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Original Article

Geomorphic Studies Of Area Around Lanja, District Ratnagiri: Remote Sensing Technique

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ABSTRACT

Aspects of the nature of landforms, landscapes, and surface processes, including their description, classification, origin, evolution, and history highlighting the physical, biological, and chemical characters is geomorphology. The main focus of tectonic geomorphology is on contrast between topography and geomorphic features generated by tectonic and erosional processes that tend to wear them down. Hence the relationship between these processes and interpretation of the resulting landscape features is the main focus of tectonic geomorphology. This paper emphasises the field data and observations pertaining to the relationship of geomorphic features, their origin and evolution because of tectonic activities in the study area. A geomorphic map has been prepared of the study area.

Keywords: Geomorphology, tectonics, marine and terrestrial geomorphic features.

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Introduction

The study of surficial geomorphic, structural and morphometric evidences of long– and short– term tectonic activity is morphotectonics. The endogenous mechanism operate and control the tectonic activities which is represented by relative movements, such as uplifting, subsidence and translation of the crust. Multi-sensor digital images and DEMs along with advanced digital image processing techniques, supported by field evidences are extremely useful to observe and map morphotectonic features.

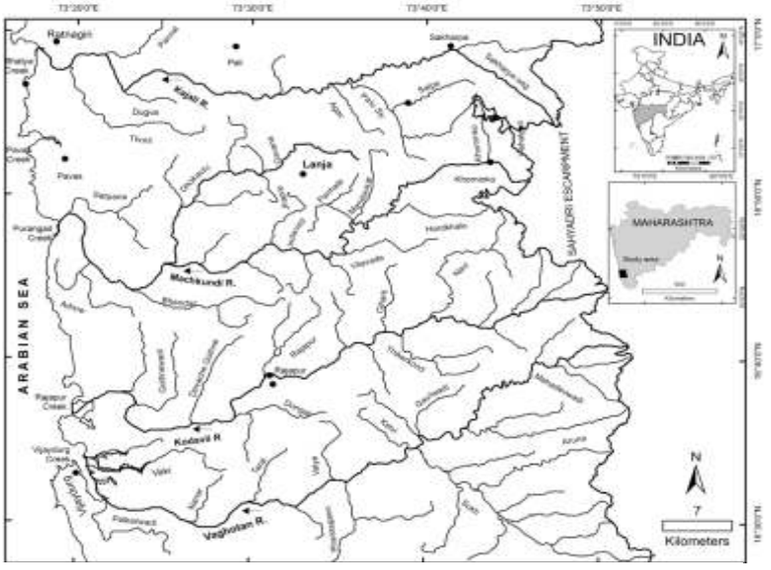

Fig.1: Location map of the study area

The analysis of these morphotectonic indicators gives a synoptic view of the (neo)tectonic activities of the region. Most of the tectonic activities dates current or geological recent times, and those can be considered as neotectonic activities. The relationship between geomorphometric elements and neotectonic landscapeis believed to be mainly indicated by bedrock joints in the area of questions.

The continental scale passive west coast margin of India representing one of the rifted margins of world has attracted many researchers because to its unique spatial position and its major role in shaping the tectonic characteristics of India. Still there is ample of scope to dive in the research in tectonics of west coast margin of India. Northern part of this west coast margin of India is covered by voluminous Deccan basaltic lava flows, covering an area about half a million square kilometres erupted 65Ma representing K-T boundary, marked by mass extinction on a global scale. Coast parallel precipitous escarpment (Western Ghat Scarp) trending nearly about N-S direction recedes eastward due to intense weathering and generates a narrow lowland at its west and a plateau at its east forms three distinct morphotectonic units from west to east are Konkan lowland(Konkan Coastal Belt), Western Ghat Scarp (called Sahyadri in local Indian language) and Deccan plateau. Formation of these morphotectonic units, their evolution, seismic events, view of mantle plume theory in its formation as well as recent trends in remote sensing are source of this research.

