CHAPTER - IX

G E O M O R P H I C E X P R E S S I O N

GENERAL

As has already been allued to, in order to go into the different aspects of the Tertiary and Quaternary rocks of the study area, the author made full use of remote sensing tools followed by actual ground truth checking. The Landsat Image and air photos have provided excellent evidences of the close relationship existing between surface morphology and sub-surface structures. In this chapter the author has exclusively dealt with the geomorphic expression of the geology of the area, as

revealed mostly by air photos.

Geomorphic expression of the underlying Tertiary geology in a terrain which is more or less featureless and covered by a thin veneer of Pleistocene are best observed. These various structures like anticlines, domes and faults are almost totally undectable on the ground. The aerial photographs allow an unexcelled view of terrain features. All of the methods for the detection of geologic structures in flatlands by the study of aerial photographs rest on one fundamental assumption. This assumption is that the affect of geologic structures is continuously propogated upward to the surface although the major development of the structure may have occured far back in the geologic past. It means that all structures, underlying the flatlands, are expressed on the present surface even though that expression may be so subtle as to escape detection by field surveying. The effect of a geologic structure may be propogated upto the surface by actual movement of rocks involved in the structure. The faults offset alluvial deposits and the regularity of the fault pattern indicates it as a regional rather than a local feature, and involves basement rocks.

Buried geologic structures are manifested on the surface by subtle topographic expressions. Reactivation of faults and draping of rocks over an upwarp results in a topographic high over the structure. This topographically high area may be

very weakly developed and may be only half-a-meter high in the centre than at the edges. Such a feature cannot be determined on the ground.

Two methods have been used to analyse the aerial photographs for the detection of subtle topographic highs. One comprised the study of the drainage pattern and the other was that of scrutiny of photographic tone.

Streams are the most sensitive indicators of structures in flatlands. A slight topographic rise in a flatland area may affect streams. A new drainage system may form and drain the high area or streams may be partly or wholly deflected around the high area, and in some cases the existing streams may be able to maintain their way across the slowly rising topographic high and not be deflected but undergo changes in channel characteristics. A stream which maintained its course across a rising uplift would show incised channel over the uplift. Thus, changes in stream pattern have been carefully examined and studied for geologic structural interpretation.

Another important aspect is of tonal variation on aerial photos. The relative tone or the tonal differences are important in distinguishing and mapping various types of stream deposits, such as abandoned meanders and old levee systems which give information on the stream development and history. Mapping of tonal anomalies or haloes are useful in the geological

interpretation.

Fracture trace and lineament mapping is possible by their manifestation as thin lines of vegetational and soil tonel, and drainage alignment on aerial photographs. The fact that these features are expressed through deposits of such recent age is evidence of their continuous upward propogation to the surface. This is attributed to neotectonic activity extending fractures, faults and highs to the surface (Agarwal, 1979). Lineaments are considered to be the only surface expression of subsurface faulting and are mappable through the above criterion on aerial photographs.

A great advantage in photogeologic interpretation from satellite imagery is the capability for truly synoptic examination of regional geologic features, such as lineaments and other geomorphic features with dimensions of tens to hundreds of kilometers, which generally are not detectable on conventional aerial photographs.

GEOMORPHIC FEATURES FROM DRAINAGE ANALYSIS

A drainage map of the study area has been made from the aerial photo-mosaic in order to study the drainage pattern and detect geologic features. Certain geologic features observed in the study area had been examined on the ground for their topographic details. Special attention was paid to the

