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Structure and Its Impact in Uthangarai and Thirthamalai Region, Tamil Nadu, India Using Remote Sensing Technique

S ANBAZHAGAN[1] AND E SARANATHAN[2]
[1] Department of Earth Sciences, Indian Institute of Technology Bombay
Mumbai 400 076, India.
[2] Institute of Remote Sensing, Anna University
Chennai 600 025, India.

ABSTRACT

The Uthangarai-Thirthamalai region in Dharmapuri district is a typical Precambrian tract in Tamil Nadu. IRS-1C satellite imagery was used for interpreting folds, faults, fractures and lineaments, in this region. As interpreted from the satellite imagery, there are five major structural domains, which control the Ponnaiyar, Pambar, Vaniyar and Kovilar river courses and other drainage pattern in this region. Presence of fault rock, epidotization and sympathetic fractures along such folds and faults reveals the intensity of tectonism in this sector. The interpreted lineaments have been classified into five major groups on the basis of their geometry and orientation. From the rose diagram, it is inferred that the NNW-SSE trending lineaments are fall in major frequency domain. The springs observed near Hanumanthirtham and Thirthamalai region could be structurally originated. The geomorphology interpreted from the satellite data has shown significant morphological expression of folds, faults and lineaments. The geophysical data have been analysed and correlated with intensity of weathering by fractures and lineaments.

Introduction

Satellite image gives an excellent visual presentation of various geological structures like faults, folds, lineaments and fractures, because of its synoptivity and multispectral nature. Remote sensing techniques have been employed for geological, structural and lineament mapping by many workers (Sahai *et al.*, 1976, Drury and Holt 1980, Drury *et al.*, 1984; Ramasamy *et al.*, 1987; Verma 1993; Kumar *et al.*, 1994; Yadav and Khan 1995; Kanungo *et al.*, 1995; Kazeem and Iqbaluddin 1995; Krishnamoorthy 1997; Ramasamy *et al.*, 1999 and Rachna Raj *et al.*, 1999). In the present study, remote sensing based analysis has been carried out in Uthangarai and

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Thirthamalai region, which forms part of Dharmapuri and Thiruvannamalai districts, Tamil Nadu, India, for mapping structures and fractures and for understanding their impact on drainage (Fig. 1). The study area is bounded by eastern longitudes 78°22' and 78°43' and northern latitudes 12°0' and 12°17' and comes in parts of Ponnaiyar river basin. This region comprises complex geological structures, prominent lineaments and different landforms. Geologists from Geological Survey of India have done considerable work in this area on geological, geomorphological and land use aspects. The State Groundwater department has prepared a detailed hydrogeomorphological map for the entire Ponnaiyar river basin. Balasubaramanian (1981) has studied the hydrogeological condition of Pambar subbasin of Ponnaiyar River. Ramasamy (1987) has discussed the structure and tectonism related to evolution of Sevathur and Jogipatti carbonatites, which is close to the study area. Ramasamy *et al.* (1987) have interpreted Precambrian fractures in Tamil Nadu from Landsat MSS and TM satellite data and classified them into four major tectonic groups. Ramasamy and Balaji (1993) have identified five sets of fracture pattern in parts of Tamil Nadu through remote sensing data and discussed their significance with reference to environmental issues. The impression of tectonism, in this part of Ponnaiyar river basin is clearly discernible in aerial and satellite data. Detailed analysis has been made on the nature of fold, fault and fractures, time of formation and their influences on drainage course.

IRS 1C LISS III False Colour Composite (FCC) imagery in hard copy has been used for structural studies (Fig. 2). Interpretation of structural trends and lineaments on IRS 1C satellite data has clearly shown the presence of folds, faults and fractures in the study area. The geomorphology has also been analysed with the help of satellite data is useful for understanding the tectonic impacts on drainage condition. The tectonic and geomorphological aspects interpreted from the remote sensing data were examined and correlated with field observations. The nature of movement along the Pambar fault zone, orientation of various fractures and their evolution are discussed.

