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**RESEARCH ARTICLE**

# STRATIGRAPHY OF *STEREISPORITES* SPP. AND ALLIED SPORES FROM THE NIGERIAN NEOGENE

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**ABSTRACT**

Various species of Pteridophytes and Bryophytes abound in the Nigerian Neogene as revealed by palynomorph records. One of the commonest is *Sphagnum* species with spores which are normally with smooth exine *(Stereisporites* spp.), which are of three types. These appear to have evolved close to the Early Late Miocene much before those with varied sculptures hereby ascribed to *Trilites* which are concentrated in the Pliocene to Early Pleistocene. Their stratigraphic ranges revealed that these latter species evolved close to the Early Pliocene and may have possibly continued to the present time. Their acmes are in the P900 subzone, while the species with smooth sculptures continue into the Late Miocene and are mostly used as the P840/P830 boundary marker. These undescribed new taxa which consist of three species of *Stereisporites*, two species each of *Camarozonosporites*, *Trilites*, and a single species each of *Echitriletes*, *Rugulatisporites*, *Selaginella*, *Triporoletes* and *Granulatisporites* sp., are hereby highlighted. The result of this investigation will aid the refinement of the existing palynological zones of the Western Niger Delta and further improve paleovegetational and paleoecological inferences henceforth.



## INTRODUCTION

Species used as stratigraphic markers are those with well defined first and last occurrence datums i.e. evolution and extinction levels. In the Niger Delta Neogene, Evamy *et al*. (1978), used several markers to define the different zonal boundaries which correlated with absolute ages defined by diagnostic foraminifera (Shell, 1998). Generally, the palynological zones in the Niger Delta appear too broad and the need to refine them has been advocated earlier by Durugbo (2010). In line with this, during the course of research using two wells, whose ages ranged from Latest Miocene to Early Pleistocene P860-P900 subzones of Evamy *et al.* (1978), several species of the diagnostic marker species *Stereisporites* spp., together with other associated spores were encountered whose occurrence pattern is hereby highlighted to infer their stratigraphic importance. In listing the flora of the Dakota Formation, Ludvigson *et al.* (2010) had ascribed representatives of the Osmundaceans, Schizaeaceans, Gleicheniaceans, Matoniacaeans, Marsiliaceans, Polypodiaceans, etc among the pteridophytes while the mosses and liverworts belong to the Bryophytes. Furthermore, the lycopods and selaginellaceans belong to the lycophytes and Selaginellaceae respectively. Both Larsson *et al*. (2006) and Tworzydło (1974) had ascribed *Stereisporites* species to the Bryophyte Family *Sphagnaceae* or peat Moss, though Riegel *et al*. (2012) had reported that *Stereisporites* species arise from club mosses (*Lycopodiales-Lycophyta*). Miller (1982) had posited that the synonyms of *Stereisporites* are (*Sphagnites* and *Sphagnumsporites) psilatus, S. antiquarporites, Rogalskaisporites cicatricosus* and *R. canaliculus.*

Different varieties of *Stereisporites* have been reported from different parts of the world. Raine *et al.* (2011) had listed such *Stereisporites* species as *S. compactus, S. minor, S. psilatus, S. cf. strictus* among components of the fossil flora of New Zealand. Tworzydło (1974) had listed *S. megastereis, S. involutus involutus, S. stereoides gracilioides* and *S. granulus* from study of Middle Oligocene to Upper Miocene sediments from Poland. Furthermore, Macphail and Truswell (2004) had recorded *Stereisporites regium* and *S. australis* among the Late Cretaceous and Tertiary species from ODP sites in Antarctica. Again, Miki (1972) had also recovered *S. antiquasporites, S. apolaris*, and *S. grossus* from the Kuji Group in Northeastern Honshu, Japan. From Miocene sediments in Turkey, Kayseri and Akgün (2008) had also recovered *Stereisporites stereoides* ssp. *stereoides, S. stereoides* ssp. *macrolides, S. involutus, Trilites* sp., *Leiotriletes microadriennis, Echinatisporites longiechinatus*, and *Polypodiaceoisporites* sp. Likewise for *Trilites*, Couper (1960) had listed the spores of *Trilites verrucatus* and *Trilites bifurcatus*, (Plate 41 nos. 3,4) forms similar to those recovered

