

Upper Jurassic—Lower Cretaceous spore-pollen assemblages in the peninsular India

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The Upper Jurassic-Lower Cretaceous spore-pollen assemblages recovered from the 'Upper Gondwana' sediments in the western, central, southern and eastern parts of the country have been reviewed. Palaeontological geological, tectonic and environmental evidences have been used for reinterpretation of palynological data. Stratigraphically important palynotaxa have been identified. The occurrence of continental Jurassic assemblages has not been considered authentic. The usage of term 'Gondwana' for continental as well as paralic sediments has been questioned. Distribution of some significant Gondwanic elements has been highlighted.

Key-words—Palynology, Stratigraphy, Upper Gondwana, Upper Jurassic, Lower Cretaceous, Peninsular India.

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सारांश

प्रायद्वीपीय भारत में उपरि जूराई-अधरि क्रीटेशी परागकण-बीजाणु समुच्चय

हरिपाल सिंह एवं बेंगलूर श्रीनिवासा वेकटाचाला

देश के पश्चिमी, मध्य, दक्षिणी एवं पूर्वी भागों में उपरि गोंडवाना अवसादों से उपलब्ध उपरि जूराई-अधरि क्रीटेशी बीजाणु-परागकण समुच्चयों का पुनरीक्षण किया गया है। पुरातात्विक, भूवैज्ञानिक, विवर्तनिक एवं वातावरणीय प्रमाणों का उपयोग परागणविक आँकड़ों की पुनर्व्याख्या करने में किया गया है। स्तरिक दृष्टि से महत्वपूर्ण परागणुवर्गक अभिनिर्धारित किये गये हैं। अलवणीय जूराई समुच्चयों की उपस्थिति प्रामाणिक नहीं मानी गई है। अलवणीय एवं तलांचली अवसादों के लिए 'गोंडवाना' शब्द के प्रयोग पर प्रश्न लगाया गया है। इसके अतिरिक्त कुछ विशिष्ट गोंडवानी अवयवों के वितरण पर प्रकाश डाला गया है।

THE Upper Mesozoic rocks are well-developed in the peninsular India and are exposed in the western, central and eastern parts of the country. They are normally termed as 'Upper Gondwana'. These sediments were laid under varied environments of deposition (marine, estuarine, continental and intertrappean). In the western part of India, Upper Mesozoic sediments depict continental as well as estuarine facies (Kutch, Kathiawar and Jaisalmer basins) whereas in the central and eastern parts of the country deposits of mainly continental facies

were laid (Satpura, South Rewa basins and Pranhita-Godavari Graben).

The Rajmahal Basin (Bihar) witnessed intermittent igneous activity resulting in the deposition of several lava flows. Intertrappean sequences hold a treasure of fossilised vegetation. The isolated patches of Upper Mesozoic sediments are also exposed along the east coast in Mahanadi, Cauvery, Krishna-Godavari and Palar basins.

Palynological information is known from most of the Upper Jurassic-Lower Cretaceous sediments.

Palynotaxa, in general, are easily identifiable as they possess distinctive morphological characteristics. Since most of the Upper Jurassic-Lower Cretaceous assemblages are grossly similar in composition, diverse opinions have been expressed in regard to age assignments of the 'Gondwana' sequence. The problem of dating known palynoassemblages is rendered difficult as many of them are not defined with respect to stratigraphic columns, thus their position in the Jurassic-Cretaceous sequence cannot be firmly established. In order to resolve some of these problems, the published palynological data have been comprehensively reassessed. Palaeontological, geological, tectonic and environmental evidences have been used as corroborative factors in deciphering stratigraphic position. Several stratigraphically important fern palynotaxa have been identified and used as workable parameters in distinguishing the Upper Jurassic-Lower Cretaceous assemblages. The occurrence of inland Jurassic continental sediments has been questioned. It has been observed that palynoassemblages of east coast of India and Western Australia are closely comparable. It has also been suggested to restrict the use of the term 'Gondwana' to a geographical context rather than to a stratigraphical one.

