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Palynology of Kamthi Formation in Godavari Graben

Suresh C. Srivastava & Neerja Jha

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Five palynological assemblages have been recognised in the Kamthi Formation of Godavari Graben. The assemblages are characterised by overall abundance of striate-disaccate pollen. The associated palynofossils, however, distinguish the palynoassemblages at various levels of the formation. The Lower Member containing coal seams shows unequivocal resemblance with the Raniganj palynoflora of Damodar Valley and Son-Mahanadi coalfields. Distinct change in lithology at the beginning of the Middle Member is marked by the appearance of *Parasaccites* rich assemblage simulating a cooling phase akin to that observed during the Talchir period. The younger sediments of the Middle Member contain *Corisaccites-Guttulapollenites* Assemblage and *Densipollenites* Assemblage in order of succession representing the uppermost Permian palynoflora in Godavari Graben. The youngest assemblage also indicates a close proximity to the Permian-Triassic transition, thus making the Kamthi Formation a time transgressive unit.

Key-words—Palynology, Kamthi Formation, Raniganj Formation, Permian/Triassic Boundary, Godavari Graben (India).

Suresh C. Srivastava & Neerja Jha, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

सारांश

गोदावरी द्रोणिका में कामथी शैल-समूह का परागाणविक अध्ययन

सुरेश चन्द्र श्रीवास्तव एवं नीरजा झा

गोदावरी द्रोणिका के कामथी शैल-समूह में पाँच परागाणविक समुच्चय बनाये गये हैं। ये समुच्चय रेखीय-द्विकोष्ठीय परागकणों की बाहुल्यता से अभिलक्षणित हैं। सहयुक्त अश्मित परागकण शैल-समूह के विभिन्न स्तरों पर विद्यमान परागाणविक समुच्चयों को विभाजित करते हैं। कोयला-सीमों से युक्त अधरि सदस्य सोन-महानदी कोयला-क्षेत्रों एवं दामोदर घाटी के रानीगंज परागाणुवनस्पतिजात से स्पष्ट समानता व्यक्त करता है। मध्य सदस्य के प्रारंभ में शैल-विन्यास में सुव्यक्त परिवर्तन **पैरासेक्काइटिस** से प्रभावी समुच्चय की उपस्थिति का द्योतक है जो कि तालचिर काल में प्रेक्षित शीतलन अवस्था से हर प्रकार से मिलता है। मध्य सदस्य के अल्पायु वाले अवसादों में **कोरिसेक्काइटिस-गुट्टुलापोलिनाइटिस** समुच्चय तथा **डेन्सीपोलिनाइटिस** समुच्चय आरोही क्रम में विद्यमान हैं जिससे गोदावरी द्रोणिका में उपरितम् परमी युगीन वनस्पतिजात की उपस्थिति इंगित होती है। अल्पतम् आयु वाली समुच्चय भी परमी-त्रिसंधी परिवर्तन से घनिष्ठता इंगित करती है जिससे कि कामथी शैल-समूह का स्वरूप एक उत्क्रमी इकाई के रूप में सामने उभर कर आता है।

SEDIMENTS overlying the Barakar Formation and underlying the Maleri Formation in the Godavari Graben were earlier included within the Kamthi ormation (King, 1881). After the identification of Barren-Measures Formation in Bheemaram area (Sengupta, 1970) and Ramagundam area (Ramanamurty, 1979), the strata occurring between the Barren-Measures and Maleri Formation are referred to the Kamthi Formation (*sensu* Ramanamurty, 1985).

KamthiFormation is spread over a vast tract of Godavari Graben (Map 1) and exhibits significant lateral and vertical variation in lithofacies. The formation attains maximum thickness around

