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Remote Sensing and Geoprocessing Use for Water Resources Monitoring of The Granulite Dome and River Basin from Eastern Ghats, India

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The aim of this work is to portray the Madhurawada dome and Gosthani river basin with about 400 sq km located North of Visakhapatnam city more precisely close to the sea of Bay of Bengal. The study was done using the IRS-IB imagery and the field survey conducted for various structural elements and geological, litho logical data. The treatment and classification of the imaginary data were synchronized with the structural element data and geological material data. For comprehensive structural analysis and microscopic scale synoptic projection diagrams for each of the fabric elements like πS_0, πS_1, πS_2, L_1, L_2, L_3, have prepared separately from the domal area and river basin area. The synopsis of fabric geometry have synchronized with the lineament frequencies obtained from the remote sensing imagery. The concentrated sets of lineament frequency trends are distinctly recognized along the zones of quartzites and sheared khondalite plains. The major axial directions of important domal fold pattern are typically represented by curvilinear lineament fabric indicating doubly plunging recumbent fold systems. Intersecting lineament pattern and their synchronized structural configuration have got great significance for the monitoring of the groundwater resource zones. The river basin regulated by structural controls were expressed with cross cutting lineament pattern. For the first time the authors delineated and monitored water resources lineament frequency zones in the domal areas and paleo-channels of the river basin.

Key Words: Dome, IRS-IB, Lineament, Palaeo channel, Fabric elements.

INTRODUCTION

The remote sensing imagery have got an advantage in the exploration of the ground water resources due to its repetitive coverage and the technological expressions that it makes. Using the IRS-IB imagery multiple quantum of lineament data was acquired and integrated with the structural element data of geological materials. This integration has yielded a specific information in targeting the ground water through significant intersectional frequency of lineaments. The investigating area is constituted with metasedimentary granulite group if rocks along the dome and river basin. The major axis of both dome and basin and Gosthani river movement are all along the NW-SE direction. On the NE part of the river drainage have expression of buried pleao-channels which are clearly visible on the imagery. The groundwater evaluation on a regional scale can be assessed only by orbital remote sensing data monitoring integrated with the processed geological data.

EXPERIMENTAL

The IRS-IB imagery study was done in area lying between latitude 17º45'-18º00' N, longitude 83º15'-83º30' E. The interpretation was done employing visual interpretation techniques to decipher lineament fabric. A lineament map (Fig. 1) showing two categories of lineaments *viz.*, (i) straight line lineaments and (ii) pairs of intersecting lineaments, was prepared to understand their expression and to correlate with geotectonic structural elements. The geological study incorporates a synthesis of structural elements. The geological study incorporates a synthesis of structural analysis conducted by the authors in the study area was shown in Fig. 2. Selective equal area projection diagrams for S_0, S_1, S_2 planes, F_1, F_2, F_3 folds and L_1, L_2, L_3 lineations of the study area are synthesized and presented in the synoptic diagrams shown in Fig. 3. From the lineament map a total of 121 straight line and intersecting pairs (18º to 42º) of lineaments was demarked, intercepted visually and analyzed for their composite significance. The regional geological structures as revealed by the structural analysis have been correlated with lineament trends deciphered from IRS-IB imagery.

Geology: Gosthani river system and Madhurawada dome were represented by khondalite group of granulites belonging to the Precambrian age. At places bear evidences of retrograde

