New and rarely reported calcareous nannofossils from the Late Cretaceous of coastal Tanzania: outcrop samples and Tanzania Drilling Project Sites 5, 9 and 15

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Abstract Field sampling and subsurface drilling in Tanzania, in and near to the coastal towns of Lindi and Kilwa, and connected to the NERC-funded Tanzania Drilling Project, have provided a wealth of Cretaceous material for analysis. The clay-rich lithologies contain nannofloras that are generally very well preserved and diverse. Consequently, several new calcareous nannofossil taxa have been discovered, and a number of taxa that are rarely reported have been recorded. These taxa are described and/or illustrated here. They include: seven new genera (Bilapillus, Duocameratus, Nicholasia, Pearsonia, Singanoa, Tanzanella, Thecatus); 17 new species of heterococcolith (Calciosolenia? huberi, Corollithion karegae, Effellithus lindiensis, Gartnerogo? coxalliae, Miravetesina bernoitii, Percivalia? dunkleyjonesii, P.? pearysonii, Placozygus bannerii, Prediscosphaera mgaya, Rhagodiscus pancoasti, Rotelapillus msayae, Staurolithites halfanii, S. handleyi, S. ngurumahambaensis, Truncatocapsus macmilleri, Zeugrhadobotaus blowii, Z. simplex); 22 new species of holococcolith (Bifidalithus mehanea, Bilapillus wadeae, Calculites cenomamicus, C. cyclops, C. juliae, C. maghredaswampensis, C. paalae, C. prosoxus, C. rosalyniae, C. turonicus, Duocameratus leari, D. stianae, Lucianorhabdas? boudagherfadeliae, L.? tabernus, L. turris, Metadoga ampulla, Munarinus mkeremei, Nicholasia baileyi, Orastrum robinsontii, Pearsonia ecclesiata, Tanzanella bownti, Thecatus varolii); four new species of nannolith (Ceratolithodes dongoii, C. ohalloraniae, Micrantholithus? nicholasi, Singanoa scapus); two new combinations (Cribrosphaerella circula (Risatti, 1973), Lucianorhabdas compactus (Verbeek, 1976)); and one taxon of elevated status (Ceratolithina capitanea (Burnett, 1997a)).

Keywords Calcareous nannofossils, holococcoliths, Cenomanian, Turonian, Campanian, Maastrichtian, taxonomy, Tanzania

1. Introduction
The Tanzania Drilling Project (TDP) was funded after three years of fieldwork (1998-2000) in the coastal Tanzania region, focussed on the towns of Kilwa and Lindi (Figure 1). The main aims of the project were to recover Paleogene and Cretaceous planktonic foraminifera of unprecedented preservation, as well as organic biomarkers, from the sediments, primarily in order to gain meaningful palaeotemperatures and atmospheric CO₂ estimates via isotopic analyses (e.g. Pearson et al., 2001; van Dongen et al., 2006). Among the ~500 outcrop samples initially collected were several of Cretaceous age. To date, those examined for calcareous nannofossils provide a discontinuous record of the Albain-Cenomanian, Turonian and Campanian-Maastrichtian (Lees, unpubl. data). Furthermore, three of the 20 sites drilled (with the collaboration of the Tanzania Petroleum Development Corporation – TPDC), between 2002 and 2005, also provided Cretaceous material. TDP Sites 5 and 9 (described in Pearson et al., 2004, 2006; Nicholas et al., 2006) recovered sediments from around the Campanian/Maastrichtian boundary, whilst TDP15 (Nicholas et al., 2006; Pearson et al., in prep.) was drilled specifically to try to recover the Cenomanian/Turonian boundary, although this proved to be elusive (Lees, unpubl. data).

Bown (2005), Bown & Dunkley Jones (2006) and Bown et al. (2007) have published extensively on taxonomic aspects of the Paleogene nannofloras, the dozens of new species described testifying to the fact that theirs is exceptionally well preserved material. Preservation of the Cretaceous material, especially from the cores, is variable, but overall seems not to be as pristine as that of the Paleogene cores, based on both planktonic foraminiferal and nannofossil scanning electron microscope observations (B.T. Huber, pers. comm., 2006; JAL pers. obs., 2004-2006). The calcareous nannofossil preservation in the Cretaceous is governed by the domination of clay in the sediment, but possibly tempered by having suffered from tropical weathering, even at depth. Having said that, there are many new calcareous nannofossil taxa in the Cretaceous material, and
this is a preliminary description of the exceptional diversity that I have observed so far.

2. Material

The Upper Cretaceous sediments belong to the Nangurukuru Formation of the Kilwa Group (as described in Nicholas et al., 2006). They represent the onset of increased subsidence across the shelf, but the sediment actually varies very little from the Cretaceous through Paleogene, being predominantly represented by dark clay, claystones and siltstones (Nicholas et al., 2006). Outcrop material included herein was collected as spot-samples from around Kilwa and Lindi (as described below; grid references refer to maps shown in Nicholas et al., 2006). Locality and age details for the outcrop spot-samples mentioned here are given in Table 1. The nannofossil biozonation of Burnett (1998a) has been applied to these samples. (Full biostratigraphical information will be provided in a separate publication.)

<table>
<thead>
<tr>
<th>sample</th>
<th>age</th>
<th>biozone</th>
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<tbody>
<tr>
<td>Around Lindi town, -UTM 37L 573393, 8894643</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lindi-99-2</td>
<td>Campanian/Maastrichtian</td>
<td>UC16</td>
</tr>
<tr>
<td>Lindi-99-3</td>
<td>Early Maastrichtian</td>
<td>UC17</td>
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<tr>
<td>Lindi-99-9a</td>
<td>Early Maastrichtian</td>
<td>UC17</td>
</tr>
<tr>
<td>Lindi-99-11</td>
<td>Early Maastrichtian</td>
<td>UC17</td>
</tr>
<tr>
<td>Lindi-99-12</td>
<td>Early Maastrichtian</td>
<td>UC18</td>
</tr>
<tr>
<td>Nguru-mahamba, SW of Lindi town, UTM 37L 561739, 8891339</td>
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<tr>
<td>Nguru-99-1</td>
<td>Middle-Late Cenomanian</td>
<td>UC3a-b</td>
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<tr>
<td>Nguru-99-2</td>
<td>Early Cenomanian</td>
<td>UC1a-2a</td>
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<tr>
<td>Nguru-99-3</td>
<td>Early Cenomanian</td>
<td>UC1a-2a</td>
</tr>
<tr>
<td>Nguru-99-4</td>
<td>Early Cenomanian</td>
<td>UC1a-2a</td>
</tr>
<tr>
<td>Nguru-99-5</td>
<td>Middle-Late Cenomanian</td>
<td>UC3a-b</td>
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<td>Nguru-99-9</td>
<td>Early Maastrichtian</td>
<td>UC17</td>
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<tr>
<td>Nguru-99-10</td>
<td>Late Campanian</td>
<td>UC15eTP</td>
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<tr>
<td>Nguru-99-12</td>
<td>Late Maastrichtian</td>
<td>UC20aTP</td>
</tr>
<tr>
<td>Matandu Bridge, west of Kilwa Kivinje (UTM 37L 531458, 9033532)</td>
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<tr>
<td>PP04-K1</td>
<td>Middle-Late Turonian</td>
<td>UC9a</td>
</tr>
<tr>
<td>PP04-K9</td>
<td>Early Maastrichtian</td>
<td>UC17</td>
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<tr>
<td>PP04-K17</td>
<td>Late Campanian</td>
<td>UC15dTP</td>
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<tr>
<td>PP04-K19</td>
<td>Late Campanian</td>
<td>UC15cTP</td>
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<tr>
<td>PP04-K20</td>
<td>Late Campanian</td>
<td>UC15dTP</td>
</tr>
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Table 1: Outcrop sample locations and biostratigraphy

3. Methods

The species described here are based on light-microscope (LM) observation only. This was performed on smear-slides, prepared as described in Bown & Young (1998). Examination was performed on a Zeiss Axio Imager.A1 at 1250x magnification. Digital images were captured with a Leica DFC280 digital camera at 640x480 pixels, using Leica FireCam software. Plates were made using Canvas software on a Mac PowerBook, as follows. In a new Canvas file, the TIFF images were first acquired (Image->Acquire->TIFF), then scaled down to 25% (Object->Scale) and cropped (Image->Area->Crop), generally to 3x3cm or 2x2cm. The resolution can also be boosted (Image->Area->Resolution->Best). These images were then arranged into plates, and scale-bars, figure numbers, taxon names, sample numbers and image-identifying numbers added. All images on the plates were taken in cross-polarised light (XPL), except for those taken with phase-contrast (PC) or bright-field (BF), these being indicated on the plates. Typically, each specimen is figured at 0° and ~45° to the polarisers.

