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Research Article

Lineament identification and Interpretation of drainage pattern by the application of IRS1D data- A case study of Babina- Nivari area of Bundelkhand craton, Central India

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Abstract:

The application of remote sensing technology has shown a great promise for large scale geological mapping. This work presents an investigation for enhancing lineaments with possible relevance of rock structures especially faults, in Bundelkhand Craton, India using IRS 1D satellite image and standard geographic information system (GIS) techniques. The capability of the IRS 1D infrared bands to detect lineaments that might be related to failure of the crust has been ascertained. The results obtained from the interpretation of remote sensing data have been compared with the drainage network at a scale of 1:50000 and geological maps at a scale of 1:50000. Lineaments related to quartz reefs have been evaluated as potential faults. The methodological approach adopted in the present mapping has contributed not only in the identification of several known large scale faults in the study area but also in the mapping of their potential extensions.

Keywords: Remote sensing, Lineaments; GIS, Faults, Bundelkhand Massif

Introduction

Fault recognition is a basic component in the field of basic, monetary and natural topography (Colwell et al ., 1983; Drury, 1987). Conventional techniques for mapping flaws require hands on work examinations. Be that it may, field work is generally tedious and may take up a very long time to finish, depending principally on the expansion and additionally the openness of the zone under scrutiny (Cracknell and Hayes 1991). Geology, disintegration, over development of vegetation, scale, involvement of the geologist and different variables control blame determination in the field.
Remote sensing has the benefit of giving brief diagrams of the locale; in this way it might specifically pinpoint the qualities of basic land highlights stretching out finished expansive ranges (Colwell et al, 1983; Drury, 1987). Instead of hands on work examinations, remote detecting alongside picture professional processing system represents a less tedious and more financially savvy techniques for blame identification. Regardless such procedures not the slightest bit supplant field examinations, however despite what might be expected they supplement each other. Flaws are regularly uncovered as direct or curvilinear follows on satellite pictures. These picture lines of various complexities are generally alluded to as lineaments (O' Leary et al, 1976) and may reach out from a couple of meters to many kilometers long. Positively not all lineaments identify with blaming. They could likewise be attributed to lithological limits, limits between various land utilizers, waste lines or even to man-made developments for example streets. Accordingly, it is difficult to decipher the potential basic inception of lineaments in view of satellite pictures as it

were. Besides, any vertical ground relocation going with disappointment of the outside layer can't be effectively identified on satellite pictures as a result of their planar view.
A fault plane may offer a favored road to dampness or vegetative development and may frame particular waste example effortlessly distinguished on satellite pictures. All the more especially, streams have a characteristic inclination to wander. Subsequent some regularly discovered sorts of stream oddities , for example , straight portions, sudden twists saw along stream courses, dislodging or even neighborhood vanishing of seepage framework into lines of sinkholes could check a blame line on a picture (Cracknell and Hayes, 1991; Miller, 1961). Moreover groundwater exchanged through flaws builds the dampness substance of soil in connection to the encompassing zone and advances particular arrangements of vegetation, unexpected changes in vegetation shade and sudden vanishing of a specific plant animal types (Miller,1961). The relationship between various bed rock structures viz. faults, fractures, joints etc and drainage patterns is well explained by various workers (Bannister and Arbor, 1980; Pohn,1983;Polishhook and Flexor,1983; Deffontaines and Chorowicz, 1991).

