AFFINITIES OF SOME INDIAN TERTIARY AND QUATERNARY POLLEN AND SPORES

P. K. K. NAIR
National Botanic Gardens, Lucknow (India).

INTRODUCTION

THE late Prof. Sahni indicated the significance of pollen and spore microfossils in considerations of the extinct floras, past climates, and the stratigraphy of coals and lignites (Sahni, 1938). The microscopic examination of coal in India started with Lomax (1927), and in later years, pioneering contributions have been made by Banerji (1932) and Virki (1937 and 1946). At the same time Wodehouse (1935) analysed the pollen flora of the Pleistocene deposits of Kashmir. Since then, a large number of spores have been described, illustrated, and classified into artificial categories, covering the entire geological time, from Palaeozoic to the Recent. The Palaeozoic, Triassic, and Jurassic 'Sporae dispersae' belong to the extinct plants, although some of them might have their equivalents among the present day plants. But the Tertiary and later Floras should be considered to bear closer affinities to the modern Flora, and the fossil pollen and spores recovered from those strata indicate the extent of such affinities. The various Indian workers were unable to recognise and identify of the plants represented by the fossil spores and pollen, due to the paucity of our knowledge on the morphology of the spores and pollen of the present day plants (Rao, 1955). In recent years much work has been carried out in this direction (Erdtman, 1952, and 1957; Nair, 1961, 1962, 1962a, 1962c; Nair and Sharma, 1962 and Nair and Rehman, 1962; Nayar and Kaur, 1963; Nayar and Shantha Devi, 1963) which has paved the way for the present attempt to suggest* the possible affinities of the fossil spores and pollen known from the Tertiary and later periods of India with their present day equivalents. It should be noted that the comparisons of the fossil spores and pollen given here relate only to the type grain considered, and this identity does not necessarily apply to grains known under the same form genera from earlier horizons.

ARRANGEMENT

In making the foregoing suggestions, the literature on the subject is classified in relation to the geological period they refer to. The pollen and spore types are arranged in the same order as given in the cited reference, and indications on the possible identity (one or more are given when the identity is provisional) are made against the name of each type. In the present communication, only those sporomorphs for which the identity could be suggested are considered, and also the observations are based on the photomicrographs, text-figures, and descriptions of pollen and spores recorded in every research contribution.

* The author wishes to record that in making these suggestions he is not criticising the observations made by any individual worker. On the contrary, the present suggestions are based in every case on the descriptions given by the author concerned.

COMPARISONS

I. TERTIARY

(A) Locality—VARKALLI, TRAVANCORE (KERALA).

(1) Ref. Rao, A. R. & Vimal, K.P. (1952.)

Microflora

Monolites–Spm. 1: Polypodiaceae (*Pyrrosia*).

Triporites–spm. 1: Urticaceae.

Triorites –spm. 1: Urticaceae (? *Morus*)

Tricolpites–spm. 1: (Apparently tricolporites with a faint ora; see photo 5; ? Leguminosae).

Tetracolporites–Spm. 1
Hexacolporites–Spm. 1
H.–Spm. 2:
} Euphorbiaceae.

(2) Ref. Vimal, K. P. (1953).

Microflora

Monolites–Spm. 2: Polypodiaceae (?*Pleopeltis*)

M.–spm. 3: Polypodiaceae.

Triletes–spm. 1: Osmundaceae.

Nonaperturites–Verruconapites–spm. 1: (grain possibly reticulate; ? Potamogetonaceae; ?? *Potamogeton*; very much close to *P. crispus*).

Monocolpites–spm. 2: Palmae (not *Borassus* as compared, because the genus has verrucate grains, which is lacking in the specimen described here).

M.–spm. 3: ? Palmae.

Tricolpites–spm. 2: ? Salicaeae.

T. spm. 3: (apparently tricolporites; see Pl IX, Fig. 15; ? Simarubaceae; ?? *Ailanthus*).

T. spm. 4: (apparently tricolporate; see Pl. IX, Fig. 17).

T. spm. 5: ? Boraginaceae.

T. spm. 6: ?? Ranunculaceae.

Tetracolpites–spm. 1; (Apparently tetracolporites; see Pl. IX, Fig. 20; Meliaceae).

