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FOSSIL FUNGAL SPORES FROM BROWN COAL OF SONDA, DISTRICT THATTA, SINDH, PAKISTAN

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Abstract

In the present paper the fallowing 35 fossils fungal spores are described from the Sonda Coal of District Thatta, Sindh including two species *Dicellaesporinites bolharensis sp. nov.* and *Lacrimasporonites sondensis sp. nov.* which are new species.

These fungal spores indicate that the coals are allochthonous and drifted through the flood water deposited in the paralic swampy vegetation in the deltaic region.

Keywords: fossils fungal spores are described of the Sonda coal.

1. Introduction

The study of fossil, fungal spores their distribution pattern have been useful tool in interpreting the past geological periods. They serve as an important indicator of past geographical conditions and are helpful in tracing the broad climatic fluctuations of past ecological ages. The distribution and floral diversity pattern also help in demarcating terrestrial and aquatic environmental variation and stratigraphic correlation of rock units particularly where other distinct faunal fossils are absent. Fossil fungal spores occur in both the coal and carbonaceous layers in the lower tertiary sediments. Paleocene sequence of Sindh is known since Blanford (1879). The coal seems to be present in Bara Formation consisting of sandstone subordinate carbonaceous material and coal whereas coal beds present are of variable thickness belonging to mid – Paleocene Ranikot Group (Shah 1977).

In Pakistan the depositional conditions of the tertiary deposit of coal found at Dandot, Salt Range (Punjab), Lakhra, Meting and Sonda of Sindh (Vimal 1952, Jain and Shah 1968, Nizamani 1982, 1984, Nizamani *et al.*, 1991), have concluded and interpreted the assemblages in terms of palaeoclimatic conditions. In these studies the vegetational makeup has been interpreted from the fossil plant material found in coal but (Sahito *et al.*, 1986, 1988, 1996) described some fungal genera such as *Cladosporites, Helminthosporites, Transeptasporites* and *Muticellaesporites* from Sonda coal and also isolated Trielete spores and winged bisacata pollen grains from Sonda coal field.

Recently (Leghari *et al.*, 2001) reported some algal species like *Botryocoecus brauni* kűtz. B. *grandis* Bischoff *et al.*, Bold, B. *minor* (Chodat) Pterova, G*eminella minor* (Naegeli), belonging to Chlorophyta.

(Shefy and Dilcher 1971) described *Multicellaesporits elongatus var. perforatus* new fungal spores and spore of *Riccia rosea V*olk *et al.,* Perold from Sonda coal deposits, District Thatta Sindh, Pakistan.

In the present study some more unreported forms of the fossil fungal spores are described which were of very rare occurrence in the coal.

2. Materials and Methods

The core samples of the Paleocene coal and associated sediments were collected from the borehole No. 18 in the Sonda coal area, the drilling proved the occurrence of a number of coal seams in the subsurface up to depth of 1200 ft.

The samples were obtained from exploratory Bore Whole Core DH No. 18 of Sonda Coal field through the courtesy of Geological Survey of Pakistan (GSP). In total 40 samples were collected, out of which 16 were selected. The coal was grayish black in colour, the samples were taken from the depth of 46–1762 meters. The Sonda coal mines (Bore whole 18) is located at Sonda which is almost 60 km in the south of Kotri, 30–35 km south from Thatta city.

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The coalfield samples were macerated by adopting Schultz's 1928) method of maceration. The microscopic slides were prepared following Kisser method (1935). The slides were studied on Ortholux II (Leitz Whatzler) microscope using ocular and stage scales for measurement of spores and Polymorphs. Photographs were taken using x10 eyepiece with 40 × or 100 × objectives.

Systematic Paleontology

In the present paper twenty one fungal spores belonging to the species of thirteen genera are described. Their details are given below.

1. *Anatolinites* sp. I (after Elisk *et al.*, 1990: 93).

Fossil fungal spores, brown in colour, flask shaped, four celled, 18.6 x 33 µm in diameter, septa 6 – 15 µm long and 1.5 – 3.6 µm broad, opaque. At the basal cell there is very minute pore, 0.6 µm thick, psilate. Occur at the depth of 177.7 meters in dark brown clay (Fig. 1).

Remarks: The present specimen shows close resemblance with the species described by Elisk *et al.*, (1990).

2. *Brachysporisporites thraceous* (after Ediger 1981: 93).

Fossil fungal spores brown in colour, 3 celled, ovoid in shape, symmetrical around the long axis, 51x72 µm in diameter, one end is more rounded. Cells are arranged in a graded series of diminishing size. Monoporate, pore at the apex of the smallest cell, pore structure simple, 3 µm in diameter. Exine wall slightly thickened around the spore. Septum dark coloured, 7.5–15 µm thick and 28.5–39 µm long and appears triangular in surface view. Spore wall 1.5 µm thick, smooth. The present specimen was found at the depth of 177.7 meters in the dark brown clay (Fig. 4).

Remarks: The present specimen shows a slightly constriction at the septal region, but the opening is not present at the septa as described by (Ediger 1981) reported from upper Eocene– Oligocene and Miocene - Pliocene sediments of Thrace Basin of Turkey. This species grow on fallen decaying leaves (Ellis and Ellis, 1985).

3. *Brachysporisporites* sp. I (after Ediger 1981: 93).

