C : DRAINAGE MAP OF THE 5<sup>th</sup> ORDER BASIN No. 3.

73° 30'

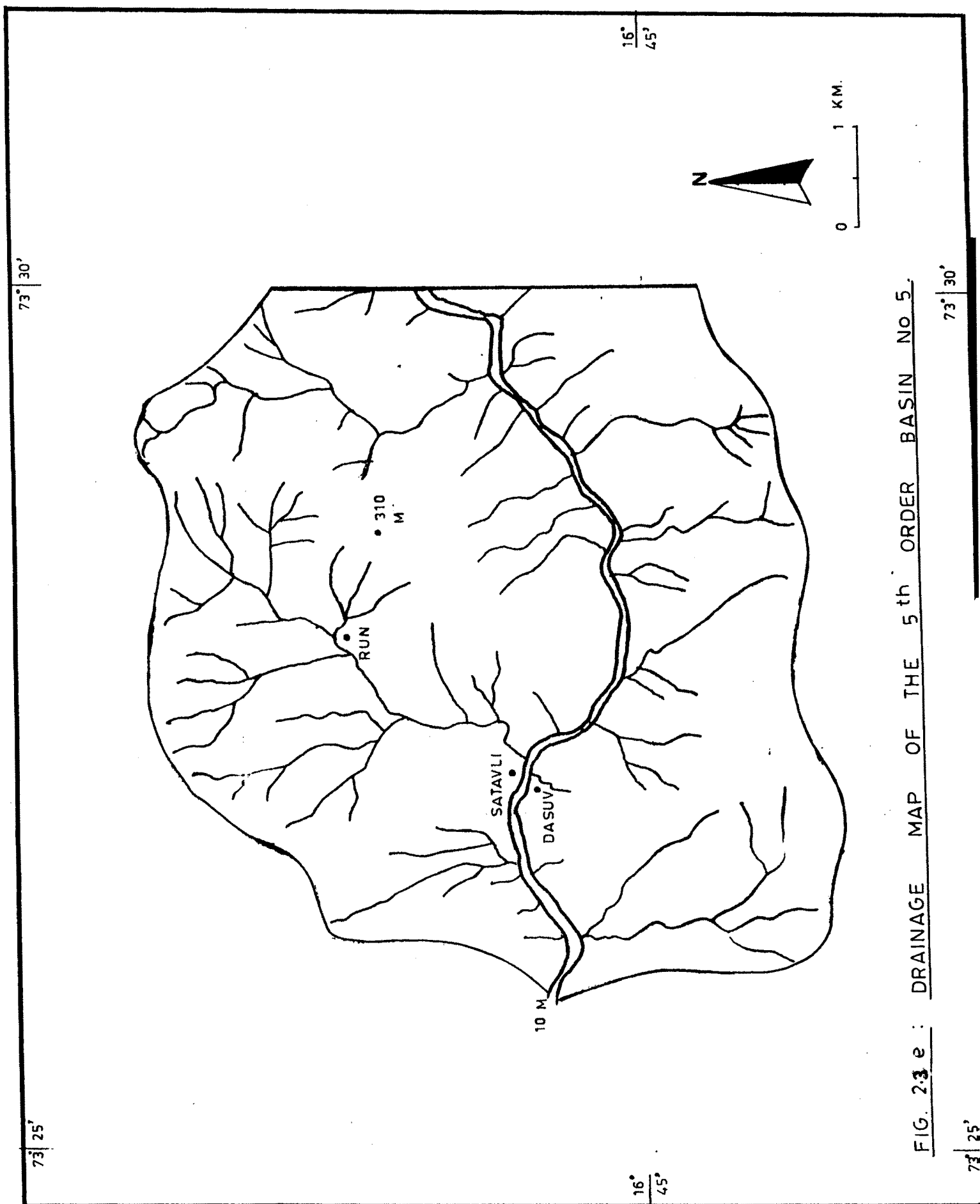
16°  
50'

