IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Remote Sensing techniques in lineaments extraction and lithounits demarcation of Namkom area Ranchi, Jharkhand

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Abstract: Remote sensing and GIS technologies empower academicians and professionals to plan and conduct a rapid, cost effective, wide ranged survey and monitoring. In addition, remotely sensed data have been proven to be an imperative tool in geological prospecting. particularly in identifying and interpreting lithological variation, landform features, drainage pattern and geomorphic indicators at regional scale, mostly in the inaccessible/ unapproachable areas. Remote sensing techniques have a potential of providing a synoptic view of a large area in single platform, where one can sense the variation cum mutual relationship of different lithological units. Subsequently, while geological investigation of a large area, the remote sensing techniques are being used to gather supplementary information for onward geological interpretation in terms of lithological assemblages, geomorphologic variation and structural trends.

Index Terms **- Remote Sensing, satellite imageries interpretation, Linear Features, litho-assemblage, Chhotanagpur Granite Gneiss Complex.**

I. INTRODUCTION

The applicability of Remote sensing has already been established as a versatile tool for mapping of large and inaccessible areas. It has also been proved as reliable technique in the preparation of need based thematic maps and generation of trustworthy data for use. Image interpretation and succeeding ground verification based on colour/ tone variation, geomorphic features, drainage pattern are routine tasks in remote sensing application (Pandey, 1987). This remote sensing technique not only saves time and effort but also found to be cost effective while preparing need based thematic geological mapping. Satellite based remote sensing technique is a convenient platform to extract accurate geological evidences like- linear features, lineaments and structural pattern etc. from the imageries. Additionally, a comprehensive litho-assemblages boundary and lineaments demarcation can also be construed through such imageries. Consequently, to draw out an accurate litho-boundary, scrupulous extraction and the interpretation of the litho-contacts need to be performed. If visual extraction of such features looks erroneous; a software driven method of lineament extraction may also be adopted. But a ground validation of the extracted features in approachable area must be done before establishing those as final facts.

Katsuaki et al., (1995), Moore et al., (1998) and Walsh (2000) states that the extraction of linear features through satellite images may broadly be categorized into-

1. Lineament enhancement and lineament extraction for characterization of geologic structure;
2. Image classification to perform geologic mapping or to locate spectrally anomalous zones attributable to mineralization (Mostafa et al., 1995; Süzen and Toprak1998);
3. And 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).

II. Study Area

The area measures about 3000 sq km covering mainly the part of stable peninsular India, most of the part is consist of Chhotanagpur Granite Gneiss Complex (CGGC). The Chhotanagpur Granite Gneiss Complex is mainly composed of granitic rocks but their mineralogical assemblage and pattern is different. The study area is bounded by latitudes 23^0 05’ 00 and 23^0 35’ 00 N and longitudes 85^0 09’ 00to 85^0 39’ 00 E that falls in the Survey of India toposheet Nos.73 E/6, 73 E/7, 73 E/8, 73 E/10, 73 E/1 and 73 E /12 (Fig. 1.1).