Fossil fungal spores brown in colour, pentacellate, ovoid, shape symmetrical, 48x75 µm in diameter. One end is more rounded. Cells are arranged in a graded series of diminishing size. Monoporate, pore at the apex of the smallest cell, simple, 3 µm in diameter, four times septate, septa with two lobes; lobes appear as triangular in surface view. There is opening on septa connecting the cell. Spore wall 1.5 µm thick, smooth and setose. The present specimen occurs at the depth of 177.7 meters in the dark brown clay (Fig. 3).

Remarks: The present specimens are pentacellate found from Sonda coal field which shows the close resemblance with tricellate *Brachysporisporites thraceous* (Ediger 1981).

4. *Brachysporisporites* sp. II (after Ediger 1981: 93).

Fossil fungal spores dark brown in colour, elliptical, 27 × 49.5 µm in diameter, 3 celled. Cells at both ends taper gradually to form a cone like structure, monoporate, pore at the apex of small cell. Septum dark colourued, 12–21 µm long and 3–4 µm thick and appears triangular in surface view. Spore wall 1.5 µm thick, 3 µm thick. The present specimen occurs at the depth of 177.7 meters in the dark brown clay (Fig. 27).

Remarks: In the present specimen opening is not present in the septa as described by (Ediger 1981) reported from upper part of Thrace Basin, Turkey.

5. *Brachysporisporites* sp. III (after Ediger 1981: 93).

Fossil fungal spores brown in colour, subcircular 27.3 × 30 µm in diameter. Cells are arranged in a graded series of minute size. Two septa, septa with dark colours, 19.5 – 23.4 µm long and 3 µm thick, monoporate, pore is at the apex of small cell, spore wall 1.5 µm thick double layered. The present specimen occurs at the depth of 114 - 177 meters (Fig. 25).

Remarks: In the present specimen opening is not present on the septa as described by (Ediger, 1981).

6. *Brachysporisporites* sp. IV (after Ediger 1981: 93).

Fossil fungal spores dark brown in colour, obovate, 33.6 × 42 µm in diameter with 3 septa. Septa 27 µm long and 3 µm thick in the center of the spore, forming a ring like structure. Monoporate, exine thickend around the pore. Spore divided longitudinally into two equal halves, Spore wall 3 µm thick. The present specimens occur at the depth of 170 meters (Fig. 24).

Remarks: This specimen is closely comparable with that of *Brachysporisporites* sp. as (Ediger 1981) reported from upper Eocene, Thrace Basin, Turkey but differs in longitudinal division.

7. *Brachysporisporites* sp.V (after Ediger 1981: 93).

Fossil fungal spores dark brown in colour, biseptate, obovate in shape, 31.5×42 µm in size. Cell arranged as graded in series of size. Septa dark coloured,

13.5–27 µm long and 3–12 µm thick. Monoporate, pore is at the apex of the small cell, exine thickened around the pore, spore wall 3 µm thick. The present specimen occurs at the depth of 177 meters in grayish green sandy clay with shelly material (Fig. 26).

Remarks: The present species was found at Sonda Coal field, is slightly larger in size than that described by (Ediger 1981) as reported from upper Eocene, Oligocene and Pliocene Thrace Basin, Turkey. All the five species of *Brachysporisporites* differ from *Brachysporiporites thraceous* (Ediger 1981) by number of cells, diameter, shape and septal structure of the spores.

8. *Chomotriletes* sp. I (after Naumova 1953: 95).

Fossil fungal bodies dark brown in colour, subcircular, 18.6-22.8 µm in diameter. Concentric ridges are present, the ridges are more prominent in outer region but obscure in middle region, spore wall setose. This species occurs at the depth of 177.7 meters in dark brown clay (Fig. 28).

Remarks: The present species is small in size than that described by Jain and (Kar 1977) reported from Neogene sediments (Miocene) around Quilon and Varkala- Kerala coast, South India.

9. *Conidium* sp. I (Geel B.V. 1978: 12).

Conidia 2–3 (6), transversely septate. Conidium 18.0–18.3 µm long and 7.5–9 µm broad, basal cell pale in colour and thin walled, not constricted at the septa. This species occurs at the depth of 177.7 meters in dark brown clay (Fig. 5).

Remarks: The present specimen shows close resemblance with that described by (Geel,1978) from Holocene Pat Bogarea in Germany and Netherlands. Fungal spores of this type, mostly found broken off at the place of attachment, occur detached in pollen samples. During the study of macrofossils these fungal spores were found in the root fragments of Ericales. *Calluna vulgaris* is probably the host plant.

10. *Dicellaesporonites bolharensis* sp. nov.

Fossil fungal spore, golden brown in colour 2 celled. Cell spherical 43.5 – 51 × 40.5 – 51 µm in diameter, slightly flattened at one end. Spore wall rough, scarbrate, 1–5 µm thick, equatorial septa are hyaline with prominent constriction (Fig. 33).

Remarks: The present specimen, found from Sonda coal field, are bigger in size with hyaline septum than that described by (Sheffy and Dilcher 1971, Elisk *et al*., 1974 and Ambawani, 1982) reported from pure clay pit of Claiborne formation of middle Eocene age, Lawerence clay pit of lower Eocene age and from Neyveli lignite bed of South India.

Regarding the age of Neyveli lignite, it is believed as of upper Miocene or Pliocene (Lakhanpal, 1970). However (Venkatachala 1973), on the basis of palynological studies of the Cauvery Basin, suggested the lower age of limit of the lignite extend up to the Eocene.

The detailed study of this genus as well as species indicated that it was previously found as small in size with dark coloured septum. Whereas the species reported from Sonda coalfield is quite large in size with hyaline septum.