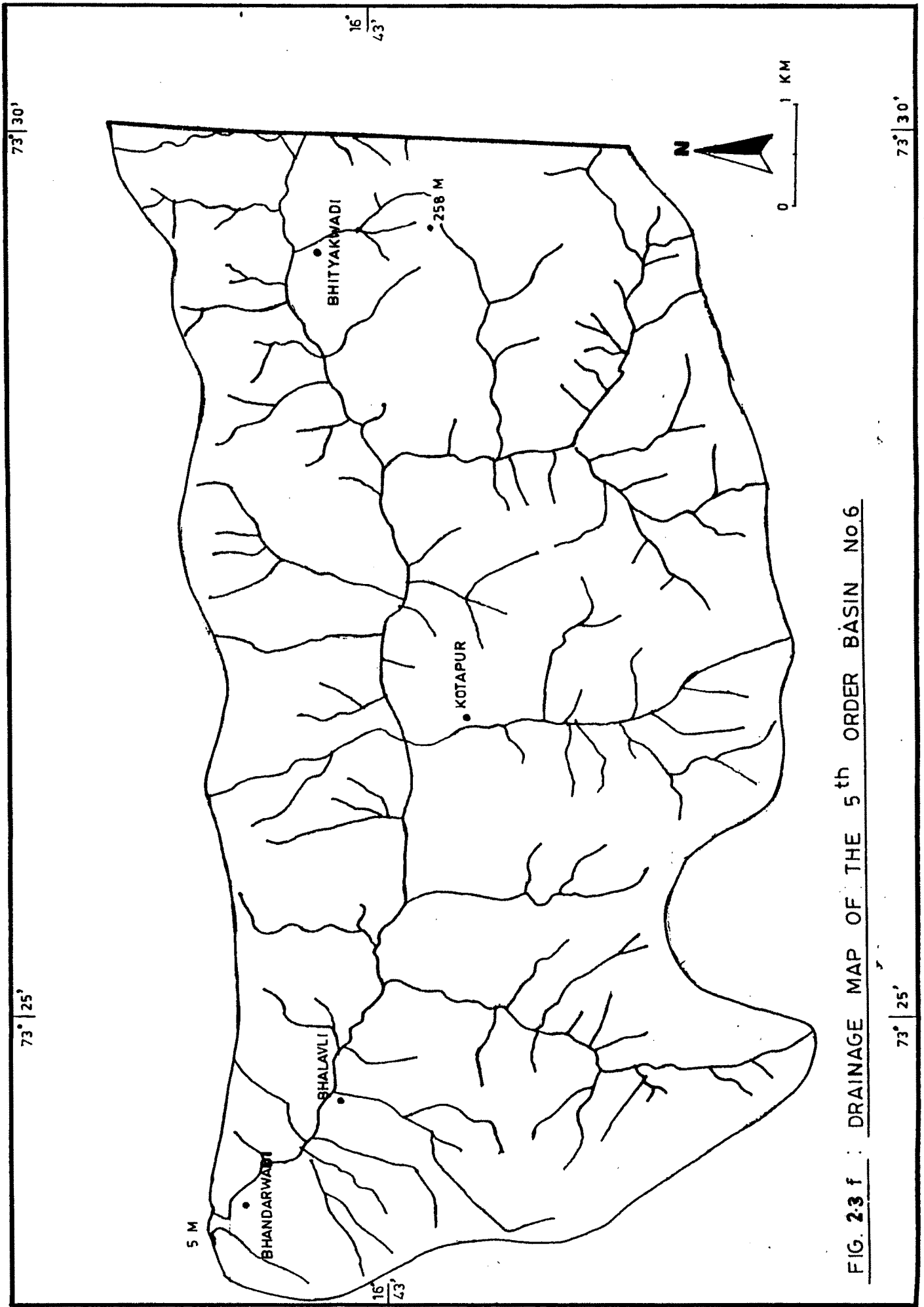


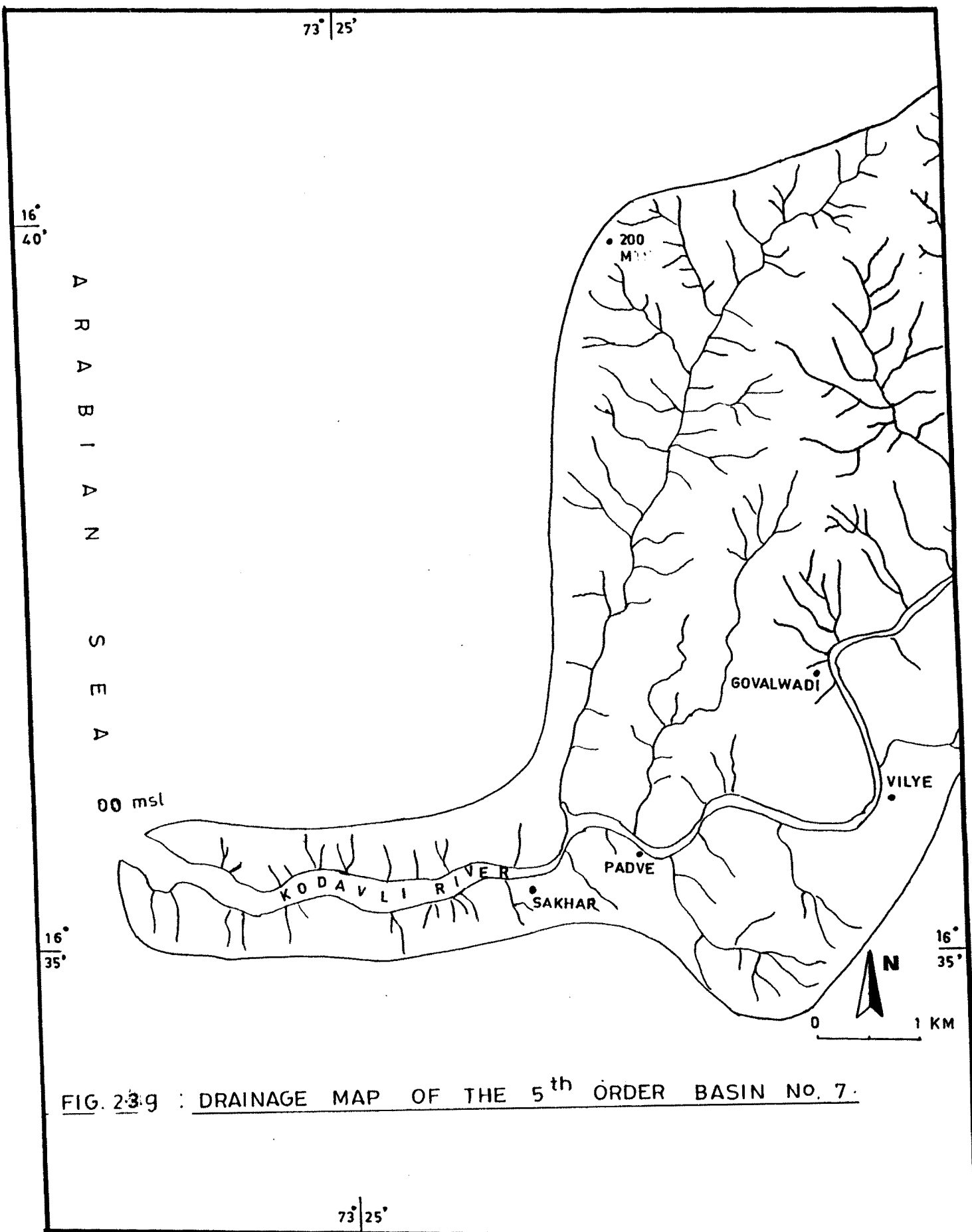
16°  
50'

FIG. 2-3d : DRAINAGE MAP OF THE 5<sup>th</sup> ORDER BASIN NO. 4

73° 30'







73° 25'

16° 35'

1. DANDA
2. VAK
3. SAKHAR
4. KOMBHE
5. AMBERKONI
6. PADVE
7. NANARWADI
8. NANAR
9. S. CHAVANWADI
10. GOTHIVRE
11. CHINCHAD

