PERMIAN LITHOSTRATIGRAPHY OF RAMAGUNDAM-MANTHENI AREA, GODAVARI VALLEY COALFIELD, ANDHRA PRADESH

B. V. RAMANAMURTY

Singareni Collieries Co. Limited, Belampalli-504 251 (India)

Abstract

Geological studies of the Gondwana sequence in the Ramagundam area of the Godavari Valley Coalfield have established for the first time, the existence of Barren Measures, which have a characteristic gross lithology of its own, and attain a considerable thickness of about 450±50 m. The strata above this, and up to the base of the overlying Maleri Formation (readjusted) is now identified as the Kamthi Formation. This formation is in turn has been broadly divided into Lower (200 m), Middle (100 m) and Upper (400 m) members. The Lower Member, containing the newly discovered 'Sondila' coal seam, bears a gross lithological similarity with that of the Raniganj Formation of the Damodar Basin, while the middle (partly) and the upper members, broadly resemble those of the Panchet Formation. The Upper Member consisting predominantly of ferruginous sandstone, forms characteristic hill ranges (similar to the oft described 'Kamthi' strata of Blanford and King) and generally unconformably overlaps the Middle Kamthi Member.

Incidentally, the palynological studies of the borehole samples have yielded characteristic miofloral assemblages, that broadly corroborate/match with the newly adopted lithostratigraphic classification.

Introduction

Stratigraphic status of Gondwana Sequence—The problem of sub-division of the Gondwana Sequence, has assumed a new dimension, with the adoption of the new 'Code of Stratigraphic Nomenclature of India (Geological Survey of India-1971). Earlier, there was a prevalent tendency to assign a chrono-stratigraphic status to these different sequences in a 'Series-Stage' heirarchy as 'Talchir Series', 'Boulder Bed Stage' etc., based on some sweeping generalisations, that these show a similar pattern of vertical sedimentary organisation in most of the belts. However, as per the new code, to accord the status of 'Series' it becomes obligatory to fix precisely the lower and upper age limits. This in turn is besieged with the problem of fixing the age limit of the unfossiliferous basal part of the Gondwana sequence (i.e. the 'Boulder Bed').

Alternatively, in the field, the various units of the Gondwana sequence are generally distinguished and described on the gross lithological characters. It is therefore appropriate to classify these terrestrial sediments in accordance with the lithostratigraphic classification. Hence, in the present work, these units are defined and recognised on the gross lithological attributes, and described as Talchir Formation, Barakar Formation, etc. Some of these formations are further sub-divided into few distinctive members, having a characteristic gross lithological assemblage. Both, the temptation to give a geographical name, and raising some of these members, which are locally become mappable, to the status of a formation is avoided, as it is felt that multiplicity of the formational names would obscure rather than clarify the mutual relations.

Godavari Valley Basin—Much of the basic geological knowledge of the Gondwana succession in the Godavari Valley owes to the pioneering work of William King 1880,

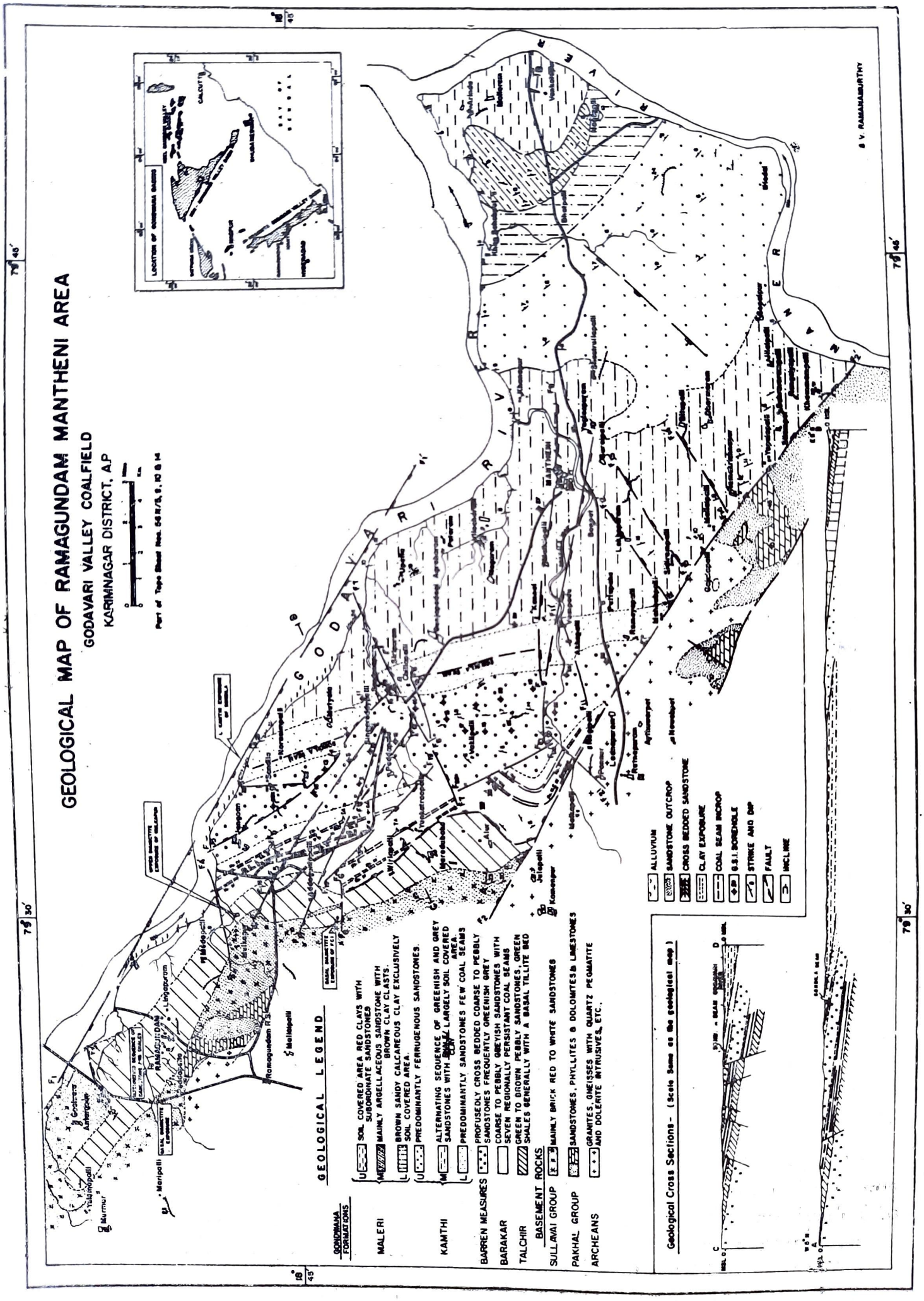
1881) and partly to T. W. H. Hughes (1877, 1878). King has geologically mapped the entire Pranhita-Godavari Basin, including the Pre-cambrians. He has established a tripartite classification of the Lower Gondwana succession into 'Talchir', 'Barakar' and 'Kamthi' Groups in an ascending order. Similarly, the Upper Gondwana succession is classified into 'Maleri', 'Kota' and 'Chikala' Groups in the main basin, and the coastal Gondwana Sequence into 'Gollapalli Sandstone', 'Raghavapuram Shale' and 'Tirupathi Sandstone'. This was largely been accepted and maintained by a host of later workers. But Sengupta (1970) identified 'Ironstone shales' and gave the details of an uninterrupted fluvial sedimentation in the Bheemaram area to the immediate north of the river Godavari and situated closely to the northern side of the area under reference. Similarly, Jain *et al.* (1964) and Kutty (1969) attempted a reclassification of the 'Post-Kamthi' and 'Pre-Kota' sequence in the northern part of the Godavari Valley Basin, around Golet and Bheemaram, where they have recognised four lithostratigraphic horizons as, Yerrapalli, Bheemaram, Maleri and Dharmaram formations. The Chikiala Formation, occurring in the northeastern part of the basin has been referred as Gangapur Formation by Kutty (1969) in the Gangapur area, in the northwestern extremity of the Godavari Valley Basin.