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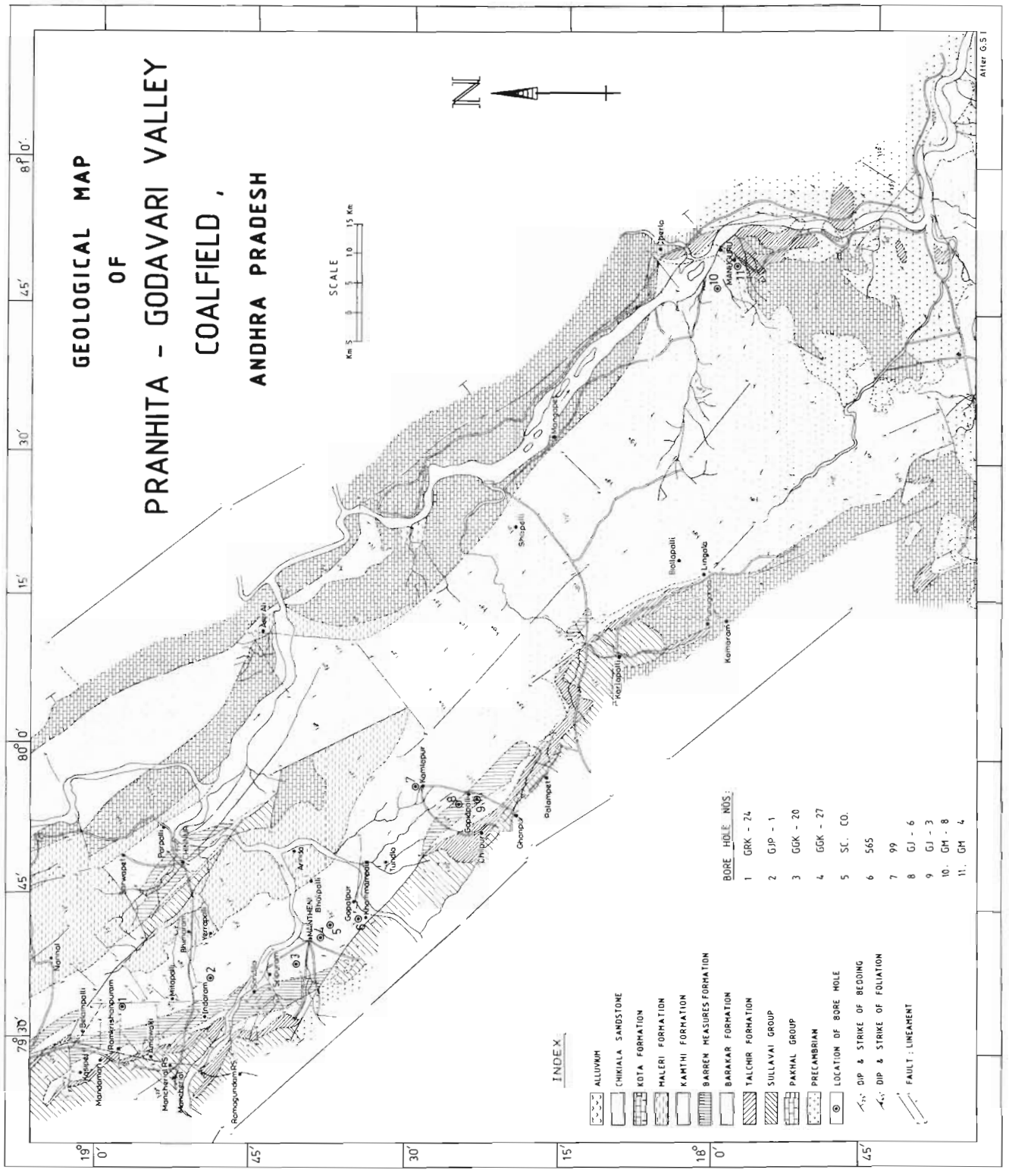


Map 1—Geological map of Pranhita-Godavari Graben, Andhra Pradesh.

Ramagundam and Mantheni areas. It has been divided into: (i) the Lower Member, consisting of greyish white, medium-grained, calcareous sandstones and a few coal seams; (ii) the Middle Member, marked by alternating sequence of medium-grained grey white sandstones, shales and variegated clays; and (iii) the Upper Member, comprising coarse-grained arenaceous facies incorporating coarse-grained ferruginous sandstones and brick-red siltstones. This member forms important topographic features in the Godavari Graben. The contact between the underlying Barren Measures and Lower Member of KamthiFormation is gradational and so also is the case between Lower and Middle members. The Middle Member is totally devoid of coal seams and the sandstone and shales bear a greenish tint and underlies the Upper Member with an unconformity.

The samples investigated have been obtained from following areas (Map 1).

1. Ramkrishnapuram —B. H. no. GRK-24
2. Jaipuram —B. H. no. GJP-1
3. Mantheni —S. C. Co. bore hole
4. Khammampalli —B. H. no. 565
5. Bhopalpalli —B. H. no. GJ-6
6. Kamalpur —B. H. no. 99
7. Manuguru —B. H. nos. GM-4 and GM-8

In addition, data from following three bore-holes have been incorporated (Bharadwaj *et al.*, 1987).

