ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.11

Remote Sensing Application in Geological and Structural Mapping of Khatu Area District Nagaur, Rajasthan

S.K. Yadav[1], S.L.Borana[2]
Scientist
Department of Remote Sensing Group
Defence Laboratory, Jodhpur, Rajasthan, India

Abstract:
The use of satellite images to generate geological maps is the most important application of the remote sensing. A study was carried out in the Khatu area of Nagaur district in Rajasthan, comprises Precambrian metasediments of the Aravalli Supergroup unconformably followed by the Jodhpur Group of rocks. A large area is covered by recent alluvium and the sand of the great Thar Desert. Remote Sensing data have been utilized for deriving structural trends and regional topography of the area. The satellite data of the study area clearly depicts post-marwar tectonic activity in the region. The basement sediments are exposed in linear fashion, whereas linear outcrops of Jodhpur group make a small angle with the trend of the Aravalli Supergroup exposed in the area. The vermiform outcrops pattern of Marwar Supergroup depicts an effect of mining as well as northwest-southwest compression. There are clear cut indications of shearing between the outcrop of Precambrian metasediment and Jodhpur group of rocks.

Keywords: Remote Sensing, Geological and Structural features

I. INTRODUCTION

The advent of remote sensing has opened up new vistas in geological and geomorphological studies. The geocoded data in the form of photographic prints (imagery) act as a better data source for the field geologist. It helps as a ready reference in the field and for interpretation as well.

During the last two decades, satellite data have been extensively used by the geologists world over mainly for mineral prospecting, oil and gas exploration, groundwater targeting,

Land resources mapping, geo-environmental evaluation, geo-engineering studies, structural and tectonic analysis and seismotectonic studies. Initially, the coarser spatial resolution data (about 80m) from the earlier earth observation satellites namely Landsat 1, 2 and 3 were mainly useful for regional level studies and mapping.

The subsequent satellites namely Landsat 4 and 5, SPOT, IRS-1A and 1B have provided medium resolution data (around 20-30m in multi-spectral and 10m in panchromatic mode). This medium data resolution was found helpful in extracting more information than that from coarse resolution data.

The coarse-to-medium spatial resolution data have inherent limitation of the scale up to which they can be enlarged. Hence, these satellite data were not of much use in conducting detailed studies and large scale mapping. Thus by and large the entire geological community was looking for the satellite data with higher spatial resolution for large scale mapping and detailed studies.

The present remote sensing satellite (IRS & Landsat), by virtue of its improved sensor capabilities, is more useful for photogrammetric purposes and relief studies, required in geology and geomorphology. In view of modern developments in the theory of plate tectonics and visualizing local events in global perspective,

A very small area to the west of the Aravalli Mountain was selected around Khatu in Nagaur district, where deformed metasediments of the Precambrian age are unconformably overlain by the rocks of the Marwar Supergroup interlayred with the volcanic possibly of the Malani age. In the proposed investigation local geological events have been studied in detail and an attempt has been made to visualize these events in the large perspective.

II. STUDY AREA

Jodhpur is centrally The study area (Fig.1) forms a part of the Survey of India Toposheet No. 451/8 and covered by longitude 74' 15 to 74' 25 E and latitude 27' 5 to 27'15N. Geographically the area is located exactly in the centre of the state of Rajasthan and constitutes the central part of Nagaur district.

The ground elevation of the area is between 300-475 meters above Mean Sea Level. several mines and quarries are in operation here producing thousands of tonnes of concrete for building and road works.

The building stone of Khatu is famous for fine carving and as a decorative stone. In all, the present study covers an area of about 12 square kilometers. Khatu village is situated on road connecting Jaipur with Jodhpur via Sikar, about 195 kilometres away from Jodhpur.

It is also well connected with Delhi by Road. The railway connecting Jodhpur with Delhi passes through Khatu. Both Chhoti Khatu (Kalan) and Bari Khatu (Khurd) villages form important railway stations on meter gauge line connecting Degana and Ratangarh stations of Northern Railway.

