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IMPACT OF DYKES ON DRAINAGE NETWORK OF THE SHIVAN RIVER IN NORTH MAHARASHTRA

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ABSTRACT:

The prominent linear dyke ridges outcropped in the Narmada-Tapi dykes' swarm which is an intrusion in the Deccan Traps. The underlying geological structures, strike of the dykes and channel patterns are valuable guide to understand the relationship among them. Dykes act as obstruction to the stream flow and cause flow diversion. Dyke geometry and pattern affect rivers and streams which are draining and crossing the dyke swarm zone. For the present study the Google Earth images, LISS III images and Cartosat DEM are used to delineate the Shivan basin and extract dykes. Shivan river basin is sixth order drainage system and it reflects superimposed drainage systems in the Tapi dyke swarm zone. It's 169 km2 (65%) area is controlled by dyke orientation. Dyke ridges are aligned in the East-West (E-W) direction which are mainly followed by lower order streams which has developed insequent, transverse drainage network in the dyke swarm zone. Since the number of dykes is less in lower parts of Shivan basin drainage network follow the general slope and oriented in North-South direction. Shivan River and its tributary streams have adjusted with dyke orientation to some extent and developed transverse drainage pattern in the area of parallel ridges of dyke.

KEYWORDS: *Deccan Traps, Narmada-Tapi dyke swarm, orientation of dykes, Google earth, LISS III, Cartosat DEM*

INTRODUCTION

The relationship between lithology and structure on one hand and the drainage network pattern on the other has long been established (Zernitz, 1932; Schick, 1965; Howard, 1967). Several studies in the past have shown that the drainage network pattern and river channel morphology reflect the integration of multiple processes and forces (Twidale, 2004). The litho-structural control on drainage network pattern is strongly evident in an area of complex structure and diverse lithology. Alignment of drainage lines, sharp bends in river courses, obtuse junction angles and breaks in the river profiles are some of the geomorphic features that could be detected visually on maps and images and could be related to joints, fractures, faults, dykes and lithological boundaries. However, in areas of uniform or homogenous lithology the control of structure is less evident. Therefore, the assessment of the control of lithology and structure in such areas is often subjective and challenging (Schick, 1965). Dykes are discordant igneous bodies of more or less tabular shape and exhibit a cross-cutting relationship with the country rocks. They occur commonly in the form of group called as swarm. When molten magma flows upward through near-vertical cracks (faults or joints) toward the surface and

cools, dykes are formed. Dykes are sheet-like igneous intrusions that cut across any layers in the rock they intrude.

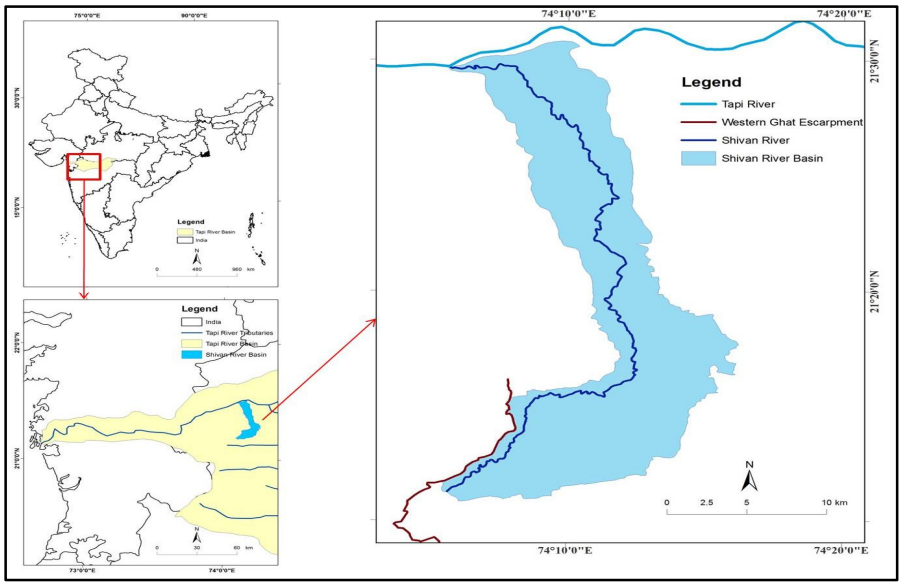
The objective of this paper is to explore the drainage-dyke relationship and to establish the nature and extent of the control of the dykes on the drainage network properties and orientation of streams.

STUDY AREA

The area under investigation covers Shivan river basin which forms part of east – west trending Tapi gaint swarm. The area extends from 21°10'49.3''N to 21°30'51.3" N latitudes and 74° 05'23.0"E to 74° 16' 15.3"E longitudes (fig.1). It originates on the northern slope of the Sahyadri mountain range at an elevation of 706 M above mean sea level and joins to the Tapi River at 100 M above mean sea level. The Shivan River flows from south-west to north-west for 59.33 KM. It is a left bank tributary of the Tapi River. The basin relief is 606 m. It is crossing through prominent linear dyke ridges. The south eastern boundary of the basin is marked by Western Ghats with steep escarpment towards west.