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from the western Niger Delta in his New Zealand Mesozoic and Cainozoic plant microfossils. Tworzydło (1974) also recorded *Trilites microvallatus,* and *T. multivallatus* from Late Oligocene to Upper Miocene of Poland.Furthermore, Graham (1999) had also recovered such Pteridaceae as *Ceratopteris, Vittariaceae, Pteris,* species of monolete fern spores Types I and II, *Cyatheaceae, Spaeropteris* sp., cf. *Antrophyum* from the Early Miocene of the Chiapas of Mexico. The Nigerian vegetation is replete with different species of pteridophytes and bryophytes, right from the mountainous ranges of the Mambilla / Cameroon border to the freshwater swamps and lowland rainforests of the Niger Delta. Among the listed endemic plants of Nigeria and Cameroon are such pteridophyte genera as *Aspleniaceae, Dryopteridaceae, Ophioglossaceae, Polypodiaceae, Pteridaceae,* and *Woodsiaceae* (Tchout *et al.*, 2006; White, 1993; Campbell and Hammond, 1989), each producing its own peculiar spore species which ultimately gets deposited in the Niger Delta. Again, McGinley (2008) writing on the Niger Delta swamp forests for the World Wide Fund for Nature (WWF), divided them into ecoregions, listing their characteristic flora among which ferns were included. The region is divided into four ecological zones namely coastal inland zone, mangrove swamp zone, freshwater zone and lowland rain forest zone (Iyayi, 2004), and it is reported to be the richest wetland in the world. Saliu and Luqman (2007) had described the Delta as "teeming with birds, marine life, giant ferns and towering mangrove plants. Furthermore, Ekpo *et al.*, (2012) had also highlighted the presence of ferns, Nipa palms and herbs in areas of low salinity around the Niger Delta. This study was undertaken to describe and name these new spore species, noting their botanical affinities and stratigraphic importance so as to list them among other Nigerian fossil palynomorphs and enhance their usefulness in age dating, palaeoecological reconstruction and palaoenvironmental inferences. Further work would investigate whether they could be used to subdivide some of the existing broad Niger Delta palynological zones.

## MATERIALS AND METHODS

Ninety-six (96) and eighty –nine (89) ditch cuttings of wells AA and AB from the offshore Western Niger Delta donated by Chevron Nigeria Limited were studied between 1980-10570 feet and 1920-9860feet respectively. Thirty grams of each sample was prepared using the standard palynological techniques of disaggregation and removal of carbonates and silicates with hydrochloric acid and hydrofluoric acid under a fume cupboard (Faegri and Iversen, 1989). The samples were further treated with hot Hydrochloric acid (HCL) and wet – sieved over a 5 - micro mesh polypropylene sieve. The Branson Sonifier 250 was further employed during sieving to facilitate complete removal of silt and clay particles. Each residue was oxidized using concentrated nitric acid ($HNO_3$) and prepared for study as strewn mounts using Loctite. A Leitz Dialux 20 EB microscope was initially used for the analysis. These palynomorphs were displayed on Charts AA, AB, for wells AA, and AB respectively. The slides were re-analyzed and the photomicrographs of the new palynomorphs and dimensions measured with a Zeiss Axioskop 2 microscope with an attached Axiocam 1Cc 1 Camera at the Palynology laboratory of the Bernard Price Institute for Paleontology, University of the Witswatersrand, Johannesburg, South Africa.

## RESULTS

The wells AA and AB yielded two hundred and thirty (230) and one hundred and seventy-three (173) palynomorph species composed of ninety – six (96) pollen species, thirty-five (35) spores, eighty-eight (88) marine elements, three (3) algae, and seven (7) miscellaneous palynomorphs for well AA. For the latter, pollen species were one hundred (100); spores, twenty-six (26); marine elements, thirty-nine (39); algae, three(3) and five (5) miscellaneous palynomorphs. The commonest spore species were species of *Laevigatosporites* sp., *Verrucatosporites* sp., *Stereisporites* sp., *Trilites* sp., *Acrostichum aureum, Polypodiaceoisporites* sp., *Selaginella myosorus, Echitriletes pliocenicus, Lycopodium* sp., *Crassoretitriletes vanraadshooveni* (aff. *Ceratopteris*), *Rugulatisporites* sp., *Camarozonosporites* sp., and *Lycopodium neogenicus.* The ages of the wells ranged from Late Miocene (P860) to Early Pleistocene (P900) of Evamy *et al*. (1978) based the behavior of diagnostic marker species. The Miocene/Pliocene boundary was defined by the Base occurrence of *Retistephanocolpites gracilis (aff. Borreria verticilata)* at 8520 feet and 9030 feet in wells AA and AB respectively. Photomicrographs of the different spore species are displayed in Plates 1-3 and described succinctly below.