Present Area—The Ramagundam area (covering around 500 sq km) forms an integral part of the vast Godavari Gondwana Basin (17,000 sq km) in its northwestern part. It is bound by Godavari River in the north and northeast, and by Maneru River in the south and southeastern part of the area. It falls partly in the Survey of India Topo sheet numbers 56 N/5, N/9, N/10 and N/14 and bound by N. Latitudes 18° 33′ to 18° 51′ and E. Longitudes 79° 24′ to 79° 50′. It is located in the Karimnagar District of Andhra Pradesh and constitutes an important coal mining centre around the township of Godavarikhani (Text-fig. 1).

Lithostratigraphy

Most of the type sections of the Gondwana Sequence were initially studied and established in the Damodar Basin of the Bihar-Bengal area; and these were later extended to the other basins, including the Godavari Valley. In these outlying basins, many a time, it was so far not possible either to properly identify or correlate some of these units with those already established in the type areas. This was mainly due to the paucity of surface exposures and the consequent lack of accurate and detail lithostratigraphic succession in these areas. However, a wealth of subsurface data on the lithostratigraphy in a part of the Godavari Valley Basin around Ramagundam-Mantheni, has accumulated during the recent regional prospecting for coal. This coupled with large-scale geological mapping has helped in building a detail lithostratigraphic succession of a considerable thickness (over 3000 m) of the Gondwana Sequence, and properly identify and correlate them with the already established units of the type areas. This has particularly helped in a proper reclassification of the Permian Gondwana lithostratigraphic succession in more detail by a proper resolution of the assorted sequence of the 'Kamthi Group' of William King (1881), and thereby leading to a better understanding the lithology, stratigraphy and the mutual relationship of the controversial 'Kamthi Group' of sediments.

The Gondwana succession consisting of the Talchir, Barakar, Barren Measures, Kamthi (into a Lower, Middle and Upper) and the Maleri (sub-divided into a Lower, Middle and Upper units) formations, is clearly demarcated (with the help of aireal photos and subsurface data) in the accompanying geological map (Text-fig. 1). The earlier stratigraphic classification of King, the modified classification by Jain *et al.* in the northern part of the basin and by the present author for the Ramagundam-Mantheni area,


GEOLOGICAL MAP OF RAMAGUNDAM MANTHENI AREA
GODAVARI VALLEY COALFIELD
KARIMNAGAR DISTRICT, A.P
Part of Toposheet Nos. 56 K/13, 9, 10 & 14
GEOLOGICAL LEGEND
GONDWANA FORMATIONS
MALERI
SOIL COVERED AREA RED CLAYS WITH SUBORDINATE SANDSTONES
MAINLY ARGELLACEOUS SANDSTONE WITH BROWN CLAY CLASTS.
BROWN SANDY CALCAREOUS CLAY EXCLUSIVELY SOIL COVERED AREA.
KAMTHI
PREDOMINANTLY FERRUGENOUS SANDSTONES.
ALTERNATING SEQUENCE OF GREENISH AND GREY SANDSTONES WITH SOIL COVERED AREA.
PREDOMINANTLY SANDSTONES FEW COAL SEAMS
BARREN MEASURES
PROFUSEDLY CROSS BEDDED COARSE TO PEBBLY SANDSTONES FREQUENTLY GREENISH GREY
BARAKAR
COARSE TO PEBBLY GREYISH SANDSTONES WITH SEVEN REGIONALLY PERSISTANT COAL BEAMS
TALCHIR
GREEN TO BROWN PEBBLY SANDSTONES, GREEN SHALES GENERALLY WITH A BASAL TILLITE BED
BASEMENT ROCKS
SULLAVAI GROUP
MAINLY BRICK RED TO WHITE SANDSTONES
PAKHAL GROUP
SANDSTONES, PHYLLITES & DOLOMITES & LIMESTONES
ARCHEANS
GRANITES, GNEISSES WITH QUARTZ PEGMATITE AND DOLERITE INTRUSIVES, ETC.
ALLUVIUM
SANDSTONE OUTCROP
CROSS BEDDED SANDSTONE
CLAY EXPOSURE
COAL SEAM INCROP
G.S.I. BOREHOLE
STRIKE AND DIP
FAULT
INCLINE
Geological Cross Sections - (Scale Same as the geological map)
GODAVARI RIVER
RAMAGUNDAM
MANTHENI
LOCATION OF GONDWANA BASINS
CALCUTTA
MADRAS
BOMBAY
A. V. RAMANAMURTHY

Text-fig. 1

is furnished in Table 1, while the detail stratigraphic succession as worked out by the recent studies is given in Table 2. The generalised columnar section of the Gondwana Sequence, of the Ramagundam-Mantheni area, along with several lithological and sedimentological parameters, on the basis of which the lithostratigraphic classification is made, is presented in Text-fig. 2 (Ramanamurty, 1976, 1980, 1981, 1983)

Table 1—Correlation of Gondwana succession

AGE		DAMODAR VALLEY GSI 1977	GODAVARI WARDHA VALLEY			
			W. KING 1981	GSI 1977*	PRESENT WORK	
	UPPER		CHIKIALA	GANGAPUR/ CHIKIALA Fm.		
JURASSIC	MIDDLE	DURGAPUR BED				
	LOWER		KOTA	KOTA Fm.		
	UPPER	MAHADEVA Fm. (SUPRA-PANCHET)				
			MALERI	MALERI Fm.		UPPER
				BHEEMARAM Fm.	MALERI	MIDDLE
TRIASSIC						
	MIDDLE			YERRAPALLI Fm.		LOWER
		PANCHET Fm.				UPPER MB
	LOWER			MANGLI BEDS	KAMTHI Fm.	MIDDLE MB
	UPPER	RANIGANJ Fm.	KAMTHI	KAMTHI		LOWER MB
			------	MOTUR LIKE	BARREN MEASURES Fm.	
PERMIAN			BARAKAR	BARAKAR Fm.	BARAKAR Fm.	
	LOWER					
			TALCHIR	TALCHIR Fm.	TALCHIR Fm.	

