**Some new fossil spores and pollen assemblage from Neyveli lignite formation, Tami Nadu, India**

**ELAYARAJA, M. AND AND KUMARASAMY, D\***

Botany Wing -DDE, Annamalai University, Annamalai Nagar-608 002

Email: dr\_kumarasamy@rediffmail.com

**ABSTRACT**

The Tertiary system of Southern India, in Tamil Nadu is divided in to the two formation. Upper Cuddalore sandstone formation and the Lower Neyveli lignite formation. The lignite fields of Neyveli region comes under the Neyveli lignite formation. Neyveli lignite formation contain lignite seam of 15 meter thick. Neyveli Lignite field, extending in the area of about 480 sq. km is the largest mining lignite field of India with an estimated reserve of lignite about 3,300 million tones favorable. The present report is about the observation of some spores of Pteridophytes and pollen grains of some Gymnosperms and Angiosperms from the Neyveli lignite formation. Tamil Nadu, India. From the observation of lignite samples it was concluded that the Neyveli formation was deposited during Tertiary (Miocene) period and the vegetation prevails during the time of deposition was tropical wet evergreen forest type. The present study is about the some spores of *Araucariacites australis, Ornatetradites droseroides, Polygonacidites frequens, Drechslera sp, Helminthosporium sp, Tetraploa sp*, *Curvularia sp, Alternaria sp,* it is first time identified in the Neyveli lignite formation.

**Key words:** Fossil fungi, Microfossils, Neyveli lignite, Tertiary flora.

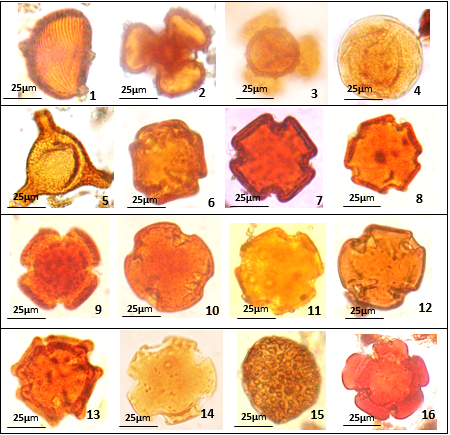
1. **INTRODUCTION**

The Neyveli lignite is largest brown coal fields of India, in Tamil Nadu. The sedimentary rocks of the Tertiary age exposed from Pondicherry in the North to Rameswaram in the South, along the coast were divided in to two formations viz. the Upper Cuddalore formation and the Lower Neyveli formation (Siddhanta, 1986). The Neyveli formation contain lignite seam of 15 meter thick. There are three distinct clay beds above the lignite which are fainly continuous and extensive. Megascopically, the lignite is banded, massive and compact in appearance. The lignite appears to be either woody, amorphous or coaly Microscopical observation of lignite sample shows, woody and non‒woody tissues of different plants, spore ‒ pollen exines, cuticles of leaves, resins, fungal spores and sclerotia (Navale, 1968). The physical components of lignite grouped under Huminite (woody and non‒woody tissues, detritus and gel); Leptinte (spores, pollens, cuticles, resins, etc); and Inertinite (fusinised organic substances) (Navale, 1968). Saxena, (1992) Published a broad report on the pollen and spores reported so far from the Neyveli lignite formation. Although many publications came out on the pollen and spore content of Neyveli lignite formation, the present study is significant in the way it contains many new reports of pollen and spores from this formation.

1. **MATERIALS AND METHODS**

The material consists of ten samples from Mine‒II area. The lignite occurs between the depths of 115.0m―128.0m. For the recovery of Palynomorphs, samples treated with concentrated nitric acid. After oxidation the residue was repeatedly washed with water and then treated with 3‒6 % of KOH solution. Slides were prepared in glycerine jelly. Morphological characters of the palynomorphs were studied and photographed using Olympus microscope attached with Olympus digital camera.