Geology

The study area comprises of a variety of rock types with complex metamorphic history. The geological details were taken from the existing map published by the Geological Survey of India (Anon, 1969). Limited field visits were also made to confirm the lithological contacts. The Precambrian metamorphites in the area include charnockites, epidote horblende gneiss, ultrabasics, pyroxene granulite and banded magnetite quartzites (Fig. 3). The western part of the study area (Dasampatti-Uthangarai region) is exclusively covered by epidote hornblende gneiss. In the hilly area, east of Pambar and Ponnaiyar rivers, surrounding Anandavadi region, hornblende biotite gneiss forms country rock. The rest of the eastern part of the area is covered by charnockites. Fissile hornblende biotite gneiss is exposed in the area south of Ponnaiyar river, near Sikkalur. Ultrabasic complex is seen in the north-western part of the study area. Pyroxene granulite and syenite occupy small areas in the eastern and north-western parts respectively. The regional foliation trend in transition and granulite zones varies from N-S to NNE-SSW direction with steep dips (70°-80°). The trend of banded magnetite quartzite is conformable to the extension of Pambar shear zone near Thirthamalai. Basic dykes along NW-SE direction occur near Ammapettai and Nippathurai areas.

Tectonism and its Impact

The Precambrian shield of South India, forms a coherent crustal segment with continuous geological activities throughout the early Precambrian period and offers an excellent ground for the study of structural and tectonic relationships. In the present study, structure and lineament mapping bring out their impact on drainage course in Uthangarai and Thirthamalai sector as interpreted from IRS-1C satellite data

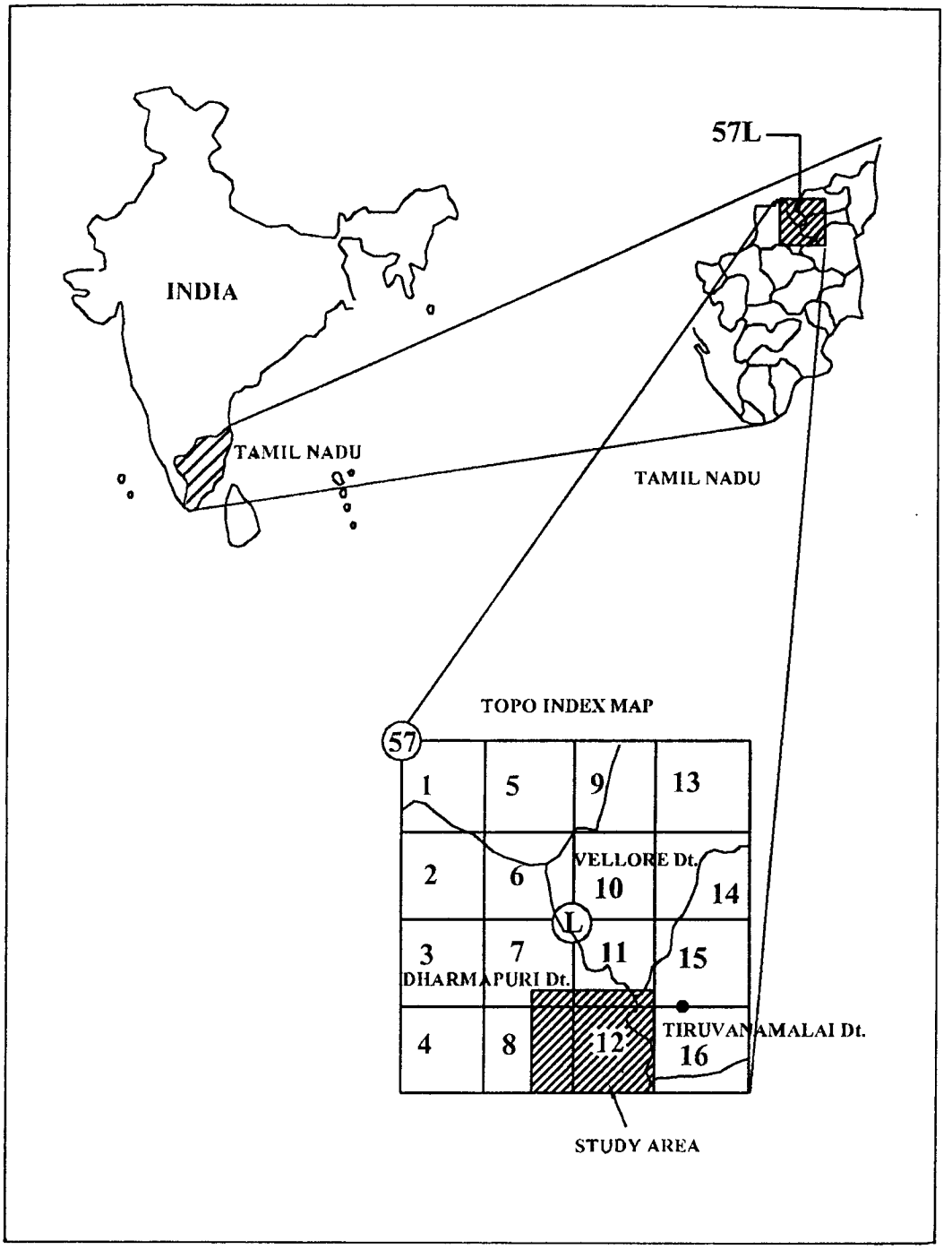


Fig. 1. Location Map

(Fig. 4). Rachna Raj *et al.* (1999) studied the tectonism and its control on drainage pattern and river flow. The important structural features in the study area identified through the satellite imagery are

