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Taxonomic Notes on Coccolithophorids from Tomboy Field, Offshore Western Niger Delta, Nigeria

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ABSTRACT

The aim of this paper is to present the taxonomic notes on Coccolithophorids found in five wells in the Tomboy Field, offshore western Niger Delta area of Nigeria. Niger Delta lies between latitudes 4° and 6° N and longitudes 3° and 9° E in the south-south geo-political region of Nigeria. Ditch cutting samples collected from five wells at the industry standard of 9.14 m depth intervals were subjected to the pipette and smear laboratory technique to prepare them for microscopic assessment for coccoliths. The Coccolithophorids (coccoliths) present in the samples were identified and their taxonomic notes were written in line with the International Code for Botanical Nomenclature.

Keywords: *Calcareous nannofossils, Coccolithophorids, Tomboy Field, offshore western Niger Delta, Nigeria*

1. INTRODUCTION

The study area is the Tomboy Field and it is located in the offshore western Niger Delta area of Nigeria (Figure 1). The Niger Delta is situated in the Gulf of Guinea on the west coast of Central Africa. It lies between latitudes 4° and 6° N and longitudes 3° and 9° E in southern Nigeria [50]. The Delta is situated at the intersection of the Benue Trough and the South Atlantic Ocean where a triple junction developed during the separation of South America and Africa in the Late Jurassic [66]. The aim of this paper is to present the taxonomic notes on identified Coccolithophorids from the Tomboy Field.

2. GEOLOGICAL SETTING

Three formations have been recognised in the subsurface of the onshore and offshore Niger Delta [17], [55], [63], [1], [38], [58]. These are the Akata, Agbada and Benin Formations. These formations were deposited in marine, transitional and continental environments, respectively; together they form a thick, overall progradational passive-margin wedge [16]. The Akata Formation, the basal unit, is composed mainly of marine shales believed to be the main source rock within the basin. The Agbada Formation is made up of alternating sandstone, siltstone and shale sequences that constitute the petroleum reservoirs of the basin and it is Eocene to Pliocene in age. The topmost unit which is Upper Oligocene to Recent is called the Benin Formation and it consists mostly of non-marine sands with shaly intercalations [16].

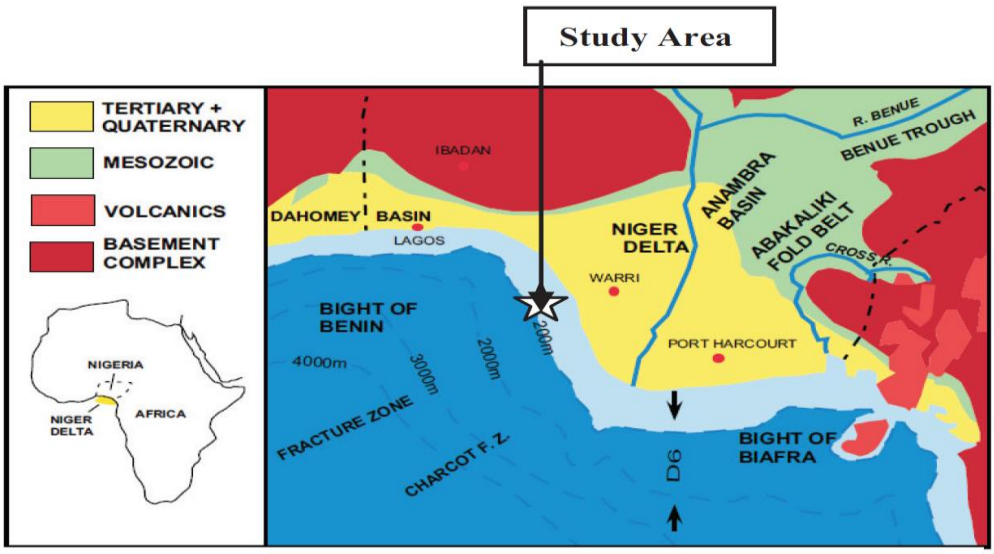


Figure 1: Index map of Niger Delta and Location of Study Area (Source: Doust and Omatsola [8])