**Plate‒1**

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| **Figure: 1.** *Shizaeoisporites eocenicus* (Selling) Potonie.**2, 3.** *Ornatetradites droseroides* Rao & Ramanujam. **4**. *Araucariacites australis* Cookson ex Couper. **5**.  *Grevilloideaepites eocenicus* Biswas. **6.** *Meliapollis firmus* (Sah) Navale & Misra. **7.** *Meliapollis iratus* Sah & Kar. **8.** *Meliapollis navalei* Sah & Kar. **9.** *Meliapollis quadrangularis* (Ramanujam) Sah & Kar. **10, 11, 12, 13.** *Meliapollis ramanujamii* Sah & Kar. **14.** *Meliapollis tamilii* Navale & Misra. **15.** *Polygonaceaepites freguens* Sah & Dutta.  **16.** *Tamilipollenites robustus* Singh & Misra. |

1. **OBSERVATION**
2. ***Shizaeoisporites eocenicus*** (Selling) Potonie (Plate-1, Fig-1)

It is a Pteridophyte spore and it is bean shaped, 32 x 21 μm in size, extending to half of the longer axis, exine 1.6 μm thick and finely striated on both surfaces, sexine 2.5 μm thick.

**Comparison**

So far, 16 species of *Schizaeoisporites* were reported from the Tertiary sediments of India. Out of these ten species (*S.* *crassimurus, S. digitatoides, S. eocenicus, S. ghoshii, S. grandiformis, S. grandistriatus S. minimus, S. perforatus, S. phaseolus, S. sinuata*) were reported from the Neyveli formation and adjoining Tertiary deposits of South India. The present species *S .eocenicus* already reported from this formation (Siddhanta, 1986).

1. ***Ornatetradites droseroides*** Rao & Ramanujam (Plate-1, Fig-2,3)

It is a Angiosperm fossil spore and it is found as tetrahedral tetrad and the tetrad is 30×35µm in size with trilete marking.

**Comparison**

So far five species of *Ornatetradites* (*O. chandae, O. droseroides, O. keralensis, O. microgranites and O. wellmanii*) reported from various Tertiary deposits of India (Kumar *et al.* 2001). But so far no species have been reported from the Neyveli formation. This is the first report of this species from the Neyveli formation.

1. ***Araucariacites australis*** Cookson ex Couper (Plate-1,Fig-4)

It is pollen of Araucariceae. Pollen flattened circular, radially symmetrical, 39‒93µm in diameter, not saccate. Exine 1.0 µm thick, sculptured with fine grana.

**Comparison**

Pollen of Araucariaceae(*Araucariacites*) so far reported from the Upper Jurassic‒Lower Cretaceous sediments. There are only two species *Araucariacites* (*A. australis and A. masolensis*) reported in the Tertiary deposits of India. This is the first report *Araucariaceae* pollen from this formation. Pollen of Podocarpaceae(*Podocarpidites*) also reported from this formation (Jeyasingh *et al,* 1989). Apart from these many petrified woods of Araucariaceae and Podocarpaceae were also reported from the Upper Cuddalore sandstone formation. This indicates the Tertiary vegetation of this region normally contain a good number of gymnosperm representatives.

1. ***Grevilloideaepites eocenicus*** Biswas (Plate-1, Fig-5)

Pollen triangular‒sub triangular in polar view with a circular central body and three projecting arms, Pollen 30×65µm, without apertures, arms 10‒30 µm long and 10.2 µm broad, sexine granular, forming negative reticulum, more pronounced and specially concentrated at the base of the arms, nexine in the pollen body is 2‒3 µm thick.

**Comparison**

This pollen related to pollen of Proteaceae. So far four species *Grevilloideaepites* (*G. eocenicus, G. inferius, G. pachyexinus and G. trilobatus*) reported from Tertiary deposits of India. Out of these four species *G. eocenicus* is the common species found in most of the Tertiary deposits of India. It was also observed in Neyveli lignite formation (Singh & Misra, 1991). The present investigation gives additional evidence for the occurrence of this species in this formation.

1. ***Meliapollis firmus*** (Sah) Navale & Misra (Plate-1, Fig-6)

Pollen quadrangular in polar view, 80×84 µm in size, tetracolporate, colpi medium to long, margin thickened, pore circular to lalongate, surface psilate.

1. ***Meliapollis iratus*** Sah & Kar(Plate-1, Fig-7)

Pollen quadrangular, 66‒90µm in size, tetracolporate, colpi long, margin thickened, exine 3‒4 µm thick, sexine thinner (1.5‒3.0 µm) than nexine, surface laevigate.