The southern region of the basin is occupied by plateau extent. North face of the plateau is characterized by valleys of northward flowing streams. Plateaus as well as valleys are intruded by east-west running dyke ridges. The slope of the Shivan basin ranges from >70° to ~5° from source to the confluence with the Tapi River. The basin relief is generally steep to gentle from south to north.

Figure 1 Location map of the study area



Geologically the Shivan river basin occupies three formations zones like two Sahyadri Group viz. the Lower Ratangarh, the Upper Ratangarh and the Alluvium as a homogeneous basalt rock basement.

Climate of the entire basin is controlled by SW monsoon .The basin experiences average annual rainfall from >700 mm in the source region to ~590 mm in the basin. (IMD, 2014)

MATERIALS AND METHODS

This study is based on two different datasets. The first set includes the information about the attributes of the dykes and the second dataset consists of the data regarding drainage basin and network parameters.

DYKE ATTRIBUTES

The dykes in the study area is mapped and digitized from Google Earth and IRS LISS-III images in ArcGIS. The Carto DEM (30m resolution) was used to identify and map the dykes in the study area. A Survey of India map of Nandurbar Quadrangle 46K (1:250000) of Gujarat, Madhya Pradesh and Maharashtra was

used to verify dyke orientation. District resource maps and geological maps of the Nandurbar and Dhule Districts, prepared by Geological Survey of India are used to identify and validate dykes. Elongated contours and form lines are helpful to trace dyke ridges and that verified on the hill shaded DEM.

The digitized maps are used to estimate various attributes of the dykes, such as length, orientation and density. Rose diagrams are prepared in the Rockworks 16 software to draw the trends of the dykes and streams orientations to compared them to understand drainage orientation.

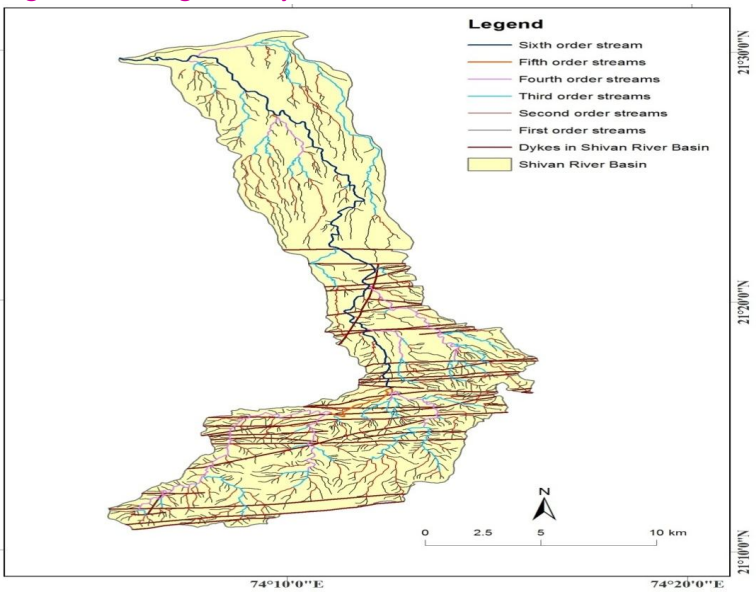
CATCHMENT MORPHOMETRICS

The drainage basin morphometric data is obtained from Survey of India (SOI) topographical maps 46-K/2, K/3, K/4 and K/7 (Scale is 1:50000), and 30-m Cartosat Digital Elevation Model (DEM). The drainage network is manually digitized and the basin is demarcated in ArcGIS using SOI toposheets. Quantitative analysis of the drainage pattern obtained from SOI toposheets. The derived morphometric parameters included – drainage basin area, stream order, basin relief, slopes, sinuosity index, etc.

The scanned maps of SOI toposheets and quadrangle maps are used and georeferenced by using ArcGIS 9.3 software. The present study is based on the analysis of 30-m Cartosat-DEM data. Linear ridges of several kilometers of length are clearly extracted from the Cartosat-DEM. In many cases the dykes do not form continuous ridges, but can be identified by strongly aligned spot heights over long distances on the topographic maps.

Field work is carried out to investigate some of the plotted dyke to understand their morphological attributes. Some of dykes are very clearly visible on the surface but some of the dykes are less than 5 m height. The Shivan river channel reaches are visited near Biladi, Nandurbar, Khamgaon and Ashte settlements. Dykes length and width and density are measured and their orientation is also identified.