11. *Dyadosporonites constrictus* (after Kar, 1977: 17).

Fossil fungal spores are dark brown in colour, uniseptate, 30.6 – 39 x 33 – 39.5 µm in diameter. Septum 24 µm long and 5.4 thick, diporate spores distinct, more or less circular, 2.4 µm in diameter with thick margin, spore wall 1–1.5 µm thick. Laevigate constricted at the septal region. The present specimen occurs at the depth of 177.7 meters in the dark brown clay (Fig. 7).

Remarks: The present specimen is smaller than that described by (Kar 1977) reported from Oligocene Kutch, western India.

12. *Fractisporonites* sp. I. (Sheffy and Dilcher, 1971: 38).

Fossil fungal spores are brown in colour, psilate, uniseriate, fragment 42 µm long, 14– 14.5 µm broad, consist of seven rectangular cells. Width variable, individual cells 4.5–5.1; 6.0–6.69 µm wide, 10.5–12 µm long. Septa opaque with small pore at each septum. Pore 0.6 µm in diameter, rest of the septa split, folded and appear as lobed. Lobes are triangular in surface view. Spore wall 1.0 – 1.5 µm thick. This species occurs at the depth of 700 meters in the brownish sandy micaceous sandstone with micaceous partings (Fig. 8).

Remarks: The present specimen is 7 celled, slightly smaller in size with few split septa and similar to that described by (Sheffy and Dilcher 1971) reported from Puryear clay pit of claiborne formation of middle Eocene age.

13. Fungal Spore sp. I. (after Jain and Gupta 1969: 108 – 109).

Phragmospore brown in colour, 4 celled, broadly elliptical in shape, 33 x 45 µm in diameter, cells slightly flattened. Septa dark coloured, lobes appear as triangular in surface view, spore becoming narrower on both ends to form small dome like cells which are hyaline. Spore wall 0.75 µm thick, spore present at the depth of 177.7 meters in the dark brown clay (Fig. 6).

Remarks: The present specimen shows close resemblance with the species described by Jain and Gupta (1969) reported from tertiary beds of Kerala coast. It is also reported by (Rao, 1958) from warkalli lignite beds of India.

14. Palaeo *Helminthosporium* sp. I Link *ex* Fr. (after Sharma 1974: 80).

Conidia golden yellow in colour, 4 celled, ellipsoidal and rounded at both ends. Conidia are 33.6 µm long and 13.5 µm broad, cell wall 3 µm thick. This species occurs at the depth of 700 meters in brownish sandstone (Fig. 9).

Remarks: The present specimen, reported from Sonda coal field, shows close resemblance with that described by (Sharma, 1974) reported from Quaternary deposits of Malvan, Gujarat, India at the depth of 10–60 cm. *Helminthosporium* sp. commonly occurs on the leaves and dead branches of the plants (Ellis and Ellis, 1985).

15. *Inapertisporites nodulus* (after Sheffy and Dilcher 1971: 39).

Fossil fungal spore dark brown in colour 36.5 x 37.5 µm in diameter, unicellular, psilate, without septa, with hyaline more or less elliptical projection, 6.0 x 14.4 µm diameter in size. Spore wall 0.5 – 0.75 µm thick, present at the depth of 177.7 meters in dark brown clay (Fig. 11).

Remarks: The present specimen is slightly larger in size than that described by Sheffy and Dilcher (1971) from Puryear clay pit of Claiborne formation of Middle Eocene age.

This species closely resembles with *Aeremomiula fagi* (Ellis and Ellis, 1985) which grows on dead branches of *Fagus grandifolia* in USA.

16. *Inapertisporites scabridus* (after Sheffy and Dilcher 1971: 40).

Fossil fungal spore dark brown in colour, subspherical in shape, 27 x 40.5 µm in size. Single celled (unicellate), non septate with small spherical projection, coarsely pitted, spore wall 0.75 µm thick around the projection and uneven (Fig. 10).

Remarks: The present specimen is larger in size than that described by Sheffy and Dilcher (1971) reported from purer clay pit of Claiborne formation of middle Eocene age.

17. *Inapertisporites ovalis* (after Sheffy and Dilcher 1971: 38).

Fossil fungal spore golden brown in colour, oval 15 x 30 µm in size; unicellular, nonseptate, spore wall double layered, 1.5 µm thick **(Fig. 34)**.

Remarks: The present specimen is larger in size than that described by Sheffy and Dilcher (1971) from purer clay pit of Claiborne formation of middle Eocene age.

18. *Lacrimasporonites basidii* Elsik 1968: 84, (after Sheffy and Dilcher 1971: 38).

Fossil fungal spore dark brown in colour, unicellular, non septate, psilate, conidia 18 x 24 µm in diameter, monosporate, with small apical pore, spatulate, spore wall with two layers 0.9 – 1.5 µm thick. Spore occurs at the depth of 177.7 meters in the dark brown clay (Fig. 12).

Remarks: The present specimen is slightly larger in size than that described by Sheffy and Dilcher (1971) reported from purer clay of Claiborne formation of Middle Eocene age.

19. *Lacrimasporonites oviformis* (after Ediger 1981: 90).

Fossil fungal spore dark brown in colour, unicellular, non septate, 21 x 24.6 µm in diameter, monoporate, pore apical, perfectly elliptical, 9 µm long and 1.5 µm wide, pore structure is simple. There is no any thickening of exine around the pore. Spore wall double layered, 0.9 – 1.5 µm thick and sparsely warts are present. This species occurs at the depth of 177.7 meters in dark brown clay (Fig. 13).