A R A B I A N S E A

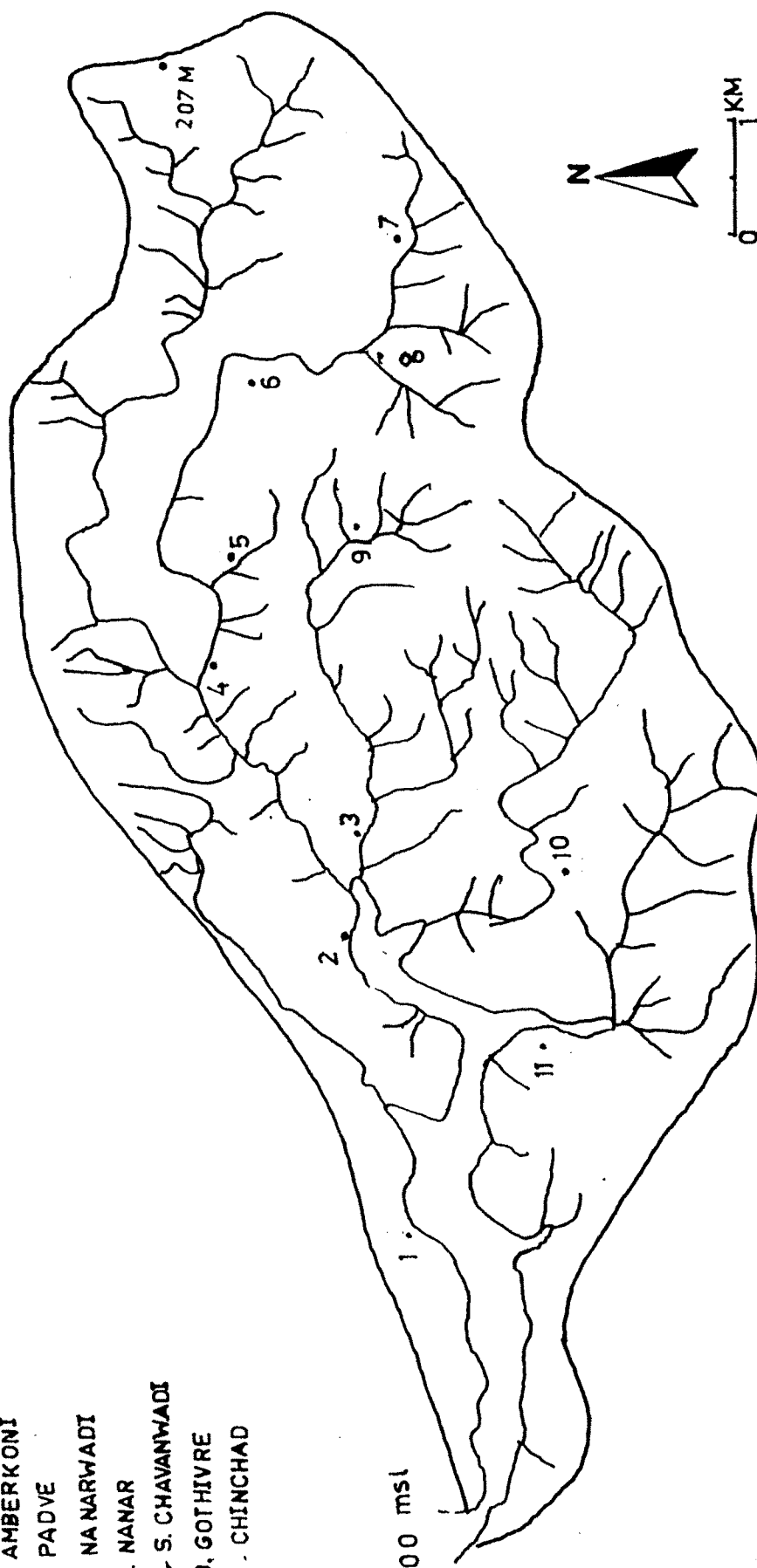


FIG 2.3 h: DRAINAGE MAP OF THE 5<sup>th</sup> ORDER BASIN No. 8

73° 25'

part.

The Konkan coastal belt has experienced changes in the sea-level due to the Pleistocene glaciation. The area under investigation has been formed through various stages of evolution. Taking into consideration these factors responsible in the development of the coastal tract, detailed and systematic geomorphological studies of the area have been undertaken.

Physiographically the investigated area can be divided into three parts from west to east, as;

- a. a narrow fringe of the Quaternary Sediments, generally more than 500 m. in width;
- b. steep rocky slopes encircling the plateaus and
- c. an undulating plateau rising 180 m. above msl in the eastern part of the area.

The geomorphic features can be classified mainly under two categories, as of the fluvial and of the marine types. The landforms identified in the region include the following features and are shown in fig. 2.4. These features along with their locations are listed in table 2.1. Various characteristics of these have been described in the following paragraphs.



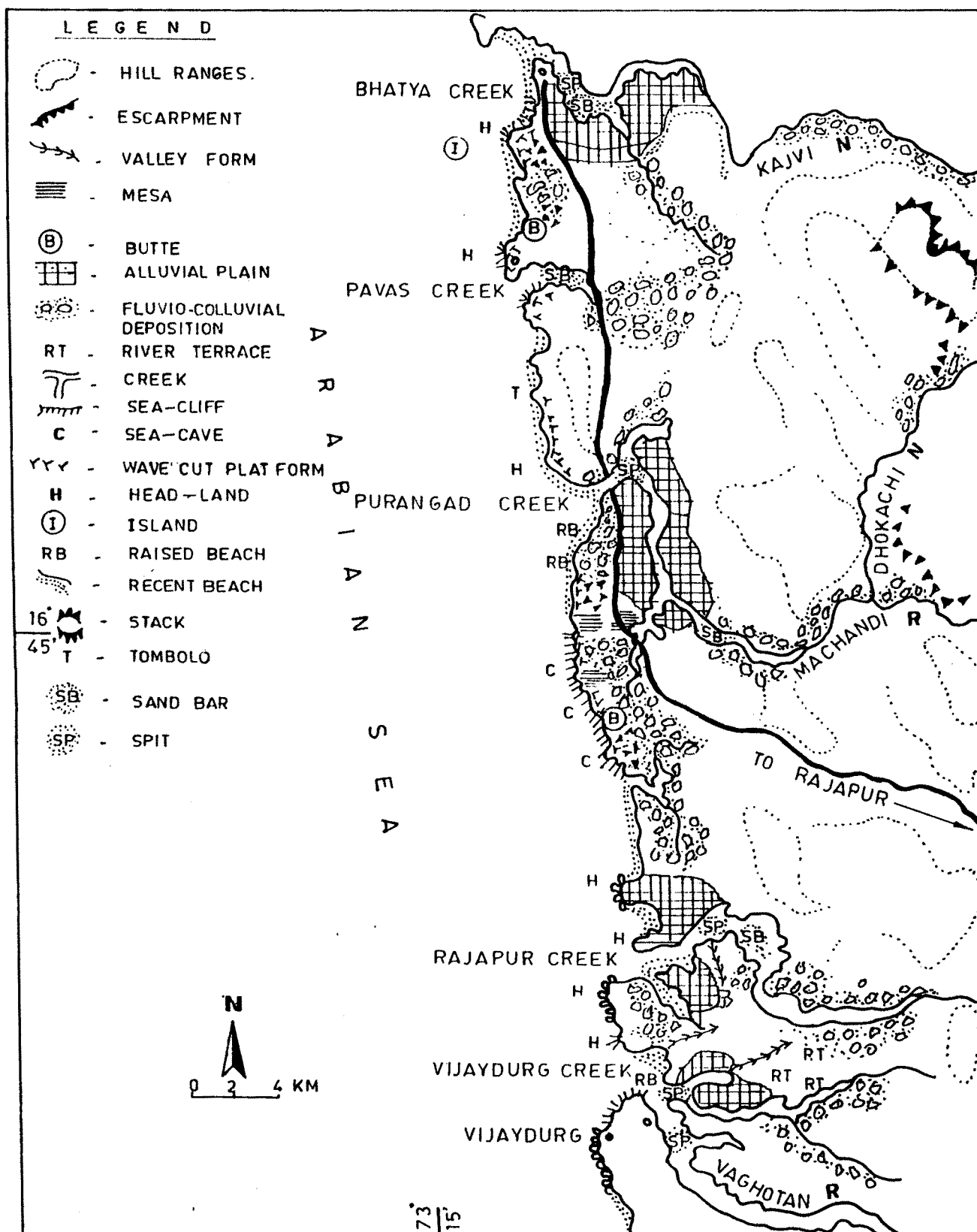


FIG. 2.4: GEOMORPHOLOGICAL MAP OF THE BHATYA VIJAYDURG AREA.

