Implication of Remote Sensing Techniques in Identification of Linear Features and Delineation of Lithotectonic Units of Badrama- Jamankira Area of Sambalpur District, Odisha, India

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***Abstract*—In any geological study, may it be regional or local, it is crucial to identify different rock units, trace out their aerial extension and draw the boundaries as accurately as possible. Remote sensing techniques have been proven through several studies worlds over, to be a reliable tool for a large area mapping and need based thematic analysis cum interpretation, as the satellite images have the capability of providing a synoptic view of a large region in one scene and allows to perceive the relations of different lithological units of a region. Vital geological information related to lithology, geomorphology, structure and tectonics are obtained through the visual as well as digital method of interpretation of satellite imageries. The tonal-textural variation exhibited by different rock types help scientists and researcher in identifying linear features, delineating lithotectonic unit and interpreting litho-assemblages of the area.**

Keywords— Remote Sensing, Linear Features, Structural pattern, lithotectonic units, Thematic mapping, Deogarh-Jamankira supracrustals, Badrama Belt.

I. INTRODUCTION

Although, the classical method of geological mapping is found to be the best suitable means for precise collection of field data, but while covering a wide area for regional geological mapping in multifaceted topography somehow limits out the physical access to the target area. Also, such strenuous field practices consume unnecessary time and efforts. Under the circumstances Remote sensing technique seems to be an advantageous option for covering a widespread area of interest. Satellite bases remote sensing techniques give us such liberty to extract accurate needful geological information in terms of linear features, lineaments and structural pattern etc. from the imageries. Further, a generalized litho-assemblages boundary and lithotectonic delineation can easily be interpreted through such imageries. Accordingly, a meticulous extraction and the interpretation of the lineament need to be done, if visual extraction looks to be inaccurate a software driven method of lineament extraction may also be adopted. But before establishing those as final facts, a ground validation of the selected area should also be done.

As stated by Katsuaki et al., (1995), Moore et al., (1998) and Walsh (2000) the extraction of linear features through satellite mages may broadly be categorized into-

(i) lineament enhancement and lineament extraction for characterization of geologic structure;

(ii) image classification to perform geologic mapping or to locate spectrally anomalous zones attributable to mineralization (Mostafa et al., 1995; Süzen and Toprak1998); and

(iii) superposition of satellite images and multiple data such as geological, geochemical, and geophysical data in a geographical information system (Novak and Soulakellis 2000; Semere and Ghebreab 2006).

As the integration of remote sensing data in actual period is supposed to be a bulk tool for extraction and interpretation of geological features numerous researches are being conducted for precise adaptation of both passive and active remotely sensed data into instinctive detection of momentous geological features like linear features.

II. STUDY AREA

The study area Badrama- Jamankira measures about 700 sq km covering parts of the supracrustal rocks of Deogarh-Jamankira area, the western part of granulite terrain (Rengali Province), a small segment of CIC covered by a narrow strip of Gondwana rocks and a trivial segment of Jharsuguda Complex, which lies in the northern part of Sambalpur district of Odisha state has been selected for regional geological mapping (Fig. 1). The R-K lineament, which defines the northern boundary of CIC and EGMB, also passes through the area. The study area is bounded by latitudes 210 28’ and 21045’ N and longitudes 840 07’ and 840 21’ E. and covers 290 sq km of Survey of India Toposheet no. 73 C/2, 30 sq km of 73 C/3, 350 sq km of 73 C/6 and 30 sq km of 73/7 as shown in Fig 1.

III. RESOURCES

To get a holistic idea about the lithotectonic units and structure of the west central part of Odisha including the study area, multiple scenes of the space borne multispectral images have been used. Both panchromatic images and false colour composite (FCC) images have also been interpreted in course of the study to outline the prominent linear features,

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lineaments and lithotectonic units. Different scene used in the present study is listed in Table- 1.