1. B. H. no. GGK-20 Ramagundam-Mantheni area
2. B. H. no. GGK-27
3. B. H. no. GJ-3 Chelpur area

PALYNOLOGICAL ASSEMBLAGES

The palynological investigations have led to recognition of five assemblages based on their morphographic characters and also quantitative representation. The distribution of various palynotaxa within the Kamthi Formation has been shown in Text-figure 1.

Assemblage 1

Faunipollenites-Striatopodocarpites Assemblage—This assemblage is characterised by dominance of striate-disaccate pollen chiefly represented by *Faunipollenites* and *Striatopodocarpites. Scheuringipollenites*, a nonstriate-disaccate, is a subdominant element. The presence of some other striate-disaccate genera is significant, viz., *Verticipollenites, Labirites, Hindipollenites, Crescentipollenites, Distriatites,* etc. Taeniate pollen *Lunatisporites,, Hamiapollenites, Corisaccites, Lueckisporites* occur in rare amounts and their behaviour is inconsistent. Nonstriate-disaccate pollen *Alisporites, Falcisporites, Vitreisporites* and *Chordasporites* also behave like taeniate-disaccate pollen grains. The percentage of trilete spores is comparatively low but the occurrence is fairly consistent. They are represented by *Horriditriletes, Brevitriletes, Verrucosisporites,, Gondisporites*, etc.

The *Faunipollenites-Striatopodocarpites* Assemblage is lithologically associated with the Lower Member and has been recorded in bore-holes GRK-24, GGK-20, GGK-27, GJ-3, GJ-6, GM-4 and GM-8 (Text-fig. 2).

Assemblage 2

Faunipollenites-Striasulcites Assemblage—The dominance of striate-disaccate pollen remains similar as in the preceding assemblage. However, *Scheuringipollenites* gives way to the genus *Striasulcites* which is restricted to the present assemblage only. Further, *Densipollenites* also appears simultaneously but remains low in percentage. *Falcisporites, Vitreisporites, Vesicaspora*, etc. remain impersistent. Though the percentage of trilete spores declines, yet the occurrence of *Gondisporites, Polypodiidites, Osmundacidites*, etc. is significant.

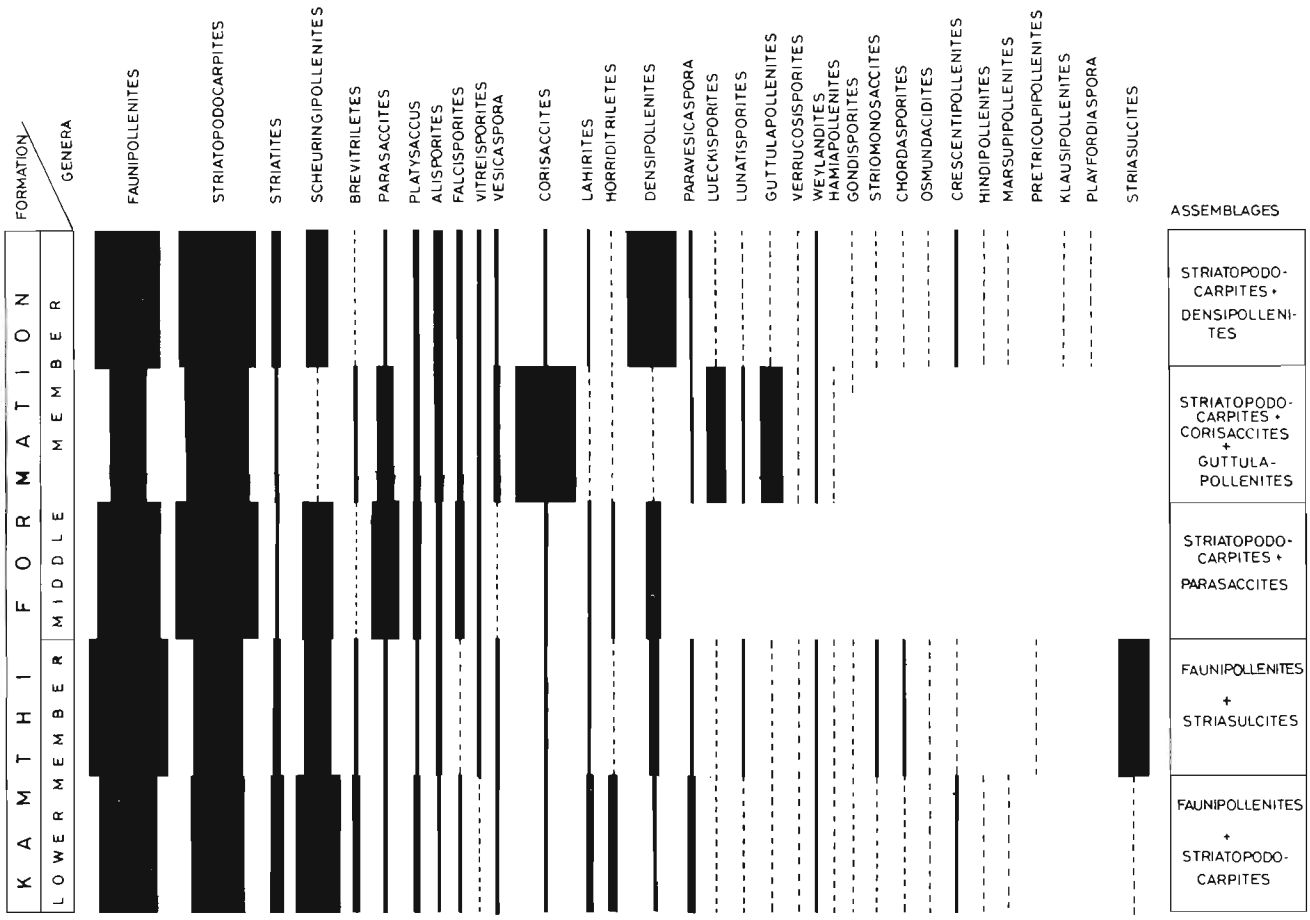
The *Faunipollenites-Striasulcites* Assemblage is well-developed in bore-hole GGK-27 between 580-385 m which marks the lower part of the Middle Member (Text-fig. 2), in bore-hole 565 between 202.25-203.75 m in carbonaceous clayey shale, in bore-hole GM-4 at 170 m in a grey clay overlying a coal band and in bore-hole GM-8 at 95-84 m.

