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An ebenaceous fossil wood from the Neyveli lignite, South Arcot District, Tamil Nadu, India

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ABSTRACT

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A fossil wood, referable to the family Ebenaceae, has been recovered from the Neyveli lignite (Miocene) of South India. The fossil wood is characterized by apotracheal parenchyma occurring in 1-2 seriate, close, concentric tangential lines at regular intervals and 1-2 seriate heterogeneous xylem rays and shows affinity with the extant taxon *Diospyros malabarica* (Desr.) Kostel., presently occurring in Indo-Malayan region. The present finding indicates existence of tropical evergreen vegetation under humid climatic condition which was responsible for the formation of lignite in the Neyveli area.

Key-words: Carbonized wood, *Diospyros malabarica* (Desr.) Kostel., Ebenaceae, anatomy, climate, Neyveli lignite, South India

INTRODUCTION

The palaeobotanical study on Neyveli lignite revealed occurrence of both mega- and microfossils. A number of angiosperm fossil woods, belonging to several families, have so far been reported from these lignites (Awasthi 1984, Agarwal 1989, 1991, 1998). Recently, more than 50 wood specimens, collected from the Neyveli Lignite Mine-I, were studied. Most of them represent families Dipterocarpaceae, Anacardiaceae, Rhizophoraceae, Ebenaceae, Combretaceae and Lecythidaceae. Of these, one new fossil wood species, showing close affinity with the genus *Diospyros* Linn. (family Ebenaceae), has been described and discussed in the present paper. Palynofloras obtained from these lignite deposits are rich in algal and fungal remains, pteridophytic spores and angiosperm pollen (Navale 1962, Thiergart & Frantz 1963, Ramanujam 1963, 1966a, b, 1967, 1982, Ramanujam & Ramachar 1963, 1980, Deb 1972, Deb et al. 1973, Venkatachala 1973, Navale & Misra 1979, Ambwani et al. 1981, Bande & Ambwani 1982, 1983, Reddy et al. 1982, 1984, Thanikaimoni et al. 1984, Ramanujam & Reddy 1984, Sarma et al. 1984, Saxena 1984, Ramanujam et al. 1984, 1985, 1988, Siddhanta 1986, Sarma & Ramanujam 1988, Sarma & Reddy 1988, Singh & Misra 1991a, b, c, Singh et al. 1992, Misra et al. 1996).

GEOLOGY OF THE AREA

The Neyveli lignite deposits are developed in the northeastern part of South Arcot basin (Ariyalur-Pondicherry sub-basin) aligned in a NE-SW direction (Lat. 11°15'-11°40'N: Long.79°25'-79°40'E) in Tamil Nadu state (Text-figure 1, Table 1). Available records suggest Eocene to Mio-Pliocene age for these deposits. The Precambrian basement (schists and gneisses) is succeeded by fossiliferous limestone, calcareous sandstone and marlstone (Late Cretaceous) whereas the Cuddalore Formation (Miocene-Pliocene) tops the sequence.

The subsurface lignite, in the upper part of Cuddalore Formation, lies as a major seam (less than 6 to 27 m in thickness) in Neyveli field at depths varying

between 45 and 150 m below ground level. There is no major depositional disturbance. The lignite seam is uniform and non-banded in nature (Balasunder 1968, Subramanian 1969, Gowrisankaran et al. 1987, Banerji 1988, Singh et al. 1992). It is massive and compact when fresh, with dark brown to black colour and granular to fibrous texture (Text-figure 1B).

MATERIAL AND METHOD

The material for the present study comprised of carbonized woods collected from the Neyveli Lignite Mine-I, Tamil Nadu, South India. For anatomical study, the microtome sections (transverse, tangential and radial longitudinal) of the wood were cut using standard techniques. Suitable thin sections were studied under high power microscope. The photographs were prepared with the help of a digital camera (DS-20) attached to the microscope. Anatomical description of the wood is according to the recommendations of IAWA Committee (1989).

SYSTEMATIC DESCRIPTION

Order: Ericales

Family: Ebenaceae

Genus: *Diospyros* Linn.

