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# DEFORMATIONAL CONTROLS IN AND LITHOSTRATIGRAPHY OF CHERLA FORMATION, ALBAKA BELT, SOUTH INDIA

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## ABSTRACT

Fault bounded outcrop of Cherla Formation, Albaka belt, South India represents the southeastern termination of the eastern belt of Proterozoic (Purana) in Pranhita-Godavari Valley. A facies association of limestone, conglomerate, arkosic grit, arkose, shale, feldspathic quartzite and quartzite constitutes Cherla Formation with quartzites forming the bulk. Sedimentary structures include cross-bedding, ripples and filled dessication cracks in psammites and algal lamination in limestone. The lithofacies association in Cherla Formation has comparables as much in Mallampalli Subgroup of Pakhal Group as in Mulug Subgroup (c.f. Srinivasa Rao *et al.*, 1979). Comparable lithofacies also occur in Somanpalli-Kopela-Patagudam area which is in northwest strike continuity of Albaka belt. These correlations are highly tentative in view of an asymmetry in development of Proterozoic rocks on two sides of the Gondwana outcrop forming the axial part of Pranhita-Godavari Valley.

Two major N-S and NW-SE trending faults separate the Cherla Formation from basement gneisses in the east and Gondwana rocks on the west; an E-W fault marks the northern boundary with the basement gneisses. Brecciation is common in fault zones and more marked where the major faults converge. Heterogeneous internal deformation is recorded in bedding parallel thrusts, thrust related folds, anastomosing shear zone cleavage at low angles to bedding lamination and brittle fractures. Consistent fold vergence and slickenside orientation indicate a south directed thrust movement internally within the formation. The structures are related to post depositional deformation of a basin margin in contractional regime influenced by fault block geometry.

## INTRODUCTION

The major Proterozoic lithostratigraphic units of Pranhita-Godavari Valley occur in two NW-SE trending belts flanking the central outcrop of Gondwana rocks (Fig. 1a). Originally named by Srinivasa Rao *et al.* (1979) the Cherla Formation crops out as small isolated pockets towards the south-eastern end of the "Upper Precambrian" Albaka belt bordering the Godavari River in Khammam district, Andhra Pradesh (A.P.). Although the work cited above gives a first report of the formation, the lithostratigraphic description is sketchy. Findings of a recent geological mapping around villages Rayusupeta, Dosinapalle, Mallaram, Gannavaram, Regunta, Tegada belonging to the Cherla Mandal, Khammam district are presented here. Details of the lithostratigraphic character of the Cherla Formation are given first. The mesoscale structures reflecting the internal deformation of the rocks of the formation are described next; on the basis of these and other geological reasoning some suggestions about the broader structural set up are presented. By referring to Proterozoic strata further afield in the Pranhita-Godavari Valley, particularly the Pakhal Group of Mulug-Pakhal and Ramgundam area (Basumallick, 1967; Chaudhuri, 1985), and deformed rocks of Somanpalli-Kopela-Patagudem area (Ghosh, 1986; Saha & Ghosh, 1986) which forms the northwestern strike extension of the Albaka belt, the stratigraphic status of the Cherla Formation is discussed in the concluding part.

## GEOLOGICAL SETTING

Rocks of the Cherla Formation occur as isolated pockets within a triangular area bounded by the hill ranges of Somandevra Quartzite Formation on the north, Talperu River in the east and part of the Bhadrachalam-Venkatpur road on the west (Fig. 1b). Faults running parallel to the three boundaries control the overall disposition of the strata. Archean Basement gneisses occur beyond the eastern boundary of the formation ; Gondwana rocks are in fault contact on the western side. The main outcrop forms the hillock (peak 190 m) north of Rayusupeta (lat. 18°4′ : long. 80°5″) off Cherla (lat. 18°04′30″ : long. 80°49′30″). Note that village Cherla proper is situated within the Gondwana outcrop. Occurring between the major faults which converge towards south, the Cherla Formation is transected by many smaller faults (Fig. 2). The general disposition of the basement gneisses, Cherla Formation and the Gondwana rocks in the area can be explained by assuming overall westerly downthrow on the major faults. The smaller faults are only at a small angle with the major ones but some transverse faults, e.g., one along the northern boundary of the main outcrop, are also recorded. Present disposition of outcrops is in part controlled by such fault blocks.