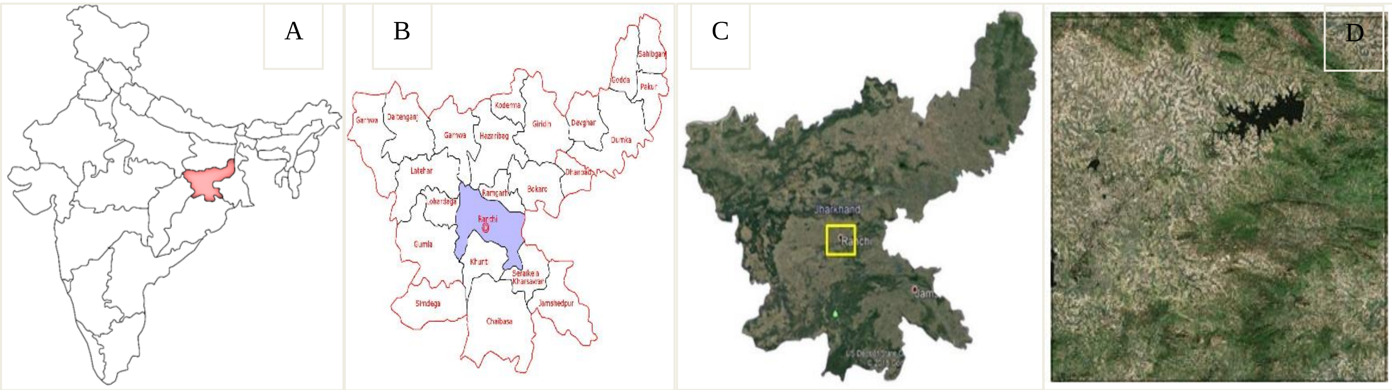

Fig. 1.1 – A) Political Map of India showing position of Jharkhand B) Political Map of Jharkhand showing position of Ranchi C) Satellite image of Jharkhand indicating study area D) Satellite image of study area.

III. Resources

To get the appropriate prima facie impression of the area and to demarcate the tentative boundary of different lithologic units, generalized/ regional structural trend, geomorphologic expression of different rock types of the area, multispectral images, panchromatic images and false colour composite images were studied in detail. In the beginning data extraction and interpretation was done by visual interpretation based on tonal, textural, colour, shape and pattern variations. But in next stage some software driven methods were also practiced for data synthesis at best accuracy. Details of datasets used for extraction and interpretation are mentioned in Table no. 2. 1.

Table- 1. DETAILS OF THE DATABASE USED FOR GEOLOGICAL INFORMATION

Sl. No.	Data Type	Satellite	Resolution	Revisit period	Path-, Row and Swath	No. of Scenes covering Ranchi district
1	IRS – P6 (Resource SAT) Multispectral Data	LISS-III	23.5 m	24 Days	105-55, 105-56 141 Km	2
2	IRS – P6 (Resource SAT) Multispectral Data	LISS-IV	5.8 m	5 days	104-54B, 104-55B, 104-55D 105-55C, 105-55D, 106-55A 106-55B 23.9 Km	30
3	Panchromatic Data (Single Band)	Cartosat -1	2.5 m	5 Days	29.4Km	20

IV. Procedure and Interpretation

Understanding the proper disposition of the boundary the geo-coded satellite imageries were placed side by side to align with the boundary of each scene through GIS software 21st Century. Once the images were properly placed, a tentative limit of the lithological units prevailing within the study area was demarcated based on traditional method of visual interpretation, i.e., observed variation in colour, tone, texture, association, drainage pattern, and vegetation.

Subsequently, the generated vector information was used at different stages in different image processing softwares for interpretation. As the multispectral satellite images Fig. 1.2) found to be useful in studying lineament and linear features, which differ from unit to unit depending on the lithic assemblage, intensity of deformation and complexity of the resulting structure, anticipated lithotectonic boundaries were demarcated. As defined by O’Leary (1976) “Lineament is a mappable simple or composite linear feature of a surface whose parts are aligned in a rectilinear or curvy linear relationship and which differs distinctly from the pattern of adjacent features and presumably reflects a subsurface phenomenon”. This definition has been followed while doing interpretation and image feature extraction in the present study (Fig.1.3).

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.

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.

Tonal contrast has been used for the identification of lineaments as associated with different lithological units or fault and shear zones.

