Chapter - 8

TECTONIC GEOMORPHOLOGY

The morphotectonic domain-II includes 07 drainages and comprises of trappean lava flows of elevation up to ~611m and coastal plain of altitude of ~0.1 m amsl (Figure 3.1). It comprises of Hiran, Somat, Singwada, Sangawadi, Rupen, Machundri and Rawal River covering approximately 2908 km^2 in the western part of the study area. The area covers the coastline from Veraval to Nava Bandar and inland area from Gir Reserved Forest to Bediya village. The entire domain covers the area about ~3000 km^2 with majority of the area covered by rocks of Deccan Trap Formation and extensively exposed Quaternary deposits near coastal area.

8.1 TOPOGRAPHIC ANALYSIS

The topographic profile of all seven drainage basin is made from the section taken parallel to the main trunk stream from source in highlands to mouth of the river in mudflats or coast. All the topographic sections are almost N-S to NNE-SSW profiles showing rugged terrain on the northern part covered by Deccan basalt and the remaining covered by Quaternary deposit overlying Tertiary sediments. In the upland zone, the undulating nature of due to the presence of hills and dyke ridges and trappean lava flows sloping coastward. The dyke ridges cuts the drainage basin transversely forming highly dissected range and valleys. The sharp escarpments were observed in the topographic profiles of Machundri (B-B′) and Rawal (A-A′) river basin sections (Figure 8.1).

The maximum elevation is more than 200 m in the upland region which gently slopes in the buried pediment zone (Figure 8.1). The upland zone narrows in this domain due to the Quaternary sediments covering majority of the area. For instance, Somat (F-F′), Sangawadi (D-D′) and Rupen river basin (C-C′) section shows rather less undulating trappean covered region (Figure 8.1). These sections are dominantly covered by Quaternary deposits overlying the trappean mountain fronts. The Quaternary deposits covers extensively up to several kilometer showing wide buried pediment zone. The buried pediment zone consists of miliolitic limestone cover over buried Tertiary sediments in almost all the profiles. The change in topography from rugged to gently southward sloping surface is due to the lithological variation also. The zone narrows towards east near the division of domains reflecting prominent change in landscape.

