THE PRESENT POSITION AND PROBLEMS OF TERTIARY PALAEOBOTANY IN INDIA

R. N. LAKHANPAL

Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

Since the second quarter of the nineteenth century, when fossil plants began to be collected in India, almost all the earlier work in Indian palaeobotany was carried out on Mesozoic and Palaeozoic fossils. Progress in Tertiary palaeobotany really started in the early thirties of the present century. The contributions have mainly been on the structure of individual fossils, mostly petrifactions, from the Deccan Intertrappean beds and from the Middle Tertiary strata of Assam and South India. Of late, some papers on the leaf impressions and pollen and spores have also appeared. At the present stage it is desirable that Tertiary plants are studied collectively as floras. This will help in solving a number of problems related to stratigraphy, palaeogeography and palaeoecology during the Tertiary period in India.

INTRODUCTION

TERTIARY beds, ranging from Eocene to Pliocene, are spread over large areas of India. According to one view, the controversial deposits of the Deccan Intertrappeans should be included in the Tertiary system while the other view regards them as Upper Cretaceous. However, the nature of their plant remains, with a preponderance of angiosperms, is so similar to that of Tertiary plants in general, that in an account like this it would not be inapt to treat the Deccan Intertrappean series along with other Tertiary beds of India.

The Tertiary exposures may be divided into two broad groups — the Peninsular and the extra-Peninsular. In the Peninsula the most significant are the Deccan Intertrappean beds. These are small lacustrine or fluviatile fossiliferous beds separating the thick lava-flows of the great volcanic formation known as the Deccan Traps. These traps today cover an area of about 200,000 sq. miles (5,18,000 sq. km.) extending over a large part of Cutch (also spelt as 'Kutch'), Kathiawar, Gujarat, Maharashtra, Madhya Pradesh and Andhra Pradesh. Other small Tertiary outcrops are exposed near the west coast of Travancore, in Gujarat, Kathiawar, Cutch and Rajasthan. A fairly widely developed series of Tertiary rocks is also found along the east coast of the Peninsula.

The extra-Peninsular Tertiary rocks are found in a belt running along the foot of the mountain ranges on the north-western, northern and eastern border of the country. All over this area, the Tertiary system exhibits a double facies — a lower marine facies and an upper fresh-water or subaerial (WADIA, 1957, p. 308).

Tertiary plants of India, along with thoes of other ages, have been collected since the second quarter of the Nineteenth century. However, they did not receive as much attention as did their counterparts of earlier ages. While admirable work had been done on the Gondwana Flora by the year 1885, the knowledge of Tertiary plants remained poor until 1921 when, reviewing the position of Indian palaeobotany at that time, Prof. B. Sahni remarked "I wish to bring the fact prominently to your notice that these Tertiary and Post-Tertiary plants of India practically all remain uninvestigated, and to suggest that they would well repay the trouble of a critical examination" (SAHNI, 1921, p. clv). Out of the large number of petrified woods, impressions of leaves and a few remains of fruits and seeds reported until then from different Tertiary horizons, perhaps the only fossils known taxonomically were a coniferous wood, *Peuce schmidiana* (SCHMID & SCHLEIDEN, 1855, p. 36) from the Cuddalore sandstones of Trivicary (now Tiruvakkarai); and two leaf-impressions, *Phyllites kamrupensis* (SEWARD, 1912) from the Middle Tertiary of Assam and *Sabal major* Heer (FEISTMANTEL, 1882) from the Kasauli beds in Western Himalayas.

Since 1921 there has been active development in all the branches of palaeobotany in India, due primarily to the outstanding contributions of Prof. Sahni and to those of other scholars inspired by his able guidance. It is proposed to give here only a concise

account of the progress made so far in Indian Tertiary palaeobotany, pointing out the problems that at present confront the workers in this field. For previous details one would do well to consult the three earlier periodical reviews by Sahni (1938), Sitholey (1955) and Rao (1958), which contain all the available references to fossil plants described until their publication.