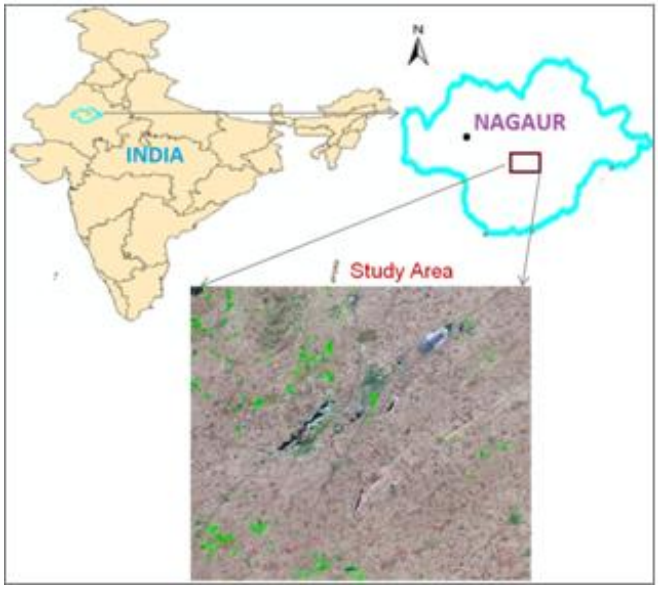

Figure.1. Map of the Study Area

The study area consists of a vast monotonous undulating sandy terrain with low to moderate gentle slope and NNE-SSW linear low ridges. Hills are flat topped; with steep escarpment of upto 90o and debris covered basal slope unit. Slope varies from 20o to 35o.The drainage is mostly internal, owing to low rainfall. There are two shallow saline depressions near Chhoti Khatu, which remain dry for the most part of the year. They have been formed due to the chocking of the former stream courses (Paliwal 1986, 1999).

Owing to the semi arid climatic conditions the vegetation of the area is mainly xerophytes. The common flora of the area include Salvadora persica (Jal), Azadirachta indica (Neem), Ficus religiosa (pipal), Acacia nilotica and A. Senegal (Babool) Prosopis Julifera (Vilayati Babool), Tecomella undulata (Rohida) Prosopis cineraria (Khejri) and a number of shrubs-Leptadenia pyrtlechnica (Khimp). Major rangeland dominated by perennial grasses like Laiurus sindicum, Cenchrus Spp., and Panicum antidotale and a number of annuals. Hilly outcrops are well vegetated with Acacia Senegal and Euphorbia caducifolia.

III. GEOLOGY OF THE STUDY AREA

The region to the west of the Aravalli Mountain in Rajasthan, hosts a variety of rock types ranging from the Precambrian to Recent in age (Fig. 2). The geological history of the region becomes more pronounced since the Terminal Proterozoic time when the tensional tectonic setting took place along the western flank of the Aravalli mountain range (Paliwal, 1994) resulting in a widespread felsic volcanism.

During the last three decades a number of geologists investigated different aspects of the rocks of the region. Blanford (1877), Hacket (1881), Oldham (1886), La Touche (1902), Heron (1933) and Pascoe (1959), Shrivastava (1971), Khilnani (1964), Mishra (1969), Paliwal (1975, 1976, 1998) and Pareek (1981,1984) tried to touch different geological aspects of these rocks. Precambrian metasediments of western Rajasthan occur in the form of isolated hills or group of hills along the western flank of the Aravalli Mountain, particularly, around Didwana, Kolia, Khatu etc. in western Rajasthan. Earlier, these deformed metasediments were considered to be part and parcel of the Aravalli system (now supergroup) by a number of workers. (La Touche, 1902; Coulson, 1933; Heron,, 1932, 1953). Later workers included these rocks in the Delhi Supergroup (Gupta et. al. 1980; Pareek, 1981, 1984, Murthy, 1979; Roy et. al. 1988). Surface outcrops are scanty, making their mutual relationship difficult to be established.

