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STRATIGRAPHY OF THE LATE PROTEROZOIC SULLAVAI GROUP, PRANHITA-GODAVARI VALLEY, ANDHRA PRADESH

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ABSTRACT

Mapping of about 800 sq kms in the southwestern outcrop belt and study of selected sections has led to the subdivision of the Late Proterozoic Sullavai Group of the Pranhita-Godavari Valley into three formal lithostratigraphic units, each of the status of a formation : (a) Ramgiri Formation, a coarse-grained, purple to red arkosic sandstones and conglomerates, (b) Mancheral Quartzite, a red coarse-grained quartzarenite and (c) Venkatpur Sandstone, a fine-grained, salmon red quartzose to subarkosic sandstone. Venampalli Sandstone Member and Kapra Sandstone Member are defined as two formal members within Ramgiri Formation

Paleocurrent pattern indicates that the alluvial fan-braided river deposits of the Ramgiri Formation and Mancheral Quartzite were derived from the opposite flanks of the basin sampling different source terrain. Ramgiri Formation was derived from Archean (?) granite gneiss complex cropping out to the south. Chert layers of underlying Pakhal and Penganga Group, and a quartzose sedimentary rock (Pranhita Sandstone of Penganga Group ?) fed the Mancheral river system. Mancheral and Ramgiri alluvium appear to have been the major source for the aeolian Venkatpur Sandstone that shows persistent northeasterly flow direction.

In contrast to traditional "layer-cake" concept, regional lithocorrelation reveal a complex mosaic of different stratigraphic units. Consequently, it is difficult to propose a "generalised" stratigraphic succession for the Sullavai Group. Initial coarse-grained alluvial fan-braided river deposit and overlying fine-grained aeolian deposit are believed to represent a distinct phase of climatic and tectonic evolution of the basin during the Late Proterozoic time.

Key-words : Sullavai Group, Pranhita-Godavari Valley, Proterozoic, stratigraphy, sedimentation.

INTRODUCTION

In terms of their huge thickness, extensive occurrence and gross similarity, the Purana successions (Holland, 1906 ; Radhakrishna, 1987) comprise a distinctive horizon in the Indian stratigraphy. Purana rocks in the Pranhita-Godavari Valley (P. G. Valley) represent one such major succession in India (Figs. 1, 2). The Purana rocks of this basin crop out in two northwest-southeast trending belts separated by an axial belt of Permo-Jurassic Gondwana rocks. The

Purana sediment of the P. G. Valley range in age from ~1400 to ~800 Ma (Vinogradov *et al.*, 1964; Chaudhuri and Howard, 1985). This paper focusses attention on the regional stratigraphy of the Sullavai Group, the youngest unit of the Proterozoic succession (Table 1) in the south-western Proterozoic belt of the P. G. Valley (Fig 1).

King (1881) first studied the Proterozoic rocks of the P. G. Valley and subdivided them into lower 'Pakhal series' and upper 'Sullavai series'. Since King, a number of workers have studied the Proterozoic sediments of the P. G. Valley (Johnson, 1967; Basumallick, 1967a, b; Chaudhuri, 1970, 1985; Subba Raju *et al.*, 1978; Sreenivasa Rao *et al.*, 1987; Chaudhuri *et al.*, 1989). However, most of the earlier publications deal with the details of the Pakhal Group, and the stratigraphy of the Sullavai Group has been discussed only in very broad outline. Sullavai Group forms a regionally extensive sheet and is the only Proterozoic unit that crops out both in the southwestern and northeastern belts. The study of the Sullavai Group therefore has important bearing on the correlation of the Proterozoic

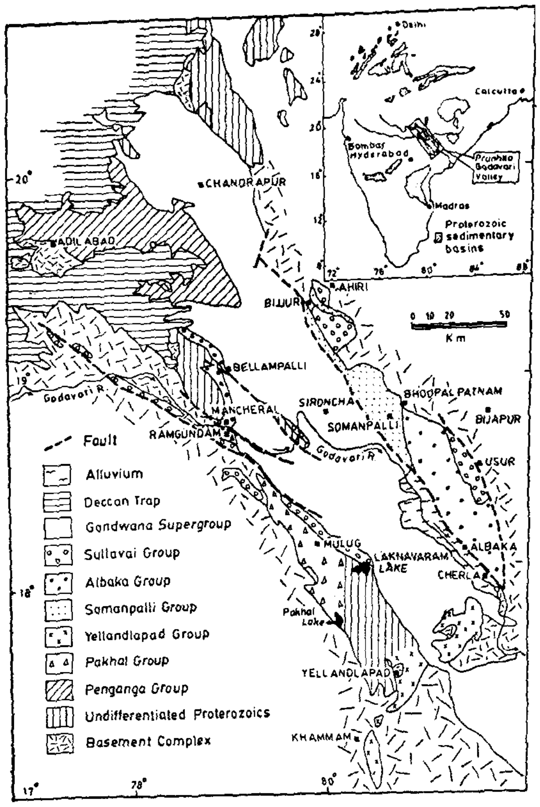

Fig. 1. Regional geological map of the Pranhita-Godavari Valley, India. Inset shows the distribution of the major Proterozoic basins of India.

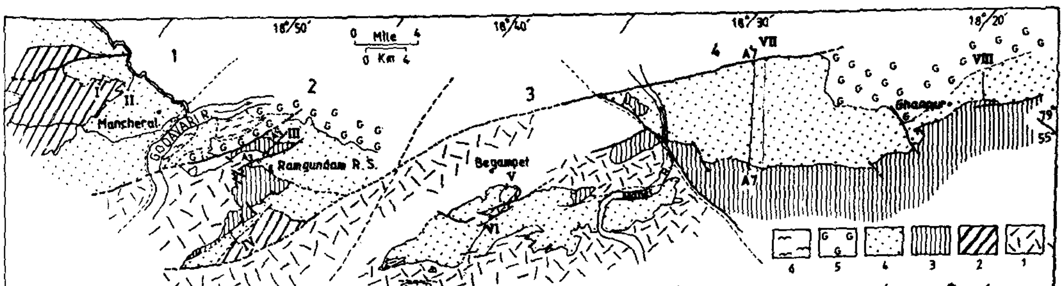

Fig. 2. Map showing the distribution of the major groups of the Proterozoic rocks in the study area; sectors defined for the convenience of the study and the positions of the measured lithologs.

Table 1

Generalised succession of Proterozoic sequences of the Ramgundam area

Stratigraphic Units					Lithology and primary structures
GONDWANA SUPERGROUP (Permian to Jurassic)					
Unconformity					
MIDDLE TO LATE PROTEROZOIC	GODAVARI SUPERGROUP	Sullavai Group		Venkatpur Sandstone	Salmon red, medium to fine, quartzose/subarkosic sandstone; well rounded grains; alternation of large planar cross beds and horizontal beds.
				Mancheral ? Quartzite ? (23m)	Mancheral Quartzite: Medium to coarse pebbly quartzose sandstone; thin lenses of conglomerate and well sorted fine sandstone; profuse planar and trough cross-beds; *channel forms*; locally abundant adhesion structures.
				Ramgiri Formation (456m) (K-Ar date 871 ± 14my)	Ramgiri Formation: Medium to coarse arkosic sandstones and conglomerates; profuse trough cross beds.
		Unconformity			
		Pakhal Group	Mulug Subgroup	Rajaram Limestone (735m)	Micritic and intraclastic limestone, calcareous shale; cross-beds and channels.
				Ramgundam Sandstone (120m)	Arkosic to subarkosic sandstone with minor shale; locally abundant glauconite; well rounded grains; well developed trough cross-beds, wave ripples, mud cracks.
				Damla Gutta Conglomerate (90m)	Pebbly arkose, chert pebble conglomerate with graded beds; trough cross-beds.
			Unconformity		
			Mallampalii Subgroup	Pandikunta Limestone (340m) (K-Ar date 1330 ± 53my)	Flat-bedded limestone and dolomite; lenses of shale and glauconitic sandstone; abundant stromatolites; silcrete horizon on top.
				Jonalarasi Bodu Formation (50m)	Interbedded limestone and quartzarenite; abundant well rounded grains; salt pseudomorphs; graded beds, trough cross-beds, mudcracks.
Unconformity					
ARCHEAN (?) BASEMENT COMPLEX					

