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Lithology, Structure and Geomorphology of the Nagari outliers, Chittoor district, Andhra Pradesh, India

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Abstract: *Nagari Quartzite of the Nallamali Group of the Cuddapah Supergroup occurs as outliers in the southern end of the Cuddapah basin. These are also called Nagari outliers named after the type area of Nagari Quartzite. All the Nagari outliers exhibit a sequence of basal conglomerate, grit and quartz arenite/quartzite. Conglomerate is mature and an oligomictic one with the pebbles of quartzite dominating over the chert, quartz, jasper and vein quartz with siliceous and ferruginous matrix. The clasts in the southern part of the outlier of Sri Kalahasti have been subjected to shearing resulting in the elongation of pebbles. The grit unit is similar to conglomerate in composition, but the grains are sub-rounded to angular, medium to coarse grained and set in a siliceous matrix. The quartzite unit in the Nagari outliers is predominantly fine grained quartz arenite and occasionally ferruginous in nature. Fining upward of this sequence can be easily recognised in this unit. There are a number of mini and intermediate cycles, the former is less than half- a- meter and the latter is up to 1 meter in thickness. The varying thickness of the quartzite in different outliers can be considered as a major cycle. These outliers reflect 2nd order topography. This also exemplifies one of the fundamental concept of geomorphology that "lithology and structure control the evolution of land forms" put forward by Woolridge. The major land forms that are clearly visible, even from a distance are the escarpments and cuestas. The hills are synclinal in structure and are made up of highly resistant quartzite. The intervening valleys that are anticlinal have granite in the core. The relative competency has played a major role in carving out the mature topography. It is evident that the synclinal structure that has developed at the time of formation has been refined by the subsequent tectonics, resulting in the formation of synclinal hills.*

Keywords: *Nagari outliers, Geomorphology, 2nd order topography, Quartzite, Land forms. Synclinal hills.*

I. Introduction

The Nagari Quartzite, exposed mainly in the southeastrn part of the Cuddapah basin rests over the Papaghni Group with a profound angular unconformity in the area south of Kadapa and further south it rests directly on the granitic basement till the end of the basin. This is dominantly an arenaceous unit with a well developed basal conglomerate. It has intercalation of purple shale beds, mostly in the lower horizons. This unit is occassionally intruded by dolerite sills. The Nagari Quartzite is named after an outlier, Nagarimur konda, (Δ 857m), situated in the southernmost part of the Cuddapah basin in the Chittoor district. Nagari Quartzite is considered homotaxial with the Bairenkonda Quartzite of the Nallamalai Group (Sen & Narasimha Rao, 1967; Nagaraja Rao 1976; Nagaraja Rao et. al., 1987).

The Nagari Quartzite is exposed continuously from Chintakommadinne in the north extending southward into the Cheyyeru country constituting the Palkonda range (west of Cheyyeru river) up to Tirumala, where the western scarp of the range demarcates the Archaean-Cuddapah boundary. Further, it occurs as the capping of the conspicuous Nagarimur Konda, after which it is named. It is seen as outliers north of Nagarimur Konda in the Narayanavanam, Virapaka Kota - Nagalapuram and Sri Kalahasti outlying ranges.

II. Objectives

Previous work: The pioneering work on the geology of the outliers was by William King (1872). He was the first to recognize the triple division character of the outliers. He gave a detailed account on the area. Murty, (1950, 1952 and 1953), carried out mapping in these area sand described the outliers. Narayanaswami (1966) described the tectonics of the Cuddapah basin as a whole in detail. Nagaraja Rao et. al., (1977) carried out the geological mapping of the terrain, using aerial photographs. This study has brought to light many features, especially the structural pattern of the doubly plunging synclines. Nagaraja Rao et. al., (1987) elucidated the stratigraphy, structure and evolution of the Cuddapah basin. Abdul Matin (1996) carried out detail structural studies on the Sri Kalahasti outlier.

III. Lithological Units Of The Nagari Quartzite And Their Characters

The following sequence of units is established in the type area:
Quartzite with inter – bedded shale.
Grit
Conglomerate

The above sequence is observed throughout the horizon. But, in the Guvvalacheruvu Ghat section, purple shale bed overlies the conglomerate instead of the grit beds. The lithology is shown (Fig.1).