Table 2.1 : Geomorphological features, Bhatya-Vijaydurg area

Processes	Name of the feature	Location	
Features	A.Erosional	1.1 Planar surface	1.1 a 20-30 m.level
due			1. Bhatya 7. Advire 2. Simeshwar 8. WadaVatye 3. Thonde 9. Jaitapur 4. Bhandari 10. Madban 5. purangad 11. Ansure 6. Satavli 12. Danda 13. Vaki
to			
Fluvial			
Processes			
		1.1 b 90-100 m. level	1. Dugva 4. Lavgan 2. Golap 5. Solgaon 3. Nakhare 6. Nanar
		1.1 c 121-130 m.level	1. Umre 4. Kalkarwadi 2. Chandrai 5. Run 3. Teliwadi 6. Dasur 7. Nanarwadi
		1.1 d 180-190 m level	1. Kapadgaon 4. Kont 2. Pali 5. Kaltha 3. Punas 6. Javre 7. Khavadi

Processes	Name of the feature	Location
		1.1 e above 260 m level
		1. Dali Dongar
		2. Deogi Dongar
Features	1.2 Hill ranges and escarpments	1.2 a
		1. Punas
		2. Budhwada
		3. Kaltha
due	1.3 Valley	1.3 a
		1. Vaki
		2. Madban
		3. Vijaydurg
		4. Wada Kumbha
to		5. Bokarwadi
		6. Agavewadi
		7. Golap
Fluvial	B. Depositional	2.1 Alluvial plains
		2.1 a
		1. Bhatya
		2. Bhandarwadi
		3. Nate
		5. Danda
		6. Vaki
	2.2 Fluvio-colluvial deposits	2.2 a
		1. Vengane
		2. Nakhare
		3. Gaokhadi
		4. Nanarkewadi
Processes	2.3 River terraces	2.3 a
		1. Vaki

Processes	Name of the feature	Location	
Features A.Erosional	1.1 Creeks	1.1 a	1. Bhatya 4. Rajapur 2. Pavas 5. Vijaydurg 3. Rurangarh
	1.2 Tidal flats	1.2 a	1. Bhatya 4. Danda 2. Pavas 5. Jaitapur 3. Gaokhadi
	1.3 Sea cliffs and sea caves	1.3 a	1. Kurli 4. Kalakawadi 2. Kasop 5. Khadakawadi 3. Bokarwadi 6. Haldavan
Marine	1.4 Wave cut platform	1.4 a	1. Vengani 4. Wada Khurd 2. Narkewadi 5. Bokarwadi 3. Desaibhand
	1.5 Headlands	1.5 a	1. Bhatya 4. Ambolgarh 2. Ranpur 5. Musakazi 3. Gaokhadi
Processes	1.6 Islands	1.6 a	1. Kosop 2. Juve Jaitapur
	1.7 Stacks	1.7 a	1. Vengani 3. Narkewadi 2. Guravwadi 4. Kalkawadi

Processes	Name of the feature	Location	
B. Depositional	2.1 Sandbars and Tombolos	2.1 a	1. Bhatya 5. Kurdha 2. Gavada Ambera 3. Gaokhadi 6. Kajli river 4. Danda 7. Bhandarwadi
	2.2 Spits	2.2 a	1. Kajli river 2. Machakandi river 3. Kodavali river 4. Vaghotan river
	2.3 Raised beaches	2.3 a	1. Gaokhadi 2. Danda
	2.4 Recent beaches		1. Bhatya 4. Bahdari 2. Narkewadi 5. Waditivare 3. Gurovwadi 6. Madban
Features due to aeolian processes	1.1 Sand dunes		1. Ranpur 2. Bhandari 3. Guravwadi 4. Gaonkhadi 5. Wadativare

## I Features Due to Fluvial Erosion :

### 1. Planar surfaces

The planar surfaces indicate the former levels of erosion, which have been mentioned in literature mainly by Radhakrishnan (1967). He believes that the position of laterites at higher elevation is due to the uplift and tilting from the original level at which it was formed. Vaidyanadhan (1967), while studying the geomorphic history of India has explained the major erosional surfaces. Pardhasaradhi (1976) observed that the laterites are restricted to the surface around 100 m. altitude. According to him, it is uplifted and flexured during Plio-Pleistocene time. The same observations have been made by Shriram and Prasad (1979) and Sambandan and Prasad (1980). The presence of the planar surfaces for all the fifth order basins present within the area have been confirmed by the field checks followed by constructing E-W topographic profiles parallel to the latitudes at 2 cm. interval on Survey of India topographic sheets on the scale 1:50,000 (Figs. 2.5a, b, c, d, e, f, g and h) and were superimposed to decipher common levels. These planar surfaces have been recorded at 20 to 30 m. 90 to 100 m. 120 to 130 m. 180 to 190 m. and over 260 m. above msl. These prominent planar surfaces have been shown in fig. 2.6. It has been observed that the lower most planar surface of 20 to 30 m. above msl corresponds to tidal flats, which merge with the lower levels of river terraces. The

- H - DEOGI (>260 M.)  
 G - DALI DONGAR(>260 M)  
 F - KAPADGAON (190 M)  
 E - CHANDRAI (130 M)  
 D - UMRE (130 M)  
 C - DUGVA (90 M)  
 B - THONDE (20 M)  
 A - SOMESHWAR (20 M)

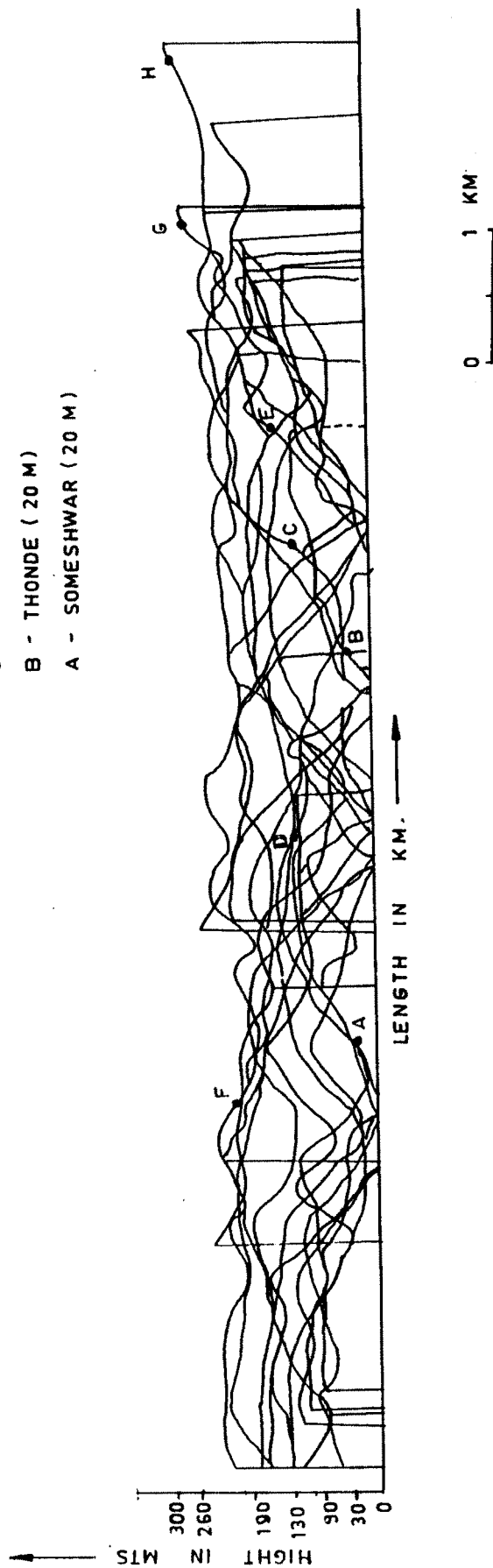


FIG. 2.5 a PLANAR SURFACES OF THE 5<sup>th</sup> ORDER BASIN No.1  
 INDICATED BY SUPERIMPOSED PROFILES.