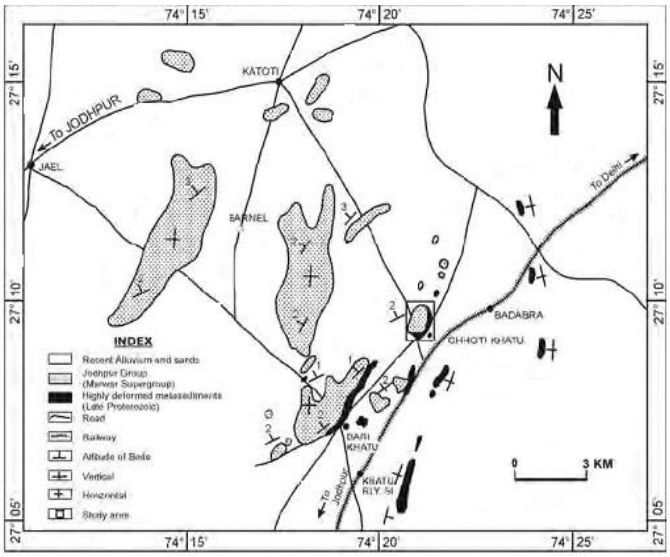

Figure.2. Geological Map of the Khatu Area, Nagaur district, Rajasthan. (Paliwal, 1998)

Rocks exposed around the Khatu area (Fig. 2) can be grouped into:- Deformed Precambrian Met sediments, Volcanics of the Malani Supergroup andCover Sediments of the Marwar Supergroup. The area around Chhoti Khatu and Bari Khatu exposes a fascinating sequence of the lower part of the Marwar Supergroup resting unconformably over the deformed metasediments of the Precambrian age. Intrestingly, the Chhoti Khatu hill displays interlayered relationship, between the valcanics and pyroclastics, possibly associated with the late phase of the Malani volcanism (Paliwal, 1998) and the sedimentaries of the Marwar Supergroup, particularly, the lower part of the succession i.e. Jodhpur Group.

Chhoti Khatu:

The entire section of Jodhpur Group of rocks is exposed in the eastern escarpment of the Chhoti Khatu hill. Different lithounits are recognizable from a considerable distance (Fig. 3). The sedimentation of the Jodhpur Group, particularly, those of the lower part i.e. Sonia Formation and Basal Conglomerate are here found interlayered with the volcanics possibly, a late phase of Malani volcanism.

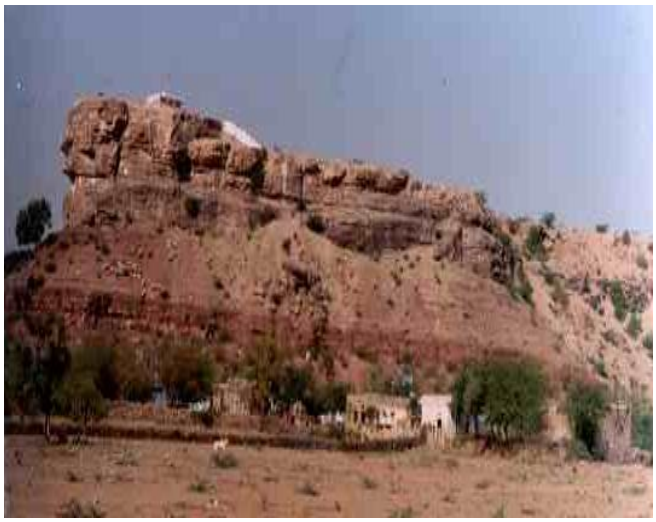

Figure.3.Panoramic View of Chhoti Khatu hill.