*Includes modifications of Jain *et al.*, 1964 and Kutty, 1969

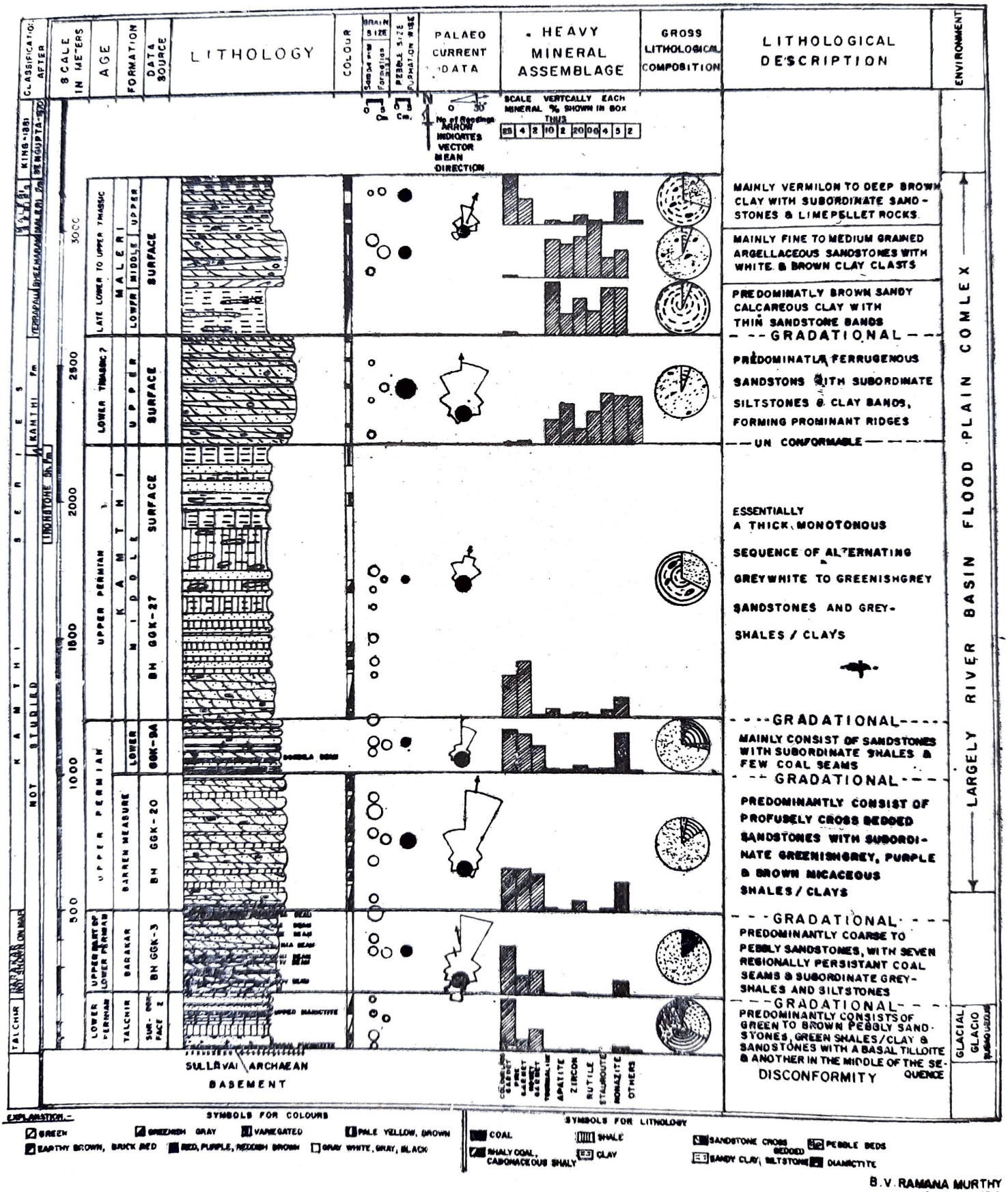
Talchir Formation

The Talchir Formation is the oldest unit of the Gondwana Sequence, exposed in this area, which unconformably overlies the Pre-cambrian basement (i.e. Proterozoic sequence of Sullavai and Pakhal Group) and conformably underlies the Barakar Formation. It forms a narrow marginal belt on the southwestern fringes of the area from around Belampalli (18° 50′ : 79° 18′) on the northwest to around Alur (18° 41′ : 79° 32′) in the southeast, for a total strike length of about 25 km with an areal extent of 45 sq km. The width varies

Table 2—Stratigraphic succession in Ramagundam-Mantheni area

Age	Group		Formation	General Lithology	Maximum thickness (m)
Late Lower to Middle Triassic	UPPER	MALERI	Upper	Mainly vermilion clays with subordinate sandstones and lime pellet rocks	200
			Middle	Dominantly argillaceous sandstones with variegated clasts (forms low hillocks)	200
			Lower	Dominantly brown sandy clays	200
?U. Permian to Early Triassic	GONDWANA	KAMTHI	Upper	Ferruginous sandstone with subordinate clays (forms prominent hill ranges)	400
				——Unconformity——	
	LOWER		Middle	Sandstones and shales	1000
			Lower	Sandstones with subordinate shale and coal seams	200
			Barren Measures	Coarse to pebbly felspathic sandstone with subordinate clays	450±50
Permian	GONDWANA		Barakar	Dominantly sandstones with seven regionally persistent coal seams and subordinate shales	
			Talchir	Greenish sandstones, clays/shales, conglomerates and boulders	200
				——Disconformity——	
			Sullavai & Pakhal	White to brown sandstones, shales, phyllites, dolomites	
				——Non-conformity——	
			Archaean	Granite with dolerite, quartz and pegmatite intrusives	

from 0.5 to 2.5 km, with a sinuous contact with the basement rocks. The exposures are scanty and no good sections of significant continuity are available. Generally, these exposures are confined to some nalla sections and railway cuttings. Those exposed near north of Peddapeta (18° 48′ : 79° 26′), east of Mulkapur (18° 47′ : 79° 29′) and southwest of Addaguntapalli (18° 45′ : 79° 31′) in the railway cutting close to the 'India House' of the Fertilizer Corporation of India, around Maredubaka (18° 42′ : 79° 31′) and Alur are worth mentioning.



B. V. RAMANA MURTHY
Geologist (Sr)

Text-fig. 2

The Talchir Formation contains a wide spectrum of lithological assembly. A broad generalised succession (constructed) of this formation is briefly described here.

The base of the formation is typified by a tillite with unsorted and unstratified rocks with outsized clasts, in a fabric of mixed grain size, ranging from clay to sand. This tillite member is succeeded by sandstone with conglomerates, followed by alternative sequence of graded greenish yellow sandstones and greyish green shales or splintery shales, which finally in turn are succeeded by fine to medium grained greenish grey sandstones with few pebble beds and an upper reworked diamictite at its base. The computed thickness of the Talchir Formation is around 200 m. The detail lithological log is presented in Text-fig. 3.

Barakar Formation

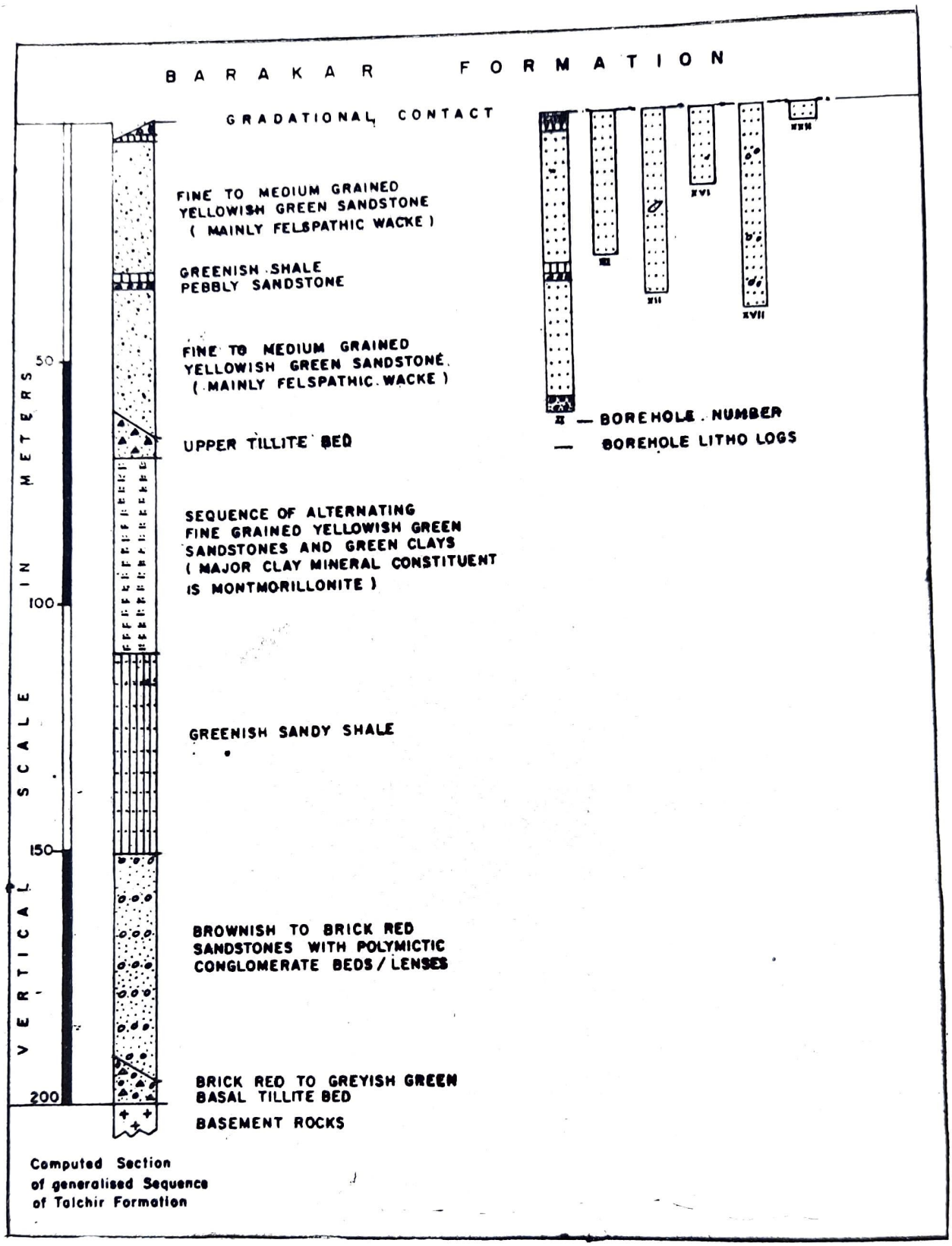
The Barakar Formation succeeds the Talchir Formation with a gradational contact, as the Talchir sandstones pass imperceptably onto the overlying sandstones of the Barakar Formation. The Barakar Formation extends as a narrow belt, with a sinuous Talchir-Barakar formational contact, for a strike length of about 20 km from around north of Ramagundam (18° 47′ : 79° 28′) in the north-west, to around Ladnapuram (18° 38′ : 79° 34′) in the south-east. The width of this formation varies from around a kilometer to 3 km, the variation in the width is mainly due to faulting and varying gradient of the beds, but on an average, it is 2 km. It covers an area of about 43 sq km and has an average stratigraphic thickness of 300 m.

