"It was surely not the class consciousness of the Victorian era - its snobbish categorization of society into Lower, Middle and Upper classes - which set the pace for dividing geological systems into Lower, Middle and Upper divisions. Whatever may have been the reasons, they at least spelt disaster for the Gondwana System, which, in our opinion, cannot stand the strain of such fragmentation."

M.R. SAHNI (1963)

3

GEOLOGICAL SETTING OF THE STUDY AREA

CHAPTER 3
GEOLOGICAL SETTING OF THE STUDY AREA

GENERAL

In the preceding chapter, the regional framework of the Pranhita-Godavari basin was furnished. In this chapter the validity of applying the existing knowledge on stratigraphy of the basin to the study area and the occurrence and significance of various structural elements were examined.

STRATIGRAPHY

King's (1881) classification of Lower Gondwana was first modified by Sengupta (1970), who reported the occurrence of a new formation between Barakar and Kamthi around Bhimaram and named it as Ironstone Shales. Subsequently, Ramanamurthy (1979), from the sub-surface data from Ramagundam-Mantheni area, identified the existence of 400 m thick sequence of Barren Measures between Barakar and Kamthi formations. Raja Rao's (1982) classification of the stratigraphy of Godavari valley is similar to that of Ramanamurthy (op. cited) while the classification proposed by Raiverman, et. al., (1985) and Kutty, et. al., (1987) differ from the earlier ones. Ramanamurthy and Rao (1987, 96) presented two revised versions of Ramanamurthy's (1987) earlier classification by correlating the member of the Kamthi Formation with and naming them after their equivalents in type locality (Damodar valley). Table 3.1 furnishes the lithostratigraphic classification of Lower Gondwana sediments of Pranhita-Godavari valley proposed by various workers.

Sengupta's (1970) classification was based on the area around Bheemaram where the exposures of Barren Measures and coal bearing lower Kamthi Member are absent. Kutty et. al.'s (1987) classification on the other hand, does not recognize the formation status of Barren Measures which due to its considerable thickness (450 m, surface) and distinct lithological characteristics merits the same. Raiverman's (1985) classification of Kamthi rocks into various formations, whose names were derived from different localities where they are best exposed, is untenable, since many of these

TABLE 3.1 : STRATIGRAPHIC CORRELATION OF LOWER GONDWANA SEDIMENTS OF PRANHITA-GODAVARI BASIN.

Damodar Valley	PRANHITA-GODAVARI BASIN							AGE
	KING (1881)	SENGUPTA (1970)	KUTTY et al. (1988)	RAJA RAO (1982) RAMANAMURTHY (1987)	RAIVERMAN et al. (1985)	RAMANAMURTHY & RAO 1987	RAMANAMURTHY & RAO 1996	PRESENT STUDY
	MALERI FORMATION (Upper Gondwana)							
Supra Panchet	KAMTHI	KAMTHI: Upper Member / Middle Member / Lower Member	KAMTHI: Upper Member / Middle Member / Lower Member	KAMTHI: Upper Member	Kudderpalli /Chintalpudi; Maner	KAMTHI	KAMTHI: Upper Member	KAMTHI: Upper Member (= Mahadeva)
PANCHET	KAMTHI	NOT STUDIED: IRON STONE SHALES	INFRA KAMTHI: Lithozone 1	KAMTHI: Middle Member	Khanapur	PANCHET	KAMTHI: Lower Member	KAMTHI: Middle Member (= Panchet)
RANIGANJ	KAMTHI	NOT STUDIED	INFRA KAMTHI: Lithozone 2	KAMTHI: Middle Member	Jalpuram	RANIGANJ: Upper Member	RANIGANJ: Upper Member	KAMTHI
	KAMTHI	NOT STUDIED	INFRA KAMTHI: Lithozone 3	KAMTHI: Lower Member	Potamadugul /Ballarshah	RANIGANJ: Lower Member	RANIGANJ: Lower Member	KAMTHI: Lower Member (= Raniganj)
BARREN MEASURES	KAMTHI	NOT STUDIED	INFRA KAMTHI: Lithozone 4	BARREN MEASURES	BELLAMPALLI	BARREN MEASURES	BARREN MEASURES	BARREN MEASURES
BARAKAR	BARAKAR	NOT STUDIED	BARAKAR	BARAKAR	BARAKAR	BARAKAR	BARAKAR	BARAKAR
TALCHIR	TALCHIR	NOT STUDIED	TALCHIR	TALCHIR	TALCHIR	TALCHIR	TALCHIR	TALCHIR

formations are essentially same lithological unit with very minor variations.