3. METHODS OF STUDY

The five wells are denoted by TMB-1, TMB-2, TMB-4, TMB-5 & TMB-6 and they have 226, 212, 222, 216 and 224 ditch cutting samples, respectively, totalling 1,100 samples that were collected at the industry standard of 9.14 m sampling intervals for analysis for coccolithophorids (coccoliths). The pipette and smear technique was used for the coccoliths preparation. The unwashed ditch cuttings were slightly rinsed to remove drilling mud. Absolute care was taken at all stages of the sample preparation to avoid contamination. About 25 grams of each sample were required but 10 grams were utilised. They were broken down by soaking and swirling in distilled water. Addition of a small quantity of sodium hexametaphoshate (calgon) helped in the dispersion of the clays and ensured even distribution of the particles in the final mount. Drops of the suspensions taken from the beakers using pipette were carefully placed on glass cover slips (22 mm x 22 mm). Few drops of distilled water were added to dilute the suspensions, which were then dried on a hot plate. Two blobs of Norland optical adhesive (Refractive Index = 1.56) were placed on glass slips with the samples inverted over the glass slides until the adhesive was completely spread evenly, resulting in clean mounts. The mounts were cured over ultraviolet light for 30-45 minutes. The glass slides were then made ready for inspection under the microscope.

4. RESULTS AND DISCUSSION

4.1 Calcareous Nannofossils

Coccoliths are the minute calcite plates produced by unicellular marine algae, the coccolithophorids. The fossil coccoliths, together with small calcite bodies of organic, but otherwise unknown origin, called nannoliths, constitute the calcareous nannofossils [51]. Coccoliths are disc-spherical shaped plates from the organism and thought to perform a protective role as well as concentrate sun rays for food synthesis. Nannofossils are largely restricted to normal marine environments and have little tolerance for either turbidity or freshwater diluted environments [50]. Their small size (less than 30 microns) allows for age determinations of even small samples such as ditch cuttings, sidewall cores, etc. and they are extremely useful for Cenozoic biostratigraphy [51], [7]. Calcareous nannofossils are classified according to the International Code of Botanical Nomenclature (ICBN) [51]. Seventeen Coccolithophorids species were identified in the study area and the taxonomic notes on them are based entirely on phenetic data, the structure and the shape of the coccoliths [50]. Plate 1 shows photomicrographs of identified taxa in the study area.

4.2 Calcareous Nannofossils Taxonomic Notes

Order Zygodiscales YOUNG & BOWN [70]
Family Helicosphaeracea BLACK [5]
Genus *Helicosphaera* KAMPTNER [35]
Synonym**:** *Helicopontosphaera*

Helicosphaera carteri (WALLICH [62]) KAMPTNER [35] [Coccosphaera] Plate 1.1
Synonym: *H. kamptneri* (HAY AND MOHLER IN HAY et al [26]) LOCKER [43] [*Helicopontosphaera*]
Variants:
H. carteri var. *burkei* (BLACK [5]) THEODORIDIS [57] - central-area closed;
H. carteri var. *hyalina* (GAARDER [18]) JORDAN AND YOUNG [33] - central-area closed;
H. acuta THEODORIDIS [57] - no true wing, slight inverse orientation of openings;
H. colombiana (GARTNER [19]) HAQ AND BERGGREN [25] - smaller wing;
H. neogranulata (GARTNER [21]) HAQ AND BERGGREN [25] - central-area with no true pores/granular;
H. paleocarteri THEODORIDIS [57] - with small pores separated from the extinction line.

Description: The most common *Helicosphaera* species. Medium to large size, flange ends in wing, two pores in central-area [7].
Range: NN1 to NN21 [51], [7].

Helicosphaera stalis THEODORIDIS [57] Plate 1.2
Variants: *H. stalis* ssp. *ovata* THEODORIDIS [57]. It has rounded, lenticular outline rather than rhombohedral; *H. girgisii* VAROL [61]:– It has closed central area.
Description: It has small, lenticular or rhomboid outline. No distinct flange ends in wing. Two normally inclined pores are found in the central area [7].
Age Range: NN6 – NN11 [51], [7].

