Chapter II

Sedimentary rocks of the study area
CHAPTER – II

SEDIMENTARY ROCKS OF THE STUDY AREA

2.1 Introduction

The area under study forms a part of Cuddapah basin. It is a narrow belt of
about 2.5 km wide in N-S direction, and about 6.5 km long in an east-west direction,
between the Motnutralapalle on the west and Kanampalle village on the east. The
mapped area is covered in toposheets 57 J/3. It forms a linear strip concave to the
north, where the concavity being the result of the gradual and continuous change of
strike.

The linear ridges rimming the basin margin and exhibiting gentle basin ward
slope are occupied by Gulcheru Formation (Fig. 2.1). The quartzite of Gulcheru
Formation is overlain by ferruginous shale, followed by Vempalle carbonates. This
shale overlying the Gulcheru quartzite is represented by small mounds with
intervening plain areas covered with alluvium, and form the main area for habitation
and cultivation. The middle parts of Vempalle Formation comprised with calcareous
purple shale also forms the broad valley and primary areas of cultivation. Uraniferous
dolostone lying stratigraphically below the purple shale are exposed on the southern
slope of the valley where as the cherty limestone unit overlying the purple shale forms
the high hill ranges.

The different lithounits exposed in the area has a NW-SE strike near the
Motnutralapalle village, gradually changing to WNW-SEE near Pulivendla (lat: 14°
25' 30", long: 78° 14") then E-W near Vemula (lat.14° 22', long. 78° 19' 30") and
finally to NE-SW near the Papaghan river (toposheet 57 J /11). They dip consistently
towards NE, N and NW in accordance with the local strike. The magnitude of the dip
varies from 10° to 30° with the average dip of about 15°.
The southern and northern limit of the study area is confined between Gulcheru quartzite and cherty dolostone of Vemapalle Formation. The Gulcheru Formation consisting mainly of arenaceous to argillaceous facies is overlain by rocks of the Vempalle Formation comprising predominantly of calcareous with some argillaceous facies. The Gulcheru Formation commences with the basal polymictic conglomerate followed by quartzite. These quartzites are coarse to fine grained, buff and light brown colour and show tabular current bedding and ripple marks. The contact between these quartzites and the overlying Vempalle formation is marked by red coloured siliceous shale and forms gradational contact.

2.2 Lithology

Carbonate facies in the study area commences with massive dolostone, followed by thin bands of intraformational conglomerate, phosphatic dolostone, purple shale and cherty dolostone. The massive dolostone is without any shale intercalations and the thickness varies from 50-90 m. Uranium mineralization is essentially associated with the phosphatic dolostone unit above the conglomerate. Thickness of this unit varies from 14.50-18 m. The phosphatic dolostone unit shows appreciable amount of detritus in the form of quartz and feldspars. Feldspar clasts are smaller in size than quartz clasts, as quartz is more resistant to weathering than the feldspars and hence remain as bigger clasts. The purple shale unit is 17-19 m thick and displays a variety of sedimentary structures with occasional specularite lenses/streaks. The cherty dolostone facies is the dominant facies among all the lithounits present in the study area and also contain intercalations of purple coloured beds of shale and siltstone few centimeters to 1m thick. At many places the transition between the cherty dolostone and shale intercalations shows brecciation pointing towards the tectonic disturbances that the basin was undergoing during the deposition.
The dolostone units in the area invariably contain stromatolites. The generalized litholog of the Kanampalle area is shown in Fig. 2.2.

2.2.1 Gulcheru Formation: It is the lower most member of Papaghni Group. It forms distinct hill ranges along the south western margin of study area. The Gulcheru Formation commences with the basal polymictic conglomerate followed by quartzite (Fig. 2.3). The conglomerate horizon is impersistently and unevenly developed over the basement along the W, SW and S margin of Cuddapah Basin and thickness varies from few centimeters to 5 meters. It contains ill sorted, sub-angular to rounded pebbles–cobbles–boulders of quartzite, chert, jasper and occasionally vein quartz and granite in siliceous matrix. The matrix also contains small pieces of the above mentioned pebbles. It is highly ferruginous in nature. The size of the conglomerate pebbles is relatively smaller in Kanampalle area and the fractures developed in the conglomerate are occasionally filled with 2-3 mm thick specularite veinlets. The quartzite pebbles are generally fractured and the fractures are developed perpendicular to the axis of elongation. Majority of the pebbles in the conglomerate are oriented parallel to the bedding plane. At places, thin conglomerate horizons are repeated after interbeded quartzite horizon.