Based on broad lithological characters, the Barakar Formation is divided into a lower and an upper member. From the base of the Barakar Formation up to the floor of the basal workable coal seam no. IV, the pack of sedimentary sequence of about 105 to 140 m is taken as the lower member. The lower member predominantly consists of medium to coarse grained, white felspathic sandstones, with a thin coal seam, and a few thin shale bands. The sandstones are calcareous at places. From the floor of the IV Seam upward, up to the Barakar-Barren Measure boundary the pack of the sediments are taken as upper member. The thickness of this upper member is around 160 to 200 m and consists predominantly of medium grained to very coarse grey-white sandstones (quartz and felspathic wackes) with subordinate grey micaceous shales and siltstones and six regionally persistent workable coal seams. The sandstones are profusely cross-bedded (mostly tabular, while wedge and trough type occur in lesser frequency). The details of the lithostratigraphy of this formation based on representative borehole logs is given in Text-fiig. 4.

Barren Measures (Iron stone) Formation

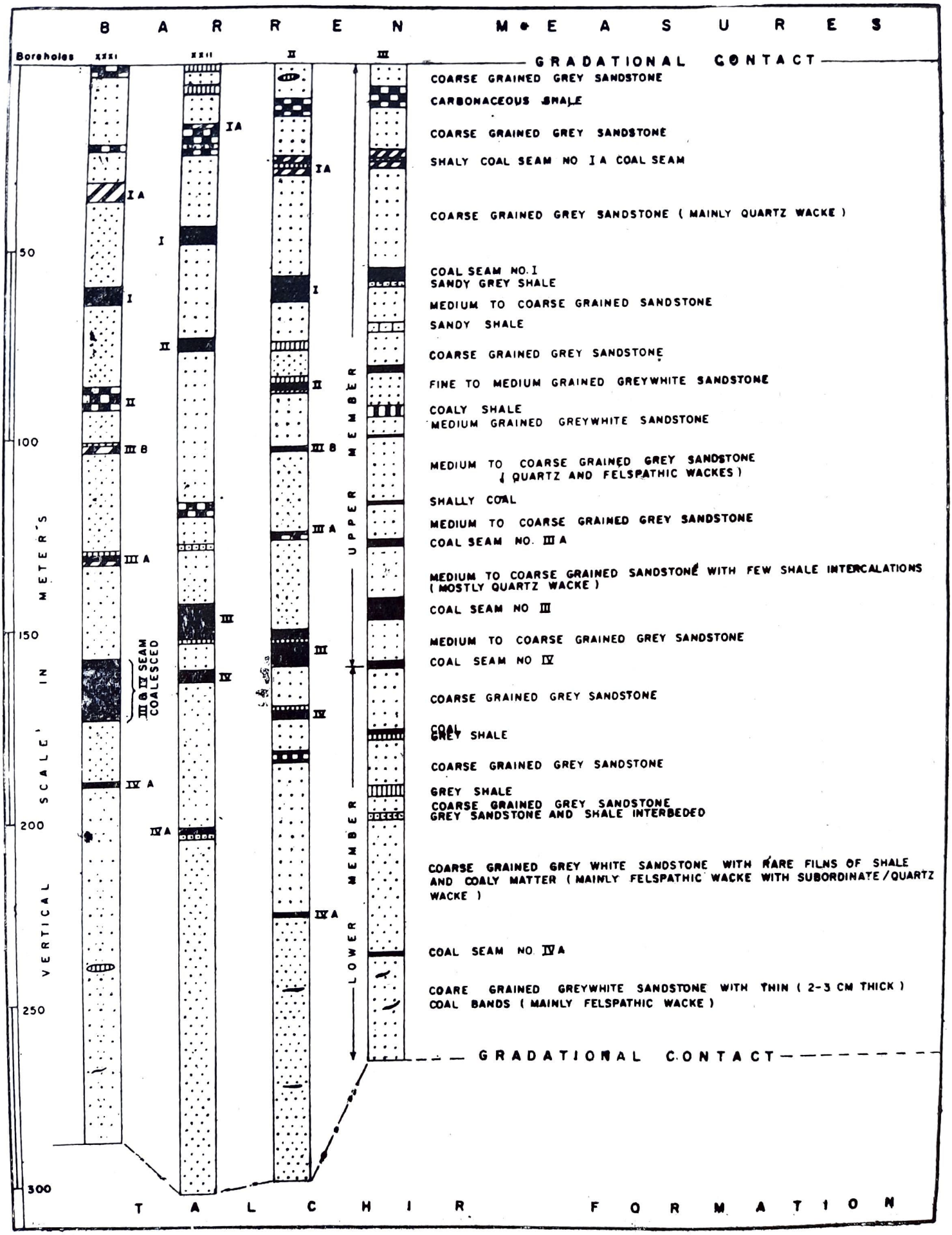
The Barren Measures occur as a narrow elongate belt trending in a north-northwest-south-southeast direction, with an areal extent of about 50 sq km, for a strike length of over 19 km from around Jangaon (18° 46′ : 79° 32′) in the north-northwest to around Ramayyapalli (18° 37′ : 79° 35′) in the south-southeast. The width of this formation varies from 2 to 4 km, the reduction of width at places is due to faulting. The stratigraphic thickness of this formation is 450±50 m.

The Barren Measures succeed the Barakar Formation conformably with a gradational contact. These consists of mostly cross-bedded (mainly planar type), medium to very coarse grained, frequently pebbly at places, greenish to grey white felspathic and ferruginous sandstones. Shales and siltstones are quite subordinate in proportion to the sandstones, and these are characteristically variegated. The carbonaceous matter is very insignificant. The sandstones and the micaceous siltstones when exposed at surface, bear