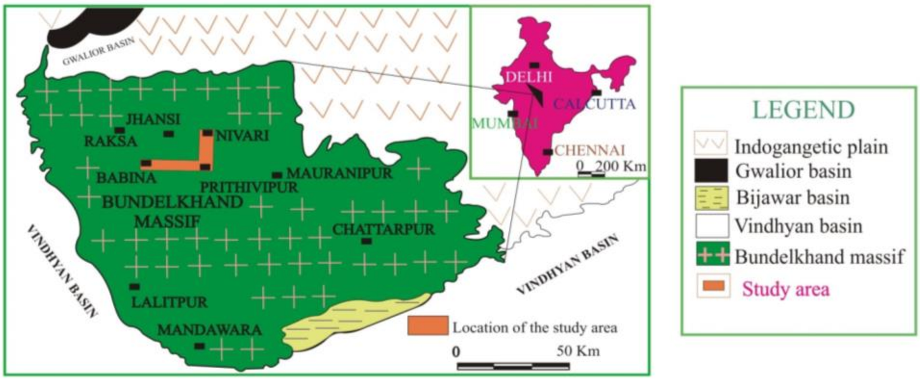

Fig.1. Location Map of the study area

Geological Setting of study area

The study area belonging to Bundelkhand craton is nestled in the northern segment of the Bundelkhand massif. On the basis of field setting and petrological observations, the following geotectonic set up and lithounits of the area were identified.
The banded light to dark grey and fine to medium grained mafic gneisses are exposed in and surroundings of Ghisauli, Badera, Jaunpur and Chaurara villages located in the south of Babina town (Fig. 2). The gneissosity commonly marked by a light quartzofeldspathic to dark grey dark mafic bands show ESE-WNW to E-W trends with steep northly dips. These rocks were affected by three phases of folding (F_1-F_3) under the influence of three tectonic episodes (D_1-D_3) and were considered equivalent to Kuraicha gneisses (3297$\pm$83 Ma; Monda et al.2002).

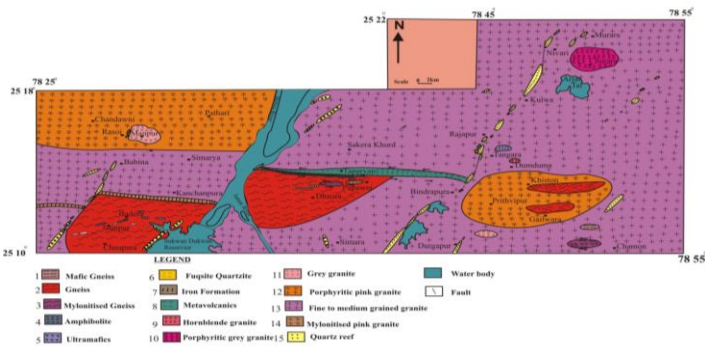

Fig.2. Geological Map of the study area

The strongly foliated streaky gneisses characterised by wider leucocratic bands and extensive shearing effects are exposed in the west of Chamon village (Fig. 2). These foliated gneisses striking in ESE-WNW directions underwent three phases of folding and commonly reported in the eastern flanks of Babina yield an age 2697+3Ma (Mondal et al.2002). The outcrops of grey and pink banded gneisses are widely exposed in the west of Papawni and Dhaura villages (Fig. 2). The lensoidal bodies are also found in the south of Khiston and north of Gailwara villages (Fig.2). The well defined foliation striking in EW to ESE-WNW directions with moderate to steep northerly (66^0) dips. In the extreme north of Papawni, a contact between amphibolites/metabasalt and these gneisses is marked (Fig. 2) and to the extreme south, these gneisses are bordered by intrusive pink granites. At some places the inclusions of metabasalt, banded iron formation (BIF) are also found. A mylonite zone in granite gneiss showing intensive effects of shearing is recognised in the east of Papawni (Fig. 2). This shear zone trending in E-W is represented by steep northly dips (65^0) and varies in width from 100-200 meter. It is extending up to western extremity of Papawni village and is well marked by pervasive mylonitic foliation and stretching lineation. Few isolated fine grained, greyish green to dark green lensoidal bodies of amphibolites associated with the older gneissic complex are exposed in the south of Badera (Fig. 2). Few outcrops of mphibolites/metabasalts (2520 Ma; Mondal et. al 2002) are also reported in the west of Papawni at the section exposed near primary school. The fine grained, greyish green to dark green low grade mafic and ultramafic lensoidal bodies associated to gneissic complex are widely occurred in a small hillock located in the north of Tangara and in the eastern segment of Badera villages (Fig. 2). These rocks mainly constitute peridotites, pyroxenes, gabbro and yield 3249$\pm$ Ma age (Mondal et al. 2002) old. Sharma and Rahman (2000) suggested that the peridotites, pyroxenes and gabbros are closely associated with metabasics and Banded Iron Formation (BIF). The fine grained well foliated fuchsite quartzite consists of thinner white quartz and thick dark green fuchsite bands. These rocks occur as isolated patches within the older mafic gneissic terrain exposed in the south of Babina and near Sukwan Dukwan reservoir (Fig. 2). These ESE-WNW trending rocks characterized by moderate ($30\text{-}40^0$) northly dips are intruded by tensional fractures and display multiple sets of joints and shearing effects.