Assemblage 3

Striatopodocarpites-Parasaccites Assemblage—In bore-hole GJ-6 (210-20 m) *Striatopodocarpites* maintains overall dominance and is followed by *Faunipollenites* (Text-fig. 2). *Parasaccites* assumes subdominance, next to the striate-disaccate pollen grains. *Densipollenites, Corisaccites* and *Guttulapollenites* occur in low percentages. The other taeniate disaccate genera are not as well represented. The trilete spores are rare. *Falcisporites, Vitreisporites*, etc. occur only sporadically. This assemblage is associated with sandy black shale, grey black shale and green sandstones and thus, occurs at the end of the coal-bearing sequence.

Assemblage 4

Striatopodocarpites - Corisaccites - Guttulapollenites Assemblage—The dominance of striate-disaccate pollen continues unabatedly in younger sediments (Middle Member). *Densipollenites* tends to increase comparatively but remains low.



Text-figure 1—Succession of various palynological assemblages in Godavari Grabven.

Corisaccites and *Guttulapollenites* together increase to subdominance, the former being more in number. *Lueckisporites* is also represented in significant percentages. *Lunatisporites, Falcisporites, Vitreisporites* appear regularly but in low percentages. In bore-hole GJP-1 (Text-fig. 2) *Corisaccites* reaches its maximum at 276 m and is associated with *Guttulapollenites* and *Parasaccites.* Towards north, in bore-hole GRK-24, this assemblage continues between 121-4-127.00 m. In bore-hole GGK-27, *Corisaccites* occurs between 334-241 m but is in low amounts while *Guttulapollenites* is almost absent. In other areas this assemblage is very poorly represented.