The status of Upper Jurassic-Lower Cretaceous spore-pollen assemblages recorded from the 'Upper Gondwana' sediments well-developed in the western, central, southern and eastern parts of the country, are reviewed. Emphasis has been laid to determine the qualitative changes occurring in the composition of the assemblages across the boundary, however, imperceptible they may appear to be numerically. It has been essential to follow this approach as the Early Cretaceous assemblages mostly exhibit a continuum of the Upper Jurassic palynoflora. Palynotaxa like *Araucariacites*, *Callialasporites* and *Podocarpidites* tend to dominate the assemblages across the boundary.

The Neocomian strata are distinguished by the presence of (incoming) cryptogamic spores, viz., *Cicatricosisporites*, *Impardecispora*, *Aequitriradites*, *Crybelosporites*, *Cooksonites*, *Foraminisporis*, *Contignisporites*, *Densoisporites*, *Haradisporites*, *Lametriletes*, *Coptospora*, *Appendicisporites*, *Boseisporites*, *Coronatispora* and by the dominance of some gymnospermous pollen like *Microcachryidites* and *Podosporites*. The other Late Jurassic fossils continue into the Neocomian.

The appearance of *Weichselia* and *Onychiopsis* was considered as infallible megafloreal evidences to date the Lower Cretaceous sediments (discussed by Sukh-Dev, 1988, this Volume). The report of ammonite fauna (Speth, 1933) from the east coast

'Gondwana' and its further study by Arkell (1956) who dated them as Early Cretaceous expressed serious doubt on the occurrence of Jurassic in the east coast of India. Since then, this problem has continued to attract attention of stratigraphers (The problems involved with marine intercalations or marine strata in the east coast are further discussed by Venkatachala and Rajanikanth, 1988, this Volume). Distribution and role of the Upper Mesozoic palynological assemblages recovered from the marine/non-marine and surface/subsurface material in deciphering environment of deposition and the time of deposition in different basins/grabens of the country need be reassessed to resolve 'The Upper Gondwana' problem in the country.

KUTCH BASIN

The Upper Jurassic-Lower Cretaceous assemblages have been studied from the Kutch Basin by Singh *et al.* (1964), Venkatachala (1967, 1969a, 1969b, 1970), Venkatachala and Kar (1967, 1968a, 1968b, 1970, 1972), Venkatachala *et al.* (1969a, 1969b, 1969c), Venkatachala and Rawat (1972), Rawat (1969, 1976) and Koshal (1975). Dependable palynological information on Upper Jurassic-Lower Cretaceous boundary has been provided by Venkatachala and Kar (1970) from the Jhuran/Bhuj formations in the Kutch Basin.

Biswas (1971) has recognized four lithological units in the Kutch mainland of which the assemblages reported from the Jhuran Formation (= Katrol Formation, Kimmeridgian—Valanginian) and Bhuj Formation (= Umia Formation, Valanginian-Aptian) have been reviewed to determine compositional changes in the palynofloras. Palynological succession of the Jhuran and Bhuj formations has been worked out by Venkatachala and Kar (1970). They have instituted three palynozones of which palynozone-1 encompasses the Jhuran Formation whereas palynozones 2 and 3 represent the Bhuj Formation. The transitional palynozone 2 is considered Berriasian in age and demarcates the boundary between the Jhuran and Bhuj formations. However, Sah (1983) considers that the Upper Jurassic-Lower Cretaceous boundary may lie within the palynozone 1 of the Jhuran Formation and suggests redefinition of the sequence between the Jhuran and Bhuj formations. Singh (1974) opines that the contact between the Jhuran and Bhuj formations is unconformable (Rajnath, 1952), therefore, the palynofloral break occurs near or after the Aptian. Jai Krishna (1983) has carried out extensive work in the Kutch area and disagrees with the contention of Rajnath (1952). This supports the

palynological conclusion of Venkatachala and Kar (1970).