Pranhita-Godavari Valley in the southwestern belt

	Mancheral area	
	Stratigraphic Units	Lithology and primary structures
	GONDWANA SUPERGROUP	
---------- Unconformity ----------		
Sullavai Group	Venkatpur Sandstone	
	Mancheral Quartzite (76m)	
	Ramgiri Formation (250 m+)	
---------- Unconformity ----------		
Penganga Group	Sat Nala Shale	Reddish brown shale with very presistent thin lamination.
	Chanda Limestone	Limestone with minor shale ; thin, presistent bedding ; matrix supported limeclast conglomerates.
	Pranhita Sandstone	Medium grained subarkosic sandstone ; locally glauconitic ; profuse trough eross-beds.
---------- Unconformity ----------		
	ARCHEAN (?) BASEMENT COMPLEX	

successions of the two belts and also on the general question of the origin of cratonic sandstone sheets (cf. Dott and Byer, 1981 ; Dott *et al*, 1986 ; Fedo and Cooper, 1990). Classification, characterisation and correlation of different lithounits of the Sullavai Group, as presented here, is based on mapping of an area of 800 sq kms in 1 : 31,680 scale and detailed logging in 11 sections spread between Mancheral (18°52′N, 79°28′E) and Ramappa (18°15′N, 79°56′E) (Fig. 2). Measurement of actual thickness is difficult due to presence of large number of intraformational faults. The thicknesses were measured in blocks not affected by such faults and the measurements, therefore, represent a minimum estimate and may be less than the actual preserved thickness of any particular unit. The area under consideration has been divided into four sectors for convenience of study and the description has been organised accordingly. These sectors, from northwest to southeast, are the Mancheral sector, Ramgundam sector, Begampet sector and the Ghanpur sector (Fig. 2). Longitude and latitude of the place names and other geographic features are given at the end (Appendix I).

PROBLEM OF NOMENCLATURE OF THE PURANA ROCKS OF THE P. G. VALLEY

A survey of the literature indicates that the Purana stratigraphy of the P. G. Valley is plagued by the use of names with varying stratigraphic connotations. King (1881) designated the sequence as the "transition series". Basumallick (1963, 1967a) described them as "Purana formations"; whereas others designated the sequence as "Purana Supergroup" (Johnson, 1967 ; Chaudhuri, 1970, 1985). 'Purana formations' is an informal term, whereas the usage of a formal term 'Purana Supergroup' contradicts its original sense. The term "Puranas" as used by Holland (1906) refers to the sedimentary successions intervening between the Archean and the Gondwana rocks in different basins that are widely apart, and evidently does not carry any lithostratigraphic connotation. By implication, Purana may qualify for the status of a diachronic unit (cf. NACSN, 1983, article 91). Subba Raju *et al.* (1978) and Sreenivasa Rao (1987) raised the status of the well established Pakhal Group (Basumallick, 1967 ; Johnson, 1967 ; Chaudhuri, 1985 ; CSNI, 1977, article no. 11.04) to the higher stratigraphic rank of "Supergroup" without any overriding consideration. Further, designation of a part of the Purana sequence of the Valley as "Supergroup", as has been done by Sreenivasa Rao (1987), violates the sense of formal stratigraphic ranking (CSNI, 1977; article 10.05) and such usage also contradicts the original connotation of King (1881) who clearly accorded similar stratigraphic status to his carbonate dominant "Pakhal series" and the siliciclastic-dominant "Sullavai series".

Chaudhuri and Chanda (1990) have redefined the sequence as the "Godavari Supergroup" after the name of the river Godavari which drains the basin. The Godavari Supergroup is a lithostratigraphic unit defined in conformity with the codes of stratigraphic nomenclature (CSNI, 1977 ; NACSN, 1983), and brings the stratigraphic status of the Purana rocks of the P.G. Valley at par with the well established Purana sequences of several other basins, namely, Vindhyan Supergroup, Cuddapah Supergroup or Delhi Supergroup. In the present work the term "Godavari Supergroup" has been used.

LITHOSTRATIGRAPHY OF THE SULLAVAI GROUP

Classification and Nomenclature

The Proterozoic succession overlying the Pakhal Group (sensu Chaudhuri, 1985) and unconformably overlain by the Talchir boulder beds of the Gondwana Supergroup in the southwestern belt is generally referred to as "Sullavais". It consists essentially of red or reddish purple sandstones and conglomerates with minor amount of shale. Detailed mapping of the sequence reveals that it can be grouped into three units mappable on 1 : 31,680 scale on the basis of lithology and texture :

(a) a conglomerate and coarse-grained sandstone of arkosic or subarkosic composition,

(b) a pebbly to coarse-grained quartzarenite with minor conglomerate, and

(c) a typically salmon red, well sorted, medium to fine grained quartzarenite/subarkosic sandstone.

King (1881) subdivided his 'Sullavai series' into the 'Encharani quartzite', the 'Venkatpur sandstone' and the 'Kapra sandstone'. King (1881) described Encharani quartzite from Ench ani Gutta as well as from the Timapuram Gutta near Mancheral. Johnson (1965) described the quartzites of Timapuram Gutta as the Ridge Sandstone. Chaudhuri (1985), on the other hand, described a quartzose sandstone from Ramagundam as Encharani quartzite and defined afresh a pebbly to conglomeratic arkosic sandstone as Ramgiri Formation of the Sullavai Group from the Ramgiri hill section.

Mapping on a regional scale and examination of the Timapuram Gutta section, the Ramagundam section, the Ramgiri hill section and the Encharani hill section indicates that the 'Encharani quartzite' of King (1881) may be classified into two lithostratigraphic units of formation status, as has been attempted by Chaudhuri (1985).

Since the term Encharani quartzite has been used with different connotations by different workers, use of this term should be discontinued. A new term "Mancheral Quartzite" is being formally introduced here for the quartzose unit, whereas the term Ramgiri Formation of Chaudhuri (1985) is retained for the arkosic unit. The definition of "Ridge Sandstone" (Johnson, 1965) is not based on specific type locality and as such is inappropriate for formal usage (CSNI, 1977 ; NACSN, 1983). Further, both the arkosic sandstone and the quartzose sandstone form similar high ridges, and designating one of them as "Ridge Sandstone" may be misleading.

The term "Mancheral Quartzite" has been coined after Mancheral, the type area ; several excellent sections of the quartzite are exposed in the hills north-west of Mancheral.

The fine-grained salmon red sandstones had been designated as Venkatpur Sandstone by King (1881) and Chaudhuri (1985), and as Kistampet Sandstone by Johnson (1967). The term Venkatpur Sandstone has been retained here in preference to Kistampet Sandstone on the ground of priority. Critical examination reveals that "Kapra Sandstone" of King (1881) is a part of the Ramgiri Formation and has been formally designated here as Kapra Sandstone Member. Another unit of the Ramgiri Formation in the Begampet sector has been accorded the status of a formal member and has been designated as Venampalli Sandstone Member.