Hexacolpites–spm. 1; (? Euphorbiaceae).

Octacolpites–spm. 2: Rubiaceae (? *Rubus* or *Galium*).

Tricolporites–spm. 1: Leguminosae (?? *Trifolium, Lotus, Medicago* etc.).

Tetracolporites–spm. 2: Euphorbiaceae.

Pentacolporites–spm. 1: Euphorbiaceae (?? *Phyllanthus*).

P. spm. 2: (? Polygalaceae).

Triorites–spm. 3: Urticaceae.

T. spm. 4: Urticaceae (? *Cannabis*; Pl. VIII, Fig 61 illustrates a tricolporate condition).

T. spm. 5: Casuarinaceae (*Casuarina*; No arci is seen in Pl. IX, Fig. 37, or Pl. IX, Fig. 62; if arci is present the grain compares more with *Alnus* pollen).

Triporites–spm. 2: Urticaceae.

Polyporites–spm. 1: Chenopodiaceae.

(B) Locality—PALANA, BIKANER.

(3) Ref. Rao, A. R. & Vimal, K. P. (1950).

Microflora

Type 1: Rubiaceae (*Rubus* or *Galium*).

Type 4: Leguminosae (? *Erythrina*).

Type 6: ? Meliaceae.

Type 7: Ranunculaceae.

Type 8: (Possibly 1-colpate, lateral view; Palmae).

Type 10: ? Caprifoliaceae.

(C) Locality—DANDOT, WEST PUNJAB (PAKISTAN).

(4) Ref. Vimal, K. P. (1952).

Microflora

Triletes–spm. 1: Ophioglossaceae (*Ophioglossum*).

T. spm. 2: Lycopodiaceae (*Lycopodium*).

T. spm. 5: Pteridaceae (? *Cheilanthes*).

T. spm. 6:
T. spm. 7:
} Osmundaceae.

T. spm. 8: Pteridaceae (? *Lindsaea*).

T. spm. 9: Pteridaceae (? *Microlepia*).

T. spm. 10: (Pollen tetrad; Possibly of *Typha*).

Nonaperturites-subpilonapites–spm. 1: *Potamogeton.*)

N. reticulonapites–spm. 1: Same as above.

Monocolpites–spm. 1: (? Monolete spore).

M. spm. 2: *Potamogeton* (1-colpate grains often found in the living species also).

Tricolpites–spm. 1: Urticaceae.

T. spm. 2: ? Ranunculaceae.

T. spm. 3: Polygonaceae (? *Polygonum*)

T. spm. 4: Cruciferae.

T. spm. 5: Nymphaeaceae (?? *Nelumbo.*)

Tetracolpites–spm. 1 : Oleaceae (? *Fraxinus*).
Hexacolpites–spm. 1 : Labiatae.
H. spm. 2 : Rubiaceae (*Rubus* or *Galium*).
H. spm. 3 : } Labiatae.
H. spm. 3 : }
Septacolpites–spm. 1 : } Labiatae.
Octacolpites–spm. 1 : } Labiatae.
Triorites–spm. 1 : Urticaceae (? *Morus*).
T. spm. 2 : Betulaceae (? *Betula*).
T. spm. 3 : Betulaceae (? *Carpinus*).

(D) Locality—DECCAN INTERTRAPPEAN.

(5) Ref. Chitaley, S. D. (1951).

Microflora

Monoporites (*Graminitites*) minor: Gramineae.
Tetrado-monoporites (*Typhidites*) spm. *Typha.*
Monosulcites (*palmidites*) *minima* } Palmae
M. (*P.*) *media.* } Palmae
M. (*P.*) *spinosa* : Palmae (? *Borassus*).
Triorites (*Betulacidites*) spm. (Possibly *Alnus*, if arci is sharp as described).
Porites spm. Compositae (Cichoreae : *Sonchus*, *Crepis* etc.).