Assemblage 5

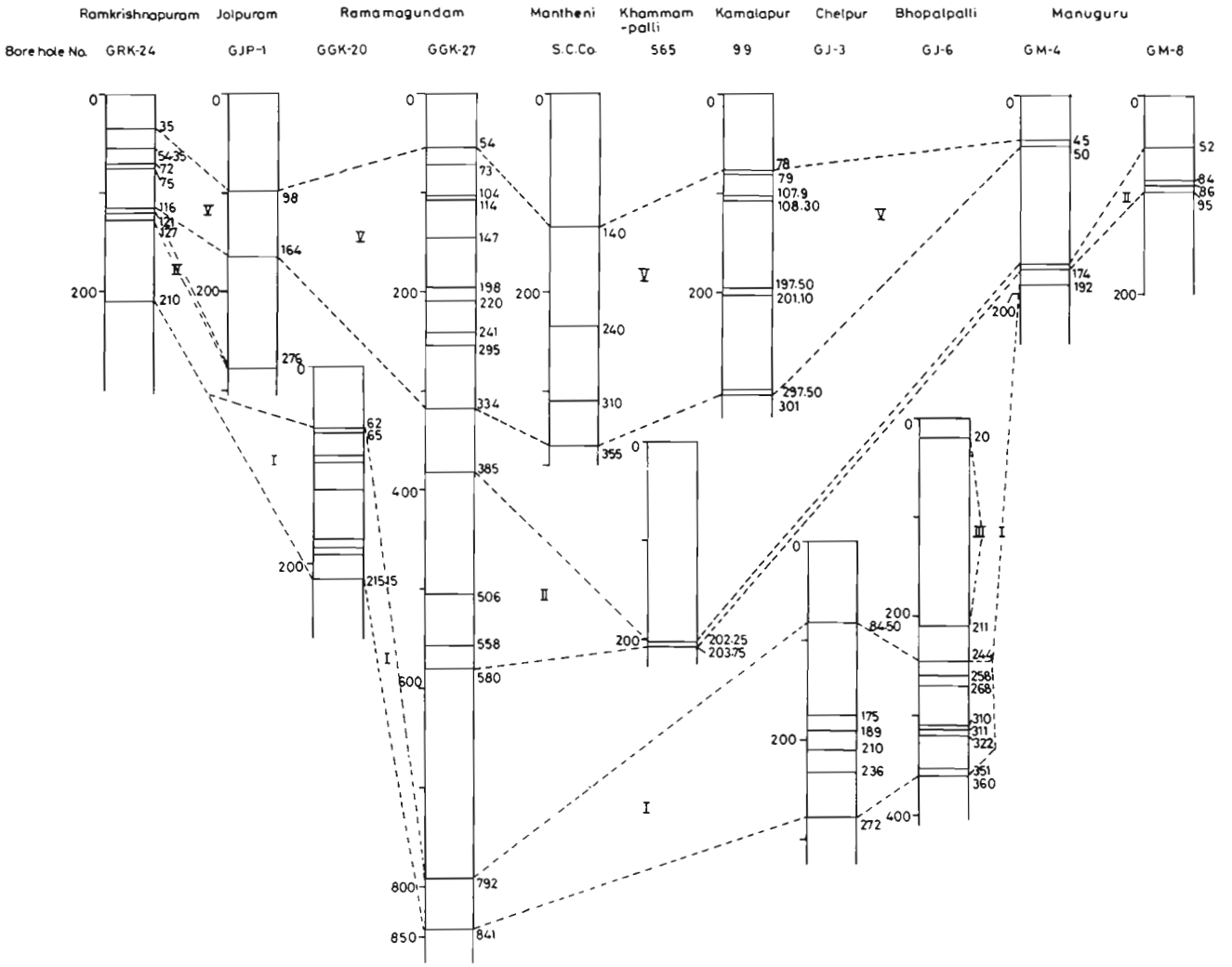
Striatopodocarpites-Densipollenites Assemblage—This assemblage is fairly well-represented in almost all the areas investigated. The sediments overlying the *Striatopodocarpites-Corisaccites-Guttulapollenites* Assemblage are characterised by a significant rise in the representation of the genus *Densipollenites.*

This assemblage succeeds *Striatopodocarpites-Corisaccites* Assemblage in bore-hole GRK-24 (116-35.95 m) and bore-hole GJP-1 (164.98 m). *Weylandites* shows a rising trend in bore-hole GRK-24. In bore-hole GGK-27 (222-54 m) *Densipollenites* records a perfect epibole and reaches overall dominance between 198-147 m. In other areas also *Densipollenites* has been observed to be closely associated with striate-disaccate pollen.

COMPARISON

A number of palynofloras described from other Lower Gondwana coalfields of India resemble one level or the other in the Kamthi Formation of Godavari Graben and their related stratigraphic comparability has also been summarised in Table 1.

Assemblage 1 closely compares with the palynological succession in Raniganj Formation of Damodar Valley (Bharadwaj & Tiwari, 1977; Bharadwaj, Tiwari & Anand-Prakash, 1979). The overall dominance of striate-disaccate genera continues throughout the entire succession.