B - NAKHARE ( 90 M )  
 A - PAVAS ( 30 M )

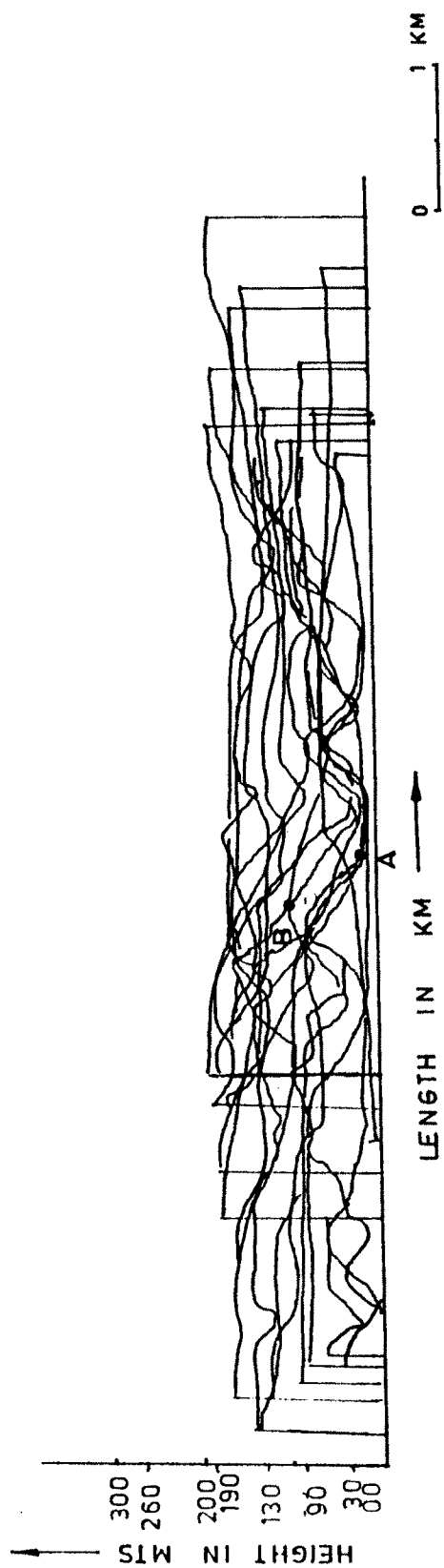


FIG. 2.5 b : PLANAR SURFACES OF THE 5<sup>th</sup> ORDER BASIN No.2  
 INDICATED BY SUPERIMPOSED PROFILES.



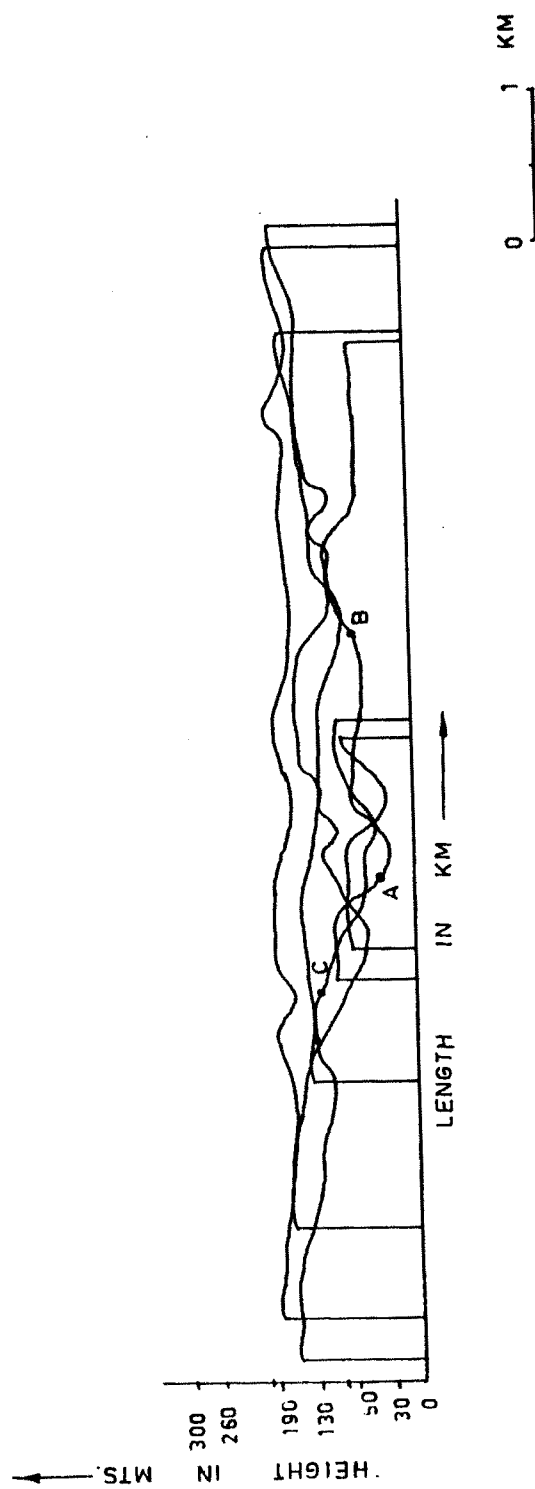


FIG. 2.5C : PLANAR SURFACES OF THE 5th ORDER BASIN No. 3.  
 INDICATED BY SUPERIMPOSED PROFILES.

C - KHAVADI (190 M)  
 B - JAVRE (190 M)  
 A - RAVARI (90 M)

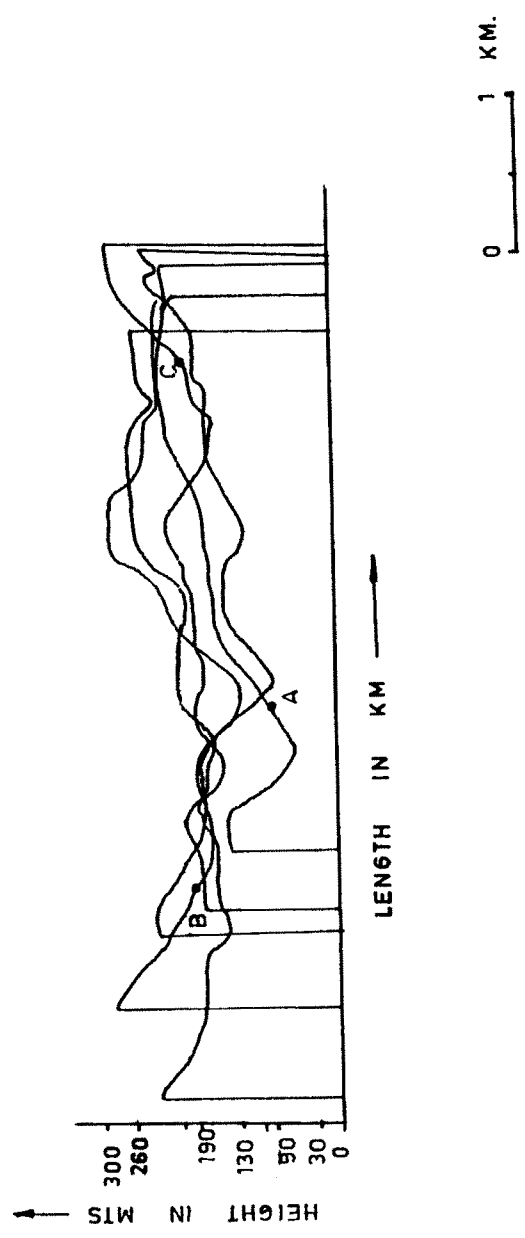


FIG. 2.5 d : PLANAR SURFACES OF THE 5<sup>th</sup> ORDER BASIN No. 4.  
 INDICATED BY SUPERIMPOSED PROFILES

C - DASUR ( 130 M )  
 B - RUN ( 130 M )  
 A - SATAVLI ( 30 M )