The reddish to dark brown, compact and banded quartz magnetite rocks sandwiched between southern gneissic complex and northern granitic massif are lying in the southwest of study area (Fig. 2). The moderately elevated hillocks of these quartz magnetite rocks exposed in the west of Papawni village exhibit irregular bands of quartz and magnetite. The quartz bands generally appear thinner than the magnetite bands. At places, the tight and similar types of folds are also recognized. The folded rafts of BIF mainly consisting of quartz and magnetite are associated with granite gneisses. The E-W trending linear small hillocks of banded iron formation rocks are exposed in the south of Babina town (Fig. 2). Sometimes these laminated bands are seemed to be displaced by minor strike slip faults. The large outcrops of fine to medium, greyish to dark pink and highly sheared volcano felsic plutonic rocks are occurred along E-W trending curvilinear zone (Fig. 2). This mylonite zone exposed at Taparyan village and extending upto Dhaura is characterized by well developed E-W trending mylonitic foliation and subhorizontal stretching lineation. The mylonite and ultramylonite zones are distinctly recognized in the south of Taparyan village. The steep ($60\text{-}70^0$) northly dipping mylonite zone recognized in the south of Taparyan village mainly comprises of mylonite and ultramylonite zones.

The fine grained, greyish green hornblende granite extending upto 2km are exposed at both sides of Nivari-Prithipur road near Dumduma (Fig. 2). At few places these rocks are intruded by minor quartz and epidote veins. The coarse grained, light to dark grey granitic rocks constituting large porphyries of quartz and feldspar (mainly orthoclase) are widely distributed in the eastern flanks of Nivari (Fig. 2). Few outcrops of fine to medium grained, massive, grey granitoids are also mapped in a dome shaped hillock exposed southeast and southwest of Prithvipur (Fig 2). The two sets of tensional fractures are oftenly intruded by quartz veins along shear planes. Few patches of these granitoids are also reported to the south of Badera and west of Jaunpur village (Fig. 2). The large tracts of massive, compact, pinkish to dark red and coarse grained pink granites are widely distributed around Prithipur and its adjoining areas (Fig. 2).These rocks are occasionally marked by one to two sets of tensional fractures and three sets of joints. The tensional fractures are occasionally healed up by different generations of quartz veins trending in NE-SW and E-W directions. These granites showing sharp contact with granite gneisses in the south of Khiston (Fig. 2) are also occurred near Chandawni, Pathari and Rasoi villages in the north-western parts of the study area (Fig. 2). The northern margins of these massive, compact granitoids are demarcated by the pink granitic gneisses. The huge outcrops of fine to medium grained, light to dark pink granitoids are dominantly recorded in the northern and southern extremities of the investigated area (Fig. 2). These granitoids mainly exposed in the surroundings of Nivari, Rajapur, Durgapur and Babina localities are considered as youngest granitic activity in the Bundelkhand massif. Although the occurrence of joints is impersistent in these lithounits but at some localities two to three sets of joints are predominantly observed. Besides the joints, one to two generations of fractures are also noticed within these granitoids.

Two prominent, moderately elevated (200-300 meters) and NE-SW trending major quartz reefs are recognized in the study area. A major quartz reef offsetting the gneisses and Banded Iron Formation (BIF) is passing from Babina and extended upto the southern part of the area (Fig. 2). This quartz reef is seemed to be truncated by oblique faults in the south of Babina. At places, the bifurcation of the reefs is also noticed in the southwest of Babina. These quartz bearing rocks are highly fractured and at places are showing two to three sets of joints. The first generation of quartz veins (Q_1) is displaced by secondary quartz veins (Q_2). These quartz veins are emplaced along NE-SW and NW-SE trending shear zones about 2000 Ma years ago (Sharma and Rahman 2000). A NW - SE trending quartz reef occured to the west of Simara (Fig. 2) is also marked by sigmoidal and sheared quartz veins. Another major quartz reef encompassing from north of Nivari is extended in the southwest of Durgapur (Fig. 2) and is recorded among the longest quartz reefs in the Bundelkhand massif (Fig. 2). This reef is also truncated by oblique faults at several places and occasionally characterized by conjugate and sheared veins.