Text-figure 2—Palynological correlation of assemblages in different bore-holes of Godavari Graben. V *Striatopodocarpites* + *Densipollenites*; IV *Striatopodocarpites* + *Corisaccites* + *Guttulapollenites*; III *Striatopodocarpites* + *Parasaccites*; II *Faunipollenites* + *Striasulcites*; I *Faunipollenites* + *Striatopodocarpites*.

However, *Indospora* and *Spinosporites* present, though in rare amounts, in Raniganj sediments of Damodar Valley have not been observed so far in the Kamthi sediments.

The palynoflora of the Jhingurdah Seam in Singrauli Coalfield (Tiwari & Srivastava, 1984) also compares closely in view of preponderance of striate-disaccate pollen grains. The trilete spores are, however, more frequent in Jhingurdah Seam which also has *Indospora* and *Kendosporites*.

The palynoflora of Raniganj Formation in Auranga Coalfield (Lele & Srivastava, 1979) has a preponderance of striate-disaccate pollen grains, but the percentage of trilete spores is relatively more. urther, *Mahudapollenites* and *Mammialetes* are absent in Assemblage 1.

An assemblage comparable to *Faunipollenites-Striasulcites* Assemblage is not known from any other basin except for the *Striasulcites* rich assemblage from Koel River Section in Hutar Coalfield (Shukla, 1983) which also has *Potonieisporites, Scheuringipollenites* and *Faunipollenites*. *Potonieisporites* is not present in this palynoassemblage of Godavari Graben. In addition, the genera *Gondisporites, Polypodiidites, Osmundacidites, Corisaccites, Guttulapollenites, Alisporites, Vitreisporites, Falcisporites, Weylandites* that occur regularly though in low percentages are absent in Hutar palynoassemblage.

Striatopodocarpites-Parasaccites Assemblage is also being first recorded from the Godavari Graben. In the Raniganj Formation of Damodar Valley, *Parasaccites* is present in *Striatopodocarpites-Densipollenites* Assemblage (Bore-hole RAD-5; Tiwari & Singh, 1983) but the percentage of this genus remains low.

Striatopodocarpites-Corisaccites Assemblage is comparable with a similar assemblage reported from

Table 1—Stratigraphic relationship of different palynoassemblages in Permian basins of India

Assemblages	Areas	*RANIGANJ COALFIELD*			North Karanpura Coalfield	Rajmahal Basin	*SON VALLEY*		Auranga Coalfield
		South of Damodar River	North of Damodar River	Ondal Area			Singrauli Coalfield	Gopad River	
STRIATOPODOCARPITES	*Densipollenites*	Bharadwaj *et al.* (1979) Machhkanda Jhor Section Section A—Grey Shale *Striatopodocarpites Densipollenites*	Bharadwaj *et al.* (1979) Nonia Nala Section—Grey Shale, Laminated Shale, Carbonaceous Shale Nonia Khal Section Carbonaceous Shale Banerji & Maheshwari (1975) Nonia Nala Section Grey Shale *Striatopodocarpites + Densipollenites*			Tiwari & Tripathi (1984) Lower part of Dubrajpur Formation		Maheshwari (1977) Carbonaceous Shale *Striatopodocarpites + Densipollenites*	
FAUNIPOLLENITES	*Corisaccites Guttulapollenites*								
	Parasaccites								
	Striasulcites								
	Striatopodocarpites	Bharadwaj *et al.* (1979) Machhkanda Jhor Section A—Carbonaceous Shale, Coal Section B—Carbonaceous Shale, Khaki Shāle *Striatopodocarpites+ Faunipollenites*	Bharadwaj *et al.* (1979) Nonia Nala Section Carbonaceous Shale, Coal *Striatopodocarpites Faunipollenites*	Kar (1970) B.H. RE9 Carbonaceous Shale, Lower Assemblage B.H.RN9 Carbonaceous Shale *Faunipollenites Striatopodocarpites*	Bharadwaj *et al.* (1979) Horam Sibadih Section Carbonaceous Shale *Striatopodocarpites + Faunipollenites*		Tiwari & Srivastava (1984) Jhingurdah Seam *Faunipollenites Striatopodocarpites*		Lele & Srivastava (1979) Sukri River Carbonaceous shale *Faunipollenites + Brevitriletes*

Contd.