(E) Locality—ASSAM

(6) Ref. Ghosh, A. K. 1941).

Microfossil

The author described a 2-winged pollen compared to that of the Podocarpaceae.

(7) Ref. Sen, J. (1948).

Microflora

The author compared a few grains to *Magnolia* (Type G), *Phoenix dactylifera* Type Gl) and Cupressaceae (Types N and 0). In the absence of photomicrographs the identification of sporomorphs is made difficult. However, there are indications of *Larix* (Type H), and *Borassus* (Type I) in the flora.

(8) Ref. Sahni, B., Sitholey, R. V. and Puri, G. S. (1948).

In the absence of photomicrographs and complete descriptions af sporomorphs no proper identity could be established. However, the drawings given could be compared to the grains of *Selaginella* (Pl. XVII, Fig. 47), *Pityrogramma* (Pl. XVI, Fig. 37), *Drymoglossum* (Pl. XVI, Fig. 44) among pteridophytes, and Compositae (Pl. XIV. Fig. 18), Betulaceae (Pl. XIV, Fig. 19), Pinaceae (Pl. XV, Fig. 36 and 29), Labiatae (Pl. XV, Fig. 27), and Urticaceae (*Cannabis*; Pl. XVI, Fig. 35), among the higher plants.

(F) Locality—KASHMIR

(9) Ref. Thierghart, F., and Prantz, U. (1962).

Microflora

Polypodiaceaesporites (Thierg.) *haardte* : Polypodiaceae (? *Microsorium* ; *Platycerium*).
Psuedoschizaea ozeanica : ?
Cyathidites kashmirensis : Cyatheaceae.
Abies pollenites (Thierg.) *kashmirensis* : Pinaceae (*Abies*).
Polyporina kashmirensis : ? Chenopodiaceae or Amarantaceae.
Quadratus indicus : Fig. 15, very close to *A. nipalensis*; arcus not clear in Fig. 16; possibly Urticaceae.
Triporocolpatus indicus : ? Fagaceae. (*Quercus*).
Umbelliferoidaepollenites kashmirensis : Umbelliferae.
Triporatus kashmirensis : Betulaceae (*Betula*).
Tubulifloridites (Cookson) *Kashmirensis* : Compositae.

(G) Locality—CANNANORE, MALABAR COAST

(10) Ref. Potonic, R., and Sah, S. C. D. (1960).

Microflora

Monoletes sp. (Pollen grain in equatorial view, see Pl. VII, Fig. 37; very close to Acanthaceae).
Polypodiidites impariter :. Polypodiaceae (?*Pleopeltis*).
Limitisporites sp. : ? Pinaceae (?? *Cedrus*).
Monosulcites parvus : Palmae (? *Phoenix*).
Cupuliferoipollenites sp. : Fagaceae (? *Castaneopsis*).
Monoporopollenites minimus : Gramineae (some grains, Pl. VII, Fig. 35, very close to Cyperaceae).
Polyadopollenites multifidus : ? Orchidaceae.

(H) Locality—CUDDALORE, MADRAS STATE, S. INDIA

(11) Ref. Navale, G. K. B. (1962).

Microflora

The author has made comparison of the fossil sporomorphs to living plants belonging to Caprifoliaceae, Cruciferae, Euphorbiaceae, Gentianaceae, Meliaceae, Ranunculaceae, Santalaceae, Gramineae, Liliaceae, and Polypodiaceae.

IV. MIOCENE

Locality—KUTCH

(12) Ref. Ghosh, S. S. and Ghosh, A. K. (1959).

Microfossil

The authors observed the occurrence of *Dipterocarpus* in the deposit.

V. PLEISTOCENE

Locality—KASHMIR (KAREWAS).

(13) Ref. Wodehouse, R. P. (1935).

(14) Ref. Nair, P. K. K. (1961).

Pollen grains recovered have been directly placed under their living equivalents (see under Analysis of microflora).