Remarks: The present specimen is slightly smaller in size and warts are sparsely present on spore wall as described by Ediger (1981) from upper Eocene, *Oligocene,* Miocene and Pliocene sediments, Thrace Basin, Turkey.

20. *Lacrimasporonites sondensis* sp. nov.

Fossil fungal spore brown in colour, unicellular, nonseptate, psilate 16.5 x 2.7 µm in size, diporate, apical pore perfectly elliptical, 7.5 µm long, very thin. Basal pore small, 0.3 µm long and 6 µm wide, pore structure simple; exine cell wall is not thick around the pore. Spore wall double layered, 0.9 – 1.5 µm thick (Fig. 14).

Remarks: Sheffy and Dilcher (1971) have described three species of the genus *Lacrimasporonites* viz. *L. levis; L. basidii* and *L. singularis*. Further more (Elisk *et al*., 1974) reported *Lacrimasporonites* sp., (Kar (1977) described *L. longus* and (Ediger, 1981) reported *L. oviformis, L. clevis* and *L.* sp I. All the above reported species are monoporate with only single apical germinal aperture (pore). But the present specimen from Sonda coal deposits at the depth of 177.7 meter from the dark brown clay material has two germinal apertures (pores), one is apical and the other is at basal end. These specimens differ from that described by (Sheffy and Dilcher 1971, Elisk *et al*., 1974; Jain and Kar 1977), Kar (1977) and Ediger (1981) as reported from Clay pit formation of middle Eocene age, and from Neogene sediments of lower Eocene age around the quilon and Varkala, Kerala Coast South India and from Oligocene sediments in the District Kutch, W. India.

In the above study all the reported species of this genus have only one apical germinal pore whereas the present specimens have apical and basal germinal pores.

21. *Monoporisporites stoverii* (after Elsik 1968: 299).

Fossil fungal spore brown in colour, subcircular in shape, 27 x 30 µm in diameter, monporate, pore distinct, hyaline, spore wall 1.5 µm thick. The present specimen occurs at the depth of 177.7 meters in dark brown clay (Fig. 15).

Remarks: The present specimen is slightly larger in size than that described by (Kar and Saxena 1974) reported from Paleocene formation of Kutch India. This species occurs on dead leaves (Ellis and Ellis, 1985).

22. *Multicellaesporites elsilkii* (after Kar and Saxena 1974: 7-8).

Fossil fungal spore brown in colour ± elliptical, tricellate 42 µm long x 30 µm broad. Cells in aperturate individual cell ± of same size. Septa 28.5 µm long and 3 µm thick, spore wall ± 1–1.5 µm thick, psilate. This species occurs at the depth of 177.7 meters in the dark brown clay (Fig. 17).

Remark: The present specimen is tricellate usually it is pentacellate and rarely in tetracellate with apical cell more or less flattened than that described by Kar and Saxena (1974). Ambwani (1982) reported it from Paleocene, Matanomadh formation of Kutch, Gujarat and also from Neveli lignite bed, South India respectively.

23. *Multicellaesporites simplicissimus* (after Sheffy and Dilcher 1971: 42).

Fossil fungal spore, dark brown in colour, ovate, tricellate, 12.0 x 22.5 µm diameter, psilate, inaperturate biseptate, septa opaque, 6 – 9 µm long and 4.5 – 5.7 µm thick. Spore wall 0.75 – 1 µm thick. This species occurs at the depth of 177.7 µm meters in the dark brown clay (Fig. 16).

Remark: The present species is larger in size as described by Sheffy and Dilcher (1971) from purer clay pit (Henry County, Tennessee) of Claiborne formation of middle Eocene age.

24. *Multicellaesporites elongatus* (after Sheffy and Dilcher 1971: 44).

Fossil fungal phragmospore, brown in colour, consisting of 7 or 8 cells, 75 µm long, 12 µm broad, cells aperturate, pore circular, 1.5 µm in diameter, situated in the center of the cell, individual cell flattened at common boundaries. One terminal cell tapers, forming flat basal attachment, psilate, septa opaque, spore wall 1.5 µm thick (Fig. 19).

Remarks: The present specimen is quite similar in shape and number of cells as described by Sheffy and Dilcher (1971) reported from puryear clay pit of Claiborne formation of middle Eocene age. Although it shows close resemblance to teliospore of *Xandochus* (SCHECT) Ramanujam (1963) in having circular pore in each cell.

25. Mycelial Fragment (after Geel 1978: 1).

Mycelial fragment pigmented with rough ends, straight, 7–8 septa, septa occur at 18–42 µm distance apart. Mycelia 243 µm broad and septa are 18–42 µm long. These mycelial fragments occur at the depth of 134.8 meters in black carbonaceous clay with leaf impression (Fig. 32).

Remarks: The present specimen shows close resemblance with that described by (Geel 1978) reported from Holocene peat Bog area from Germany and the Netherlands.

26. *Pluricellaesporites melanii* Van Der Hammen (after Elisk 1968: 307).

Fossil fungal spore brown in colour, 4 celled, cells, are 27.6 - 30.6 x 13.5 – 16.5 µm in diameters. Septa thick and distinct, 6.9 – 12 – 13.5 µm long 1.5–2 µm thick, perforated, spore wall 1.5 µm thick, laevigate. The present specimens occur at the depth of 177.7 meters in the dark clay (Fig. 20).