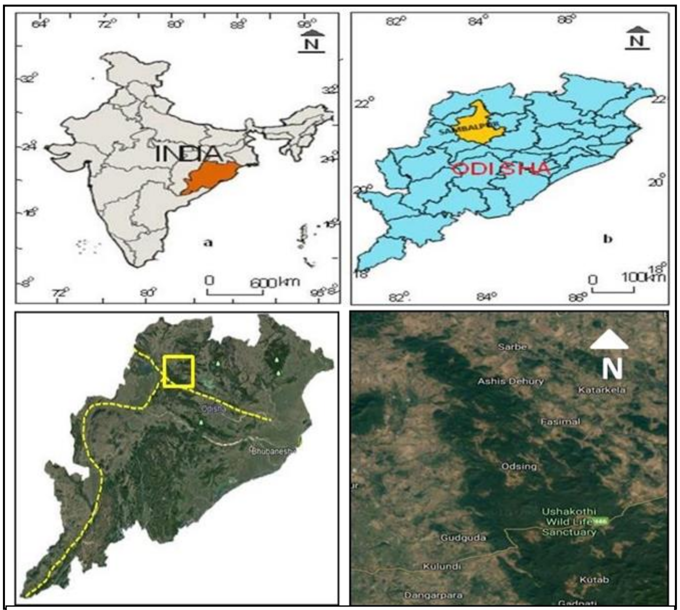

Fig. 1. A. India Map showing the position of Odisha, B. Map of Odisha showing the location of Sambalpur district C. Satellite image map showing the three crustal blocks (North Odisha-Singhbhum Craton, NOSC; Central Indian Craton CIC and Eastern Ghats Mobile Belt, EGMB. D. Satellite image covering the study area.

Table- 1. Details of the database used for geological information

Sl. No.	Type of Material and Scale	Name of Satellite and Path- Row	Sensor used and Spatial resolution	Band No.	Wave Length in µm
1	B & W Paper Print 1:250000	LANDSAT 151-045	ERTS 80m x 80m	4 5 6 7	0.50-0.60 0.60-0.70 0.70-0.80 0.80-1.00
2	B & W Transparency 1:1,000,000	LANDSAT 141-045	MSS 80m x 80m	2 4	0.60-0.70 0.80-1.00
3	B & W Paper Print 1:250,000	LANDSAT 141-045	MSS 80m x 80m	1 2 3 4	0.50-0.60 0.60-0.70 0.70-0.80 0.80-1.00
4	B & W Paper Print 1:250,000	LANDSAT 141-045	TM 30m x 30m	1 2 3 4 5 7	0.54-0.52 0.52-0.60 0.63-0.69 0.76-0.90 1.55-1.75 2.80-2.35
5	FCC Paper Print 1:250,000	LANDSAT-2	TM 30m x 30m	FCC 2,3, 4	
6	FCC Paper Print 1:50,000	IRS-IA 22-53 A1A2B1B2	LISS-II 36.25m x 36.25m	FCC 2,3,4	
7	Digital data	IRS-ID	LISS-II		
8	Digital data	Downloaded from open E-sources			

IV. PROCESDURES & INTERPRATATION

At the outset, a mosaic was prepared manually by placing the imageries side by side in such a sequential order of latitude and longitude so that the photo/ image features look connected through one another. In the initial stage, visual method of interpretation was adopted, i. e., lithic units and structural features were differentiated based on observed variation in tone, colour, texture, shape, size, pattern, association, vegetation cover and drainage pattern. After the imageries covering the west-central part of Odisha were placed properly the relevant features were traced on a tracing sheet. Based on the distinct characteristics seven lithotectonic units were outlined (Fig. 1. 1.), which are as follows-

1. Bonai Granite Complex,
2. Tamperkola Granite,
3. Deogarh Belt,
4. Badarma Belt,
5. Kuchinda Granitic Complex,
6. Jharsuguda Granitic Complex, and
7. Sambalpur Granitic Complex.

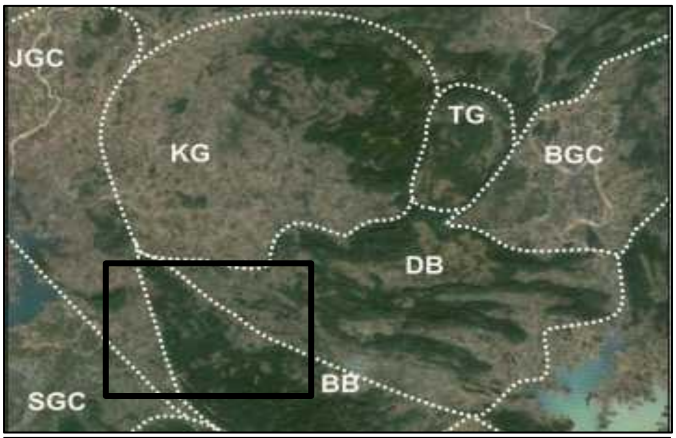

Fig. 1. 1. Map showing lithotectonic units in the west central part of Odisha

Apart from delineation of lithotectonic units, lineament analysis forms an important component of satellite image interpretation. Lineament is variously defined. In the present study, the definition of O'Leary et al., (1976) has been followed while doing interpretation and image feature extraction. According to them "a lineament is a mappable linear feature of a surface (may be simple or composite) whose parts are aligned in a rectilinear or curvilinear relationship and which is differ distinctly from the adjacent features and reflects a subsurface phenomenon".