The modified lithostratigraphic succession of Lower Gondwana sediments of the study area (Table 3.2 and Fig. 3.1) broadly corresponds to the lithic units established in Ramagundam-Mantheni area, south of Godavari by Ramanamurthy (1985, 1987).

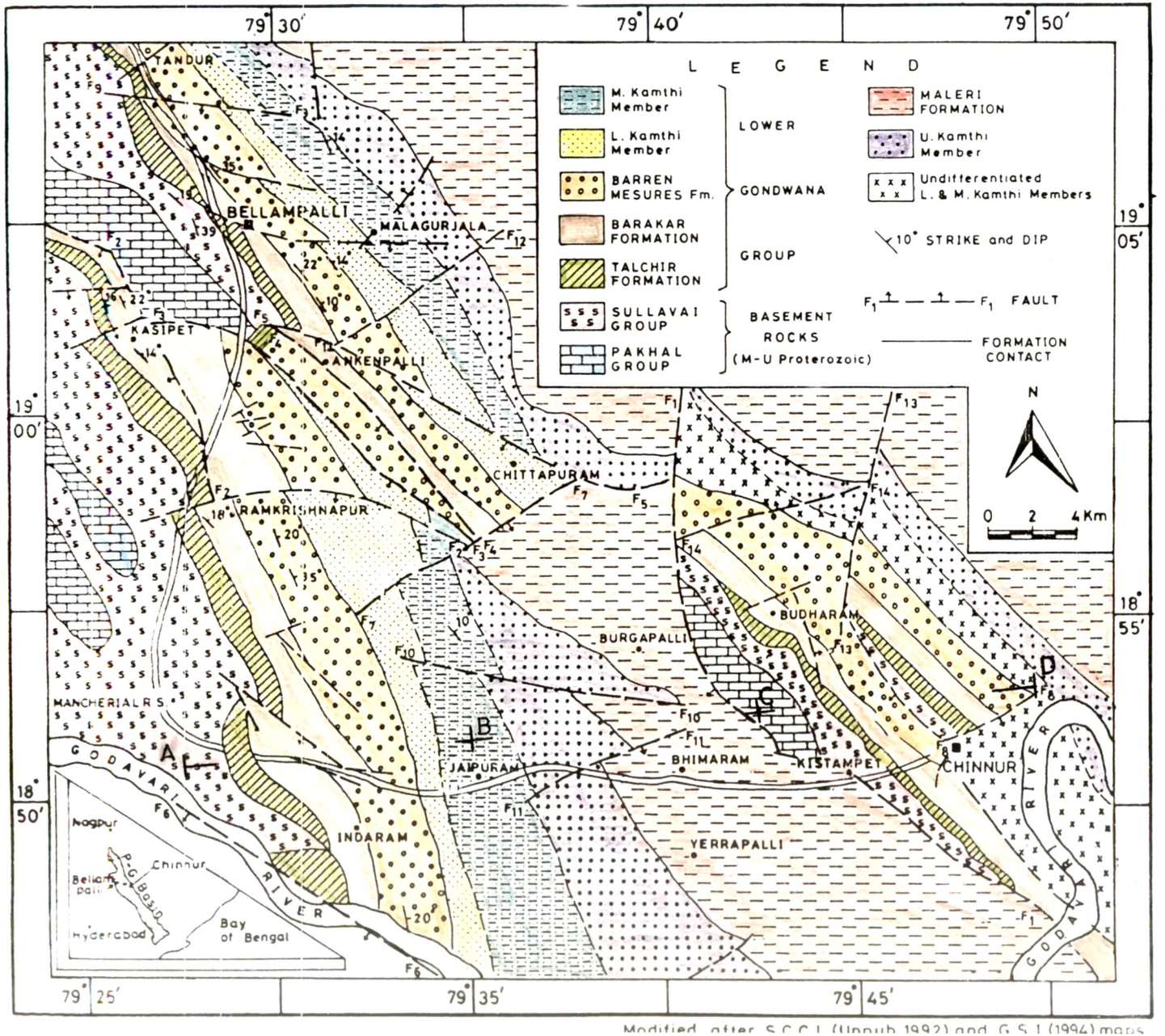
While the stratigraphic positions of Talchir, Barakar and to some extent Barren Measures find unequivocal acceptance in all the proposed lithostratigraphic classifications, status of Kamthi Formation is characterized by differing views and introduction of formation names of type section in Damodar Valley. Sengupta's (1970) and Kutty et. al.'s (1987) division of Kamthi Formation into 3 members of exclusive Triassic age does not fit into the stratigraphy of the present area. Ramanamurthy (1985, 87) divided the Kamthi Formation lithologically into 3 mappable members, assigning a lower Triassic age for the upper Member and an Upper Permian age for the Lower and Middle Members. Further, he (1987) had correlated these members with Ranigunj, Panchet and Mahadeva Formations of the type locality and subsequently (Ramanamurthy and Rao, 1987, 1996) elevated them to and renamed them after the formation of the type area.