APPRAISAL OF THE PRESENT POSITION

Peninsular Tertiary Floras — The earliest and the most worked out of the Indian Tertiary floras is of course the Deccan Intertrappean. It is mostly silicified and often very well preserved, representing the groups fungi, algae (including charophytes), water ferns, conifers and angiosperms (both monocots and dicots). A survey of the Deccan Intertrappean flora has recently been published by Prakash (1960) in which he has enumerated more than 100 plants belonging to 48 recognizable genera distributed among 31 families. Since then another about 25 fossil forms have been reported or described from this flora (Details in VERMA, 1965). Notwithstanding some taxa which may represent different organs of the same plant, the total number of known components is still quite large. The knowledge of the Deccan Intertrappean flora seemingly appears to have reached a stage where with some final critical studies it may be possible to work out the composition of this interesting flora and its palaeoecological and palaeogeographical interpretation. But these studies are confronted with a number of difficulties and need considerable light on a few important facets of this flora.

First and foremost, there are quite a few forms which, despite their beautifully preserved structural details, have so far defied all attempts at their identification with the modern plants. The very name of one of the commonest fossils, *Enigmocarpon* (SAHNI, 1943a) suggests the difficulty which was met with in its identification. It is now generally agreed upon that *Enigmocarpon* is the fruit of a Sonneratiaceous plant of which *Sahnianthus* (SHUKLA, 1944a) is the flower. But recently Verma has found in the peel-section of a piece of chert from Mohgaon Kalan, a *Sahnianthus* flower with anthers containing pollen grains in situ. The structure of these pollen grains is quite different from that of Sonneratiaceous or Lythraceous pollen. In view of this discovery we are back to the enigmatic taxonomic position of these well known fruit and flower forms.

Another very common Intertrappean flower is *Sahnipushpam* of which hundreds of specimens have been examined, but so far we are not even sure of the family to which it belongs. According to Verma (1956), who was the first to describe this flower, it is allied to Sonneratiaceae; whereas Prakash (1956), in a description published a few months later, places it nearest Myrtaceae. However, on the basis of further observations Prakash & Jain (1964) have suggested that it may belong to Araceae. Chitaley (1964) has recently added some more details to the structure of this flower but has kept the affinities of the flower still 'open'.

A dicotyledonous fruit, *Indocarpa intertrappea*, has recently been described by Jain (1964) who has tentatively placed it under Guttiferae but could not find any modern genus to which it could be assigned.

Amongst the monocots, although the anatomy of *Viracarpon* and *Tricoccites* has been worked out in detail (RODE, 1933; SAHNI & RODE, 1937; SAHNI, 1944; CHITALEY, 1955, 1957, 1958), their affinities are still uncertain. Of all the fossil palms known from these beds, except for *Palmoxylon sundaram* which was compared with *Cocos* by Sahni (1946), none else has been assigned to any modern genus. There are doubts even about the *Cyclanthodendron* (SAHNI & SURANGE, 1953) belonging to Cyclanthaceae and not to some other family. Similarly the affinities of four coniferous cones and about half a dozon coniferous woods have still to be established. These are only the most glaring examples out of a large number of fossil forms comprised by the Deccan Intertrappean flora whose modern equivalents have yet to be traced out.

This leads to the difficulty of palaeoecological interpretation of this flora. Obviously, unless we know the modern equivalents of the Intertrappean fossils, it is not possible to derive any detailed and dependable conclusions and, consequently, we can only build up a generalized picture of the environments that prevailed around the deposition sites of this flora.

As, known at present, the Deccan Intertrappean flora also raises an interesting palaeogeographical problem. The occurrence

of *Nipa* and many kinds of palms suggests affinities with the Malayan type of vegetation. But there are some elements whose modern relatives are found in Tropical America. For example *Rodeites* (SAHNI, 1943b) has been compared with the sporocarp of *Regnellidium*, a water fern of Brazil. *Cyclanthus* and *Carludovica*, with which *Cyclanthodendron* has been tentatively compared, are also tropical American genera. Prakash (1962) has suggested close relationship of the genus *Mohgaostrobus* with the family Araucariaceae. Similarly the four species of *Dadoxylon* (SHUKLA, 1938, 1944b; BILLIMORIA, 1948; CHITALEY, 1949) show Araucarian affinities. Araucariaceae is aslo distributed in South America besides being found in New Zealand, Australia, New Guinea and Malay region. This South American element in the Deccan Intertrappean flora needs a more careful investigation and has important palaeogeographical significance.