CHARACTERIZATION OF THE FORMATIONS

Ramgiri Formation

The Ramgiri Formation comprises pebbly to pebble-free arkosic sandstone, conglomerate and minor mudstone. This is the thickest and most extensive unit of the Sullavai Group and is characterised by purple to red colour with white blotches, arkosic composition, coarse grain size and ubiquitous trough cross-beds. The typical red colour with white blotches is absent over a considerable stretch in the Begampet sector, where the sandstone and conglomerate are dirty white or white. However, the facies and the paleocurrent pattern remain the same irrespective of their colour. Chaudhuri (1985) defined the Ramgiri hill section in the Begampet sector as the type section for this formation. Nalla Gutta section south of Aklaspur in the Ramgundam sector is an additional reference section, where all the major sandstone and conglomerate facies are well exposed. Thickest occurrence of the Ramgiri Formation has been noted around Ramgundam (more than 445 m) and it thins out both to the northwest and southeast where the unit is about 200 m thick.

Kapra Sandstone Member and Venampalli Sandstone Member are two mappable but areally restricted units occupying specific stratigraphic positions within the Ramgiri Formation. The rest of the formation, a complex of highly variable facies and facies assemblages has not been assigned to any formal member (cf. NACSN, 1983, article 25).

Trough cross-beds of varying scale are the most abundantly developed primary structures in the sandstones of the formation. Cosets of troughs generally forms sheet-like units bounded by extensive planar as well as concave up erosional surfaces. Large planar

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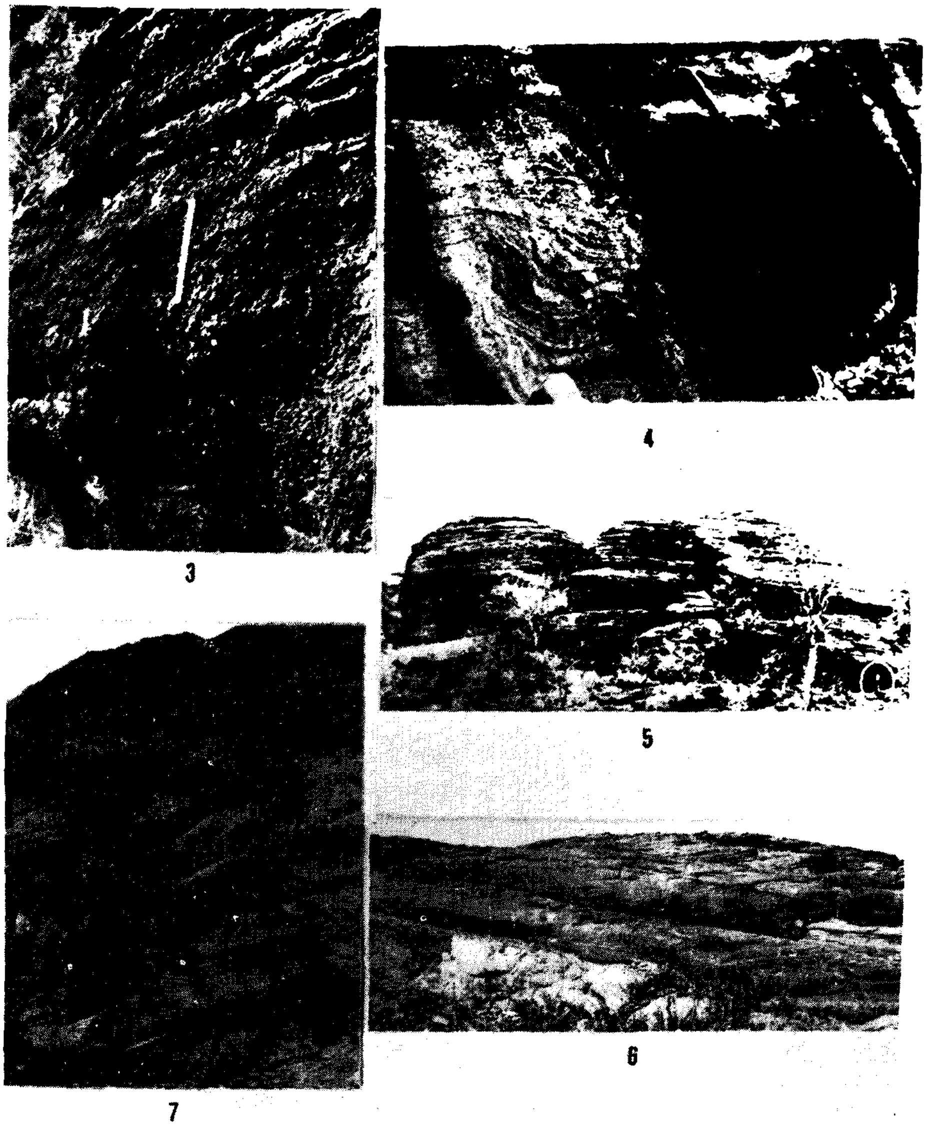
Fig. 3. Conglomerate of the Ramgiri Formation. Note low-angle and horizontal stratification, small scours (below the scale), sharp base of the beds and interbedded sandstones. Nalla Gutta section. Scale = 30 cm.

Fig. 4. Intense penecontemporaneous deformation in pebbly, coarse-grained sandstone of the Ramgiri Formation ; Ramgiri Hill section, Begampet sector.

Fig. 5. Spectacular flat-topped, vertical-sided ridges of Kapra Sandstone Member ; Nasaram Gutta, Ghanpur sector. Human figure for scale.

Fig. 6. Coset of planar cross-beds in the Mancheral Quartzite, Ramgundam Gutta.

Fig. 7. Typical sequence of Venkatpur Sandstone showing alternating large planar cross-beds and flat-beds ; stone quarry west of Bellampalli Railway Station.



Figs. 3-7

cross-beds, 0.30 to 1.72 m thick, are locally abundant.

The conglomerates of the Ramgiri Formation are mostly clast-supported with sandstone matrix (Fig. 3) ; pebbles range in size from 20 to 100 mm. Clasts are dominantly of vein quartz with rare fragments of chert, granite or metaquartzite. The conglomerate beds normally have slightly scoured irregular base ; they vary in thickness from 0.1 to 3.0 m, and show planar, trough or low-angle cross-beds. Several 20 to 30 cm thick massive conglomerate beds have flat non-erosional basal contact, matrix-supported texture and inverse grading. Generally individual beds pinch out within a short distance but conglomeratic zones occurring at several stratigraphic levels extend over several hundreds of metres to a few kilometres.

Thin sequences of red or greenish grey mudstone or muddy fine sandstone with well developed ripple lamination and thin parallel laminae occur interlayered with other facies of this formation. Low-lying areas east of the Encharani hill (Ghanpur sector) show extensive development of the mudstone facies.

The Ramgiri Formation is at places affected by intense soft sediment deformation. In the Ramgiri hill section, lower 100 m of the scrap section is pervasively deformed and the sequence gradually passes upward into undeformed facies. The intensity of deformation varies from total destruction of the original structures by liquefaction of the beds to well developed disharmonic folds (convolute laminations ; Fig 4) to gentle slumping and oversteepening of the foresets.

Paleocurrent direction of this formation is highly variable though a strong south-easterly mode is discernible in many sections. However, the paleocurrent direction abruptly changes to south and southwest in the Ghanpur sector.