4. Gross assemblage composition

Species richness is typically very high in this material, comparing favourably with the global diversity estimates of Bown et al. (2004), and preservation varies from good to moderate. Holococcoliths and very small (<3µm) taxa are frequent components of the assemblages, although individual holococcolith species are usually rare to few in abundance.

Coccospheres are also frequently represented, particularly those of taxa with placolith morphology (e.g. Biscutum, which shows a plethora of coccosphere shapes (PI.5, figs 2-10, 12-15), Cribrosphaerella and Discorhabdus). Whilst the nannofloras are not particularly dominated by any one taxon, Corollithion, Cribrosphaerella, Discorhabdus, Prediscosphaera, Watznaueria and Zeugrhabdus are the most common assemblage components. Notably, the typically common Campanian lucianorhabdids and Calculites obscurus seen elsewhere are absent from, or very rare in, these assemblages. This may indicate that they are not tropical taxa.

The seldom reported Prolatipatella multicarinata occurs as a rare, yet quite consistent component, in sediments from TDP9 (Upper Campanian-Lower Maastrichtian). Lees (2002) indicated its status as a Tropical taxon, and this is supported by its unusually consistent presence in Tanzania. Repagulum parvidentatum is a rare, but sometimes consistent, component of these low-latitude nannofloras also. This underlines the fact that, whilst an increase in its abundance may be used as a proxy for cooler water, its mere presence in an assemblage may not. Its occurrence in these well-preserved samples may also involve a preservational bias.

5. Systematic palaeontology

The terminology used in the descriptions below follows
the guidelines of Young et al. (1997). The biozonation is that of Burnett (1998a). Only details of taxa and taxonomic references that do not appear in Bown (1998) are provided here. In the taxonomic descriptions below, ‘L’ = length, ‘W’ = width, ‘H’ = height. The taxonomic section is arranged in three parts: heterococcoliths, holococcoliths and nannoliths. Within each part, taxa are arranged alphabetically, first according to the order, then family, then genus, then species.

5.1 Heterococcoliths

**Order ARKHANGELSKIALES** Bown & Hampton in Bown & Young, 1997

**Family KAMPTNERIACEAE** Bown & Hampton in Bown & Young, 1997

*Gartnerago chiasta* Valor, 1991

Pl.3, figs 19, 20

*Gartnerago? coxalliae* sp. nov.

Pl.6, figs 34-37. **Derivation of name:** After Dr. Helen Coxall (Cardiff University), Cenozoic micropalaeontologist on the TDP team. **Diagnosis:** A medium-sized species with a rim that is reminiscent of that of *Gartnerago* (bright outer cycle, dark inner cycle, but lacking a central plate). The wide central area is open and spanned by a complex bar, aligned with the short axis, that remains quite dark in XPL. The bar bifurcates where it joins the rim. **Differentiation:** The bars in other species of *Gartnerago* are of simple construction and do not bifurcate. **Holotype:** Pl.6, figs 36, 37. **Holotype dimensions:** L = 7.04µm, W = 4.84µm. **Paratype:** Pl.6, figs 34, 35. **Type locality:** TDP5, Machole, south of Kitulo Hill, near Lindi, coastal Tanzania. **Type level:** TDP5/10-2, 15-16cm; UC15eTP, Late Campanian. **Occurrence:** TDP5 and TDP9, Late Campanian-Early Maastrichtian (UC15eTP-17); Matandu Bridge (Kilwa), Late Campanian (UC15eTP). **Diagnosis:** This new species is distinguished from other placozygids by its wide, bright inner cycle, narrow central area and almost indistinguishable short-axis bar. **Holotype:** Pl.7, figs 21, 22. **Holotype dimensions:** L = 4.4µm, W = 3.08µm. **Paratype:** Pl.7, figs 19, 20. **Type locality:** Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level:** Sample Nguru-99-10; UC15eTP, Late Campanian. **Occurrence:** Nguru-mahamba, Late Campanian-Early Maastrichtian (UC15eTP-17).

*Placozygus fibuliformis* (Reinhardt, 1964) Hoffmann, 1970

Pl.7, figs 27-30

*Placozygus sp.*

Pl.7, figs 31, 32

*Placozygus spiralis* (Bramlette & Martini, 1964) Hoffmann, 1970

Pl.7, figs 23-26

**Remarks:** Burnett (1998a) has been somewhat responsible for confusing the placozygid taxonomy. The original description of *spiralis* includes small size and small perforations either side of the bar; thus Burnett’s (1998a, pl.6.2, fig.26a) illustration of *P. fibuliformis* is actually *P. spiralis*. *P. fibuliformis* (illustrated here in Pl.7, figs 27-30) has more open perforations and a bar in which the elements can be easily discerned. This species equates to Burnett’s (1998a) illustrations (in pl.6.2, figs 26b-27b) of *P. cf. P. fibuliformis*. The larger and more highly birefringent form illustrated by Burnett (1998a, pl.6.2, fig.28) as *P. spiralis*, and here in Pl.7, figs 31 and 32 (as *Placozygus* sp.), is possibly a new species.

*Staurolithites ellipticus* (Gartner, 1968) Lambert, 1987

Pl.8, figs 28-35

*Staurolithites flavus* Burnett, 1998b

Pl.8, figs 40-43

*Staurolithites halfanii* sp. nov.

Pl.6, figs 13-21. **Derivation of name:** After Mr. Hafani R. Halfani (TPDC, Dar-es-Salaam), TDP facilitator. **Diagnosis:** A small species of *Staurolithites* with an indistinct, unicyclic rim that possesses a dark, thin, axial cross...
with a delicate spine and a small, distinctively highly birefringent spine-top, visible when the coccolith is rotated away from 0°. **Differentiation:** This new species is distinguished by its bright spine-top and low-birefringence bars. **Holotype:** Pl.6, figs 19-21. **Holotype dimensions:** L = 3.96 µm, W = 3.08 µm. **Paratypes:** Pl.6, figs 13-18. **Type locality:** TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. **Type level:** TDP15/31-1, 10cm; UC6b, Early Turonian. **Occurrence:** TDP15, Early Turonian (UC6b).

**Staurolithites handleyi** sp. nov.
Pl.6, figs 28-33. **Derivation of name:** After Mr. Luke Handley (Bristol University), organic geochemist on the TDP team. **Diagnosis:** A small species of *Staurolithites* with a bicyclic rim, the inner cycle of which is bright. The axial cross appears to be composed of single bars that are bright at 0°, becoming dark upon rotation. **Differentiation:** This new species is distinguished by its bicyclic rim and the particular simplicity of its cross. **Holotype:** Pl.6, figs 30, 31. **Holotype dimensions:** L = 3.96 µm, W = 3.08 µm. **Paratypes:** Pl.6, figs 28, 29, 32, 33. **Type locality:** TDP9, Nangurukuru junction, SW of Kilwa Kivinje, coastal Tanzania. **Type level:** TDP9/14-1, 36cm; UC17, Early Maastrichtian. **Occurrence:** TDP9, Late Campanian-Early Maastrichtian (UC15eTP-17).