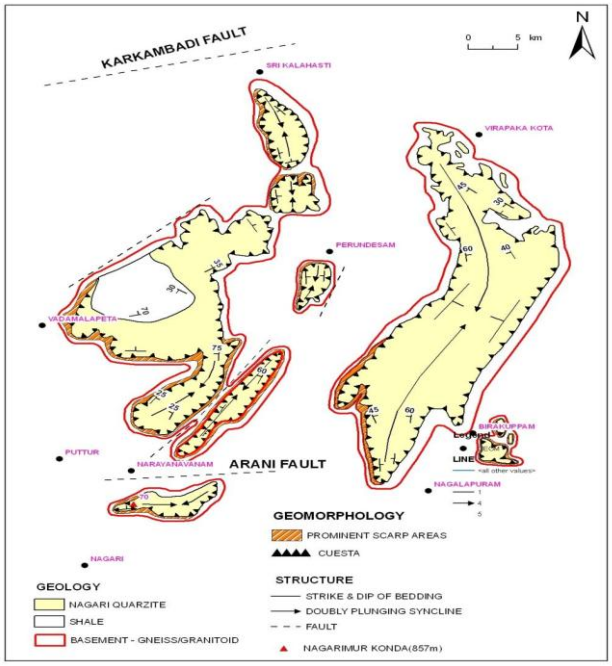

Fig.1. Geology, Geomorphology and Structural Disposition of the Nagari outliers

Conglomerate and grit:

This is an oligomictic conglomerate with pebbles of quartzite dominating over the chert, jasper and vein quartz with siliceous and ferruginous matrix. The conglomerate is best developed in the northern part of the Nagari horizon in the area south of Apparajupalle, located 6km south-west of the Kadapa town. In this area, the basal beds have sub-rounded to rounded and moderately sorted boulders of quartzite, measuring up to 1m along the longer axes. This is like a boulder bed. This is followed by cobble/pebble bed, which in turn is overlain by grit, and the total thickness of the conglomerate is about 35 - 40 m. King (1872) called this conglomerate as Chintakommadinne conglomerate and considered it as ferruginous conglomerate. The conglomerate when traced further south in the strike direction gets reduced in thickness, measuring about 1-7 m. However, there is no change in composition except a slight change in constitution i.e., absence of the basal boulder bed. The conglomerate bed in the Tirumala hills, the location where GSI has identified and preserved it as a National Monument, is a thin oligomictic conglomerate having the same composition as stated above. But, the conglomerate exposed behind the Karnataka choultry i.e., on the way to Microwave station at Tirumala, is a polymictic conglomerate having boulders of hornblende granite, in addition to the normal constituents of quartzite, chert, jasper and vein quartz, in a siliceous/ferruginous matrix.

The conglomerates are well developed in the Nagari and adjacent outliers. The constitution and composition of the conglomerate is similar to that in Apparajupalle, i.e., the basal boulder beds have well rounded boulders measuring up to 20 cm along the longer axes, which is mainly due to tectonic affect in this area.

The conglomerate in the Sri Kalahasti outlier is mainly clast dominant, oligomictic, and mature. The normal size of the clasts is 4 to 5 cms along the longer axes and there are still smaller clasts indicating highly ill sorted nature. However, all the pebbles are quartzitic in composition and well rounded pointing to their maturity (Fig.2). There are very a few places, where the conglomerate is matrix dominant. In the southern part, the clasts in the conglomerate are stretched due to the effect of tectonism (Fig.3). The conglomerate beds in the other outliers are not well developed.

Fig.2.The well rounded Conglomerate pebbles

Fig.3.The conglomerate is not well developed in thin pebble bed

The conglomerate is followed by grit. But the grits noticed in the outliers are constituted of angular to sub-rounded, medium to coarse-grained quartz grains with siliceous matrix. The coarseness of the grains and the saccharoidal nature of the unit have facilitated deep weathering resulting in the formation of a typical geomorphic unit i.e., like a wall like feature. In the Nagari horizon wherever the conglomerate is absent, the basal beds are mostly gritty in nature.