Table 1 (*Contd.*)

Lesser Himalaya	Tethyan Himalaya	Satpura Basin	*GODAVARI GRABEN (Present investigation)*						
			Ramkrishanpuram	Ramagundam	Chelpur	Bhopalpalli	Kamalapur	Khammampalli	Manuguru
Tiwari & Kumar (1986) Amkhal Formation *Striatopodocarpites + Densipollenites*	Tiwari *et al.* (1984) Malla Johar, Kuling Shale *Striatopodocarpites + Densipollenites*	Bharadwaj *et al.* (1978) Bijori Formation *Striatopodocarpites + Densipollenites*	*Striatopodocarpites + Densipollenites*	*Striatopodocarpites + Densipollenites*		*Striatopodocarpites + Densipollenites*	*Striatopodocarpites + Densipollenites*		*Striatopodocarpites + Densipollenites*
		Striatopodocarpites + Guttulapollenites + Corisaccites	*Striatopodocarpites + Corisaccites + Guttulapollenites*	*Striatopodocarpites + Corisaccites + Guttulapollenites*					
						Striatopodocarpites + Parasaccites			
				Faunipollenites + Striasulcites				*Faunipollenites + Striatopodocarpites + Striasulcites*	*Faunipollenites + Striasulcites*
			Faunipollenites Striatopodocarpites	*Faunipollenites Striatopodocarpites*	*Faunipollenites Striatopodocarpites*	*Faunipollenites + Striatopodocarpites*			*Faunipollenites + Striatopodocarpites*

Table 2—Stratigraphic status of Kamthi Formation in Godavari Graben

AGE	DAMODAR VALLEY	GODAVARI GRABEN							
	G.S.I. (1977)	King (1881)	Sengupta (1970)		Kutty et.al.(1987)		G.S.I. (1882)		Raiverman et al. (1985)
TRIASSIC	PANCHET	UPPER GONDWANA							
PERMIAN	RANIGANJ	KAMTHI	KAMTHI	UPPER MEMBER	KAMTHI	UPPER MEMBER	KAMTHI	UPPER MEMBER	KUDUREPALLI / CHINTALPUDI
				MIDDLE MEMBER		MIDDLE MEMBER			MANER
				LOWER MEMBER		LOWER MEMBER			
			IRON STONE SHALES		INFRA KAMTHI	LITHOZONE - 4		MIDDLE MEMBER	KHANAPUR
			BARAKAR			LITHOZONE - 3			JAIPURAM
						LITHOZONE - 2		LOWER MEMBER	POTAMADUGU / BALHARSHAH
	BARREN MEASURES					LITHOZONE - 1	BARREN MEASURES		BELLAMPALLI
	BARAKAR	BARAKAR			BARAKAR		BARAKAR		BARAKAR
	TALCHIR	TALCHIR	TALCHIR		TALCHIR		TALCHIR		TALCHIR

the Bijori (Sukhtawa) Formation in Satpura Basin (Bharadwaj *et al.*, 1978). *Corisaccites-Guttulapollenites* occupy a third place in the order of dominance in Satpura Basin but in Godavari Graben this pollen-complex assumes overall dominance.

Striatopodocarpites, Densipollenites Assemblage is fairly well distributed in Damodar Valley, Singrauli and Auranga coalfields and Satpura Basin. In Damodar Valley this assemblage is present in the Late Permian (Tiwari & Singh, 1983) and continues up to the base of the Lower Triassic. In Satpura Basin, *Densipollenites* rises to dominance near the top of the Bijori Formation succeeding the *Corisaccites* rich assemblage (Bharadwaj *et al.*, 1978).

The striate-disaccate rich assemblage associated with *Densipollenites* from Gopad River Section (Maheshwari, 1967) resembles Assemblage 5. The palynoassemblages described from the lower part of the Dubrajpur Formation in Rajmahal Basin (Tiwari & Tripathi, 1984), the Kuling Shale in the Malla Johar area, Kumaon Himalaya (Tiwari *et al.*, 1984), and the Amkhal Formation in the Lesser Himalaya of Tehri Garhwal District (Tiwari & Kumar, 1986) contain a large number of taxa found in *Striatopodocarpites-Densipollenites* Assemblage and thus bear a qualitative resemblance.