Venampalli Sandstone Member : It is best exposed in the low-lying ridges north of

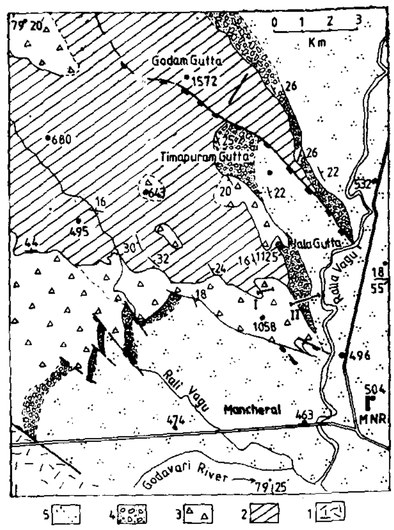
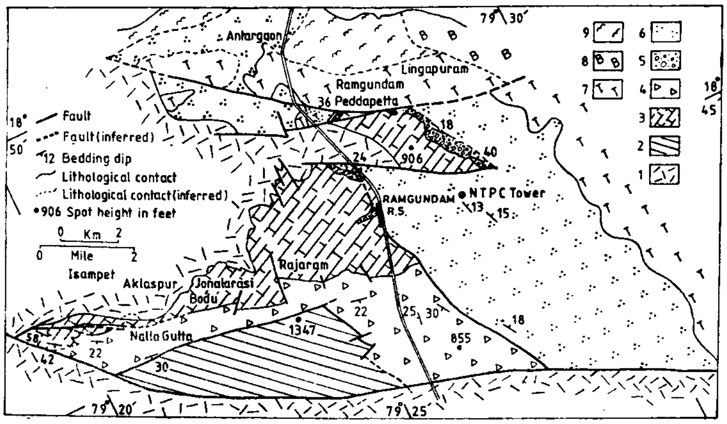


Fig. 8. The log through the Venampalli Sandstone Member, north of Venampalli. Note a wave-rippled lower shale dominated part.

Venampalli in the Begampet sector and comprises a thin basal green shale sequence and overlying thicker white, buff or light greenish coarse-grained arkose (Fig. 8). The maximum preserved thickness of the sequence is 126 m. The greenish colour is due to the presence of authigenic ferricillite (Dasgupta *et al.*, 1990). A peculiar massive weathering makes identification of the primary sedimentary structures very difficult. Large planar bounding surfaces, indistinct but ubiquitous medium or small trough cross-beds, and locally fine-grained wavy laminated beds characterise the sequence.

The green mudstone and interlayered coarse sandstone beds show abundance o wave ripple cross-lamination and large symmetrical megaripples. Trough cross-be data indicate strongly unimodal paleocurren



. Fig. 9. Geological cross-section along the line A_7-A'_7 shown in Fig. 2. Note the low-angle discordance of the Kapra Sandstone Member with the underlying part of the Ramgiri Formation.

towards southeast.

Kapra Sandstone Member : This member forms the uppermost part of the Ramgiri Formation around Kapuram and Nasaram Gutta in the Ghanpur sector. The section around Nasaram Gutta is defined here as the type section of this member. In the type section it is about 75 m thick. Kapra Sandstone Member is reddish to white, coarse-grained, arkosic sandstone with dispersed pebbles that vary from 10-15 mm in their longest dimension. The sandstone shows abundant trough cross-beds with individual cross-sets 5 cm to 15 cm thick. Small isolated channels occur at places. The sandstone forms spectacular flat-topped ridges with vertical sides (Fig. 5). Nearly subhorizontal beds of the Kapra Sandstone overlie the gently dipping beds of the rest of the Ramgiri Formation with a low-angle discordance (Fig. 9). Exposurewise mean of paleocurrent directions of the member varies from 123° to 156°.

Lithologically, the Kapra sandstone is very similar to the small trough cross-bedded facies of the Ramgiri Formation. It has been delineated as a separate member because of the angular discordance with the rest of the Ramgiri sequence and the distinctive geomorphic form that this unit displays. It may be mentioned here that the criteria used for the definition of the Kapra Sandstone Member are very similar to those used in defining an allostratigraphic unit (NACSN, 1983, article 58).

Mancheral Quartzite

This is a deep brown to red, poorly sorted, pebbly to fine-grained quartzarenite with minor amount of conglomerate. In the Ramgundam area planar cross-beds are well developed, whereas trough cross-beds are the dominant sedimentary structures at Mancheral. Numerous mud clasts, thin sheets of conglomerate and shallow or deep channels are common in both the places. Planar cross-beds vary in thickness from

12 cm to 130 cm, averaging around 40-50 cm, and occur as isolated or grouped sets (Fig. 6). Trough cross-beds are 2 - 15 cm in thickness. Cosets of troughs locally build up 30 - 81 cm thick sheet-like sand bodies. Extensive quartz overgrowth, diffuse or concentrated blotches of iron oxide, and infiltrated secondary clay matrix at places characterise the sandstones. At Ramgundam area the mean paleoflow direction is towards southwest and that at Mancheral area is towards north.

At places, polymict boulder pebble conglomerate with clasts of quartzite, chert, vein quartz and intraformational sandstone occurs as 3 - 5 m thick channel-fill lenses. Pebbly conglomerates occur commonly as thin sheets and less frequently as 10 - 30 cm thick horizontally stratified beds. Muddy fine sandstone and mudstone interbeds occur in units, 5 cm to 23 cm thick, and show well-developed ripples, shallow scour pools and mud cracks.

Salmon red, well sorted fine to medium grained quartzarenite occurs as tabular sheets at several stratigraphic levels at Ramgundam and Bellampalli areas. Some of the beds are characterised by adhesion structures, whereas others are massive or trough cross-bedded.

Mancheral Quartzite does not occur south of Ramgundam, whereas it forms prominent ridges around Mancheral and further north. It is very well exposed in the scrap section of Timapuram Gutta designated here as the type section of the formation. Excellent exposures in the north-eastern slope of the Ramgundam Gutta exhibit all the characteristic features of this formation, and this area is defined as an additional reference section. The maximum preserved thickness of the formation, as measured in the Mancheral area, is 77 m and the preserved sequence at Ramgundam section is about 30 m thick.

Venkatpur Sandstone

The Venkatpur Sandstone consists of salmon red beds of well sorted, medium to fine-grained quartzose to subarkosic sandstone, and subordinate amount of red siltstone. The sandstone is characterised by high degree of textural uniformity throughout the area. It is a soft, poorly indurated sandstone and normally forms low-lying and small hillocks. King (1881) first proposed and defined this unit from Venkatpur in the Chelvai area (a little beyond the south-eastern end of the area mapped during this study). However, best natural exposures in the study area occur north of Jala Gutta near Mancheral in the stone quarries near the Bellampalli railway station and in the creeks north of the Laknavaram Lake. These sections are proposed here as additional reference sections for the Venkatpur Sandstone. The thickest observed section in the Laknavaram area measures 60 m. At Mancheral this unit is about 50 m thick and thickness at the Ramgundam Gutta is less than 30 m.

Meter-scale planar tabular or planar wedge shaped cross-beds (up to 3 m thick) is the hallmark of this sandstone. The cross-beds normally alternate with flat-bedded facies (Fig. 7) locally displaying intense soft sediment deformation. Aeolian translatent strata (Hunter, 1977) and adhesion structures are common. Channel-fill sand bodies and small scale aqueous cross-beds are locally present. Wave or current ripples and mud cracks may be locally abundant.

Paleocurrent measurements from the large cross-beds show remarkably persistent north-easterly flow direction.

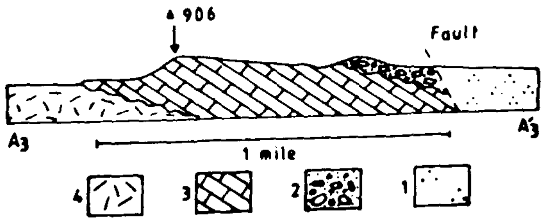


Fig. 10. Geological map of the Mancheral area.

LOCAL STRATIGRAPHIC SEQUENCES

Mancheral area (Fig. 10)

This is the only area where, in a few sections, all the three Sullavai formations occur in a few sequence. In the southern part of Jala Gutta, 5 km NNW of Mancheral, the Ramgiri Formation is developed as the basal unit of the Sullavai Group. The subhorizontal Ramgiri Formation unconformably overlies the deformed beds of the Penganga Limestone. Mancheral Quartzite conformably overlies the Ramgiri Formation. The contact between the two is marked at several places by lenticular conglomerate units that at one place attain a maximum thickness of 18 m. The Venkatpur Sandstone overlies the Mancheral Quartzite with a gradational contact marked by an 18 m thick transitional zone. The rocks of the Permo-Jurassic Gondwana Supergroup overlies the Venkatpur Sandstone in most of the sections in the area.