**Staurolithites ngurumahambaensis** sp. nov.
Pl.6, figs 22-27. **Derivation of name:** From Nguru-mahamba, where the species is described from. **Diagnosis:** A small species of *Staurolithites* with a dark, unicyclic rim, wherein the bars aligned with the long axis of the ellipse are dark, whilst the short-axis bars are highly birefringent. **Differentiation:** This new species is distinguished by its bright short-axis bars and dark long-axis bars. **Holotype:** Pl.6, figs 24, 25. **Holotype dimensions:** L = 3.08 µm, W = 2.2 µm. **Paratypes:** Pl.6, figs 22, 23, 26, 27. **Type locality:** Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level:** Sample Nguru-99-5; UC3a-b, Middle-Late Cenomanian. **Occurrence:** Nguru-mahamba, Middle-Late Cenomanian (UC3a-b); TDP15, Early Turonian (UC6b).

**Staurolithites zoensis** Burnett, 1998b
Pl.8, figs 36-39

Zeugrhabdotus acanthus Reinhardt, 1965
Pl.7, figs 33-42; Pl.8, figs 1, 2

Zeugrhabdotus biperforatus (Stover, 1966) Burnett in Gale *et al.*, 1996
Pl.9, figs 1, 2

Zeugrhabdotus cf. Z. bicrescenticus (Stover, 1966) Burnett in Gale *et al.*, 1996
Pl.9, figs 3-7

**Remarks:** Z. cf. *Z. bicrescenticus* has two miniscule crystals, that are bright in XPL, inserted between the bars where the bars join the rim, such as is seen in *Z. diplogrammus*. These are not apparent in *Z. bicrescenticus*.

Zeugrhabdotus biperforatus (Gartner, 1968) Burnett, 1998b
Pl.9, figs 8, 9

Zeugrhabdotus cf. Z. biperforatus (Gartner, 1968) Burnett, 1998b
Pl.9, figs 10, 11

**Remarks:** Z. cf. *Z. biperforatus* is generally more narrowly elliptical, has a more-open central area and a narrower inner cycle than *Z. biperforatus*.

Zeugrhabdotus blowii sp. nov.
Pl.8, figs 20-27. **Derivation of name:** After Prof. Walter Blow (deceased), whose work on the planktonic foraminifera of coastal Tanzania in the 1960s, with Prof. Fred Banner, eventually led to the search for pristine preservation that resulted in the TDP. **Diagnosis:** A small species of *Zeugrhabdotus* with quite low birefringence that has a simple, disjunct bar composed of two elements. The bar is almost invisible at 0°. At 45°, the bar and rim have the same birefringence. **Differentiation:** This new species is distinguished from other zeugrhabdotids by the simplicity of its bar and by the way in which the bar goes into extinction at 0°. The Jurassic *Z. fixus* is superficially similar to the new species, but has a bar with higher birefringence and a perforation in the centre of the bar that the new species lacks. **Holotype:** Pl.8, figs 22, 23. **Holotype dimensions:** L = 3.52 µm, W = 2.64 µm. **Paratypes:** Pl.8, figs 20, 21, 24, 25. **Type locality:** TDP5, Machole, south of Kitulo Hill, near Lindi, coastal Tanzania. **Type level:** TDP5/10-2, 15-16cm; UC15eTP, Late Campanian. **Occurrence:** TDP5, Late Campanian (UC15eTP); TDP15, Early Turonian (UC6b).

Zeugrhabdotus embegeri (Noël, 1958) Perch-Nielsen, 1984
Pl.7, figs 1-12

**Remarks:** This heavily calcified species has a rhomb-shaped, composite bar and very small to no perforations in the central area. The ragged-looking specimens in Pl.7, figs 1-6 are interpreted as showing the proximal view of this species, with the rhomb-shaped base to the bar being discernable, surrounded by the base-plate.

Zeugrhabdotus erectus (Deflandre in Deflandre & Fert, 1954) Reinhardt, 1965
Pl.9, figs 21-24; Pl.9, figs 19, 20?

Zeugrhabdotus noeliae Rood *et al.*, 1971
Pl.8, figs 10-17

Zeugrhabdotus praesigmoides Burnett, 1998b
Pl.8, figs 3-9

Zeugrhabdotus simplex sp. nov.
Pl.8, figs 18, 19. **Derivation of name:** From the Latin
Hill, near Lindi, coastal Tanzania.

ing an axial cross.

other Late Cretaceous eiffellithids in being small and having a simple, slender bar dividing the wide, open central area.

36-37 cm; UC15eTP, Late Campanian.

ranges up into the Maastrichtian. It is distinct from other zeugrhabdotids in having a simple, bifurcating cross that takes up more of the central area. Furthermore, E. lindien-

8.80 µm, W = 6.16 µm.

tral area shows low birefringence.

Remarks: The rim, inner cycle, and characteristically dark central area of this new species are somewhat reminiscent of Percivalia species by its distinctive axial cross and its lack of perforations in the central plate. Remarks: The rim, inner cycle, and characteristically dark central area of this new species are somewhat reminiscent of Percivalia, although scanning electron microscopy is needed to confirm the generic assignment. Holotype: Pl.3, figs 40-42. Holotype dimensions: L = 6.82 µm, W = 4.84 µm. Paratypes: Pl.3, figs 31-34, 37-39. Type locality: TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. Type level: TDP15/25-1, 10 cm; UC6b, Early Turonian. Occurrence: TDP15, Early Turonian (UC6b); Nguru-mahamba, Early Cenomanian (UC1a-2a).

Zeugrhabdotus xenotus (Stover, 1966) Burnett in Gale et al., 1996

Family EIFFELLITHACEAE Reinhardt, 1965

Eiffellithus lindensis sp. nov.

Pl.6, figs 1-12. Derivation of name: After the town of Lindi, near which the species was first identified. Diagnosis: A small species of Eiffellithus in which the small, indistinct central cross is axially aligned. The inner cycle fills the central area. Differentiation: This new species is easily distinguished from E. eximius, which is much larger, and has a distinctive, bifurcating cross that takes up more of the central area. Furthermore, E. lindensis ranges up into the Maastrichtian. It is distinct from other Late Cretaceous eiffellithids in being small and having an axial cross. Holotype: Pl.6, figs 3, 4. Holotype dimensions: L = 4.4 µm, W = 3.08 µm. Paratypes: Pl.6, figs 5-10. Type locality: TDP5, Machole, south of Kitulo Hill, near Lindi, coastal Tanzania. Type level: TDP5/6-3, 36-37 cm; UC15eTP, Late Campanian. Occurrence: TDP5 and TDP9, Late Campanian-Early Maastrichtian (UC15eTP-17); Lindi area, Campanian-Maastrichtian (UC16).

Family RHAGODISCACEAE Hay, 1977

Percivalia? dunkleyjonesii sp. nov.

Pl.3, figs 29-42. Derivation of name: After Mr. Tom Dunkley Jones (UCL), Cenozoic nannopalaeontologist and roustabout on the TDP team. Diagnosis: This medium-sized species possesses a narrow, bicyclic rim and a central plate of laterally-oriented laths at the centre of which is an indistinct cross. This axial cross has two distinctive ‘buttons’, outlined by dark extinction lines, making up the short-axis bars. The ‘buttons’ are visible when the coccolith is oriented both at 0° and 45°. The entire central area shows low birefringence. Differentiation: This new species is distinguished from all other Percivalia species by the distinctive ‘buttons’ and central-area laths. Remarks: The rim and inner cycle of this species are somewhat reminiscent of Percivalia, although scanning electron microscopy is needed to confirm the generic assignment. Holotype: Pl.3, figs 40-42. Holotype dimensions: L = 6.82 µm, W = 4.84 µm. Paratypes: Pl.3, figs 31-34, 37-39. Type locality: TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. Type level: TDP15/25-1, 10 cm; UC6b, Early Turonian. Occurrence: TDP15, Early Turonian (UC6b); Nguru-mahamba, Early Cenomanian (UC1a-2a).