Palynozone 1 of the Jhuran Formation is characterised by the restricted occurrence of *Katrolaites* and comparatively less diversity of cryptogamic spores. *Callialasporites*, *Alisporites*, *Podocarpidites*, *Platysaccus*, *Microcachryidites*, *Podosporites* and *Classopollis* are well-represented. *Cicatricosisporites australiensis* makes its first appearance in the transitional Palynozone 2 and is considered to demarcate the Jurassic-Lower Cretaceous boundary. The presence of this palynofossil has been used to distinguish the Lower Cretaceous assemblages from the Upper Jurassic ones (Srivastava, 1978). Some of the other stratigraphically important constituents of this zone are: *Cyathidites cutchensis*, *C. pseudopunctatus*, *C. grandis*, *Concavissporites indicus*, *Murospora punctata*, *Aequitriradites verrucosus*, *Coptospora*, *Trilobosporites*, *Platysaccus indicus* and *Schizosporis* spp. It is dominated by the genus *Impardecispora* and *Araucariacites*. Palynozone 3 shows further amplification and diversification of the cryptogamic spores with distinctive morphology. There is no marked diversification in the gymnospermous pollen assemblage. The Upper Jurassic gymnospermous pollen represented by *Araucariacites*, *Callialasporites*, *Podocarpidites*, *Classopollis*, *Cycadopites*, *Microcachryidites* and others transit into the Lower Cretaceous assemblages and are represented in different proportions. Some of the important cryptogamic palynofossils of the Palynozone 3 are: *Gleicheniidites senonicus*, *Appendicisporites* sp., *Baculatisporites comaumensis*, *Neoraistrickia verrucata*, *Pilosisporites notensis*, *Foveosporites canalis*, *Trilobosporites hannonicus*, *Sestrosporites pseudoalveolatus*, *Coronatispora perforata*, *C. telata* and *Foraminisporis* sp. *Araucariacites* is well-represented (by 20-70 per cent).

Appendicisporites appears in the Walkamota Section and *Ephedripites* is observed in the overlying Dayapar assemblage. The Jhuran Formation Palynozone 1 is dated as Upper Tithonian in age and is designated as the *Impardecispora* assemblage and contains *Araucariacites* and *Callialasporites* which are also dominant. It is considered to range in age from Berriasian to Hauterivian. Palynozone 3 is designated as *Appendicisporites* assemblage and is considered Aptian in age. *Ephedripites* occurs in the Dayapar sediments which overlie the Walkamota Section. It is indicative of post-Aptian age. Palynozone 3 also contains phytoplankton which suggest a marine influence. Singh (1974) believes that the palynofloral change observed by Venkatachala and Kar (1970) in Palynozone 3 occurs

around Albian. However, this observation is not supported by palynological and other evidences.

The spore-pollen assemblages described from the Bhuj beds represented at Ghuneri and Trambau (Singh *et al.*, 1964) do not contain *Appendicisporites* and as such they are comparable to the lower part of the Palynozone 3. They are considered Berriasian-Hauterivian in age.

Kar (1972) reported that the Upper Jurassic Jhuran Formation contains 21 genera and 50 species whereas the Lower Cretaceous Bhuj Formation has 46 genera and 70 species. He indicated that the Lower Cretaceous assemblages are characterized by the presence of distinct genera like *Coptospora*, *Cooksonites* and *Aequitriradites* and divided the Lower Cretaceous assemblages into two zones. The Lower Zone is represented by *Bhujiasporites*, *Concavissimisorites* and *Impardecispora*. The Upper Zone has *Staplinisporites*, *Densoisporites*, *Polycingulatisporites* and *Cingulatisporites*. Critical evaluation of these zones shows that they broadly fall within the age limits of palynozones 2 and 3.