## LITHOSTRATIGRAPHY

The best part of the preserved sequence is exposed in the main outcrop north of Rayusupeta. The sequence can be best studied in a traverse along latitude 18°04′30″ N between longitudes 80°50′50″ E and 80°50′05″ E. At the eastern extremity of this traverse the brecciated gneisses on Talperu river bed are followed by a limestone. This is followed by a conglomerate band on the western bank of Talperu River. The limestone-conglomerate boundary is fault controlled. West of this fault, conglomerate-grit-arkose-quartzite form a conformable sequence (Table 1). Contacts between different units in this sequence are gradational. Both the grit and arkose are cross-bedded. Individual sets are planar tabular, lenticular to wedge shaped, apparently with highly variable foreset azimuth locally resembling a herring-bone pattern (Pl. 1a). Between the western bank of Talperu river and the summit of the hill north of Rayusupeta bedding is steep (50°—90° dip) and the stratigraphic facing

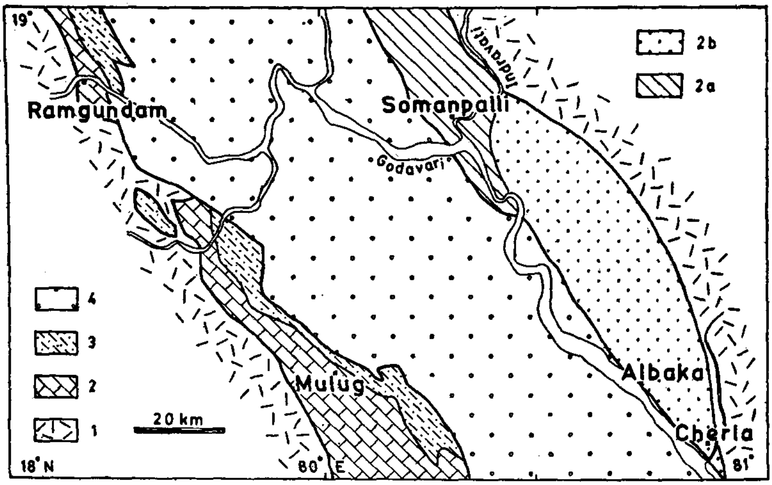


Fig. 1a. Geological map showing distribution of rock groups of Pranhita-Godavari Valley ( modified after King, 1881 ). Differentiation within the eastern Proterozoic belt is on the basis of Saha & Ghosh ( 1986 ) and some previously unpublished works of Geological Studies Unit, I.S.I. 1 = basement gneiss ; 2=Pakhal Group ; 3 = Sullavai Group ; 2a=deformed Proterozoic sequence of Somanpalli area ; 2b = Albaka sequence ; 4 = Gondwana rocks ; 2, 3, 2a, 2b are Proterozoic.

is towards west; strata are right way up. Such local steepness is related to faults. On the western slopes of the hill quartzite beds are gently dipping (<20°) with dip direction between NNW and NE. These gently dipping quartzites are thin bedded with ripple marks and traces of filled dessication cracks on rippled bedding surface (Pl. 1b). While conglomerate and grit develop locally, arkose and quartzite are more persistent in the mapped area.

Brecciated quartzites constitute the exposures along the low lying ridge east of Tegada (lat. 18°2′15″ N : long. 80°50′30″E), between villages Kaliveru and Anjanapuram (Fig. 1b). Small hills north-northwest of Dosinapalle (lat. 18°5′10″ N : long. 80°51′30″ E) are also of brecciated quartzite with local gritty patches. Sandstone intercalated with thin shale partings occur in fault contact with brecciated gneiss east of Gannavaram (lat. 18°5′35″ N: long. 80°48′50″ E). Patches of brecciated limestone (algal laminites) also occur northwest of Gannavaram colony (lat. 18°6′30″ N : Long. 80°48′30″ E) and in a small quarry ( lat. 18°4′20″ N : long. 80°50′10″ E ) north of Rayusupeta. At the latter place lower Gondwana boulder beds are in direct contact with Cherla Formation rocks.