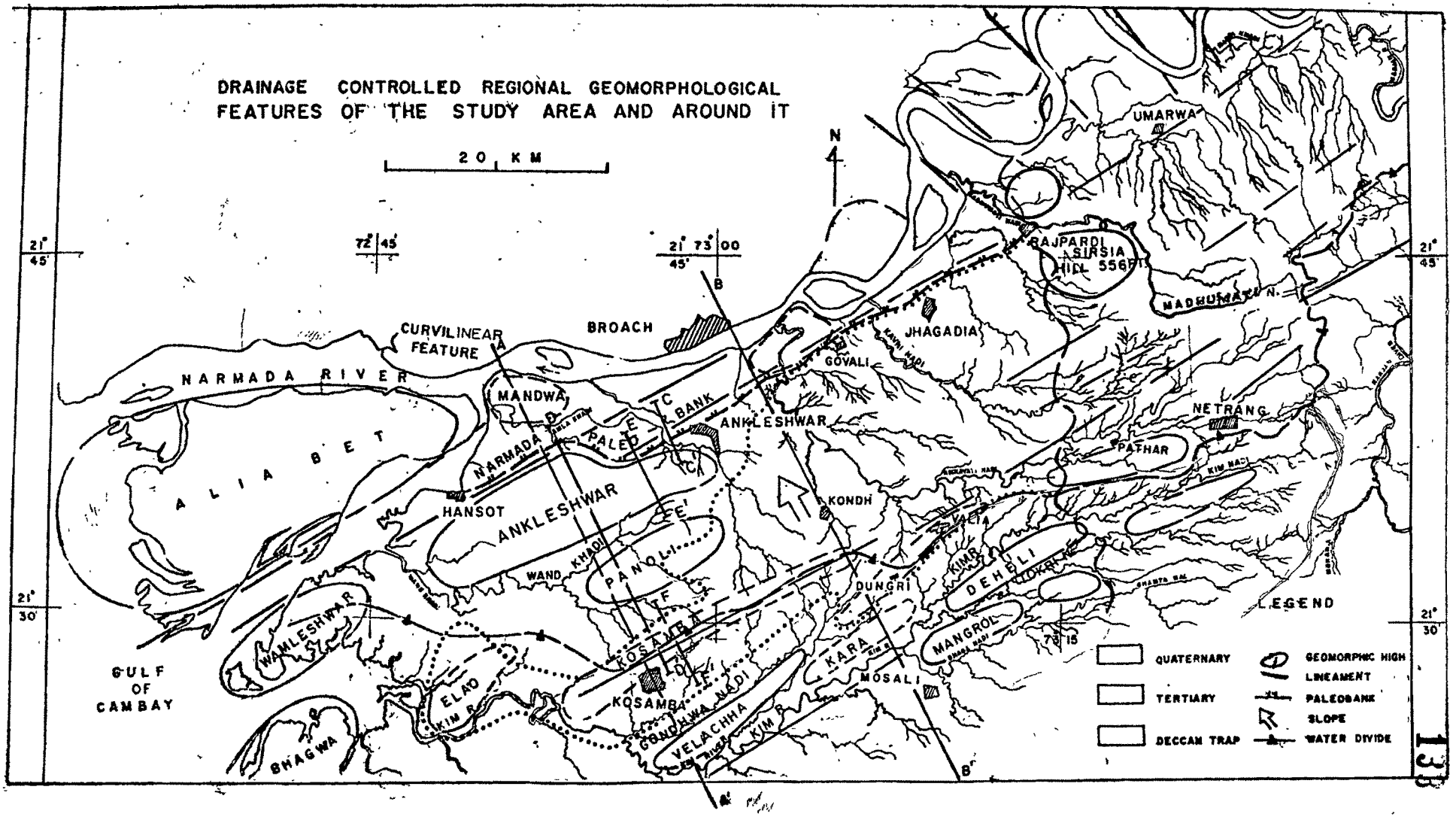
mapping of geologic features representing structural highs and corresponding structural lows from the drainage pattern. The drainage pattern map (Fig.IX.1) indicates that there are 17 significant and prominent circular to elliptical geomorphic features in the study area and its neighbourhood. The drainage map has been prepared to include the neighbourhood of the study area so that the geomorphic features could be studied in the regional perspective and the features could be viewed in totality and continuity.

The most striking characteristics of the geomorphic features delineated are that they are linear and trend NE-SW. This trend is in conformity with that of the geological structures mapped from the exposed rocks of the Tertiaries.

Mandwa Geomorphic Feature

It is located in the NW of the study area. It is a near circular feature, and is marked by the semi-circular course of the Narmada river, specially marked by the left bank of the river (Fig.IX.1). The circumventing of the river around it is also conspicuously marked in the Landsat Image (Fig.VIII.1, Plate VIII.1). The course of the river suggests the presence of a topographic high which the Narmada river had to circumvent in its downward course WSW of Broach town. This geomorphic feature is in alignment with the Aliabet geomorphic high to the SW, and could possibly be the NE part of that overall high.