Geomorphology is the study of the nature of landforms, landscapes, and surface processes, including their description, classification, origin, evolution, and history highlighting the physical, biological, and chemical aspects (Morisawa and Hack, 1985, Baker, 1986, Keller and Pinter, 2002). Geomorphic record includes tectonically generated various landforms and the Quaternary deposits that capture the immense amount of information from the last few thousands and extend to almost two million years (Keller and Pinter, 2002) and hence these are significant tools in tectonic studies.

Tectonic geomorphology focuses on the contrast between topography and geomorphic features generated by tectonic and erosional processes that tend to wear them down. Hence the relationship between these processes and interpretation of the resulting landscape features is the main focus of tectonic geomorphology (Bull 1984, Baker 1986, Burbank and Anderson, 2001). Geomorphic markers are geomorphic features or surfaces that provide clues to estimate differential or absolute deformation and hence these play an important role in analyzing tectonic geomorphology. These reflect tectonic signals by attributing their spatial occurrence and geometry of geomorphic features (Burbank and Anderson, 2001). Tectonic and erosional processes modify the geometry of markers while episodic tectonic activities are responsible for superimposition of new features on the older one.

The literature studies on the DVP and western continental margin of India indicate that the numerous processes such as magmatic, tectonic, sea level change and works of fluvial, marine and aeolian are responsible in the development of the existing landscape. Thus, this chapter focuses on the field investigations of lithology, structures and related geomorphic features to understand processes, style of tectonic deformation and palaeo-stress.

DATA USED AND METHODOLOGY:

Field investigations have been carried out at the number of selected locations, which are tectonically and geomorphologically significant. For this purpose, geomorphic and lineament maps generated by the remote sensing analysis and DTA were used as a base map. The SOI toposheet (1:50,000) and GPS (3m precision) instrument were also used during field visits. Direct observations were made in the coastal regions and bedrock channels along the stream segments controlled by lineaments and their intersection locations. The coastal and fluvial features such as wave-cut platforms, wave-cut notches, raised beaches, incised valleys and river terraces, hanging valleys, potholes and waterfalls respectively are indicators of tectonic activity. These features and uplifted peneplains were studied and compared with different locations. The geomorphic landforms and relationship between joint sets were studied. The attitudes of fracture cleavages and joint sets were also measured with the help of the Brunton compass. Locations of all of these observations were recorded with the help of GPS. The zoomed in images of Google earth were studied in synoptic view of inaccessible coastal and inland areas. The genetic classes

of joints and palaeo-stress axes have been inferred with the help of relationships between the conjugate sets of joints and surface morphology of fractures (Fig. 2A and B), (Dunne and Hancock, 1994). The geomorphic maps are generated using remote sensing, DTA and field records (Fig.3)

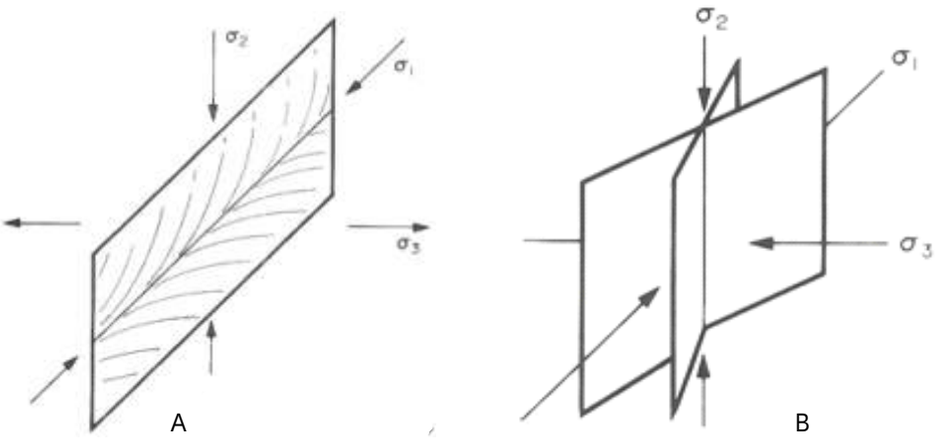

Fig. 2: Inferring directions of ? 1, ? 2 and ? 3 (maximum, intermediate and minimum principal stresses) from (A) A single extension fracture bearing a plumose marking with a well-developed axis and (B) Relationship between neoformed conjugate fractures and total principal stress axes at the time of failure.(After Dunne and Hancock, 1994)