- A fault zone passing through Pambar river to Thirthamalai (1)
- Hanumanthirtham fractures intersection zone (2)
- Vaniyar fault along Vaniyar river (3)
- Shear structural movement near Ammapettai-Nippathurai area (4)
- Shear structural movement near Sengappadi and adjacent areas (5)

Tonal and textural contrasts in different rock types help to interpret the structural features from the satellite data. The structural trends are exhibited as linear and curvilinear outcrop pattern in the satellite imagery. Straight drainage course, vegetation banding, long and linear dark tone contrast and soil tone differences are the key factors for interpreting lineaments from the satellite data. Satellite data interpretation is followed by extensive field visits in the study area to confirm the interpreted structural and lineaments pattern.

Pambar River flows along a NNW-SSE fault zone and joins with Ponnaiyar river along the same alignment. This fault zone extends further south and passes through Thirthamalai finally to reach Attur valley covering about 150 km in length. Banded Magnetite Quartzite (BMQ) is exposed in Thirthamalai along this fault zone. Along this zone, several fractures with vertical dips have been observed. At Nariyampatti-Pavakkal area, where the Pambar river joins the Ponnaiyar, two sets of fractures have been observed, i.e., in ENE-WSW and NNW-SSE trending fractures (Fig. 4). Along these fractures, the rocks are highly pulverized. The presence of fault rock (mylonite) over a distance of 3 to 4 km is an indication of its intensity. Pambar fault zone appears to be a strike slip fault, where the shear zone passes along magnetite quartzite. A spring is also observed on the top of the hill near Thirthamalai. The quantity of water released from the spring is measured about 1.5 gpm. A major NE-SW trending fracture, controls the Vaniyar river course. Epidotisation and vertical dips have been observed along this fracture confirm the structural movement. Transverse fault interpreted through satellite data near Vaniyar river has been confirmed during the field visit. The drainage course shows distortions in this area, indicating a sinistral strike slip movement of the western and eastern blocks.

There are four major lineaments interpreted from the satellite data near Hanumanthirtham area. All the four lineaments cut across the Ponnaiyar river. The river flows along an E-W trending lineament. It suddenly turns and follows NE-SW trending lineament. Other two lineaments trend N 10° E and N 35° E respectively. At their intersection point, a spring is observed. All along the four fractures, epidotisation is conspicuous.

The structural trend lines interpreted from the satellite imagery and strikes/dips measured from the field help to identify the plunging folds in this region. There are two plunging anticlines, one plunges in NE direction near Ettapatti and another in SW direction near Sengappadi. The noses of the plunging folds were highly deformed and Ponnaiyar River takes its path around the nose of the folds. First it flows along the nose of north easterly plunging fold near Ettapatti, then it suddenly turns into south and flow along NE-SW trending lineaments near Nippathurai. Further down, it flows around the nose of another plunging anticline near Sengappadi. Due to shearing stress, the stretch in between these two plunging folds was displaced and fractured. This is clearly evident by the displacement of dykes observed near south of Ammapettai. Near Sengappadi village, due to tensional forces, fractures were developed radial to the nose of the fold. Such fractures were filled-up with epidots and potash feldspars, indicate the nature of metamorphism in this region. In the east of Sengappadi village, Kovil River joins the Ponnaiyar river along a fault zone