Quartzite (Ferruginous Quartzite/Quartz Arenite):

The quartzite of the Nagari Quartzite in general is ferruginous quartzite and can be called as iron oxide quartzite. All through its strike length, this character is conspicuous. But, this ferruginous quartzite is interbedded with quartz arenite bands as noticed on the way to Tirumala. These are fine to medium grained, white to half white (slightly brownish) and thick-bedded quartzite. But towards north in the main basin, these gradually give way to iron oxide quartzite, as seen in the Chintakommadinne area located 5km southwest of the Kadapa town. The Nagari horizon has also shale intercalations associated with quartzite unit as noticed in the Tirumala ghat section. These are thinly bedded and ferruginous and can be easily identified by their geomorphic expression, i.e., they form slight depressions if they are on slopes or; they form valleys if their magnitude is high. These beds also grade gradually into quartzite units suggesting lateral facies variation.

The lithology, structure and land form of the Nagari Outliers is shown in (Fig.1). The quartzite unit of the outliers in general is orthoquartzite type, occassionally; it also indicates a ferruginous nature. The grain size of the orthoquartzite is generally fine and only at few places as in the case of Narayanavanam outliers it is medium grained. It is seen that the quartzite unit has a number of fining upward sequences in the form of mini and intermediate cycles. The thickness of the mini cycle is less than half a meter. The intermediate ones

are up to one meter. In fact the bedding type of joints noticed in these can be considered as reflection of intermediate cycles. The total thickness of the quartzite unit varies in each outlier; this thickness in each outlier can be identified as a major cycle.

The quartzite units in almost all the outliers exhibit planar cross bedding (Fig.4) and ripple marks. The former is conspicuous in the Sri Kalahasti outlier on way to the temple tank. This unit in the Virapanakota–Nagalapuram outlier reflects fine-grained and cherty nature with a greasy look. It breaks with conchoidal fracture and gives metallic sound when hit with hammer. In the Nagalapuram outlier, the quartzite unit indicates spotted nature. The same unit in the Vadamalapeta outlier has the development of a few white micaceous minerals, because of which the surface reflects vitreous nature.

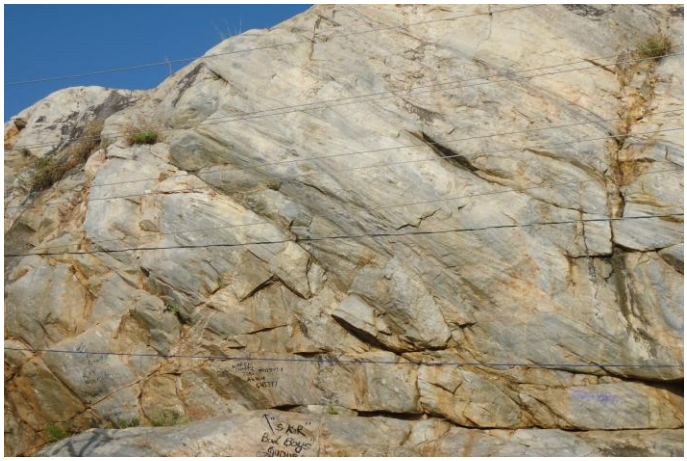

Fig.4.The quartzite unit exhibiting planar cross bedding

IV. Structure Of The Nagari Outliers

All the outliers exhibit the doubly plunging synclinal structure. The fold axis in the southern part plunges towards NNE at about 30^0 and in the northern part it plunges to SSE at the same angle. This gives a curved nature to the fold axis. This is very conspicuous in the Nagalapuram-Virapaka kota outlier. Similarly, all the outliers reflect doubly plunging nature. This is clearly seen in the satellite image also (Fig.5).