A strip of basement gneiss generally intervenes between the Cherla Formation rocks and the Somandevra Quartzite of Somandevra Gutta (Fig. 1b). However, a small lenticular patch of limestone associated with arkosic grit is exposed along the

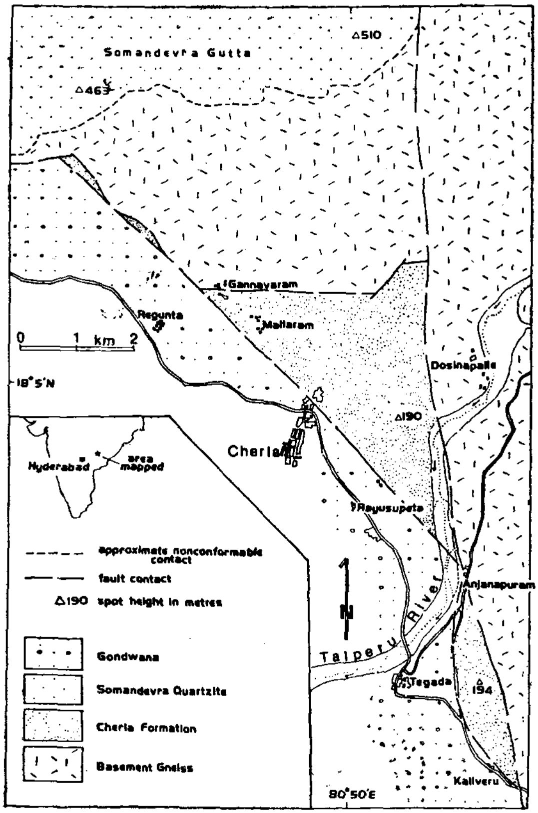


Fig. 1b. Geologic setting of Cherla Formation and location map of Cherla area.

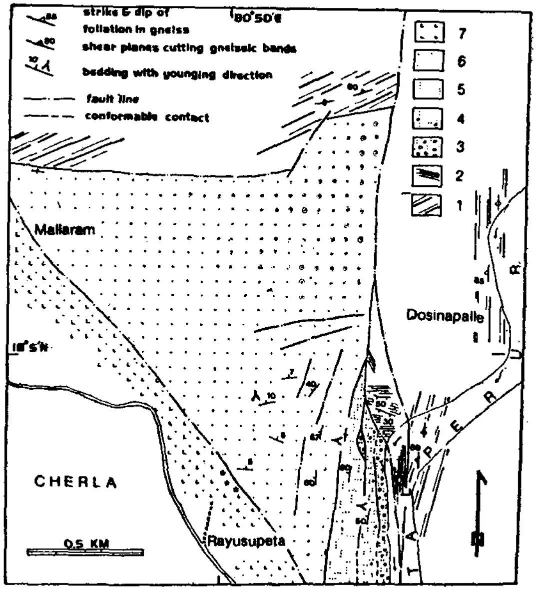


Fig. 2. Geological map showing constituent units of Cherla Formation in the main outcrop north and east of Rayusupeta. 1 = basement gneiss, 2 = limestone, 3 = conglomerate, 4 = arkosic grit, 5 = arkose, 6 = quartzite, 7 = Gondwana rocks; astericks for boulder bed (Talchir) occurrence.

western boundary fault northwest of Gannavaram colony. This exposure of supposedly Cherla Formation is in closest proximity of the southern boundary of Somandevra Quartzite.

## MESOSCALE STRUCTURE

Brecciation is a common feature in rocks of the formation. In bedded quartzites bedding planes or fractures subparallel to bedding are marked by slickenside striation and accretionary quartz crystal fibre growth (slickencryst of Hancock, 1985). These are very common in the main outcrop north of Rayusupeta where overall bedding dips gently (5°—15°) towards north or north-east. Here, the slickenside azimuth is N-S. Asymmetric folds on subhorizontal E-W axis with a short steep southerly limb are common ; subhorizontal shear planes at small angles to overall bedding orientation locally truncate the steeper limb of these folds (Fig. 3). Hinges of such folds become less conspicuous and curve as the amplitude diminishes along a hinge. Consistent sense