SAURASHTRA BASIN

The Dhrangadhra palynoassemblages (Varma & Rawat, 1964; Venkatachala & Rawat, 1970) are Lower Cretaceous in age. The presence of *Appendicisporites* and *Impardecispora* in the Dhrangadhra assemblage dates it to Aptian. This conclusion is comparable with the information known from Palynozone 3 of Kutch. Singh (1974) believes that the lower part of the Dhrangadhra Formation may belong to Upper Jurassic which is not tenable on the basis of available palynological data.

JAISALMER BASIN

The Upper Jurassic-Lower Cretaceous sediments of Jaisalmer Basin are represented by the Bedesir Formation and Parihar sandstones. Palynological reports on the Upper Jurassic-Lower Cretaceous assemblages are scarce. However, Banerjee (1972) worked out Khara Tal Well no. 1 for its palynofossil contents. Palynological assemblage representative of strata encompassing depth levels between 1492.02-1719.03 m contains such characteristic palynotaxa as *Cicatricosisporites*, *Appendicisporites*, *Pilosisporites* and *Trilobosporites* rendering it comparable with the *Appendicisporites* assemblage of Bhuj (Aptian). Palynological study of the subsurface sediment of Manhera Tibba structure, Jaisalmer (Lukose, 1974) shows that the Goru Formation assemblage is probably Aptian-Lower Albian in age. Broadly it is comparable to the *Coptospora cauveriana* Zone but also contains some floral elements like

Clavatipollenites and *Triporoletes* (= *Rouseisporites*), the identification of which needs confirmation. Since palynofossils are not illustrated in the paper reassessment is not possible.

SATPURA BASIN

The Sehora assemblage from the Jabalpur Formation was described by Dev (1962). He recorded several palynofossils that are known from the Upper Mesozoic rocks of Australia. The assemblage also contains reworked Permian striated-bisaccate pollen. The assemblage was considered by him as younger than that recorded from the Rajmahal Formation. The Jabalpur Formation assemblage (Singh, 1966) was studied from the same sediments exposed along the Sher River near Sehora and Harad River near Hathnapur. Several palynotaxa characteristic of Lower Cretaceous age were recorded. The characteristic palynofossils that help for Lower Cretaceous age assignment are: *Cicatricosisporites*, *Triporoletes* (= *Rouseisporites*), *Coptospora*, *Crybelosporites*, *Contignisporites*, *Aequitriradites*, *Densoisporites* and *Cooksonites*. Gymnospermous pollen are represented by *Callialasporites*, *Araucariacites*, *Platysaccus*, *Podocarpidites*, *Podosporites*, *Vitreisporites*, *Classopollis* and *Cycadopites*. Kumar (1973) carried out detailed taxonomic study on the material supplied by Singh (1966) describing several taxa which provided additional data favouring a Lower Cretaceous age assignment. However, on the basis of quantitative analysis of the same assemblage, Bharadwaj *et al.* (1972) assigned an Upper Jurassic age. This controversy has been discussed in detail by Rao and Venkatachala (1971) and Singh (1972, 1974) who reassign them to Berriasian-Aptian age. The *in situ* spores of *Weichselia reticulata* (Stokes *et al.*) Fontaine have been studied by Alvin (1971). They are closely comparable to the specimens included under the genus *Lametatriletes* which has consistently been reported from Sehora, Hathnapur and Lameta Ghat assemblages. *Weichselia reticulata* has a world-wide occurrence in the Lower Cretaceous. The presence of *Lametatriletes* spp. signals the occurrence of *Weichselia* in the sediments of Jabalpur Formation though the megafossil genus has not been as yet discovered.

