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# Mapping of Lineaments in Adwa River Basin Using Remote Sensing and GIS Techniques

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**Abstract:**

*Large parts of our planet Earth consists of hard rock's, where water is restricted to secondary permeability, and thus to the fractures and the weathered zones. As the success ratio of drilling in hard rock terrain may be low, and the use of geophysics is often considered too expensive, the study of lineaments from remotely sensed imagery offers an attractive alternative analysis technique. High production areas in hard-rock aquifers are generally associated with conductive fracture zones. An effective approach for delineation of fracture zones is based on lineament indices extracted from satellite imagery. Together with a detailed structural analysis and understanding of the tectonic evolution of a given area it provides useful information for geological mapping and understanding of groundwater flow and occurrence in fractured rocks. The accuracy of extracted lineaments depends strongly on the spatial resolution of the imagery, higher resolution imagery result in a higher quality of lineament map. This paper is aimed at characterizations of the geological as well as the geomorphological lineaments of Adwa river basin to infer fault structures, especially those produced by neotectonic activities. Lineament analysis of Adwa River basin and adjoining area were carried out using a remotely sensed IRS-LISS-3 Satellite imagery for the analysis of the areas based on the frequency and density of lineaments on the lithology. The area comprising 351 lineaments in the rocks of Proterozoic, Deccan trap, and Upper Gondwana formation. The lineaments of the study area comprises of part of the Son Narmada Tapti Lineament System*

*which has numerous long and short fractures/lineation whose structural trends are mainly to the Son Narmada Tapti Lineament and gets the special significance to the given study area. The extracted lineaments were statistically analyzed to determine lengths and intersections of the lineaments to create rose diagram and lineament map.*

**Key words:** Lineaments, Neotectonic, LISS-III satellite image, River basin

## 1. Introduction

A lineament is a mappable linear or curvilinear feature of a surface whose parts align in a straight or slightly curving relationship. The term lineament was first introduced by W. H. Hobbs in 1904 that recognized the existence of linear geomorphic features and interpreted them as surface expressions of zones of weakness or structural displacement of the earth's crust. Lineaments are linear features on the Earth's surface, usually related to the subsurface phenomena. Lineaments seen on remote sensing data like satellite image/aerial photographs and geophysical data etc. are of great relevance to geoscientists as they reflect various structural features and tectonic set-up of an area. The surface features making up a lineament may be geomorphological, i.e. caused by relief or tonal, i.e. caused by contrast differences. Straight stream valleys and aligned segments of a valley are typical geomorphological expressions of lineaments. A tonal lineament may be a straight boundary between areas of contrasting tone. Geomorphic features, which appear as lineaments on the maps, aerial photographs and satellite images include streams, linear valleys and ridgelines. Lineament studies have vast applications in different disciplines of geosciences for example identification of tectonic features, recognition of folds and

faults, exploration of mineral deposits, petroleum prospects and groundwater etc.

The Adwa river basin has been evolved as a result of typical hydro geomorphic processes of semi-arid zone, operating under the influence of active tectonic lineaments. A detailed analysis of stream morphology in relation to geology and lineaments carried out over the entire Adwa River Basin indicated the morphological control of the streams while flowing over the lineaments from the western to the eastern part of the basin.

## Objective of the study

The purpose of this study is to analyze the spatial distribution of lineaments extracted from remotely sensed satellite data to analyze length and orientation for the understanding of the faults and their association to the Son Narmada Lineaments. Thus to prepare a detailed classification of major and minor lineaments and their influence on hydro geomorphic processes in the Adwa river basin this study has been undertaken.

## 2. Study Area

The Adwa River is the tributary of the Belan river and the Belan river is the tributary of the Tons and then the Ganges river system. The Adwa River meets the Belan River in the Mirzapur district of Uttar Pradesh though the pear shaped basin of the Adwa River stretches between two states i.e. Uttar and Madhya Pradesh. The boundary of the two states almost bisects the Adwa river basin. The latitudinal and longitudinal extent of this basin is from $24^{o}$ 34' N to $24^{o}$ 54' N and from $82^{o}$ 06' E to $82^{o}$ 33' E respectively. This study area covers the total area of 826sq.km approximately. Long hot summers, moderate monsoon rains and pleasantly cool winters are the basic characteristics of the Adwa river basin.