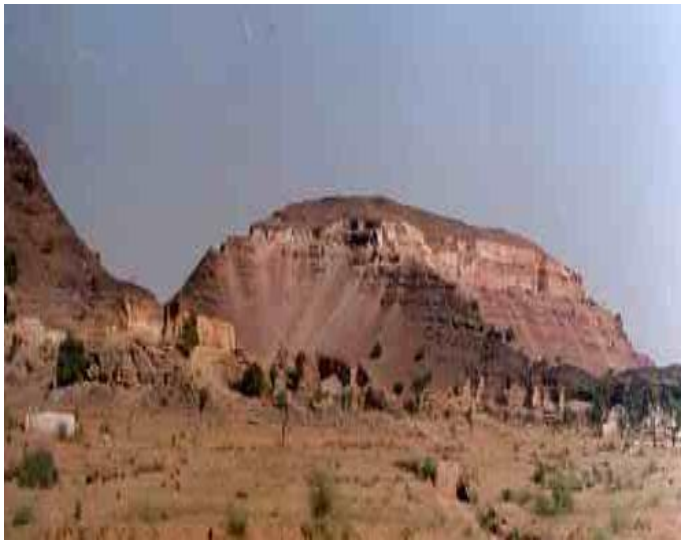

Figure.4. Sedimentary hill of bari khatu.

Bari Khatu Section: Around Bari Khatu (Δ473) a fascinating sequence (Fig. 4) of the Jodhpur Group of the Marwar Supergroup is exposed in the hill section just near the Bari Khatu village. Here the relation between the underlying deformed metasediments and the rocks of the Jodhpur Group can not be observed, as the base of the Marwar Supergroup is not exposed. However, further east of village Bari Khatu contact between the two can easily be seen at the red hill (Δ 429) where mining operation for red ochre is in progress.In the main Bari Khatu section the base of the Jodhpur Group of rocks is not seen . However, the oldest lithounit of this section is exposed in the western part of the Bari Khatu hill. Here mining activity is going on for a very good quality of sandstone. This sandstone, because of its massive nature and compactness, is being used for carving fine decorative and ornamental works like `Jalis'.

IV. DATA USED AND METHODOLOGY

The following satellite data are used in analysis.

a) Landsat TM data Path/Row 92/53, Sub scene acquired on 30-1-17

b) IRS-1C L-III data Path/Row 92/53, Sub scene acquired on 12-5-02

c) Collateral Information Data: SOI Toposheet 45I/8 Scale 1:50000, 1989, Geological Survey Quadrangle, Didwana 45I 1:250000 Scale 1986 and District Gazetteers, Nagaur district 1994. The Satellite data (Landsat TCC&FCC, IRS L-III FCC) were visually interpreted based on standard interpretation keys which include tone, texture, patterns, size, association etc. Various geomorphic units and associated geologic features were delineated and these are depicted on to the base map prepared from SoI Toposheet. These geomorphic features were evaluated critically in terms of lithology and associated structural features. Existing geomorphic maps and collateral data were also used, supplemented by field checks. Digital data was also processed using Silicon graphics image processing system. Image processing techniques like image enhancement and band rationing were applied to data. Contrast enhancement makes an image easier to analyze and interpret. The range of brightness value present on an image is referred as contrast which makes the features stand out more clearly. In ratioing technique, DN value of one band is divided by that of any other band in the sensor array. This process highlights certain features in distinctive class and also reduces the events of shadowing. The base map with detail interpreted information is digitized as line vector layer and further editing is done with the ARC GIS Software. Final thematic maps were generated in ArcGIS format as hardcopy output.

V. RESULT AND DISCUSSIONS

The remote sensing study of the area emphasises on the interpretation of satellite imagery (Fig 5&6) and preparation of thematic maps. The remote sensing study of the area reveals the main structural elements visible on satellite imagery. The lineament pattern, interpreted from the imagery may be ascribed to the deformation process that also gave rise to present structural set up of the study area. As a whole three sets of lineaments were demarcated and they were found to trend in NNE-SSW, N-S & SE-NW directions. But major trend of the lineaments is in NNE-SSW direction. From the remote sensing point of view the study area is characterized by the occurrence of slate, quartzite phyllites, sandstone and shale. Due to advantage of synoptic viewing the remote sensing provides an effective tool to delineate lineaments and other geomorphological features.