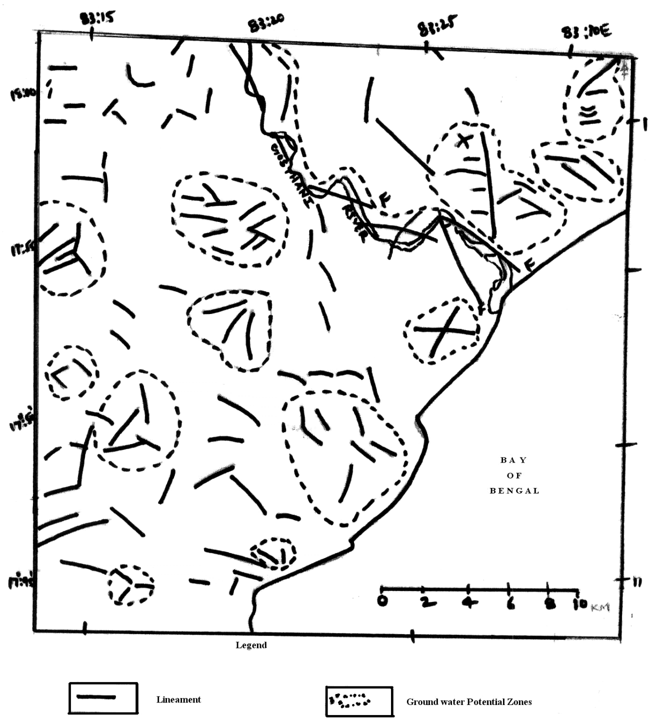

Fig. 1. liniamentmap of gosthani river zone

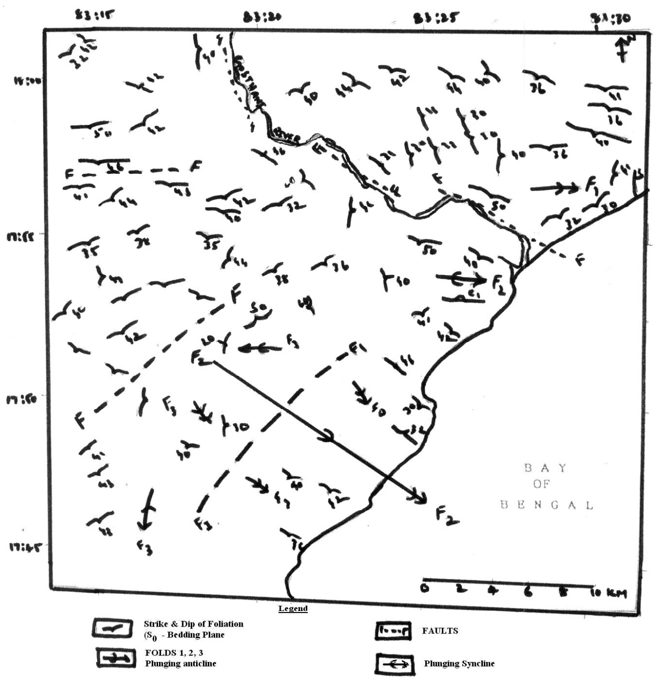

Fig. 2. Structural map of Gosthani river zone

facies of metamorphic conditions. The metamorphism and at places the migmatization are mutually interrelated with consequential developments caused by deformation processes during the easternghat orogeny from early Precambrian through till date. The three major phases of deformation have been recorded in the study area. For comprehensive structural analysis and microscopic scale synoptic projection diagrams for each of the fabric elements like πS_0, πS_1, πS_2, L_1, L_2, L_3 have prepared separately from the domal area and river basin area. From a critical study of the selective projection diagrams