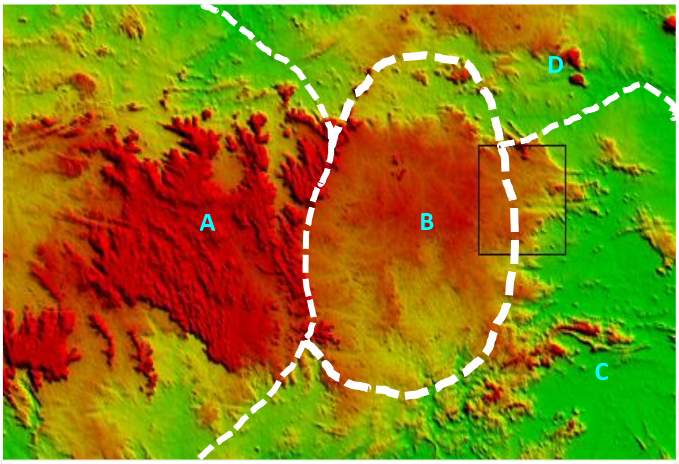

Fig. 1.2. Multispectral image of the region around the study area

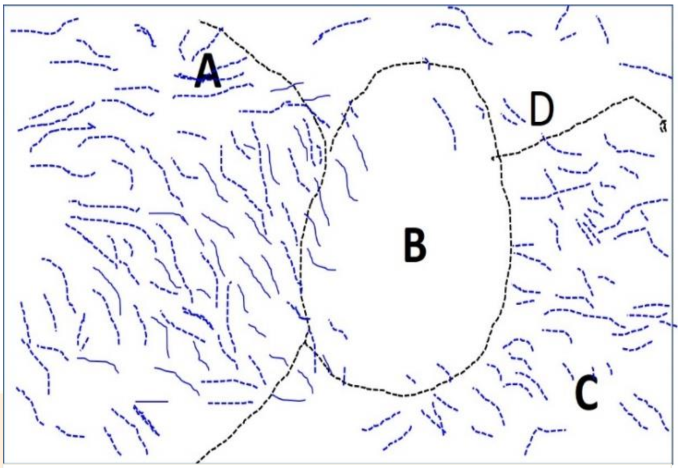

Fig. 1.3. Interpreted map of the Multispectral image of the region around the study area

It is perceived from the interpreted satellite images that four lithological units are present in the study area. The unit boundaries have been outlined based on varying image features which make them look different from one another. Considering the various visible parameters like-tone, texture and colour indicating specific dissimilarity in outcrop pattern, vegetation cover, geologic structural features and drainage pattern the lithounits boundaries were demarcated (Fig. 1. 4). The units are named as –

1. Namkom Litho-unit, 2. Rarha-Lotang Litho-unit, 3. Bariyatu Litho-unit and 4. Pithoriya Litho-unit

Namkom Litho-Unit

The unit identified as Namkom litho-unit lies in the west- central part of the study area. It is characterized by two distinct tonal-textural combinations. Some parts exhibit light pink to grayish colour and have fine texture. These areas are almost free from any linear features suggesting the area to have a nearly flat topography. The area close to the southern boundary exhibit dark pink to red colour and is characterized by discontinuous curvilinear features. Ground truthing revealed that the area is occupied by granite gneisses and well foliated metamorphic rocks like schists and phyllites of different composition.

Rarha-Lotang Litho-Unit

Rarha-Lotang belt covers the almost half of the study area running parallel to the boundary line in the north and east of the study area. This unit depicts a rugged topography with vegetation cover. It is characterized by light brown colour and medium to fine grained texture in the IRS-IB, LISS III FCC tonal contrast is also low. 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 metamorphic rocks 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.