In a small outlier near Goddapur, in the Mancheral sector, the Ramgiri Formation unconformably overlies steeply inclined beds of the Penganga Group and in the hill range, 6 km north-northwest of Bellampalli Railway Station, Mancheral Quartzite unconformably overlies the Sat Nala Shale of the Penganga Group with a low angular discordance. The unconformity between the Penganga rocks and the overlying Sullavai rocks is also seen in the small hillock 3 km north of the village Kasipet where coarse and poorly sorted Mancheral Quartzite overlies the deformed Sat Nala Shale. In all these sections small fragments of brown Sat Nala shale (Penganga Group) occur in the sandstones of both the Ramgiri Formation and the Mancheral Quartzite.

Ramgundam area (Fig. 11)

In this area Mancheral Quartzite and Ramgiri Formation do not occur together in any single section, but crop out separately in isolated fault-bounded blocks. Chaudhuri (1985) reported intertonguing relationship between the quartzose and arkosic units of the Sullavai Group from the north-western corner of this area. However, no such intertonguing relationship has been observed by this author. The quartzose sandstones referred to by Chaudhuri (1985, Fig. 2) has been reinterpreted on the basis of lithology, primary structures and field disposition as part of the Mulug Subgroup of the Pakhal Group. North of the Ramgundam Railway Station and west of the railway line, a narrow strip of the Mancheral Quartzite dips north-easterly and overlies gently folded beds of the Pandikunta Lime-

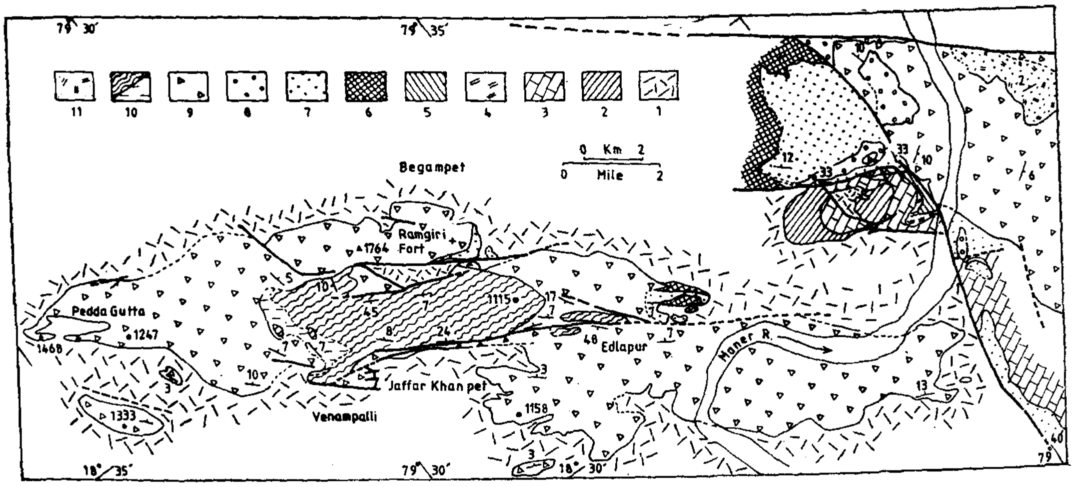


Fig. 11. Geological map of the Ramgundam area.

stone and southeasterly dipping beds of the Damala Gutta Conglomerate, both of the Pakhal Group. In Ramgundam Gutta it overlies the Rajaram Limestone in the southern part, whereas in the north it overlies successively older formations of the Pakhal Group. As also noted earlier (Chaudhuri, 1970, 1985; Chaudhuri and Chakraborty, 1987) the contact between the Mancheral Quartzite and underlying Pakhal Group is erosional and the fragments of the underlying Pakhal rocks abound in the conglomerate lenses in the Mancheral Quartzite. The contact is clearly an unconformity.

South of Kundanapalli Ramgiri Formation overlies highly weathered and ferricritised Rajaram Limestone, whereas further west near Aklaspur it overlies the Damala Gutta Conglomerate or the Pandikunta Limestone. Therefore, Ramgiri Formation also overlies the Pakhals unconformably. Ramgiri Formation is well exposed in the Nalla Gutta hill ranges, where several conglomeratic zones are present at different stratigraphic levels.

South of Nalla Gutta and north of Taklapalli a thick sequence of Penganga limestone and sandstone occurs in a triangular fault-bounded block, as also reported by Sreenivasa Rao (1987) and Chaudhuri *et al.* (1989). However, due to its faulted contacts with the adjacent Sullavai rocks the relationship between the Penganga and the Sullavai Groups in not discernible in this region.

The Venkatpur Sandstone is juxtaposed above the Mancheral Quartzite along a fault contact in the Ramgundam Gutta (Fig. 12), whereas it conformably overlies the Mancheral Quartzite in the section north of Ramgundam Railway Station. But its contacts with the Ramgiri Formation is faulted everywhere in the Ramgundam area.

Begampet area (Fig. 13)

Ramgiri Formation alone is exposed ir

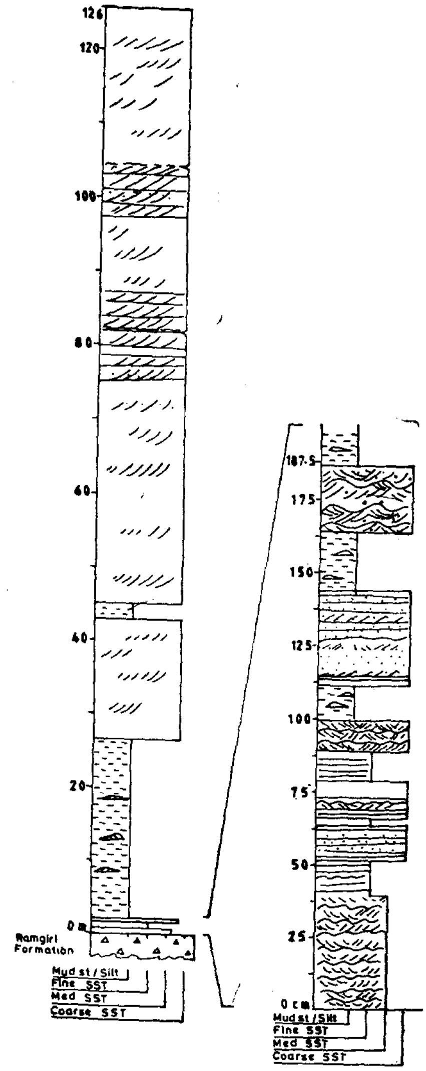


Fig. 12. Geological cross-section along the line A_8-A'_8 shown in Fig. 2.

his area, and unconformably overlies the ranitic basement as well as the quartzose andstone of the Pakhal Group. The quart-ose Pakhal sandstone around Adwi Sri-ampur and Edlapur has been mapped as the Upper Pakhal quartzite, because its correlations either with the Mulug Orthoquartzite or the Ramgundam Sandstone is uncertain. The contact between the Ramgiri arkose and the underlying granite is marked by pronounced topographic irregularity. In Pedda Gutta within a horizontal distance of 1.6 km the contact comes down by about 135 m. Similar change in elevation is also observed in the section south-southeast of Jaffar Khanpet which indicates an undulating pre-Sullavai topography and the erosional nature of the sub-Sullavai surface.

The facies assemblage varies widely in different localities. The Venampalli Sandstone Member occupies a large area north-northeast of Jaffar Khanpet and Venampalli. In its area of occurrence the member occurs as the uppermost unit of the Ramgiri Formation. The contact of the basal shale-sandstone alternation unit of the Venampalli Sandstone Member with underlying sandstones of the Ramgiri Formation is gradational in the western side of the main outcrop (Fig. 8), whereas in the eastern side of this outcrop the contact is sharp (Fig. 13).