***Diospyros neyveliensis* D. Mukherjee & M. Prasad, sp. nov.**

Plate 1, figures 1, 3-5, 7-9

Material: 3 pieces of carbonized woods, measuring 4-6 cm in length and 3-5 cm in width.

Description: Wood diffuse porous. Growth rings indistinct. Vessels small to medium sized, tangential diameter 64-120 μm; radial diameter 68-208 μm; solitary as well as multiples of 2-4 (rarely 6), 5-6 vessels per mm^2. The vessels are filled with dark contents (probably resin), circular to oval when solitary while those in radial multiples are generally flattened at the points of contact (Plate 1, figures 1, 3-4); vessel members 160-400 μm in length with usually truncate to tailed end, perforations simple; intervessel pits small to medium (4-6 μm) in diameter, alternate, orbicular to oval in shape; bordered, pits alternate with linear to lenticular apertures (Plate 1, figure 9). Parenchyma apotracheal and paratracheal; paratracheal parenchyma scanty associated with the vessels; apotracheal parenchyma 1-2 seriate, regular concentric slightly wavy lines, about 15-20 lines/mm (Plate 1, figures 1, 3); parenchyma cells thin walled, 12-16 μm in diameter and 55-180 μm in length. Xylem rays fine, 1-2 seriate, mostly uniseriate, 14-30 μm in width and 3-8 cells and 120-750 μm in length (Plate 1, figures 5-7); ray tissues heterogeneous with rays composed of both upright and procumbent cells; ray cells thin walled; tangential height of procumbent cells 16-26 μm in diameter and 16-68 μm in radial length; tangential height of upright cells 40-60 μm and 16-35 μm in radial length. Ray cells profusely crystalliferous in nature (Plate 1, figure 8). Fibres aligned in radial rows, polygonal, semi-libriform, moderately thick walled, non-septate; 12-16 μm in diameter; 150-330 μm in length.

Holotype: LU.NL -01, Department of Geology, Lucknow University, Lucknow.

Locality: Neyveli Lignite Mine-I, Tamil Nadu, South India.

Horizon and Age: Neyveli Formation, Miocene.

Modern affinities: The diagnostic features of the fossil wood, such as 1-2 seriate, close, concentric,

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Plate 1

1, 3-5, 7-9. *Diospyros neyveliensis* sp. nov. 1. Cross section of the wood in low power, showing shape, size and distribution of vessels and parenchyma, Slide no. LU.NL-01. 3. Cross section, magnified to show the distribution of vessels and wavy pattern of parenchyma lines, Slide no. LU.NL-01. 4. A part of cross section, highly magnified to show the scanty parenchyma and vessels filled with dark resinous matter, Slide no. LU.NL-01. 5. Tangential longitudinal section, showing mostly uniseriate xylem rays and the nature of fibres and parenchyma strands, Slide no. LU.NL-02. 7. A part of tangential longitudinal section, magnified to show the details of xylem ray cells (upright and procumbent cells as seen in living wood of *D. malabarica*), Slide no. LU.NL-02. 8. Radial longitudinal section showing heterocellular xylem rays, Slide no. LU.NL-02. 9. Magnified intervessel pit pairs, Slide no. LU.NL-03.

2, 6. *Diospyros malabarica* (Desr.) Kostel. 2. Cross section, showing similar shape, size and distribution of vessels and parenchyma. 6. Tangential longitudinal section, showing similar structure of xylem rays and nature of fibres and parenchyma strands.