Remark: The present specimen is 4 celled, usually it is 3 celled as described by (Jain and Kar 1977) from Miocene sediments around Kerala coast, south India.

27. *Pluricellaesporites* sp. I (after Jain and Kar 1977: 112).

Fossil fungal spore brown in colour, fusiform, 5 celled, 24 x 69 µm in diameter. Septa distinct with small pore at the center, operculum 2 celled. Spore wall 0.75 µm thick, laevigate. This species occur, at the depth of 392 meters in black shale with abundant carbonaceous material (Fig. 18).

Remark: The present specimen is 5 celled as compared to that described by Jain and Kar (1977) which is seven celled reported from Neogene sediments around Varkala, Kerela Coast, South India, but shows resemblance with *P. hilsii* Elisk (1968) in having flaps at each septum. These species are found on dead leaves and stems.

28. *Pluricellaesporites plannus* Triv and Verma 1969 (after Kar and Saxena 1974: 13).

Fossil fungal spores brown in colour, elliptical with unequal broad ends, octacellate, 75 – 80 µm long, 7.5 µm broad at the center. Cells are square in shape, 7.5 – 9 µm long and 6.7 – 7.5 µm broad. Cells are slightly bigger at the middle region. Septa dark coloured, 7.5 µm long and 3 µm thick, cells are

constricted. Spore wall 0.5 – 0.75 µm thick. This species occurs at the depth of 177.7 meters in dark brown clay (Fig. 31).
Remark: The present specimen closely resembles with the species reported by Kar (1977) from Paleocene - Oligocene of Kutch, India.

29. *Pluricellaesporites serratus* (after Sheffy and Dilcher 1971: 46).
Phragmospore light brown in colours consisting of 5 irregular oblong cells, 27 µm long and 10.2 µm broad at the middle region of the phragmospore. Cell at one end is rounded with opaque disk – shaped plate. Pores at the opposite end, septa with irregular outline 3 µm thick, laevigate. These specimens occur at the depth of 177.7 meters in the dark brown clay (Fig. 22).

30. ***Pluricellaesporites* sp. I (after Kar *et al.*, 1970: 148).**
Fossil Fungal sopre dark brown in colours 5 celled, monoporate, each cell 6 – 12 µm broad, 40.5 µm long and 13 µm broad at the middle. Cross wall (septa) bilobed, triangular in surface view, cell wall 3 µm thick and psilate (Fig. 35).
Remarks: The present specimen is smaller in size than that described by Kar *et al*., (1970) from Tura formation of Garo Hills, Assam.

31. *Pluricellaesporites vermiculus* (after Ediger 1981: 92).
Fossil fungal spore, golden brown in colour, 2 celled, cells are aligned inline, nearly symmetrical around the long axis, flattened at boundary, convex on sides. First cell rounded on three sides. Last cell hyaline and flattened, 15.9 x 2.0 µm diameter in size.
Septa dark coloured, 11.5 µm long and 3 µm thick, irregular pits are present on the surface. Spore wall 1.5–3.0 µm thick, double layered and Scabrate sculpture. The present specimens occur at the depth of 177.7 meters in dark black clay of Sonda Coal field area (Fig. 23).
Remarks: The present specimen is 2 celled found at the depth of 177.7 meters. Ediger (1981) reported 3 or more celled specimens from upper Eocene – Oligocene and Miocene – Pliocene sediments from Thrace Basin, Turkey.

32. *Palaeo – Aspergillus multiseriate* (after Wolf 1966: 109).
Conidiophores brown in colour, 44 µm long and 6 µm broad, terminal ends with dispersed head measuring 15x15 µm in diameter, cononidia 4.5-6 µm in diameter (Fig. 2).
Remarks: The present specimen was found in Sonda Coal field at the depth of 177.7 meter in dark brown clay. This species shows close resemblance with *Aspergillus* sp. conidiophores described by Wolf (1966) from African lake sediments. This species grows on dead wood and bark of various trees (Ellis, 1976).

33. *Staphlosporonites allomorphus* (after Sheffy and Dilcher 1971: 49).
Fossil fungal spore dark brown in colour, multicellular, multiseptate, 11–12 to 14–15 or more celled, with irregular cell size, spore with oblong body, 60 -63 µm long and 13.5 – 18 µm broad at the middle region of the spore cell, imperturate cell gradually tapers to single cell, usually elongated, while the terminal cell is ± rounded. In the region of basal cell while in the rest of the portion of spore the septa are transverse as well as longitudinal. In the extreme of basal cell the septa are hyaline; rest of the septa is dark brown in colour and opaque and is 1.5 µm thick and smooth. This species occurs at the depth of 134.9 meter in black carbonaceous clay with abundant leaf impressions (Fig, 21).
Remarks: These fungal spores resemble with the modern genus *Alternaria* (Pirozynski, 1976). The present specimen shows close resemblance with that described by Tiwari *et al*., (1983) reported from Paleozoic-Mesozoic Tethyan sequence in Malla Johar area, Kumaon, Himalya, India.