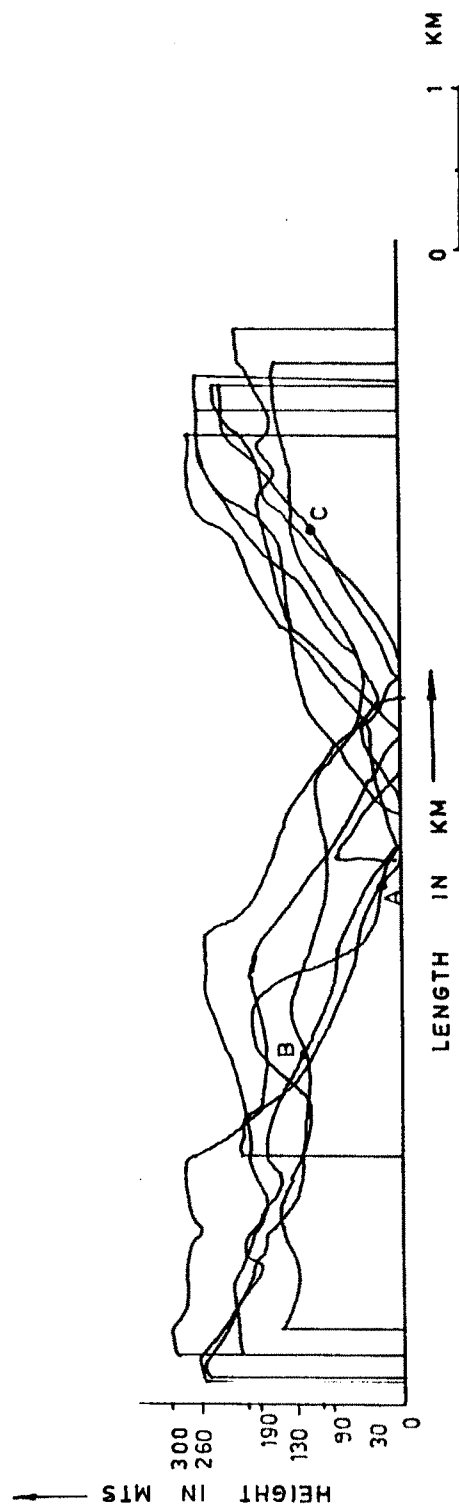


FIG. 2.5e : PLANAR SURACES OF THE 5<sup>th</sup> ORDER BASIN NO. 5  
 INDICATED BY SUPERIMPOSED PROFILES

- C - KOTAPUR (90 M)
- B - BHARDAWADI (90 M)
- A - BHALAVLI (30 M)

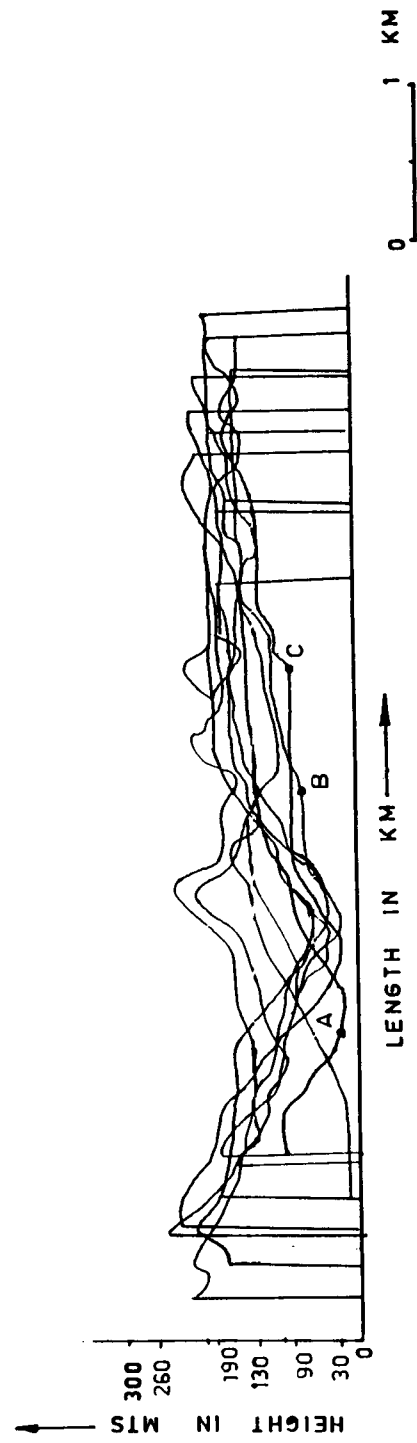


FIG. 2.5 f : PLANAR SURFACES OF THE 5<sup>th</sup> ORDER BASIN No. 6.  
INDICATED BY SUPERIMPOSED PROFILES.

- C - DHOPESHWAR (130 M)
- B - VILYE (90 M)
- A - DEVACHE GHOTNE (30 M)

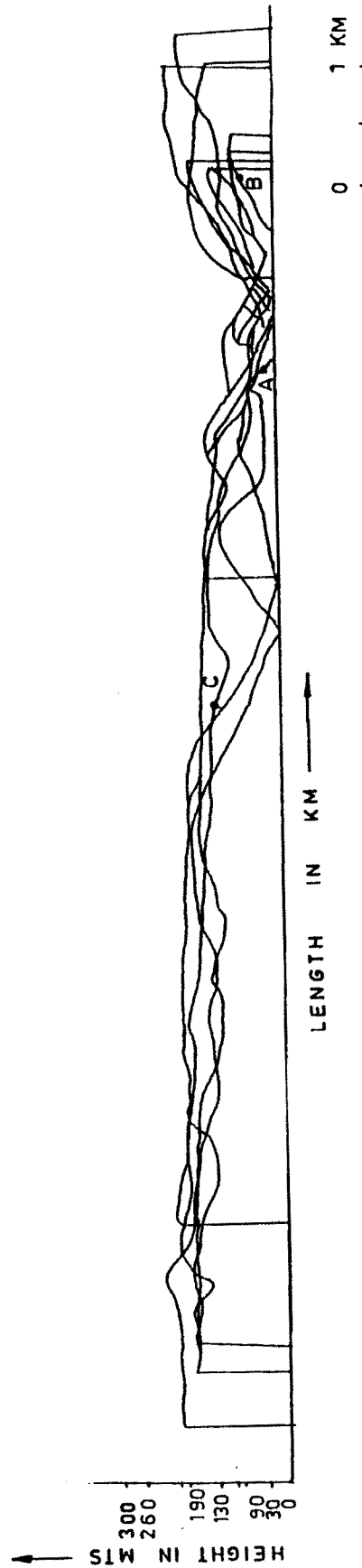


FIG. 2.59. : PLANAR SURFACES OF THE 5<sup>th</sup> ORDER BASIN No.7.  
INDICATED BY SUPERIMPOSED PROFILES.