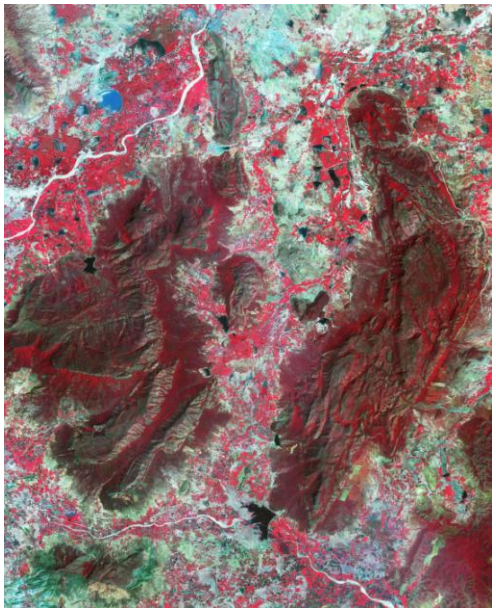

Fig.5.The Satellite Imagery reflecting doubly plunging nature

The curving of the fold axes has modified the morphology/configuration of the outliers. The compression in the WNW – ESE direction has given rise to the first deformation to the outliers. The sigmoidal nature of the axis could be attributed to a major shear movement along the Karakamabadi fault in the north and the river Arani fault in the south, (Fig.1).

Faults trending NNE-SSW are also observed at Narayanavanam, Vadamalapeta and Perundesam (Fig.1). The effect of tectonism is seen in the form of grooves and lineation and in the formation of quartz veins (Fig.6). The clasts in the conglomerate are also stretched due to tectonism as observed in the area south of the Sri Kalahasti outlier.

Fig.6. The effect of tectonism in the form of grooves, lineation and in the formation of quartz veins

Shearing is very common in all the outliers. The quartzite is highly crushed (Fig.7) due to the shear effects that are best observed in the Nagalapuram outlier.

Fig.7. The highly sheared quartzite

In the southern end of the Nagalapuram outlier, the top most quartzite unit stands up majestically as a big wall (Fig.8). The dip of the bed in this outlier can be visualised even from a distance, (Fig.5), as there are argillaceous and arenaceous units alternating with each other and the former supporting the dense vegetation. The beds at the end of the outlier dip towards north at an angle of 45^0–55^0. There are thin assorted beds of conglomerate within this. The quartzite pebbles in the conglomerate are well rounded and reflect clear effects of shear. The fracture system noticed in the pebbles is not mirrored in the matrix.

Fig.8. The top most quartzite unit in the outlier stands up majestically as a big wall

V. Morphology Of The Outliers

Vaidyanadhan (1964) described the geomorphology of the Cuddapah basin. The geomorphic expression of an each outlier can be considered as the reflection of lithology and structure to a great extent.

Though all the Nagari outliers are separated, interestingly, their geomorphic expression is similar, i.e., all are synclinal hills (Fig.1). This again points to the influence of lithology in the formation of the order of topography. The geomorphological land forms in terms of cuesta and scarp are shown in (Fig.1).

The major geomorphic land forms that are visible clearly are the scarps and the cuestas.

Scarps:

These are seen all around the hills of the Nagari outliers. The degree of development varies from place to place, as the units involved are rudaceous and arenaceous that are resistant to weathering they are standing out as majestic scarps. However, the nature of the litho units, viz., conglomerate, grit and quartz arenite have a say in the final formation of scarp.

The conglomerate beds form scarps of lesser magnitude**,** due to the coarseness of the rock. Further, the pebbles can be easily removed by the weathering of the matrix; the grit is more compact and stands up as scarps of considerable magnitude and it is the quartzite, which stands up as high scarps (like majestic walls), due to fineness, cherty and compact nature of the unit (Fig.8)**.**

Cuesta:

All the outliers have cuesta type of land form, wherein, the obsequent slope is partly represented by the scarp and rest by debris slope and the consequent slope is indicated by the gentle dip - slope, (Fig.9).

Fig.9. The outlier exhibiting cuesta type of land form

VI. Geomorphic Evolution Of The Nagari Outliers

The study of the image (Fig.5) clearly indicates that all the outliers structurally represent synformal hills separated by anticlinal valleys. The synclinal hills and anticlinal valleys generally reflect second order or mature topography. This is also designated as reversal in topography. Wooldridge and Morgan, (1937) authoritatively advocated the development of 2nd order topography.

This is a result of the rocks in the anticlinal area being are generally softer, so that it can be easily brought down to the ground level by pediplanation or peneplanation and the rocks in the synclinal portion should be harder and resistant to weathering, so that they can stand out as hills. The net result will be the rocks in the synclinal troughs will be standing out as hills and the rocks in the anticlinal core will be valleys. Similar set up can be observed in the case of the topography south of the river Cheyyeru in the Nandalur area of the Cuddapah basin, where carbonate (in the core of an anticline) and quartzite (in the form of lenses in the trough of a syncline) are involved in the formation of 2nd order topography. The ultimate result depends upon the relative hardness of the lithounits involved.