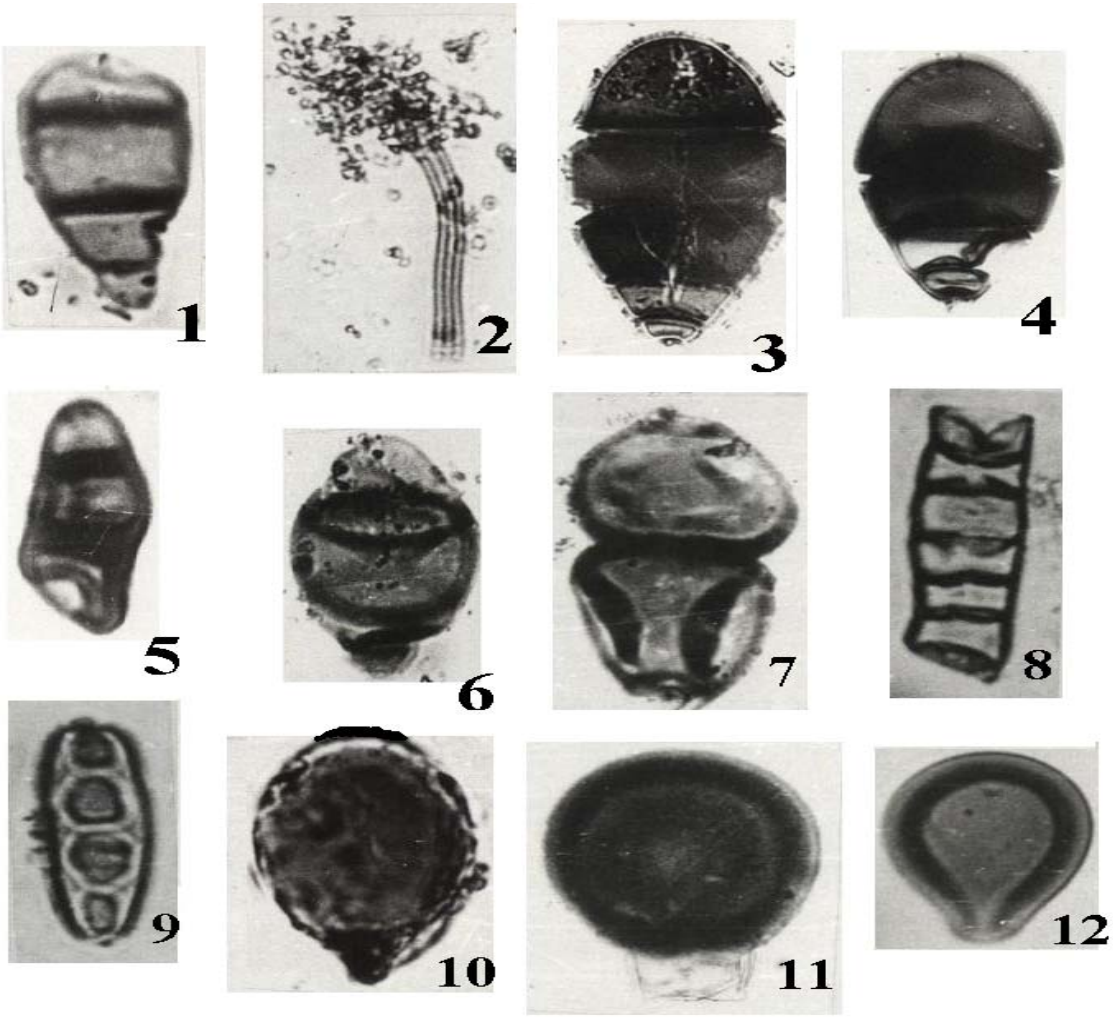
34. *Striadisporites sanctaebarae* Elisk and Jansonius 1974, (after Ediger 1981: 100).
Fossil fiungal spore elliptical 40.5 x 24 µm in size, diporate, pore very minute, 0.6 µm in size, situated at both ends of the spore, wall 0.9 µm thick, psilate (Fig. 29).
Remarks: The present specimen is slightly smaller in size than that described by Ediger (1981) reported from late Eocene – Early Oligocene – Thrace Basin, Turkey.

35. *Tricellaesporites triangularis* (after Sheffy and Dilcher 1971: 53).
Fossil fungal spore brown in colour, cells spherical, united in a triangular cluster, individual cell 30 – 40.5 x 42 – 49.5 µm in diameter in size. Cell is aperturate, three linear septa are visible, spore surface psilate (Fig. 30).
Remarks: The present specimen is larger in size then that described by Sheffy and Dilcher (1971) reported from prier clay pit of Claiborne formation of Middle Eocene age.