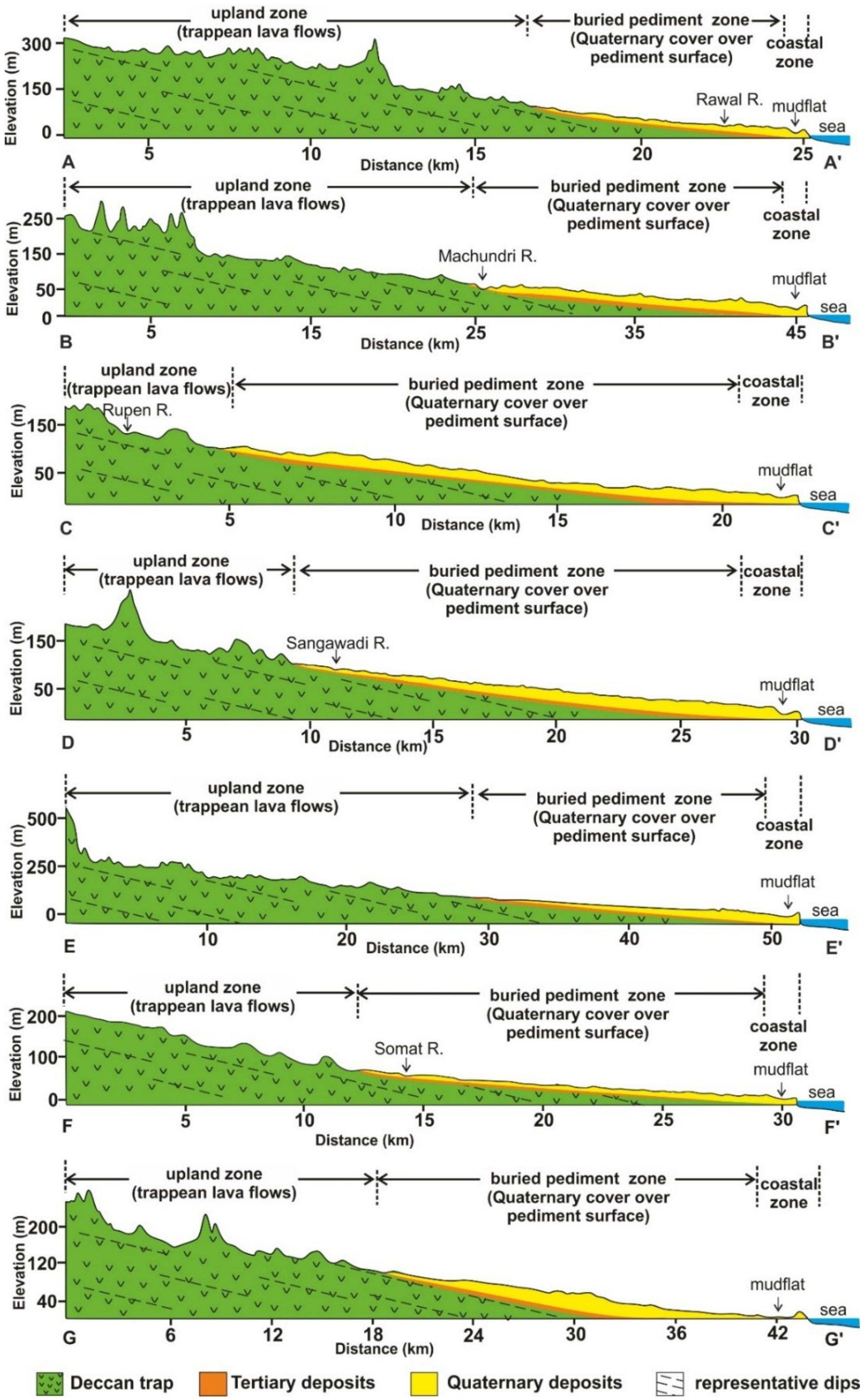

Figure 8.1 N-S topographic profiles of morphotectonic domain-II showing three geomorphic zone. Cross section A-A′ to G-G′ shown in figure 3.4. Note the buried pediment zone widens towards western sections from G-G′ to A-A′. The escarpments

observed in the section along Machundri and Rawal River where Quaternary cover narrows. Coastal zone mainly shows mudflats and coastal cliffs at places.

At few places, ~1-2 meter alluvium deposits also observed. The Quaternary deposits dominantly covers the pediment surface over the retreated hills near upland zone and Tertiary sediments in the buried pediment surface. The eroded surface is not exposed due to the thick Quaternary cover. This zone continues till the coast where river meets the Arabian Sea. The coastal zone shows mudflats but does not cover vast area. However, the extensive mudflats are observed very less towards west. The altitude of the coastal cliffs also varies from eastern to western region. In the Diu Island, these miliolite cliffs are observed up to ~15 to 20 m height. This zone also consists of alternate beach dune complexes, miliolite cliffs showing sea caves, sea arcs and present day marine notch (Figure 8.1).

8.2 DEM ANALYSIS

The DEM of the present study area (Domain II) shows various prominent geomorphic features such ~E-W and ~NW-SE trending miliolite ridges in the southern part near coastal zone, rugged terrain of trappean rocks in the northern upland region, deeply incised rivers flowing south etc. The rivers flowing from the undulating topography incising forming deep valleys and gorges are noticeable in the DEM. The discontinuous elevation and gradient change between rugged and flat terrain is clearly observed. At the upland zone, the rugged topography shows some specific trends of the linear dykes and ridges. Three major river viz., Hiran, Singwada and Machundri are seen as deeply incised channels and prominent straight courses are observed on the Quaternary surface. The sharp bending and meandering of the rivers is observed in both the terrains. The other major river channels like Somat, Sangawadi and Rupen are also draining towards south in between the mentioned rivers which are vaguely visible in the DEM. The most prominent feature observed other than these incised rivers are the ridges parallel to the coastline. These ridges shows two prominent trends in the eastern part (~NW-SE) and western part (~E-W) of the domain II. The straight river channels bends abruptly near the transversely running miliolite ridges and flows towards south incising these ridges. In the southernmost region, near Diu, the mudflats emerging inland is also detected cutting the ~E-W trending miliolite ridge.