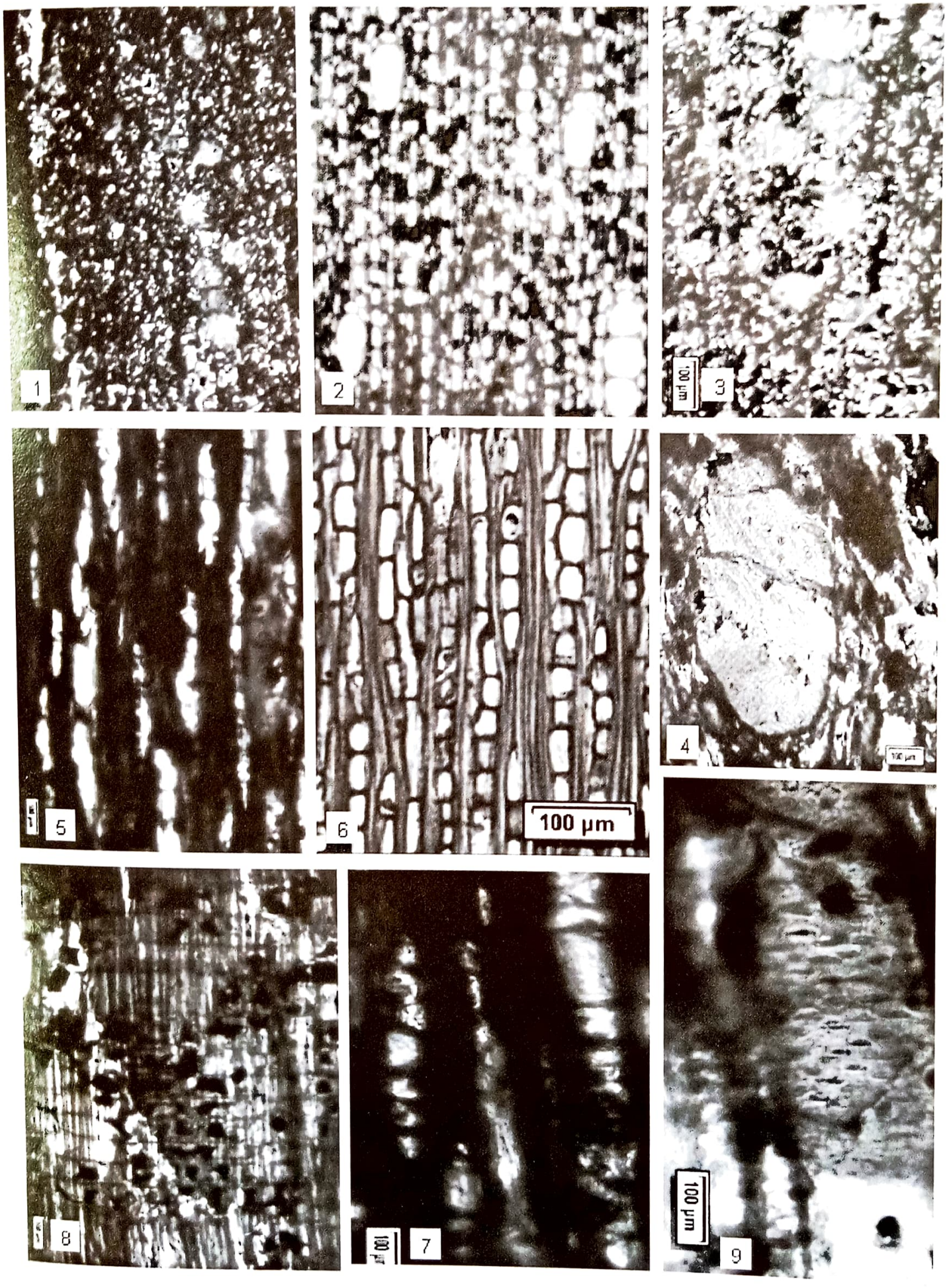
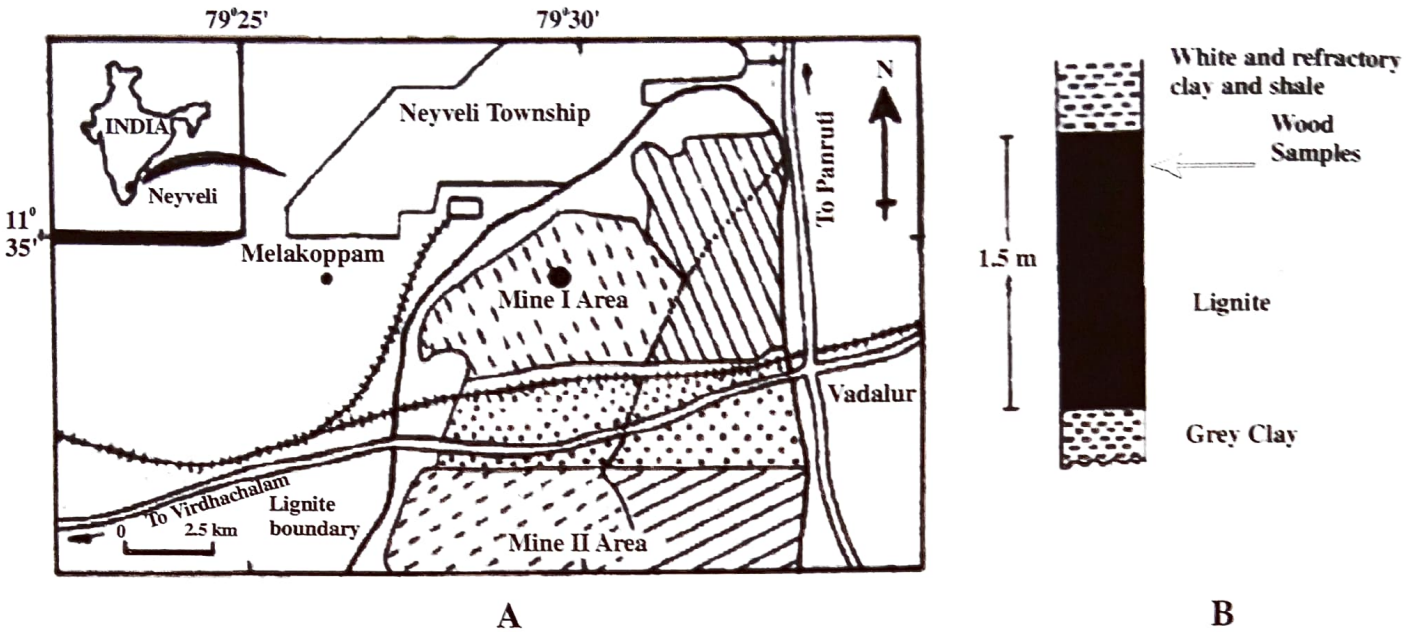