SOUTH REWA BASIN

The Bansa Formation assemblage (Maheshwari, 1974) shows the abundance of *Araucariacites* (23-58%) and *Callialasporites* (19-34%). The other gymnospermous elements are represented by *Properinopollenites*, *Alisporites*, *Podocarpidites* and

Cycadopites which are frequent in occurrence. The distribution of *Microcachryidites* and fern spores in the assemblage is reported to be infrequent. However, the presence of *Coniatisporites*, *Impardecispora apiverrucata*, *Lametatriletes*, *Densoisporites mesozoicus*, *Metamonoletes* and *Crassimonoletes* (Singh *et al.*, 1964) shows its closer affinity with the Berriasian-Hauterivian assemblages of Kutch. Palynological composition of the Berriasian-Aptian assemblages recorded from the South Rewa and Satpura basins (Dev, 1962; Singh, 1966; Bharadwaj *et al.*, 1972; Kumar, 1973; Bharadwaj & Kumar, 1974a, b; Maheshwari, 1974) are closely comparable to the Bhuj Formation Palynozones 2 and 3 as well as to the Trambau and Ghuneri assemblages (Singh *et al.*, 1964). It is possible that the Jurassic sequence in this area has either been eroded or represents a non-depositional phase.

RAJMAHAL BASIN

The Rajmahal Formation assemblages (Rao, 1943; Mittre, 1954; Sah & Jain, 1965) hitherto considered Bajocian to Oxfordian are comparable to the Jabalpur assemblages and hence are considered Lower Cretaceous in age. These assemblages contain *Impardecispora purverulenta*, *Foraminisporis asymmetricus* and *Cicatricosisporites australiensis* which have been used to date the Lower Cretaceous. The presence of *Foraminisporis asymmetricus* indicates that these assemblages could range from Barremian to basal Aptian. The Mandro Well Section assemblage (Maheshwari & Jana, 1983) is also stated to be of Lower Cretaceous as it contains *Aequitriradites* and *Cooksonites*. There are several thick basaltic flows in the Rajmahal Basin which are intermittently intercalated with 11 Intertrappean beds (Ramaswamy, 1952-53). The lower five Intertrappean beds contain plant remains. Cycadophytic remains dominate the second and third Intertrappean beds whereas the fourth one contains dominance of conifers (*Nipania*). Singh, G. (1974) considers that the Rajmahal sediments might represent a big time interval and the upper flows might be of Lower Cretaceous age. The Rajmahal traps have been dated radiometrically as Lower Cretaceous (McDougall & McElhinny, 1970).

Palynoassemblage zones A-F (Tiwari *et al.*, 1984) have been recognised from the subsurface sequence of the NE Rajmahal Basin. These contain Dubrajpur Formation and Intertrappean beds. The zones have been dated as late Lower Triassic (Zone A-C), Late Jurassic (Zone D) and Early Cretaceous (Zone E-F). A re-examination of the palynological composition of the assemblage zones D-F affirms the

presence of Early Cretaceous palynofossils like *Aequitriradites*, *Coptospora*, *Cooksonites*, *Impardecispora*, *Cicatricosisporites*, *Triporoletes* (= *Rouseisporites*), *Densoisporites* and *Neoraistrickia truncata*. The stratigraphic importance of the occurrence of these fossils in the assemblage Zones D-F is significant. There appears to be a time gap suggesting an unconformity between assemblages C and D.

PRANHITA-GODAVARI GRABEN

The Gangapur Formation unconformably overlies the Kota Formation in the Pranhita-Godavari Graben. Palynological assemblages of the Gangapur Formation are assigned Neocomian-Aptian age. The assemblages have been extensively studied by Rao *et al.* (1979), Ramanujam and Rao (1979), Rao and Ramanujam (1979), Ramanujam and Rao (1980), Maheshwari (in Bose, Kutty & Maheshwari, 1982) and Ramakrishna and Ramanujam (1987). A distinctive assemblage (Ramakrishna & Ramanujam, 1987) is described from the outcrops in the Adilabad District. Some of its important constituents are *Cicatricosisporites australiensis*, *C. hughesii*, *Aequitriradites spinulosus*, *Cooksonites minor* and *Microcachryidites antarcticus* associated with gymnospermic saccate and non-saccate pollen. This assemblage is closely comparable to those recovered from Anksapur, Rallapet and Wankalam (Ramanujam & Rao, 1979; Rao *et al.*, 1983; Bose, Kutty & Maheshwari, 1982). No angiospermic pollen grains have been found. The usual Neocomian-Aptian palynofossils belonging to the cryptogams constitute the important aspect of the above assemblage (stratigraphic implication of these assemblages has been discussed by Venkatachala & Rajanikanth, 1988, this Volume).