## Table 1

**Lithostratigraphy of Cherla Formation**

| Sequence | Lithounits | Maximum Thickness (metres) | Character |
|---|---|---|---|
| Somandevra Quartzite | | | |
| ——fault—— | | | |
| Cherla Formation | quartzite | 70 m | mainly well sorted quartz arenite; grades to feldspathic quartzite especially with coarser interbeds; thin pebbly and gritty horizon as well as shaly partings common; ripples, filled dessication cracks, parallel lamination as sedimentary structures. |
| | arkose | 50 m | well sorted, coarse to medium grained; lenticular to planar tabular crossbedding with highly variable foreset azimuth. |
| | grit | 15 m | arkosic; grades to a lithic arenite with fragments of acid gneiss, hornblende-gneiss, vein quartz, feldspar; cross-bedded. |
| | conglomerate | 10 m | quartz pebble conglomerate; pebbles angular to subrounded; gritty arkosic matrix, massive to thick bedded. |
| | ——fault—— | | |
| | limestone | | algal laminite; occasional ripple |
| ——fault—— | | | |
| Basement gneiss (Archean) | | | quartz-feldspar gneiss, pegmatite-gneiss, hornblende-gneiss; highly brecciated. |

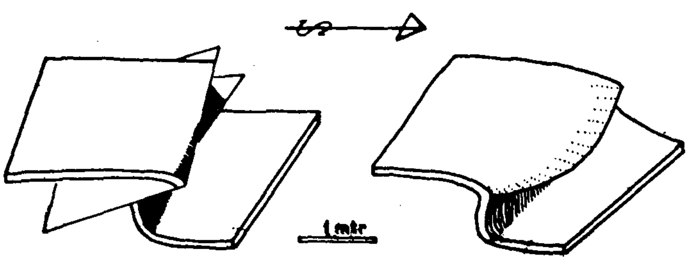


Fig. 3. Field sketch of mesoscopic folds in quartzites of Cherla Formation, perspective drawing.