Percivalia? pearsonii sp. nov.

Pl.3, figs 25-28. Derivation of name: After Prof. Paul Pearson (Cardiff University), co-chief and Cenozoic micropalaeontologist on the TDP team. Diagnosis: This medium-sized species possesses a narrow, bicyclic rim, a central-area plate, and a central, axially-aligned cross, each bar of which is divided into two. The cross is located in the centre of a central plate. The cross and plate show very low birefringence in XPL. Differentiation: This new species is distinguished from other Percivalia species by its distinctive axial cross and its lack of perforations in the central plate. Remarks: The rim, inner cycle, and characteristically dark central area of this new species are somewhat reminiscent of Percivalia, although scanning electron microscopy is needed to confirm the generic assignment. Holotype: Pl.3, figs 27, 28. Holotype dimensions: L = 6.60 µm, W = 4.40 µm. Paratype: Pl.3, figs 25, 26. Type locality: TDP9, Nangurukuru junction, SW of Singino Hill, near Kilwa Kavinje, coastal Tanzania. Type level: TDP9/21-1, 50 cm; UC17, Early Maastrichtian. Occurrence: TDP9 and Nguru-mahamba, Early Maastrichtian (UC17).

Ragodiscus pancostii sp. nov.

Pl.4, figs 1-4; Pl.4, figs 5, 6? Derivation of name: After Dr. Richard Pancost (Bristol University), organic geochemist and palaeoceanographer on the TDP team. Diagnosis: A small, elliptical species of Ragodiscus that bears a very small, delicate spine. The spine-tip appears bright in XPL. Differentiation: Similar to R. achlyostaurion, but with a spine-base/top that is much smaller, and does not occupy most of the central area. R. gallagheri is somewhat similar, but has no spine and is more narrowly elliptical. The specimen in Pl.4, figs 5, 6 has a narrower, brighter rim, which differs from that seen in R. pancostii; this specimen may be Orastrum partitum. Holotype: Pl.4, figs 1, 2. Holotype dimensions: L = 3.96 µm, W = 2.86 µm. Paratype: Pl.4, figs 3, 4. Type locality: TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. Type level: TDP15/15-1, 10 cm; UC6b, Early Turonian. Occurrence: TDP15, Early Turonian (UC6b).

Order PODORHABDALES Rood et al., 1971, emend. Bown, 1997

Family AXOPODORHABDAEAE Bown & Young, 1997
**Cribrocorona echinata** (Burnett, 1998b) Lees & Bown, 2005
Pl.4, figs 39-42

**Cribrosphaerella circula** (Risatti, 1973) comb. nov.
Pl.4, fig.37


**Cribrosphaerella ehenbergii** (Arkhangelsky, 1912)
Deflandre in Privetan, 1952
Pl.4, figs 32-34 – typical subrectangular, coarse-grilled forms; Pl.4, figs 35. 36 – irregularly-rimmed forms; Pl.4, fig.38 – elliptical, fine-grilled form

**Family** **BISCUTACEAE** Black, 1971

**Biscutum ellipticum** (Górka, 1957)Grün in Grün & Allemann, 1975
Pl.5, figs 1-10, 12-15

**Biscutum portulakum** Wind & Wise, 1977
Pl.5, figs 18-21

**Biscutum hayi** (Black, 1973) Jakubowski, 1986
Pl.5, figs 22, 23

**Biscutum salebrosum?** (Black, 1971) Jakubowski, 1986
Pl.5, figs 24-31

**Discorhabdus ignotus** (Górka, 1957) Perch-Nielsen, 1968
Pl.5, figs 11, 16, 17

**Family** **CRETARHABDACEAE** Thierstein, 1973

**Miravetesina bergenii** sp. nov.
*Non* 1966 *Coccolithus ficula* Stover: p.138, pl.5, figs 5, 6; pl.9, fig.11.
*Non* 1998b *Retecapsa ficula* (Stover) Burnett: pp.138-139; *non* Burnett, 1998a, p.180, pl.6.7, fig.8.
1998 *Miravetesina ficula* (Stover, 1966) Bergen in Bralower & Bergen: p.75, pl.1, figs 13a, 13b; pl.2, fig.11.
Pl.5, figs 32-35, 38-40. **Derivation of name:** After Dr. Jim Bergen (BP, Houston), seasoned calcareous nannofossil taxonomist and biostratigrapher. **Diagnosis:** A medium-sized species of *Miravetesina* with a wide, granulate central area bearing a slightly sigmoidal, delicate, axial cross. **Differentiation:** Distinguished from *M. favula* (e.g. see Bown & Cooper, 1998, pl.4.13, fig.17) by its more pronounced and slightly sigmoidal, axial cross, and its much younger age. **Remarks:** *Retecapsa ficula*, as illustrated by Burnett (1998a), bears closest resemblance to Stover’s (1966) line-drawing of *ficula* (pl.9, fig.11), whilst his light-micrographs (including the holotype) show specimens with a narrow central area. Consequently, the form illustrated as *M. ficula* by Bergen in Bralower & Bergen (1998) is not *ficula*, but a new species, *bergenii*. **Holotype:** Pl.5, figs 32-35. **Holotype dimensions:** L = 6.82µm, W = 5.28µm. **Paratypes:** Pl.5, figs 38-40. **Type locality:** Lindi area, coastal Tanzania. **Type level:** Sample Lindi-99-11; UC17, Early Maastrichtian. **Occurrence:** Lindi area, Early Maastrichtian (UC17); TDP9, Late Campanian-Early Maastrichtian (UC15E-17); TDP15, Early Turonian (UC6b); Bounds core, western Kansas (Bralower & Bergen, 1998), Middle-Late Turonian (UC8b-9b).

**Family** **PREDISCOSPHAERACEAE** Rood *et al.*, 1971

**Prediscosphaera mgayae** sp. nov.
Pl.5, figs 36, 37, 41-44. **Derivation of name:** After Mr. Elvis Mgaya (‘Mr. K’) (TPDC, Dar-es-Salaam), field driver and drilling assistant on the TDP team. **Diagnosis:** A small, elliptical species of *Prediscosphaera* with a delicate axial cross and a very narrow, low-birefringence inner rim-cycle. **Differentiation:** *P. spinosa* has a thicker, bright inner rim-cycle and a subrectangular outline. *P. stoveri* is small, with a bright inner cycle that almost fills the central area. *P. arkhangelskyi* has a distinctive cross and thick, bright inner cycle. Other species of the genus have either circular outlines or crosses at 45˚ to the ellipse axes. **Holotype:** Pl.5, figs 36, 37. **Holotype dimensions:** L = 4.84µm, W = 3.08µm. **Paratypes:** Pl.5, figs 41-44. **Type locality:** TDP9, Nangurukuru junction, SW of Singino Hill, near Kilwa Kivinje, coastal Tanzania. **Type level:** TDP9/19-1, 30cm; UC17, Early Maastrichtian. **Occurrence:** TDP9 and Lindi area, Early Maastrichtian (UC17).