Lastly, the geological age of the Deccan Intertrappean series has been a matter of controversy since long. This question will also have to be examined with an open mind after the composition of this flora has been studied more thoroughly.

In Rajasthan, near Barmer, there are Fuller's earth deposits of Eocene age. They contain remains of fishes and echinoderms along with impression of leaves and fruits. Lakhanpal & Bose (1951) have described from these deposits leaves resembling those of *Mesua* and *Garcinia* and fruits comparable with those of *Garcinia, Calophyllum* and other Guttiferous plants. From the same beds Kaul (1951) has described a palm fruit under the name *Cocos sahnii*. The occurrence of *Mesua* and other Guttiferous plants suggests that during Eocene period there was a rich forest at a place which is now a desert. Further detailed work on the fossil plants of this area promises interesting results.

Another flora of the Peninsular India which has now been considerably well investigated, comprises the petrified woods of the Cuddalore Sandstones in South Arcot district of Madras. It is the richest known flora of fossil woods in India. Some of the specimens are about 15 metres long and some more than a man's height in girth. The exact age of the Cuddalore Sandstones is not yet determined but it is considered to be Upper Miocene or Pliocene by Krishnan (1960, p. 555) while Wadia (1957, p. 314) believes a great part of the Cuddalore sandstone to be of Miocene-Pliocene age.

The petrified woods of Cuddalore Series have been investigated by Schleiden (in SCHLEIDEN & SCHMID, 1855), Sahni (1931a, 1931b), Ramanujam (1953a, 1953b, 1953c, 1954, 1955, 1956a, 1956b, 1956c, 1957, 1958, 1960, 1961), Navale (1956, 1957, 1959, 1962a, 1963a, 1963b, 1964a, 1964b, 1964c) and Lakhanpal & Awasthi (1964, 1965). So far 48 species belonging to 29 genera have been described by these workers. These belong to 11 families of dicotyledons, 1 of monocotyledons and 2 of gymnosperms. Recently a comprehensive study of these woods was taken up at this Institute by Awasthi. He has revised the identification of 11 species described by the earlier workers and has described 20 new species of dicotyledons in his thesis (AWASTHI, 1965). Thus, this flora is fairly well known now. Besides the question of determining the geological age of this flora, there is also a palaeoecological and phytogeographical problem: How to explain the occurrence of Podocarpaceous and Taxodiaceous plants along with very abundant tropical dicotyledonous plants of the Indo-Malayan type. At present there is only one naturally occurring conifer in South India, viz., *Podocarpus wallichianus* C. Presl (RAIZADA & SAHNI, 1960, p. 105) which usually grows at altitudes of 900-1500 m.

From the Pliocene of Cutch, Ghosh & Ghosh (1959) have described a fossil wood as *Dipterocarpoxylon malavii*.

There are a number of lignite deposits of various Tertiary epochs in the Peninsular India, i.e., Palana (Eocene) in Rajasthan, Neyvelli (Miocene) in Madras, and Warkalli (Miocene) and Cannanore (Upper Miocene or Pliocene) in Kerala. Plant microfossils from Palana, Warkalli and Neyvelli lignites have been studied by Jacob & Jacob (1950), Rao & Vimal (1950, 1952a, 1952b) and Vimal (1953a, 1953b). Rao (1956) has given a comparative account of the pollen and spores from these deposits. Further palynological investigations have been carried out by Navale (1962b) on Neyvelli and by Potonié & Sah (1960) on Cannanore lignites. These pollen and spores have mostly been classified artificially and their identification with modern plants is either doubtful or not known at all. For reliable palaeoecological and phytogeographical

interpretation, further detailed observations on these microfossils are very desirable.

Extra-Peninsular Tertiary Floras — Of the Tertiary of Extra-Peninsular India, most of the work has been carried out on the fossil plants of Assam. In Assam the Tertiary deposits probably attain the maximum thickness, at places being more than 15000 metres thick. However, the area is much disturbed and there are several gaps in the succession, the most important being the absence of the top part of Oligocene.