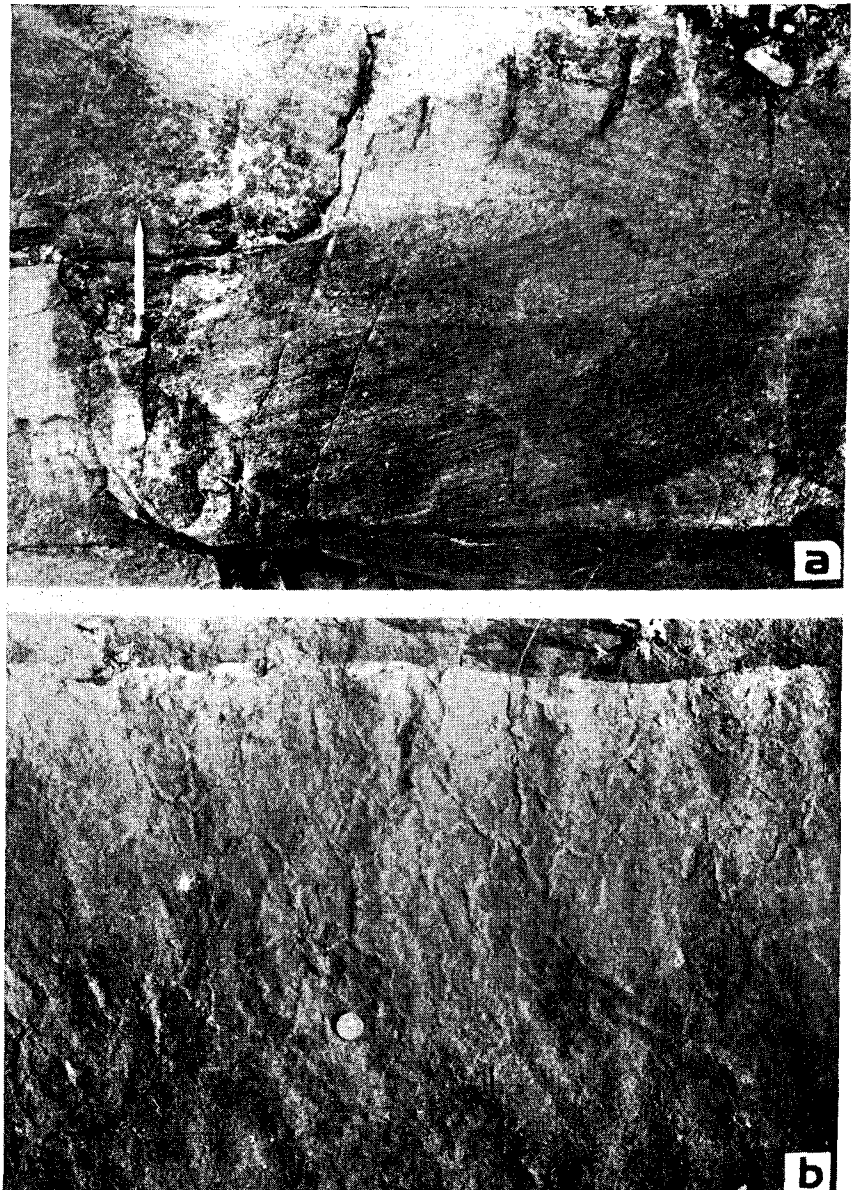


Plate 1. Sedimentary structures in Cherla Formation ; (a) cross-bedding in arkose, horizontal section exposing sub-vertical beds, set boundaries run N-S ; (b) filled dessication cracks in rippled quartzite, plan view, subhorizontal bedding surface with ripple axis trending N-S.