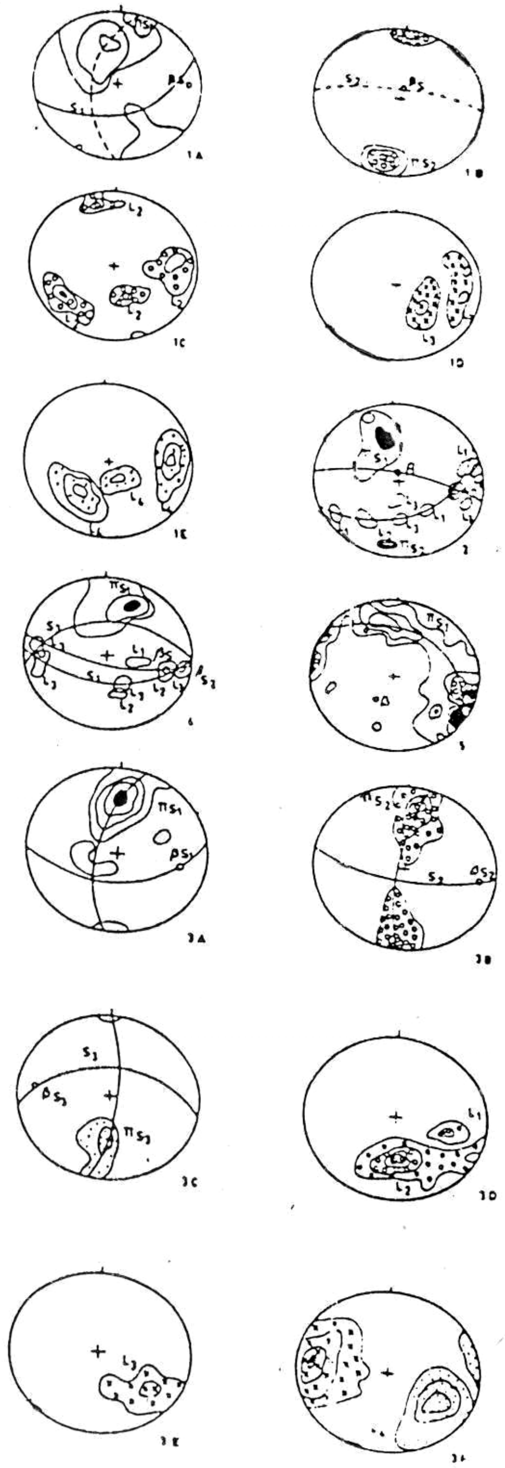

Fig. 3. (1) Synoptic projection diagrams from North West of Madhurawada of Visakhapatnam sector (a) Synoptic πS_1 diagram, Contours 1-49 (13 %); (b) Synoptic πS_2 diagram, Contours 415-38 (46 %); (c) Synoptic L_1 diagram, Contours 2-7 (18 %); (d) Synoptic L_2 diagram, Contours 5-16 (26 %); (e) Synoptic lineation diagram for different lineations (45, 25 & 25 %); (2) Synopsis of structural geometry for North West of Madhurawada of Visakhapatnam; (3) Synoptic πS_1 diagram for North West of Madhurawada of Visakhapatnam sector; (a) πS_0 Contours 6-12-20 (22 %); (b) πS_1 Contours 1-7-12 (15 %); (c) πS_2 Contours 1-3-20 (30 %); (d) L_1, L_2 Lineations contours 20-60 (45 %); (e) L_3 Lineation diagram controus 3-14 (27 %); (f) L_4 Lineation diagram Contours 1-8-20-24 (27 %); L_3 Lineation Contours 1-7-12-17 (32 %); (4) Synoptic of structural geometry for North East of Madhurawada of Visakhapatnam sector; (5) Synoptic πS_1 diagram for south of madhurwada of Visakhapatnam sector

and the structural maps, intricate geometric interrelation between the mega fabric elements of different generations are quite clear. The S_1 schistosity plane exhibits general uniformity at each location, but modified immediately in the next location, expressing across fold nature. There is a considerable variation in orientation of L_2 liniations in different locations, as well as on fold puckers in different locations suggest variable orientation of F_1 folds in this sector. Crenulation foliation (S_2) developed on attenuated limbs and axial planes of L_3 lineations on fold puckers show marked effect of forming in Madhurawada location.

RESULTS AND DISCUSSION

The structural analysis of the dome and basin tectonite reveals marked homogeneity in respect of their structural frame work and different phases of deformation. The first phase deformation in the form of small scale tightly appressed folds of reclined to inclined orientation developed on stratification lamination (S_0) is recorded in the area. The mineral schistosity (S_1) exhibits axial planar relationships with the recognizable earliest fold forms (F_1) and the hinges of F_1 folds were preserved with a set of stripping lineations on the khondalites parallel to the fold axes. Stripping and mineral lineations parallel to F_1 axes mark the first phase deformation expressions, which are correlatable with that of intersecting lineament expressions identified from the IRS-IB imagery. The L_1 lineations that include mesoscopic fold axis on bedding (S_0), stripping lineations marked by intersection of bedding and schistosity (S_1) planes, orientation of stretched amygdule like lensoid bodies and the mineral lineations show a stricking parallelism and are related to F_1 fold movement. F_1 folds in the sector are mostly tight similar folds of buckle origin with reclined geometry depicting high angular relationship between S_0 and S_1, planes near the hinges[1,2].

The folds have a general NE-SW to ENE-WSW axis and both limbs dip at steep angles (50º to 85º) towards south east, having axial planes parallel to limbs, the F_2 folds are not regionally continuous. They are normal, open to tight folds. Superposed F_2 folds over F_1 folds, allowed the first phase F_1 folds to change their plunge angles and directions. At west of the Madhurawada dome the synformal F_2 fold intersects a F_1 basin, the plunges of the latter may further be accentuated. Similarly if an antiformal F_2 fold intersects a F_1 dome, the plunges of the F_1 may be further accentuated, which is evident on the southern part of Madhurawada dome. These F_2 folds have NNW-SSE to NW-SE axial trends and the axial planes are nearly vertical or steeply disposed in the easterly direction. Southernly plunging normal, gentle warp like minor folds, micro-corrugations are correlated to these folds. The F_2 folds and puckers have deformed development of interference patterns (type-2, Ramsay[1]), depending on stress resistance and other factors the amplitude/wave length ratio between 41 and 76 (subclass 1C to class 2 of Ramsay[1]). These large scale structures defined by the repetition of the lithounits and minor structures depicts and almost asymmetrical uplift, low plunging synforms with axial culminations and depressions on IRS-IB imagery expression of pairs of intersecting lineaments are almost all coordinated with the structural elements described above for the phase two deformations. Hence, it can be attributable that the imagery expressions in the form of intersecting lineaments are absolutely correlatable with the F_2 folds.