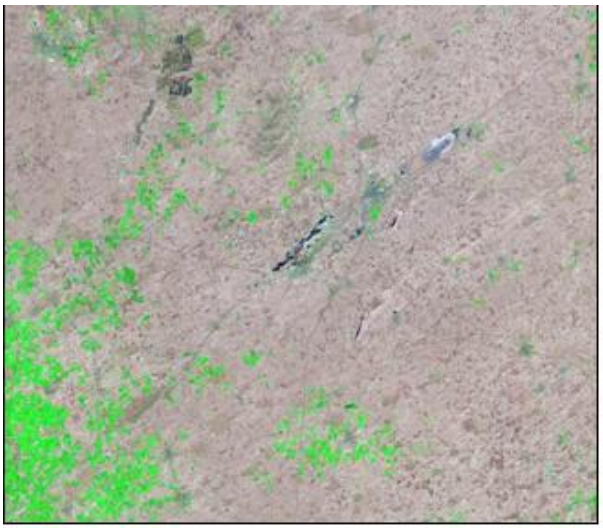

Figure.5. Landsat TCC Image of the Study Area.

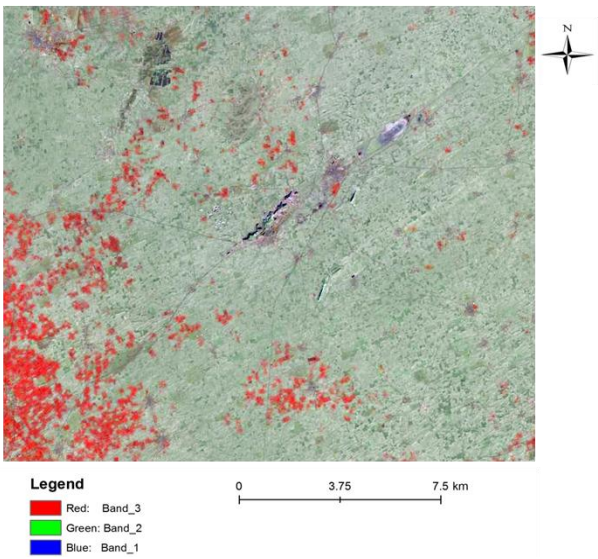

Figure.6 Landsat FCC Image of the Study Area.

Geology of the study area including deformed Precambrian metasediments, volcanics of the Malani Supergroup and cover sediments of the Marwar Supergroup has been discussed in detail. In addition to this elaborated geological successions along the Chhoti Khatu and Bari Khatu hills have also been illustrated and discussed in details.

VI. OBSERVATIONS FROM THE SATELLITE IMAGERY

The remote sensing study of the area **Geomorphology:** Based on Principle Interpretation keys, ground truth observations and collateral information major geomorphic units such as deeply buried pediments, moderately buried pediments, residual hills, playa, stabilized dune, dune complex, eolian plane shallow, eolian plane moderate and buried plane shallow are identified and they are represented in Figure 7. Eolian plane and pediments form the major part of the area. Thickness of deep pediment varies from 5 to 20 meters. These features rest on tectonic depressions and erosional surfaces of the older rocks. This is overlain by 15 meter consolidated sandy loams. This is followed by three cycles of Aeolian deposits, along with interstratified playa and fluvial deposits. Residual hills of very small extents resulting from denudation are present in the South-eastern and South central part. The lithological constitution of these residual hills varies from phyllite, quartzite to slate. Denudation hills are mostly covered with xerophytes plants. The lower parts of the residual hills are covered with thick aeolian sediments. These are recognized by the elongated patterns and dark grey tone on imagery. The Inselberg are present at some places with pediments.