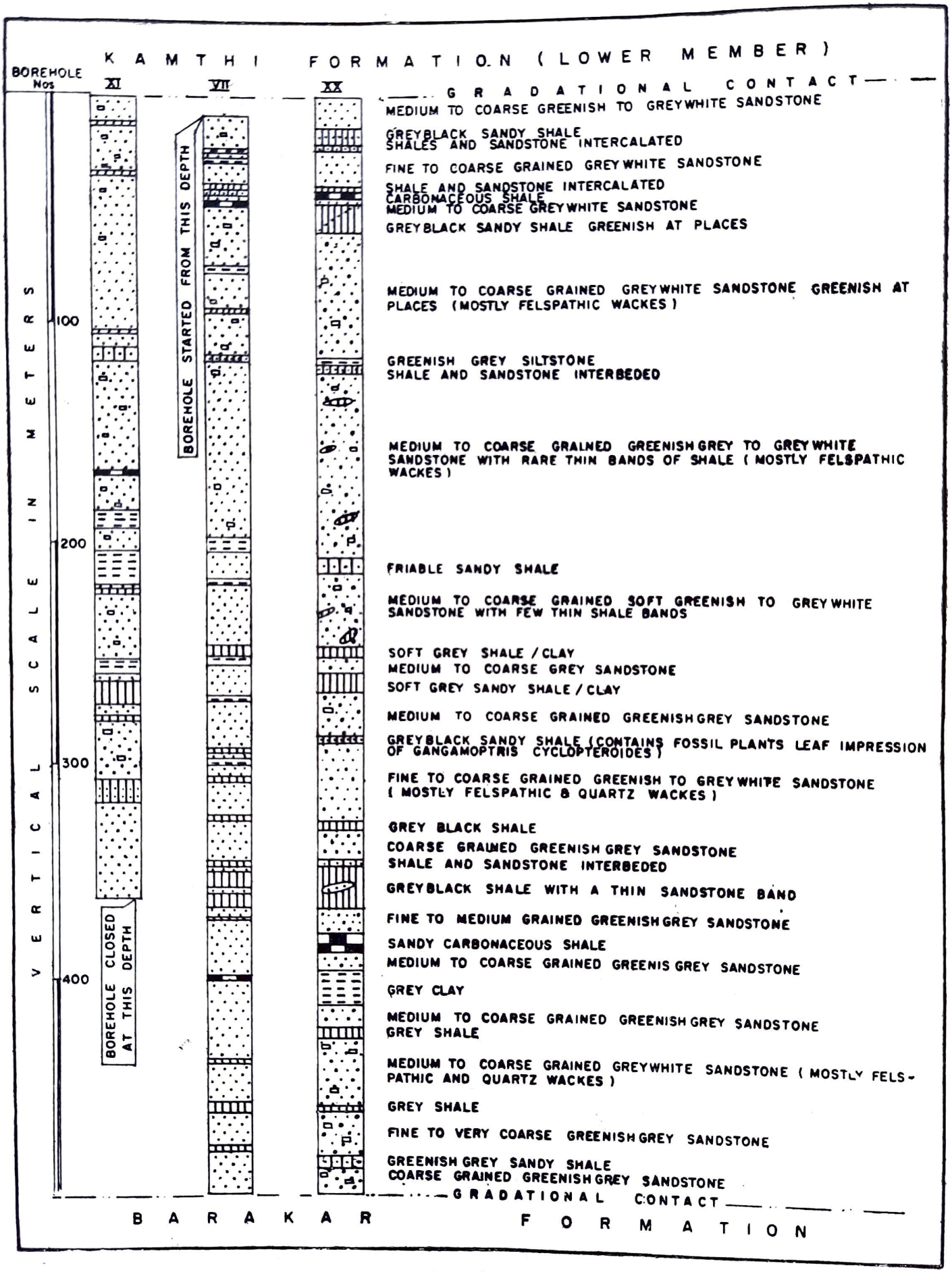


Text-fig. 3

a dark brown to brick-red hue and weather into hard tabloid blocks. These are well exposed on the banks of Godavari River near Jangaon (18° 46′ : 79° 32′), and in the southern part of the area, around Peddapeta (18° 43′ : 79° 33′), Vakilpalli (18° 41′ : 79° 34′) and Akkapalli (18° 39′ : 79° 36′). The detailed lithostratigraphy based on representative borehole logs is given in Text-fig. 5.


B A R R E N M E A S U R E S
Boreholes XXXI XXII II III
GRADATIONAL CONTACT
COARSE GRAINED GREY SANDSTONE
CARBONACEOUS SHALE
COARSE GRAINED GREY SANDSTONE
SHALY COAL SEAM NO I A COAL SEAM
COARSE GRAINED GREY SANDSTONE (MAINLY QUARTZ WACKE)
COAL SEAM NO. I
SANDY GREY SHALE
MEDIUM TO COARSE GRAINED SANDSTONE
SANDY SHALE
COARSE GRAINED GREY SANDSTONE
FINE TO MEDIUM GRAINED GREYWHITE SANDSTONE
COALY SHALE
MEDIUM GRAINED GREYWHITE SANDSTONE
MEDIUM TO COARSE GRAINED GREY SANDSTONE (QUARTZ AND FELSPATHIC WACKES)
SHALLY COAL
MEDIUM TO COARSE GRAINED GREY SANDSTONE
COAL SEAM NO. III A
MEDIUM TO COARSE GRAINED SANDSTONE WITH FEW SHALE INTERCALATIONS (MOSTLY QUARTZ WACKE)
COAL SEAM NO III
MEDIUM TO COARSE GRAINED GREY SANDSTONE
COAL SEAM NO IV
COARSE GRAINED GREY SANDSTONE
COAL
GREY SHALE
COARSE GRAINED GREY SANDSTONE
GREY SHALE
COARSE GRAINED GREY SANDSTONE
GREY SANDSTONE AND SHALE INTERBEDED
COARSE GRAINED GREY WHITE SANDSTONE WITH RARE FILNS OF SHALE AND COALY MATTER (MAINLY FELSPATHIC WACKE WITH SUBORDINATE QUARTZ WACKE)
COAL SEAM NO IV A
COARE GRAINED GREYWHITE SANDSTONE WITH THIN (2-3 CM THICK) COAL BANDS (MAINLY FELSPATHIC WACKE)
GRADATIONAL CONTACT
UPPER MEMBER
LOWER MEMBER
III & IV SEAM COALESCED
VERTICAL SCALE IN METER'S
50
100
150
200
250
300
T A L C H I R F O R M A T I O N