The conglomerate is overlain by the quartzites. These are coarse to fine grained, compact varieties of buff and light brown colour at places with thin bands of conglomerates. They show tabular current bedding and ripple marks. The trend of Gulcheru Formation is N70° to 80°W - S70° to 80°E with 7°-14° dip towards N20° to 10°E direction. Around Motnitalapalle village, the Gulcheru quartzite is fine grained, pink to greyish in colour and bedded in nature. It trends along N50°W-S50°E direction with 11° dip towards NE and often displays planar cross bedding and mostly symmetrical ripple marks.
Three generations of joint patterns viz. N10° to 15°E - S10° to 15°W; N65°E - S65°W and N65° to 70°W - S65° to 70°E are observed in the area. Quartz veins are intruded along NNE-SSW direction and are intersected by the later generation joints.

The contact between these quartzites and the overlying massive dolostones of Vempalle formation is usually marked by red coloured ferruginous shale (Fig. 2.4) which on weathering gave rise to red soil which is good for cultivation. The transition from the quartzites to the shale and from the shale to the overlying limestones is fairly
Vempalle Formation

Fig. 2.2
2.2.2 Vempalle Formation: It consists of a large thickness of cherty dolostone, shale and dolomitic limestones occupying 4 to 6 km wide zone. Topography is somewhat rugged. These limestones are covered with a thin layer of soil. The total estimated thickness of these carbonate rock sequence is 1900 m (Nagaraja Rao et al. 1987). Vempalle Formation is divided into five major lithounits based on the megascopic observation. They are:

a) Massive dolostone
b) Polymictic intraformational conglomerate
c) Phosphatic dolostone
d) Purple shale
e) Cherty dolostone

2.2.2a Massive dolostone: The red shale of Gulcheru Formation is overlain by massive, compact fine grained and pale yellow to grey coloured dolostone. The contact between red shale of Gulcheru Formation and massive dolostone is gradational. The massive dolostone is without any shale intercalations (Fig. 2.5). Its thickness ranges from 100 to 200 m. The thickness of the massive dolostone decreases northwestward. At places it is stromatolitic. Occasionally dispersed rounded quartz clasts as detritus are seen embedded in the calcareous matrix. gradational. The shale unit conformably resting over the Gulcheru quartzite is exposed in SE of Motnutralapalle and Kanampalle villages. The intervening 2 km stretch along the strike direction is covered with sandy soil mainly derived from the Gulcheru quartzite.
Fig. 2.3: Field photograph showing unconformity contact between the basement granite and Gulcheru Formation.

Fig. 2.4: Field photograph showing the contact between the Gulcheru quartzites and the overlying massive dolostone of Vempalle formation marked by red ferruginous shale.
2.2.2b Polymictic intraformational conglomerate: The thickness of this conglomerate facies varies from 10 cm to 3 m and occurs only at the base of the mineralized phosphatic dolostone. It is clast supported at the base and grades upward to matrix supported conglomerate. Clasts include subangular to well rounded quartz, chert and quartzite lithic pebbles, medium to coarse grained quartz sand and minor amounts of mud. The conglomerate facies is crudely graded but lacks other sedimentary structures. This facies is inconsistent and very well developed in Kanampalle in the west to Gidankivaripalle in the east. The coarse grained texture and rounded pebbles in conglomerate at the base of the mineralized dolostone are indicative of a relatively high energy depositional environment (Fig. 2.6).

