A PALYNOLOGICAL APPROACH TO THE STUDY OF WARKALLI DEPOSITS OF KERALA IN SOUTH INDIA*

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ABSTRACT

The paper deals with the main results of a palynological study of the Warkalli beds along the west coast of Kerala in South India. A large number of excellently preserved spores of pteridophytes and pollen grains of angiosperms have been recovered from the lignites and clays of Warkalli beds. In addition, these beds have also yielded a good number of fungal spores and fruit bodies. The beds, however, do not contain any gymnospermous pollen.

Polypodiaceae and Schizaeaceae are the most abundant families among the pteridophytes. Heavily sculptured (verrucate-tuberculate) species of *Polypodiisporites* are the predominant taxa among the pteridophytic spores. The following angiospermous families have been recognized in the Warkalli palynoflora, viz. Potamogetonaceae, Liliaceae, Palmae, Nymphaeaceae, Loranthaceae, Oleaceae, Euphorbiaceae, Rhizophoraceae, Bombacaceae, Araliaceae, Symplocaceae, Rubiaceae, Anacardiaceae, Caprifoliaceae, Caesalpiniaceae, Compositae, Combretaceae, Sapindaceae, Meliaceae, Sapotaceae, Hippocrateaceae, Ctenolophonaceae, Labiateae, Polygalaceae, Apocynaceae, Myricaceae, Myrtaceae, Proteaceae, Sonneratiaceae, Tiliaceae, Haloragaceae, Olacaceae, Thymeliaceae, Chenopodiaceae-Amaranthaceae complex, and Droseraceae.

The palynological assemblage of the Warkalli beds shows striking resemblances with that of the Quilon beds of Lower to Middle Miocene age.

The Warkalli beds appear to have been laid down in brackish to fresh waters under terrestrial conditions near the coast line.

INTRODUCTION

The Tertiary deposits, scattered all along the west coast of the Kerala State in South India as more or less discontinuous patches, consist of the Lower Quilon beds and the Upper Warkalli beds. The former represent a marine facies and the latter the continental facies. The Quilon beds consist of richly fossiliferous limestones with stringers of carbonaceous clays, calcareous clays, and sands. The Warkalli beds, however, consist of variegated sands and sandstones, white plastic clays, carbonaceous clays, and associated seams of lignite. The entire Tertiary sequence of Kerala overlies directly the Archaean crystalline complex consisting of Khondalites, Leptynites, Charnockites and mica-hornblende gneisses, and underlies a variable thickness of recent to subrecent marine and estuarine sediments.

Recently, RAO AND RAMANUJAM (1975) published the main results of their comprehensive palynological study of the Quilon beds. It is intended in the present contribution to place on record the main results of a detailed palynological study of the Warkalli beds with particular reference to the nature of the spore and pollen assemblage and its bearing on the floristics, geological age and the palaeoenvironmental setup. A detailed paper encompassing the systematic palynology and the elaborate treatment of the above aspects will be published elsewhere.

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KING, as early as 1882, described the type section of Warkalli beds from the cliffs at Warkalli (Varkallai). According to a recent observation of POULOSE AND NARAYANASWAMI (1968) the Warkalli deposits extend all along the west coast of Kerala as somewhat detached outcrops. The best sections of Warkalli beds are exposed in the sea cliffs at Varkallai, Vettur and Kundara China-clay mine in South Kerala and in the sea cliffs at Cannanore and quarry cuttings at Palayangudi, Payyanur, Nileshwar and Kaland in North Kerala. In the sea cliffs at Varkallai these beds have the following sequence in descending order :

Laterite
Sandy clays
Alum clays
Lignite beds.

The bottom lignite beds rest on loose white sand. A number of samples have been collected from these lignites both vertically and horizontally for palynological study. The lignite is fairly thick, dark brown, easily breakable and rich in vegetable detritus. A few samples of carbonaceous clay and lignite were also collected from the Cannanore area. Further, some samples of peaty lignite have also been investigated from the Alleppey area.