Helicosphaera obliqua BRAMLETTE and WILCOXON [8] Plate 1.3
Description: It is medium sized, with sub-rectangular shape and weakly birefringent. The wing ends in spur, and the central area has two prominent pores, which have inverse orientation [7].
Age Range: NP24 – NN6 [51], [7].

Helicosphaera perch-nielseniae (HAQ [23]) JAFAR and MARTINI [30] Plate 1.4
Variant: *H. elongata* THEODORIDIS [57]:- It is more elongate and more rectangular in outline.
Description: Like *H. obliqua* but pores narrower and shape more oblong and less spindle-like [7].
Age Range: NP23 – NN6 [51], [7].

Family Pontosphaeracea LEMMERMANN [40]
Genus *Pontosphaera* LOHMANN [44]
Synonyms: *Crassapontosphaera* BOUDREAUX AND HAY [6]; *Discolithina* LOEBLICH AND TAPPAN [40]; *Discolithus* HUXLEY [28]; *Koczyia* BOUDREAUX AND HAY [6].

Pontosphaera japonica (TAKAYAMA [56]) NISHIDA [48] [Discolithina] Plate 1.5
Synonym: *Discolithus millepuncta* GARTNER [19].
Description: Rim flush with central-area pores very small (<0.1μm) often infilled during diagenesis [7].
Range: Paleogene to NN21 [51], [7].

Order Prinsiales YOUNG & BOWN [70]

Family NOELAERHABDACEAE JERKOVIC [32] emend. YOUNG & BOWN [70]

Synonym: Gephyrocapsaceae Black [5]
Genus *Cyclocargolithus* BUKRY [10]
Cyclicargolithus floridanus (ROTH & HAY in HAY et al. [26]) BUKRY [10] Plate 1.6
Description: Circular to sub-circular with small central-area. Common form < 11µm. Often dominates assemblages [7].
Range: Paleogene to NN7 (but last occurrence is diachronous) [51], [7].

Genus *Reticulofenestra* HAY, MOHLER AND WADE [27]
Synonym: *Dictyococcites* BLACK [4] - like *Reticulofenestra* but with closed central-area.

Reticulofenestra pseudoumbilicus (GARTNER [19]) GARTNER [20] [Coccolithus] Plate 1.7
Variants:
R. ampliumbilicus THEODORIDIS [56] - forms with very wide central-area, possibly an early growth phase.
R. antarctica (HAQ [24]) DRIEVER [14] [*Dictyococcites*] - closed central-area.
R. tenuistriata (KAMPTNER [37]) MARTINI [46] [*Coccolithus*] - *sensu* VAROL [61] = 5 – 7µm *R. pseudoumbilicus*.
Description: Coccoliths > 5 µm (BACKMAN [2], [3], [69]. Often dominates Middle Miocene - Early Pliocene assemblages [7].
Remarks: For biostratigraphy it is better to separate the > 7 µm specimens; i.e. a definition of > 7 µm is preferable for unambiguous identification of both the NN15/NN16 boundary (last occurrence of *R. pseudoumiblicus*) and the NN10A/B boundary (start of small *Reticulofenestra* interval/*R. pseudoumbilicus* paracme) [7].
Range: NN4 to NN15 [51], [7].

Reticulofenestra haqii BACKMAN [2] Plate 1.8

Description: Coccoliths small (3-5µm), intergrades with *R. pseudoumbilicus* [7].

Range: NN2 to NN15 [51], [7].

Order COCCOSPHAERALES HAECKEAL [22] Taxa include:

- **Coccolithaceae**
- **Calcidiscaceae**
- **Hymenomonadaceae** (neritic with no known fossil record)
- **Pleurochrysidaceae** (neritic with no known fossil record)

Family Coccolithaceae POCHE [52] emended. YOUNG & BOWN [70]
Genus *Coccolithus* SCHWARZ [54]

Coccolithus pelagicus (WALLICH [62]) SCHILLER [53] [Coccosphaera] Plate 1.9
Variant: *C. pelagicus* ssp. *floralis* WEI & WISE [65].
Description: Morphotypes size: 3-16 microns, central area open with transverse bar. Collar formed from upper cycle of central area [7].
Age Range: Paleogene – Pleistocene (NN21) [51], [7].