Fig. IX·1


DRAINAGE CONTROLLED REGIONAL GEOMORPHOLOGICAL FEATURES OF THE STUDY AREA AND AROUND IT
20 KM
N
72° 45'
21° 73° 00'
45'
21° 45'
21° 30'
UMARWA
RAJPARDI
SIRSIA HILL 556 FT.
MADHUMATI N.
JHAGADIA
GOVALI
BROACH
CURVILINEAR FEATURE
NARMADA RIVER
MANDWA
NARMADA
PALEO
C BANK
ANKLESHWAR
NETRANG
PATHAR
KIM RIVER
ALIA BET
HANSOT
ANKLESHWAR
KONDH
WAND KHADI
PANOLI
DUNGRI
DEHELI
TOKRI
KIM
WAMLESHWAR
GULF OF CAMBAY
ELAV
KIM R.
KOSAMBA
GONDHWA NADI
VELACHHA
KIM
KARA
MOSALI
MANGROL
BHAGWA
LEGEND
QUATERNARY
TERTIARY
DECCAN TRAP
GEOMORPHIC HIGH
LINEAMENT
PALEOBANK
SLOPE
WATER DIVIDE

The southern channel of the Narmada river appears to have cut across the feature separating the Aliabet Island from the Anklesvar area to the SE, and as discussed earlier there is a tendency for this channel of the Narmada river to be weak and the main flow is observed along the northern channel.

This geomorphic feature lies between the left bank of the Narmada river and the Narmada paleo-bank. This suggests that in the geologic past the Narmada river was flowing over this feature with its left bank along the paleo-bank and debouching in the Gulf of Cambay along its present southern channel. With the late Quaternary neotectonic activity, the Hansot-Anklesvar area was uplifted which made the Narmada river to migrate northward and possibly opened up a new channel to the north giving rise to the Aliabet island. Thus the Mandwa geomorphic feature has a significant geomorphic aspect.

Ankleswar Geomorphic Feature

This feature is located SW of Ankleswar town and is the largest in the area. It is about 25 km long and about 15 km wide. It trends NE-SW, and is marked by the circumventing of the Narmada paleo-bank to the NW and the course of the Wand Khadi to the south. This feature is also prominently marked on the Landsat Image of the area. It is a gentle topographic high. This feature represents the surface expression of a

gravity and magnetic anomaly high (Agarwal, 1983) and has been proved to be a large subtle doubly plunging anticlinal structure from the seismic surveys. This structure, in fact marks the site of a large oil and gas field of Cambay basin with hundreds of deep wells drilled over it (Fig.IX.2.A). The NE-SW trend of the geomorphic feature is similar to the exposed Jhagadia anticline to the NE described in Chapter-VI. This indicates that it has been formed as a result of the same tectonic process.

Elao Geomorphic Feature

It is located in the SW part of the study area. The feature is about 10 km long and 4 km wide. It trends NE-SW, and lies between the Kim river and the Wand Khadi. The Kim river circumvents round the southern and the southwestern part of the feature. Small tributaries of the Kim river flow along the sides of it indicating the presence of a topographic high due to the uplift over the feature.