### Systematic Palynology

The rules on priority and typification by the International Code of Botanical Nomenclature (ICBN, Stafleu, 1978) were followed in defining the nomenclature of species. In classifying palynomorphs, the works of Potonié (1931, 1960), Naumova (1939), Kremp (1965) and Pascher (1914) were consulted. Systematic palynological description was carried out largely on new and renamed palynomorphs.

DIVISIONBRYOPHYTA
CLASS MUSCI
SPORITES H. Potonié 1893
CLASSTRILETES Reinsch, 1881, emend. R. Potonié and Kremp, 1954
FAMILY SPHAGNACEAE
1. Genus *Stereisporites* Pflug 1953
***Stereisporites laevigatus*** n.sp.

**Plate 1, Figs.1a-1f**

*Derivatio nominis***:** Named after the psilate sculpture compared to other *Stereisporites* species together with the scar terminating in a " y " fashion. *Description/Remarks:* Spheroid trilete spore with long distinct laesurae extending to the margins, bifurcating and partly covered by surface ornamentation at the edges. Grain shows laevigate sculpture increasing from the equator (proximal area) toward the margins (distal area).

*Fig.1a:* ***Stereisporites laevigatus***
*Equatorial diameter: 51.95µm. Length 47.04µm, Length of laesure 23.86µm.*

*Location: Well AA 4470ft: Coordinate: 108.6 X 113.3 (X400)*
*Fig. 1b: Stereisporites laevigatus*
*Dimensions: Equatorial diameter: 43.34µm, Length. 41.88 µm, Length of laesure. 19.94 µm*
*Location: Well AB. 3840ft: Coordinate: 85.0 X14.5 (X400)*

*Fig 1c: Stereisporites laevigatus*
*Dimensions: Equatorial diameter: 41.66µm, Length. 43.53µm, Length of laesure. 19.83µm*
*Location: Well AB: 8340ft: Coordinate: 99.8 X11.2 (X400)*
*Occurrence: Common*

*Fig. 1d: Stereisporites laevigatus*
*Dimensions: Equatorial diameter: 42.42µm, Length 41.11µm, Length of laesure 21.25µm*
*Location: Well AB 4110ft: Coordinate: 88.5 X 05.2 (X400)*
*Occurrence: Common*

*Fig. 1e: Stereisporites laevigatus*
*Dimensions: Equatorial diameter: 38.26µm, Length. 37.23µm, Length of laesure. 18.63µm*
*Location: Well AB 5670ft: Coordinate: 86.8 X 24.9 (X400)*

*Fig. 1f: Stereisporites laevigatus*
*Dimensions: Equatorial diameter: 28.81µm, Length. 31.40µm, Length of laesure 17.49 µm*
*Location: Well AA 9500ft: Coordinate: 110.5 X 13.2 (X400)*
Remarks: These species are similar to *Sphagnum pedatiformis* of (Bolkhovitina, 1959) from the Upper Cretaceous of the Vilyuisk basin Siberia, though these Niger Delta species are larger in size with thicker exine.
*Locations: Well AA, Well AB*
*Age*: Late Miocene - Pleistocene.
*Occurrence*: The specie is commonly distributed from the Late Miocene (P840) to the Early Pleistocene (P900) Subzones of Evamy *et al.* (1978) in the wells AA and AB.