Figure 2 Drainage and Dyke orientation in the Shivan River basin



DYKES AND SUPERIMPOSED DRAINAGE DEVELOPMENT

The drainage of the Shivan River system is not uniformly distributed over the study area. A modified dendritic drainage pattern is identified on the lithological, structural variations limited at the dyke ridges zones. The uncommon nature of the local geological structure and slope has determined the extent of superimposed drainage characteristics. Transverse or lateral consequent streams originate on the slope of dykes and joined the main stream. Many streams of Shivan flow transversely across dyke structures and slope. Channel curves, bends, diversions, junction angles, breaks in path are anomalies noted in the basin.

The present dyke-drainage network expression is superimposed drainage system in relations to the well outcropped dyke structure. In the 65% area of the Shivan drainage basin (169km2), represents superimposed drainage in dyke structure zone (Fig.2).

Shivan river basin reflects superimposed drainage systems in the Tapi dyke swarm subset region. Dyke ridges are aligned in the East-West (E-W) direction which are mainly followed by lower order streams which has developed insequent, transverse drainage network in the dyke swarm zone. Since the number of dykes is less in lower parts of Shivan basin drainage network follow the general slope and oriented in North-South direction. Shivan River and its tributary streams have adjusted with dyke orientation to some extent and developed transverse drainage pattern in the area of parallel ridges of dyke. The Shivan basin shape is typically narrower than surrounding drainage basins.

DYKES AND OVERALL STREAM ORIENTATION PATTERN RELATIONSHIPS

The Rockwork 16 software is used to prepare rose diagrams of dykes orientation and stream directions for each stream order. Rockwork software helps to draw rose diagram by using a line endpoint data and generates a directional diagram that depicts the orientations of the linear features. The dykes' strikes are mainly orient in E-W direction.

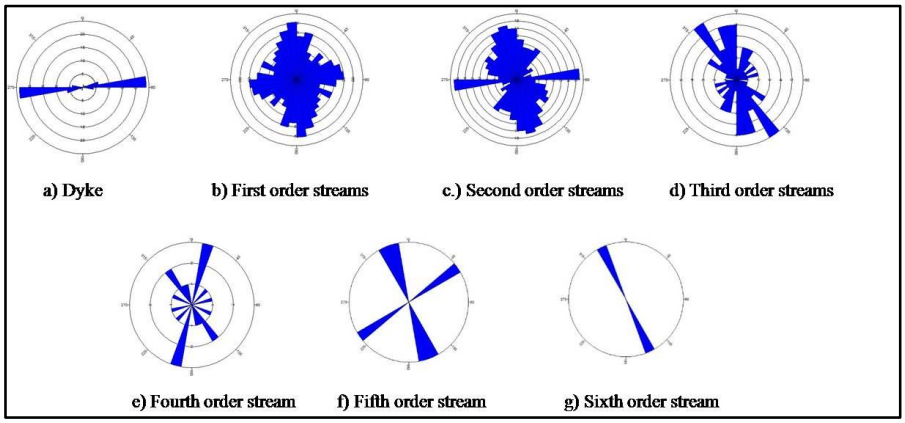


Fig.3 Rose diagrams of dykes and streams orientation

Fig.3 shows conspicuous strike of dykes and streams order wise rose diagrams. The mean value of dykes' orientation is 83°N. In each stream order the stream flow direction and the dyke strikes show coinciding directions over certain distances. It is observed that dyke orientation has greatly impacted on first order streams. The streams in each order have east-west orientation which shows an impact of dykes. The streams flows in other direction are insequent streams and are the indicator of dyke impact within the basin. The dyke orientation impact is greatly observed on initially developed streams along dyke ridges on either slope. Hence, it can be interpreted that, lower the stream order, higher is the impact of dykes on stream orientation. While higher the stream order, lower is the control of dyke on stream orientations.

CONCLUSION

The large mafic dyke swarm around Nandurbar is mapped within basin area of 262 km2. The total length of Sivan river is 59.33 km. There are total 37dykes exposed ranging from <1 km to 14 km in length. The intruded dykes are of highly weathered basalt flow of compound pahoehoe. Total length of dykes is 201.58 km. with density of 0.76 km per sq.km. Sinuosity index of Shivan River is 1.21, which indicates sinuous river characteristics. The orientation of lower and middle order tributary streams is controlled by the dyke properties formed genetic streams evolution in the basin. The response of the drainage network to dyke control is inversely related to the stream order network. The dykes have a greater control on lower order stream than the higher order stream attributes. Diversion of streams, bends, insequent, subsequent and resequent streams are developed in the river basin. The dyke ridges play an important role as water divide in

the drainage basin, which directs shape and size of drainage basin to some extent. The investigation of orientation of dykes and stream directions in the Shivan drainage basin throws light on the relationships between them. The alignment of stream flow is oriented some extent to the respect of geological structure of dykes. Shivan river course has adjusted to some extent to dyke orientation and developed transverse drainage pattern in the alternating parallel ridges of dyke. Linear ridges of dykes have modified main dendritic drainage pattern.

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