In the study area, the Lower Kamthi Member conformably succeeds the Barren Measures with a gradational contact and comprises of medium grained greyish white argillaceous sandstones with few shaly coal seams. The Middle Kamthi Member consists of alternating sequence of medium to fine grained sandstones, shales and clays. The lower part comprises of medium grained sands and shales with a conspicuous greenish tint. Towards the top of the Middle Member, shales change to clays or mudstones with intervening beds of sandstones. Some red brown patches makes their appearance and the clays become variegated in appearance. The greenish colour of the lower part is rarer in the upper part. The clays are characterized by nodules and concretion of calcareous material. The Upper Kamthi is an arenaceous unit starting with a basal part of purple brick red coloured, very fine grained, sandstones and passing gradationally upward into a coarse to very coarse, ferrugenuous sandstones characterized by pebbles and clasts of siltstones, quartzites and bands of hematite.

TABLE 3.2 : LITHOSTRATIGRAPHIC SUCCESSION OF GONDWANA SEDIMENTS AROUND BELLAMPALLI-CHINNUR AREA, PRANHITA-GODAVARI BASIN, ANDHRA PRADESH.

AGE	SUPERGROUP	GROUP	FORMATION	LITHOLOGY
Middle to Upper Triassic	GONDWANA	UPPER GONDWANA	Maleri	Soft red mudstone and coarse buff sandstones with lime pellets and clay galls.
Lower to Middle Triassic			Kamthi	UPPER Coarse grained, ferrugenous, compact sandstones with numerous clay clast and pebbles of cherty siltstones and secondary hematitic bands at bedding planes. Basal part marked by very fine grained sandstones.
				Unconformity
Upper Permian to Early Triassic		LOWER GONDWANA		MIDDLE Alternating sequence of medium grained white to greenish grey sandstone and green calcareous clays. Upper part marked by variegated clay and calcareous nodules.
Upper Permian				LOWER Medium to coarse grained, greenish grey to grey white feldspathic sandstones with few coal seams and subordinate shales.
Middle Permian			Barren Measures	Medium to coarse grained, greenish grey to grey white feldspathic sandstones with subordinate variegated clay and micaceous siltstones.
Lower Permian			Barakar	Medium to very coarse grained grey white sandstones with subordinate shales and few workable coal seams. Lower part pebbly with few shale bands.
Basal Permian			Talchir	Fine grained sandstones, splintery green clay/shale, khaki coloured clays, pebble bed and diamictite.
				Unconformity
Upper Proterozoic	Sullavai Group			Medium to coarse grained, white to brick red sandstone, at places quartzitic and mottled shales.
				Unconformity
Middle Proterozoic	Pakhal Group			Grey shales, phillite, dolomite and marble with excellent bedding planes.

Fig. 3.1 : GEOLOGICAL MAP OF BELLAMPALLI - CHINNUR AREA, PRANHITA - GODAVARI BASIN, ANDHRA PRADESH



Modified after S.C.C.L. (Upputuri 1992) and G.S.I. (1994) maps

Now, analyzing the new classification of Ramanamurthy and Rao (1987, 1996, Table 3.1) one finds that the Permo-Triassic boundary passes through the upper part of the erstwhile (Ramanamurthy, 1985, 87) middle member of Kamthi Formation. The modifications made in Ramanamurthy and Rao's (1987, 1996) classification with respect to Ramanamurthy's earlier classification are as follows:

1. The basal coal (Sondilla seam) bearing Lower Kamthi Member has been raised to the status of formation and has been named as the Ranigunj Formation. Reason for the new name is the presence of coal seam.