A dark grey, fine to medium grained and NW-SE trending dolerite dyke is exposed in the southeast of Arjar Tal (Fig. 2). These dykes showing intrusive relationship with pink granites are also regarded as discontinuous features and follow en echelon fractures in the Bundelkhand massif (Basu 1986). The doleritic dykes yield an age 1799 Ma (Sarkar et. al 1990) intruded within Bundelkhand granite exposed at Kalinjhar fort in U.P. Recently Rao et al. (2005) estimated the age of mafic and ultramafic dykes 2150 Ma and 2000Ma by Ar^{40}/Ar^{39} method.

Methodology

The methodology in this paper for lineament identification with possible origin has been divided into three implementation phases;

i. Image processing for the enhancement and digitizing of lineaments in using a IRS 1D LISS III product (Fig.3)

ii. Emphasis has been given to large scale lineaments that might have relevance with specific geomorphology and drainage patterns commonly related to faults.

iii. Setting up procedures through a Geographic Information System (GIS) for the evaluation of the quartz reef lineaments detected on IRS 1D, for identification of potential faults.

Evaluation of lineaments as potential faults

Any linear or curvilinear feature observed on the processed IRS1D multispectral image that might be related to potential fault and alignments have been digitized. Auxiliary data such as

i. The geological map published by the GSI at scales 1:200000

ii. The drainage network digitized by the survey of India toposheet at a scale of 1:50000 and have been inserted into a GIS for evaluation of the lineaments detection.

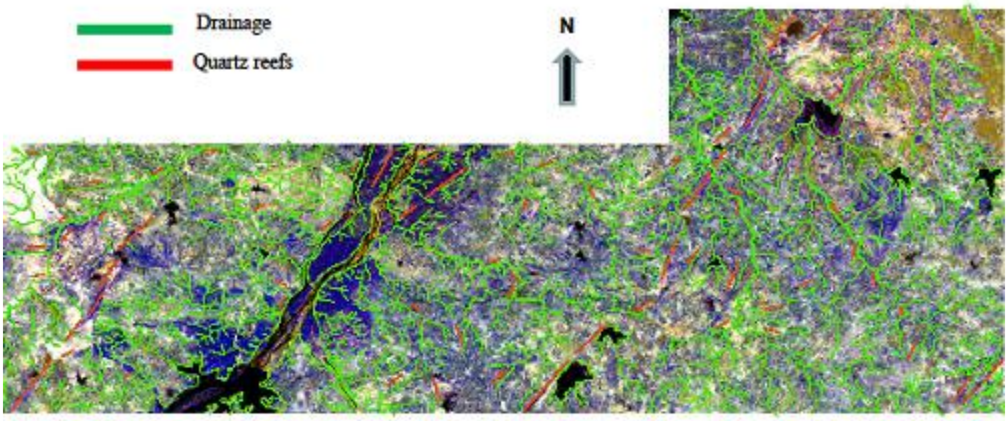

Fig. 3.Satellite imagery (IRS-LISS III) showing relationship between drainage and lineaments

Result

The determination in the source information is a confinement in basic understanding of landforms. This impediment is identified with the remote detecting strategies utilized and the assistant data (e.g. topographical information, maps and field perceptions) that can bolster the elucidation. Various examinations have been made to grow such connection between the tectonics and streams in the different structural zones by traditional field strategies.

At first the base information for lineament thinks about were immediate perceptions of the scene and geographical maps. A lineament translation can be made outwardly. The translations of lineaments in view of geographical rise information and geophysical information are essentially fundamentally the same as an area of a lineament is predominantly distinguished by;

i. Change in altitude/level
ii. Change in pattern
iii. Change in gradient
iv. Occurrence of linear minima/maxima
v. Displacement of reference structures /surface

When handling base information for lineament understanding the general thought is to improve the area of minima/maxima changes in dislodging of reference structures (drainage). The study also attempts the possibility to visualize the effect of neotectonic activity (Pliocene-recent) by dealing structures that comprise five complimentary approaches:

i. Lineament analysis
ii. Drainage analysis to define the regional fracture pattern
iii. Analysis of the volcano morphology
iv. Interpretation of remote sensing data (Satellite images, air photos) and digital elevation model (DEM) imagery.
v. Field work to verify the interpretation to infer the kinematics of the interpreted structures.