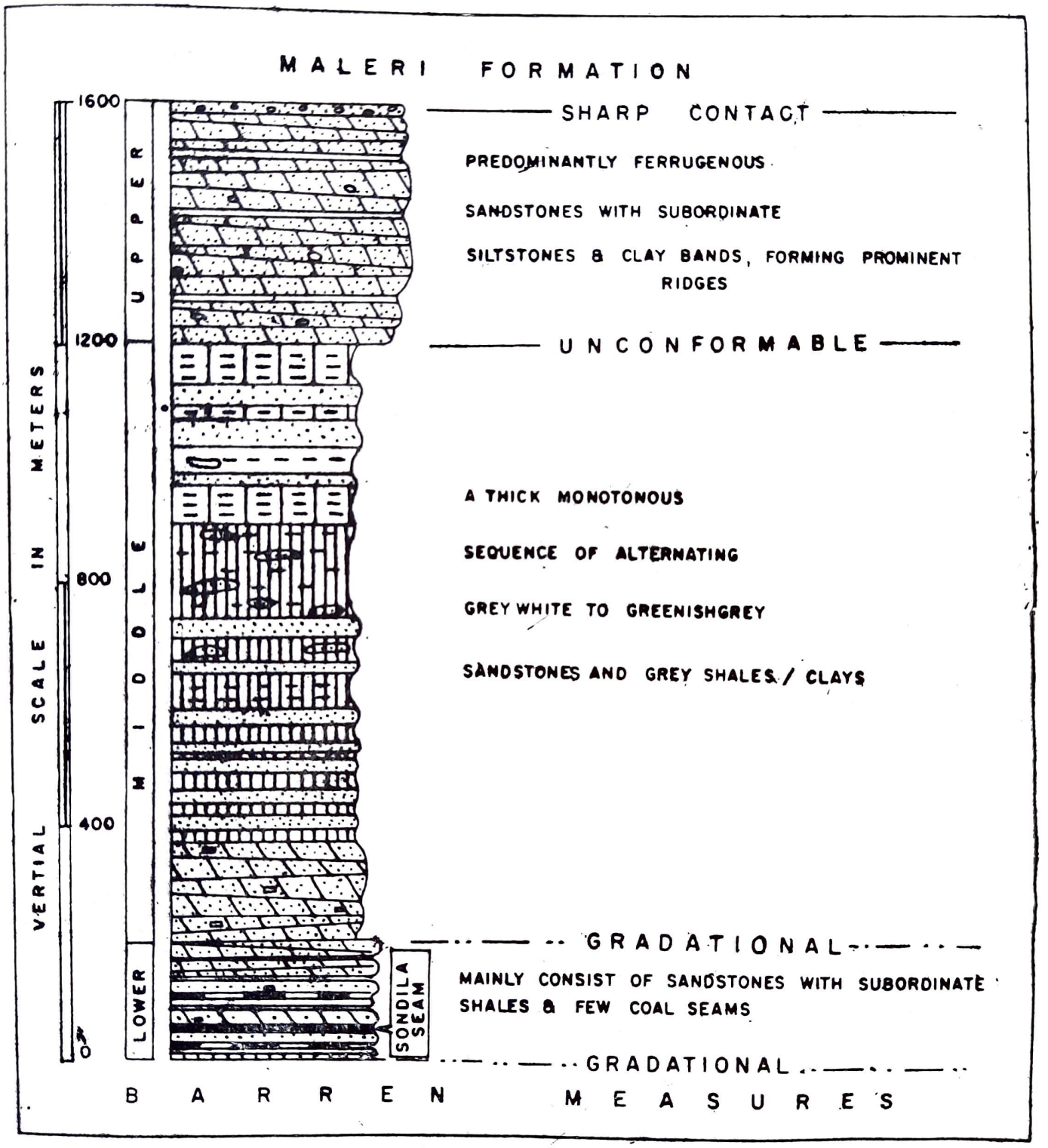
Text-fig. 4


KAMTHI FORMATION (LOWER MEMBER)
BOREHOLE Nos
XI
VII
XX
GRADATIONAL CONTACT
MEDIUM TO COARSE GREENISH TO GREYWHITE SANDSTONE
GREYBLACK SANDY SHALE
SHALES AND SANDSTONE INTERCALATED
FINE TO COARSE GRAINED GREYWHITE SANDSTONE
SHALE AND SANDSTONE INTERCALATED
CARBONACEOUS SHALE
MEDIUM TO COARSE GREYWHITE SANDSTONE
GREYBLACK SANDY SHALE GREENISH AT PLACES
MEDIUM TO COARSE GRAINED GREYWHITE SANDSTONE GREENISH AT PLACES (MOSTLY FELSPATHIC WACKES)
GREENISH GREY SILTSTONE
SHALE AND SANDSTONE INTERBEDED
MEDIUM TO COARSE GRAINED GREENISH GREY TO GREYWHITE SANDSTONE WITH RARE THIN BANDS OF SHALE (MOSTLY FELSPATHIC WACKES)
FRIABLE SANDY SHALE
MEDIUM TO COARSE GRAINED SOFT GREENISH TO GREYWHITE SANDSTONE WITH FEW THIN SHALE BANDS
SOFT GREY SHALE / CLAY
MEDIUM TO COARSE GREY SANDSTONE
SOFT GREY SANDY SHALE / CLAY
MEDIUM TO COARSE GRAINED GREENISH GREY SANDSTONE
GREYBLACK SANDY SHALE (CONTAINS FOSSIL PLANTS LEAF IMPRESSION OF GANGAMOPTRIS CYCLOPTEROIDES)
FINE TO COARSE GRAINED GREENISH TO GREYWHITE SANDSTONE (MOSTLY FELSPATHIC & QUARTZ WACKES)
GREY BLACK SHALE
COARSE GRAINED GREENISH GREY SANDSTONE
SHALE AND SANDSTONE INTERBEDED
GREYBLACK SHALE WITH A THIN SANDSTONE BAND
FINE TO MEDIUM GRAINED GREENISH GREY SANDSTONE
SANDY CARBONACEOUS SHALE
MEDIUM TO COARSE GRAINED GREENIS GREY SANDSTONE
GREY CLAY
MEDIUM TO COARSE GRAINED GREENISH GREY SANDSTONE
GREY SHALE
MEDIUM TO COARSE GRAINED GREYWHITE SANDSTONE (MOSTLY FELSPATHIC AND QUARTZ WACKES)
GREY SHALE
FINE TO VERY COARSE GREENISH GREY SANDSTONE
GREENISH GREY SANDY SHALE
COARSE GRAINED GREENISH GREY SANDSTONE
GRADATIONAL CONTACT
BARAKAR FORMATION
VERTICAL SCALE IN METERS
100
200
300
400
BOREHOLE STARTED FROM THIS DEPTH
BOREHOLE CLOSED AT THIS DEPTH

Text-fig. 5

Kamthi Formation

This formation in all probability attains its full thickness in the entire Godavari Valley Coalfield where the total thickness, computed from surface and subsurface data, is of the order of 1600 m. Based on broad lithological attributes, this formation can be subdivided into three members as Lower, Middle and Upper. The generalised lithostratigraphy of this formation, partly based on surface exposures and borehole logs, is presented in Text-fig. 6.



Text-fig. 6

Lower Kamthi Member—This member forms a narrow belt in a north-northwest—south-southeast direction for a strike length of about 18 km from around Sondila (18° 46′ : 79° 33′) in the northwest to around Mahabubpalli (18° 37′ : 79° 36′) in the south-east.

It conformably succeeds the Barren Measures with a gradational contact, and comprises predominantly grey-white, frequently calcareous, medium to coarse grained sandstones with few coal seams and subordinate shales. The base is defined by a micaceous shale which is not generally exposed, but noticed in the borehole cores. Over this a calcareous sandstone bed which is seen well exposed both on the river bank of Godavari near Sondila and also at places in the area closely to the east of the bore-hole nos. 6, 15, 19, 21 and 23.

A coal seam of economic significance is recorded for the first time in this coalfield from this Lower Kamthi Member which is named as 'Sondila Seam'. It occurs about 50 to 60 m from the base of the Lower Kamthi Member. No outcrop of this seam is seen, but the projected incrop position coincides with a depression along the southern bank of the Godavari River near Sondila Village. Perhaps the sandstone with a thin band of carbonaceous shale exposed here could be the floor of the seam. Hence this seam has been named after this village as 'Sondila Seam'. The total thickness of this member is around 200 m. The detail lithostratigraphy based on representative borehole logs is presented in Text-fig. 7.

Middle Kamthi Member—This member has a larger areal extent of about 140 sq km and occurs as a wide belt extending from around Mutayala (18°46′ : 79°35′) and Mahabubpalli forming the western margin to Khanapur (18°40′ : 79°42′) and Gopalpur (18° 35′ : 79°44′) forming the eastern margin of this member.