Considering the size and extent of Tertiary deposits in Assam, the number of fossil plants described therefrom is rather small. Most of the fossil woods from the Middle Tertiary of this area have been described by Chowdhury and his associates. They have been referred to the genera *Glutoxylon* (CHOWDHURY, 1934, 1936), *Dipterocarpoxylon* (*D. garoense* CHOWDHURY, 1938), *Cynometroxylon* (CHOWDHURY & GHOSH, 1946), *Pahudioxylon* (CHOWDHURY, GHOSH & KAZMI 1960) and *Kayeoxylon* (CHOWDHURY & TANDAN, 1949). Recently *Terminalioxylon* (PRAKASH & NAVALE, 1963) and new species of *Shoreoxylon* and *Dipterocarpoxylon* (EYDE, 1963) have further been described from this area. Detailed investigations on the fossil woods of Assam have been taken up by Prakash who has quite a large number of them to work on.

A few leaf impressions have been recorded from an Eocene deposit in the Garo Hills by Lakhanpal (1955a). They have been referred to the genera *Trema, Neolitsea, Grewia* and *Bombacites*. He has also reported remains of *Nelumbium* (LAKHANPAL, 1955b) from the same deposit. From a Miocene locality a few miles southwest of this area, he has recorded the occurrence of *Nipa* (LAKHANPAL, 1952).

Sahni, Sitholey & Puri (1948) tried a correlation of the Tertiary rocks of Assam by microfossils. They macerated 22 samples from various deposits, which yielded spores of pteridophytes and pollen grains of angiosperms and gymnosperms besides leaf cuticles, fungal mycelia and chitinous remains of animals, etc. However, detailed results of this work are yet to be published.

In 1948 Sen studied the microfossils of a coal seam at Laitryngew, on the basis of which he assigned the Cherra Sandstone to the lowermost Eocene but mentioned that further detailed study of this problem was necessary. Sah & Dutta (1966) are further investigating this problem and have found evidence that supports this view.

Recent visits to a few localities in Assam have shown that there is a wealth of material which can be collected from this region and studied both for mega- and microfossils. A detailed palaeobotanical study of the Tertiary deposits of Assam will not only help in the stratigraphy of this area but also reveal the succession of changes in the ecology and grography of this area through the Tertiary period.

Another Extra-Peninsular Tertiary deposit from which some fossil plants have been described are the Lower Miocene beds of Kasauli. Feistmantel (1882) had referred a supposedly palm leaf from Kasauli to *Sabal major*. This identification was later doubted by Prof. Sahni (1953) in a posthumous paper in which he described a fragment of a monocotyledonous leaf and three ill-preserved leaf impressions referred to the form genus *Dicotylophyllum*.

From the Siwalik beds, which extend over a large area in the foot hills of the Himalaya, a number of fossil woods and leaf-impressions have been reported but except two woods, *Anisopteroxylon jawalamukhi* (GHOSH & GHOSH, 1958) and *Dipterocarpoxylon* (RAWAT, 1964), others have not been described so far. This study would be very interesting, especially as the fauna of these deposits is so well known.

CONCLUSION

From the foregoing short account of Tertiary palaeobotany in India it is quite obvious that we are still in the preliminary stages and considerable work has yet to be done*. The material consists of all types of fossil forms ranging from petrified woods,

*Since presenting this paper at the Special Session of the Palaeobotanical Society in December, 1964, the author has seen Prof. B. Sahni's posthumous monograph on the fossil monocotyledons of India (Sahni, 1964). This monumental work deals with impressions of leaves and petrifactions of stems and fruits. Under the leaf impressions are described *Poacites sivalicus* from the Lower Siwalik of Poonch, *Poacites rajaoriensis* and "plicated parallel veined leaves" from the Murree series of Poonch, *Sabalites microphylla* from the Kasauli beds and another *Sabalites* sp. from a Miocene deposit midway between Rawalpindi and Srinagar (Kashmir).

Amongst the petrified stems are included a species of *Culmites* (*C. cutchensis* from an unknown locality in Cutch) and thirtythree species of *Palmoxylon*. Of the palmoxyla, eleven species are from

the Deccan Intertrappean series; two either from Nerbada alluvium or from the Deccan Intertrappean series; one from the Bhuj series of Cutch and another from an unknown locality in Cutch (probably Cretaceous); two from the Siwalik beds of Jammu; one from the ?Miocene beds near Pondicherry; and one from an unknown horizon near Tiki in South Rewah. The rest of the *Palmoxylon* spp. are either from countries outside the present boundaries of India or from unknown deposits.