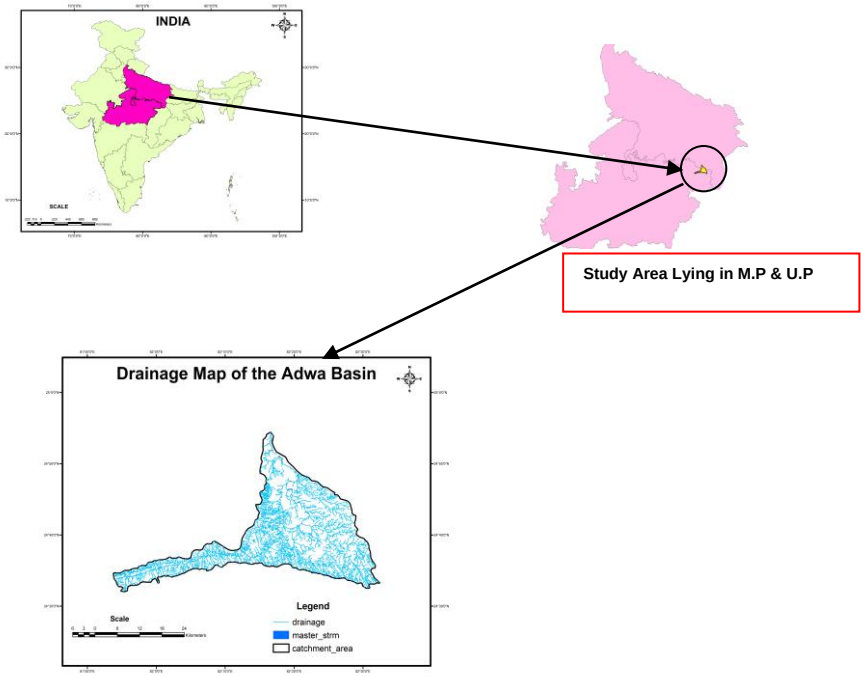


**Fig. 1 Study Area with its general drainage**

## 3. Geology of the Study Area

Geologically the area mapped forms part of Vindhyan Plateau. The river basin lies in between Ganga River Basin in the North and Vindhyan Mountain System in the South. The rocks of the Kaimur group being the oldest in the area, forms vast plateau on both the flanks of Belan River and its tributary mainly Adwa River. These are overlain by the rocks of the Rewa Group which comprises of argilloarenaceous sequence. Many different tectonic phases and neotectonic movements have intensively affected these rocks. Sedimentary structures preserved indicate on a shallow water stables shelf environment. Both planar and trough shaped cross beds have been recorded. Cross beds indicate northwest to southeast palaeo current direction, some evidences of neo tectonic have been recorded from rocks of the

Dhandraul Formation. Ichno-fossils have been identified in Lower Rewa sandstone of Rewa Group. The two-third of the southern part of the Adwa basin lies in Northern Foreland of Peninsular India (NFPI) and only one – third of northern portion of basin lies on the fertile Gangetic plain.

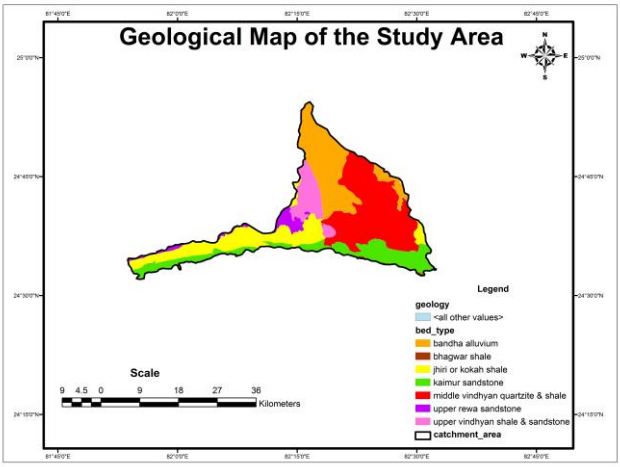


**Fig. 2 Geological Set-up of the Study Area**

## 4. Lineament

Lineaments/fractures are defined as mappable linear surface features, which differ distinctly from the patterns of adjacent features and presumably reflect subsurface phenomena (O'Leary et al. 1976). Satellite data along with aerial photographs are widely used to extract lineaments for different studies. The study of lineaments has been applied successfully to structural geology studies and their applications such as ore forming systems, mineral exploration, petroleum etc.

The tectonic framework in and around the Adwa River Basin is related with the adjoining Central Indian Tectonic Zone (CITZ) and more so with the Narmada Son North Fault (NSNF). The major lineament directions in the Adwa River Basin are East-Northeast (ENE). North-Northwest (NNW) and

South-Southeast (SSE). These directions have been correlated with the Neo-Tectonics by Pati.et.al (2006).