***2.*** *Stereisporites laevigatus*

Genus *Stereisporites* Cookson ex Couper
***Stereisporites laevigatus var. agbadaensis*** n.sp.
**Plate 1, Figs. 1g-1h**
*Derivatio nominis***:** Named after the Agbada Formation one of the lithologic units in the Niger Delta.
*Description/Remarks:* Specimen is psilate, largely subcircular to spherical in shape, variable in size, trilete with long thick distinct laesurae extending to the margins, terminating in a "y" fashion (bifurcating). Exine thick at the edges and the species is similar to *S. laevigatus* but differs by having thicker exine together with a thick and irregularly shaped laesure (thickened lips 3-3.35*µm).*

*Fig. 1g: Stereisporites laevigatus var. agbadaensis*
*Dimensions: Equatorial diameter: 48.72µm, Length. 41.90µm, Length of laesure 20.04µm*
*Location: Well AB 8340ft: Coordinate: 95.8 X 19.4 (X400)*

*Fig. 1h: Stereisporites laevigatus var. agbadaensis*
*Dimensions: Equatorial diameter: 48.70µm, Length. 47.33µm, Length of laesure. 27.89 µm*
*Location: Well AA 6000ft: Coordinate: 109.4 X 20.5 (X400)*
Remarks: The species is similar to *S. laevigatus but* differs by having thicker exine together with a thick (3-3.35*µm)* and irregularly shaped laesure. Furthermore, the scars, though thicker, and slightly raised, closely resemble *Granulatisporites* sp. (Plate 6 # 14) of Miki (1972).
Locations: Well AA, Well AB
Age: Late Miocene - Pleistocene.
Occurrence: The species is commonly distributed from the Late Miocene (P840) to the Early Pleistocene (P900) Subzones of Evamy *et al.* (1978) in the wells AA and AB.

***3.*** *Stereisporites annulus*
Genus *Stereisporites* Cookson ex Couper
***Stereisporites annulus*** n.sp.

**Plate 1, Figs. 1i – 1l**

*Derivatio nominis***:** Named after the ring like structure at the middle of the grain. Sculpture psilate and the scar terminating in a " y " fashion compared to other *Stereisporites* species. Slightly smaller than *S. laevigatus* and a little larger than *Stereisporites regium* of Macphail and Truswell (2004). Morley and Richars,1997) had referred to these species as *Anthoceros* with distal annulus.
*Description/Remarks:* Specimen is largely subcircular to spherical in shape, variable in size, trilete with long distinct laesurae extending to the margins, bifurcating and partly covered by surface ornamentation at the edges with ring like structure around the equator. Grain shows smooth ornamentation.
*Fig. 1i: Stereisporites annulus*
Dimensions: Equatorial diameter: 36.51µm, Length. 35.09µm, Length of laesure 19.30µm
Location: Well AB 9210ft: Coordinate: 92.3 X15.3 (X400)

Fig. 1j: *Stereisporites annulus*
Dimensions: Equatorial diameter: 39.00µm, Length.36.27µm, Length of laesure 18.97µm
Location: Well AB 3870ft: Coordinate: 83.4 X16.10 (X400)

Fig. 1k: *Stereisporites annulus*
Dimensions: Equatorial diameter: 36.66µm, Length. 34.79µm, Length of laesure 20.15µm
Location: Well AB 9030ft: Coordinate: 84.4 X18.3 (X400)

Fig. 1l: *Stereisporites annulus*
Dimensions: Equatorial diameter: 35.31µm, Length. 33.47µm, Length of laesure17.69 µm
Location: Well AB 2790ft: Coordinate: 113.3 X16.2 (X400)
Occurrence: Common:
Type Species: The species is similar to *S. laevigatus* but differs by being slightly smaller in size and the presence of the ring like structure at the equator.
*Type Species:* The species is similar to *Cadiospora* spp. Potonie and Kremp (1956) but differs by having thinner exine and the laesure extending into the inner wall. Furthermore, the ring like structure closely resemble those on *Cingulatisporites caminus* (plate 13, fig. 5) of Brenner (1963) from the Potomac Group of Maryland, U.S.A.
Locations: Well AA, Well AB
Age: Late Miocene - Pleistocene.

Occurrence: The species is commonly distributed from the Late Miocene to the Early Pleistocene (P860-P900) Subzones in the wells AA and AB.