**Order** **STEPHANOLITHIALES** Bown & Young, 1997
**Family** **CALCIOSOLENIACEAE** Kampnert, 1927

**Calciosolenia fossils** (Deflandre in Deflandre & Fert, 1954) Bown in Kennedy *et al.*, 2000
Pl.1, figs 1-6

**Calciosolenia? huberi** sp. nov.
Pl.1, figs 7-13; Pl.1, figs 14-18? **Derivation of name:** After Dr. Brian Huber (Smithsonian, Washington), Mesozoic micropalaeontologist on the TDP team. **Diagnosis:** A medium-sized species of *Calciosolenia?* possessing a distally-orientated spur-like extension to the rim, located at one end of the coccolith, observable in side view. **Differentiation:** No other species of *Calciosolenia* possess a spur-like rim extension. This species is questionably placed in *Calciosolenia* based on a slightly oblique view (Pl.1, fig.11) that suggests this assignment, although it is unusual to observe *Calciosolenia* specimens in side view. Specimens with thickened rims, shown on
Family STEPHANOLITHIACEAE Black, 1968

**Corollithion completum** Perch-Nielsen, 1973

Pl.1, figs 19, 20

**Corollithion exiguum** Stradner, 1961

Pl.1, figs 33, 34

**Corollithion karegae** sp. nov.

Pl.1, figs 25-32. **Derivation of name:** After Ms. Amina Karega (TPDC, Dar-es-Salaam), nanno- and micropalaeontologist on the TDP team. **Diagnosis:** A small species of *Corollithion* with very low birefringence, a very narrow, slightly brighter inner rim-cycle, and an almost indistinguishable, dark outer cycle, in which a plate composed of six segments completely fills the central area. **Differentiation:** This new species has distinctively low birefringence. In other species, the bright inner-cycle is thicker and much more visible. The dark central plate that fills the central area of the new species is composed of six segments, whilst in *C. kennedyi* (Pl.1, figs 21, 22) and *C. completum* (Pl.1, figs 19, 20) the central plates have higher birefringence and are divided into four blocks. **Holotype:** Pl.1, figs 31, 32. **Holotype dimensions:** L = 3.96 µm, W = 3.08 µm. **Paratype:** Pl.1, figs 25, 26. **Type locality:** TDP5, Machole, south of Kitulo Hill, near Lindi, coastal Tanzania. **Occurrence:** TDP5, Late Campanian. **Occurrence:** TDP5, Late Campanian/Early Maastrichtian (UC15eTP-UC16); TDP9, Late Campanian/Early Maastrichtian (UC15eTP-UC17); Matandu Bridge (Kilwa), Late Campanian (UC15dTP); Lindi area, Campanian/Maastrichtian (UC16).

**Corollithion kennedyi** Crux, 1981

Pl.1, figs 21, 22

**Corollithion signum** Stradner, 1963

Pl.1, figs 23, 24

**Darwinilithus pentarhethum** Watkins in Watkins & Bowdler, 1984

Pl.4, figs 19-28

**Rhombolithion rhombicum** (Stradner & Adamiker, 1966) Black, 1973

Pl.1, figs 35, 36

**Rhombolithion rotatum** (Rood et al., 1971) Black, 1973

Pl.1, figs 37, 38

**Rotelapillus msakyaee** sp. nov.

Pl.4, figs 29-31. **Derivation of name:** After Ms. Emma Msaky (TPDC, Dar-es-Salaam), palynologist on the TDP team. **Diagnosis:** A medium-sized species of *Rotelapillus* that is elliptical, both in outline and central area. The central area contains a non-axially-aligned, low-angled cross that is dark in XPL. **Differentiation:** This new species is distinguished from all other cross-bearing *Rotelapillus* species by its elliptical outline and central area; all other species are circular in outline. **Holotype:** Pl.4, figs 29, 30. **Holotype dimensions:** L = 6.16 µm, W = 3.96 µm. **Paratype:** Pl.4, fig.31. **Type locality:** TDP9, Nangurukuru junction, SW of Singino Hill, near Kilwa Kivinje, coastal Tanzania. **Type level:** TDP9/9-2, 39 cm; UC17, Early Maastrichtian. **Occurrence:** TDP9, Early Maastrichtian (UC17).

**Truncatoscaphus macmillanii** sp. nov.

Pl.1, figs 39-41. **Derivation of name:** After Dr. Ian McMillan (Cardiff University), micropalaeontologist on the TDP team. **Diagnosis:** A small, low-birefringence species of *Truncatoscaphus* with a relatively short and broad polygonal rim, containing a clearly discernable longitudinal bar from which four very barely discernable, transverse bars extend down each side of the end thirds of the coccolith. Centrally, four further, clearly discernable bars interlock to form a distinctive cross. **Differentiation:** The new species most closely resembles the Jurassic *T. intermedius* and *T. delftensis*, but both of these have more elongated and narrower outlines, and the latter has more bars. Neither possesses the distinctively-arranged central bars. The new species is the youngest *Truncatoscaphus* recorded. **Holotype:** Pl.1, figs 39-41. **Holotype dimensions:** L = 3.52 µm, W = 2.2 µm. **Type locality:** TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. **Type level:** TDP15/15-1, 10 cm; UC6b, Early Turonian. **Occurrence:** TDP15, Early Turonian (UC6b).

**PLACOLITHS OF UNCERTAIN AFFINITY**

**Prolatipatella multicarinata** Gartner, 1968

Pl.3, figs 13-16

**Repagulium parvidentatum** (Deflandre & Fert, 1954) Forchheimer, 1972

Pl.3, figs 11, 12, 17, 18

5.2 Holococcoliths

Family CALYPTROSPHAERACEAE Boudreaux & Hay, 1969

**Remarks:** The classification of Mesozoic holococcoliths is problematical. The majority are very small, therefore rim-structure details and some central-area features are at the very limits of light-microscopic observation. Because of their very low preservation potential, they are typically rare in occurrence, and so scanning electron microscope observation is often not practicable. Generic classification is consequently subjective, being predominantly reliant on central-area features. Additionally, matching side
views of rare holococcoliths with their base-plate views is not easy; most biostratigraphic analysis or reconnaissance work is done on permanently-mounted slides. This may result in multiple taxonomic designations for the same species.

Several previously unreported taxa are present in the Tanzanian material. Whilst I attempted to match side views with base-plate views, the specimens are generally rare and these images were taken on permanently-mounted smear-slides.

_Acuturris scotus_ (Risatti, 1973) Wind & Wise in _Wis et Wind_, 1977
Pl.11, figs 22-24

**Bifidalithus mchnaei** sp. nov.
Pl.10, figs 66-71. **Derivation of name:** After Mr. Ephrem Mchana (TPDC, Dar-es-Salaam), for expert technical assistance during TDP drilling. **Diagnosis:** A small species of _Bifidalithus_ Varol, 1991 in which the two main constituent elements contain a single perforation each, arranged around the short-axis junction between the elements. The junction between these elements appears raised. **Differentiation:** This species is distinct from _B. geminicatillus_ in possessing perforations. In side view (Pl.10, figs 70, 71), the raised area where the elements join appears to arch over a cavity above a monoperforate proximal plate. **Holotype:** Pl.10, figs 68, 69. **Holotype dimensions:** _L_ = 4.62µm, _W_ = 3.08µm. **Paratypes:** Pl.10, figs 66, 67, 70, 71. **Type locality:** TDP5, Machole, south of Kitulo Hill, near Lindi, coastal Tanzania. **Type level:** TDP5/9-1, 48-49cm; UC15eTP, Late Campanian. **Occurrence:** TDP5, Late Campanian (UC15eTP); TDP9, Early Maastrichtian (UC17).

_Bilapillus_ gen. nov.

**Bilapillus wadeae** gen. et sp. nov. **Derivation of name:** From the Latin ‘_bi_’, meaning ‘two’, and ‘_lapillus_’, meaning ‘little stone’, referring to the central structure of this genus. **Diagnosis:** A holococcolith with a simple rim that is bright in XPL. At 0˚ in XPL, the extinction lines are aligned with the polarising directions. On rotation, the extinction lines form v-shapes at the ends of the lith that are truncated by the ends of the perforation. The central perforation appears to contain a structure (Pl.10, figs 37, 38), but this is not resolvable. **Differentiation:** The elongated, irregular-looking central perforation and vague central structure distinguish this from other _Calculites_ species. **Holotype:** Pl.10; figs 37, 38. **Holotype dimensions:** _L_ = 4.40µm, _W_ = 2.64µm. **Paratypes:** Pl.10, figs 39-42. **Type locality:** Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level:** Nguru-99-1; UC3a-b, Middle-Late Cenomanian. **Occurrence:** Nguru-mahamba, Middle-Late Cenomanian (UC3a-b).