The fossil fruits dealt with are species of *Nipadites*, *Palmocarpon*, *Tricoccites*, *Viracarpon* and *Amomocarpum* from the Deccan Intertrappean series and two species of *Carpolithus* (one from Pakistan and the other without any details).

flowers and fructifications to leaf impressions. Methods will, therefore, have to be devised for deriving uniform palaeoecological and phytogeographical conclusions from such diversified evidences. Furthermore, to confirm and supplement the data furnished by megafossils, palynological studies will also have to be carried out wherever possible. Finally, extensive observations on the modern vegetation of India and the neighbouring countries are also necessary for dependable interpretation of the available details of our Tertiary floras.

REFERENCES

AWASTHI, N. (1965). Further studies on the fossil woods from the Cuddalore series of South India. *Ph. D. Thesis, Univ. Lucknow.*

BILLIMORIA, J. J (1948). A new species of *Dadoxylon* from C. P. *Palaeobot. India.* **6**: 260, 1947.

CHITALEY, S. D. (1949). On a new species of *Dadoxylon*, *Dadoxylon eocenum* sp. nov., from the district of Chhindwara, C. P. India. *J. Indian bot. Soc.* **28**(4): 227-237.

Idem (1955). On a fructification from the Intertrappean flora of the Madhya Pradesh, India. *Palaeobotanist.* **3**: 9-17, 1954.

Idem (1957). On the fructification of *Tricoccites trigonum* Rode from the Deccan Intertrappean series of India. *Ibid.* **5**: 56-63, 1956.

Idem (1958). Seeds of *Viracarpon hexaspermum* Sahni from the Intertrappean beds of Mohgaon Kalan, India. *J. Indian bot. Soc.* **37**(3): 408-411

Idem (1964). Further observations on *Sahnipushpam. J Indian bot. Soc.* **43**(1): 69-74.

CHOWDHURY, K. A. (1934). A fossil dicotyledonous wood from Assam. *Curr. Sci.* **3**(6): 255-256.

Idem (1936). A fossil dicotyledonous wood from Assam. *Ann. Bot. Lond.* **50**(199): 501-510.

Idem (1938). Two fossil dicotyledonous woods from the Garo Hills, Assam. *Rec. geol. Surv. India.* **73**(2): 247-266.

CHOWDHURY, K. A. & GHOSH, S. S. (1946). On the anatomy of *Cynometroxylon indicum* gen. et sp. nov., a fossil dicotyledonous wood from Nailalung, Assam. *Proc. nat. Inst. Sci. India.* **12**(8): 435-447.

CHOWDHURY, K. A., GHOSH, S. S. & KAZMI, M. H. (1960). *Pahudioxylon bankurensis* gen. et sp. nov.— a fossil wood from the Miocene bed of Bankura district, West Bengal, India. *Ibid.* **26 B** (1): 22-28.

CHOWDHURY, K. A. & TANDAN, K. N. (1949). *Kayeoxylon assamicum*, gen. et sp. nov.— a fossil dicotyledonous wood from Assam. *Ibid.* **15**(2): 59-65.

EYDE, R. (1963). A *Shoreoxylon* and two other Tertiary woods from the Garo Hills, Assam. *Palaeobotanist.* **11**(1&2): 115-121, 1962.

FEISTMANTEL, O. (1882) Note on remains of palm leaves from the (Tertiary) Murree and Kasauli beds in India. *Rec. geol. Surv. India.* **15**(1): 51-53.

GHOSH, S. S. & GHOSH, A. K. (1958). *Anisopteroxylon jawalamukhi* sp. nov.: a new fossil record from the Siwaliks. *Sci. & Cult.* **24**: 238-241

Idem (1959). *Dipterocarpoxylon malavii* sp. nov. — a new fossil record from the Pliocene of Kutch. *Ibid.* **25**: 328-332.

JACOB, C. & JACOB, K. (1950). Cuticles from the Tertiary lignite of Cuddalore, S. Arcot, India. *Proc. 7th int. bot. Congr. Stockholm*: 572-573.

JAIN, R. K. (1964). *Indocarpa intertrappea* gen. et sp. nov., a new dicotyledonous fruit from the Deccan Intertrappean series, India. *Bot. Gaz.* **125**(1): 26-33.