2. The basal part (550 m) of the middle member is annexed to the Ranigunj Formation as its upper non-coal bearing member. They advocate the similarity in miofloral assemblage between this part and the upper part of Ranigunj Formation of Damodar Valley.

3. The remaining 450 m of the former Middle Kamthi Formation has been identified as Panchet Formation of Early Triassic age (Ramanamurthy and Rao, 1987). This renaming is based on two reasons a) 'first onset of prevalent red colour', b) 'presence of miofloral elements of Lower Triassic age'. Subsequently, the name Panchet and the status of formation status were discarded and the unit was included as a Lower member of the Kamthi Formation (Ramanamurthy, 1996).

4. The Upper Kamthi Member was raised to Kamthi Formation of Lower Triassic age. This modification is based on a) the lithological similarity with the 'Kamthi Group', described by Blanford (1871, 1872), King (1881) and Hughes (1878) and others in adjacent Wardha basin and b) on the presumption that the upper member underlies the Yerrapalli Formation which contains faunal remains of late Lower to early Middle Triassic age.

Now, in the light of author's observations, the modifications proposed by Ramanamurthy and Rao (1987) has some shortcomings in regard to lithostratigraphy.

Modification No. 1 : Although the Lower Kamthi Member is showing the

presence coal seam, it's lithology is at gross variance with that of Ranigunj Formation in Damodar Valley. In the Mohuda basin of Damodar Valley, where the Ranigunj Formation is having maximum thickness of 600 m, it's lithology is dominated by shales and siltstones. The sandstones occur mainly as lenticular bodies (Casshyap, 1980). In Pranhita-Godavari basin the Lower Kamthi Member is characterized mainly by medium to coarse sandstones with subordinate shales.

Modification No. 2 : Although palynoassemblage of lower part of the Middle Kamthi Member is similar to that of upper part of Ranigunj Formation (Srivastava and Jha, 1987), lithologically the sandstones and shales of the lower part of the Middle Member are distinct from the underlying Lower Member being more argillaceous in character, greenish in colour and devoid of coal.

Modification No. 3 : The upper part of the Middle Member has been named as Panchet Formation by Ramanamurthy (1987), because of `frequent incoming of miofloral elements of Lower Triassic age' and `first onset of prevalent red colour and calcareous nature of clays with coarse sandstones'. Here, the present author is not casting any doubt on the possible existence of the Permo-Triassic boundary at the base of the upper part of the Middle Member. Indeed, according to Srivastava and Jha (1987), decline of palynoflora Densipollenites at the top of the lower part of the Middle Member indicates a close proximity towards the Lower Triassic boundary. But, the Panchet Formation in Damodar Valley is not just red coloured calcareous clays and sandstones but is represented by a lower greenish essentially sandstone-shale facies and an upper red mudstone - sandstone facies (Dutta and Laha, 1979; De, 1979 b). In Godavari basin, more so in the study area, the alternate sequence of greenish -grey shales and sandstones of the lower part of Middle Member gradationally changes into an alternate sequence of red/brown calcareous clays and medium to coarse grained sandstones in the upper part. Thus, the whole of the Middle Member and not just the upper part, can be compared lithologically to Panchet Formation. Palynofloral assemblages, on the other hand, indicates that the Permo-Triassic boundary lies somewhere between the transition zone of the two aforesaid lithological units of the Middle Member. Thus it is not possible to split the Middle Member into two parts and compare them and to an name them as Ranigunj Formation and Panchet Formation.

Inclusion of the upper part of the erstwhile (Ramanamurthy, 1987) Middle Member into the new Kamthi Formation (Ramanamurthy and Rao 1996) as Lower member is not acceptable due to the following reasons :

- The unit is a localised one and not mappable on a regional scale.
- The arenaceous Upper Kamthi Member overlies the Middle (Ramanamurthy '1987) or Lower (Ramanamurthy & Rao,1996) members with a pronounced unconformity as indicated by its overstep nature on younger formations (Lakshminarayana, 1996; Ramanamurthy, 1987). This denotes an interruption in sedimentation and tectonic readjustments in and around the depositional regime (Sirinivasa Rao, et. al., 1979). The contact between the Lower Member and its underlying units, on the other hand, is gradational and represents an uninterrupted sedimentation (discussed in Ch-8). The Upper Member thus represents a different tectonosedimentological set up and clubbing it together with the argillaceous Lower Member within a formation on the basis of time-concept (palynological and fossil evidence) is a violation of lithostratigraphic scheme of classification.