But, the nature of the rocks in the synclinal hills and the anticlinal valleys of the Nagari outliers are both hard rocks, i.e., quartzite and granite respectively. Though both the rocks involved are hard and compact, the relative competency has played a major role in carving out the mature topography. The granite being relatively softer was brought down in relief. Structure has also played its role in the process of bringing down the relief.

Structure versus Geomorphology:

Structurally all the outliers reflect doubly plunging synclines. The question that arises is that whether the 2nd order topography is due to the structure or due to the geomorphic imprint?. In the earlier paragraphs, it was stated that the quartzite being very resistant to weathering is standing out majestically. An attempt has being made to consider the role of structure is carving out the 2nd order topography.

The foundering of the earth's crust at different places, has given rise to minor individual basins. These were separated by the inter-basinal granitic basement highs.

From the above consideration, it is evident that the beds in the outliers could have had qua qua inversal dips due to the basinal feature of the site of deposition. This set up due to subsequent compression has gained hight perpendicular to the direction of compression refining the structure. The compression involved helped in shortening of the crust and raising the elevation of the sediment and the granitoid basement. The fracture system resulted due to the tectonism has affected the basement as well as the sediments. This fabric developed due to tectonism has quickened the work of geomorphic processes in bringing down the relief of the granitic basement, which is relatively softer especially in the inter outlier areas. Philips (2005) stressed that the fundamental control on landscape evolution of the Nagari outliers is weathering. The same is true in the case of Nagari outliers in the outlier zone, the basement is protected by the ultra resistant quartzite. The quartzite, thus gained the higher relief reflecting the present configuration.

The said analysis clearly points to the fact that the concept of Wooldridge (1937) is applicable to the formation of 2nd order topography of the Nagari outliers.

Thus, the entire set up of the Nagari outliers is evidence supporting the theory, that the evolution of landforms is controlled to a large extent by two factors, i.e., the lithology and structure.

VII. Conclusions

All the outliers of the Nagari Quartzite reflect the triple division of basal conglomerate followed by grit that inturn is overlain by quartzite. Each lithological unit can be recognised from a distance due to their geomorphic expression. Doubly plunging synclinal structure is common to all the outliers. The major geomorphic features are scarps and cuestas. The 2nd order topography, i.e., synclinal hills and anticlinal valleys is very conspicuous in the outliers. The development of 2nd order topography has been initiated from the beginning of the formation of outliers. The role of lithology and structure in the evolution of land forms is clearly reflected in the outliers. The refolded structure could be due to major shears acting between Karkambadi in the north and the river Arani in the south.

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References

[1]. King, W., (1872) On the Cuddapah and Kurnool Formations in the Madras Presidency. Mem. Geol. Sur. Ind. 8. pp 1-320.
[2]. Nagaraja Rao B. K., and Ramalingaswamy, G., (1976) Some new thoughts on the stratigraphy of Cuddapah Super group, seminar on Kaladgi-Badami, Bhima and Cuddapah Super group, Mysore; Abstracts pp. 17-20.
[3]. Nagaraja Rao, B.K., Rajaurkar, S.T., and Ramalingaswamy, G., (1987) Stratigraphy, Structure and Evolution of the Cuddapah Basin - Mem. Geol. Soc. India, 6, pp. 33-86.
[4]. Phillips, J. D., (2005) Weathering, instability, and landscape evolution, Journal of the Geomorphology, 67, pp. 255-272.
[5]. Sen, S. N. and Narasimha Rao, Ch (1967) Igneous activity in Cuddapah Basin, adjacent areas and suggestions in the Palaeogeography of the basin, In symposium on upper mantle Project proceedings National Geophysical Research Institute, Hyderabad, pp. 261-285.
[6]. Vaidyanathan, R., (1964) Geomorphology of the Cuddapah basin, Jour. Ind.Geosci. Ass. 4, pp. 29-36.
[7]. Wooldridge, S.W., and Morgan, R.S., (1937) The Physical basis of Geography:an outline of Geomorphology, London: Longmans. pp. 3479-3486.