8.2.1 Slope data

The slope map of the present study area (domain II) is classified into three degrees of slope viz., 0º to 19° (very gentle to gentle slope), 20° to 45° (moderate slope) and 46° to 89° (steep slope). The abrupt change in slope observed at few places in this domain where there is sharp contact between trappean dykes and gently sloping Quaternary surface. The change in the degree of slopes on the rugged terrain shows several linear dykes' cross-cutting the trappean lava flows. Moreover, the steep slope is also observed on the river channels in the rugged as well as flat regions. This is due to the sharp vertical cliffs sloping > 46° throughout the channels till the coastal zone where the river meets sea. This clearly infers the major rivers like Hiran, Singwada and Machundri in this domain are still incising sharply on the Quaternary surface after miliolite deposits. The Somat, Sangawadi and Rupen river cliffs shows moderately to gentle slops which are faintly observed on the map. Furthermore, in between the dykes on the uneven topography of steeper slopes at the highlands, there is a sharp slope break observed from steep (>45°) to very gentle (<19°) due to the sharp incision of rivers forming deep valleys and gorges. The aeolianite ridges running parallel to the coast trending E-W and NW-SE shows moderate slope towards south and steep slope towards north. There is also a ~NE-SW trend of some of these ridges noticeable to the west of Singwada River with a slope break of 36°. The coastline from Veraval to Diu shows the steep slope due to the presence of marine coastal cliff and present day beach dune complex alternatively. The flat gently sloping (<19°) Quaternary surface covers the southern part of the domain apart from the coast parallel ridges.

8.2.2 Aspect data

The aspect map shows varied pixels with the majority of the area is sloping towards south and southwest. Considering all the drainage basin, the slope of either sides of the main trunk streams shows east to southeast and west to northwest tilt. The undulating trappean lava flows in the uplands shows pixels of varied direction of slopes. The linear aeolianite ridges running parallel to the coast, as mentioned previously, shows prominent north to northwest direction of slope. In the slope map, the northern steep slope indicates the leeward side of these ridges while the south to southwest direction of moderate slope infers as windward side.