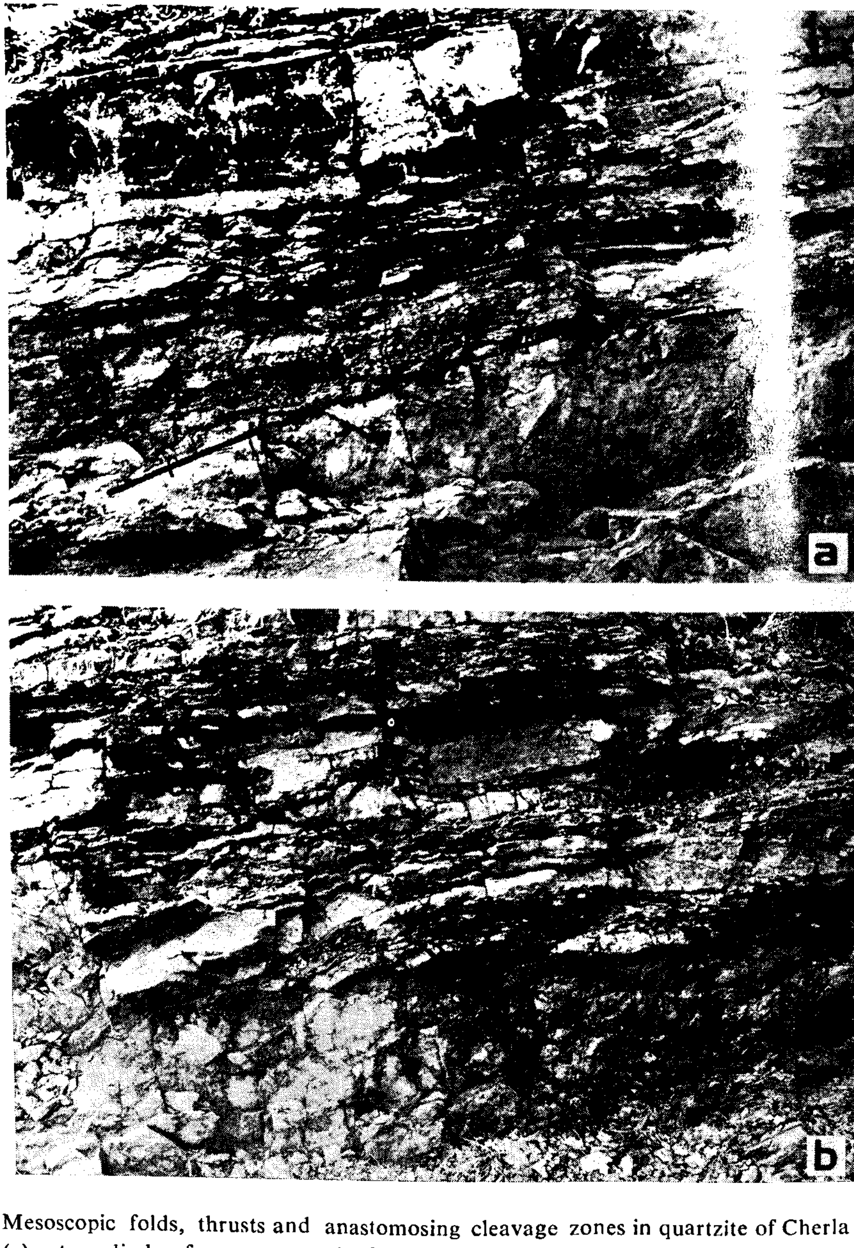


Plate 2. Mesoscopic folds, thrusts and anastomosing cleavage zones in quartzite of Cherla Formation ; (a) steep limb of an asymmetric fold cut by a thrust, the sole of which is indicated by a thick broken line running from bottom left to middle right of the photograph ; E-W section looking north. This small thrust is associated with a zone of anastomosing cleavage ; two other similar dislocation zones above are also marked by thick broken lines ; middle and top of the photograph ; (b) lenticles or relatively less deformed quartzite interspersed with zones of anastomosing cleavage, E-W section ( parallel to fold axis ) looking north ; note fractures at acute angles disrupting steep limb of an asymmetric fold into rhombic blocks ( bottom right ) ; lense cap is 5 cm across in both (a) and (b).

of fold asymmetry and slickenside steps indicate thrust movement towards south (cf. Gay, 1970 ; Lundberg & Moore, quoted in Hancock, 1985). Spaced fractures at an acute angle to bedding, and smeared with cataclastic products define an anastomosing cleavage ; fractures ( joints ) of vertical to subvertical orientation transect this cleavage. These steep fractures are commonly at a high angle with the fold hinges. Lenses of quartzite with sedimentary fabric are interleaved with such zones of anastomosing cleavage (Pl. 2a, b).

Small scale disharmonic folds in limestone and conglomerate bands are indicated by bedding attitude variation. Short breccia bands locally offset such fold limbs in limestone. These structures are localised in the vicinity of the major fault separating the limestone and conglomerate lithounits.

## DISCUSSION ON CONTROLS OF DEFORMATION

The outcrop of the Cherla Formation is fault bounded. Boundaries with basement gneisses in the east and Gondwana rocks on the west follow two major (N-S and NW-SE trending) steep faults converging towards south. The outcrop convergence also marks the termination of the preserved Albaka belt Proterozoic.

The internal deformation of the Cherla Formation as detailed above is in the form of bedding parallel thrusts, anastomosing shear zone foliation and folds with consistent vergence. One may be tempted to interpret these as distributed deformation within a block bounded by two major faults. However, this view presupposes contemporaneity of the faults. Geologic relations favour both Gondwana and Proterozoic blocks as down faulted with respect to the basement gneiss. It is postulated that these faults are linked with basin margin faults which controlled the opening up of the Proterozoic basin, and later the extent of Gondwana basin. Apart from a gentle tilt in bedding orientation, any distributed deformation is altogether absent from Gondwana rocks even within a few tens of metres of the western boundary fault. Moreover, Gondwana strata elsewhere in Godavari Valley are associated with a series of strike faults and oblique faults on which normal movement is the rule (Geologists of Singareni Collieries Co., personal communication). This corresponds to a syn- to post-Gondwana extensional regime in the Godavari Valley. On the other hand, the eastern boundary fault demarcating the Proterozoic basin margin is associated with general steepening of beds of Cherla Formation and disharmonic folds in limestone on Talperu River bank. Pre-Gondwana (possibly late Proterozoic) contractional regime is recorded in the Albaka belt folds (Srinivasa Rao *et al.*, 1979) and cleavages of fold thrust belt particularly in the Tippapuram Shale Formation occurring north and northeast of Cherla (but outside the area shown in Fig. 1b ; for stratigraphic position of Tippapuram Shale Formation see Table 2). Cleavage in this belt has a consistent westerly dip, and slickensides with accretionary quartz crystal growth fibres mark low angle thrust surfaces (west dipping). The crystal growth fibre lineation indicate thrust movement towards east (north-east) in Somandevra Quartzite Tippapuram Shale sequence.