4. Discussions

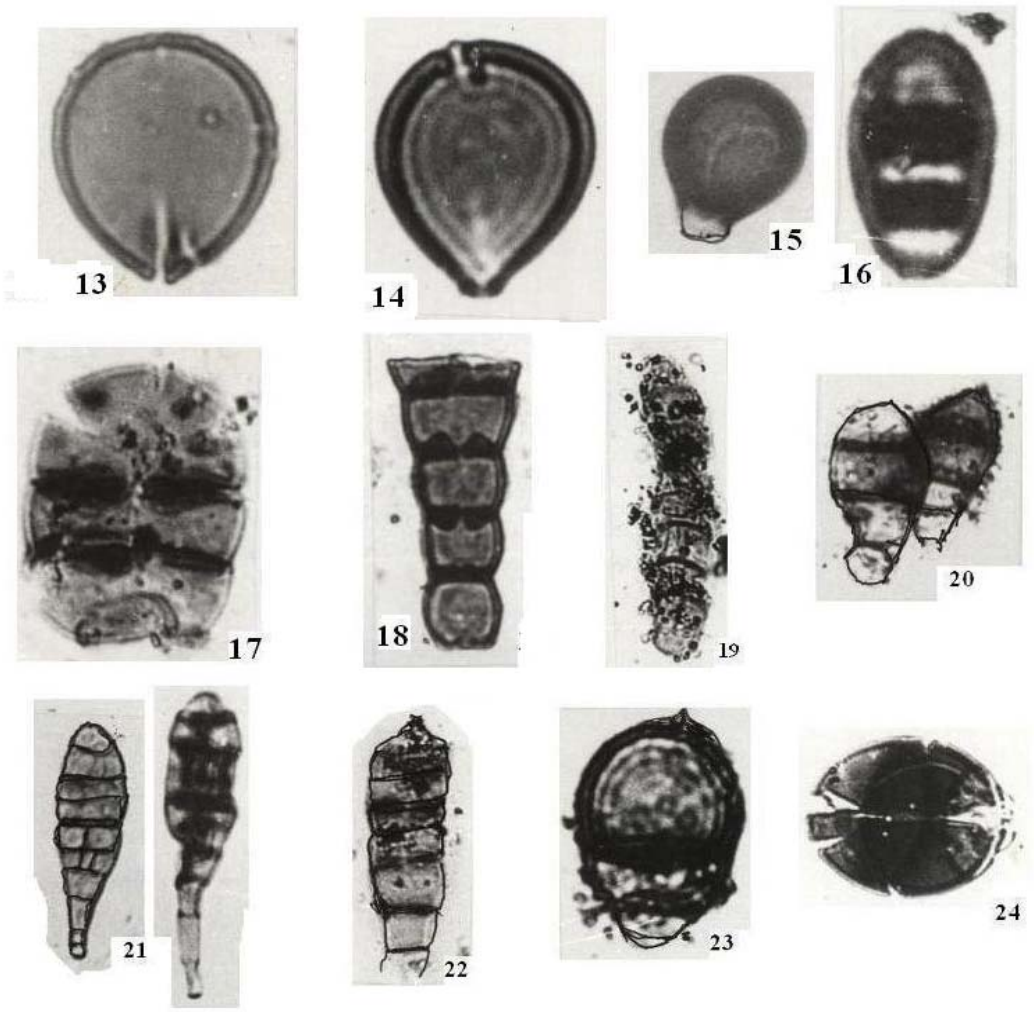
In the present fungal spore stratigraphic study of Bara formation sequence in Sonda coal field area forty-one samples from DH18 core have been

Plate No. 1 Figs. 1 – 12
Fossil fungal spores from brown coal of Sonda, District Thatta, Sindh, Pakistan



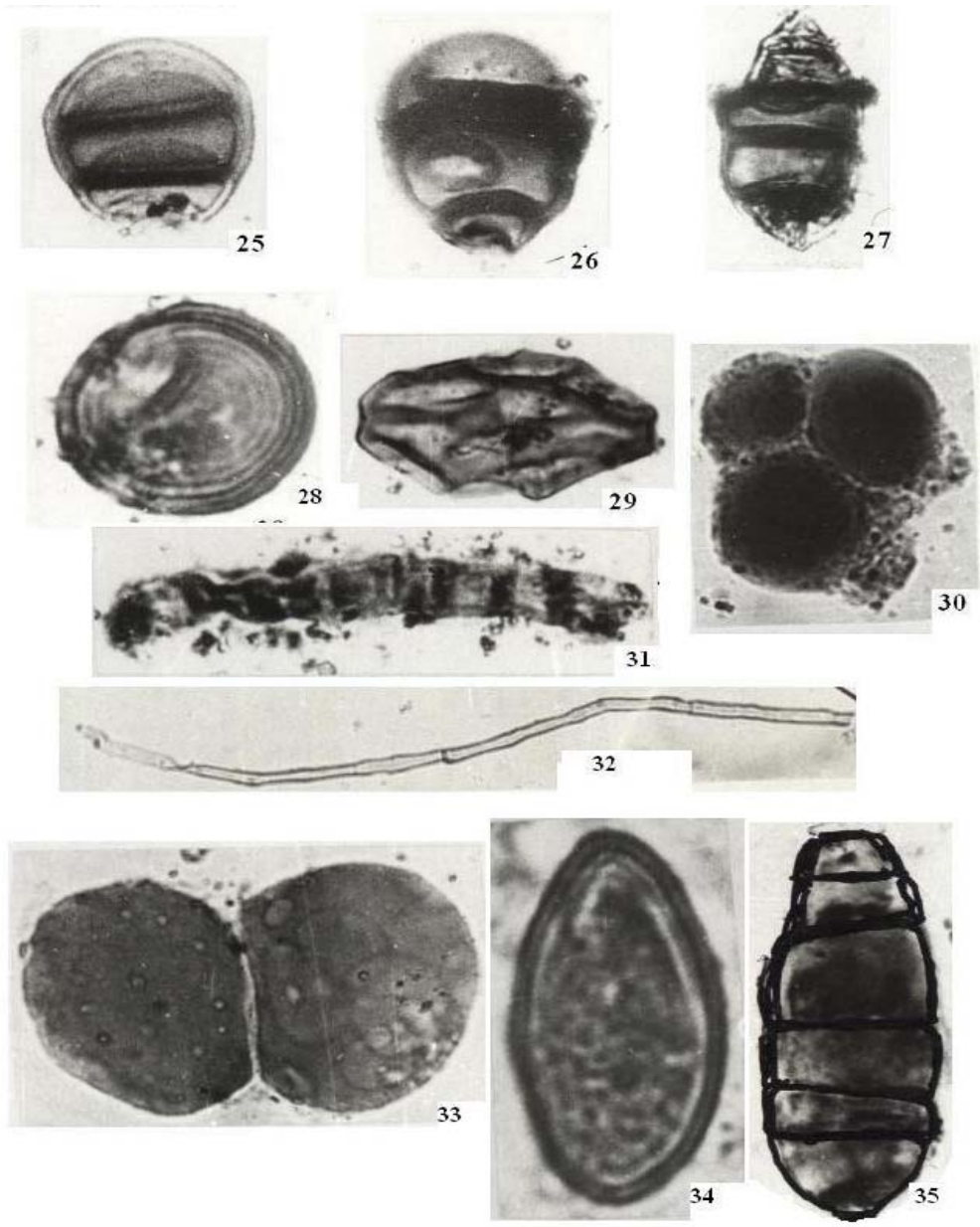
1. Anatolinites sp. I 10 x 40
2. Paleo Aspergillus multiseriate 10 x 40
3. Brachy sporisporites sp. I 10 x 40
4. Brachy-sporites thracieous Ediger 10 x 40
5. Conidium sp. 10 x 40
6. Fungal spore sp. I Jain & Kar 10 x 40
7. Dyadosporonites constrictus 10 x 40
8. Fractisporonites sp. 10 x 40
9. Paleo-Helminthosporium sp. 10 x 40
10. Inapertisporites scabrides 10 x 40
11. Inapertisporites nodulus. 10 x 40
12. Lacrimasporonites basidii 10 x 40