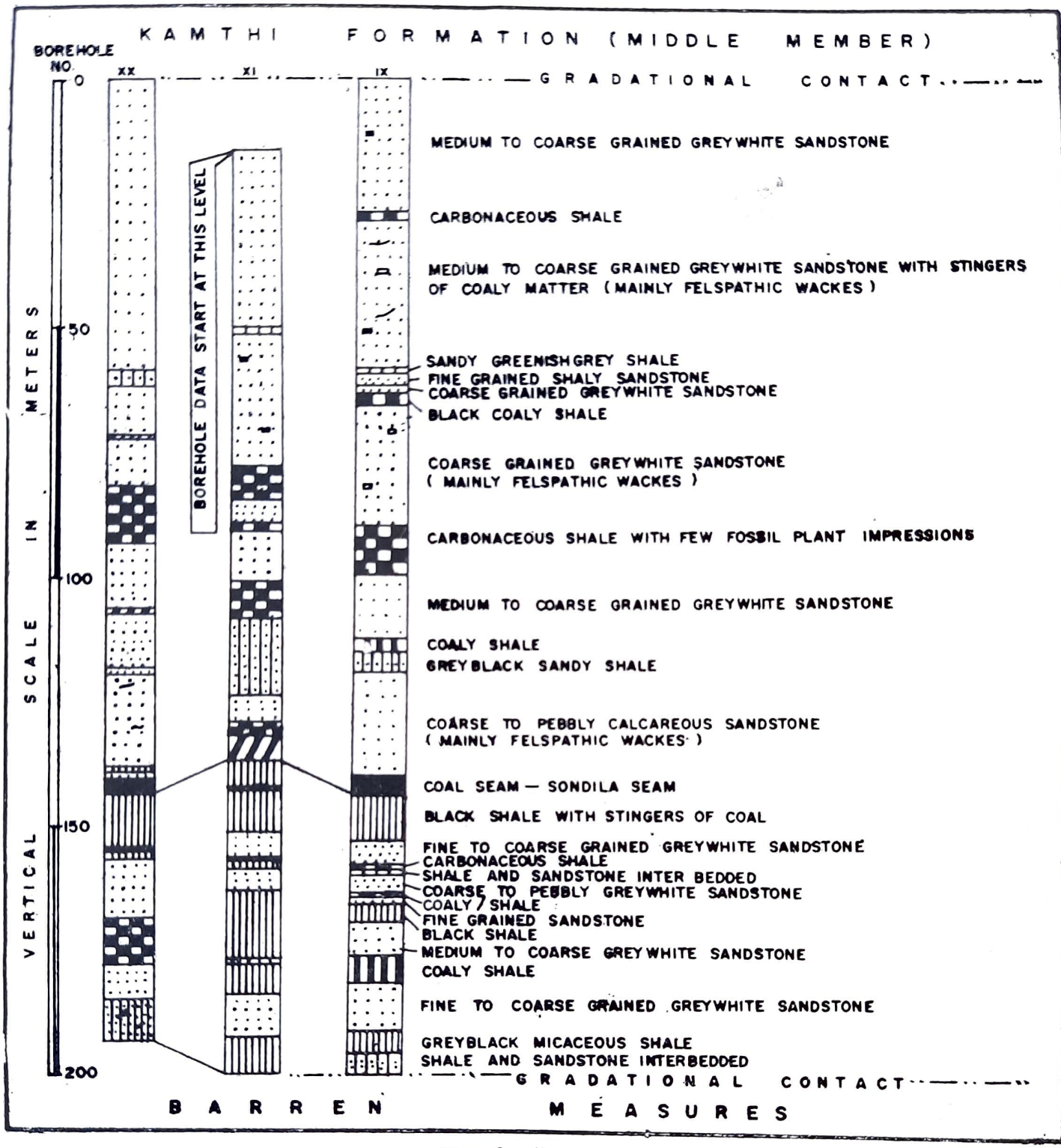
The Lower coal-bearing member grades upward on to a thick (1000 m) monotonous sequence of alternating, medium to coarse grained, grey-white to pale greenish-grey sandstones, shales and variegated clays of the Middle Kamthi Member. The sandstones and shales wear frequently a greenish tint. This member exhibits recurring fining upward cycle, which is defined by a coarse to pebbly sandstone at the base and siltstone at the top. The cyclic pattern in some cases is abbreviated or imperfectly developed. The sandstones are profusely cross-bedded which at times show convolute cross-bedding, have an erosional surface at their base. This member is remarkably devoid of carbonaceous matter. The shales/clays are characterised by the presence of few hard modules and concretions of calcareous material. One of the good section is partly exposed in the nalla about a kilometer east of Siripuram (18° 43′ : 79° 36′). Here from around junction of the Siripuram-Uppatla cart tract with the major nalla, southwards for about a kilometer, an alternating sequence of coarse grained, pale brown, friable sandstones with purple, brick-red, pale violet and grey clays are exposed. Similarly, pale green clays, deceptively looking like the clays of Talchir Formation are exposed in a nalla south of Sitampet (18° 14′ : 79° 41′) where these beds are juxtaposed with the basement rocks, due to the boundary fault. W. King (1881) mistook them for Talchir clays.

This member being essentially consisting of soft and friable beds, occupies a low country and is mostly soil covered with rare exposures.

Upper Kamthi Member—This member occupies a rectangular terrain, with an areal extent of about 100 sq km. It forms a prominent hilly terrain situated to the east of Mantheni (18° 38′ : 79° 39′) between Khanapur, Gopalpur on its western margin and Bhatpalli (18° 39′ : 79° 46′) close to its eastern margin.

It overlies the Middle Kamthi Member and rests on different units of the Middle Kamthi Member with an unconformity.

The Upper Kamthi Member is defined by a medium to coarse grained arenaceous facies, and gives rise to prominent topographic features. This member forms the hill ranges, comprising coarse grained sandstones with bands of ferrugenous sandstones



Text-fig. 7

and brick-red siltstones. The sandstones are characterised by bands of channel-lag conglomerates. They have innumerable clasts of white, violet, yellow and purple shales as well. A hard and compact violet claystone is associated with this member. The top most bed is a thick, brick red coarse argillaceous sandstone with numerous well rounded quartz pebbles of 0.5 to 6.0 cm in diameter occurring in the channel-lag conglomeratic reefs. The dark brown layers of hematite usually 0.5 to 3 cm thick are commonly found on the bedding, cross-bedding and joint planes of the sandstones. The sandstones are highly cross-bedded, being mainly planar type (large to medium size, occurring either solitary or

in sets) and at places cut-and-fill structures are also observed. Based on the strike-dip data, the thickness of this member is estimated to be around 400 m. A characteristic feature of these sandstones is the marked absence of fresh felspar grains and these fall mainly into quartzwacke type. This unit bears a close lithological similarity with the sandstones often described as 'Kamthi Formation' by Blanford and others.

Maleri Formation

The Maleri Formation succeeds the Kamthi Formation (Upper Member) conformably. Only a part of the Maleri sequence (lower part) is exposed in the area investigated, as the rest of the sequence (upper part up to the Maleri-Kota Formation junction) is located further towards dip side of the area (i.e. to the east). Based on the broad lithological attributes, the exposed Maleri sequence of this area has been divided into three lithological units, a lower, middle and upper as shown in the accompanying geological map (Text-fig. 1). Further details of this sequence are not furnished since these sediments constitutes basically a part of the Triassic stratigraphic succession, and consequently excluded from the purview of the present paper.

Palynological studies

Palynological studies of the borehole samples (Borehole nos. GGK-20 and GGK-21 and SC-1 of Mantheni area) and few surface samples (from the Middle Kamthi Member, around Mantheni, Sitampet, Jillapalli and Rangaipalli) were carried out at the Birbal Sahni Institute of Palaeobotny.

From a perusal of the miofloral assemblage data presented in Table 3, it is seen that the Barakar Formation contained a mioflora rich in *Scheuringipollenites* and subdominant *Parasaccites* while the Barren Measures is dominated by striated disaccates (chiefly *Faunipollenites*) and is associated with the characteristic occurrence of *Densipollenites*. Nonstriated disaccates of the former zone have reduced to subdominance. The Lower Kamthi Member shows declining of *Densipollenites*, which loses its significance associated with the increase in *Striatopodocarpites*, while nonstriated disaccates continue to remain subdominant. The middle part of the Middle Kamthi Member (B. H. Sample of GGK-27) is dominated by *Striatopodocarpites* and *Faunipollenites* with subdominant *Densipollenites* represents a close resemblance with the Upper Raniganj mioflora of the Damodar Valley and is in very close proximity with the Raniganj/Panchet transition. The Mantheni borehole (containing comparatively a younger sequence constituting a middle to upper part of the Middle Kamthi Member) has yielded a mioflora with dominant *Faunipollenites*, *Striatopodocarpites* and subdominant *Scheuringipollenites*, *Densipollenites* and rare *Corisaccites*, *Crescentipollenites*, *Callumispora*, *Falcisporites* and *Playfordiaspora*, etc. This suggests the frequent incoming of miofloral elements of Lower Triassic age. It is probable that these beds are in a transition zone, and above it, the Lower Triassic mioflora could be expected. Unfortunately, the surface samples of the strata younger to the Mantheni borehole sequence, (i.e. samples from Ranagaipalli, etc.) did not yield any miofloral assemblage so far (Dr. D. C. Bharadwaj & Dr S. C. Srivastava : personal communication).

From the above data it is seen that the miofloral assemblages broadly matches with the lithostratigraphic classification, and also suggestive that probably the Permo-Triassic boundary straddles through the upper part of the Middle Kamthi Member.