Bedding in sedimentary rocks represent an anisotropy which controls deformation in shallow crustal levels especially in the brittle regime ( Donath, 1961 ; Anderson, 1964). The low angle thrusts subparallel to bedding, anastomosing shear zones, etc. in Cherla Formation reflect the above control. The fold vergence and slickenside orientation indicate a dominant south directed thrust movement so far as internal deformation of the Cherla Formation is concerned. The mesoscale structures in Cherla Formation described above can be interpreted in terms of larger bedding parallel thrusts mainly south directed with longitudinal and transverse ramps.

Except for a small limestone-arkose patch along the western boundary fault northwest of Gannavaram Colony, Somandevra Quartzite is separated from Cherla Formation by a strip of basement gneiss ; an E-W fault demarcates the northern boundary of the main outcrop of Cherla formation. South directed thrust movement internal to Cherla formation is in contrast with the dominant northeast directed thrust movement recorded in Somandevra Quartzite —Tippapuram Shale rocks. In contiguous areas of the Albaka belt (including Rayusupeta area forming the main outcrop of Cherla Formation), the internal deformation in Proterozoic rocks are likely indicators of broadly contemporaneous contractional regime that moulded the northeastern Proterozoic basin margin.

## STRATIGRAPHIC STATUS

The Pakhal Group of Mulug-Pakhal area, Warangal district and correlatable units of Ramgundam area are part of a continuous belt of Middle to Upper Proterozic sediments on the southwestern side of the Pranhita-Godavari Valley (P. G. Valley) ( Basumallick, 1967 ; Chaudhuri, 1985 ) ; this southwestern Pakhal belt is separated from the "Upper Precambrian" Albaka belt in the northeast by a 50 kms wide stretch of Gondwana rocks along the axis of P. G. Valley (King, 1881). More recently some observations on the geology of the Timmed-Somanpalli-Chandur-Tarlagudem area (Gadchiroli district in Maharashtra and Bastar district in Madhya Pradesh ) have been made ( Ghosh, 1986 ; Saha and Ghosh, 1986 ; Table 2 ). The last mentioned area falls on the same northeastern belt of Proterozoic as Albaka rocks and is about 100 kms from Albaka ; it is only natural to seek comparable lithostratigraphic horizons in geographically contiguous areas which intuitively appear to be integral parts of a broadly contemporaneous belt of sedimentary rocks ; on the other hand, across strike correlations at the formation level without sufficient geochronological control, and where outcrops are separated by much younger sediments (in the present case Gondwana rocks), are fraught with difficulties as exemplified by the case of the Cherla Formation.

Srinivasa Rao *et al.* (1979) postulated that Cherla Formation is equivalent to the Lower Pakhal Mallampalli Subgroup of Mulug-Pakhal area. The basis of such correlation was similarity in gross lithologic attributes and relative stratigraphic position. The dominant lithofacies in Cherla Formation is quartzite with features indicating

Table 2

**Subdivisions of major Proterozoic sequences in different parts of Pranhita-Godavari Valley**

| | P. G. Valley<br>King (1881) | | Pakhal-Mulug area<br>Basumallick (1967) | Venkatpur-Cherla area<br>Srinivasa Rao *et al.* (1979) | **Somanpalli-Kopela-Patagudem area<br>Ghosh (1986), Saha & Ghosh (1986)<br>West of Indravati river | East of Indravati river |
|---|---|---|---|---|---|---|
| | | | | Usur Sandstone | | |
| | Sullavai sandstones | | Sullavai Group | Doli Sandstone | | |
| | | | | Nambi Breccia | | |
| | | | | ——disconformity—— | | |
| | | | | Albaka Sandstone | | |
| | angular | | | Utlapalli Conglomerate Member | | Albaka Sandstone |
| | ——unconformity—— | | ——disconformity*—— | ——disconformity—— | | |
| | | | Mulug Subgroup | Tippapuram Shale | | |
| Pakhal Series | Albaka subdivision | Pakhal Group | | Somandevra Quartzite | | |
| | | | ——disconformity—— | ——?disconformity—— | Po Gutta Sandstone | ——fault—— |
| | | | | | ——unconformity—— | |
| | Pakhal subdivision | | Mallampalli Subgroup | Cherla Formation | Kopela Shale formation | |
| | | | | ——fault—— | | |
| | | | | | Bodela Vagu formation | Tarur Nala formation |
| | | | | | ——fault—— | |
| | | | | | Somnur formation | |
| | angular<br>——unconformity—— | | ——unconformity—— | | | |
| | Gneiss (Azoic) | | Granites, gneiss, etc. | Archean Gneissic Complex | Basement gneiss | |