Plate 1



Text-figure 1. A. Showing location of Neyveli Lignite Mine 1, South Arcot District, Tamil Nadu; B. Stratigraphic section showing sample position.

tangential lines at regular interval and 1-2 seriate heterogeneous xylem rays, are seen in the extant woods of the families Apocyanaceae, Ebenaceae, Rubiaceae and Sapotaceae (Pearson & Brown 1932, Metcalfe & Chalk1950). Presence of small to medium sized vessels with small pits, frequent upright cells and non-septate fibres collectively suggest its affinity with the genus *Diospyros* Linn (Maba Forst.) of the family Ebenaceae. The members of other families differ from the present fossil either in vessel size or in the distribution of parenchyma. However, on critical examination of thin sections of about 40 species of the genus *Diospyros* Linn. and other published anatomical details (Kanehira 1924, Desch 1959, Kribs 1951, Normand 1960, Miles 1972, Ilic 1991), it was found that the fossil wood is closer to *D. malabarica* (Desr.) Kostel. (BSIP wood slide no. 2307, Plate 1, figures 3, 6).

Fossil records and comparison: Fossil woods resembling the genus *Diospyros* Linn. are described under the form genus *Ebenoxylon* Felix 1882. So far, 26 species of this genus have been recorded from the Tertiary sediments of India and abroad. Of which, 12 species are known from the Indian subcontinent (Table 2). The present fossil wood has been compared with all the known Indian species as well as available species of other continents. It was found that the present fossil

Table 1. Geological succession around Neyveli Lignite field, South India (after Subramanian 1969).

Age	Formation and Lithology
Recent	Soil, alluvium, laterite and kankar
Late Miocene	Cuddalore Formation: Argillaceous sandstone, lignite bearing sandstone, grits, sands, clays and pebbles
----------Probable unconformity----------	
Eocene	Black clay, shale, grey limestone with fossils
----------Unconformity----------	
Mesozoic (Cretaceous)	Ariyalur Formation: Shale, limestones, siliceous limestones, marls, etc.
----------Unconformity----------	
Precambrian (Archaean)	Intrusive dolerites, quartz veins, granitoids, gneisses

wood is entirely different from them in one or other characters; however, it shows some similarity with the fossil wood, *Ebenoxylon kalagarhensis* Prasad 1989, described from the Middle Miocene sediments of Kalagarh area, Uttarakhand. Both the fossil woods, from Neyveli and Kalagarh, possess 1-2 seriate, regular concentric lines of apotracheal parenchyma, 1-2 seriate (mostly uniseriate), heterogeneous xylem rays and small to medium bordered pits. However, the present species differs from *E. kalagarhensis* in the size of vessels. The fossil wood *Ebenoxylon arcotense* (Awasthi) Awasthi 1984, described from the same locality, is also different from the present fossil wood as it bears vessels