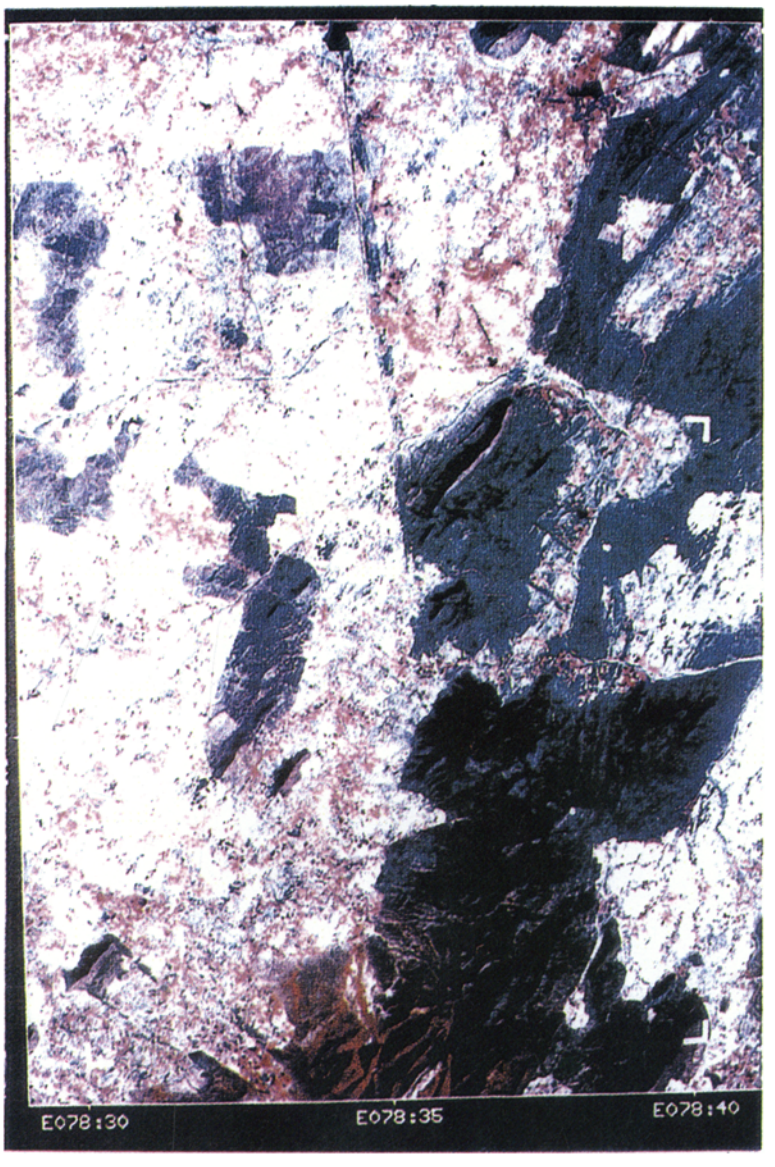


Fig. 2. IRS-1C LISS III Satellite imagery of study area

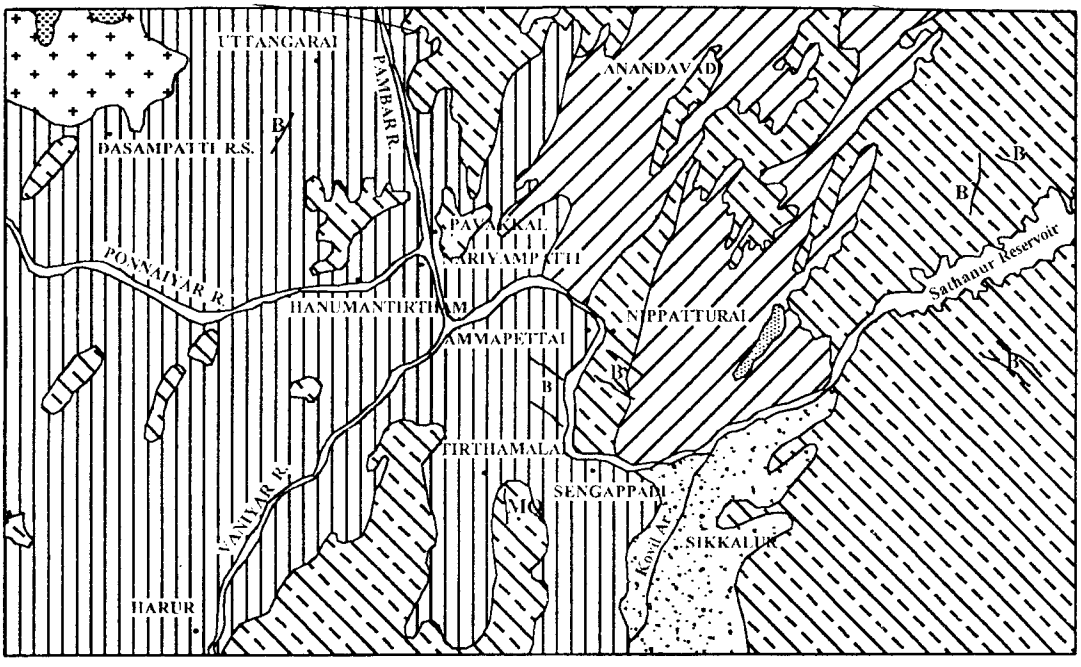
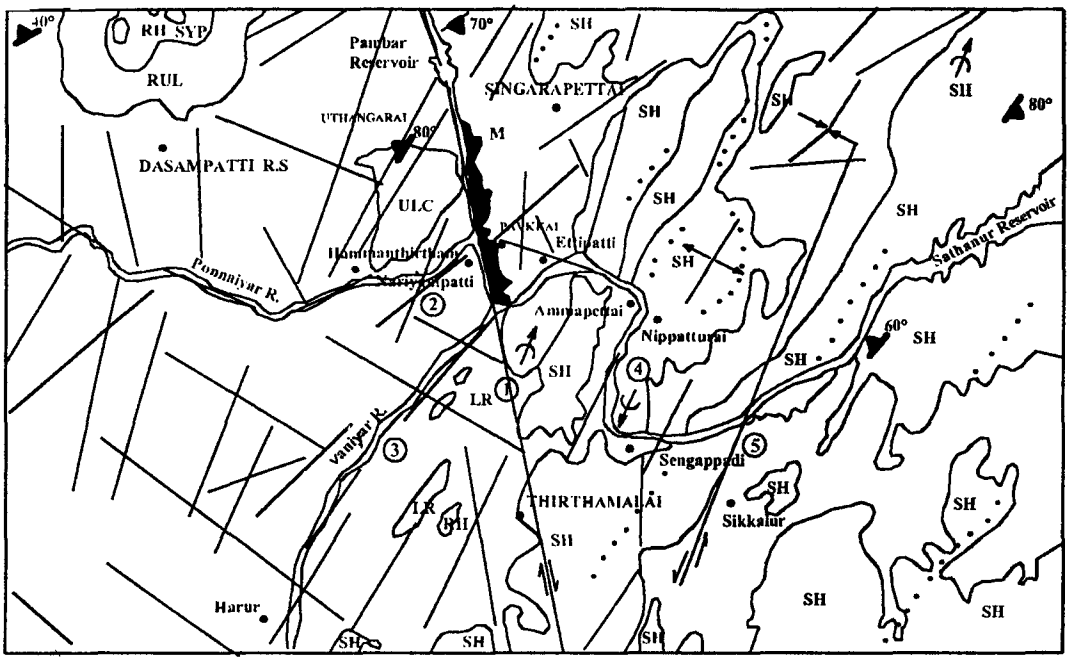


Fig. 3. Geology Map of Uthangarai-Thirthmalai region



SCALE

2.5 0 2.5 5 km

Index

SH	STRUCTURAL HILLS
RH	RESIDUAL HILLS
LR	LINEAR RIDGES
M	MYLONITE RIDGE
RUL	ROLLING UPLAND IN ULTRABASIC COMPLEX
ULC	UPLAND IN CHARNOCKITE
SYP	SYENITE PLUG

	ANTICLINE
	SYNCLINE
	PLUNGING ANTICLINE
	FAULT
	LINEAMENT
	STRUCTURAL TREND
70°	FOLIATION & DIP

Fig. 4. Structure and Lineament of Uthangarai-Thirthmalai region (Based IRS-1C Satellite data interpretation with limited field checks)