Ghanpur area (Fig. 14)

In this area, between the Maner river and the Ramappa tank, the Sullavai rocks overlie mainly the Pakhal rocks. They appear to be structurally conformable though the Sullavai rocks overlie different Pakhal units at different localities and the contact between them is erosional and locally undulating. Immediately to the east of the Maner river the Sullavai rocks overlie the limestones of the Mallampalli Subgroup, whereas near the Ramappa tank or further southeast beyond the mapped area, they

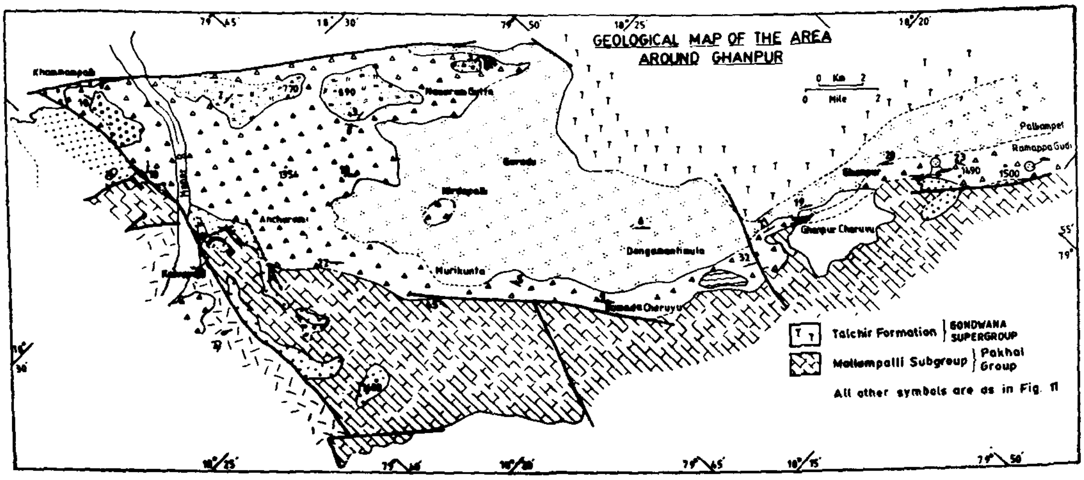


Fig. 13. Geological map of the Begampet area.

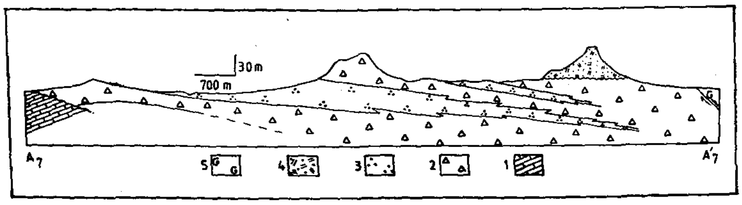


Fig. 14. Geological map of the Ghanpur area.

overlie deformed Mulug Shale, or Mulug Orthoquartzite of the Mulug Subgroup (cf. Basumallick, 1967a).

The Sullavai sequence in this area consists of Ramgiri Formation and the Venkatpur Sandstone. The latter directly overlies the former through a transitional zone, or the two intertongue with each other. The transition zone is marked by intercalation of thin tongues of flat bedded fine to coarse-grained Venkatpur Sandstone with Ramgiri arkose. The intercalated zone is well developed at the northwestern corner of the Ghanpur tank, and at a place ~3.5 km southeast of Ghanpur where this zone is about 50 m thick, and a few tongues of Venkatpur Sandstone occur within the Ramgiri Formation (Fig. 15, section VIII).

The Kapra Sandstone Member overlies the rest of the Ramgiri Formation with a slight structural discordance around Nasaram Gutta (Fig. 9). A small outlier of the Venampalli Sandstone occurs near Dongamantimala.

The Sandstone of Ramgiri Formation in this sector are less felspathic compared to

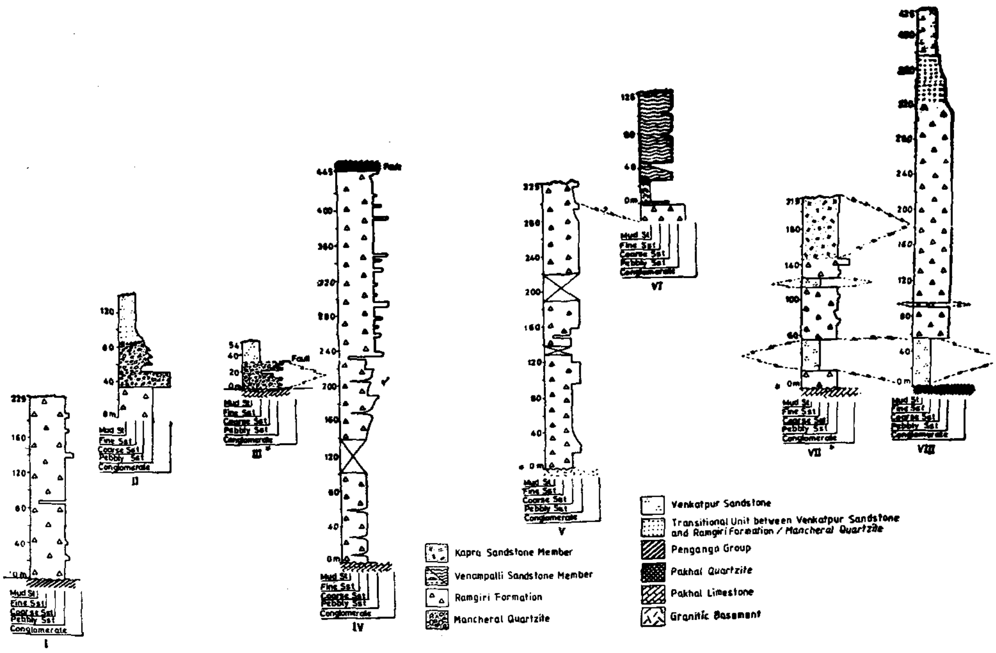


Fig. 15. Correlation of measured vertical logs in different sections of the study area. I, II, III .... denotes the section numbers whose positions are indicated in the Fig. 2. Asterisks in section III and VII refer to respective geological cross-sections (see Fig. 9 & 12).

those in the Ramgundam or Begampet sectors. In two exposures, near Papan Bodu (hill) and Dongamantimala, they become quartzose, and feldspar content, in general, decreases southeastward.

REGIONAL CORRELATION AND STRATIGRAPHY OF THE SULLAVAI GROUP

The Pakhal Sullavai contact in different sectors is an irregular, undulating, erosional surface marked by angular discordance and overstepping of the Sullavai sandstones over successively older Pakhal formations and on to the Basement Complex. The contact is clearly an angular unconformity surface, though locally, the overlying and underlying successions may be structurally conformable. The present investigation does not support an earlier suggestion that Sullavai is a facies variant of Pakhals (Heron, 1949; Pascoe, 1950, p. 494). The considerable difference between the K-Ar age dates obtained from the glauconitic minerals of the lower Pakhal Pandikunta Limestone (1300 $\pm$ 53 Ma) and from the Venampalli Sandstone Member of the Sullavai Group (871 $\pm$ 14 Ma; Chaudhuri and Howard, 1985) lends support to this interpretation. The gently dipping undeformed beds of the Sullavai Group, in a number of sections in the Mancheral-Bellampalli area, overlies the deformed and folded limestone and shale sequences of the Penganga Group. At several places the Sullavai sandstones incorporate fragments of the Penganga shale. The Sullavai-Penganga relationship, therefore, is also that of an angular unconformity. The field relations contradict the earlier suggestion by Chaudhuri *et al.* (1989), on the basis of the radiometric age data, that the Penganga Group is younger than the Sullavai Group.