RESULTS AND DISCUSSION:

1. GEOMORPHIC FEATURES:

Based on remote sensing analysis and DTA studies the study area has been subdivided into three geomorphic subzones. These subzones from west to east are DTL, LRL and EFH. However, observed erosional and depositional geomorphic features are described under two heads, 1) coastline features and 2) coastal plains.

1.1 Coastline Geomorphic Features:

Coastline region of the study area exhibits both erosional and depositional geomorphic features. Most important geomorphic features are cliffs, wave-cut terraces, stacks, islands, headlands, beaches, raised beaches, tombolo etc. (Fig. 3)

1.1.1 Sea cliff:

The significant coastal erosional features are the west facing sea cliffs (Plate 1). These are seen all along the coast encircling the headlands. The heights of cliffs are in the range of 10 to 20m. Most of the cliffs in southern segments are capped by laterites. The height of cliffs decreases from northern Ratnagiri coast to southern Vijaydurg coast. These are controlled by N-S and conjugate sets of N230W and N330E joints.

1.1.2 Wave-cut terraces and Sea notch:

Most of the Sea cliffs are bordered by wave-cut terraces at their base. Large sized blocks of massive basalt and laterites have settled on them, as a result of mass wasting. These terraces were exposed at the time of low tide. They exhibit conjugate fracture sets in massive basalt. These terraces are of varying length and widths. A marine notch exists at the base of the cliff, near Ratnagiri, at about 4.5km south of the Bhatya creek (Plate 2). The notch was observed 6m asl associated with abrasion platform of about 75m width. These features represent the abandoned cliff and platform revealing fall in sea level.

1.1.3 Stack and Island:

Stack exists at about 4km north of Pavas creek and due west of the Vengani village (Plate 3). It seaward face is concave representing abandoned cliff associated with abrasion platform. This stack signifies the eastward retreating palaeo coast. The landmass 10m asl was observed off Ratnagiri as a small island.

1.1.4 Headlands:

Numbers of massive basaltic headlands were observed along the coastal tract of the study area. Their seaward faces are nearly straight, vertical and trending in NNW direction indicating control of weak planes. Prominent headland is observed near Ambolgad, north of Rajapur creek.

1.1.5 Estuaries and Promontories:

The coastal area is characterized by indention by five estuaries and few promontories. All estuaries in the study area are funnel shaped outline except at Vijaydurg creek. Estuaries are narrow and small in the northern region of the study area; Bhatya creeks, Pavas creeks and Purangad creeks, while southern estuaries; Rajapur creek and Vijaydurg creek are wide open to the sea and relatively large. Vijaydurg estuary is highly indented and is classified as a salt - wedge estuary where fresh water flow predominates and this is evidenced by the presence of the sand bars at the mouth of Vaghotanriver.
The promontory north of Ambolgad at Wada Vetye is about 3km in length and show heavy turbidity currents releasing in the Arabian Sea. More erosion and ultimate deposition of sediments in the sea is the result of rejuvenation.

1.1.6 Tidal flats:

The deposits in the river mouth are tidal flats. Convex and large sized tidal flats occur at Rajapur and Vijaydurg estuaries and concave and small shaped tidal flats occur at Bhatya and Purangad estuaries. These tidal flats constitute sand, mud and marsh covered by mangrove as moved inland. The concave shaped tidal flats suggest erosional phase while convex shape suggest their accretionary nature.