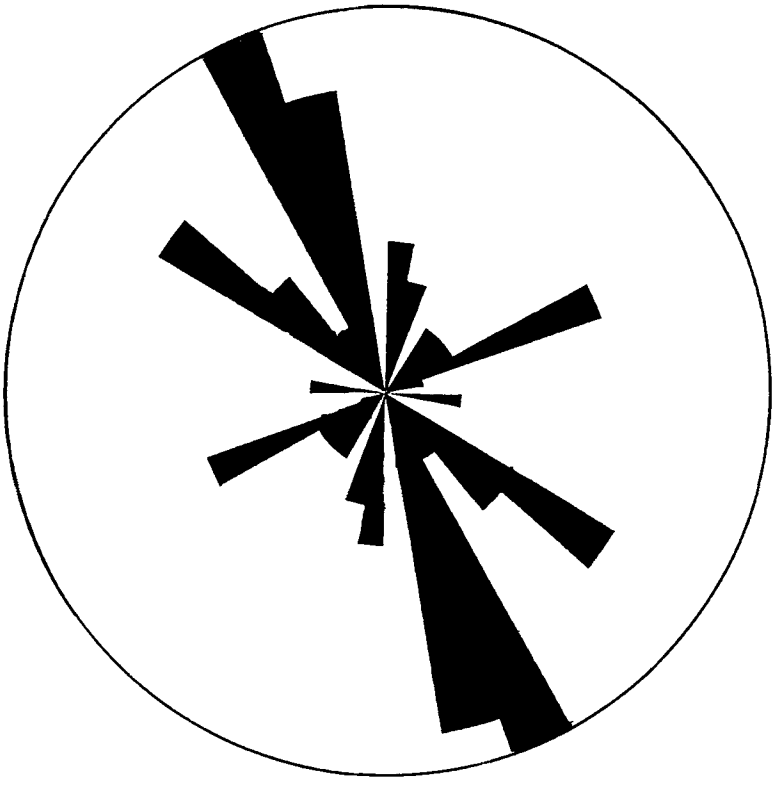


Fig. 5. Rose Diagram showing the Lineaments frequency distribution in Uthangarai-Thirthmalai region

trending NE-SW direction.

Ground resistivity surveys were carried out and the results were correlated at the locations of major lineaments and fractures. Highly weathered and fractured condition was observed along the folds at Ettipatti region, where the weathered and fractured zone thickness ranges from 25m to 50m depths. In such zones, groundwater potential is comparatively higher than the surrounding area. However, some of the lineaments are coincide with the high apparent resistivity, where intense epidotization is correlated.

Significant morphological changes due to tectonism were inferred in the geomorphological map interpreted from IRS 1C satellite data. Folded structures form topographic highs and standout as structural hills. Some of the major lineaments control the river courses and the minor fractures and lineaments are expressed along buried pediments. Along Pambar fault zone, mylonitization standout as linear ridge. The axial portion of the plunging fold at Sengappadi is highly pulverized, eroded and planation has taken place and geomorphologically, it is expressed as 'erosional plain'.

Results and Discussion

The structure and its impact in Uthangarai-Thirthamalai region is attributed to the Eastern Ghat Orogeny resulting in folding and faulting of the strata. The rocks are tightly folded into anticlines and synclines. The anticlines show crenulated nature. Even though, there are many periods of folding, only the latest two or three can be recognized, since the traces of earlier ones

have been obliterated by the Precambrian metamorphism (Ramasamy 1987). Large numbers of sympathetic fractures are observed along the fault zone parallel to them. The friction created during the movement along the fault zone has caused crushing and alteration of the surrounding rocks near the fault plane. The formation of trap-shotten gneiss and local epidotisation are common along these zones. Due to high-grade metamorphism, the basic rocks of gabbroic nature have been converted into granulitic rocks. Migmatization of these has given rise to the charnockitic rocks, which have been degraded into epidote hornblende migmatites.

Interpretation of IRS 1C satellite data has revealed the presence of a number of major lineaments, fractures and fault pattern in Uthangarai and Thirthamalai region. There are two major faults identified in this area, one is Pambar fault from Uthangarai to Thirthamalai and another at Nippathurai – Segappadi region. The Pambar fault is dextral slip fault and the other one is sinistral slip fault. Based on their geometry and orientation, the lineaments were grouped into five generations, corresponding to five deformation phases. The earliest recognizable lineaments (L1) are in ENE-WSW direction, which is perpendicular to Eastern Ghat orogeny. The subsequent second set of lineaments (L2) are aligned in NNE-SSW direction and third set (L3) in WNW-ESE direction. The fourth and fifth sets of lineaments are in NE-SW and NNW-SSE direction respectively. The orientation of lineaments is represented as true angular plot in the rose diagram (Fig 5). The interval of angle is 10° and the length of the radius is proportional to the frequency of that orientation.

Conclusion

The topography and drainage course in Uthangarai-Thirthamalai sector is predominantly controlled by tectonism. The faults, plunging folds and fracture systems are clearly interpretable through satellite data and were confirmed during the field visits. Two significant springs are observed in this region, one near Hanumanthirtham in Ponnaiyar river bed itself and another one at top of the hills near Thirthamalai indicate that the fault system may be deep seated. The Banded Magnetite Quartzites (BMQ) associated with Pambar fault need further study to identify any deformational structures like brecciation and mylonitization along the fault zone. The Uthangarai-Thirthamalai sector is interesting and promising area for further investigation on mineralisation and ground water prospecting. Further micro-level structural analysis of this region will be of interest.

Acknowledgment

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