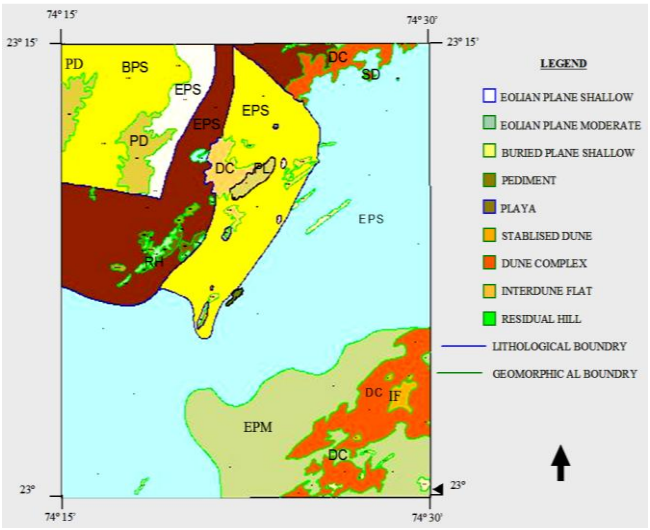

Figure.7. Geomorhology map of the Khatu-Nagaur area (Interpretation based on satellite data.)

The Active aeolian plane: It is unstablized in nature and appears as light grayish and light yellowish tone on the imagery. Partially stabilized aeolian plane is undulating to gently undulating, having cultivated with large field patterns and appears as light brown to yellow colour tone on imagery. Being a part of Thar Desert, the area shows undulating sandy terrain, marked with NW-SE to NE-SW trending dunes punctuated by Inselberg and NNE- SSW Linear ridges. The stabilized and wind blown sand dunes , overlying calcareous sand , pseudocoglomerate, Kankar or gypsite beds appears light yellow to dull white on imagery. The consolidated sands are fine, moderately, sorted, finely skewed and leptokurtic. The coeval playa deposits compose clayey marls, spongy chalk with embedded gastropod shells.

Structure Interpreted: The remote sensor study of areas reveals structural elements visible on satellite imagery are lineaments. Total twelve lineaments are seen on the imagery with length ranging from 1 to 10 km. The lineament patterns (Fig. 8), interpreted from the imagery may be ascribed to the deformation process that also gave rise to present structural setup of the study area. Some lineament intersects each other. As a whole, three sets of lineaments were detected and they were found to trend in NNE- SSW, N-S& SE-NW. but major trends of lineaments are NNE to SSW. The metasediments of the study area show a general NNE-SSW trend with moderate to very steep westerly or easterly dips. The rocks of the Marwar Supergroup show a horizontal to sub-horizontal disposition with gentle rolling dip. The general strike of the rock varies from NE-SW to N10W-S10E with 3-8 northing dip.

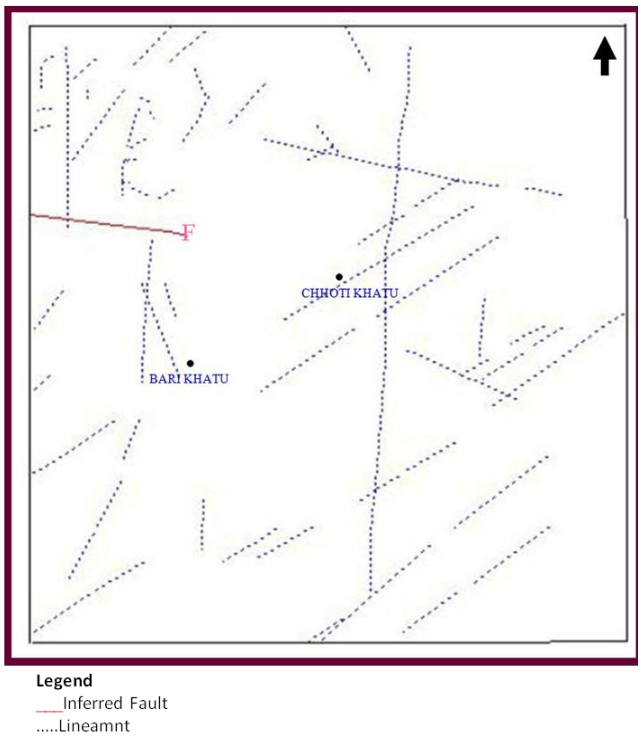

Figure.8. Lineament Map of the Area. (Based on satellite Image)

VII. CONCLUSION

Land From the remote sensing point of view the study area is characterized by the occurrences of slate, quartzite, phyllites, sandstone, shale and rhyolite as major litho-units. The geological & geomorphological study by Remote Sensing techniques aided by field studies of area are used to delineate varies landforms and thematic maps. Generally it is difficult to identify the lineaments in the fields, but Remote Sensing data could effectively be used to identify them, due to the advantage of synoptic viewing.The deformation pattern of the metasediments, structural style and geometry of rocks evolved out of a polyphase deformation comprising successive four phases of folding episodes and ductile shear zone have been studied in detail. This includes different types of folds associated with the above folding episodes and their corresponding planar and linear structures.