ANALYSIS OF MICROFLORA

Rao (1955) made some observations on the composition of the flora represented by the pollen and spores occurring in Indian Tertiary lignites. But his inferences were based on "provisional comparisons" of the microfossils to their possible living equivalents, thereby providing room for a reconsideration of the Indian Tertiary vegetation. Also, inferences on the nature of the flora and the climate have been drawn regarding the Quaternary (Karewas) of Kashmir (Wodehouse, 1935; Nair, 1961). But for the above, there has not been any serious attempt to evaluate the evidences presented by the pollen and spore fossils, mainly due to the difficulties encountered in the matter of identifying the plants represented by those microfossils. However, an insight into the nature and composition of the Indian Mesozoic and Cainozoic floras is made possible by the present attempt to associceht ate the pollen and spore form genera to respective taxa of (living) plants.

TERTIARY FLORA

Rao (1955) indicated the similarity of Tertiary floral assemblages from Varkalli (Kerala), Dandot (Pakistan) and Palana (Rajasthan), and also noted the affinity of the Indian flora to the corresponding Australian flora. Apart from the above localities, microflora from the Deccan Intertrappean, Assam, Kashmir, Cannanore (Malabar), and Cuddalore are known and the constituents of the flora are as follows :

Pteridophyta

Cyatheaceae, Lycopodiaceae (*Lycopodium*), Ophioglossaceae (*Ophioglossum*) Osmundaceae (*Osmunda*), Polypodiacease (*Drymoglossum*, *Microsorium*, *Platycerium*, *Pleopeltis*, and *Pyrrosia*), Pteridaceae (*Cheilanthes*, *Lindsaea*, *Microlepia* and *Pityrogramma*) and, Selaginellaceae (*Selaginella*).

Gymnospermae

Pinaceae (*Abies*, *Larix*, and *Pinus*) and Podocarpaceae (*Podocarpus*).

Angiospermae

Acanthaceae, Betulaceae (*Alnus*, *Betula* and *Carpinus*), Boraginaceae, Caprifoliaceae, Casuarinaceae (*Casuarina*), Chenopodiaceae (*Chenopodium*), Compositae (*Launea*, *Sonchus*, Asteroideae), Cornaceae (*Cornus*), Cruciferae, Cyperaceae, Euphorbiaceae (*Phyllanthus*), Fagaceae (*Castaneopsis* and *Quercus*), Gentianaceae, Gramineae, Labiatae, Leguminosae, (*Trifolium*, *Lotus*, *Medicago* etc; *Erythrina*), Liliaceae, Magnoliaceae, Nymphaeaceae (*Nelumbo*), Oleaceae, Orchidaceae, Palmae (*Borassus* and *Phoenix*), Potamogetonaceae (*Potamogeton*), Ranunculaceae, Rubiaceae (*Rubus*, *Galium* etc.), Salicaceae Santalaceae, Simarubaceae (*Ailanthus*), Tiliaceae (*Tilia*), Typhaceae (*Typha*), Umbelliferae, and Urticaceae (*Cannabis*, *Debregesia* and *Morus*). The floral assemblages of each locality are as follows :

(i) Varkalli, Travancore (Kerala) : Osmundaceae, *Pleopeltis*, *Pyrrosia* and other Polypodiaceae, Boraginaceae, *Casuarina*, *Chenopodium*, Meliaceae, *Phyllanthus*, Legumnoi-

sae, Palmae, Polygalaceae *Potamogeton*, Ranunculaceae, *Rubus* or *Galium*, *Salix*, *Ailanthus*, *Cannabis*, *Morus* and other Urticaceae.

(ii) Palana, Bikaner (Rajasthan) : Caprifoliaceae, *Erythrina*, Meliaceae, Palmae, Ranunculaceae and *Galium*.

(iii) Dandot (West Punjab, Pakistan) : *Lycopodium*, *Ophioglossum*, *Osmunda*, *Cheilanthes*, *Lindsaea*, *Microlepia*, *Betula*, *Carpinus*, Cruciferae, Labiatae, *Nelumbo*, Oleaceae, *Polygonum*, *Potamogeton*, Ranunculaceae, *Galium*, *Typha*, and *Morus* and other Urticaceae.