DISCUSSION

Raiverman, Rao and Pal (1985) have reviewed the entire geological succession in Pranhita-Godavari Graben and have provided a new classification on the basis of photogeological techniques and detailed geological field mapping. They have raised the status of Kamthi to a group and divided it into five formations. Their correlation with earlier classification schemes is shown in Table 2. Kutty *et al.* (1988) have restricted the limits of the Kamthi Formation as equivalent to the Upper Member of the Kamthi Formation only. However, in the present investigation the classification in vogue by the Geological Survey of India (Raja Rao, 1982) has been followed. The non-coal-bearing predominantly arenaceous sequence of Barren Measures conformably grades into the coal-bearing Lower Kamthi Member. However, the palynological assemblage changes from the *Densipollenites* rich assemblage of Barren Measures to *Faunipollenites-Striatopodocarpites* rich assemblage with near absence of *Densipollenites* of Lower Kamthi Member. The appearance of *Gondisporites, Falcisporites, Vitreisporites, Corisaccites, Lunatisporites, Weylandites*, etc. though in rare amounts, nevertheless indicates a younger affinity being characteristic of the Raniganj and Panchet assemblages in Damodar Valley. Thus, the palynoflora of the lower part of the Raniganj Formation appears almost coeval with that of the Lower Member of Kamthi Formation. The *Faunipollenites-Striasulcites* Assemblage is associated with coal seams in Manuguru area, but in Ramagundam area it is recorded above the coal-bearing horizon in the beginning of Middle Member.

The sediments between 792-580 m in bore-hole GRK-27, which include the transition from Lower to Middle Member, have not yielded pollen and spores hence it is difficult to comment on the exact stratigraphic status of *Striasulcites* but from the present evidences it appears that the *Striasulcites* assemblage reached its peak at the end of coal-forming phase. The sedimentation of the Lower Member appears to have commenced in a prevailing fluvial environment in relatively deep and narrow to straight sinuous channels. A warm and humid climate seems to have provided a luxurient growth of gymnosperms and pteridophyte which have contributed largely to the coal formation.

The incoming of *Parasaccites* at the base of the Middle Member coupled with the greenish sandstone and shales is significant as it marks the culmination of coal-forming phase. *Parasaccites* is known to have been associated with glacial and cold climate in the Lower Gondwana Sequence and hence a similar cooling though short-lived is envisaged to have been the cause of culmination of coal forming process in the Godavari Graben. *Densipollenites* commencing after the *Parasaccites* phase, continued up to the middle part of the Middle Member which is comparable with the coal-less Barren Measures, denoting a comparative aridity in the climate.

The *Striatopodocarpites-Densipollenites* Assemblage continues up to the top of the Raniganj Formation (Upper Permian) and is succeeded by the cavate-cingulate-taeniate rich assemblage of the Panchet Formation (Lower Triassic, Tiwari & Singh, 1983). In the Godavari Graben epibolic development of *Striatopodocarpites-Densipollenites* Assemblage is noticed within the lower 334 m of the Middle Member in Ramagundam area. The decline of *Densipollenites* is recorded at the top of the sequence indicating a close proximity towards the Lower Triassic boundary. There is every likelihood that the Permian-Triassic boundary lies within the upper part of the Middle Member. Lithologically also the sandstones and shales of this Member are distinct from the underlying Lower Member being greenish in colour and devoid of coal. Some pale-green clays, apparently looking like Talchir needle shales (King, 1881) are exposed around Sitampet. Similar shales are also exposed near Rangaipalli and Jillapalli villages in shallow wells. These khaki green shales which are apparently younger than the Middle Member of Ramagundam-Mantheni area may infact prove to be equivalent to the Panchet Formation.

Evidences indicate that the Lower Member containing coal seams is equivalent to the lower part of the Raniganj Formation of Damodar Valley while the lower part of the Middle Member corresponds to the upper part of the Raniganj Formation and the Bijori Formation in Satpura Basin. The Lower Triassic equivalent palynoflora is expected within the upper part of the unexplored Middle Member. In other words, the Kamthi Formation is time-transgressive palynologically, ranging in age from Upper Permian to ?Triassic.

CONCLUSION

Five palynological assemblages can be recognised in the Kamthi Formation of the Godavari Graben. Assemblage 1 from the Lower Member shows a uniform similarity with Raniganj palynoassemblage of Damodar and Son-Mahanadi grabens. This assemblage is associated with the coal-bearing sediments of the Raniganj Formation. The lithological changes at the base of Middle Member are associated with the appearance of *Striatopodocarpites-Parasaccites* rich assemblage (Assemblage 3). These changes together document an intensive cooling phase, though restricted, simulating the one observed during Talchir Formation. The younger palynological assemblages (Assemblages 4 and 5) are more closer to the palynological succession observed in Satpura Basin and Salt Range, Pakistan. *Densipollenites* rich assemblage in Godavari Graben declines within the Middle Kamthi Member and a larger part of the sequence yet remains to be explored palynologically. The Permian-Triassic boundary is expected within the Middle Kamthi Member.

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