FAMILY CALCIDISCACEAE YOUNG & BOWN [70]
Genus *Calcidiscus* KAMPTNER [34]

Type species: *C. quadriforatus* (subj. j. syn. of *C. leptoporus).*
Synonyms:

Cyclococcolithina WILCOXON [67];
Cyclococcolithus KAMPTNER [35];
Cycloplacolithus KAMPTNER [37].

Variant:
Cycloperfolithus LEHOTAYOVA AND PRIEWALDER 39] - with fine grill in central-area, and bicyclic proximal shield.

Species-level Description & Remarks:

Calcidiscus is common throughout the Neogene and shows significant variation in size, number of elements, opening of central area, and structural details.

C. quadriperforatus; large, 7-10 µm, with zone of obscured sutures. Haploid phase produces septate holococcoliths (formerly classified as *Syracolithus quadriperforatus*)

C. leptoporus - intermediate; 5-8 µm, with continuous sutures. Haploid phase produces planar holococcoliths (formerly classified as *Crystallolithus rigidus*)

C. leptoporus - small; 3-5 µm, with kinked sutures. Haploid phase not known.

By comparison Pliocene *Calcidiscus* assemblages are usually classified into:

C. leptoporus; 3-8 µm circular to sub-circular with closed central area

C. tropicus & *C. macintyrei*; 5-11 µm circular with open central area.

Calcidiscus leptoporus (MURRAY AND BLACKMAN [48])

LOEBLICH & TAPPAN [42] [Coccosphaera] Plate 1.10
Variant: *Cd. fuscus* (BACKMAN [3]) JANIN [31].

Description: Species of *Calcidiscus* producing circular to sub-circular coccoliths with, closed central-area. *Cd. leptoporus* is small and broadly elliptical [51], [7].

Remarks: This is something of a default name applied to a wide range of morphotypes but in most assemblages there is clearly a separation between slightly sub-circular forms with a closed central area (*leptoporus*) and circular forms with an open central area (*tropicus*) [51], [7].

Range: NN2 to NN21. FO of *Cd. leptoporus* is placed in Early Miocene [51], [7].

Calcidiscus premacintyrei THEODORIDIS [57] Plate 1.11

Description: Large, weakly elliptical species of *Calcidiscus*, central area open, and distinctly elliptical [7].

Remarks: This species is similar to *Cd. macintyrei* but is limited in stratigraphical range and readily distinguished by the elliptical central area [51], [7].

Range: NN4 to NN6. LO of *Cd. premacintyrei* is placed at near top of NN6 (Serravellian, Middle Miocene) [51], [7].

Genus Umbilicosphaera LOHMANN [44]
Synonym: *Geminilithella* BACKMAN [3]
Umbilicosphaera jafarii MÜLLER [47] Plate 1.12

Variant:

Umbilicosphaera petaliformis VAROL [59] - similar but with bicylic proximal shield.

Synonyms:
Umbilicosphaera jafarii MÜLLER [47], [25], [59]
Cyclococcolithus krejcigrafii JAFAR [29] *Cyclococcolithus stradneri* JAFAR [29] *Umbilicosphaera sibogae* (WEBER-VAN [64]) GAARDER [18], [25]

Geminilithella jafarii (MÜLLER) BACKMAN [3].
Umbilicosphaera petaliformis VAROL [59], [60].

Description: Small circular species of *Umbilicosphaera* with narrow central-area. Distal shield slightly wider than proximal shield [51], [7].

Remarks: Very common. Shields often separated. Isolated distal shields show no birefringence and are almost invisible in cross-polars; but are dark in phase contrast, and so discernible. Isolated proximal shields show the reverse behaviour; they are practically invisible in phase contrast but give a weak extinction cross in cross-polars. The entire coccolith has the combined properties; and so is visible in both phase contrast and cross-polars, although due to its small size it is not obvious that the birefringence is a product of the proximal shield. *U. jafarii is* distinguished from *U. foliosa* primarily by its smaller size, but it also has a smaller central opening, and the sutures on the distal shield are straight. Because of its smaller size it is also much less strongly birefringent than *U. foliosa.* Size: 3-4 (rarely 5) microns [51], [7].