MAHANADI BASIN

The Mahanadi Basin is mostly concealed by the Holocene deposits. However, the Athgarh Formation is exposed near the western margin of the basin, southwest of Cuttack, which has been considered late Mesozoic in age. This formation contains several plant megafossils (Jain, 1968; Patra, 1973, 1980). The megafloral assemblage indicates an Early Cretaceous age for this formation.

Maheshwari (1975) described a palynoassemblage from the Sidheshwar Hill and Jagannath Prasad quarry containing the Lower Cretaceous palynofossils: *Impardecispora* sp. and *Podosporites tripakshii*. Jana and Tiwari (1986) reinvestigated this assemblage and assigned an Upper Jurassic age and

considered it homotaxial with the Rajmahal Assemblage zones D-F (Tiwari *et al.*, 1984) and Jabalpur Assemblage (Kumar, 1973). These assemblages, i.e., Jabalpur and zones D-F of Rajmahal have been reassessed and dated Early Cretaceous in age. The Athgarh assemblage also contains *Lametriletes indicus* (cf. spores of *Weichselia reticulata*), *Boseisporites praeclarus*, *Monolites indicus* and *Onychiopsis* (Patra, 1973) which further confirm an Early Cretaceous assignment.

CAUVERY BASIN

The Upper Mesozoic sediments (continental, paralic to marine) are exposed as detached patches in the Cauvery Basin. The Sivaganga beds overlie the Archaean complex and are overlain by the Dalmiapuram Formation which is dated Aptian-Early Albian on both palynological and faunal evidences (Bhatia & Jain, 1969; Rao & Venkatachala, 1971; Venkatachala & Jain, 1969; Venkatachala *et al.*, 1972). Several palynologists have studied surface and subsurface material from the Cauvery Basin, viz., Banerjee and Misra (1968), Jain and Subbaraman (1969), Venkatachala (1973), Venkatachala and Sharma (1974a, 1974b) and Maheshwari (1986). Four palynological zones have been recognised in the Jurassic-Cretaceous subsurface sequence—*Callialasporites segmentatus* Zone containing an impoverished assemblage which was earlier assigned an Upper Jurassic (Tithonian) age, is reassigned a Lower Cretaceous age (Berriasian) because of the presence of *Cicatricosisporites australiensis*. The succeeding *Microcachryidites antarcticus* Zone (Neocomian) contains characteristic palynofossils, viz., *Microcachryidites*, *Cooksonites* and *Aequitriradites*. This zone has been identified in several subsurface sequences. Most of the Lower Cretaceous elements continue to occur in the succeeding *Coptospora cauveriana* Zone (Aptian-Lower Albian). However, the first appearance of *Coptospora* and *Polypodiaceoisporites* and others gives a distinctive character to this zone. The first appearance of *Appendicisporites* is noteworthy (see Venkatachala, 1974 for a detailed discussion). *Ephedripites* is present at the top of the zone. The Dalmiapuram Grey Shale assemblages (Rao & Venkatachala, 1971; Jain & Subbaraman, 1969; Jain & Taugourdeau-Lantz, 1973; Venkatachala & Kumar, 1980) are contemporaneous with the *Coptospora cauveriana* Zone. These have been recovered from several subsurface sequences in the basin. Jain and Taugourdeau-Lantz (1973) assign an Early Albian age to the Dalmiapuram Formation.