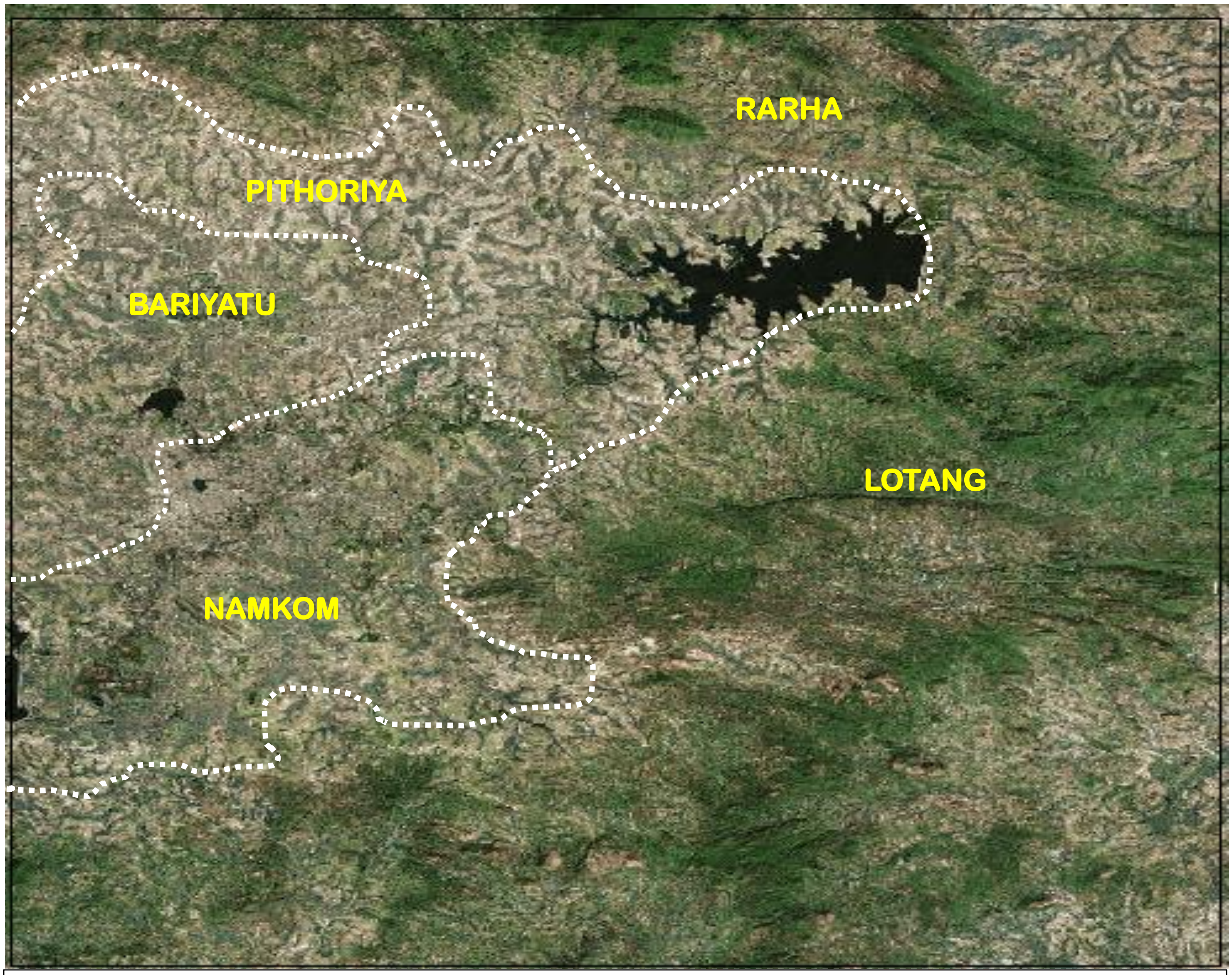

Fig. 1.4. Satellite image showing different litho units of the study area

Bariyatu Litho-Unit

The Bariyatu litho-unit lies in the west central part of the study area. In the satellite imageries, it appears to have a uniform grey to light grey tone. The IRS-IB, LISS-III, FCC, indicates that the area is virtually free from any lineament and the topography is almost flat, mostly covered with top soil. At places fine to medium grained signatures of granitic exposures are observed and at places metasedimentary exposures are also noticed.

Pithoriya Litho-Unit

This litho-unit covers the south and east-central part of the study area. In the IRS-IB, LISS III FCC, this unit displays brown to deep brown colour indicating presence of prominently developed linear and curvilinear features over major parts of the area. In the satellite imageries, it exhibits a very coarse-grained fabric, i.e., the topography is rugged. Overlying the interpreted map on toposheet suggests this unit to cover the hill ranges of the area. Dendritic pattern of drainage can easily be visualized in the software driven analytical image. The area is occupied by granite gneiss and other metasedimentary rocks. While geological mapping, the presence of many more rock types like amphibolite, calc gneisses, biotite schist and granites could be found. Variation in the attitude of foliation indicates that the area has witnessed multiphase deformation.