PALYNOLOGICAL RESULTS

There has been very little published work on the palynology of the Warkalli beds. VIMAL (1953) briefly reported the palynoflora of the Warkalli lignite. RAMANUJAM (1960, 1972) studied some pteridophytic spores from this lignite and noted the presence of *Neyvelisporites*, *Microfoveolatisporis*, *Schizaeoisporites*, *Polypodiidites*, *Foveosporites* and *Lycopodiumsporites*. POTONIÉ AND SAH (1958) gave a brief account of some spores and pollen from the lignite of the Cannanore beach area. RAMANUJAM (1967) recently recorded the abundant occurrence of syncolpate and parasyncolpate pollen referable to Myrtaceae from the Alleppey area. More recently RAMANUJAM AND PURNACHANDRA RAO (1973) provided a detailed documentation of *Ctenolophonidites* pollen from the Warkalli lignite and commented upon the abundance of *Ctenolophonidites costatus* resembling the pollen of the modern *Ctenolophon engleri*.

Palynologically the clays and lignites of the Warkalli beds are found to be considerably rich. A good number of excellently preserved spores of pteridophytes and pollen of angiosperms, besides fungal spores and fruit-bodies, have been recovered in the present study. As in the Quilon microflora (RAO & RAMANUJAM, 1975), the angiosperms constitute the predominant elements and the gymnosperms are conspicuous by their absence. But unlike the Quilon beds, no hystrichosphaerids were recovered from any of the Warkalli samples.

The microfloral assemblage (excluding fungal elements) recovered in the present study encompasses more than 60 genera and 100 species. The pteridophytic spores recorded are referable to Lycopodiaceae, Schizaeaceae, Adiantaceae and Polypodiaceae ; of these Polypodiaceae and Schizaeaceae are abundantly represented. The important pteridophytic taxa of the Warkalli beds are *Verrucosisporites* (*V.* cf. *pulvinulatus* Manum, 1962), *Pteridacidites* (*P. rotundus* Sah, 1967), *Neyvelisporites* (*N. bolkhovitinai* Ramanujam, 1972), *Schizaeoisporites* (*S. phaseolus* Delcourt & Sprumont, 1955; *S. digitatoides* (Cookson) Potonié, 1951) and *Polypodiisporites* (*P. ornatus* Sah, 1967; *P. impariter* Potonié & Sah, 1967; *P. perverrucatus* Couper, 1953). Species of *Polypodiisporites* heavily ornamented with large verrucae or tubercles are abundantly represented.

The angiosperms constituting the bulk of the flora are represented by the pollen of both monocotyledons and dicotyledons. Some of the more commonly met with monocotyledonous taxa are Potamogetonaceae (*Retipilonapites* sp.), Liliaceae (*Liliacidites* sp.,

Smilacipites sp.), and Palmae (*Palmaepollenites kutchensis* Venkat. & Rawat, 1969; *P. cauveriensis* Venkat. & Rawat, 1972; *Arecipites* sp., *Spinizonocolpites* sp., *Paravuripollis mulleri* Rao & Ramanujam, 1977; *Edvapollis punctatus* Rao & Ramanujam, 1977; *Longapertites hammenii* Rao & Ramanujam, 1977; *L. klinkenbergii* Rao & Ramanujam, 1977; *Verrumonocolpites* sp. and various species of *Dicolpopollis*).

Among the dicotyledonous pollen, the following are the more important taxa :

Retibrevitricolpites sp.
Rananculacidites communis Sah, 1967
Rananculacidites sp.
Retitricolpites sp.
Retitrescolpites sp.
Clavatricolpites sp.
Punctatricolpites sp.
Stephanocolpites arcotense Ramanujam, 1966
Polycolpites granulatus Sah & Kar, 1970
Ctenolophonidites costatus Hoeken-Klinkenberg, 1966
Retistephanocolpites sp.
Psilatricolporites sp.
Caprifolipites sp.
Cauveripollis superbus Venkatach. & Rawat, 1973
Retitricolporites sp.
Araliaceoipollenites potoniei Ramanujam, 1966
Palaeocoprosmadites sp.
Zonocostites sp.
Compositoipollenites sp.
Bombacacidites sp.
Margocolporites tsukadii Ramanujam, 1966
M. sitholeyi Ramanujam, 1966
Symplocoipollenites sp.
Hippocrateaceaedites sp.
Gothanipollis sp.
Myrtaceidites eugenioides Cookson & Pike, 1954
M. parvus Cookson & Pike, 1954
Cupaniedites sp.
Sapotaceoidaepollenites cf. *neyvelii* Ramanujam, 1966
S. africanus Sah, 1967
Meliapollis sp.
Polygalacidites sp.
Diporites sp.
Verrutriporites sp.
Proteacidites truncatus Cookson, 1950
Intratriporopollenites sp.
Myricipites harrisii (Couper) Dutta & Sah, 1970
M. sp.
Florschuetzia sp.
Trilatiporites noremi Ramanujam, 1966
Subtriporopollis scabratus Venkatach. & Rawat, 1973
Haloragacidites sp.