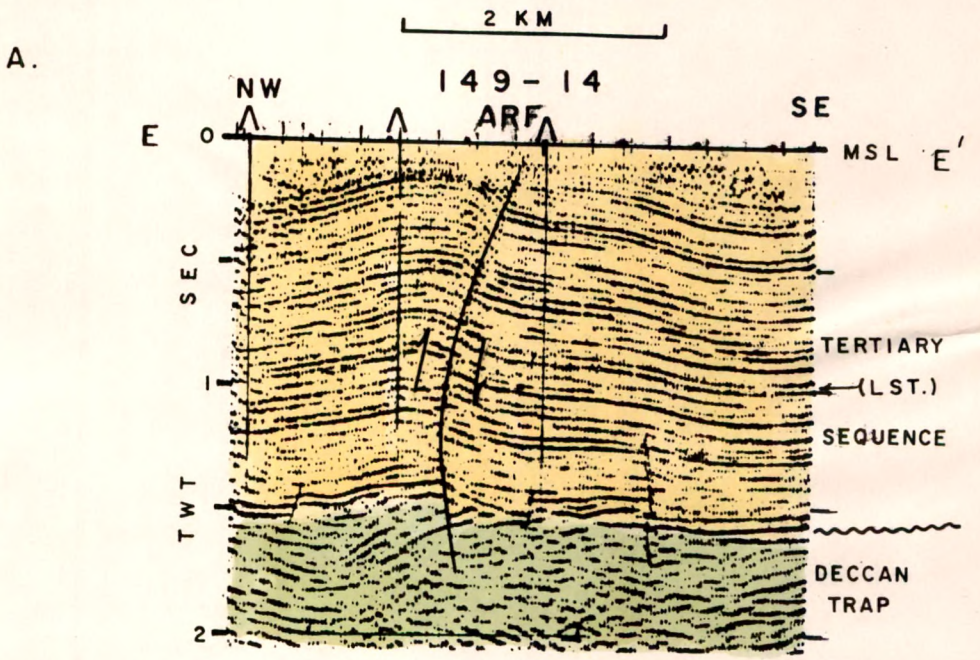
Panoli Geomorphic Feature

It is located between the Ankleswar and Kosamba towns. It trends NE-SW, and has a length of 15 km and a width of 5 km. Its geomorphic high expression is marked from the drainage pattern of the tributaries of the Wand Khadi (Fig.IX.1). The northern branch of the Wand Khadi flows SW along the low area. Its

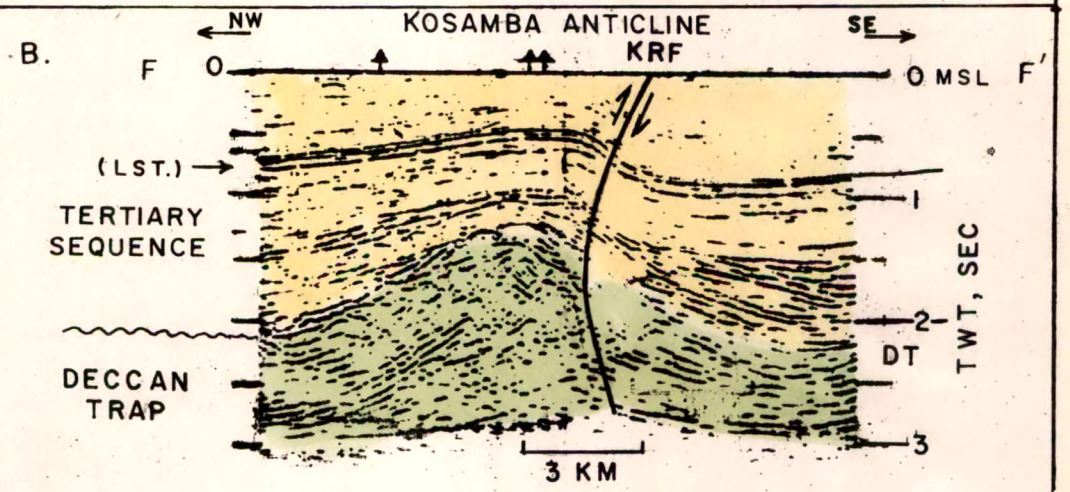
Fig. IX·2

FOLDING AND REVERSE FAULTING OF TERTIARIES

(FOR LOCATION SEE Fig·IX·1)



SEISMIC SECTION ACROSS ANKLESHWAR ANTICLINE SHOWING ANKLESHWAR - REVERSE FAULT ALONG SE LIMB



SEISMIC SECTION ACROSS KOSAMBA ANTICLINE SHOWING KOSAMBA REVERSE FAULT ALONG SE LIMB

AFTER AGARWAL, 1984

southern branch circumvents round the SW part of the geomorphic feature. One branch, however, cuts across the feature and joins the northern stream and is incised over the high suggesting a late uplift of the feature. East of the feature the drainage pattern changes and the streams flow N to NNW suggesting a change in the topographic expression of geomorphic features and their structural style. The geomorphic feature is aligned NE-SW which is similar to that of the exposed structural trends to the NE.

Kosamba Geomorphic Feature

It is located in the Kosamba area, and is a linear feature marked by the water divide of the Kim and the Narmada river tributaries. It extends for a length of about 30 km with a width of 3 km. It is a prominent and significant geomorphic high well represented by a topographic high. The National Highway No.8 runs across it, and while travelling from Broach to Surat, before meeting the side road to Kosamba town, a gentle rise in the ground is noticed and near the highest point which marks the crestal part of the structure, cherry red soil of Babaguru formation is noticed. The gentle topographic high of the Kosamba geomorphic feature extends all along the water divide and is easily discernible on topographic maps, aerial photographs and Landsat Image. On the Landsat Imagery the Kosamba feature is distinct from the lighter

tone and lineament trend. Seismic surveys and deep drilling carried out for oil exploration in the area had confirmed the presence of a structural high all along the geomorphic high (Fig. IX.2.B).