_Calculites pleniformis_ gen. nov.

**Calculites cyclops** sp. nov.
Pl.10, figs 10-13; Pl.10, figs 14-17. **Derivation of name:** From the Latin ‘_Cyclops_’, the mythical race of one-eyed giants, referring to the single, relatively wide central perforation. **Diagnosis:** A small species of _Calculites_ that has a relatively wide central perforation. At 0˚ in XPL, the extinction lines are aligned with the polarising directions. On rotation, the lines become v-shaped and occupy the ends of the lith. **Differentiation:** The wide central perforation distinguishes it from other species of _Calculites_. **Holotype:** Pl.10, figs 10, 11. **Holotype dimensions:** _L_ = 4.84µm, _W_ = 3.52µm. **Paratypes:** Pl.10, figs 12, 13. **Type locality:** TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. **Type level:** TDP15/15-1, 10cm; UC6b, Early Turonian. **Occurrence:** TDP15, Early Turonian (UC6b); Matandu Bridge (Kilwa), Middle-Late Turonian (UC9a); Nguru-mahamba, Early Cenomanian (UC1a-2a).

**Genus Calculites** Prins & Sissingh in Sissingh, 1977

**Remarks:** New species that, in XPL, are bright across the entire holococcolith have here been placed in _Calculites_.

_Calculites axosuralis_ Bergen in Bralower & Bergen, 1998
Pl.9, figs 33-36, Pl.9, figs 37, 38?

_Calculites cenomaniacus_ sp. nov.

Pl.10, figs 37-42. **Derivation of name:** After the Cenomanian, from which it is described. **Diagnosis:** A small species of _Calculites_ with an irregular-looking, elongated central perforation. At 0˚ in XPL, the extinction lines are aligned with the polarising directions. On rotation, the extinction lines form v-shapes at the ends of the lith that are truncated by the ends of the perforation. The central perforation appears to contain a structure (Pl.10, figs 37, 38), but this is not resolvable. **Differentiation:** The elongated, irregular-looking central perforation and vague central structure distinguish this from other _Calculites_ species. **Holotype:** Pl.10, figs 37, 38. **Holotype dimensions:** _L_ = 4.40µm, _W_ = 2.64µm. **Paratypes:** Pl.10, figs 39-42. **Type locality:** Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level:** Nguru-99-1; UC3a-b, Middle-Late Cenomanian. **Occurrence:** Nguru-mahamba, Middle-Late Cenomanian (UC3a-b).

**Calculites juliae** sp. nov.
Pl.13, figs 32, 33. **Derivation of name:** After Ms. Julia Pearson, member of the TDP support team. **Diagnosis:** A small species of _Calculites_, comprising a narrow rim enclosing a multiperforate plate (six perforations, two larger ones situated at each end of the lith and four smaller ones arranged around the outsides of the middle of the
Calculites maghradaswampensis sp. nov.

Pl.10, figs 19-22; Pl.10, figs 23-26? Derivation of name: After Maghreda Swamp, where TDP15 was drilled.

Diagnosis: A medium-sized species of *Calculites* with a small central perforation. In XPL at 0°, the extinction lines are aligned with the polarising directions, but the short-axis line is offset. On rotation, these form a sigmoidal x-shape across the lith. Differentiation: Distinguished from other *Calculites* by its kinked extinction lines and central perforation. Holotype: Pl.10, figs 19, 20. Holotype dimensions: L = 5.28µm, W = 3.52µm. Paratype: Pl.10, figs 21, 22. Type locality: TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. Type level: TDP15/7-1, 10cm; UC6b, Early Turonian. Occurrence: TDP15, Early Turonian (UC6b); ?TDP5, Late Campanian (UC15eTT).

Calculites obscurus (Deflandre, 1959) Prins & Sissingh in Sissingh, 1977

Pl.9, figs 29-32

Calculites paulus sp. nov.

Pl.10, figs 18, 27. Derivation of name: From the Latin ‘paulus’, meaning ‘little’, referring to the size of this species. Diagnosis: A very small species of *Calculites* that has an elongate, narrow central perforation. At 0° in XPL, two extinction lines are aligned with the polarising directions, but the short-axis line is offset. On rotation, the lines become v-shaped and occupy the ends of the lith. Differentiation: The very small size and elongate, narrow central perforation distinguish this species from other *Calculites*. Holotype: Pl.10, figs 18, 27. Holotype dimensions: L = 2.64µm, W = 1.76µm. Type locality: TDP9, Nangurukuru junction, SW of Singino Hill, near Kilwa Kivinje, coastal Tanzania. Type level: TDP9/9-2, 39cm; UC17, Early Maastrichtian. Occurrence: TDP9, Early Maastrichtian (UC17).

Calculites percernis Jeremiah, 1996

Pl.10, figs 46-53

Calculites proscissus sp. nov.

Pl.10, figs 43, 44; Pl.10, figs 45, 54? Derivation of name: From the Latin ‘proscissus’, meaning ‘slit’, referring to the central slit-like perforation typical of this species. Diagnosis: A small species of *Calculites* with an elongated, very narrow central perforation (or slit). At 0° in XPL, the extinction lines are aligned with the polarising directions. On rotation, the extinction lines join with the central slit to form an H-shape. Differentiation: The central slit distinguishes this from other *Calculites* species. Holotype: Pl.10, figs 43, 44. Holotype dimensions: L = 4.18µm, W = 2.86µm. Type locality: TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. Type level: TDP15/25-1, 10cm; UC6b, Early Turonian. Occurrence: TDP15, Early Turonian (UC6b).

Calculites rosalyneiae sp. nov.

Pl.13, figs 30, 31. Derivation of name: After Ms. Rosalyn Pearson, member of the TDP support team.

Diagnosis: A small species of *Calculites* comprising four blocks divided by wavy sutures that form an H-shape. Each plate has a perforation towards the centre. The blocks appear to go into extinction separately. The lith appears similar at all angles of rotation in XPL. Differentiation: The new species is superficially similar to *C. obscurus*, but bears a perforation in each quadrant, and the extinction pattern is dissimilar. Holotype: Pl.13, figs 30, 31. Holotype dimensions: L = 4.40µm, W = 3.08µm. Type locality: TDP5, Machole, south of Kitulo Hill, near Lindi, coastal Tanzania. Type level: TDP5/5-1, 66-67cm; UC15eTT-16, Late Campanian-Early Maastrichtian. Occurrence: TDP5, Late Campanian-Early Maastrichtian (UC15eTT-16).

Calculites turonicus sp. nov.

Pl.10, figs 33-36. Derivation of name: After the Turonian, from which it is described. Diagnosis: A small species of *Calculites* which bears a very small central perforation and in which the central part is slightly darker in XPL than the outer part (there is no discernable rim). At 0° in XPL, the extinction lines are aligned with the polarising directions and bifurcate (indicating a rim block in extinction?) at each end of the lith. The central perforation is not obvious in this direction, where the extinction lines meet. On rotation, the extinction lines form v-shapes that do not join in the centre of the lith. The small perforation is then clear. Differentiation: The new species bears a resemblance to *C. percernis* (see Pl.10, figs 46-53), but the latter is generally smaller and the central area is not slightly darker than the rim. The extinction lines of *C. percernis* are also different, with the short axis line being kinked, so as to appear offset, rather than straight, as in the new species. Holotype: Pl.10, figs 33, 34. Holotype dimensions: L = 3.96µm, W = 2.86µm. Paratype: Pl.10, figs 35, 36. Type locality: TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. Type level: TDP15/25-1, 10cm; UC6b, Early Turonian. Occurrence: TDP15, Early Turonian (UC6b).

Duocameratus gen. nov.