For comprehensive structural analysis on microscopic scale, synoptic projection diagrams for each of the fabric elements like πS_0, πS_1, πS_2, L_1, L_2, L_3 have prepared location wise. For determining the geometric interrelations between the preferred orientation of various fabric elements in locations around NW of Madhurawada pronounced maxima of S planes and lineation poles from corresponding synoptic diagrams, which shows the synopsis of fabric geometry, which yielded the following information. The synoptic diagram of πS_2 poles for NW of Madhurawada shows a pronounced 13 % maximum, the mean S_1 plane corresponding to which dips 60º N 170º, the poles are mostly concentrated in NW quadrant and form an incomplete girdle the pole βS_1 of which plunges 30º/100º. This represents the axis of flexure and forming of S_3 related to F_2 folds of second phase tectonic activity. The synoptic diagrams for πS_1 poles from the south of Madhurawada shows two sets of pronounced 15 % peripheral maxima and an incipient girdle, the pole (βS_1) of which plunges 60º WSW. In different parts of the domain of this fold closure, the β axis change its orientation depending on the re-existing orientation of the S_1 pole and the axial plane of the Macroscopic of F_3 fold. The synoptic diagram (synopsis of fabric for the east part of Madhurawada) of πS_2 poles shows pronounced 23 % maxima the means S_1 poles corresponding to which dips 60º/ N 179º. The poles are mostly concentrated in NW and NE quadrant and form an incomplete girdle, the pole βS_1 of which plunges 30º/N 100º, 46 % L_3 maximum and falls on mean S_2 plane for this part of the area the coincidence of mean S_1/S_2 intersection with L_3 maximum in NW and E side of Madhurawada area suggest synchronous development of S_2 on S_1 and S_0 during F_2 folding pronounced L_3 maximum for these two locations plunging 30º/N 100º and 40º/N 100º, respectively suggest that deformation plane contain plunge is inclined at *ca.* 70º to 80º towards N 280º. River Gosthani passes through the sheared zone along the three important fault systems which are more or less parallel to the plunge directions of the major folded litho units. The long distance lineaments expressed in the imagery are similar to that of fault plane represent the compressional strain in the area. The imagery interpreted lineaments belonging to the different phases of folding axial planes, faults, fractures, coinciding one with the other. All these lineaments are therefore parallel or sub-parallel to axial directions of the major folds. Hence, all these lineament expressions are typical informants of geological features[3,4].

The geo-processed data and their synchronized lineaments drawn from imagery have considerable bearing on subsurface water resources in any terrain. The lineaments with in the group of gneissic complexes vary significantly and they are genetically related to the tectonic features. Some of the complex lineaments are the synoptic feature zone for the favourable groundwater locations in these parts of the gneissic terrain. In addition to the recognition of individual major lineaments along the quartzite terrains for the groundwater is multiplied at the intersection points of these lineaments associated with other members of the khondalite group of gneissic complexes so as to identify such zones. The areas of maximum values are inferred as the most probable/potential areas of groundwater accumulation.

The weathered zones/soil cover dense fractures, joint planes and crenulation cleavages, *etc.*, are the important natural parameters controlling the groundwater accumulations. The major axial directions of important domal fold pattern are typically represented by curvilinear lineament fabric indicating doubly plunging recumbent fold systems. Intersecting lineament pattern and their synchronized structural configuration have got great significance for the monitoring of the groundwater resource zones.

The areas of maximum potential values for groundwater accumulation are recorded in the study area as: (a) The lineament intersecting points. (b) Multiple, parallel, long and short lineament zones in which land covered in between the lineaments. (c) Palaeo-channels confined to the NE part of the existing river flow channels.

In the study area, the intersecting lineaments recorded on quartzite zones are most favourable locations for putting bore wells (represented in Fig. 1). The lineaments intersecting zones in the Pedi plain areas are favourable zones for large diameter dug wells. For the first time the authors delineated groundwater resource lineament frequency zones in the area.

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