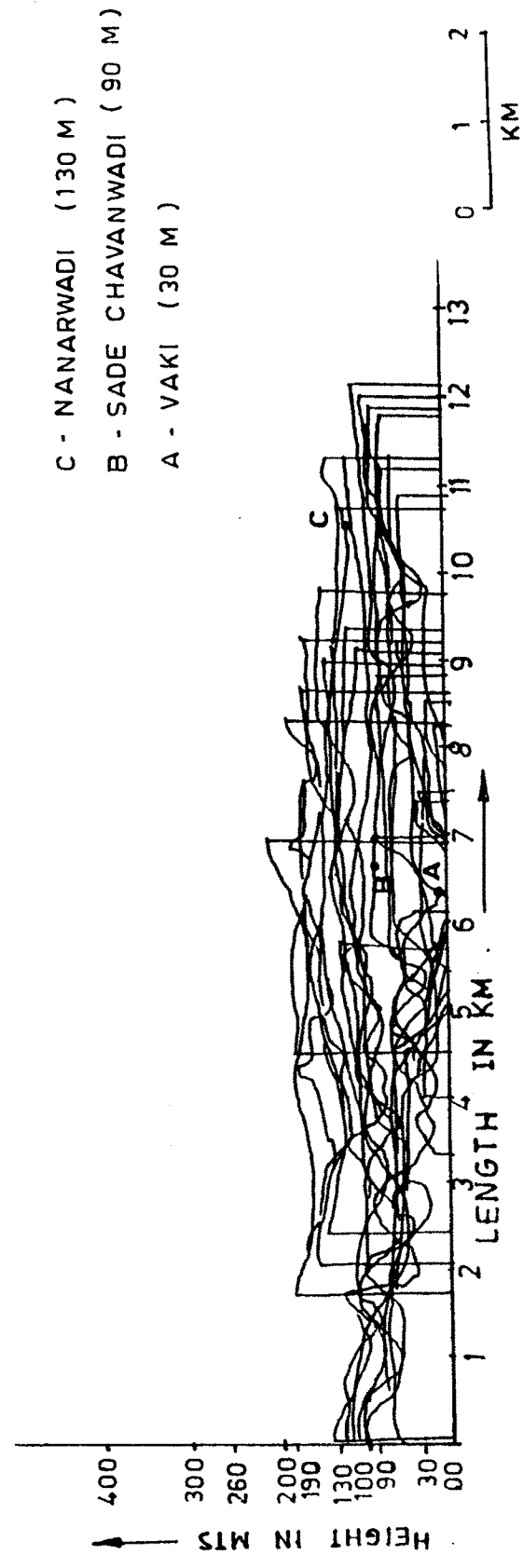


FIG.2.5h: PLANAR SURFACES OF THE 5<sup>th</sup> ORDER BASIN No8.  
INDICATED BY SUPERIMPOSED PROFILES.



presence of raised beach sections of the Quaternary Sediments also correspond to the same level (Plate I, Photo 2).

## 2. Hill ranges and Escarpments

The hill ranges are present mainly in the eastern part of the area. The hills exhibit escarpments upto 100 m. in height. The strikes of these hill ranges are oriented in nearly NNW-SSE and NE-SW directions. These are the major lineaments on the satellite imageries and topographic sheets. It has been observed that generally the western sides of the hill ranges are the escarpments, while in other directions the hills have gentler slopes. During the field investigations, the escarpments have been observed at about 1.5 km. due north of Punas and at about 1 km. south of Budhwadi.

## 3. Valleys

The river valleys are about 12 to 15 km. in length and flow nearly in E-W direction. The valley sides are generally steep in the upper reaches. At the mouth of the river, valleys are broad and 'U' shaped. The width varies from 200 to 600 m. Development of river terraces on the Vaghotan river has been observed at Vaki, Madban and Jaitapur villages. The height of the terrace from the river bed is about 2 to 2.5 m.

## 4. Mesa and Butte

Mesa or the table-land topography is commonly



represented by plains and plateaus in the area investigated. They differ in size and also in height above the surrounding ground. They are mainly flat topped, while other hill tops have very gentle but uniform slopes. Mesas are capped by the laterites, which preserve their surfaces from rapid erosion. The mesas have been observed north of Bokarwadi and west of Agavewadi. (Plate II, Photo 1).

## II Features Due to Fluvial Deposition

### 1. Alluvial plain

The alluvial plain consists of gravel, sand and slit which have been developed on either side of the major rivers, viz, Kajali, Machakandi, Kodavli and Vaghotan. The alluvium at some places is found to be more than 10 m. thick and merges with the extensive tidal flats. This has been observed at Bhatya, Bhandarwadi, Nate, Jaitapur, Danda and Vaki. A typical alluvial plain feature is developed at about 500 m. due SW of Danda.

### 2. Fluvio-colluvial deposits

These deposits consist of huge boulders, gravels, and fines that accumulate at the foot of the hill ranges due to gravity sliding. The laterites are found to be the main constituents of these deposits. They are noticed due west of Vengani, Nakhare, Gaonkhadi and also due west of Nanarkewadi, Desaibandh, Bokarwadi, Tulsunde. A typical colluvial deposit

has been observed at about 200 m. due west of Nakhare village. (Plate II, Photo 2)

### 3. River terraces

These are developed in the lower reaches of the major river valleys, and range in height from 2 m. to 6 m. with the width of about 25 m., such a typical terrace is observed at Vaki in the Machakandi river course having the thickness of about 2 to 3 m. consisting medium to fine grained sand and silts. A typical river terrace is developed near Vaki village. (Plate III, Photo 1)

## III Features Due to Marine Erosion

### 1. Creeks

The coastal tract is embanked by a number of creeks. The major ones are at Bhatya, Pavas, Purangad, Rajapur and Vijaydurg creeks. These are developed generally in east-west direction and have been found to follow prominent lineaments on topographic sheets and also on LANDSAT-1 imageries. Besides these creeks, there are also few minor creeks present in the area.

### 2. Tidal flats

These are extensively developed at Bhatya, Pavas, Gaonkhadi, Danda, Jaitapur and Pangerwadi. The consolidated and unconsolidated fine sized sediments form the constituents of mudflats. These are covered by a thin veneer of mud, along

with encrustations of salt. Towards the sea-front, they are influenced by the tides. These mudflats towards east merge with 20 m. planer surface.