KAUL, K. N. (1951). A palm fruit from Kapurdi (Jodhpur, Rajasthan desert), *Cocos sahnii* sp. nov. *Curr. Sci.* **20**: 138.

KRISHNAN, M. S. (1960). Geology of India and Burma. *Madras.*

LAKHANPAL, R. N. (1952). *Nipa sahnii*, a palm fruit in the Tertiary of Assam. *Palaeobotanist.* **1**: 289-294.

Idem (1955a). Recognizable species of Tertiary plants from Damalgiri in the Garo Hills, Assam. *Ibid.* **3**: 27-31, 1954.

Idem (1955b). On the occurrence of *Nelumbium* in the Tertiary of Assam. *J. Indian bot Soc.* **34**(3): 222-224.

LAKHANPAL, R. N & AWASTHI, N. (1964). *Mesuoxylon arcotense* gen. et sp. nov., a fossil dicotyledonous wood from the Tertiary of South Arcot district, Madras, India. *Palaeobotanist.* **12**(3): 260-264, 1963.

Idem (1965). Fossil woods of *Calophyllum* from the Tertiary of South India. *Ibid.* **13**: 328-336.

LAKHANPAL, R. N & BOSE, M. N (1951). Some Tertiary leaves and fruits of the Guttiferae from Rajasthan. *J Indian bot. Soc.* **30**(1-4): 132-136.

NAVALE, G. K. B. (1956). On two new species of *Terminalioxylon* Schonfeld from the Tertiary beds of South India. *Palaeobotanist.* **4**: 35-39, 1955.

Idem (1957). *Sapindoxylon indicum* sp. nov., a new fossil wood from the Tertiary beds of South India. *Ibid.* **5**: 73-77, 1956.

Idem (1959). Occurrence of fossil *Cynometra* from the Cuddalore series near Pondicherry, India. *Ibid.* **7**(1): 6-11, 1958.

Idem (1962a). *Phyllanthinium bangalamodense*: a new species of fossil Euphorbiaceous wood from the "Cuddalore Series" of India. *Ibid.* **9**: 11-16, 1960.

Idem (1962b). Pollen and spores from Neyveli lignite, South India. *Ibid.* **10**: 87-90, 1961

Idem (1963a) Fossil woods of Leguminosae from Tertiary rocks of Cuddalore series near Pondicherry, India. *Ibid.* **11** (1 & 2): 54-65, 1962.

Idem (1963b). Some silicified Dipterocarpaceous woods from Tertiary beds of the Cuddalore series near Pondicherry, India. *Ibid.* **11** (1& 2): 66-81, 1962.

Idem (1964a). *Castanoxylon* gen. nov. from Tertiary beds of the Cuddalore series near Pondicherry, India. *Ibid.* **11** (3): 131-137, 1962.

Idem (1964b) *Anogeissusoxylon indicum* gen. et sp. nov. from the Tertiary rocks near Pondicherry, India. *Ibid.* **11** (3): 154-158, 1962.

Idem (1964c). *Ailanthoxylon pondicherriense* sp. nov. from Tertiary beds of the Cuddalore series near Pondicherry, India. *Ibid.* **12** (1): 68-72, 1963.

Potonié, R. & Sah, S. C. D. (1960). Sporae dispersae of the lignites from Cannanore beach on the Malabar coast of India. *Ibid.* **7** (2): 121-135, 1958.

Prakash, U. (1956). On the structure and affinities of *Sahnipushpam glandulosum* sp. nov. from the Deccan Intertrappean series. *Ibid.* **4**: 91-100.

Idem (1960). A survey of the Deccan Intertrappean flora of India. *J. Paleont.* **34**(5): 1027-1040.

Idem (1962). Further observations on a petrified ovuliferous cone (*Mohgaostrobus sahnii* gen. et sp. nov.) from Mohgaon cherts in the Deccan. *Palaeobotanist.* **10**: 1-5, 1961.

Prakash, U. & Jain, R. K. (1964). Further observations on *Sahnipushpam* Shukla. *Ibid.* **12** (2): 128-138, 1963.

Prakash, U. & Navale, G. K. B. (1963). *Terminalioxylon chowdhurii* sp. nov.: a new fossil dicotyledonous wood from the Tertiary rocks of Assam. *Idid.* **11** (1 & 2): 49-53, 1962.