Early investigators, viz., Hudson (1974), Kutina, (1974) have separated several classes of lineaments corresponding to such structures penetrating the earth's crust as near vertical faults, different joint patterns, shear zones steep vertical compositional banding or planer tectonic fabric. Following their pattern of separating different types of structural elements, the following procedures have been adopted to delineate different types of lineaments existing at the regional scale (Fig. 1. 2).

(1) Discontinuous linear/ curvilinear features have been related to deformational or compositional layering.

(2) Continuous straight lineaments, curvilinear features within a specific lithological unit have been considered to represent folds, mega joints or faults.

(3) Curved but continuous lineaments have been taken either to represent deformational banding on regional scale or shear zones.

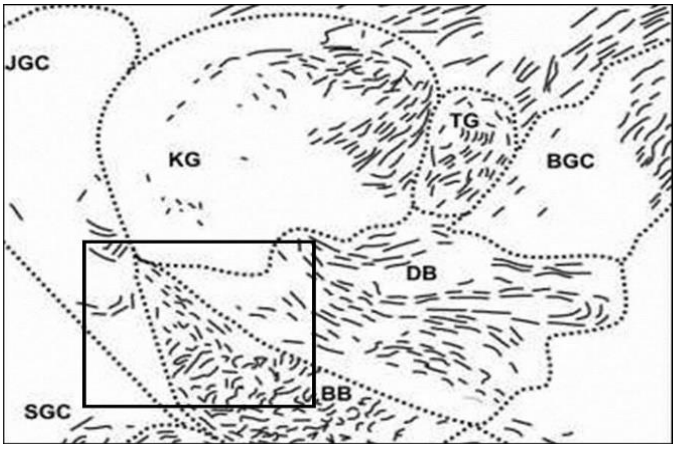

Fig. 1. 2. Map showing lineament and linear feature in different lithotectonic units

Image interpretation and subsequent ground validation clearly confirms that different colour/ tone, geomorphic features, drainage pattern provide reliable information about different rock types (Pandey, 1984). A course texture indicates very rugged topography, which itself hints presence of massive crystalline rocks cut across by faults and joints. In the colour or the tonal variation is reflected the nature of vegetation and composition of the rocks that occupy a region. Drainage pattern provides additional information about the lithological characters because the pattern is controlled to a large extent by the competency/ erodibility of the rocks and structures viz. bedding, foliation, joints, faults, shears etc. Granitic rocks form flat or moderately undulated terrain, and exhibit light colour with little tonal variation. Such an area is characterized by dendritic drainage and occasionally rectangular or angular drainage pattern. Dark tone signs basic rocks. Metasedimentary rocks with alternate competent and incompetent lithology usually show linear and curvilinear features which run parallel to one another in close cluster. In such areas, the drainages run parallel to the hills giving rise to parallel/ subparallel drainage pattern. As the infiltration of water is more in the metasedimentary rock types, the drainage density is comparatively less than igneous/ crystalline rocks.

Subsequently, digital interpretation of the images which cover the study area was done. The downloaded/ scanned raster images (.jpeg/.pdf) were georeferenced in desired projection system through suitable software like- Global Mapper and Arc GIS. Various maps, viz. terrain model (Fig. 1. 3.), ridge slope (Fig. 1. 4.), slope direction (Fig. 1. 5.) were prepared through software aided analytical techniques.

The information generated through visual and digital interpretation helped to trace the boundaries of lithotectonic blocks, identify rocks of different parentage, trace out structural features and made the job of geological mapping much easier (Fig. 1. 6.). In the absence of satellite images and the modern tools and techniques of extraction of geological information, it would have been difficult to complete geological mapping of a terrain like the present one within a short time period.