2.2.2c Phosphatic dolostone: This lithounit hosts uranium mineralization and consists of mixed siliciclastics, carbonate, and phosphatic rock associations. The base of this association is marked by a transition from pebbly sandstone to siltstone and thin beds of argillaceous dolostone. Near the top, the dolostone subsequently changes from phosphatic dolostone to purple shale facies. This mixed carbonate-clastic sequence is very distinct in the study area. It ranges in colour from light grey to dark grey when fresh, weathers brown colored, and is commonly interbedded with siltstone which occur as thin elongated lenses or tabular beds 5–50 cm thick. It consists of subrounded to rounded very fine quartz grains in a black phosphatic matrix. Phosphate occurs as elongate to irregular laminae and range in size from a few millimeters to 1 cm thick (Fig. 2.7a and b). This unit commonly contains minor amounts of pyrite. The uranium mineralization is hosted by this unit and the mineralized phosphatic dolostone is darker in colour when compared to the non mineralized phosphatic dolostone.
2.2.2d **Purple Shale:** This lithounit overlies uraniferous dolostone unit and underlies the cherty limestone unit. Geomorphologically it forms a valley because of erosion due to its soft nature. Shale is purple coloured and locally calcareous when grades to limestone. This unit is laminated to thin bedded ranging from few centimeters to few decimeters with local wavy laminae, hummocky cross stratification and soft sediment deformation including small folds and microfaults. The argillaceous fine silt/sandstone is also found locally as thin lenses within this unit (Fig. 2.8).

2.2.2e **Cherty Dolostone:** This unit represents and covers the major thickness of the Vempalle Formation. It forms hills with well bedded unit and are characterised by distinct elephant skin weathering. Cherty dolostone is fine-grained white, pale grey, buff coloured with occasionally intercalated thin bands and lenses of reddish usually calcareous shale (Fig. 2.9). The thickness of this dolostone unit is estimated at 1500-1700 m and is generally well bedded but may show slight crumpling at places. Stromatolites are ubiquitously present.
Fig. 2.5: Field photograph showing Massive dolostone in Kanampalle area.

Fig. 2.6: Field photograph showing Conglomerate in Kanampalle area.
Fig. 2.7a: Field photograph showing Radioactive Dolostone in Kanampalle area.

Fig. 2.7b: Field photograph showing Stromatolites in Uraniferous dolostone near Kanampalle.
Fig. 2.8: Field photograph of well bedded Purple shale in Kanampalle area.

Fig. 2.9: Field photograph of well bedded Cherty dolostone with shale intercalation in Kanampalle area.
2.2.2f Volcanic Flows: The Vempalle Formation shows contemporaneous igneous activity represented by sills, volcanic flows and other intrusives. These volcanics form high ridges where lenses of ignimbrites are seen. It consists of fragments of Gulcheru quartzite and Vempalle carbonates within the ferruginous fine grained matrix of volcanic rocks (Fig. 2.10a & b).

The above described five major lithounits of Vempalle Formation, show a specific trend of thinning from Tummallapalle to Kanampalle and further west towards NG Palle and Murarichintala. Thickness of Gulcheru Formation and Vempalle Formation gradually reduces as we move from east to west (Fig. 2.11). Massive limestone and phosphatic dolostone of Vempalle Formation also follows the trend. There is a marked increase in the siliciclastic components from east to west in the phosphatic dolostone. It has been observed at Pulasalanutalla that the dolostone is directly overlying the Gulcheru Formation and the lower unit of massive dolostone is missing.

2.3 Structures

The mineralised dolostone and the associated lithologies in the stratigraphic column of Vempalle Formation in Kanampalle area is marked by number of sedimentary structures. These structures can be broadly divided into two categories viz. primary structures and secondary structures. Other than the sedimentary structures, at many places post depositional deformation structures like small and large scale faults are also observed.
2.3.1 **Primary sedimentary structures:** Primary structures in sedimentary rocks are formed during deposition. The quartz arenites of Gulcheru formation show a variety of primary sedimentary structures like transverse symmetrical ripples (Fig. 2.12a), interference ripples, planar and herringbone cross bedding. The siliceous bands associated with dolostone (phosphatic and cherty) show structures like wave ripples (Fig. 2.12b and c) and planar cross bedding (Fig. 2.12d).