Table 2. Fossil woods referred to the family Ebenaceae

Fossil Taxa	Locality	Horizon/Age
Ebenoxylon ebenoides Schenk 1883, Kaiser 1890	Libyan desert near Regenfeld	Late Cretaceous
Ebenoxylon diosyroides Eilix 1882, 1883, Kaiser 1890	Antigua	Tertiary
Ebenoxylon speciosum Platen 1908	California	Tertiary
Ebenoxylon tenax Beck 1886, Kaiser 1890, Schonfeld 1947	Saxony	Oligocene
Ebenoxylon tunetanum Fliche 1898, Edwards 1931	Tunisia (Ain Cherichera)	Pliocene
Ebenoxylon sp. Fliche 1898	Myteline (Orthymnos)	Tertiary
Ebenoxylon boreale Platon1908	Alaska	Tertiary
Ebenoxylon aegypticum Krausel 1939	Egypt	Tertiary (Oligocene)
Ebenoxylon knollii Hofmann 1944, Greguss 1956	Prambachtrichen, Darno Berges (Kom Heves), Hungary	Oligocene
Ebenoxylon hofmannae Greguss 1956	Darno Berges , Hungary	Oligocene
Diospyros sp. cf. *D. ebenaster* Greguss 1967	Hungary	Miocene
Ebenoxylon miocenecum Prakash 1978, Antal et al. 1996	Kalagarh (Uttarakhand), W. Bengal, India	Late Miocene
Ebenoxylon siwalicus Prakash 1981	Kalagarh (Uttarakhand), India	Late Miocene
Ebenoxylon obliquiporosum Awasthi & Ahuja 1982	Varkala Beds, Kerala, South India	Mio-Pliocene
Ebenoxylon deccanense Trivedi & Srivastava 1982	Deccan Intertrappean, Madhya Pradesh, India	Early Tertiary
Ebenoxylon kalagarhensis Prasad 1989	Kalagarh (Uttarakhand), India	Middle Miocene
Ebenoxylon candoleana Prasad 1993	Kalagarh (Uttarakhand), India	Middle Miocene

of comparatively larger size (140-250 μm) and the xylem rays are composed of oval to circular cells (procumbent cells) as compared to mainly upright cells (elongated cells). The other species can be differentiated in having different size and frequency of the vessels and nature of parenchyma band. The rays in these species are either homogeneous or have only few upright cells. In view of the noted differences, the present fossil wood is attributed to a new species as *Diospyros neyveliensis*.

DISCUSSION AND CONCLUSION

The present investigation on the carbonized woods, collected from the Miocene sediments of Neyveli Lignite deposits, South India, revealed occurrence of a new taxon, *Diospyros malabarica* (Desr.) Kostel. of the family Ebenaceae. Although a number of taxa are known from this fossil site but none of them are referable to this species. The genus *Diospyros* Linn. comprises about 500 species referable to trees and shrubs. It is widely distributed throughout the tropical and subtropical regions of the world (Willis 1973). About 40 species have been found to occur in the Indian region that mostly grow in South India, Sri Lanka, Myanmar, Bangladesh and the northern parts of India (Gamble 1972, Purkayastha 1982). The comparable species *Diospyros malabarica* (Desr.) Kostel. presently grows in the Indo-Malayan region (Desch 1957). Thus the occurrence of this Malayan representative in Neyveli area (India) suggests that some of the flora of south-east region must have been migrated to Neyveli before being fossilized during the Miocene time. The genus *Diospyros malabarica* (Desr.) Kostel. of evergreen forests of Malayan region indicates prevalence of warm and humid climate in the Neyveli area during the Miocene period.

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