(iv) Deccan Intertrappean : Compositae, Gramineae, Palmae (*Borassus*) and *Typha*.

(v) Assam : *Drymoglossum*, *Microlepia*, *Pityrogramma*, *Selaginella*, *Larix*, *Pinus*, *Podocarpus* Betulaceae, Compositae.

(vi) Kashmir : Cyatheaceae, *Microsorium*, *Platycerium*, *Abies*, *Alnus*, *Betula*, *Chenopodium*, Compositae, *Quercus*, and Umbelliferae.

(vii) Cannanore, Malabar : *Pleopeltis*, Pinaceae, *Alnus*, Acanthaceae, Cyperaceae, *Castaneopsis*, Gramineae, Orchidaceae *Phoenix*.

(viii) Cuddalore, Madras : Polypodiaceae, Casuarinaceae, Cruciferae, Euphorbiaceae, Meliaceae, Ranunculaceae, and Santalaceae.

It is significant that the gymnospermous flora has been restricted to Assam, Kashmir, and Cannanore, the last of which is surprising because there is no indication of the existence of gymnosperms in the neighbouring deposits at Varkalli (Kerala) and Cuddalore (Madras State). Compared with the Jurassic vegetation, it is clear that there has been a decrease in the pteridophytes and a corresponding increase in the angiospermous plants during the Tertiary period. Certain plants like *Potamogeton*, and *Galium*, occurring in widely separated places as Varkalli, and Dandot is indicative of the wide distribution of certain plants and the prevalence of uniform climatic conditions suited to their growth. Particular mention may be made of a colporate type (Navale, 1962; *Tetracolporites*) of pollen (? Meliaceae), which is possibly an index type, occurring in Cuddalore, Palana, and Varkalli.

PLEISTOCENE FLORA

The knowledge about the Indian Pleistocene flora is confined to the Karewa formations, Kashmir. The flora is known (Wodehouse, 1935; Nair, 1960) to consist of the following plants.

Gymnosperms : *Abies*, *Cedrus*, *Larix*, *Picea*, *Pinus*, *Cupressus* and *Ephedra*.

Angiosperms : *Alnus*, *Artemisia*, *Azadirachta*, *Betula*, *Carpinus*, Chenopodiaceae, Compositae, *Corylus*, *Fraxinus*, Gramineae, *Juglans*, *Jussiaea*, *Maoutia*, *Maclura*, *Myriophyllum*, *Nelumbo*, *Persicaria*, *Plantago*, *Polygonum amphibium*, *P. plebeium*, *Quercus*, *Rhus*, *Salix*, *Trapa*, *Typha*, *Ulmus*, Umbelliferae, *Utricularia*, *Valeriana*, and *Viburnum*.

From the palynological data, it has been observed that in the lower Karewas there was possibly a dominant vegetation made by *Typha*, and gradually migration of trees occurred resulting in a forest vegetation dominated by *Alnus*, which eventually had undergone destruction to give way to plains dominated by such weeds as chenopods, *Plantago* and the grasses.

ACKNOWLEDGEMENTS

The author is grateful to Prof. K. N. Kaul, Director, National Botanic Gardens, Lucknow for his encouragement. He is thankful to his friend and colleague, Dr. B. K. Nayar, for his valuable help in making suggestions for the identity of the pteridophytic spores.

REFERENCES

Banerji, A. K. 1932, Microscopic study of some Indian coals, *Rec. Geol. Surv. India 66*, III 333-47.

Bose, M. N. 1952, Plant remains from Barmer District, Rajasthan. *J. sci. industr. Res. 11B* : 185-90.

CHITALEY, S. D. 1951, Fossil microflora from Mohgoan Kalan beds of the Madhya Pradesh India. *Proc. nat. Inst. Sci. India 17*; 375-85.

ERDTMAN, G. 1952, Pollen morphology and Plant Taxonomy. Angiosperms. Amquist & Wiksell, Stockholm.

ERDTMAN, G. 1957, Pollen and Spore morphology Plant Taxonomy. Amquist & Wiksell, stockholm.