Raizada, M. B. & Sahni, K. C. (1960). Living Indian Gymnosperms. Pt. I (Cycadales, Ginkgoales and Coniferales). *Indian For. Rec.* n. s. (Botany). **5**(2): 73-150.

Ramanujam, C. G. K. (1953a). *Palmoxylon arcotense* sp. nov., a fossil palm resembling the living genus *Livistona* from South India. *Palaeobotanist.* **2**: 89-91,

Idem (1953b). On two new species of *Mesembrioxylon* from the vicinity of Pondicherry, South India. *Ibid.* **2**: 101-106.

Idem (1953c). Fossil woods resembling *Mangifera*, *Shorea* and *Albizzia* in the Tertiary rocks of S. Arcot, India. *Curr. Sci.* **22**: 336-337.

Idem (1954). Fossil woods belonging to Guttiferae, Celastraceae, Leguminosae, Sonneratiaceae & Euphorbiaceae from Tertiary rocks of South Arcot district, Madras. *J sci. industr. Res.* **13B**(2): 146-147.

Idem (1955). On some silicified woods from near Pondicherry, South India. *Palaeobotanist.* **3**: 40-50, 1954.

Idem (1956a). Fossil woods of Dipterocarpaceae from the Tertiary of South Arcot district, Madras. *Ibid.* **4**: 45-56.

Idem (1956b). On two new species of *Terminalioxylon* Schönfeld from the Tertiary rocks of South Arcot district, Madras. *J Indian bot. Soc.* **35**(1): 103-113.

Idem (1956c) Fossil woods of Euphorbiaceae from the Tertiary rocks of South Arcot district, Madras. *Ibid.* **35** (3): 284-307.

Idem (1957). On the occurrence of fossil wood of *Sonneratioxylon dakshinense* sp. nov. from the Tertiary of South Arcot district, Madras. *Palaeobotanist.* **5**: 78-81, 1956.

Idem (1958). *Palmoxylon puratanum*, a new species of petrified palms from the Tertiary rocks of South Arcot district, Madras. *J. Indian bot. Soc.* **37** (1): 128-137.

Idem (1960). Silicified woods from the Tertiary rocks of South India. *Palaeontographica.* **106B**: 99-140.

Idem (1961). A fossil dicotyledonous wood resembling the modern *Tamarindus* from the Tertiary rocks of South Arcot district, Madras. *Palaeobotanist.* **8**: 38-42, 1959.

Rao, A. R. (1956). Some observations on pollen found in Indian Tertiary lignites. *Ibid.* **4**: 57-59, 1955.

Idem (1958). History of botanical researches in India, Burma and Ceylon. Part III: Palaeobotany. *Bangalore City.*

Rao, A. R. & Vimal, K. P. (1950) Plant microfossils from Palana lignite Eocene, Bikaner. *Curr. Sci.* **19**(3): 82-84.

Idem (1952a). Tertiary pollen from lignites from Palana (Eocene), Bikaner *Proc. nat. Inst. Sci. India.* **18**(6): 595-601.

Idem (1952b). Preliminary observations on the plant microfossil contents of some lignites from Warkalli in Travancore. *Curr. Sci.* **21**: 302-305.

Rawat, M. S. (1964). A new record of *Dipterocarpoxylon* from Siwalik formation of Uttar Pradesh. *Sci. & Cult.* **30**: 337-338.

Rode, K. P. (1933). A note on fossil angiospermous fruits from the Deccan Intertrappean beds of Central Provinces. *Curr. Sci.* **2**: 171-172.

Sah, S. C. D. & Dutta, S. K. (1966). Palynological studies on the Upper Mesozoic and Tertiary succession of Assam: 1. Miospore assemblage from the Cherra stage of the South Shillong platcau. *Palaeobotanist.* **15.**

Sahni, B. (1921). The present position of Indian palaeobotany. *Proc. Asiat. Soc. Beng.* (N. S.) **17**(4): clii — clxxv.

Idem (1931a). Revisions of Indian fossil plants. Pt. II — Coniferales (b. Petrifactions). *Palaeont. indica.* n. s. **11**: 51-124.