Microbially induced sedimentary structures (MISS) are primary sedimentary structures formed by the interaction of microbes (bacteria, fungi, protozoans and algae) with sediment and physical agents of erosion, deposition, transportation or deformation traces of microbial activity (Noffke, 2003). MISS include stromatolites, wrinkle marks (sometimes described as an elephant-skin texture), microbial mat chips, mat curls and a variety of other forms. The siliciclastic basal Gulcheru Formation of the Proterozoic Cuddapah basin preserves abundance of mat induced sedimentary structures like old elephant skin, wrinkle structure, palimpsest ripples etc. in the vicinity of Pullivendla town (Chakrabarti and Shome, 2010), which is in proximity to the study area.
Fig. 2.10a: Field photograph of Ignimbrites in Vempalle Formation near Kanampalle.

Fig. 2.10b: Field photograph of Volcanic flows with rock fragments of Gulcheru quartzite and Vempalle carbonates exposed near Kanampalle.
Fig. 2.11

INDEX

- CHERTY DOLOSTONE
- MASSIVE DOLOSTONE
- GULCHERU FORMATION
- PHOSPHATIC DOLOSTONE
- BASEMENT GRANITE
- STROMATOLITE
- CROSS STRATIFICATION
- PYRITE
- BRECCIATION
- DESiccATION CRACKS
- SPECULARITE LENSES/STREAKS
Fig. 2.12a: Field photograph showing Wave ripples in Gulcheru quartzite near Kotala.

Fig. 2.12b: Field photograph showing Wave ripples in phosphatic dolostone exposed near Kanampalle.
Fig. 2.12c: Field photograph showing Wave ripples in siliceous bands of cherty dolostone exposed near Kanampalle.

Fig. 2.12d: Field photograph showing Planar cross bedding in siliceous bands of phosphatic dolostone near Kanampalle.
Stromatolites are abundant with variable structures which occur within all the carbonate units of Vempalle Formation of the study area. King (1872) was the first to report stromatolites in the region. He referred to them as ‘crude columnar segregations’ on limestone bedding surfaces of the Vempalle Formation in the Papaghanai valley and near Soorepally, which are located in the area both in the west of Vempalle and south of Pulivendla. Most other reports of Cuddapah stromatolites are also from the Vempalle Formation, throughout its outcrop, and have usually referred them to either Collenia Walcott or Cryptozoon Hall (Srinivasa Rao, 1943, 1944, 1949; Viswanathiah and Govindarajulu, 1963; Vaidyanathan, 1961; Viswanathiah and Aswathanarayana Rao, 1967; Prasad and Verma, 1967; Lotze, 1967; Nageswara Rao, 1994).

The stromatolites in the Kanampalle area show various morphologies dominated by columnar type (Fig. 2.13) with lesser amount of stratiform (Fig. 2.14) and domal (bulbous) type (Fig. 2.15). Some domal and columnar type stromatolites are horizontally elongated and/or arranged. The lamination of the domal as well as columnar type stromatolites are often laterally linked (Fig. 2.16 and 2.17). Gururaja and Chandra (1987) gave detailed descriptions of stromatolites from the Vempalle and Tadpati formations and recognized a high diversity assemblage including Collenia Walcott, Columnocollenia Korlyuk, Gymnosolen Steinmann, Inzeria Krylov and Jacutophyton Schapovalova. In addition, a wide variety of ministromatolites are present in the Vempalle Formation, including Alcheringa Walter, Asperia Semikhatov, Conistratifera Zhu, Xu and Gao, Kanpuria Raaben, Liaoheela Cao, Microstylus Komar, Minicolumella Raaben, Paraboxonia Zhu, Pilbaria Walter and Tibia Bertrand-Sarfati (Sharma and Shukla, 1998). These stromatolites appear to have
been deposited in relatively shallow water and large colonies of stromatolites indicating quiet low-energy conditions.