GHOSH, A. K. 1941, Fossil pollen in the Tertiary rocks of Assam. *Sci.* and *Cult. 6*: 674.

GHOSH, S. S. & GHOSH, A. K. 1959, *Dipterocarpoxylon malavii* sp. nov. A new fossil record from the Pliocene of Kutch. *Sci.* & *Gult. 25*: 328-32.

LAKHANPAL, R. N. & NAIR, P. K. K. 1956, Some abnormal pollen grains of *Picea Smithiana* Boiss. *J. Indian cot. Soc. 35* (4) : 426-29.

LOMA, J. E. 1927, The preparation and examination of some Indian Coals. *Rec. Geol. Surv. India 66*: III 333-47.

NAIR, P. K. K. 1960, Palynological investigation of the Quaternary (Karewa) of Kashmir. *J. sci. industr. Res. 19 c*: 145-54.

NAIR, P. K. K. 1961, Pollen grains of Indian Plants I. *Bull. Natl. Bot. Gardns.* No. 53.

NAIR, P. K. K. 1962, Pollen grains of Indian Plants II. Ibid. No. 60.

NAIR P. K. K. 1962a, Pollen grains of Indian Plants III. Ibid. No. 63.

NAIR, P. K. K. & SHARMA, M. 1962, Pollen grains of Indian Plants. IV. Ibid. No. 65.

NAIR, P. K. K. & REHMAN, K, 1962, Pollen grains of Indian Plants V. Ibid. No. 76.

NAYAR, B. K. & KAUR, S. 1963, Spore morphology of some Indian members of Lomariopsidaceae. *Pollen et Spores. 5*: 87-97.

NAYAR, B. K. & Shanta Devi 1963, Spore morphological studies of Indian ferns. Aspidiaceae. *Grana Palynologica* (in press).

NAVALE, G. K. B. 1962, Pollen and spores from Neyveli lignite, South India. *Palaeoboanist 10* : 87-90.

POTONIE, R. & SAH, S. C. D. 1962, Sporae dispersae from Cannanore beach on the Malabar Coast, South India, Ibid. *7*: 121-35.

RAO, A. R. 1943, Jurassic spores and sporangia from the Rajmahal Hills, Bihar, *Proc. Nat. Acad. Sci. India 13* (Part 3) : 181-97.

RAO, A. R. 1955, Some observations on pollen found in Indian Tertiary lignites. *Palaeobotanist* 3: 57-89.

RAO, A. R. & VIMAL, K. P. 1950. Plant microfossils from Palana lignite (? Eocene), Bikaner. *Curr. Sci. 19* 82-84.

RAO, A. R. & VIMAL, K. P. 1952, Preliminary observations on the plant microfossil contents of some lignites from Warkalli in Travancore. *Curr. Sci. 21*: 302-5.

SAHNI, B. 1938, Recent advances in Indian Palaeobotany *Proc. 25th Indian Sci. Congr.*

SAHNI, B. *et al.* 1948, Palaeobotany in India *J. Indian bot. Soc.* 262-63.

SEN. J. 1948, Microfossils of Assam coal fields-1. The coal seam at Laitryngew and the age of the Cherra sandstone *Bull. Bot. Soc. Bengal.* 2 (2) 1-11.

THIERGHART, E. & PRANTZ. U. 1962, Some spores and pollen from a Tertiary brown coal deposit in Kashmir. *Palaeobotanist 10*: 84-86.

VIMEL, K. P. 1952, Spores and pollen from Tertiary lignites from Danbot, West Punjab (Pakistan). *Proc. Indian Acad. Sci. 36*: 135-47.

VIMEL, K. P. 1953, Tertiary spores and pollen from Warkalli lignites, Travancore Ibid. *38*: 195-210.

VIRKKI, C. 1937, On the occurrence of winged spores in the lower Gondwana rocks of India and Australia. Ibid. *6* (6) : 428-30.

WODEHOUSE, R. P. 1935, The Pleistocene pollen of Kashmir with an introductory note by H. De Terra. *Mem. Conr. Acad. Sci. 9*: 1-18.