Idem (1931b). Materials for a monograph of the Indian petrified palms. *Proc. Acad. Sci. Unit. Prov.* **1**: 140-144.

Idem (1938). Recent advances in Indian palaeobotany. *Proc. 25th Indian Sci. Congr.* (Part 2): 133-176.

Idem (1943a). Indian silicified plants. 2. *Enigmocarpon parijai*, a silicified fruit from the Deccan, with a review of the fossil history of the Lythraceae. *Proc. Indian Acad. Sci.* **17** (3)B: 59-96.

Idem (1943b). Deccan Intertrappean Series. Palaeobotany in India-IV *J Indian bot. Soc.* **22**(2-4): 179-181.

Idem (1944). Takli near Nagpur — Genus *Viracarpon* Sahni. Palaeobotany in India — V *Proc. nat. Acad. Sci. India.* **14**(1 & 2): 80-82.

Idem (1946). A silicified *Cocos*-like palm stem, *Palmoxylon* (*Cocos*) *sundaram*, from the Deccan Intertrappean beds. *J. Indian bot. Soc. Iyengar Comm. Vol.*: 361-374.

Idem (1953). Angiosperm leaf-impressions from the Kasauli beds, N. W. Himalayas. *Palaeobotanist.* **2**. 85-87.

Idem (1964). Revisions of Indian fossil plants. Part III — Monocotyledons. *Monogr. Sahni Inst. Palaeobot.* **1**.

SAHNI, B. & RODE, K. P. (1937). Fossil plants from the Intertrappean beds of Mohgaon Kalan, in the Deccan, with a sketch of the geology of the Chhindwara district. *Proc. nat. Acad. Sci. India.* **7**(3): 165-174.

SAHNI, B., SITHOLEY, R. V. & PURI, G. S. (1948). Correlation of Tertiary succession in Assam by means of microfossils. Palaeobotany in India-VI. *J. Indian bot. Soc.* **26**(4): 262-263, 1947.

SAHNI, B. & SURANGE, K. R. (1953). On the structure and affinities of *Cyclanthodendron sahnii* (Rode) Sahni & Surange from the Deccan Intertrappean series. *Palaeobotanist.* **2**: 93-100.

SCHMID, E. E. & SCHLEIDEN, M. J. (1855). Über die Natur der Kiesel-Hölzer. *Jena.*

SEN, J. (1948). Microfossils of Assam coalfields-1. The coal seam at Laitryngew and the age of the Cherra sandstone. *Bull. bot. Soc. Beng.* **2**(2): 1-11.

SEWARD, A. C. (1912). Dicotyledonous leaves from the Coal Measures of Assam. *Rec. geol. Surv. India.* **42**(2): 93-101.

SHUKLA, V. B. (1938). On a new species of *Dadoxylon, D. deccani*, sp. nov., from the Deccan Intertrappean series. *J. Indian bot. Soc.* **17** (5-6): 355-367.

Idem (1944a). On *Sahnianthus*, a new genus of petrified flowers from the Intertrappean beds at Mohgaon Kalan in the Deccan and its relation with the fruit *Enigmocarpon parijai* Sahni from the same locality. *Proc. nat. Acad. Sci. India.* **14**(1-2): 1-39.

Idem (1944b). *Dadoxylon resinosum* sp. nov. from the Chhindwara district of the Central Provinces. *J Indian bot. Soc.* **23**(3): 83-90.

SITHOLEY, R. V. (1955). The Mesozoic and Tertiary floras of India — a review. *Palaeobotanist.* **3**: 55-69, 1954.

VERMA, J. K. (1956). On a new petrified flower, *Sahnipushpam shuklai*, sp. nov. from the Intertrappean beds of Mohgaon-Kalan in the Deccan. *J. palaeont. Soc. India.* **1**: 131-141.

Idem (1965). Further contribution to the knowledge of the Deccan Intertrappean flora. *Ph. D. Thesis Univ. Lucknow.*

VIMAL, K. P. (1953a). Tertiary spores and pollen from Warkalli lignites, Travancore. *Proc. Indian Acad. Sci.* **38B**(5): 195-210.

Idem (1953b). Occurrence of *Botryococcus* in Eocene lignites of Cutch. *Curr.. Sci.* **22**: 375-376.

WADIA, D. N. (1957). Geology of India. *London.*