VIII. ACKNOWLEDGEMENT:

The authors are thankful to the Director DL, Jodhpur for help and encouragement during the study.

IX. REFERENCES

[1]. Bakilwal, P.C. and Ramasamy, S.M., 1987, Lineament fabric of Rajasthan and Gujarat. Rec. Geol. Surv. India, 113(7), 54-64.

[2]. Chauhan, D.S. Dubey, J.C. and Bhanwara, Ram, 1991. Geological analysis of part of the Nagaur Basin in the vicinity of Jodhpur city. In: S.K. Tandon, Charu C. Pant and S.M. Casshyap (eds.), Sedimentary basins of India-Tectonic context : Gyanodaya Prakshan, Nainital, 63-73.

[3]. Heron, A.M. 1932, The Vindhyans of western Rajputana. Rec. Geol. Surv. India, 65(4), 457-489.

[4]. Paliwal, B.S. 1975. Phosphatic algal stromatolites in the Trans Aravalli Vindhyans of Badi-Khatu, district Nagaur, Rajasthan. Curr. Sci. 44(5) : 161.

[5]. Paliwal, B.S. 1976, Note on the layered chromatographical structures in the Vindhyan sandstone of Badi Khatu, district Nagaur, Rajasthan, India: Bulletin Indian Geologists Association, v. 9(1), p. 17-22.

[6]. Paliwal, B.S. 1998b. Felsic volcanics interlayered with sediments of the Marwar Supergroup at Chhoti Khatu. Jour. Geol. Soc. India, 52, 81-86.

[7]. Paliwal, B. S., Yadav, S.K., Rathi, R and Baghela, A; Sandstone with layered chromatographical structures: a prospective decorative stone; Sandstone Spectrum-03, Dept. of Mines & Geology Govt. of Rajasthan, Udaipur, 2003. Pp-16-25.

[8]. Paliwal, B.S., Kaushik S. K and Yadav, S. K. 2009. Status of deformed Proterozoic metasediments exposed along the western flank of the Aravalli mountain range in Rajasthan (India).193-214 Indian Journal of GeologyVol.78, NOS.1-4.pp-193-214.

[9]. Pareek, H.S. 1983. Stratigraphy of northwestern Indian and its correlation with that of Indus basin. Pakistan, Malagasy and Sourth Africa. Geophytology, 13, 1-21.

[10]. Roy, A.B. and Jakhar, S.R., 2002. Geology of Rajasthan Precambrian to Recent., Sci. Pub (India), Jodhpur pp 1-418.

[11]. Shrivastva, B.P., 1971, Rock Stratigraphic nomenclature for the sedimentaries of west-central Rajasthan:Bulletin Geologica, Mining and Metallurgical society of India, v. 44, p.1-19.

[12]. Sinha-Roy, S. Malhotra G. and Mohanty, M., 1998. Geology of Rajsthan. Geol. Soc. India. 278p.

[13]. Yadav, S. K., 2002. Tectonism and Sedimentation along the western Flank of the Aravalli Mountains: Geological Investigation around Khatu, district Nagaur, Rajasthan, Unpublished Ph.D. Thesis, J.N.V. University, Jodhpur, Rajasthan.

[14]. Yadav, S. K., Paliwal, B. S and Kumar, N; Geological Mapping of the Arid Part of the Nagaur District Using Satellite Data; Proc. of 24th ISRS Annual Convention and National symposium, pp. 194; Jaipur; Nov. 3-5, 2004.