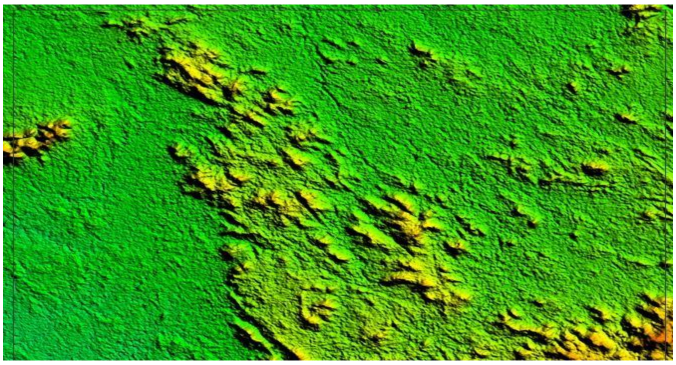

Fig. 1. 3. Terrain model map of the study area

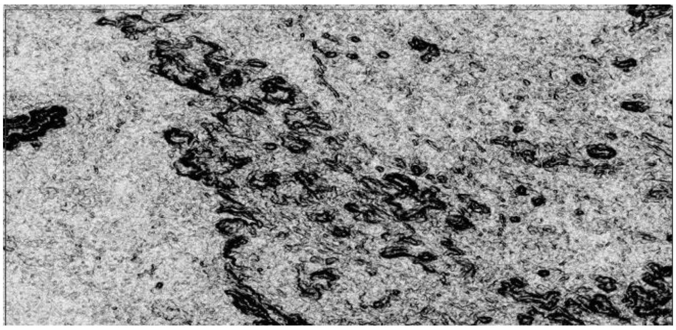

Fig. 1. 4. Ridge slope map of the study area.

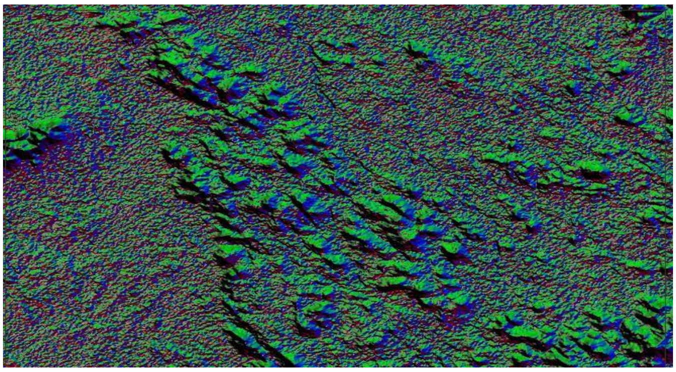

Fig. 1. 5. Slope direction map of the study area

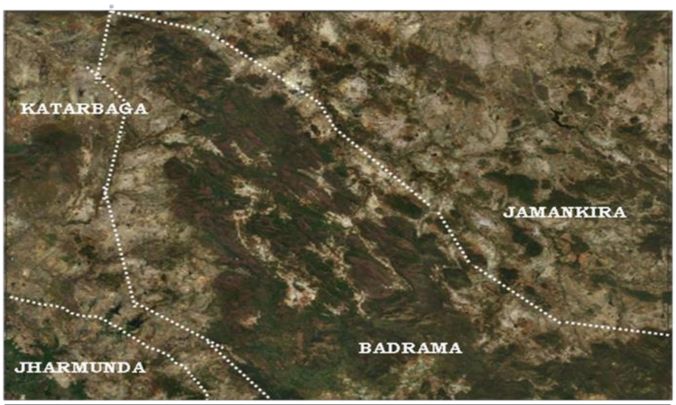

Fig. 1. 6. Satellite image of the study are showing block boundaries

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Unit- I: Jamankira Lithotectonic Unit

The Jamankira lithotectonic unit is a part of Deogarh belt, covers the eastern part of the study area. This litho-unit displays lot of colour variation in the IRS-IB, LISS III FCC. It also exhibits variation in texture from very coarse to fine.