Table 3—Palynological data of Permian Sequence

Lithostratigraphy		Borehole No.	Depth m	Miofloral Assemblage	Equivalent Biozone in Damodar Valley
	Upper			Hill forming sandstone sequence which has not yielded any miospores Surface samples zone of Rangaipalli/Jillapalli which have proved to be barren of miospores	
Kamthi Formation	Middle	Mantheni		*Faunipollenites* + *Striatopodocarpites* dominant, *Densipollenites* subdominant *Corisaccites*, *Crescentipollenites*, *Callumispora*, *Falcisporites* and *Playfordiaspora* rare	
		GGK-27	73		Raniganj-Panchet Transition
				Striatopodocarpites + *Faunipollenites* dominant, *Densipollenites* subdominant, *Verticipollenites* + *Distriatites* + *Gondisporites*	Upper Raniganj
			558	*Faunipollenites* + *Scheuringipollenites* dominant, *Sriatopodocarpites* + *Striomonosaccites*, *Verticipollenites* subdominant	Transition
	Lower	GGK-27	675		
				Faunipollenites + *Striatopodocarpites* dominant, *Scheuringipollenites* + *Vesicaspora* + *Eupunctisporites* Subdominant	Raniganj
Barren Measures Formation			840	*Faunipollenites* + *Densipollenites* dominant	Barren Measures
Barakar Formation		GGK-20		*Scheuringipollenites* dominant *Parasaccites* subdominant	Barakar
				Parasaccites dominant with few nonstriate disaccates	Karharbari

Discussion

Earlier, the entire Lower Gondwana sediments overlying the Barakar Formation and underlying the Maleri Formation were included in the 'Kamthi Group' of William King (1881) in the Pranhita-Godavari Gondwana Basin. But the present work, based on the detail geological mapping and detail lithostratigraphy based on sub-surface borehole data,

has brought to light significant information regarding the Permian stratigraphy and also its economic potentialities (i.e. coal seams) in more detail than hitherto known.

The name 'Kamthi' was first introduced by W. T. Blanford (1872) while examining a group of rocks in the neighbourhood of the military station of Kamthi (21° 10′ : 79° 15′) near Nagpur. Initially, he has no intention to retain the name, as he thought, that evidence might be accumulated soon to identify the rocks so designated as members of the groups already established in the Damodar Valley Basin. But though the fossil plants in the Kamthi beds 'connect them with the Damudas, the mineral character of the Kamthis is at variance with that of both the Ironstone shales and the Raniganj groups' (Blanford, 1872 & T. W. H. Hughes, 1877). The Kamthi Formation was later identified in the Wardha and Godavari basins (Blanford, 1872; Hughes, 1877; W. King, 1881). Hughes considered them to be 'unconformable to Barakars overlapping them extensively but nevertheless a member of the Gondwana Series and represents in time the upper division of Damuda Series, and possibly also a portion of Panchet Formation of Bengal. It is the most extensively developed series in the field, covering a large unbroken area of several hundred square kilometers on the left side of the Wardha. It is devoid of coal.....'

Thus the Kamthi Formation or the name continued to exist because of its characteristic lithological and palaeontological attributes.

Based on the present work, it has now been possible to study the sedimentary organisation and lithological attributes of the post-Barakar and pre-Maleri Formation in more detail. The present studies have established beyond doubt, the existence of 450±50 m thick, non-coal bearing, essentially an arenaceous unit with a characteristic lithology of its own, sandwitched between two coal-bearing formations, viz., the underlying Barakar Formation and the overlying Kamthi Formation (Lower Member). Hence, this unit has been identified as Barren Measures. (Ramanamurty, B. V. 1976, 1980, 1981, 1983).

The Barren Measures conformably grade upwards into the Kamthi Formation. For descriptive purpose, the entire strata that is encompassed between the Barren Measures and the Maleri Formation (readjusted) is referred to here as 'Kamthi Formation'. It is very significant to note, that the lower member of this formation bears a striking resemblance to the Raniganj Formation of the Damodar Valley Basin while a part of the Middle and Upper members broadly resembles the Panchet sequence. In other words, the Kamthi Formation is homotaxial with the Ranigunj and Panchet formations of the Damodar Valley.

The low-rising hillocks situated between Arinda (18° 41′ : 79° 49′), Bhatpalli (18° 38′ : 79° 46′) were mapped by King as the top-most unit of the 'Kamthi Series'. These sandstones form a huge lensoid body which totally tapper to the south, where the underlying and overlying clayey units of this lensoid body merge together. Since the overlying unit is already included in the 'Maleri Series' by King, and the fact that the underlying clayey unit of these sandstons bears a close lithological similarity with the Maleri clays and merge with them in the southern part of the area, clearly places this unit as a part of the Maleri Formation (as Lower Maleri Member).

Though the Lower, Middle and Upper Kamthi members bear a broad lithological similarity with that of the Raniganj and Panchet formations the term 'Kamthi'is retained for these formations, mainly as this term has been so much ingrained in the geology of these areas and secondly the work has to be extended to the other parts of the Godavari Valley to delineate these new units, and carryout the detail supporting laboratory studies (palaentological, palaeobiological and sedimentological) for a complete stratigraphic analysis.

Conclusions

The detail lithostratigraphy of these Gondwana sediments has brought to light for the first time new finds and information regarding the Permian stratigraphy, and its economic potentialities in more detail than hitherto known. Earlier, the entire Gondwana sediments overlying the Barakar Formation and underlying the 'Maleri Group' (of King) were included in the 'Kamthi Group'. Now these have been identified and demarcated and resolved into :

(a) 450 ± 50 m thick Barren Measures overlying immediately the Barakar Formation with a gradational contact.

(b) Kamthi Formation (1600 m) overlying the Barren Measures and underlying the Maleri Formation (readjusted). The Kamthi Formation in turn has been broadly divided into a Lower (200 m), a Middle (100 m) and Upper (400 m) member.

For the first time, a workable coal seam, named as 'Sondila' seam has been found in the Lower Kamthi Member, which bears a gross lithological and palynological similarity with that of the Raniganj Formation of the Damodar Basin.

While the Middle Kamthi Member contains a thick monotonous sequence of alternating sandstones and shales/clays and Upper Kamthi Member consisting predominantly ferruginous sandstones, forms characteristic hill ranges, bearing a close lithological similarity to the oft described Kamthi sequence of the type area of the Wardha Valley and Kamthi. The Upper Kamthi Member generally overlaps the underlying Middle Kamthi Member (unconformably) on different units.

It is probable that the Permo-Triassic boundary straddles through the Middle Member of Kamthi Formation gradationally without a perceptible sedimentological break.

The upper limit of the 'Kamthi Series' of King has been readjusted. The top most sandstone ridges of 'Kamthi Group' are included in the Maleri Formation (as middle Maleri unit) and the underlying sandy clay beds are also similarly included in the Maleri Formation (as lower Maleri unit).

Thus from the foregoing presentation, it is observed that a complete stratigraphic succession of Permian age is preserved in this part of the Godavari Valley Basin, which offered a scope for a meaningful stratigraphic analysis. The chief contribution being the identification of yet another younger coal-measure (i.e. Lower Kamthi Member=Raniganj Formation of the Damodar Valley Basin), underlain by the newly identified Barren Measures. The new stratigraphic classification that is presented for the Ramagundam-Mantheni area, can have an important bearing on the problem of Gondwana classification, not only in other parts of the Godavari Valley, but equally in the other outlying Gondwana basins, especially in the Wardha Valley, and Son-Mahanadi basins, where the knowledge about the lithostratigraphic succession is still incomplete. The varied, but partly overlapping nature of the lithological, biological and chronological characters of these Gondwana sediments poses problems for fixing a proper criteria and basis for correlation. Construction of a detail lithostratigraphic succession (preferably by borehole sub-surface data) of as many a local section as possible should be the initial object and then resolve them properly on the gross lithological characters for a proper correlation with the already established type sections, as has been done in this study. This will go a long way for a meaningful stratigraphic analysis of this important coal-bearing succession.

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