DIVISIONTRACHEOPHYTA
CLASS LYCOPODINAE
FAMILY DICKSONIACEAE

Genus *Trilites* Erdtman ex Couper emend. Dettmann 1963

**4.** Genus *Trilites* Cookson ex Couper
***Trilites bamfordae*** n.sp.

**Plate 2, Figs. a- d**

*Derivatio nominis***:** Named after Prof. Marion Bamford a renowned South African palaeobotanist. *Description/Remarks:* Trilete spore, circular to subtriangular in polar view, with long distinct laesurae terminating in a "y" fashion and extending into the inner margins of cingulum and partly covered by surface ornamentation at the edges. Grain shows coarse verrucate increasing from the equator (proximal area) toward the margins (distal area), variable in size, with thin cingulum and central body without zona. The distal surface is slightly echinate sculptured (Morley and Richards,1997) had called these species *Anthoceros* echinate.

*Fig. 2a: Trilites bamfordae*
Dimensions: Equatorial diameter: 41.39µm, Length. 39.82µm, Length of laesure18.82µm
Location: Well AA. 6720ft: Coordinate: 105.9 X 08.4 (X400)
Occurrence: Common

*Fig. 2b: Trilites bamfordae*
Dimensions: Equatorial diameter: 41.48µm, Length. 40.04µm, Length of laesure17.80µm
Location: Well AB 5280ft: Coordinate: 113.3 X16.2 (X400)
Occurrence: Common

*Fig. 2c: Trilites bamfordae*
Dimensions: Equatorial diameter: 33.69m, Length. 34.34µm, Length of laesure 16.90µm
Location: Well AA 9500ft: Coordinate: 88.10 X 25.3 (X400)
Occurrence: Common

*Fig. 2d: Trilites bamfordae*
Dimensions: Equatorial diameter: 41.02µm, Length. 39.07µm, Length of laesure 21.09 µm
Location: Well AA 4200ft: Coordinate: 98.5 X 11.5 (X400)
Occurrence: Common
Type Species: The species is similar to *Trilites bifurcatus* Couper (1960) and *Cingulatisporites bifurcatus* (Martin, 1973) in Raine *et al.* (2011), but differs by having thicker laesure and irregularly distributed verrucae on its exine.
Locations: Well AA and well AB.
Natural affinity: *Lycopsida* (Raine et al. 2011)

***5.****Trilites irregularis*
Genus *Trilites* Cookson ex Couper
***Trilites irregularis*** n.sp.

**Plate 2, Figs. e - h**
*Derivatio nominis***:** Named after the irregular sculptures of the variants.
*Description/Remarks:* Trilete spore, circular to subtriangular in polar view, with long distinct laesurae terminating in a "y" fashion and extending into the inner margins of cingulum, variable in size, with thin cingulum and central body without zona. The distal surface is slightly echinate sculptured.

*Trilites irregularis*
*Fig. 2e: Trilites irregularis*
Dimensions: Equatorial diameter: 38.98µm, Length. 39.59µm, Length of laesure 18.30µm
Location: Well AB 2790ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare

*Fig. 2f: Trilites irregularis*
Dimensions: Equatorial diameter: 36.41µm, Length. 36.39µm, Length of laesure 19.54µm
Location: Well AA 8430ft: Coordinate: 85.7 X 23.9 (X400)
Occurrence: Rare

*Fig. 2g: Trilites irregularis*
Dimensions: Equatorial diameter: 41.49µm, Length. 39.04µm, Length of laesure 21.64µm
Location: Well AB 3690ft: Coordinate: 106.5 X 15.7 (X400)
Occurrence: Rare
*Fig. 2h: Trilites irregularis*
Dimensions: Equatorial diameter: 35.31µm, Length. 33.47µm, Length of laesure 17.69µm
Location: Well AB 2790ft: Coordinate: 113.3 X 16.2 (X400)
Occurrence: Rare

*Occurrence*: The specie is commonly distributed from the Late Miocene (P860) subzone to the Early Pleistocene (P900) subzone in the wells AA and AB.
*Type Species:* The specie slightly resembles J*imboisporites senonicus* Miki (1972) plate 7 Fig. 2, but differs by having irregularly distributed verrucae on its exine and tapering at one end. The sculpture further resembles *Jimboisporites senonicus* of Miki (Plate 7 figs. 2-4)

**6.** Genus *Trilites* Cookson ex Couper
***Trilites nigeriensis*** n.sp.
**Plate 2, Figs. i-j**
*Derivatio nominis***:** Named after Nigeria from which the samples were got.
*Description/Remarks:* Specimen is largely subcircular to spherical in shape, variable in size, trilete with long distinct laesurae with wide lips extending to the margins and terminating in a "y" fashion (bifurcating) and partly covered by surface ornamentation at the edges.