1. ***Meliapollis navalei*** Sah & Kar (Plate-1, Fig-8)

Pollen subcircular to pentagonal, 50‒52 µm in size, pentacolporate, brevicolporate, colpi faintly seen, lalongate, 6‒7 µm in diameter with thickened margins, exine 6‒7 µm in thick, surface laevigate,

1. ***Meliapollis quadrangularis*** (Ramanujam) Sah & Kar (Plate-1, Fig-9)

Pollen almost circular in polar view, 36×38 µm in size, tetracolporate, colpi medium to long, exine thick and surface psilate,

1. ***Meliapollis ramanujamii*** Sah & Kar (Plate-1, Fig-10,11,12,13)

Pollen subcircular‒circular, 52×57 µm, tetracolporate, colpi medium, faintly visible, pore circular, lalongate, margin thickened, amb square, 6.0µm across, exine 1.6‒2.6µm thick, surface laevigate.

1. ***Meliapollis tamilii*** Navale & Misra (Plate-1, Fig-14)

Pollen sub circular to pentagonal, 110×130 µm in size, pentacolporate, brevicolporate, colpi faint, lalongate, with thickened margins, exine 4.0‒6.6µm thick, sexine slightly thinner than nexine, surface laevigate,

**Comparison**

The pollen of the genus *Meliapollis* is very much similar to the pollen of extant Meliaceaemembers. So far 13 species of *Meliapollis* reported from the various Tertiary deposits of India. Most of these species (11) were reported from the Neyveli lignite formation (Rao, 2000). Only two species viz. *M. minutes and M. quilonensis* were not so far reported from this formation. This observation shows that many members of Meliaceaewere present in the Tertiary vegetation of this area.

1. ***Polygonacidites frequens*** Sah & Dutta (Plate-1, Fig-15)

Pollen of Polygonaceae affinity.Pollen prolate spheroidal, 35‒40 µm×38‒45 µm in size, tricolporate, colpi long, exine thick, columellate, columella broader towards the poles, surface broadly reticulate.

**Comparison**

So far two species Polygonacidites (*P. frequens and P. zonoidies*) reported from the Tertiary deposits of India. Recently Mandaokar and Mukherjee, (2014) reported this fossil pollen from Panruti region (Cuddalore sandstone formation). This is the first report of this species from the Neyveli lignite foramation.

1. ***Tamilipollenites robustus*** Singh & Misra (Plate-1, Fig-16)

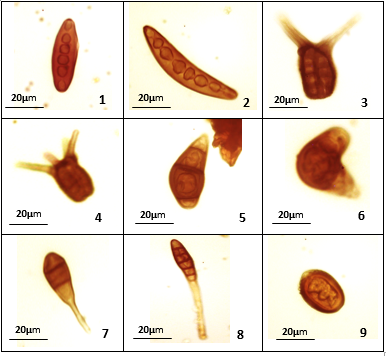
Pollen circular in polar view, 114‒120 µm in size, pentacolporate, colpi medium to long, margin thickened, pore circular to lalongate with thickened margins, exine 4.0‒6.6 µm thick, sexine slightly thinner than nexine, surface laevigate.

**Comparison**

So far two species (*T. grandis and T. robustus*) of *Tamilipollenites* reported from Neyveli lignite formation and these species so far not been reported from other Tertiary sediments of India.

**Plate-2**

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| **Figure-1.** *Drechslera sp.***2**. *Helminthosporium sp*Link ex Fr. **3, 4.** *Tetraploa sp* Berk & Br. **5, 6**.  *Curvularia sp*Boedijn.  **7, 8**.  *Alternaria sp*Nees ex Wallr. **9.** Fungal spores. |

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1. **OBSERVAATION**

***I. Drechslera sp*** (Plate-2, Fig-1,)

Spores of *Drechslera* occur individually and have very thick walls. In additions the septa between cells appear to be incomplete and are called pseudosepta. The shape of the spores varies. They can be straight, slightly curved, club-shaped, cylindrical, or elliptical. The texture on the surface of the spores is usually smooth,

**Comparison**

Several genera of very similar fungi including the genera *Drechslera, Bipolaris,* *Helminthosporium*, and *Exserohilum* have very similar spores and this spore type should be called *Drechslera*-type spores. The fungi are either plant pathogens or saprobes in the natural environment (Smiley *et al*, 2005).