While carrying out the geological mapping of the area, with the help of the aerial photographs and ground checking, subtle anticlinal structures namely Kosamba and Dinod along this geomorphic feature had been mapped by the author. These have been described already in Chapter-VI (Structural style and Tectonic Framework). The Dinod structural feature, in particular, is very clearly represented as a doubly plunging elongated anticline with light and dark tonal bands on the aerial photographs.

Dungri Geomorphic Feature

It is located in the SE of the study area (Fig.IX.1), and trends NE-SW. The feature is 16 km long and 2 km wide, and occurs as a narrow gentle topographic high with a very subtle geomorphic expression. The village Dungri is situated in the central topographic high area, and on ground mapping the area is covered by nearly horizontal foraminiferal coquina limestones, hard and compact thereby resistant to weathering and exposed all along the geomorphic area, and also acting as the water divide of the tributaries of the Amravati stream to the NW and that of Kim river to the SW. At the SW end of the feature,

it is drained by two branches of the tributary of the Kim river. These branches drain the sides of the feature, and the axial part of the feature lies in between the branches as a high ground. A little south of Valia town to the NE, there are quarries near village Kanerav where the exposed foraminiferal coquinoidal limestone is dug up and used as a road metal in the nearby areas. The gentle dips to the NW and SE and the crestal part of the Dungri anticline have been observed. This anticlinal feature has already been described in Chapter-VI. The areal extent and trend of the Dungri feature could only be delineated from the detailed geomorphic investigations in the field with the help of aerial photographs. The light and dark tones on the photographs mark the trend of the structure and also indicate a NE plunge between the Valia town and the Kanerav village.

Velachha Geomorphic Feature

It is located in the southern part of the study area and is SE of Kosamba town (Fig.IX.1). The feature trends NE-SW and is about 15 km long and 3 km wide. It lies between the Kim river, and the Gondhwa Nadi which is it's branch. The feature is marked by a NE-SW trending topographic high between these two streams. The feature is in the SW extension of the Dungri anticlinal geomorphic high to the NE. Though no rock exposures were found on ground checking it is likely that the Velachha geomorphic high represents the continuation of the

Dungri anticlinal structure to the NE. The Gondhwa Nadi and the Kim river flow toward SW along the NW and SE sides of the Velchha high. The high banks of the order of 2 to 5 meters at places suggest that there had been a vertical mild uplift in the area which had incised the river, and meandering along its entire course suggests an increased gradient related to the uplift due to neotectonism.

Kara Geomorphic Feature

It is located in the SE part of the study area, and is to the SE of the earlier described Velachha-Dungri features. It also trends NE-SW with a length of 15 km and is about 2 km wide (Fig.IX.1). The Kim river flows SW along it's SE limit, and the NW boundary is drained by a branch of Kim river. This branch seperates the Kara geomorphic feature from the Dungri feature to the NNE. This feature also is in alignment with the regional NE-SW structural grain of the exposed and the partially exposed Tertiary structures, and suggests that it is related to a structural high well represented by a subtle topographic high from the drainage pattern.

Deheli Geomorphic Feature

It is located at the extreme SE part of the study area and trends NE-SW (Fig.IX.1). The feature is about 15 km long and 3 km wide. It is drained along its NW boundary by the Kim river

and along the SE by the Tokri Nadi, a tributary of the Kim river. The gentle topographic high area marks the Deheli feature.

It is important to note the significance of the SW flowing courses of the Kim river and its tributaries in the southern and south-eastern part of the study area where the above described Velachha, Kara and Deheli geomorphic features have been delineated. The drainage in this part of the area trends NE-SW and suggests that they are controlled by the uplift in the area. The trend of these uplifted features is in conformity with the exposed structures.

Gowali Geomorphic Feature

It is located ESE of the Broach town across the Narmada river in the northern part of the study area (Fig.IX.1). It is about 7 km in length and 4 km wide. The feature is situated between the Narmada river paleo-bank and the left bank of the Narmada river, near village Govali along the Broach-Jhagadia road. The entire area of the feature lies in the abandoned part of the Narmada river when it migrated northward. The existence of the feature is marked by the change in the course of the Narmada river. The Narmada river turns NW from its SW course, circumvents round the Govali feature and again resumes its SW course (Figure IX.1). The SE boundary of the Gowali feature is marked by the Narmada river paleo-bank, the remnants

of which can be seen along the new road across the Narmada river.