Range: NN2 to NN19 [51], [7].

Umbilicosphaera rotula (KAMPTNER [36]) VAROL [59] [*Cyclococcolithus*] Plate 1.13

Synonyms:
Cyclococcolithus rotula KAMPTNER [36], [47], 29].
Cyclococcolithus aequiscutum GARTNER [19].
Cyclococcolithus cricotus GARTNER [19] (=*Pseudoemiliania lacunosa*).
Calcidiscus aequiscutum (GARTNER) LOEBLICH & TAPPAN [42] (=*Coronocyclus nitescens*).
Cyclolithella rotula (KAMPTNER) HAQ & BERGGREN [25].
Geminilithella rotula (KAMPTNER) BACKMAN [3], [57].

Variant: *Umbilicosphaera lordii* VAROL [59].

Description: *Umbilocosphaera* coccoliths with wide central-area, and narrow rim with shields of similar size. The distal shield is slightly domed and it is formed of shallowly imbricated elements, giving a complex suture pattern. The proximal shield consists of a single cycle of non-imbricated elements with nearly radial sutures; it is nearly flat except for a collar on its lower surface. A well developed tube separates the shields [51], [7].

Remarks: Often placed in *Geminilithella* [7].

Range: NN2 to NN16 [51], [7].

FAMILY SPHENOLITHACEAE DEFLANDRE [11]
Genus *Sphenolithus* DEFLANDRE [11]

Synonyms: *Furcatolithus* MARTINI [45]; *Sphenaster* WILCOXON [68].

Sphenolithus abies DEFLANDRE in DEFLANDRE & FERT [13] Plate 1.14

Description: typical form is a moderately elevated sphenolith with cuspate outline and with extinction line going down the long axis of the spine [7].

Remarks: Similar to *S. moriformis* in lacking prominent apical spines but more elevated and with cuspate outline. Specimen becomes less distinct with poor preservation. The classic *S. abies* form is distinctive and did not occur in the Early Miocene but consistent separation from *S. moriformis* is difficult [7].

Range: NN7 to NN15 [7].

Sphenolithus moriformis (BRÖNNIMANN & STRADNER [9] Plate 1.15
Synonym**:** *S. pacificus* MARTINI [45].
Variant**:** *S. compactus* BACKMAN [3] - small form.

Description**:** Beehive-shaped sphenolith, apical elements not in extinction in vertical position. No spine, upper and lower parts of similar size [7].

Remarks**:** Lower and Middle Miocene sphenoliths are highly variable and *S. moriformis* is something of bucket shape identification. **Size**: 3-8 microns (size varies considerably between samples, but there have been no systematic studies) [7].

Range: Lower Eocene to NN10 [51], [7].

Sphenolithus heteromorphus DEFLANDRE [12] Plate 1.16

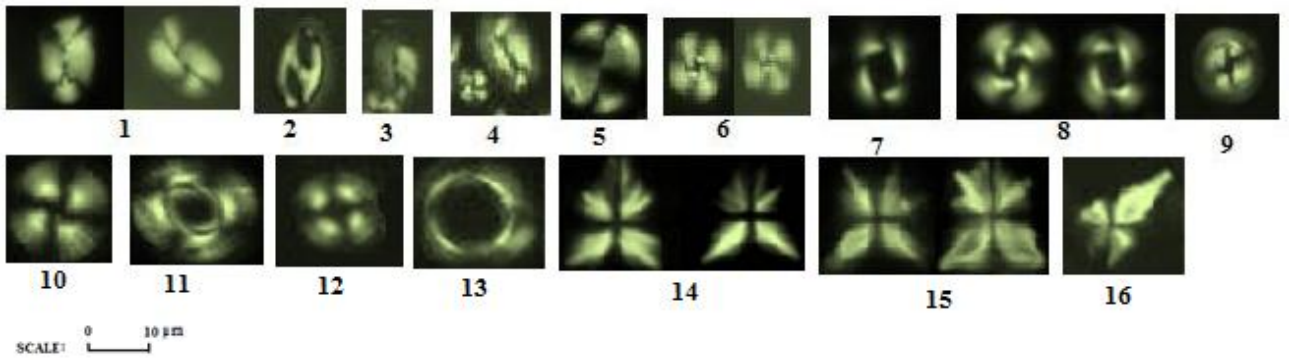
Description: Species has prominent monocrystalline apical spine that is very well-developed and also possesses lateral elements that are nearly as large as the proximal elements [7].