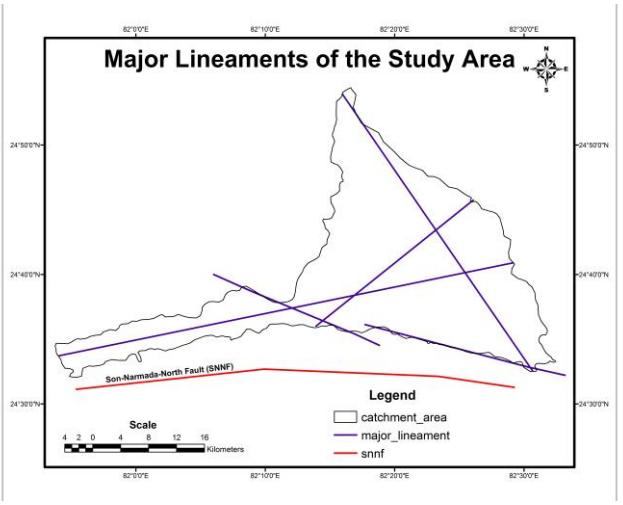


**Fig.3 Major Lineament Map of the Study Area**

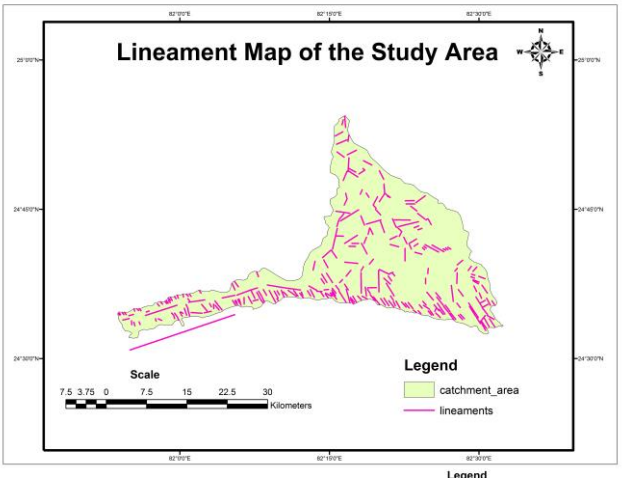


**Fig. 4 Lineaments of the Study Area**

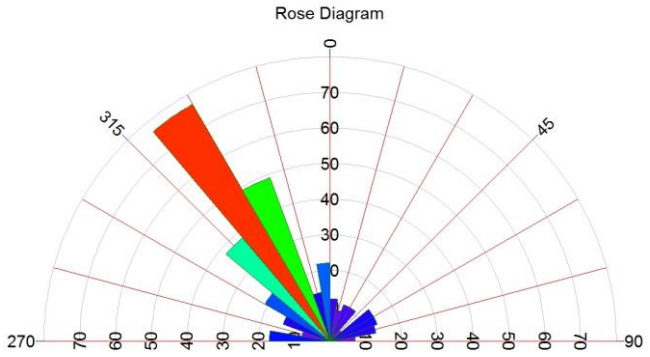


**Fig. 5 Rose Diagram of Lineament Distribution of the Study Area**

## 5. Methodology for Lineament Analysis

For the present study the IRS P6 LISS III 2010 satellite data was used to delineate Quaternary litho units of the Adwa River. Active channels and floodplain features were mapped. The digital data format from Indian remote sensing satellite (IRS P6) of LISS-III with 23.5m spatial resolution with four spectral bands was used to meet the requirement of area under study. The image taken was false color composite (FCC) on 1:50,000 scale, having band combination of 4:3:2:1 (NIR: red: green). The SOI toposheets and digital satellite data were geometrically rectified and geo-referenced and merged using Arc GIS 9.3.Lineament map has been prepared by detecting and tracing lineaments from satellite imageries on the basis of textural, soil tonal, vegetation, topographic and drainage linearity (Lillesand 1989; Drury 1990) by visual interpretation and compared to geological maps of the study area in an attempt to find obvious correlations of rocks and structures with individual lineaments.. The non-structural and 'false' lineaments have been eliminated after comparing lineament map with the corresponding toposheets (63L/1, 63L/2, 63L/5, 63L/6, 63L/10, and 63H/14) and field verification leaving the 'geologic lineaments'. The litho logical map has been prepared by visual interpretation of the satellite imageries and field investigation.

The structural data featuring joints/fractures, foliations and lineament orientations have been analyzed very critically. Several lineaments run NE-SW, NW-SE, E-W and WNW-ESE directions (Fig. 4), which control the basement structure in the study area.

Some additional digital image processing techniques like contrast enhancement, contrast stretch, color composites and spatial filtering is also used to mark lineaments using Erdas Imagine 9.1 (image processing software). ArcGIS 9.3 (a GIS software) was used for database creation, azimuth direction, lineaments length and lineaments classification using different criteria e.g. direction, origin and types etc.

The study of these lineaments in relation to geology, structure, magnetism, mineralization and deep geophysical responses etc. led to the classification of these lineaments into various groups and classes.