Padwania Geomorphic Feature

It is located in the eastern part of the study area, close to the Deccan Trap outcrops to the east (Fig.IV.1). The feature is marked by light and dark tone on the aerial photographs. The feature also exhibits a SW plunge from the pattern of the tonal change. The area of the feature is covered by cultivable ground and to the NE the outline of the feature is not seen on the aerial photographs. Along the north-south road, near Padwania village, yellow and variegated clays of the Vagadkhol formation are exposed forming the axial part of the structural high.

Gallyaphalla Geomorphic Feature

It is located south of the above described Padwania feature, in the eastern part of the study area (Fig.IV.1). This feature is also marked by light and dark tone on aerial photographs. The feature exhibits a SW plunge and falls within a cultivable land. The road joining Gallyaphalla with Padwania to the north, runs N-S, and exposures of Vagadkhol formation are seen. After some gap, covered with soil to the east, Deccan Traps are exposed.

Hutiyapur Geomorphic Feature

It is located further south of the above described Gallyaphalla feature and is marked by a faint lighter tone on the aerial photographs as compared to the darker tone in the surrounding area (Fig.IV.1). It also exhibits a SW plunge though not very distinctly. Along the road to Dharoli town to the south, on its crossing the feature, Vagadkhol conglomerates are seen exposed at a place to the east of the road.

TOPOGRAPHIC PROFILES ACROSS GEOMORPHIC FEATURES

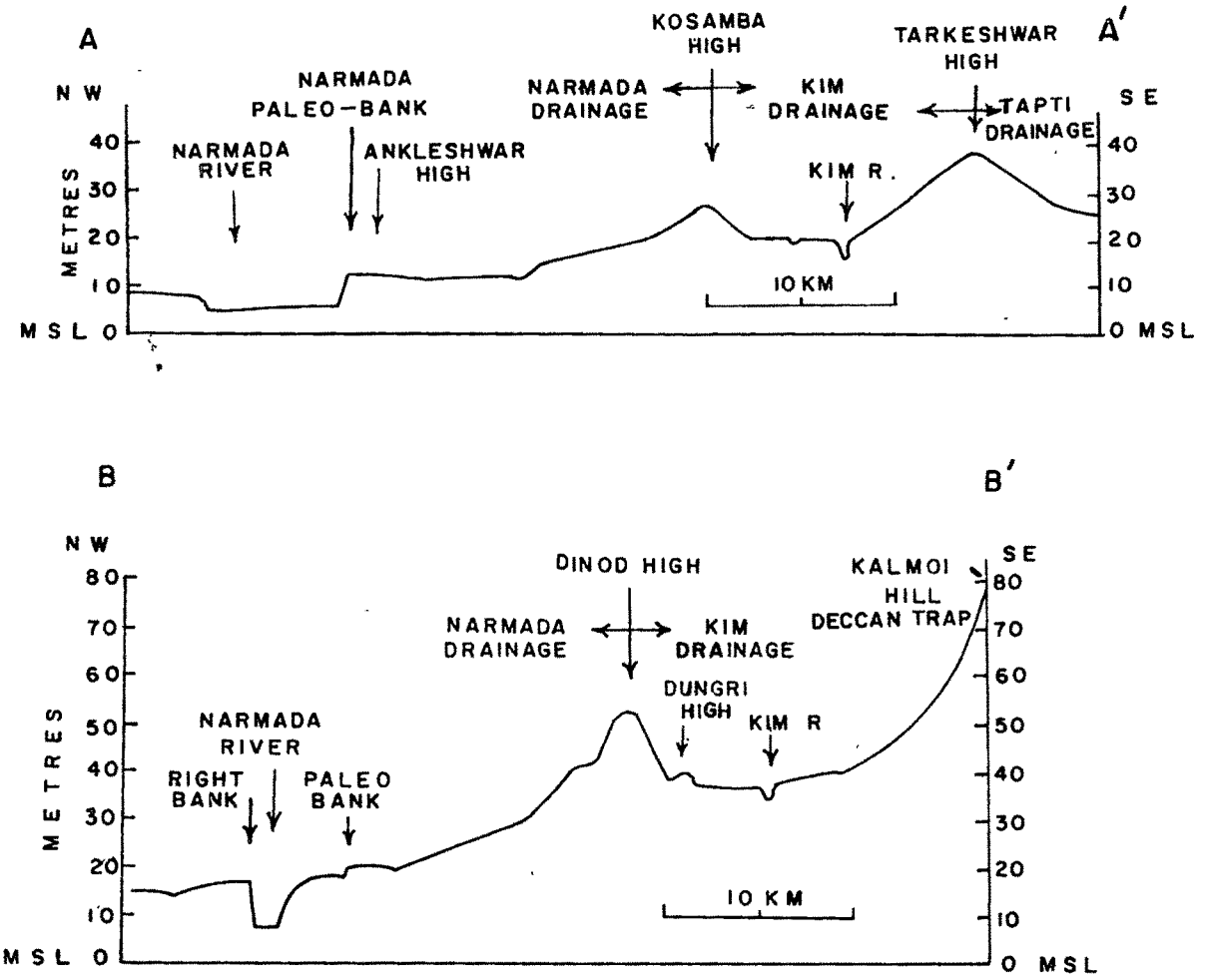
An attempt has been made to bring out the topographic manifestations of various geomorphic features across the NE-SW general structural trend by drawing two topographic profiles (Fig.IX.3). The profiles 'A' and 'B' cut across the entire area. The heights along the profiles have been taken from the topographic maps. The following features have been identified and their significance is also indicated.