Linear and curvilinear features are very prominent in the central part of this unit where the texture is coarse. The linear features are less prominent and discontinuous in southern part. Field verification revealed that the areas which are thickly forested, appear brown to red whereas the areas with poor vegetation look light grey to pink. The areas characterized by linear features were found to be occupied by well foliated (metasedimentary) rocks, mostly coarse grained quartzites of different colour and composition. The areas having fine texture are mainly covered by granitic rocks with a thin blanket of soil at places. Drainage pattern observed within this unit varies from dendritic to parallel from place to place depending on the rock type present. It was established that the variation in colour, texture, distinction of linear features and drainage pattern is the reflection of the presence of varied rock types in this unit

Unit- II: Badrama Lithotectonic Unit

To the southwest of Deogarh belt lies the Badrama Belt. This belt appears to be sinuate shaped, and covers the central part of the study area. The outline is that of a leaf, which gets wider in the southern side and acute towards north. In the IRS-IB, LISS III FCC this unit displays brown to deep brown colour. Linear and curvilinear features are numerous and prominently developed over major parts of the area. About 110 lineaments of different lengths have also been delineated. Based upon their orientation these lineaments have been classified. The prepared rose diagram (Fig. 1. 8.) suggests that statistically the NW-SE (N1200 to N1300) trending lineaments are maximum in numbers in the area.

In the satellite imageries, it exhibits a very coarse-grained fabric, i. e., the topography is rugged.

Superimposition on toposheets suggests this unit to cover the hill ranges like Gudguda- Chinimahul in the south and Sarbe to Samarsingha in the north. Ushakothi wildlife Sanctuary falls within this unit. Dendritic pattern of drainage can easily be visualized in the software driven analytical image. Sarkar et al., (2000) stated that the area is occupied by charnockites and garnetiferous granite gneiss. During geological mapping, many more rock types like hornblende schist, garnetiferous biotite schist, calc gneiss, granite gneisses, garnetiferous granite gneisses, hornblende granite gneiss, migmatite, dolerite could be identified. Prominent foliation is the result of deformation. The variation in attitude of structural features suggest the rocks of this block have undergone multiphase deformation.

Unit- III: Katarbaga Lithotectonic Unit

Katarbaga lithotectonic unit lying to the west of Badrama Lithotectonic unit is a small segment of the falcate shaped Jharsuguda Granitic Complex of Naik (1989). It covers only 30 sq km of the study area. The contact between Badrama Belt and Jharsuguda Granitic Complex is almost straight one and is clearly seen in the satellite images as a lineament. It is identifiable based on the tonal and textural variation of the two units. While Badrama belt is characterized by red to dark brown colour and coarse texture representing a thickly forested area with rugged topography, Jharsuguda Granitic Complex has light pink to grey colure and fine texture in IRS-IB, LISS-III, FCC, except a small area showing coarse texture with prominent linear pattern. Ground truthing revealed the area to be occupied by granitic rocks within which occur metasediments like biotite schist and quartzites. The area in the southernmost and central parts of this unit exhibiting coarse texture are occupied by curvilinear ridges and are composed of well bedded, sheared quartzite.