Apart from getting information about the litho unit mentioned above, informations have been gathered from satellite imageries, by generating multi-thematic maps like digital terrain map (Fig. 1. 5), ridge slope shade map (Fig. 1. 6), slope direction map (Fig. 1. 7).

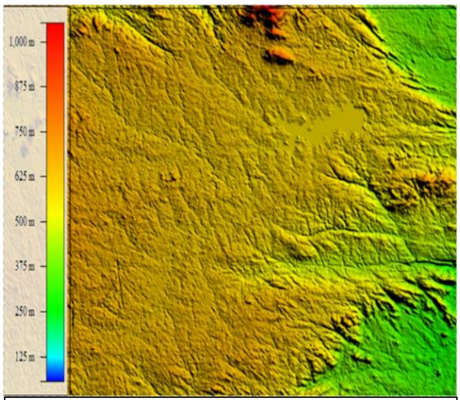

Fig. 1.5. Terrain image of the study area

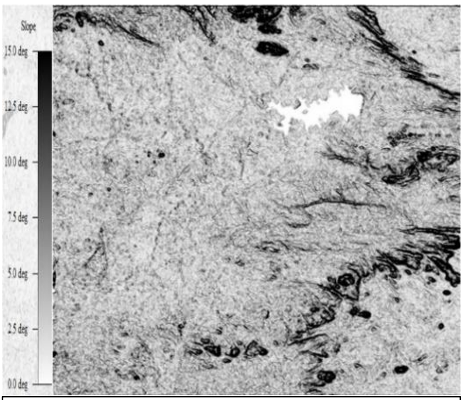

Fig. 1.6. Ridge slope image of the study area

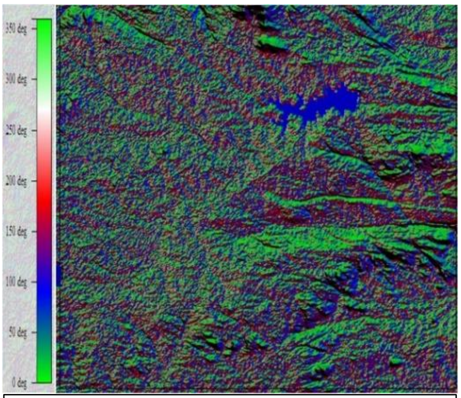

Fig. 1.7. Ridge slope direction image of the study

V. Discussion

By integrating the gathered data along with the data generated from satellite imageries, it is observed that, a few prominent lineaments divide the study area in to four blocks. Apart from these major lineaments a large number of lineaments of different lengths have also been delineated. Considering the attitudinal orientation, those lineaments have been plotted to prepare a rose diagram which indicates that NW-SE (N1100 to N1200) trending lineaments are maximum in numbers in the study area.

It has been found that the nature of the linear features, representing the bedding and foliation are having different trends. In Rarha-Lotang unit, lineaments are prominent and organized. They are parallel to subparallel. in other lithounits, lineaments are observed but are less prominent and short in length and messed up at places. The rest two lithounits are almost free from prominent lineaments; only a few short lineaments are noticed.

A course texture in the satellite image indicates very rugged topography, which depicts presence of massive crystalline rocks. Presence of lineaments suggest the existence of faults and joints. The colour or the tonal variation is related with the nature of vegetation and the composition of rocks that occupy a region. Drainage pattern is controlled to a large extent by the competency of the rocks and the 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 areas are characterized by dendritic drainage and occasionally by rectangular or angular drainage pattern. Dark tone signs basic rocks. Areas with metasedimentary sequences/ rocks with alternate competent and incompetent lithology usually show a linear and curvilinear feature which runs 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 density of the drainages is found comparatively less than igneous/ crystalline rocks.

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