In Mancheral area, the Mancheral Quartzite conformably overlies the Ramgiri Formation with a fairly thick conglomerate marking the contact at places. At Ramgundam, on the other hand, both the units unconformably overlie different Pakhal formations in separate fault blocks. Mancheral Quartzite is not developed southeast of Ramgundam. The Venkatpur Sandstone overlies the Mancheral Quartzite in Mancheral and Ramgundam sectors either gradationally or sharply. But over a long stretch in the Begampet and Ghanpur sectors, where Mancheral Quartzite is absent, it either intertongues or gradationally overlies the Ramgiri Formation. Figure 15 attempts to correlate the measured sections. Clearly, a generalised order of vertical superposition of lithostratigraphic units can not be proposed. The variable relationship between the three formations in different parts of the area under consideration indicates that the depositional systems were partly overlapping in time in different parts of the basin.

The Mancheral Quartzite is more restricted in occurrence compared to the Venkatpur Sandstone and the Ramgiri Formation. In Mancheral area the depositional regime of the quartzite replaced that of the Ramgiri arkose with time. In Ramgundam area, on the other hand, occurrence of both the formations on the same units of the Pakhal Group at different places and their markedly different mean paleotransport direction indicate different depositional loci of the two systems. It is, however, difficult to comprehend the temporal relationship between them in Ramgundam area. The depositional system of the Mancheral Quartzite did not develop in the Ghanpur and Begampet areas. In these sectors the Venkatpur system started to develop overlapping in time with the Ramgiri system. It is difficult to comprehend the temporal significance of the absence of Mancheral Quartzite because of the lack of any key bed or time marker.

Sedimentation and paleocurrent

The distinctive lithology, sedimentary structures and their organisation and distinctive paleodispersal pattern of each of the Sullavai formations are the imprints of their respective depositional regime. Large scale geometry of the lithounits and their interrelationship in space are the product of interaction between depositional processes and basin tectonism (cf., Galloway, 1981 ; Miall, 1984 ; Prave *et al.*, 1991).

Laterally extensive, sheet-like units of small trough cross-beds and lenticular to wedge-shaped conglomerate units of the Ramgiri Formation have been interpreted to represent a distal alluvial fan setting (Chakraborty, 1988, 1991b). Similar sheetflood deposits with local lenses of fan-head channel conglomerates characterise these

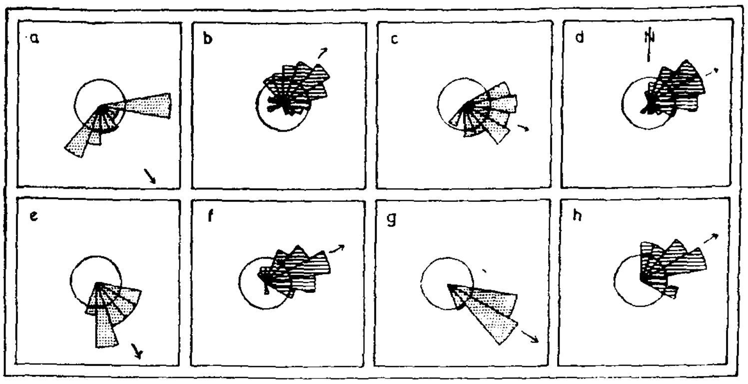


Fig. 16. Summary of the paleocurrent data from the Ramgiri Formation.

settings (cf., Heward, 1978 ; Blair, 1987 ; DeCelles *et al.*, 1991). On the other hand, pebbly sandstone facies of the Ramgiri Formation, characterised by large planar cross-beds and cosets of trough cross-beds and frequently organised in fining-upwards sequences, is interpreted to represent an alluvial plain setting dissected by braided streams (Chakraborty, 1988, 1991b). Exposurewise mean paleocurrent direction of the Ramgiri Formation shows wide scatter. However, facies-wise measurements show that fan-related strata consistently yield a north-east to eastward flow direction, whereas the data from alluvial plain-braided stream deposits show a south-eastward paleoflow direction in the Ramgundam and Begampet area (Fig. 16).

In the Ramgumdam area, poorly sorted pebbly sandstones of Mancheral Quartzite show several large-scale concave-up channel-form erosion surfaces that are overlain by fining-upwards sequences. These sequences have been interpreted as high gradient braided fluvial deposits (Chakraborty, 1988, 1991b). Thin units of fine-grained, salmon red sandstones within Mancheral Quartzite represent wind blown sands which in places covered up the distal part of the Mancheral alluvial plain (Chakraborty and Chaudhuri, 1993). Data collected from the Mancheral fluvial deposits in the Ramgundam area show paleocurrent direction towards southwest (Fig. 17).

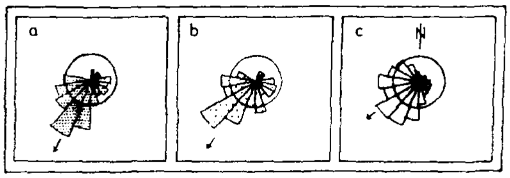


Fig. 17. Paleocurrent pattern of the Mancheral Quartzite in the Ramgundam area.

Venkatpur Sandstone records deposition in an extensive aeolian sand sea (Chakraborty, 1988, 1991a). Measurements from locations scattered across the study area indicates a very consistent paleowind direction to the northeast. The paleowind pattern of the Venkatpur Sandstone is believed to indicate presence of a stable high pressure cell in the area during the Late Proterozoic time.

Notwithstanding the broad similarities of depositional environment (alluvial fan-braided river), caliber of sediment load (conglomerate - coarse-grained sandstone) and occurrence in correlatable stratigraphic position, the remarkable contrast in the lithology of Ramgiri Formation and Mancheral Quartzite is somewhat confusing. However, opposing paleocurrent patterns of the Ramgiri fan system and the Mancheral fluvial system indicate presence of opposing paleoslopes on the two flanks of the basin. Two systems, therefore, sampled two different source terrains. Abundance of fresh felspar and granite fragments and flow from the southwest indicate that the Archean (?) granite gneiss complex exposed to the south of the Sullavai outcrop belt was the source rock for the Ramgiri Formation. Preliminary petrographic study of the Mancheral Quartzite shows abundance of chert and sedimentary quartzite fragments possibly derived from the chert beds and nodules which are common in both the Pakhal and Penganga limestones unconformably underlying the Mancheral Quartzite. It is difficult to pin point the source rock for the quartzite fragments. There is at present no outcrop of older quartzite north, northeast of the Mancheral exposures and the area is now covered by younger Gondwana rocks. Mulug Orthoquartzite of the Pakhal Group (Basumallick, 1967a) and Pranhita Sandstone of the Penganga Group are potential candidates for the Mancheral source rock. Mulug Orthoquartzite crops out only in the southeastern part of the area. In contrast, Pranhita Sandstone crops out extensively in the Ramgundam-Mancheral areas, which are also the areas where the Mancheral Quartzite is well developed. Although these evidences are suggestive of Pranhita Sandstone as a possible source rock, a definitive correlation would require systematic patrographic study.

Stratigraphic relationship of the Venkatpur Sandstone with both the Mancheral Quartzite and the Ramgiri Formation indicates that these intrabasinal alluvium were probably the major source of the aeolian system. A regional wind direction to the north east and subarkosic composition (Chaudhuri, 1970) of the sandstone support its derivation from the Ramgiri arkosic sandstones.