*Fig. 2i: Trilites nigeriensis*
Dimensions: Equatorial diameter: 38.92µm, Length. 33.98µm, Length of laesure19.29µm
Location: Well AA 3840ft: Coordinate: 83.5 X 11.7 (X400)
Occurrence: Common

*Fig, 2j: Trilites nigeriensis*
Dimensions: Equatorial diameter: 38.70µm, Length. 36.05µm, Length of laesure 18.92µm
Location: Well AA 9500ft: Coordinate: 85.2 X 23.5 (X400)
Occurrence: Common

Occurrence: The specie is commonly distributed from the Late Miocene to the Early Pleistocene (P860-P900) in the wells A and B.
*Type Species:* The species is slightly similar to *Jimboisporites senonicus* of Miki (1972), plate 7, figs 2-4., but differs by having thicker laesure and irregularly distributed verrucae on its exine. Again the sculpture is smoother compared to *J. senonicus* with more coarse surface ornamentation,
Locations: Well AA and well AB.
Age: Late Miocene - Pleistocene.

***7.****Fig. 2k: Trilites nigeriensis var. jimbo*
Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm
Location: Well AA. 6720ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare
*Fig. 2l: Trilites nigeriensis var. jimbo*
Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm
Location: Well AA. 6720ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare

*Occurrence*: The species are commonly distributed from the Late Miocene (P860-P900) to the Early Pleistocene in the wells AA and AB.
*Type Species:* The species 2k is similar to *Cingulatisporites bifurcatus* Couper (1960); plate 2 fig. 3, 4 but differs by having a less prominent laesure and irregularly distributed verrucae on its exine. Furthermore, 2l resembles *Stereisporites* (*Distgranisporites* sp.) of Crosbie (1985); plate 1, fig 16 except for the thicker laesure and strikingly double wall.
Locations: Well AA and well AB.
*Age*: Late Miocene - Pleistocene.

**Plate 3:**

**8.** Genus *Camarozonosporites*
***Camarozonosporites salamii*** n.sp.
**Plate 3, Figs. a-j**

*Derivatio nominis***:** Named after Prof. Salami the foremost Nigeria palynologist.
*Description/Remarks:* Specimen is largely subcircular to spherical in shape, variable in size, trilete with long distinct laesurae with wide lips extending to the margins and terminating in a "y" fashion (bifurcating) and partly covered by surface ornamentation at the edges.

*Plate 3, Fig. 3a: Camarozonosporites salamii*
Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm
Location: Well AA. 6720ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare

*Fig. 3b: Camarozonosporites salamii*
Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm
Location: Well AA. 6720ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare

Occurrence: The species are commonly distributed from the Late Miocene (P840-) to the Early Pleistocene in the wells AA and AB.

Type Species*:* The species 3a is similar to *Camarozonosporites rudis* (Leschik, 1955) Klaus 1960 in Raine *et al.* (2011), but appears more circular and slightly bigger.
Locations: Well AA and well AB.
*Age*: Late Miocene - Pleistocene.

***9.*** *Rugulatisporites neogenicus*
Genus *Rugulatisporites* Cookson ex Couper

***Rugulatisporites neogenicus*** n.sp.
**Plate 3, Fig. c- f**

*Derivatio nominis***:** Named after the rugulate sculpture similar to *R. caperatus* a Cretaceous to Earliest Tertiary spore species.
*Description/Remarks:* Specimen is largely circular to spherical in shape, variable in size, trilete with long distinct laesurae extending to the margins, bifurcating. Exine thick and partly covered by surface ornamentation at the edges. Grain shows clear rugulate increasing from the equator (proximal area) toward the margins (distal area).