2.3.2 Secondary sedimentary structures: Sedimentary structures formed after deposition are termed as secondary sedimentary structures. These structures form by chemical, physical and biological processes inside the sediment. Some of the secondary structures noticed in the study area are stylolites, load casts, convolute bedding and mud cracks. The shale units of the study area show evidences of subaraiul exposure in the form of mudcracks (Fig. 2.18a and b).
Fig. 2.13: Field photograph showing Columnar stromatolites in cherty dolostone near Kanampalle.

Fig. 2.14: Field photograph showing Stratiform stromatolites in cherty dolostone in Kanampalle.
Fig. 2.15: Field photograph showing Domal (bulbous) stromatolites in cherty dolostone of the study area.

Fig. 2.16: Field photograph showing Laterally linked columnar stromatolites in Cherty dolostone of the study area.
Fig. 2.17: Field photograph showing Laterally linked domal stromatolites in phosphatic dolostone of Kanampalle area.

Fig. 2.18a: Field photograph showing Mudcracks in the phosphatic dolostone of Kanampalle area.
Fig. 2.18b: Field photograph showing Mudcracks in the purple shale near Kanampalle.

Fig. 2.19: Photograph showing Stylolite in core sample of phosphatic dolostone from Kanampalle.
2.3.2a **Stylolites:** These are serrated surfaces at which mineral material has been removed by pressure dissolution, in a process that decreases the total volume of rock. Insoluble minerals like clays, pyrite, oxides remain within the stylolites and make them visible. Stylolites formed here are usually parallel to the bedding surface (Fig. 2.19).

2.3.2b **Load casts:** These are secondary structures that are preserved as bulbous depressions on the base of a bed. They form as dense, overlying sediment (usually sand) settles into less dense, water-saturated sediment (usually mud) below. Here the overlying dense unit is cherty dolostone forming the load cast in the mud/shale below (Fig. 2.20).

2.3.2c **Convolute bedding:** It is the contorted laminae usually confined to a single layer of sediment, resulting from subaqueous slumping. It is marked by parallel beds both on top and bottom and may be attributed to seismic activity during sedimentation (Fig. 2.21).

2.3.3 **Post depositional deformation structures:** These structures are developed in the lithostratigraphical units in response to stress induced by the tectonic activity after the deposition of the sediments. Flexure and fault induced structures are included under this category. Small scale faults and offsets are observed at many places in outcrop as well as in core logs. At places the cherty dolostone and shale intercalations are seen showing small scale reverse faults (Fig. 2.22a and b). The core logs also show small scale faults, indicating towards the seismic pulses and the deformation that the basin underwent during deposition.
2.4 Depositional Environment

The Gulcheru Formation comprises mainly of conglomerate, arkose, quartzarenite with shale intercalations. The basal conglomerate with mature quartz pebbles reflect shoreline features indicating high energy wave winnowing process while the overlying arkose bed indicates deposition in tectonically active provenance with little transportation and quiet deposition under stable conditions (Nagaraja Rao et al., 1987). The deposition of quartzarenite reflects tidal flat environment as evidenced by herringbone cross bedding, mudcracks and interference ripples. Presence of glauconite in the rocks of Gulcheru Formation indicates shallow marine conditions. Glauconite also indicates tidal flat sequence (Klein, 1977; Singh, 1980).

Five lithofacies have been identified in the Vempalle Formation and grouped on the basis of composition, grain, types, sedimentary structures, diagenesis and vertical facies relationship. These lithofacies are grouped into two genetically significant facies associations i.e. peritidal siliciclastic carbonate and deep subtidal. The lithology, major sedimentary structures and environmental interpretations of facies and facies associations are summarized in Table 2.
Fig. 2.20: Field photograph showing Load cast in the shale intercalations in cherty dolostone near Kanampalle.

Fig. 2.21: Field photograph showing Convolute bedding in Cherty dolostone near Motuntalapalle.
Fig. 2.22a: Field photograph showing small scale reverse fault developed in cherty dolostone and shale intercalation exposed near Motuntalapalle.