1.1.7 Recent beaches, Sand bars and Raised beaches:

Numbers of beaches were observed in several localities along the coast. These are crescent shaped and their locations are controlled by N-S and one of the conjugate sets of joints. The beaches are sandy and maintained a gentle gradient. Their length varies from 0.5km to 2.5km whereas width varies from 10m to 0.8km. Sandy beaches are found at bay heads, along straight shoreline, on the seaward side of sandbars. Stony beaches are found at the mouth of the promontory. Primary features like ripple marks and reel marks were observed on the beach surface in the low-tide region. The sandbars consist of sand, gravel and heavy minerals. Well developed spits have been observed at the Purangad and Vijaydurg creeks.

Raised beaches were observed far inland about 400m to 1.2km from msl. These are roughly parallel to the coast and covered with vegetation. Their height ranges from 0.60m to 2.0m indicating a lowering of sea level. The raised beaches constitute tightly packed sand particles and semi-consolidated sediments, indicating their stabilization.

1.1.8 Tombolo:

The Tombolo (headland attached to the mainland by narrow sandbar) occurs in Ambolgad and south of Agargula near a Kurdha village (Plate 4).

Plate 1: Sea cliff near Bhatya Creek.

Plate 2: Sea notch observed 6m asl, 4.5km south of Bhatya creek.

Plate. 3: Stack observed due west of Vengani village.

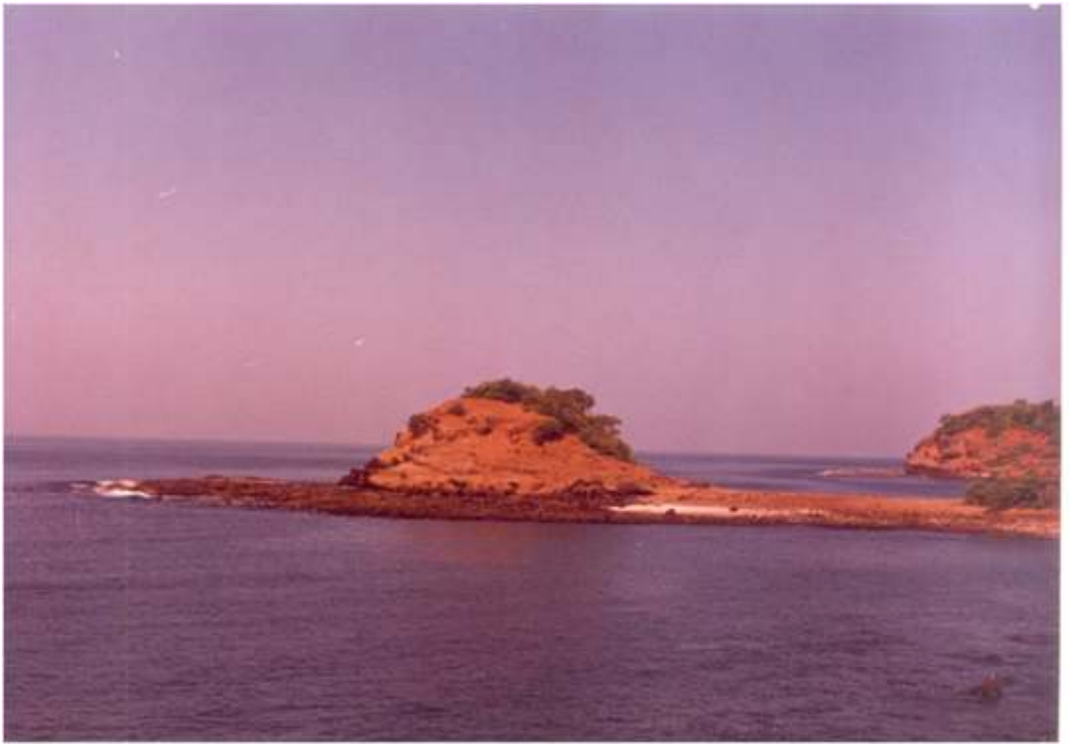

Plate 4: Tombolo near Ambolgad.