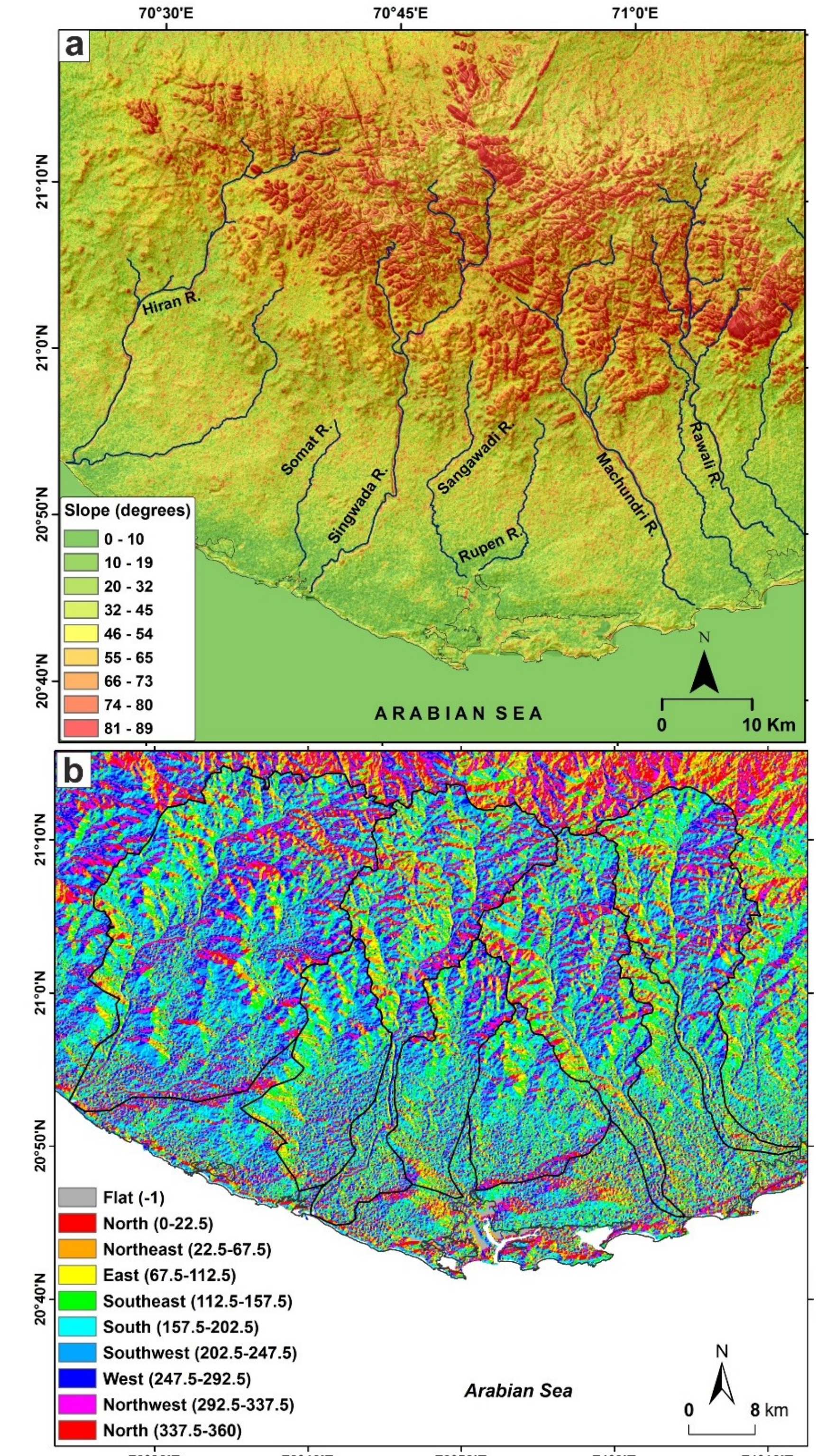

Figure 8.2 a) Slope map showing steep slopes in the upland zone, moderate to gentle slope on the buried pediment cover and coastal zone. Note the varying trend of linear ridges and dykes showing steep vertical escarpments. b) Aspect map showing direction of these slopes in color pixels. Majority of the area is sloping towards south and southwest.

The map shows ~NE-SW trend of the aeolianite ridges almost transverse to the coastline towards eastern side of the study area. While, some ridges are parallel to the shoreline showing ~NW-SE trend towards west of the study area. The pixels on the cliffs of the straight channel courses flowing towards south shows slope direction east and west. Moreover, the pixels in the entire coastline with steep slope (> 45°), as described earlier, shows north to northwest slope. The regional slope is towards south and southwest apart from the trappean rocks and miliolite ridges.

8.3 LINEAMENT ANALYSIS

The western part or domain II of the study area covers >3000 km^2 with lineament density less than domain II (Figure 8.3). The area comprises of similar lithology as that of domain II, however the geomorphology and structural geology of this area differs to some extent. Around 519 lineaments traced in this zone with the help of remote sensing and GIS (Figure 8.3). The total lineament length in this zone is 1702.84 km. The maximum lineament length is 13.4 km while the minimum length is about 0.6 km. The individual basin were considered for the study of the lineaments area wise. The main purpose of the lineament extraction from every basin is to understand if there is even a minor variation in the dominant trend. Over all, the area consists of three dominant trend viz., ~N-S, ~NW-SE and ~NE-SW from Veraval to east of Una (Figure 8.3).

The Rawal river basin, west of Malan river basin, shows completely different trend when traced and analyzed. The Rawal river basin covers approx. 370 km^2 with 85 features traced showing two prominent trends viz., ~WNW-ESE and ~NE-SW. The NE-SW trend is basically the dykes and channel incisions while the WNW trend is most prominent shows the extension of ~NW trending dykes running from the north of the Hiran river basin swinging westward. Both these trends are observed on the uneven topography comprising Deccan lava flows. The Hiran river basin covers ~939 km^2 with 119 lineaments traced showing NNE-SSW, ENE-WSW and NW-SE as major trends. The linear features in this basin is the long running dykes extending from NW towards SE and NNE trending ridges and river channels. The lineaments observed on the rugged terrain consisting of trappean lava flows and dykes and on the Quaternary surface comprising ~NW trending aeolinite ridges parallel to the present coastline.