Modification No. 4 : Raising the status of Upper Kamthi Member to Kamthi Formation of Lower Triassic age (Ramanamurthy and Rao, 1987) means that the name Kamthi now represents an integral part of Upper Gondwana Group. If the Upper Member broadly resembles the lithology of Mahadeva Formation, then why not to call it as Mahadeva Formation? The reason that Ramanamurthy and Rao (1987) gave in favour of calling the Upper Kamthi Member as a distinct Kamthi Formation is that the lithology of this member matches with the lithological description of Kamthi Group described by Blanford (1871, 1872); King (1881); and Hughes in adjacent Wardha and Mahanadi basins. But in Godavari valley `Kamthi Group' of Hughes (Op. cited), King (Op. cited) encompasses huge strata of sediments lying between Barakar and Maleri `Group' and consists of an assemblage of sediments of varying lithology and characters. On the other hand, the lithology of Upper Kamthi Member are having so close similarity with Mahadeva Formation (e.g. layers of hematitic clays and platy veins of hard dense ferrugenous matter, Krishnan, 1968), that it will be more appropriate to name it as Mahadeva Formation. The point here, is that when the two lower members are being correlated with and named according to the formations in type sections, why not the upper member is being correlated with and named after similar formation (Mahadeva) near

Pachmari which falls exclusively in Triassic ? Thus, it is not possible to bring the Kamthi stratigraphy within the framework of type section in Damodar valley.

In Damodar valley, the Raniganj-Panchet boundary which denotes a sharp lithofacies change from a coal-measure to a green-red mudstones-arkosic sandstones association is equivalent to a distinct Permo-Triassic time boundary (Mitra et. al. 1979). In other words, the lithostratigraphic boundary between the Ranigunj and Panchet Formations is synchronous with the Permian - Triassic time boundary. This isochroneity loses its perfection in Pranhita-Godavari basin where the Kamthi Formation transgresses the Permo-Triassic time horizon. As per article No.404 of code of stratigraphic nomenclature of India (1971) or article No.22e of North American Stratigraphic Code (1982), the boundaries of most stratigraphic units may transgress time horizon and time concepts do not play any part in differentiating or determining the boundaries of lithostratigraphic units. This is exactly the case in Pranhita-Godavari basin, where any attempt to bring the time concepts into lithostratigraphic classification may lead to multiplicity of names and unnecessary confusion. Although in Indian literature the terms Lower and Upper Gondwana respectively refer to Permian and Mesozoic sediments, it is observed that except, Damodar Valley, in all other Gondwana basins, the Permo-Triassic boundary straddles through the uppermost member of uppermost formation of the Lower Group.

Thus, the earlier classification of Ramanamurthy (1987) holds good in the study area also. The author has cited reasons for not adopting the later classification (Ramanamurthy and Rao, 1987, 1996) of calling the members of Kamthi Formation as Raniganj, Panchet Formations etc. It should be noted that equivalence can certainly be maintained between the Kamthi members and type locality formations but renaming the members after the stratotype formations will lead to much complexity in the stratigraphy of Kamthi sequence of rocks which has, for years, come to be known as belonging to Lower Gondwana Group of rocks of Permian Period.

STRUCTURAL SET-UP

GENERAL

A close look at the geological map of P. G. basin reveals that the surface exposures of various lithounits are controlled by structures. The major

structures observed are faults, in general normal (Fig. 3.1) but their trends are either longitudinal or transverse. Often, these faults have disposed the outcrops into various inliers and have caused repetition of beds, offsetting them into various configurations.

Although folds are not encountered within the limits of the study area, Lakshminarayana, et. al., (1992) envisaged an open type of syncline as structural setting for the deposition of Gondwana in Pasra-Venkatapuram area south-east of Chinnur. To understand the depositional environment, which is dealt with in detail in later chapter, the structural set-up of the basin is discussed below.

NATURE OF CONTACTS

In the study area, the nature of contact between the Gondwana rocks and Proterozoic basement is unconformable and not faulted. Fault controlled boundaries within the Gondwanas are found in Chittapuram-Mandamarri region where post-Kamthi normal faulting has given rise to a repetition of beds along the strike.