*The subdivisions proposed by Chaudhuri (1985) for Proterozoic sequence of Ramgundam area is essentially the same as that of Basumallick (1967), but the relation between Pakhal Group and Sullavai Group is regarded as an angular unconformity by Chaudhuri. **Proposed rock units are only informal at this stage.

shallow water deposition. Although relatively insignificant in volume, limestone (algal laminite) and arkose are associated with quartzite in most outcrops. The main outcrop north of Rayusupeta shows 5-10 metres thick quartz-pebble conglomerate at the base. Dolomite-chert described by Srinivasa Rao *et al.* (1979), in present author's opinion, are only silicified patches locally associated with brecciated quartzites and other lithotypes. One may find comparable lithofacies association as much in the lower Pakhal Mallampalli Subgroup as in the upper Pakhal Mulug Subgroup. Also there is an internal unconformity within the Pakhal Group recorded both from Mulug-Pakhal and Ramgundam area (Basumallick, 1967 ; Chaudhuri, 1985). In these areas the carbonate facies in either subgroup develops in volumes comparable to those of the psammites. This is in contrast with the meagre volume of carbonate rocks in the Cherla Formation. Moreover, the total preserved thickness of the Mallampalli subgroup in Mulug or Ramgundam area is much higher compared to that of the Cherla Formation.

The fault bounded disposition of the Cherla Formation rocks poses some problem in ascertaining the true stratigraphic relationship between this formation and the Somandevra Quartzite (cf. Srinivasa Rao *et al.*, 1979). The only hint that Somandevra Quartzite has a higher stratigraphic position comes from the fact that the overall 'Younging' direction in the Albaka belt is towards north and Cherla Formation crops out south of Somandevra Quartzite. However, Cherla Formation, Somandevra Quartzite, Tippapuram Shale and possibly also Albaka Sandstone may represent adjoining lithofacies strips in a broader near shore shallow marine environment. Hence, any correlation of these rocks across the strike and beyond the intervening outcrop of Gondwana rocks should be viewed with appropriate caution.

The Somandevra Quartzite-Tippapuram Shale are grouped together as equivalent of the Mulug Orthoquartzite-Mulug Shale pair of Mulug area (Srinivasa Rao *et al.*, 1979). There is no doubt about the similarity in lithologic attributes of the units in two areas. Neither, their general position as middle to upper Proterozoic is in question. The thick Albaka Sandstone occurring exclusively in the eastern belt, a prolific mid-Proterozoic limestone development recorded mainly in the western belt, as well as the existence of highly deformed sedimentaries in areas north-north-west of Albaka (Saha & Ghosh, 1986) point only to the inherent asymmetry in the development of Godavari basin during the Proterozoic.

The Albaka Sandstone of the Albaka area continues in a north-north-west direction in the Bastar district of Madhya Pradesh and adjoining Gadchiroli district of Maharashtra. However, here a highly deformed sequence of sedimentary rocks including greywacke and volcanogenic sediments, intervenes between the outcrops of Albaka Sandstone and the Gondwana rocks (Ghosh, 1986 ; Saha & Ghosh 1986). These highly deformed rocks are associated with less deformed and possibly younger shallow water sandstones (e.g. Po Gutta Sandstone) and shales around Somanpalli, Kopela and

Patagudem, Maharashtra. The lithofacies association of this younger mildly deformed unit has comparables in the Albaka belt of Albaka-Cherla area.

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