Type species: *Duocameratus leariae* gen. et sp. nov. Derivation of name: From the Latin ‘duo’, meaning two, ‘camera’, meaning ‘vaulted chamber’ and ‘atus’, mean-
**Turonian.**

**Tanzania.**

**Maghreda Swamp, NW of Kilwa Kivinje, coastal**

**Paratypes**

**Holotype dimensions**

\[ H = 3.08 \mu m, W = 3.52 \mu m. \]

**Diagnosis**

Pearson (Cardiff), member of the TDP support team.

**Pl.13, figs 60-65.**

These bright points are situated in the middle of the base mark where the septum dividing the cavity joins the rim. The base/proximal plate and a pointed 'roof'. Bright points with thin rims and proximal plates. A central septum divides the cavity into two. Where the septum meets the external structure, the joints are thickened and appear bright in most orientations.

**Duocameratus leariae** gen et sp. nov.

**Pl.13, figs 51-59.**

**Derivation of name:** After Dr. Carrie Lear, Cenozoic palaeoceanographer on the TDP team.

**Diagnosis:** A small species of *Duocameratus* in which the distal end of the septum is brightened and thickest, forming a subtriangular apex that distinguishes this species.

**Holotype:** Pl.13, figs 51-53. **Holotype dimensions:** \( H = 4.40 \mu m, W = 3.52 \mu m. \)

**Paratype:** Pl.13, figs 54-57. **Type locality:** Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level:** Nguru-99-1; UC3a-b, Middle-Late Cenomanian. **Occurrence:** Nguru-mahamba, Middle-Late Cenomanian (UC3a-b).

**Duocameratus sianiae** gen et sp. nov.

**Pl.13, figs 60-65.**

**Derivation of name:** After Dr. Siani Pearson (Cardiff), member of the TDP support team.

**Diagnosis:** A small species of *Duocameratus* that is irregularly pentagonal and house-shaped, with an almost flat base/proximal plate and a pointed ‘roof’. Bright points mark where the septum dividing the cavity joins the rim. These bright points are situated in the middle of the base and the peak of the ‘roof’. **Holotype:** Pl.13, figs 60, 61. **Holotype dimensions:** \( H = 3.08 \mu m, W = 3.52 \mu m. \)

**Paratypes:** Pl.13, figs 62-65. **Type locality:** TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. **Type level:** TDP15/5-1, 10cm; UC6b, Early Turonian. **Occurrence:** TDP15, Early Turonian (UC6b).

- Holococcolith indeterminate 1 side view
- Pl.11, figs 47-49
- Holococcolith indeterminate 2 side view
- Pl.11, figs 50-52
- Holococcolith indeterminate 3 side view
- Pl.13, figs 48-50
- Holococcolith? indeterminate side view
- Pl.13, figs 66-68

**Genus Lucianorhabdus** Deflandre, 1959

**Remarks:** New species that have significant spines that are most frequently observed in side view are here placed in *Lucianorhabdus.*

**Lucianorhabdus? boudagherfadeliae** sp. nov.

**Pl.11, figs 43-46.**

**Derivation of name:** After Dr. Marcelle Boudagher-Fadel (UCL), planktonic and larger benthic foraminifera expert.

**Diagnosis:** A small species of *Lucianorhabdus*? with a relatively short, hollow spine that terminates bluntly and at an angle. The angled termination is visible when the lith is rotated, in XPL. The small base-plate rim is relatively thick and the plate has a thin proximal cycle. The base-plate is perforate and contains a structure that is not discernable. **Differentiation:** Other lucianorhabdids do not possess the central structure that is hinted at as lying beneath the spine-base. The short spine and its angled termination is distinctive. **Holotype:** Pl.11, figs 43-46. **Holotype dimensions:** \( H = 4.40 \mu m, W = 4.40 \mu m. \)

**Paratype:** Pl.11, figs 43, 44. **Type locality:** Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level:** Nguru-99-1; UC3a-b, Middle-Late Cenomanian. **Occurrence:** Nguru-mahamba, Middle-Late Cenomanian (UC3a-b).

**Lucianorhabdus compactus** (Verbeek, 1976) comb. nov.


**Lucianorhabdus maleformis** Reinhardt, 1966

**Pl.11, figs 17, 18**

**Lucianorhabdus? tabernus** sp. nov.

**Pl.12, figs 45-47.**

**Derivation of name:** From the Latin ‘*taberna*’, meaning ‘hut’, referring to the simple hut-shaped outline of the species. **Diagnosis:** A cavate species of *Lucianorhabdus?* with a medium-sized base-plate and short, conical spine. In XPL at 0°, the lith is of low birefringence, and the thin base-plate is almost invisible. On rotation, the spine becomes bright and the base-plate just visible. **Differentiation:** Shorter than other lucianorhabdids, with a wider spine and equilateral-triangular outline. The new species bears some resemblance to the Paleocene *Semihololithus tentorium* Bown, 2005 (pl.31, figs 11-20), however, the new species has a much thinner, simpler base-plate and goes completely into extinction at 0°, unlike *S. tentorium*. **Holotype:** Pl.12, figs 45-47. **Holotype dimensions:** \( H = 5.28 \mu m, W = 5.72 \mu m. \)

**Type locality:** Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level:** Nguru-99-5; UC3a-b, UC3a-b, Middle-Late Cenomanian. **Occurrence:** Nguru-mahamba, Middle-Late Cenomanian (UC3a-b).

**Lucianorhabdus turris** sp. nov.

**Pl.11, figs 1-6.**

**Derivation of name:** From the Latin ‘*turris*’, meaning ‘tower’, referring to the solid base and long, tapering spine of the species. **Diagnosis:** A species of *Lucianorhabdus* with a relatively long, hollow spine, that tapers to a point. The spine may be straight or may lean to one side. In XPL, the medium-sized base-plate has a narrow rim and appears as a solid block in the middle when rotated, whilst at 0°, there appears to be a central perforation in the plate, as it becomes optically discontinuous. **Differentiation:** The new species differs from other lucianorhabdids in having a pointed spine, that may or
may not lean, without a terminal plug or plate. It is distin-
guished from Acuturris scotus by its larger size and thick,
solid base-plate. **Holotype**: Pl.11, figs 1-4. **Holotype
dimensions**: $H = 8.36\mu m$, $W = 5.72\mu m$. **Paratypes**: Pl.11, figs 5, 6. **Type locality**: Nguru-mahamba, SW of Lindi
town, coastal Tanzania. **Type level**: Nguru-99-5; UC3a-b,
Middle-Late Cenomanian. **Occurrence**: Nguru-maham-
ba, Middle-Late Cenomanian (UC3a-b).

*Munarinus keadyi* Risatti, 1973

Type species: *Munarinus mkeremei* sp. nov.

**Derivation of name**: From Mr. Michael
Mkereme (TPDC, Dar-es-Salaam), for expert technical
assistance during TDP drilling. **Diagnosis**: A small species of *Munarinus* possessing a relatively wide central
perforation that is spanned by a disjunct bar that joins the
rim with straight edges and spans the short axis. At 0°
in XPL, the extinction lines are aligned with the polaris-
ing directions, and on rotation these form v-shapes at the ends
of the lith, the bar is not visible at 0°, becoming bright on
rotation. **Differentiation**: *M. keadyi* is smaller, with a nar-
rower central perforation and with a short-axis bar that is
subrhombic. The pointed ends of that bar slot into the rim.
**Holotype**: Pl.13, figs 8, 9. **Holotype dimensions**: $L = 4.84\mu m$, $W = 3.52\mu m$. **Type locality**: TDP5, Machole,
south of Kitulo Hill, near Lindi, coastal Tanzania. **Type
level**: TDP5/9-1, 48-49cm; UC15eTP, Late Campanian.
**Occurrence**: TDP5, Late Campanian (UC15eTP); Nguru-
mahamba, Middle-Late Cenomanian (UC3a-b); Arabian
Peninsula, Early Campanian (Varol, pers. obs., 2007).