*Plate 3: Fig. 3c: Rugulatisporites neogenicus*
Dimensions: Equatorial diameter: 25.25µm, Length. 23.86µm, Length of laesure 11.82µm
Location: Well AB 3420ft: Coordinate: 99.5 X 24.8 (X400)
Occurrence: Common

*Plate 3, Fig. 3d: Rugulatisporites neogenicus*
Dimensions: Equatorial diameter: 27.61µm, Length. 27.13µm, Length of laesure 11.20µm
Location: Well AA 3930ft: Coordinate: 92.3 X 18.3 (X400)
Occurrence: Common
*3e: Rugulatisporites neogenicus*
Dimensions: Equatorial diameter: 24.34µm, Length. 25.40µm, Length of laesure 10.8µm
Location: Well AA 8340ft: Coordinate: 91.5 X 10.7 (X400)
Occurrence: Common

*Plate 3, Fig. 3f: Rugulatisporites neogenicus*
Dimensions: Equatorial diameter: 27. 13µm, Length. 27.61µm, Length of laesure 11.20µm
Location: Well AA 4510ft: Coordinate: 92.3 X 18.3 (X400)
Occurrence: Common
Occurrence: The specie is rarely distributed from the Middle Miocene (P840-P900) to the Early Pleistocene in the wells A, B and C.

Type Species: The specie is similar to *Rugulatisporites caperatus* Couper (1960) but differs by having thicker walls.
Locations: Well AA, well AB and well AC
Age: Middle Miocene – Early Pleistocene.

***10.*** *Echitriletes merenensis*

Genus *Echitriletes* Cookson ex Couper
***Echitriletes merenensis*** n.sp.

**Plate 3, Fig. g**

*Derivatio nominis***:** Named after the Meren field of Chevron Nigeria Limited and its echinate sculpture. Resembles *E. pliocenicus* a Pliocene to Pleistocene Nigerian Tertiary spore species but with shorter and wider laesure. Laesure of *E. pliocenicus* extends to the margins.
*Description/Remarks:* Specimen is largely circular to spherical in shape, variable in size, trilete with short laesurae not extending to the margins. Grain shows clear echinate at the edges increasing from the equator (proximal area) toward the margins (distal area).

*Plate 3, Fig. 3g: Echitriletes merenensis*
Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm
Location: Well AA. 6720ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare
*Age:* The specie is rarely distributed from the Late Miocene (P840-P900) to the Early Pleistocene in the wells AA and AB.
*Type Species:* The specie is similar to *Foraminisporis wonthaggiensis* of Mildenhall (1994) pl. 4, fig. 5, but differs by having shorter echinate irregularly distributed on its body and a thinner exine.

***11.****Plate 3, Fig. 3h: Selaginella warriensis*
*Derivatio nominis***:** Named after Warri a prominent town in the oil rich Niger Delta region. Resembles *Selaginella myosorus* a Miocene to Pleistocene Nigerian Tertiary spore species.
*Description/Remarks:* Specimen is cingulate, variable in size, trilete with wide laesurae not extending to the margins.
Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm
Location: Well AA. 6720ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare
Type Species: The specie slightly resembles *Cingutriletes cestus* except that the scar of *S. warriensis* is wider and thicker and the features further resemble those of *Selaginella myosorus*. Again, the double wall of *C. cestus* Stevens (1981) in Raine *et al.* (2011) appears thicker and the laesure is thinner and extends to the margin.
*Age*: Middle Miocene – Early Pleistocene.

***12.****3i: Triporoletes gigantus*
*Derivatio nominis***:** Named after its bigger size compared to the more common *Triporoletes neogenicus* Dimensions: Equatorial diameter: 82.61µm, Length. 80.09µm, Length of laesure 44.28µm
Location: Well AA 6720ft: Coordinate: 97.1 X 23.3 (X400)
Occurrence: Very rare
Description/Remarks: The species is larger than *T. neogenicus* and slightly resembles *Triporoletes reticulatus* of Mildenhall (1977), except that the network does not extend outwards and the scar is more pronounced in *T. gigantus.*

***13.****Plate 3, Fig. 3j: Granulatisporites neogenicus*
*Derivatio nominis***:** Named for its occurrence in the Neogene section of the Meren field of Chevron Nigeria Limited and its granulate sculpture.
*Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm*
*Location: Well AB 5670ft: Coordinate: 95.2 X 20.10 (X400)*
*Occurrence*: The specie is rarely distributed from the Late Miocene (P840) to the Early Pleistocene (P900) in the wells AA and AB.
*Type Species:* The specie is similar to *G. pliocenicus* but differs by in having shorter echinate irregularly distributed on its body and exine.