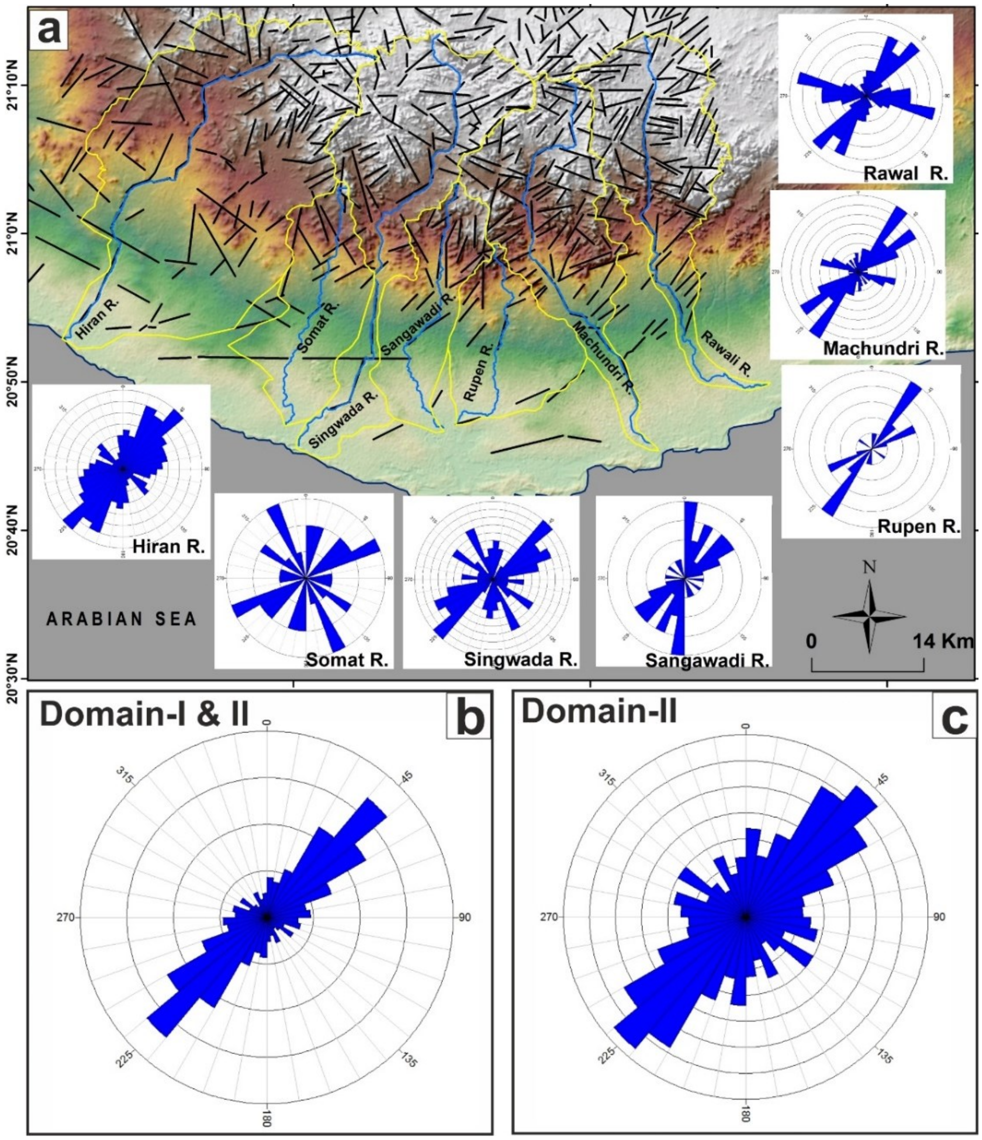

Figure 8.3 Lineament map of morphotectonic domain-II. a) Domain-II shows seven seaward flowing major rivers. The rosette diagram is plotted basin wise from Hiran River in the west to Rawal River in the east. Note the variation in lineament trend near the Rawal River. Multiple lineament trends observed compared to domain-I. b) Dominant trends of overall study area showing, NE-SW, ENE-WSW and NNE-SSW. c) Overall domain-II shows NNE-SSW, NE-SW and E-W trend.

The maximum area of Somat, Sangawadi and Rupen river basin is covered by Quaternary deposits overlying the Tertiary rocks. The total lineaments traced in these three drainage basins, covering almost ~704 km^2, is about 58 showing three major trends viz., N-S, NE-SW and NW-SE. The lineament density is high in Singwada and Machundri river basin covering approx. 894 km^2. The total linear features traced is about 169 showing different trends. The Singwada river basin shows NW-SE, NNW-SSE, N-S and NE-SW major trends. This is due to several cross cutting dykes running on the trappean lava flows. The dominant trend of the lineaments from Rawal basin to Hiran basin shows significant variation which differs this domain from domain-I. Rawal and Machundri basin shows NE-SW and NW-SE trend due to the dyke ridges. However, from Rupen to Somat River, multiple lineaments observed due to extensively long dyke ridges coming from north, west and northwest. Due to these structural lineaments the domain is seen as highly fragmented upland area with high dissected hills, ridges and valleys. Hiran basin shows the scattered ridges all trending between NNE-SSW to E-W in the undulated hilly terrain. The morphotectonic domain-I shows very significant NE-SW trending structural lineaments that controls the maximum area. However, domain-II shows multiple dykes of varying trends that terminate to the east of Rawal basin which is the easternmost margin of the morphotectonic domain-II. Such distinction infers that the control on landscape of both the domains varies due to diverse tectonically and structurally controlled attributes.