1. Right-bank of Narmada river: In both the profiles A and B, the bank is marked as vertical cliffs due to the northward migration of the river and cutting along the bank.

2. Narmada river paleo-bank: The abrupt rise beyond the abandoned channel of the river well marked in profile-A

Fig. IX · 3

TOPOGRAPHIC PROFILES



TOPOGRAPHIC PROFILES ACROSS GEOMORPHIC FEATURES IN ANKLESHWAR AND KOSAMBA AREA

NOTE . 1 FOR LOCATION SEE FIG. IX · 1

2 VERTICAL EXAGGERATION 245 X HORIZONTAL

indicates the position of the abandoned left-bank of the Narmada river, designated as the Narmada paleo-bank (Fig.IX.1). It shows how the river migrated northward leaving behind the cliff of the left-bank during Quaternary (Plate VIII.1).

3. Ankleswar geomorphic high: On profile-A, close to the paleo-bank a pronounced topographic high, representing the Ankleswar geomorphic high is observed(Fig.IX.2.A).This topographic high is the surface manifestation of the Ankleswar structure, and is a major oil and gas field of the area. The uplift along the Ankleswar-Jhagadia, NE-SW, high during Quaternary was responsible for the circumventing of the Narmada river round the NE part of the Ankleswar high, and its northward migration.

4. Kosamba, Dinod and Dungri topographic highs: Along the topographic profile-A further to the SE, a high representing Kosamba geomorphic high is observed. From the geological and seismic data (Fig.IX.2.B) the topographic high is the surface manifestation of Kosamba structure, which is a small size oil and gas field. It may however be pointed out that the apparent high hill like appearance of the Kosamba and Dinod topographic highs is due to a large exaggeration of vertical scale which is 245 times of the horizontal scale. This has been done with a view to show up the gentler topographic

features. The topographic highs are infact only a few tens of metres high. The average height along the profile-A ranges between 5 to 40 metres in the length of 38 kms, and along profile-B between 15 to 55 metres in the length of 33 kms (distances are from the NE ends of the profiles to the Kim river). The above clearly demonstrates that the general topographic expressions of the area, through which these two profiles traverse are that of a nearly flat area. The meticulous plotting of heights along these two profiles have helped in the demarcation of various geomorphic features, through the above methodology.

The Dinod topographic high on profile-B stands out clearly, and the Dungri high by a very gentle high separated by a topographic low through which a tributary of Kim river flows.

5. Water divide of Narmada river and Kim river drainage systems: Kosamba and Dinod topographic highs form the areas along which the water divide of Narmada river to the NE and the Kim river drainage systems to the SW passes. The gradient of the Narmada drainage system is more as compared to that of Kim river drainage system.

6. Evidence of the presence of faults: The detailed analysis of the curves on the topographic profiles-A and B clearly brings out the effect of faults on the topography of the area. The Narmada paleo-bank, specially along profile-A suggests a fault with down throw towards NE along which the left bank of the river was present before the Narmada river migrated northward to its present course.