KRISHNA-GODAVARI BASIN

The Godavari Depression contains Golapalli Sandstone, Raghavapuram Shale and Tirupati Sandstone in an ascending order whereas Budavada Sandstone, Vemavaram Shale and Pavalur Sandstone are exposed in the Krishna Depression. These units have been considered time equivalents and representing facies variations (Venkatachala & Sinha, 1986). Palynological assemblages have been studied by Ramanujam (1957), Kar and Sah (1970), Rao and Venkatachala (1971) and Sharma *et al.* (1977). These assemblages have been assigned Neocomian-Aptian age. A marked palynofloral similarity has been observed in the assemblages recovered from the Krishna Depression, Bapatla-Velupcharla Ridge and West Godavari Depression (Sharma *et al.*, 1977). This information made it possible to establish a homotaxial nature of sediments encountered in the subsurface sequence in the two depressions of the Krishna-Godavari Basin (Raghavapuram/Vemavaram shales). In a comprehensive study of stratigraphy, age and palaeoecology of 'Upper Gondwana' equivalents of the Krishna-Godavari Basin (Venkatachala & Sinha, 1986) major environmental regimes varying from non-marine in the west to shallow marine in the east through transitional swampy environment have been delineated on the basis of palynofossils.

Some of the important constituents of this assemblage are *Appendicisporites sellingsii*, *Cicatricosisporites ludbrookii*, *C. hughesii*, *Impardecispora apiverrucata*, *Crybelosporites velatus*, *Cooksonites variabilis*, *Aequitriradites spinulosus* and *Microcachryidites antarcticus*. Detailed account of Neocomian-Aptian palynoassemblages containing phytoplankton from the subsurface of Godavari and Krishna depressions have been rendered by Sharma *et al.* (1970), Venkatachala (1977) and Venkatachala and Sinha (1986). Neocomian-Aptian palynoassemblages (Venkatachala, 1977) recovered from the shallow wells drilled in the West Godavari Depression as well as Krishna Depression demonstrate the presence of phytoplankton in addition to some of the following characteristic palynofossils: *Bhujiasporites*, *Cicatricosisporites australiensis*, *C. ludbrookii*, *C. hughesii*, *Trilites verrucosus*, *Plicifera senonicus*, *Impardecispora purverulenta*, *Crybelosporites stylosus*, *Densoisporites velatus*, *Appendicisporites sellingsii*, *Coronatispora* sp., *Cooksonites variabilis*, *Microcachryidites antarcticus* and *Podosporites tripakshii*.

Sastri *et al.* (1963), Bhalla (1969) and Bakshi (1966) date the Raghavapuram shales as Early Cretaceous on the basis of faunal assemblages. In

fact, the entire sequence of exposed Upper Mesozoic rocks in the "East-coast Gondwana" is assigned Lower Cretaceous age (Mitra *et al.*, 1971).

PALAR BASIN

The Sriperumbudur beds are poorly exposed in the Palar Basin and overlie the Talchir Formation unconformably. They contain splintery grey and greenish shales and have interbedded sandstone and limestone. Scattered outcrops of the Satyavedu beds overlap the Sriperumbudur beds transgressively.

Spore-pollen/phytoplankton assemblages distinctly of Neocomian-Aptian age recovered from the Kancheepuram area have been described by Ramanujam and Srisailam (1974), Ramanujam and Varma (1977), Venkatachala (1977) and Ramanujam *et al.* (1980).

The Kattavakkam bore-hole assemblage (Ramanujam & Srisailam, 1974) was dated as Late Jurassic which was earlier assigned Early Cretaceous age (ONGC unpublished reports). The presence of *Impardecispora apiverrucata*, *Cicatricosisporites australiensis* and *Concavisporites cutcbensis* makes it cogent to reaffirm Lower Cretaceous age.