INLIERS

Four prominent inliers are mapped within the limits of the study area viz. two around Chinnur and two around Bellampalli. Around Chinnur (Fig.3.1) near Kistampet, the Proterozoic sediments are surrounded by Gondwanas. East of this inlier very near to Chinnur, a narrow patch of Sullavai Formation occurs sandwiched between Barren Measures in the west and Talchir in the east.

In the Bellampalli region, near Akenpalli, a narrow strip of Barakar inlier is exposed, surrounded on almost all sides by rocks of Barren Measures Formation. Near Kasipet, inlier by Pakhal rocks occurs, bordered by Barakar Formation on the south and west and Sullavai Formation on north and east.

One notable feature observed is that the western borders in all these inliers are fault controlled, whereas in the eastern borders normal stratigraphic relationship exists. The dislocation along these faults vary from one another depending on the amount of reactivation these faults have encountered during

various episodes of Gondwana sedimentation and thereafter. Hence, the present day existence of various inliers in the study area, are fully structurally controlled.

FAULTS

The Gondwana sediments in the study area exhibit northwest-southeast trending linear pattern parallel to the major lineament along Archean-Proterozoic boundary. The occurrence of more younger sediments towards the center of the area indicates that the Gondwana sediments got deposited in the structural lows already formed on the Pakhal-Sullavai basin over the Archaean basement. This may be on account of block faulting movement which has taken place prior to and during sedimentation. The sedimentary sequences in the study area have been dissected by a large number of longitudinal, transverse and oblique faults.

Longitudinal Faults

The most prominent of the longitudinal faults is the one (F_1F_1) running from Kistampet to Duba Ghutta over a length of 26 km. In the southern part near Kistampet, the trend of the fault is SE-NW which swerves to north-south direction towards north. Along this fault, the Gondwana sediments are juxtaposed against the Proterozoic rocks. The throw of the fault is towards south-west and is of the order of 2500 meters. NNW-SSE trend of this fault indicate that the fault might have a Pre-Gondwana ancestry. Its occurrence in the central part of the basin and juxtaposition of Maleri sediments against it point to the fact that major activation took place after the deposition of Upper Gondwana sediments. This is evidenced by the presence of coal bearing Barakar Formation at a much shallower depth than in the western part of the study area.

In the northwestern part of the area near Kasipet, one major NW-SE trending fault (F_2 F_2) has brought the Barakar and Barren Measures formations against the Pakhal basement.

Southeastward extension of this fault (F_2 F_2') and two other almost parallel faults (F_3 F_3 and F_4 F_4) have resulted in repetition of beds in

Chittapuram - Akenpalli - Ramkrishnapur region. In the extreme south-west, the study area is delimited by Godavari fault (F_6 F_6) which runs parallel to the river for a length of 22 km. Southeasterly extension of this fault can be traced to the central part of the basin where it marks the contact between Maleri and Kamthi formations (Lakshminarayana, 1996).

Transverse faults

The transverse faults are oriented in E-W to NE-SW direction. Two major transverse faults are Chittpuram-Ramakrishnapuram fault (F_7 F_7) and Chinnur fault (F_8 F_8). In the first case, the Maleri sediments are juxtaposed against Barakar, Barren Measures and Kamthi formations while in the second case, the Kamthi sediments are abutting against the rocks of Sullavai, Talchir, Barakar and Barren Measures formations. Near Chittapuram (F_5 F_5) Tandur (F_9 F_9) Bhimaram, (F_{11} F_{11}), Burgapalli (F_{10} F_{10}), Budharam (F_{14} F_{14}, F_{13} F_{13}) and Akenpalli (F_{12} F_{12}) the transverse faults have caused lateral shifting in the strike of the lithounits.

In the study area, most of the longitudinal faults are extension related type. Cross-section (Fig. 3.2) across the study area, and the nature of movements of the blocks along the longitudinal faults point to the fact that strecting on NE-SW directions created normal extension faults. This is evidenced from the uniform lithology or continuity of any units encountered across the basin, though they are separated by the older Proterozoic sediments. It might be possible that the extension of the crust on account of the tension has been accommodated by sedimentaries during the Gondwana time. However, along the western margin the rocks of Talchir Formation show en-echelon faulting pattern with respect to Sullavai rocks of Proterozoic age. It is difficult to determine the exact ages of the faults, but since they are transecting almost all the formations, it can be said that the faults are post-Maleri in age and/or might be reactivated during post-Maleri times.