***14.****Camarozonosporites merenensis*
Genus *Camarozonosporites* (Couper 1953) Dettmann & Playford 1968
*Camarozonosporites* ***merenensis*** n.sp.

**Plate 3, Figs. k and l.**

*Derivatio nominis***:** Named after the Meren field of Chevron Nigeria Limited and its echinate sculpture. Resembles *E. pliocenicus* a Pliocene to Pleistocene Nigerian Tertiary spore species but with shorter and wider laesure. Laesure of *E. pliocenicus* extends to the margins.
*Description/Remarks:* Specimen is slightly subangular to spherical in shape, variable in size, trilete with regulate, short laesurae not extending to the margins. Grain shows clear rugulate which spread across the surface.

Plate 3, Fig. 3k: *Camarozonosporites merenensis*
Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm
Location: Well AA. 6720ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare
Age: The species is rarely distributed from the Late Miocene (P840-) to the Early Pleistocene in the wells AA and AB.
*Type Species:* The species especially its clear regulate sculpture is similar to *Camarozonosporites ohaiensis of Vadja & Raine 2011 fig. 5l* but differs by having more pronounced laesure mark.

*Plate 3,* ***Fig. 3l:*** *Camarozonosporites merenensis*

*Derivatio nominis***:** Named after the Meren field of Chevron Nigeria Limited and its echinate sculpture. Resembles *E. pliocenicus* a Pliocene to Pleistocene Nigerian
Dimensions: Equatorial diameter: 44.51µm, Length. 40.20µm, Length of laesure 20.38µm
Location: Well AA. 6720ft: Coordinate: 95.2 X 20.10 (X400)
Occurrence: Rare
*Age:* The species is rarely distributed from the Middle Miocene to the Early Pleistocene in the wells AA and AB.
*Type Species:* The specie resembles *Rugulatisporites trisinus* Jersey and Hamilton 1967 in Raine *et al.* (2011) fig. 5O, but differs by having less pronounced laesure mark than *R. trisinus.*

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## DISCUSSION

Among the different species of *Stereisporites* herein described, *S. laevigatus* are the largest in size. The smallest are these Niger Delta species are *S. annulus* which still appear larger than such already published species as *S. australis, S. regium, stereoides, S. psilatus, S. minor, S. apolaris, S. grossus, and S.* . However, the sizes compare favorably with those of *S. antiquasporites* figure 18 no. 7 of Foersterling (2011), and *S. compactus* of Raine *et al.* (2011). Again, the Niger Delta *Stereisporites* species generally appeared larger than most of the other cited species possibly due to evolutionary advancement as most of the others species mentioned were of ages older than the Late Miocene to Early Pleistocene Niger Delta taxa. Miller (1982) had reported that the moss and liverworts fossils for the Palaeocene-Eocene epoch known then confirmed the presence of several species from most major groups. He cited Partyka (1976) who had listed six taxa assigned to *Sphagnum* from Russian Palaeocene-Eocene strata and also opined that both Pteridophyte and Bryophytes thrived till the Recent. Their recovery of these species from the Miocene to Early Pleistocene of the Niger Delta is therefore not out of place but agrees with this assertion. The species *Trilites bamfordae* which shows close resemblance to *Trilites bifurcatus* seem to have close evolutionary trend with the Nigerian variants. Couper (1961) had recovered them from the Pleistocene Nukumaruan stage in New Zealand, and found them to range from Earliest Miocene to Pleistocene. Possibly, they evolved earlier in New Zealand having been recovered from Late Miocene to Early Pleistocene strata in Nigeria (Evamy *et al*. 1978; Morley and Richards, 1997). Kayseri and Akgün (2008) had also recovered species of both *Stereisporites* and *Trilites* from Miocene sediments of Turkey.

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