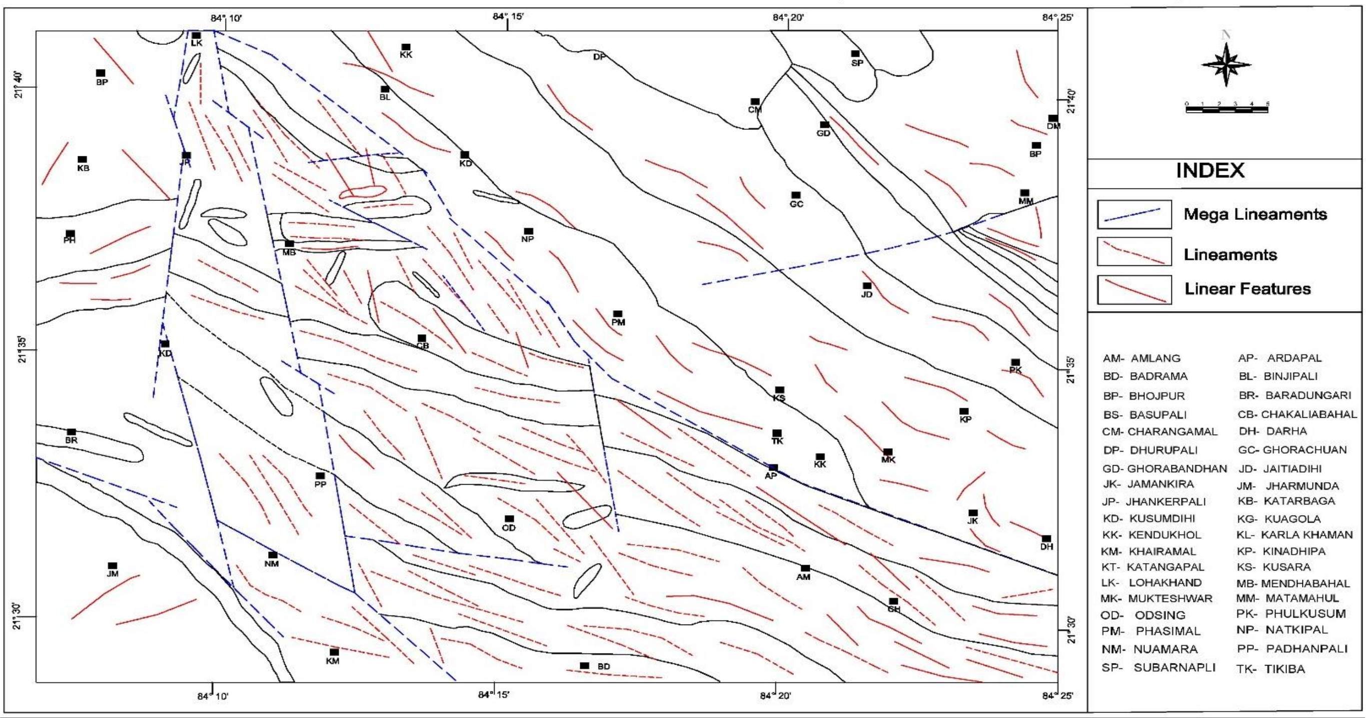

Fig. 1.7. Lineament Map of the study area

Unit- V: Jharmunda Lithotectonic Unit

Jharmunda lithotectonic unit forms a small part of study area. It lies in the south-western corner and is separated from the Katarbaga lithotectonic unit by a prominent lineament. Tonal and textural signatures indicate that the area is flat and almost free from prominent linear or curvilinear features, light pink to grey colure and fine texture in IRS-IB, LISS-III, FCC indicative of an area with no forest cover. These features suggest it to be occupied by much denuded granitic rocks and or soil. While ground validation the area is found to be occupied by grained porphyritic granite.

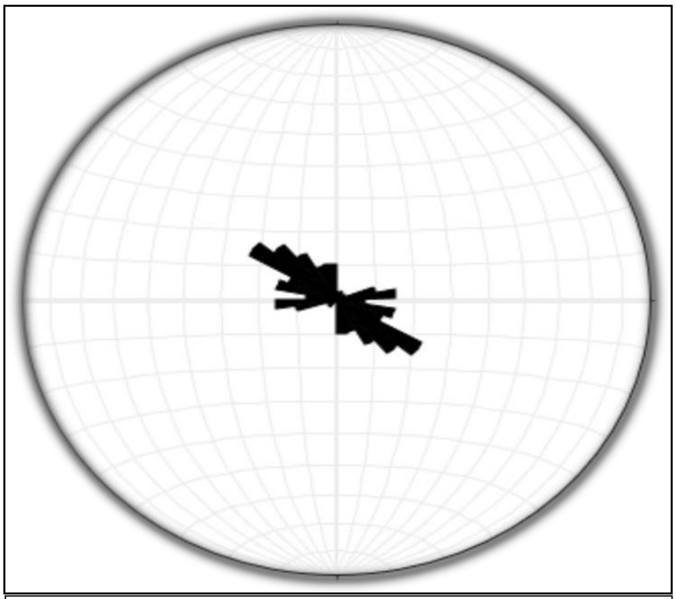

Fig. 1.8. Rose diagram showing lineament's orientation

V. DISCUSSION

Based on the date obtained from visual and digital interpretation of satellite images, a lineaments map of the study area is prepared (Fig. 1. 7.). It is established from the generated data that mega-lineaments divide the study area into four blocks, each block having a characteristic rock assemblage and structural features of its own. Apart from these numerous major and other lineaments of different lengths have also been delineated. Their orientation differs from block to block. Whereas, NW-SE trending lineaments are more in Badrama and Jamankira blocks. The N-S and E-W trending lineaments in Katarbaga block are more.

In each block the nature of the linear features, representing the bedding and foliation traces are different suggesting rocks of different blocks were folded separately. In Badrama lithotectonic unit, lineaments are prominent but short in length, muddled and exhibit much variation in their trend. In Jamankira litho-unit, lineaments are less prominent, short in length, organized and mostly remain subparallel to each other. The Katarbaga lithotectonic unit only two lineaments could be recognized.

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