Fig. 2.22b: Photograph showing small scale faults in shale core collected from Kanampalle.
Carbonate facies are subdivided into depth-restricted zones, where there are extreme variations in water depth, salinity and organisms. The term peritidal (Folk, 1973) is generally used to describe a variety of carbonate environments associated with low energy tidal zones, especially tidal flats. Traditionally three main zones are recognised, i.e., 1) supratidal, 2) intertidal, and 3) subtidal environments, where there are extreme variations in water depth, salinity and organisms.

2.4.1 Supratidal zone: Supratidal zone refers to environment that is generally above the tidal range and is thus wet with seawater only during storm events, which transport carbonate sediment in.

2.4.2 Intertidal zone: This lies between the normal low-tide and high-tide levels and is alternately flooded by marine water and exposed (Tucker et al, 1990) and is hospitable to calcareous algal mats. Deposits are laterally persistent, evenly bedded limestone and dolomite that often preserves flat laminations and shallowing upward cycles that are often repeated to great thickness.

Because many carbonate allochems behave hydrodynamically like sand, most of the sedimentary structures associated with clastic shorelines are also found in intertidal carbonate environments. Due to the daily alternation of the tides intertidal environments often contain carbonate (dolomite) mudflats, evaporites, herringbone cross-stratification, shell debris, rip-up clasts, mud cracks and algal mats. Fenestral (sheet like) porosity or birds-eye structures are caused by the dissolution of evaporites or from voids originally filled with gas.
2.4.3 **Subtidal zone:** This is the permanently submerged area seaward of the tidal flats (Tucker et al, 1990). Subtidal environments have normal marine waters with a narrow range of salinity and are well oxygenated.

Subtidal environments can have a wide distribution of facies associated with both water depth and wave energy. Repetitive changes in sea level cause cyclic deposition on carbonate platforms, which can be readily identified in the field. For subtidal facies, relative water depth may be inferred by the relative abundance of shaley interbeds and the thickness of carbonate layers.

Facies of the Vempalle Formation are comparatively simple, with shoaling-upward trends. The Upper Vempalle Formation is rich in stromatolitic dolostone and cherty dolostone, with shale intercalations. It displays greater facies variability, with an outer shelf marked by a stromatolite-rich peritidal carbonate complex that may have served as a barrier (Sami and James, 1994).
Table 2: Description and interpreted depositional environments of facies and facies association of Vempalle Formation.

<table>
<thead>
<tr>
<th>Lithofacies</th>
<th>Constituents</th>
<th>Bedding and structures</th>
<th>Interpretation</th>
<th>Facies associations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale</td>
<td>Purple shale and rare siltstone</td>
<td>Laterally continous, thin bedded, parallel laminations.</td>
<td>Deep subtidal occasionally shallowing to wave base.</td>
<td>Deep subtidal</td>
</tr>
<tr>
<td>Cherty dolostone-shale.</td>
<td>Uniformly chertified, thin dolostone layers interbedded with shale and siltstone</td>
<td>Laterally continous, wave ripples, fenestrae, dissolution cavities, dessication cracks and brecciation; small to large columnar and domal Stromatolites.</td>
<td>Intertidal to supratidal</td>
<td>Peritidal siliciclastic carbonate</td>
</tr>
<tr>
<td>Phosphatic dolostone.</td>
<td>Dark, relatively organic rich laminae &amp; light coloured laminae, low relief domal Stromatolites, 15% terrigenous sand grains.</td>
<td>Irregular laminae, fenestrae, dessication cracks, brecciation, wave ripples/small scale cross bedding.</td>
<td>Intertidal to supratidal</td>
<td></td>
</tr>
<tr>
<td>Massive dolostone.</td>
<td>Massive, light coloured, coarse sparry dolomite, centimetre sized domal Stromatolites and thin microbial laminae, upto 10% well sorted quartz, silt and sand grains.</td>
<td>Massive units, fenestrae, vugs, breccias, dessication cracks.</td>
<td>Intertidal to supratidal</td>
<td></td>
</tr>
</tbody>
</table>
Stromatolites in this complex vary in shape and size. Stromatolites are indicative of shallow water conditions. The morphometry of the stromatolites is an important indicator of the energy condition during its growth in depositional set up (cf. Krylov, 1976; Walther in Reading, 1996). Large colonies of stromatolites could only grow in quiet and low-energy conditions. Owing to a possible presence of a paleotopographic high towards north, the wave action might have increased promoting growth of highly elongated stromatolitic forms parallel to the current directions. Chert deposition in upper part of Vempalle Formation indicates non supply of detritus and tectonically inactive source area. The brecciated nature of the chert reflects contemporaneous fluctuations during deposition of chert. The forces which were responsible for bringing lava up may have caused brecciation of chert in the earlier stages (Nagaraja Rao et al., 1987).