Plate No. 2 Figs. 13 – 24
Fossil fungal spores from brown coal of Sonda, District Thatta, Sindh, Pakistan



13. Lacrimasporonites oviformis 10 x 40
14. Lacrimasporonites sondensis sp. nov 10 x 40
15. Monoporisporites stoverii 10 x 40
16. Multicellaesporites simplicissimus 10 x 40
17. Multicellaesporites elsikii 10 x 40
18. Pluricelleasporites sp. I Jain and Kar 10 x 40
19. Multicellaesporites elongatus 10 x 40
20. Pluricellaesporites melanii 10 x 40
21. Staphlosporonites allomorphus 10 x 40
22. Pluricellaesporites serratus 10 x 40
23. Pluricellaesporites vermiculus 10 x 40
24. Brachysporisporites sp.4. 10 x 40

Plate No. 3 Figs. 25 – 35
Fossil fungal spores from brown coal of Sonda, District Thatta, Sindh, Pakistan



25. Brachysporisporites sp. 3 10 x 40
26. Brachysporisporites sp. 5 10 x 40
27. Brachysporisporites sp. 2 10 x 40
28. Chromotriletes sp. I 10 x 40
29. Striadiporites sanctaebarae 10 x 40
30. Tricellaesporites triangularis 10 x 40
31. Pluricellaesporites planus 10 x 40
32. Mycelial fragment 10 x 40
33. Dicellaesporites bolharensis sp. nov. 10 x 40
34. Inapertisporites ovalis 10 x 40
35. Pluricallaesporites sp. I Kar *et al*. 10 x 40

investigated in which core samples 6 and 7 were obtained from a depth of 134 to 177.7 meter in dark brown clay. Most of the fungal fossil remains were found from sediments in between the coal seams and the carbonaceous layers immediately above or below the coal seams.

The fungal spores recorded include *Anatolinites* sp. *Brachysporisporites thraceous, Brachysporisporites* sp. I to sp. V, *Dicellaesporites bolharinesis* sp. *nov., Lacrimasporonites sondanesis* sp. *nov., Lacrimasporonites oviformis, Pluricellaesporonites vermiculus* and *Striadosporites sanctaebarae.* These forms are reported to occur commonly and abundantly throughout the sequence from 490 – 2780 meter by (Ediger 1981) from Thrace Basin, Turkey.

However, in the present investigation the above cited species are found in the sediments from upper part of the core of Bara formation.

The new species of *Lacrimasporites sondensis* sp. *nov.* and *Dicellaesporonites bolharensis* sp. *nov.* are reported in the present investigation of Sonda Coal basin sediments. The fossil fungal species *Chromotrilates* sp. I and *Pluricelleasporites melanii* from neogene sediments from Quillion and Verkala Kerala coast, South India (Kar, 1977) are in close agreement with the spore assemblage recorded in this study. Our specimens agreed with *Multicellaesporites elongates* and *Lacrimasporonites basidi* (Sheffey and Dilcher, 1971) reported from Claiborne formation of middle Eocene age, *Dyadosporonites constrictus* from Oligocene sediments of Kutch, western India (Karr, 1977) and *Paleo–Aspergillus multiseriate* from African lakes sediments (Wolf, 1966).

The fossil fungal spores *Imapertisporisporites scarbidus* and *Tricelleosporites triangularis* reported from Claiborne formation of middle Eocene age (Sheffy and Dilcher, 1971), are similar to the forms recorded from carbonaceous layer in the present investigation, the findings of this investigation are in agreement with the findings of earlier workers.

All the fungal spores and pollen grains are terrestrial in nature (Pirozynskii, 1979), many of the spores and conidia can be compared with those of living fungal spores (Ellis 1976, 1985). Member of the fungal genera are cosmopolitan and can occur or grow on a wide variety of dead wood, dead leaves and algae, vegetative material and also on living plants. All the material is allochthonous and drifted through the water and deposited in Paleocene environment. All the fungal spores rotting the wood, algal and other vegetation also growing on the fertile and dead vegetation soil are allochthonous and drifted in the paralic swampy vegetation in the deltaic region.

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