Lineament Analysis

The lineaments in the form of quartz reefs are identified in the study area. The orientation of majority of quartz reefs is NE-SW, the other orientation identified are NW-SE and E-W. These quartz reefs are the most spectacular linear features in the area. A major quartz reef offsetting the gneisses and banded iron formation (BIF) is passing from Babina and extending up to the southern part of the study area. (Fig.4).Another quartz reef encompassing from north of Nivari and extending to the southwest of Durgapur is recognized as the longest quartz reef in the Bundelkhand massif.

Lying in the southeast of Arjar Tal are exposed dark grey, fine to medium grained and NW-SE trending doleritic dykes (Fig.4)

Drainage Pattern

The drainage of the area and quartz reef (Fig.4) have been examined and generated. Linearity of quartz reef has been examined in relation to the course followed by te streams. Quartz reefs doesn’t coincide with long linear drainage lines but seems to act as breaker or diverter in drainage linearity and sudden river bends may be attributed to potential fault zones. These particular lineaments are also related with a sudden course shift and inactive stream channel. The area is hard rocky terrain but still higher drainage density in such a region must indicate that some active tectonic activity is present. Here in this study only first two approaches could be discussed due to absence of other three approaches required. Drainage anomalies occur in all subarea irrespective of the age of outcropping rock. The fact that the youngest rocks affected by drainage anomalies are of Pliocene age indicate their neotectonic significance. The major trend of drainage network anomalies inn the study area is NW-SE in all subareas and rock types. This argues that arc parallel anomalies represent neotectonic features . Another trend observed in the study area is NE-SW.

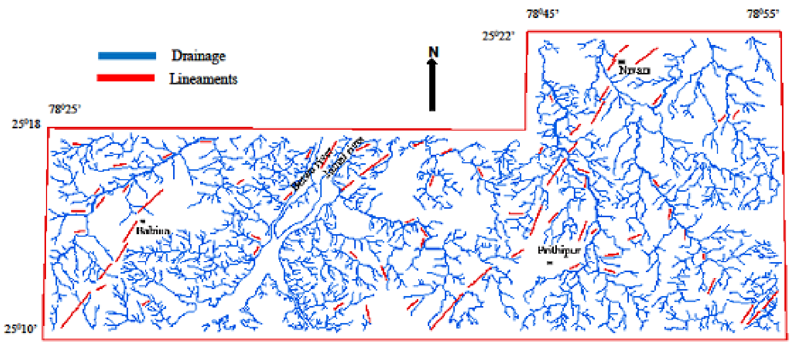

Fig. 4.. Relationship between drainage pattern and major lineaments extracted from various toposheets and IRS- LISS III images in the study area

Results of drainage network anomalies are consistent with results of lineament analysis. Both methods reveal the significance of NE-SW and NW-SE oriented lineament sets which are interpreted as sub vertical fracture zones. Possibility of arc-parallel and arc-oblique lineaments has been recognized in this study area.

Conclusions

The adjustments towards stream is for the most part because of tectonics and the subsurface lithology of the zone. The waste system of the range keeps on creating with the difference in tectonics. Because of the basic multifaceted nature it is essential to quantify the impact of streams and lineaments on each other. The neighborhood connection recommends that the lineaments and streams in the territory collaborate with each other and impact their introduction and style. The principle wellspring of this impact might be tectonics of the zone.

We at that point look at lineaments and seepage system and attempt to make sense of their impact on each other, yet the visual translation isn’t sufficient to give adequate data because of auxiliary intricacy of the Bundelkhand craton. It is particularly a method for preparatory graphical exploratory examination that empowers the client to rapidly assess in how far streams are influenced by dynamic structural procedures. The restricted lineaments have their paly fit as a fiddle of the neighborhood seepage however they are additionally controlled by major structural components.

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