1) Stream and streams segment designates relatively short; straight channel reaches commonly connecting at sharp, angular junctions. Stream segments include the shortest lineaments recognized, as short as 2 km long. Stream segments were delineated only if they were part of a distinctive sequence of linear channels.

2) Drainage line designates linear valley trends independent of the orientation or linearity of channel segments.

3) Scarp and fault line scrap designates a prominent topographic break evident because of changes in land cover or land use, changes in drainage pattern, variations in outcropping rock units, or the presence of shadows on the imagery.

4) In dividing lineaments between the high plains and rolling plains categories, the scarps of the caprock escarpment boundary feature are considered separately as a unique physiographic category.

5) Geologic contact designates linear contacts between surficial materials with different reflectivity.

6) Tonal anomaly designates as a linear feature.

Based on the length of individual lineaments, such lineaments have been classified:

(i) Micro
(ii) minor
(iii) medium
(iv) major
(v) mega

### 5.1. Lineament Extraction

Two most widely used common methods for the extraction of lineaments from satellite images are:

1) Visual extraction: At which the user primarily starts by image processing method to make edge enhancements, using the directional and non directional filters such as the Laplacian, and Sobel, then the lineaments are digitized manually by the user.

2) Automatic (digital) extraction: different computer-aided methods for lineament extraction have been proposed. Mainly used in the lineament extraction methods are based on edge enhancement techniques.

In this study, the author has used the Visual Extraction technique to extract lineaments from the satellite image and 5 major and 346 micro, minor and medium lineaments are extracted from IRS LISS-3 images data. The resulted lineament maps (shown in Figures 3 and 4) and the frequency distribution of micro, minor and medium lineaments are represented with the help of a rose diagram as seen in Fig.5. Manually extracted lineaments are evaluated in order to extract further information on the distribution and nature of the lineaments.

### 5.2. Lineament Length

In the study area, there are 5 major and 346 minor lineaments of different length (as counted using Arc GIS 9.3 software). The 346 lineaments are further classified on the basis of their

length into three categories. There are 296 lineaments of the micro type (< 2km) which is equal to about 84.33% which covers the larger part of the study area and 49 lineament are minor type which is equal to 13.96% and while only 1 is of medium category (Table 1). The resulting map reveals a range of lengths which are indicative of several geo-tectonic and geomorphic controls, mainly the power of the tectonic forces, rock hardness and consolidation, geomorphic setting of terrain where lineaments exist.

**Table.1 Details of Different Lineament Types**

| S. No. | Type of Lineaments | Total Number | Percentage |
|---|---|---|---|
| 1. | Micro (< 2kms) | 296 | 84.33% |
| 2. | Minor (2 to 10kms) | 49 | 13.96% |
| 3. | Medium (10 to 20kms) | 1 | 0.28% |
| 4. | Major (20 to 100kms) | 5 | 1.42% |
| | Total Number of Lineaments | 351 | |

### 5.3. Classification of Lineaments

The length of lineaments can be used for further classification keeping in mind the high resolution data/large scale of mapping (up to 1:5000) possible. Lineaments can be classified based on their length as (i) micro: <2 km, (ii) minor: 2-10 km, (iii) medium: 10-20 km, (iv) major: 20-100km, and (v) mega > 100 km.

### 5.4 Lineament Trends in the Area

Most of micro, minor and medium lineaments trends are N, NE, E, W, and NW It suggests that the trends are East- West, East-North East, West-South West, Northwest-Southeast, and North-South axis which is also the principal direction of the regional structures directions. In the study area mega lineament are absent.

## 6. Conclusion

Satellite data has provided evidence to lineament identification and mapping. This study demonstrates the satellite lineament interpretation of the study area. The result derived from the study area of the analyzed lineament/fracture indicates that the area has numerous long and short fractures whose structural trends are mainly in North to North West direction. The cross-cutting of major lineaments is relatively high in central part of the study but low in the other part of the study area (Figures 4). The lineament intersection density shows the tectonic activity in the study area. It has been found that most of the major orientations in the field could be successfully detected from the satellite image. The results show that the remote sensing and GIS technique is competent of extracting lineament trends for the tectonic analysis. The total of 5 major and 346 micro, minor and medium lineaments were extracted from the satellite image with a total length of 647.025 km. The rose diagram (Figure 5) shows the directional frequency of the mapped lineaments over the area which has major trends in the North and North West trends. Apart from the prominent trends the lineament from the study area shows a strong correlation with the Son-Narmada-North-Fault (SNNF) which lies immediate to the south of the study area and these lineaments are result of release of hidden subsurface tectonic pressure in the form of linear features intersection and cross cutting geological structures. The detailed study of the linear valley indicates that it is a very apt location for water resource potential by acting as an overhead tank in the form of dam and using the water in the form of drip irrigation as this area has insufficient rainfall.

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