1.2: Geomorphic Features in the Coastal Plains:

The most common erosional features observed are escarpment, ridges, mesas, buttes, eroded hills, 'V' shaped valleys, hanging valley, incised channels, waterfalls, plunge pools, cascade and potholes. River terraces, braided channels and point bar deposits were

observed along major rivers and their major tributaries (Fig. 3).

1.2.1 Escarpment and Ridges:

The most conspicuous feature east of coastal plains is the escarpment facing towards west. It rises from broad valleys of streams to its crest. Its maximum elevation reaches to 1050m asl in the northern part of the area and decreases towards south. The average elevation is 800m asl. The steeply sloping scarp exposes basaltic lava flows. Number of east west trending ridges and valleys originated in escarpment region and extend towards west with decrease in height.

1.2.2 Mesas, Buttes and Eroded Hills:

The plateau region of the coastal plain has been dissected by deep valleys to form plateaux, mesas in DTL. Sides of mesas and plateaux are steep to moderately sloping while their top surfaces are broad, flat and horizontal. However, most of them are gently sloping seaward (Plate 5). Number of symmetrical buttes of varying heights and eroded hills exist in LRL and mostly south of Machkundiriver. These are composed of basaltic flows and covered by laterite caps. Few of them are composed of Kaladgi sedimentary quartzites. Numerous plateaux and eroded hills occur in DTL and LRL respectively.

1.2.3 Valleys:

Deep valleys are seen in the escarpment and western plateau. These are either steeply sloping 'V' or 'U' shaped valleys. Most of the river and tributary valleys in DTL subzone are 'V' shaped. The river Dhokachi and other streams in DTL have deep incision (Plate 6). The stream valleys crossing L_4 lineament namely, Rajapur, Valye and Phanasgaon are very deep reflecting their rejuvenation. Channels and valleys in the LRL, around Lanja, are shallow, wide and have moderate to low gradient, whereas, in the Khorninko block, N-S controlled Agav, Palu and Khorninko valleys are deep, 'V' shaped with moderate to steep gradient. The occurrences of large sized lateritic blocks and boulders in the Khorninko valley suggest the presence of high level laterites at crest of the escarpment and relic upland near Vishalgad. The stream channels in Sukh block are comparatively wide and shallow.

1.2.4 Fluvial erosional features:

Most of the channels of major rivers and tributaries are bedrock except in the coastal region where major rivers have broad flood plains and alluvial deposits. The indicators of active incision channels were observed such as waterfalls, cascades plunge pools and potholes.

The prominent small waterfalls, cascades and potholes were observed along the Dhokachi, DevacheGothne and Taral streams in the DTL subzone. Waterfalls and potholes are also found all along the streams controlled by N-S lineaments such as Palu, Agav, Salpe and Mandavkar in the EFH subzone. The stream channels controlled and crossed by L4 lineaments namely, Jhapre, Rajapur, Valye and Phanasgaon have a number of cascades and potholes. The number of ponds were located in the channels of stream segments controlled by NW-SE lineaments such as a Sakharpa segment of Kajaliriver, Vilavade, Panhale and Sukh in the EFH subzone indicating tilt against their gradient.

The largest recorded waterfall of 20m height is shown in topographic map (47H/9), west of Vishalgad, in the upper reach of Khorninko channel flowing across the relic part of upland. Medium waterfalls about 4 to 8m height and plunge pools are observed near Argaon and Bhatwadi along the tributaries of Vilavade and Rajapur streams in the EFH and DTL subzones respectively.

Out of westerly flowing parallel tributary streams, Salpe and Aruna are the streams with numerous potholes and waterfalls; especially Salpe stream has giant potholes of 4 to 2m diameter and about 2-3m depth (Plate 7). These are controlled by ENE-WSW trending lineament. These features indicate rejuvenation of ENE-WSW lineament.

Tributary streams of N-S trending Palu and Agav exhibit hanging valleys at their confluence points also suggest active incision of these streams. These features support the

uplift of the region east of L2 lineament during which ENE-WSW as well as NW-SE trending lineaments have been rejuvenated. The streams except Aruna in the southern EFH subzone do not exhibit waterfalls and potholes.