The SW side of the Dinod topographic high is steeper as compared to the NE, and suggests a fault along the SW side which is corraborated by the field geological data.

Similarly the SW side of the Kosamba high is somewhat more steeper than the NE, and suggests a fault along the SW side, and this is corraborated by the geological and seismic data.

SIGNIFICANCE OF LINEAMENTS OBSERVED ON AERIAL PHOTOGRAPHS AND LANDSAT IMAGE

A number of linear features have been observed while studying the aerial photographs and the Landsat Image of the study area. These lineaments are of great importance in the structural interpretation as many a times they represent the surface manifestation of the deep seated basement faults. Because of their subtle expression they remain undetected on

ground mapping. At times after observing them on the photos some of them could be identified and mapped on the ground. The lineaments mapped are described hereunder.

Narmada Paleo-bank: The NE-SW trending nearly a straight lineament, 55 km long is observed on the Landsat Image by the side of Narmada river (Plate VIII.1). The feature is marked by a dark tone to the NW and a light tone to the SE side. The darker tone represents the area which had been left behind by the Narmada river as it migrated to the NW to its present course. On ground checking it has been found that the lineament represents the abandoned left bank of the river when it was flowing further to the SE against the high ground representing the structural high of Jhagadia-Dadhal and Ankleswar anticlines (Figure VI.2). The Narmada river has migrated to as much as 6 km to the NW due to a tilting caused by uplift of the Jhagadia-Ankleswar area. The linearity further suggests the presence of a fault along the paleo-bank with the down-throw side to the NW. A seismic profile which passes across the lineament does indicate the presence of a fault of the nature of a reverse fault (Fig.VI .2) with the SE side as the upthrow side (Agarwal,1983). All along the lineament a number of villages are located as it forms a high ground so as to save themselves from the fury of floods of the Narmada river during the monsoon season.

The lineament to the SW becomes curvilinear beyond

Ankleswar town, indicating that at that time the left bank of the Narmada river was circumventing topographic high, a manifestation of the Ankleswar anticlinal structure described earlier. Possibly, had the imagery studies been possible earlier, the Ankleswar structure could have been delineated without seismic surveys.

Talodra lineaments: A set of lineaments, trending ENE-WSW along the SSE limb of the Talodra anticline, are observed on aerial photos. These features on ground checking have been found to represent the hard and compact cherry red sandstones of Babaguru formation. Along the E-W road, near Darmuda village, cherry red sandstones, hard and compact, dipping 48 degrees due south are seen. The steep dips are due to their nearness to the Talodra fault (Figure IV.1).

Limet lineament: It is observed south of village Limet and is marked by the course of Amaravati Nadi which flows close to the village, and the lineament is clearly seen on aerial photograph. The river follows the trend of the lineament. On ground mapping the lineament is represented by the vertically dipping conglomerate beds (Plate V.6.C) which are hard and compact due to calcareous matrix. These conglomerates belong to the Kand formation.

Kosamba lineaments: On the Landsat Image as well as on the aerial photographs NE-SW trending lineaments are observed

between the Kosamba and Valia towns. On ground mapping they are found to represent the water divide of the Narmada and Kim rivers, and in the water divide area the cherry red sandstones and agate conglomerates which are hard and compact due to oxidation of iron minerals, imparting a hematitic like hardness to the rocks, are exposed. These rocks are resistant to weathering and do not support thick vegetation. A major reverse fault runs along the SE margin of these lineaments known as the Kosamba reverse fault as mapped from the seismic data (Fig.IX.2.B).

Lineaments in Deccan Trap rocks: Adjoining the exposed Tertiaries, in the Deccan Traps to the east, lineaments have been observed both on the Landsat Image(Plate VIII.1, Fig.VIII.1) as well as on aerial photographs. In the SE part of the area, near Koyali Vav village a number of NE-SW trending lineaments in the Deccan Trap country(Fig.IV.1) are seen on air photos. On ground checking they represent narrow hills of basalt rock. The trend suggests the faulting of the Deccan Trap along with the Tertiaries during the Late Cenozoic tectonic activity due to which the Tertiaries have been deformed along the NE-SW trends.

In the easternmost part of the study area hills of Deccan Traps are present and on aerial photos NE-SW and N-S fault/fracture trends are seen. Further north near Rajpardi there is a 171 m. Sirsia hill of Deccan Trap which also trends NE-SW.