### 3. Sea cliffs and sea caves

Sea-cliffs are developed along the shore line due to the erosional activity of the sea waves. The cliffs are commonly 15 to 20 m. in height and have been traced at about 150 m. south of Bhatya (Plate III, Photo 2) at about 200 m. due west of Vengani, about 200 m. due north of Bokarwadi, about 300 m. west of Kalakawadi, about 500 m. west of Wada Kombha, wadavatye, about 100 m. due south of Bakale and at Pangerwadi. The fresh and the degraded cliffs found along the coastal area could be of pre-, inter and post-glacial period. Such types of features have been observed along the coast of Western Scotland by Gray (1973).

Due to differential erosional activities of sea-waves, the sea caves have developed in the amygdaloidal, brecciated basaltic flows and in the lithomarge clay beds. They are observed at about 500 m. due west of Khadakawadi, 1 km. due south of Guravwadi and 1.5 km. due west of Haldvanwadi. (Plate IV, Photo 1) and (Plate IV, Photo 2).

### 4. Wave-cut platform

These are developed usually at the foot of the marine cliffs. They are best developed due west of Vengani, about

100 m. due south of Guravwadi, about 150 m. due west of Nanarkewadi, about 500 m. due west of Desaibandh, at Bokarwadi, about 100 m. due west of Wadakhurd and about 200 m. due west of Kalakawadi (Plate V, Photo 1). Large boulders of laterites have been found to be resting on the wave-cut platform, which are released from adjacent the sea-cliff. The rocks constituting sea-caves and sea-cliffs are lateritised. The rolled lateritic boulders present on the wave-cut platform are subjected to wave action exhibiting honey-comb structure, resulted due to differential erosion. Such feature is observed at about 500 m. due south of Bokarwadi village (Plate V, Photo 2).

#### 5. Headland

Number of headlands have been observed along the coastal tract of the investigated area. They represent the resistant, compact and hard rocks, devoid of any fractures. The prominent ones are observed at Bhatya, Ranpur, Gaonkhadi, Ambolgarh, Musakazi, Tulsunde. These headlands generally trend in NNW and SSE directions. A typical headland has been observed at Ambolgarh (Plate VI, Photo 1).

#### 6. Islands

The detached landmass has been observed in the form of Brum Mundle Rock Island exposed due NW of Kasop village, and about 1 km. due north of Juve Jaitapur, with an average elevation of about 10 m. above msl.

## 7. Stacks

Due to the continuous wave attack, wave-cut plain got widened as the shore-line was cut and gave rise to a typical erosional feature in the form of isolated column on the wave-cut platform, called as stack. Such types of stacks are observed at about 200 m. due west of Vengani, at about 1 km. due south of Guravwadi, at about 500 m. due west of Nanarkewadi and about 2 km due west of Kalakawadi village.

#### IV Features Due To Marine Deposition :

##### 1. Sandbars, Tombolos, and Spits

Sandbars are the depositional features developed at the mouth of all the rivers of the investigated area. The sediments have been supplied by the rivers, which, in turn, have been reworked by the sea-waves. The shapes of the sandbars are developed according to the intensity and direction of the approach of the sea-waves. In the present area, the sandbars are developed at Bhatya, Pavas, Ranpur, Gavda, Ambera, Gaonkhadi, Bhanderwadi, Danda. These sand-bars consist of sand and gravels alongwith the heavy minerals, and are developed parallel to the beaches. The well developed sandbar in the form of tombolo is seen at Kurdha (Plate VI, Photo 2).

The spits along the estuaries and backwaters are formed due to Pleistocene tectonism. It has been observed that the West Coast of India experience long-shore currents flowing from south to north. Nair (1987). The spits are formed due to prolonged northerly moving long-shore currents (Sambhasiva Rao, 1987). Well developed spits have been developed at the mouths of Kajali river, Machkandi river, Kodavli river and Vaghotan river. A typical well developed spit is observed due west of Pangerwadi.

## 2. Raised beaches

Adjucent to the high tide zone, towards the land, the raised marine beach sections have been observed. These are present all along the northern part of the investigated coast. However, the raised beaches have also been observed in the southern part i.e. at Gaonkhadi and Danda. The elevation of these beach sections vary between 0.60 m. to 1.30 m., extending for about 400 m. to 1.8 km. . A raised marine beach section, covered by the suru plantation is observed at Bhatya village. (Plate VII, Photo 1) The presence of raised beach sections along the coast represent the sea-level changes during the Quaternary period (Sukhtankar, 1986). These raised beaches consist of fine to medium sand comprising fragments of lamillibranch shells.

## 3. Recent beaches

Beaches having variable width are observed at Bhatya, Nanarkewadi, Ranpur, Bhandari, Giravwadi, Gaonkhadi, Wadativare, Madban. Beaches are extended from 300 m. to 4.6 km., with average width of about 250 m.

Primary Sedimentary features like ripple marks, reel marks are commonly observed in the low-tide region, having alternate strips of white and dark coloured sands along with lateritic fragments.

#### 4. Sand dunes

Sand dunes are developed adjacent to the raised beach section. However, they are found to be stabilised due to vegetation cover. Whereas, those adjacent to the beach appears to be in the process of formation.

The stabilised dunes are about 3 to 5 m. in height. The height is increasing gradually towards south. They are composed of fine-grained sand with broken fragments of lamellibranch shells along with the heavy minerals. The good sections have been observed at Bhatya, Ranpur, Bhandari, Guravwadi, Gaonkhadi, Wadativare, Kasop. (Plate VII, Photo 2)

#### DISCUSSION

The coastline under present investigation is marked by the geomorphic features of both fluvial and marine origin. From the characteristics of geomorphic features, it is seen that the coastline is predominated by the marine geomorphic origin. These are of both marine erosional and marine depositional characters. The spatial distribution, however, does not indicate any specific pattern and it is found that the features of the marine origin have been intercalated by those of marine depositional characters. These features indicate mixed response of the coastline to tectonic/neo-tectonic activities.

The present coast under investigation is developed due to rifting and faulting of the Indian Subcontinent from South



Africa under the Plate Tectonics concept. The rifting has been considered along NNW direction and has classified the coast line under present investigation as an evidence of submergence (Ahmed, 1972; Dikshit, 1976 and Powar, et. al., 1978). According to Powar, et. al. (1978), the presence of hinge fault axis, which runs in E-W direction along the Kundalika river has given rise to the geologic features of emergent characters to the north of hinge line, whereas, the features of submergence to the south of hinge-line.

On the basis of geomorphological characters of primary and secondary laterites, it can be inferred that the coastal tract around Ratnagiri has experienced neo-tectonic activity. According to Kale and Rajguru (1985), it is represented by Neogene and Quaternary marine transgressional and regressional cycles. On the basis of the geomorphic features, it is a "Ria coast" of submerged type (Bruckner, 1989). The detailed evolutionary history of Konkan Coast including the shoreline has been presented by Powar, et. al. (1978), Patil (1981), Tiwari (1984), Bruckner (1987, 1989). They have indicated that the coast is resulted due to marine transgression and it is being formed and subjected to marine regression phases, during the Holocene period.

The presence of headlands, sea-cliffs and islands in the area of investigation suggest the submergence of the coast. Whereas, presence of raised marine terraces suggests the marine transgressional phase. Thus the coast reveals the

development of geomorphic features of both i.e. marine erosional and depositional types.