According to Chetty (1996) it can be said that transpressional tectonics in the form dextral strike slip regime that dominated the late stage collisional processes during the evolution of Eastern Ghat Granulite Terrain was responsible for the successive development of block faulted troughs and complexities of fault-patterns in the Pranhita-Godavari Gondwana basin.

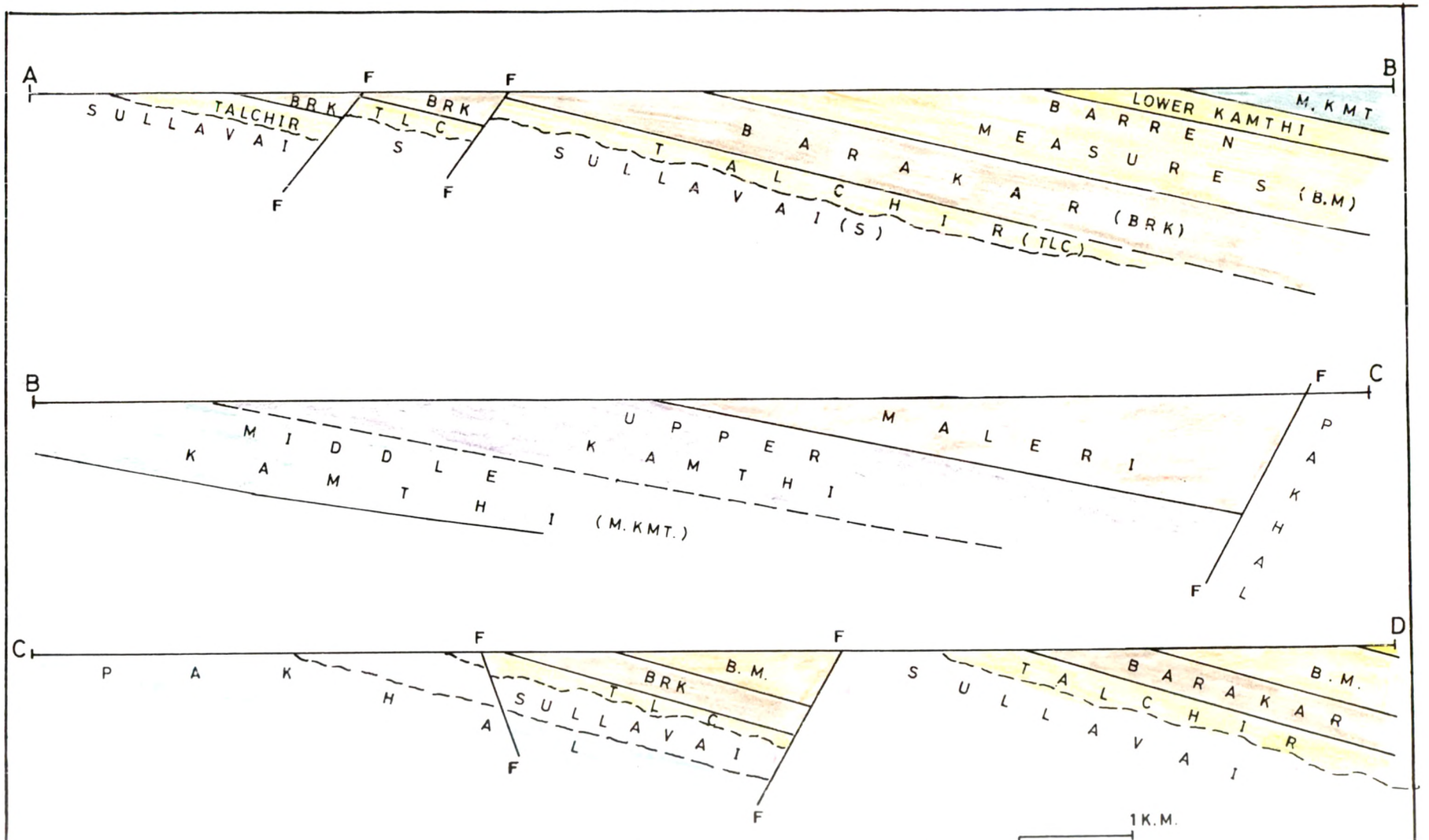


Fig.3.2 : Geological cross-sections of Gondwana formations along Mancherial - Chinnur profile.
(For A-B-C-D profile, pl. refer Fig.3.1)