A semi-arid climate has been inferred for the underlying Middle Proterozoic Pakhal Group on the basis of occurrence of sabkha sequences (Chaudhuri *et al.*, 1987). Red colouration of Ramgiri arkoses, interlayered aeolian or sabkha sequences within the Mancheral Quartzite indicate similar set-up for the basal Sullavai rocks. Regional climate might have evolved to a more arid one during the Venkatpur time. Presence of extensive alluvial fan-derived coarse-grained, immature sediment in the lower part of the Sullavai Group indicate presence of granitic highlands along the southwestern margin of the Sullavai basin. Basin margin highlands can locally attract rainstorms and generate coarse-grained alluvial sedimentation (Blackey, 1986 ; Stewart, 1991). Denudation of these highlands can therefore increase the severity of the climate aiding thereby establishment of a large erg system in the basin. Fig. 18 shows the postulated paleogeographic set-up of the Pranhita-Godavari Valley

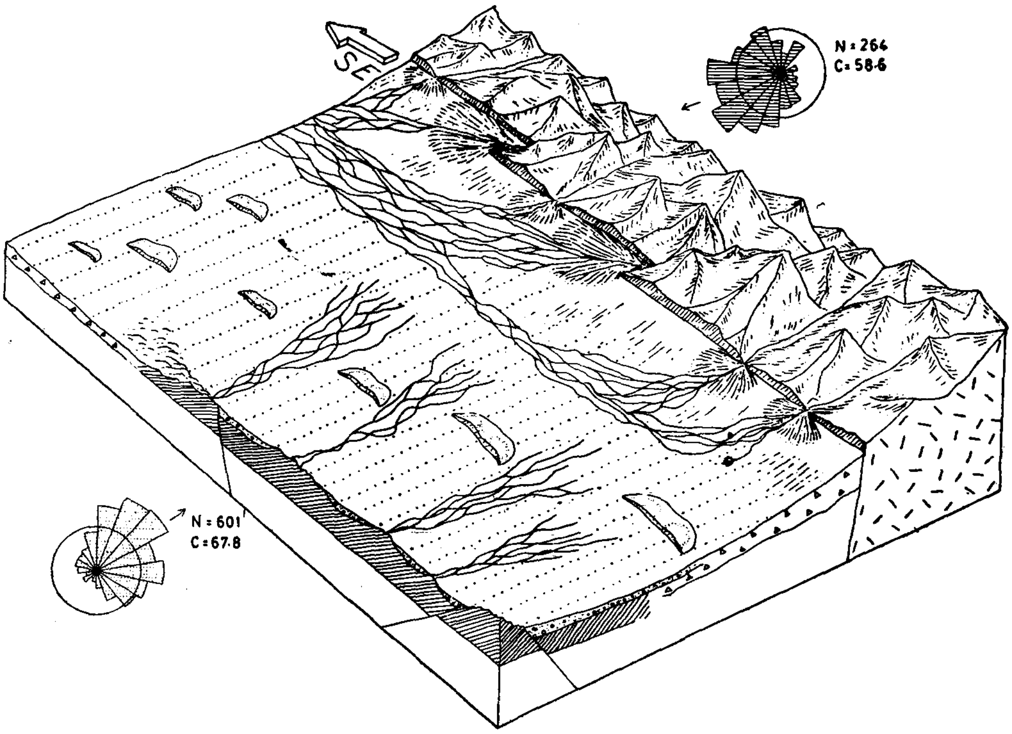


Fig. 18. Diagram showing schematically the reconstructed paleogeography for the closing phase of the Sullavai sedimentation.

during the Late Proterozoic time.

DISCUSSION AND CONCLUSIONS

Thickness variation (notably that of the Ramgiri Formation) and lateral pinching out of lithologic units indicate differential subsidence during deposition as well as diachronous change in depositional environment. However, in most of the complete stratigraphic sections, a fluvial sandstone, either Ramgiri Formation or Mancheral Quartzite, occurs unconformably above the underlying basement and is followed gradationally upward by aeolian Venkatpur Sandstone. This broad characteristic seems to persist throughout the studied area and is believed to represent a near complete sequence of basin initiation and filling-up. Exclusively continental sedimentation history appears to usher in the grand finale of Proterozoic sedimentation in the Pranhita-Godavari Valley and distinguishes it from the marine Pakhal and Penganga Group of sediments.

As is evident from the figure 15, it is not possible to erect a generalised stratigraphic succession of the Sullavai Group, as the formations in a regional scale are not homotaxial but are marked by pinching out, thickness variation, and vertical and lateral gradation in all stratigraphic levels. It is evident that the lithounits were partly coeval with each other.

The Sullavai Group, bounded between two basin-wide unconformities and characterised by continental clastics, represents a separate pulse of extension and basin-fill during the Late Proterozoic time. Initial phase was characterised by rapid subsidence and development of basin margin highlands that contributed a large amount of coarse-grained clastics. Subsequent decrease in the rate of subsidence and denudation of basin margin highlands restricted supply of coarser material to the basin-fill. Basin continued to subside more slowly, possibly under the influence of sediment load as the fine-grained aeolian and sabkha sediments accumulated.

Following conclusion can, therefore, be drawn from the present study of the Sullavai Group :

(i) The Sullavai Group unconformably overlies both the Pakhal and the Penganga Groups in the southwestern Proterozoic belt of the P-G Valley and is unconformably overlain by Gondwana rocks.

(ii) The Sullavai Group can be subdivided into three formations, namely, Ramgiri Formation, Mancheral Quartzite and Venkatpur Sandstone. Venampalli Sandstone and Kapra Sandstone are two formal members within the Ramgiri Formation and occur as distinctive lenticular units.

(iii) Contrary to the traditional concept of 'layer cake arrangement', correlation of Sullavai formations in a regional scale reveals a complex stratigraphic architecture. It is difficult to propose a 'generalised' succession of the Sullavai Group of rocks.

(iv) Ramgiri and Mancheral sandstones were laid down by alluvial fan-braided river system coming down from two opposing flanks of the basin. Venkatpur erg system covered up the basin during its terminal phase. Change in depositional regime is believed to reflect a change from semi-arid climatic set-up.

(v) Sullavai Group represents a near complete sequence of basin filling. Bounded by two regional unconformities at the base and at the top, the Group represents a separate phase of basin extension and filling-up in the Late Proterozoic history of the Pranhita-Godavari Valley.

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APPENDIX—I

(Latitude & Longitude of the localities and other geographic features referred to in the text)

Adwi Srirampur	18°30'N	79°38'E
Aklaspur	18°47'N	79°21'E
Ancharami	18°28'N	79°42'E
Begampet	18°36'N	79°34'E
Bellampalli	19°03'N	79°26'E
Bellampalli Railway Station	19°03'N	79°26'E
Chelvai	18°15'N	80°12'E
Dongamantimala	18°19'N	79°49'E
Edlapur	18°32'N	79°34'E
Encharani Gutta (Hill)	18°29'N	79°44'E
Ghanpur	18°18'N	79°53'E
Goddapur	18°57'N	79°22'E
Jafar Khan Pet	18°33'N	79°31'E
Jala Gutta	18°54'N	79°25'E
Kapuram	18°30'N	79°45'E
Kasipet	19°02'N	79°26'E
Kistampet	18°51'N	79°45'E
Kundanapalli	18°45'N	79°26'E
Laknavaram	18°09'N	80°05'E
Mancheral	18°52'N	79°26'E
Nalla Gutta (Hill)	18°46'N	79°22'E
Nasaram Gutta (Hill)	18°27'N	79°47'E
Papan Bodu	18°27'N	79°49'E
Pedda Gutta (Hill)	18°38'N	79°26'E
Ramappa	18°15'N	79°56'E
Ramgiri Fort Hill	18°34'N	79°33'E
Ramgundam	18°48'N	79°27'E
Ramgundam Gutta (Hill)	18°47'N	79°27'E
Ramgundam Railway Station	18°46'N	79°26'E
Timapuram Gutta (Hill)	18°58'N	79°24'E
Venampalli	18°45'N	79°33'E

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