Remarks: *S. heteromorphus* has a well developed quadrate base, in which the the upper part is nearly as large as the proximal part, which distinguishes it clearly from *S. belemnos*. Also the spine typically has a rather bulbous base in contrast to the straight-sided *S. belemnos* [7].

Range: NN4 - NN5 (but rather prone to reworking). FO of *S. heteromorphus* defines the base of NN4, while the LO defines the top of NN5 Zone, which also defines the boundary between NN5 and NN6 [51], [7].

5. CONCLUSION

Seventeen Coccolithophorids species were identified and taxonomic notes based entirely on phenetic data, structure and shape was recorded for them in accordance with the International Code of Botanical Nomenclature (ICBN). Coccolithophorids are also called coccoliths. The coccoliths in the study area are grouped into three Orders. They are **Order Zygodiscales** YOUNG & BOWN [70], **Order Prinsiales** YOUNG & BOWN [70], and **Order Coccosphaerales** HAECKEAL [22]. Order **Zygodiscales** YOUNG & BOWN [70] is made up of two families, namely: **Family Heliocosphaeracea** BLACK [5] and **Family Pontosphaeracea** LEMMERMANN [40]. On the other hand, **Order Prinsiales** YOUNG & BOWN [70] has a family member called **Family Noelaerhabdacea** JERKOVIC [32]. The **Order Coccosphaerales** HAECKEAL [22] has five family members, namely: **Family Coccolithacea** YOUNG & BOWN [70], **Family Calcidiscaceae**, two others (that is, **Family Hymenomonadaceae** and **Pleurochrysidaceae Family** do not have any fossil record), and **Family Sphenolithaceae** DEFRANDRE [11]. The taxonomic study of these coccoliths is very important because they are very useful index and biozone fossils and good paleogeographic indicators besides their far-reaching economic, industrial applications.



1. *Helicosphaera carteri* (WALLICH [62]) KAMPTNER [35]
2. *Helicosphaera stalis* THEODORIDIS [57]
3. *Helicosphaera obliqua* BRAMLETTE & WILCOXON [8]
4. *Helicosphaera perch-nielseniae* (HAQ [23]) JAFAR & MARTINI [30]
5. *Pontosphaera japonica* (TAKAYAMA [56]) NISHIDA [49]
6. *Cyclicargolithus floridanus* (ROTH & HAY IN HAY ET AL. [26]) BUKRY [10]
7. *Reticulofenestra pseudoumbilicus* (GARTNER [19]) GARTNER [20]
8. *Reticulofenestra haqii* BACKMAN [2]
9. *Coccolithus pelagicus* (WALLICH [62]) SCHILLER [53]
10. *Calcidiscus leptoporus* (MURRAY AND BLACKMAN [48]) LOEBLICH AND TAPPAN [42]
11. *Calcidiscus premacintyrei* THEODORIDIS [57]
12. *Umbilicosphaera jafarii* MÜLLER [47]
13. *Umbilicosphaera rotula* (KAMPTNER [36]) VAROL [59]
14. *Sphenolithus abies* DEFLANDRE in DEFLANDRE & FERT [13]
15. *Sphenolithus moriformis* (BRÖNNIMANN & STRADNER [9])
16. *Sphenolithus heteromorphus* DEFLANDRE [12]

Plate 1. Photomicrographs of Coccolithophorids from Tomboy Field

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