The other Early Cretaceous palynoassemblages contain the following important markers: *Impardecispora apiverrucata*, *Neoraistrickia truncata*, *Cicatricosisporites australiensis*, *Aequitriradites spinulosus*, *A. verrucosus*, *Cooksonites variabilis*, *Coptospora* sp., *Foraminisporis*, *Crybelosporites* sp. and *Microcachryidites antarcticus*. Murthy and Sastri (1962) have dated the Sriperumbudur beds on the basis of foraminiferal evidence as Lower Cretaceous. Sastri and Mangain (1971) also dated the Upper Gondwana sediments of the Krishna-Godavari Basin and correlated them with the Sriperumbudur and Satyavedu beds.

CONCLUDING REMARKS

The Upper Jurassic-Lower Cretaceous boundary may be placed at the top of the Jhuran Formation in the Kutch Basin on the basis of palynological data. The Upper Jurassic assemblage of Kutch (Jhuran Formation) is characterized by the restricted presence of *Katrolaites* and comparatively less diversity of cryptogamic spores. The transitional zone is distinct by the advent of *Cicatricosisporites australiensis*. Its first appearance is usually considered to distinguish the Lower Cretaceous. This zone also depicts the dominance of *Impardecispora* and *Araucariacites*. The Neocomian-Aptian assemblages, in general, show further amplification and diversification of cryptogamic spores with

distinctive morphology, viz., *Appendicisporites*, *Aequitriradites*, *Impardecispora*, *Foraminisporis*, *Lametriletes* and several others. These forms are not encountered in the Upper Jurassic assemblages.

The base of the Lower Cretaceous sediments is marked by the appearance of a new set of cryptogamic spores which possess distinctive morphology though they remain low in number. Their stratigraphical importance in delineating the Upper Jurassic-Lower Cretaceous boundary has proved to be beyond doubt. Quantitative changes in the composition of the palynofloras, particularly of gymnospermous pollen (such as *Classopollis*, *Callialasporites* and others) seem to represent different depositional environments. Such changes, however, striking they may appear to be, are certainly of less stratigraphic importance.

The Jurassic-Cretaceous transitional strata usually exhibit a great diversity of spores and high percentage of bisaccate pollen of gymnosperms. This distinct change in the composition of the palynofloras near the Jurassic-Cretaceous boundary is a world wide phenomenon. The appearance of cryptogamic spores like *Cicatricosisporites* and *Impardecispora/Trilobosporites* at or near the J-C boundary is almost universal. *Appendicisporites* is restricted to the Cretaceous strata only. *Aequitriradites*, *Pilosisporites*, *Cooksonites*, *Coptospora*, *Crybelosporites* and *Foraminisporis* assume greater stratigraphic importance.

It seems possible to generalize that *Microcachryidites* and *Podosporites* are typical elements of the Jurassic-Cretaceous Gondwanic assemblages distributed in Australia, New Zealand, India, South Africa, Madagascar and southern South America.

Determination of precise contemporaneity of some palynoassemblages discussed here is difficult as the data are not related to stratigraphic columns.

Satpura, South Rewa, Rajmahal and East Coast basins contain only Lower Cretaceous palynoassemblages ranging in age from Berriasian to Aptian. It appears that either the Jurassic sediments were eroded in this area or represent a non-depositional phase.

Kutch and Rajasthan basins seem to have witnessed shallow marine sedimentation during the pre-Cretaceous Period (faunal and phytoplankton evidence) whereas in the eastern sector it started during the Lower Cretaceous in response to the rifting activity.

Detailed comparisons of the Upper Mesozoic palynoassemblages particularly of Neocomian age from India and Australia led Sastri *et al.* (1981) to believe that the east coast of India and west coast of Australia were juxtaposed. It is possible to draw

conclusion that the continental deposits of the Rajmahal Basin (Neocomian) may represent an extended part of the Great Artesian Basin of Australia.

The term 'Gondwana' was proposed to include inland continental sediments. The marine sediments of Kutch and others with the continental sequence in the peninsular India were later included as marine intercalations. The term 'Gondwana' in the present context thus appears to be continuously expanded to include paralic as well as marine sequences. It is necessary to review and restrict the use of the term 'Gondwana' to a geographical context rather than to a stratigraphic one.

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