Plate 5: Laterite capped mesa on top of seaward facing cliff exhibits resistance to erosion. Note the seaward sloping lateritic terrain.

Plate 6: Deeply incised river valley of Dhokachi stream in DTL subzone.

Plate 7: Giant potholes and cascades in the lower reach of Salpe stream.

1.2.5 Fluvial depositional features:

The fluvial depositional features observed in the study area are river terraces, point bars and braided channels (Fig.4.3).

Paired and unpaired terraces were encountered at various locations along the channels of major rivers and major tributaries in DTL and EFH subzones. Depositional sequence of these terraces in EFH is; soil at the top followed by sandy soil and sand underlain by a layer of sub-angular to rounded pebbles and cobbles resting on weathered basalt or red bed. Most of the river terraces in the EFH subzone are very narrow except along the uppermost reaches of Kajali, east of Kirbet, in north and along upper reaches of the Kodavliriver in south. The Sakharpa segment of upper reach of Kajaliriver, east of Kirbet village, exhibits river terraces and distinct braided patterns (Plate 8). The Sakharpa valley shows strath terraces throughout its length. The braided river channels in the upper reach of Kajaliriver are also indicative of eastward tilt against its westward flow direction. Relatively broad river terraces were observed along the N-S segment (Plate 9) of the Kodavliriver (L6), near Adavli and its upstream segments near Raypatan and Talavde villages. Similarly, these are also located along Jamda stream, the upstream reach of Vaghotanriver, between Javlethar and Math Khurd villages. The Vaghotan channel, near Kharepatan (Plate 10) shows two paired terraces.

Narrow and short length paired terraces were located along the Palu (Plate 11) and Agav streams controlled by N-S lineaments. Terraces observed along Palustream near the Shiposhi village exhibit two paired terraces, of which, the older one constitutes consolidated rounded pebble to cobble sized sediments. This character reveals that the Palu stream has undergone two cycles of episodic rejuvenation. The E-W flowing Salpe stream (Plate 12) controlled by ENE-WSW lineament also exhibits three pairs of terraces and few strath terraces between Salpe and Daphalewadi villages in the EFH subzone indicate episodic uplift. The tilt towards the east is supported by the tilted lava flow contact

located near Daphlewadi and Khorninko villages (Plate 12).

The river terraces in the LRL subzone are small in dimensions and either unpaired or paired. The streams coinciding and crossing the L4 lineament exhibits narrow paired terraces. In this zone, the river Kodavli near Rajapur shows two pairs of terraces.

Plate 8: Google Earth image of the upper reach Sakharpa segment of Kajaliriver showing braided pattern and paired terraces under cultivation.

Plate 9: Paired river terraces along N-S segment of Kodavliriver, near Adavli.

Plate 10: Paired river terraces observed along Vaghotanriver, near Kharepatan.

Plate 11: Two paired terraces along Palu stream. The oldest one is composed of consolidated sediments.

Plate 12: Three paired terraces along Salpe stream, located between Salpe and Daphalewadi villages.

Plate 13: Typical section of terraces shown by the streams in the study region. This section was observed along Palu stream near Shiposhi village.

CONCLUSION:

The coast line characterized by the presence of raised beaches and sea notches at various levels reveal a mixed type of cost and also support the fall in sea level. Thus the landforms developed on the Lanja coastal plains are the result of mainly fluvial and tectonic activities; however there are also signs of marine activities. These also reflect the polycyclic evolution as a consequence of the combined effect of climatic changes and tectonic uplift. The active tectonic is responsible for the development of drainage patterns and landforms in the northern and southern EFH and LRL. The abnormal trellis and asymmetrical patterns are dominant in the Khorninko block while parallel patter dominates in Sukh block. The deep valley segments associated with cascades, potholes and abnormal drainage patterns indicate the active tectonics. Narrow and braided stream channels and broad river terraces in the Khorninko and Sukh blocks respectively also confirm the active tectonics. Thus, divergences in structure and differential uplift rates are responsible for the development of varied landscapes in the study area.

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