Pseudonothofagidites kutchensis Venkatach. & Rawat, 1969
Parsonsidites psilatus Couper, 1960
Thomsonipollis sp.
Periporopollenites sp.
Polyporina globosa Sah, 1967
Clavaperiporites jacobii Ramanujam, 1966
Anacolosidites luteoides Cookson & Pike, 1954
A. sp.
Droseridites spinosa Cookson, 1947

In addition to these, some extremely interesting pollen grains referable to Loranthaceae, Combretaceae, and Droseraceae pollen tetrads with verrucate-tuberculate sculpture have also been recorded. A number of the above taxa (marked sp.) constitute new taxa. The following dicotyledonous families have been recognized in the palynoflora of the Warkalli beds, viz. Nymphaeaceae, Loranthaceae, Oleaceae, Euphorbiaceae, Rhizophoraceae, Bombacaceae, Araliaceae, Symplocaceae, Rubiaceae, Anacardiaceae, Caprifoliaceae, Caesalpiniaceae, Compositae, Combretaceae, Sapindaceae, Meliaceae, Sapotaceae, Hippocrateaceae, Ctenolophonaceae, Labiatae, Polygalaceae, Apocynaceae, Myricaceae, Myrtaceae, Proteaceae, Sonneratiaceae, Tiliaceae, Haloragaceae, Olacaceae, Thymeliaceae, Chenopodiaceae-Amaranthaceae complex, and Droseraceae.

The Warkalli microflora compares favourably with the microfloras of the Lower to Middle Miocene Quilon beds (Rao & Ramanujam, 1975, 1977), Miocene of Cauvery Basin (Venkatachala & Rawat, 1973), Neyveli lignite of Tamil Nadu (Ramanujam, 1966, 1966-67), and the Neogene of Rusizi Valley of Barundi in Africa (Sah, 1967). The resemblances both qualitatively and quantitatively between spore and pollen assemblages of the Warkalli and Quilon beds are indeed striking.

COMMENTS ON THE GEOLOGICAL AGE OF WARKALLI BEDS

The Quilon beds consisting essentially of limestones intercalated with clays, on foraminiferal and molluscan evidence have been considered either as Lower Miocene (Burdigalian) or Middle Miocene (Vindobanian) (Jacob & Satry, 1952 ; Dey, 1962). The evidence from the palynological assemblage also is in general conformity with the Lower to Middle Miocene age assigned to these beds. The continental Warkalli beds overlying the marine Quilon beds, however, are usually considered to be younger than the latter and of Upper Miocene or Mio-Pliocene age (see Poulose & Narayanaswami, 1968).

The present study has brought to light the significant similarity between the spore and pollen complexes of the Quilon and Warkalli deposits. This prompts us to consider that perhaps there had not been much of a time lag between the Quilon and Warkalli beds and that the continental Warkalli beds probably constitute a later phase of deposition during the Lower to Middle Miocene age itself. In other words, the difference between the Quilon and Warkalli beds is more of a facial expression than of temporal significance. More elaborate and extensive palynological work encompassing numerous borehole and surface samples is envisaged to confirm the interpretation presented here.

PALAEOECOLOGICAL INTERPRETATION

Like the Quilon flora, the Warkalli flora too shows a number of essentially tropical rain forest elements which point towards a tropical climate with plenty of rain fall during the Neogene times of Kerala (see Rao & Ramanujam, 1975). The evidence provided by

a large number of microthyriaceous fungi from the Warkalli beds is in conformity with this interpretation (RAMANUJAM & RAO, 1973a ; RAO & RAMANUJAM, 1976).

The occurrence of pollen referable to *Sonneratia* (Sonneratiaceae), *Rhizophora* (Rhizophoraceae), *Lumnitzera* (Combretaceae), *Brownlowia* (Tiliaceae), *Nipa*, *Calamus*, *Iriartea*, *Metroxylon* (Palmae), Araliaceae and Droseraceae clearly points towards lowland mangrove swampy conditions along the coast line. Further, the occurrence of pollen referable to Potamogetonaceae, Nymphaeaceae and Haloragaceae indicates the presence of fresh water ponds or lakes dotting the landscape, probably a little away from the mangrove belt towards inland. In conclusion, the Warkalli beds appear to have been laid down in brackish to fresh waters under terrestrial conditions not far away from the coast line.

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