`Dolomite of “primary” origin develop in the carbonate sequence on very low gradient tidal flats and coastal sabkhas which might be either marginal to shallow-marine or a lagoonal set up under extreme arid conditions dominated by circulation of hot supersaline brine (Reading, 1996). Transportation, breaking down and deposition of intraclasts signify wave action. Wave ripples, fenestrae, dissolution cavities, dessication cracks, brecciation, columnar and domal stromatolites, muddrapes and herringbone cross bedding (Fig. 2.22c), in the phosphatic dolostones indicate that the deposition may have occurred in an intertidal environment influenced by a complex interaction between fair weather waves and tidal currents (e.g. Reineck and Singh, 1980; Wright and Short, 1984).

The peritidal carbonate complex displays an overall shoaling-upward trend, expressed by an upward increase of shallow-water features such as small-scale wave ripples, microbial laminae, fenestrae, vugs, tepees, desiccation cracks and exposure-related brecciation (Jiang,
et.al, 2002). These features are prevalent in massive dolostones of the studied area indicating their deposition in peritidal carbonate complex. Evidences of repeated exposure are present in the lithounits of Vempalle Formation in the form of dessication cracks in different levels (Fig. 2.22d & e).

The phosphatic dolostone facies is, however, gradational to the upper calcareous shaly facies, which deposited under deep subtidal environment. Occasional increase of terrigenous clastics is observed in the lithounits (Fig. 2.22f), which is a response to the redistribution of topographic highs in the source area. Siliclastic sedimentation within the region of shallow carbonate production is most dictated by the character of the onshore sediments. Along with relative or absolute changes in sea level, storm deposits and fluvial activity widely control the magnitude, extent, and character of allochthonous siliclastic transport and deposition.
Fig. 2.22c: Field photograph showing Herringbone cross bedding in phosphatic dolostone near Kanampalle.

Fig. 2.22d: Field photograph showing dessication cracks in different levels in phosphatic dolostone near Motuntalapalle.
Fig. 2.22e: Field photograph showing dessication cracks in different levels in massive dolostone near Kanampalle.

Fig. 2.22f: Field photograph showing Increase of terrigenous siliciclastics in Cherty dolostone-shale intercalation near Motuntalapalle.
The following list outlines considerations for siliclastic influence on shallow water carbonates:

1. The energy of the environment characterizes sediment grain size. Typically coarser sediments are found where hydraulic regimes are intense and finer sediments are allowed to settle out of suspension in quieter waters. Storm deposits and regions where wave energy is high exemplify the former, while lagoons and tidal flats may have the latter as in the case of Vempalle Formation.

2. A drop in sea level or regional tectonic uplift may result in a progradation of terrigenous sediment seaward. This newly introduced sediment may blanket exposed carbonates and influence topography by controlling local weathering.

Based on the above observation it could be concluded that Gulcheru Quartzite was deposited in shallow marine tidal flat environment and Vempalle Formation in carbonate tidal flat environment consisting Peritidal siliciclastic carbonate and deep subtidal environment. It displays an overall shoaling-upward trend, expressed by an upward increase of shallow-water features with siliciclastic influx due to sea level changes.