***II. Helminthosporium sp*** (Plate-2, Fig-2)

In this spore common pathogens of grasses, conidia 4 to 8 celled, thick walled, cylindrical or ellipsoidal, often curved a little, gradually narrowing at both ends, the ends, rounded, 85-95 µm in length, and 15-20 µm in breadth.

**Comparison**

It is frequently presented in fossiliferous site, this spores have been recovered from the Quaternary deposits of Malvan, Surat District, Gujarat (Sharma, 1976)and Neogene sediments of Mahuadanr valley, Latehar district, Jharkhand,India (Sanjai *et al,* 2008) and fungal remains from the flandrian deposits in the whittlesey mere region hunts, England (Mittre, 1975).

***III. Tetraploa sp*** (Plate-2, Fig-3, 4)

Conidia quadriseriate, oblong ornamented, generally with four setose, two long and two short, and septate, appendages, the size of the body variable from 25-40 µm long, 15-30 µm broad, setae 20-40 µm long, 3-5 µm brod.

**Comparison**

In this types of spores have been recovered from the Quaternary deposits of Malvan, Surat District, Gujarat (Sharma, 1976) and fungal remains from the flandrian deposits in the whittlesey mere region hunts, England (Mittre, 1975).

***IV. Curvularia sp*** (Plate-2, Fig-5, 6)

The present specimen is a conidium of *Curvularia sp.* It is four celled, cells are slightly curved and thick walled. This type of conidium so far reported only from quaternary deposits. Very rarely it was also reported from Tertiary deposits.

**Comparison**

In this types of spores have been recovered from the Quaternary deposits of Malvan, Surat District, Gujarat (Sharma, 1976)and recently recovered Neogene sediments of Mahuadanr valley, Latehar district, Jharkhand,India (Sanjai *et al,* 2008) and fungal remains from the flandrian deposits in the whittlesey mere region hunts, England (Mittre, 1975).

**V.** ***Alternaria sp*** (Plate-2, Fig-7, 8)

Conidia multicellular, with both transverse and longitudinal septa, much variable in size and shape, obclavate to elliptical or ovoid, 45-80 µm long, 10-15 µm broad at its widest and provided with an apical appendage.

**Comparison**

In this types of spores have been recovered from the Quaternary deposits of Malvan, Surat District, Gujarat, India. (Sharma, 1976) and fungal remains from the flandrian deposits in the whittlesey mere region hunts, England (Mittre, 1975).

***VI.* Fungal spores**(Plate-2, Fig-9)

This types of fossil spores unicellates, brown in color, thick walled outer layer, and cells are single, monospore, pore presented one side only, 50-90 µm long, 15-20 µm broad, it is very rare in this formation.

This types of fossil spores could not be assigned for any extant fossiliferrous deposits.

1. **DISCUSSION**

Pollen reported so far from the Neyveli lignite formation are comes from the angiosperm families such as *Araliaceae, Aquifoliaceae, Brassicaceae, Caprifoliaceae, Lamiaceae, Haloragaceae, Hippocreteaceae, Liliaceae, Meliaceae, Myricaceae, Myrsinaceae, Nyssaceae, Olacaceae, Oleaceae, Polygonaceae, Potamogetonaceae, Rhamnaceae, Rubiaceae, Santalaceae, Symplocaceae.* Apart from these, fruiting bodies and spores of Microthyriaceous fungi, spores of Pteridophytes, and Gymnosperms also observed in the lignite samples, but they are poorly represented. This pollen flora suggest a tropical‒humid climate with higher rainfall during the time of sedimentation. In general, the Tertiary floristic components of South India clearly indicates the occurrence of discrete pockets of brackish water or estuarine mangrove swamps adjacent to the coastline and tropical wet ever green forest slightly away from it (Ramanujam, 1982).

The several genera of very similar fungi including the genera *Drechslera, Bipolaris, Helminthosporium,* and *Exserohilum* have very similar spores and this spore type should be called *Drechslera-*type spores. The fungi are either plant pathogens or saprobes in the natural environment (Smiley *et al,* 2005)*.* However, the *Helminthosporium* species is mostly parasitic grasses,The *Tetraploa* species is commonly dominated with grasses and sedges (Subramanian, 1971).

The observations of pollen grains also suggest that the main lignite seam is mainly composed of angiosperm dominant vegetation during the time of deposition. The similar palynomorphs encountered in all mines of Neyveli lignite shows that there is no signification difference in the vegetation and palaeoecology of these areas.

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