*Ovenia dispar* (Varol in Al-Rifaï et al., 1990)

**Derivation of name**: After Dr. Trevor Bailey (Natural History Museum of Wales, Cardiff), Cenozoic palaeoceanographer on the TDP team.

**Diagnosis**: A medium-sized species of *Ovenia* that in XPL has a bright rim and dark central plate, bearing a usually barely-discernable x-shaped structure. At 0° in XPL, the extinction lines are aligned with the polarising
directions, appearing darker on the rim and barely dis-
cernable on the plate. On rotation, these become v-shaped
on the rim, occupying the ends of the lith, but bend where
they move onto the plate, where again they are barely dis-
cernable. In PC, the plate appears to be multi-perforate
(Pl.10, fig.3). **Differentiation**: The size and relatively
wide rim and central area are distinctive. The x-shaped
central structure distinguishes it from other species of the
genus. **Holotype**: Pl.10, figs 4, 5. **Holotype dimensions**: $L = 6.16\mu m$, $4.84\mu m$. **Paratypes**: Pl.10, figs 1-3, 6, 7. **Type locality**: Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level**: Nguru-99-1; UC3a-b, Middle-Late Cenomanian. **Occurrence**: Nguru-maham-
ba, Early-Late Cenomanian (UC1a-3b).

*Ottavianus terrazetus* Risatti, 1973

**Derivation of name**: After Dr. Stuart
Robinson (UCL), Cretaceous palaeoenvironmental spe-
cialist.

**Diagnosis**: A medium-sized species of *Orastrum*
that in XPL has a bright rim and dark central plate, bearing
a usually barely-discernable x-shaped structure. At 0° in
XPL, the extinction lines are aligned with the polarising
directions, appearing darker on the rim and barely dis-
cernable on the plate. On rotation, these become v-shaped
on the rim, occupying the ends of the lith, but bend where
they move onto the plate, where again they are barely dis-
cernable. In PC, the plate appears to be multi-perforate
(Pl.10, fig.3). **Differentiation**: The size and relatively
wide rim and central area are distinctive. The x-shaped
central structure distinguishes it from other species of the
genus. **Holotype**: Pl.10, figs 4, 5. **Holotype dimensions**: $L = 6.16\mu m$, $4.84\mu m$. **Paratypes**: Pl.10, figs 1-3, 6, 7. **Type locality**: Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level**: Nguru-99-1; UC3a-b, Middle-Late Cenomanian. **Occurrence**: Nguru-maham-
ba, Early-Late Cenomanian (UC1a-3b).

*Ovenia hillii* Crux, 1991

**Derivation of name**: After Dr. Chris
Nicholas (Trinity College, Dublin University), sedimentologist, structural
geologist and TDP co-chief. **Diagnosis**: Delicate-looking
holococcoliths that, in side view, have the outline of a hol-
low isosceles triangle. The base-plate is virtually invis-
able. Where the spine joins the base-plate, there are two
bright spots.

*Nicholasia baileyi* gen et sp. nov.

**Derivation of name**: After Dr. Trevor
Bailey (Natural History Museum of Wales, Cardiff), Cenozoic palaeoceanographer on the TDP team.

**Diagnosis**: As for the genus. This species is very small. The 'spine' appears to terminate bluntly and is generally dark. **Holotype**: Pl.13, fig.71. **Holotype dimensions**: $H = 2.20\mu m$, $W = 1.76\mu m$. **Paratypes**: Pl.13, figs 69, 70, 72, 73. **Type locality**: Nguru-mahamba, SW of Lindi town, coastal Tanzania. **Type level**: Nguru-99-10; UC15eTP, Late Campanian. **Occurrence**: Nguru-mahamba, Late Campanian (UC15eTP); TDP15, Early Turonian (UC6b); Matandu Bridge (Kilwa), Middle-Late Turonian (UC9a).

Genus *Munarinus* Varol in Wise & Wind, 1977

**Remarks**: New species with bright rims and dark central
plates have here been placed in *Orastrum*.

*Orastrum perspicuum* Varol in Al-Rifaï et al., 1990

**Derivation of name**: From the Latin
*Orastrum* (with -a- before the stem of the word) as a
complementary term for *Ovenia* in the name of the new
species. **Diagnosis**: Medium-sized species of *Orastrum*
possessing a relatively wide central perforation that is
spanned by a disjunct bar that joins the rim with straight
gaps and spans the short axis. At 0° in XPL, the extinc-
tion lines are aligned with the polarising directions, and
on rotation these form v-shapes at the ends of the lith, the
bar is not visible at 0°, becoming bright on rotation.
**Holotype**: Pl.13, figs 14, 15, 18-25. **Paratypes**: Pl.13, figs 16, 17 side view? **Type locality**: Pl.13, figs 14-17

*Orastrum robinsonii* sp. nov.

**Derivation of name**: After Dr. Stuart
Robinson (UCL), Cretaceous palaeoenvironmental spe-
cialist.

**Diagnosis**: A medium-sized species of *Orastrum*
possessing a relatively wide central perforation that is
spanned by a disjunct bar that joins the rim with straight
gaps and spans the short axis. At 0° in XPL, the extinc-
tion lines are aligned with the polarising directions, and
on rotation these form v-shapes at the ends of the lith, the
bar is not visible at 0°, becoming bright on rotation.
**Holotype**: Pl.13, figs 8, 9. **Holotype dimensions**: $L = 4.40\mu m$, $W = 4.18\mu m$. **Type locality**: TDP5, Machole,
south of Kitulo Hill, near Lindi, coastal Tanzania. **Type
level**: TDP5/9-1, 48-49cm; UC15eTP, Late Campanian.
**Occurrence**: TDP5, Late Campanian (UC15eTP); Nguru-
mahamba, Middle-Late Cenomanian (UC3a-b); Arabian
Peninsula, Early Campanian (Varol, pers. obs., 2007).

*Metadoga ampulla* Lees & Varol sp. nov.

Pl.11, figs 25-28. **Derivation of name**: From the Latin
‘*ampulla*’, meaning ‘flask’, referring to the similarity of
the coccolith in side view to a standard laboratory flask.

**Diagnosis**: A small species of *Metadoga* that has a simple
flask-shaped outline in side-view. The holococcolith is
cavate and the upper half of the lith goes into extinction
in XPL at 0°. **Differentiation**: The new species differs from other species of *Metadoga* in having the distinctive
standard flask outline and in lacking a mid-lith collar.

**Holotype**: Pl.11, figs 25, 26. **Holotype dimensions**: $H = 4.40µm$, $W = 4.18µm$. **Type locality**: TDP5, Machole,
south of Kitulo Hill, near Lindi, coastal Tanzania. **Type
level**: TDP5/9-1, 48-49cm; UC15eTP, Late Campanian.
**Occurrence**: TDP5, Late Campanian (UC15eTP); Nguru-
mahamba, Middle-Late Cenomanian (UC3a-b); Arabian
Peninsula, Early Campanian (Varol, pers. obs., 2007).

*Ovenia hillii* Crux, 1991

**Derivation of name**: From the Latin
*Ovenia* (with -a- before the stem of the word) as a
complementary term for *Ovenia* in the name of the new
species. **Diagnosis**: Medium-sized species of *Ovenia*
possessing a relatively wide central perforation that is
spanned by a disjunct bar that joins the rim with straight
gaps and spans the short axis. At 0° in XPL, the extinc-
tion lines are aligned with the polarising directions, and
on rotation these form v-shapes at the ends of the lith, the
bar is not visible at 0°, becoming bright on rotation.
**Holotype**: Pl.13, figs 14, 15, 18-25. **Paratypes**: Pl.13, figs 16, 17 side view? **Type locality**: Pl.13, figs 14-17
Owenia cf. O. hillii? Crux, 1991 side view
Pl.12, figs 48, 49

Remarks: Unlike O. hillii side view, O. cf. O. hillii? side view has a much shorter spine that either flares at the end, or is capped by a plug that overhangs the top of the spine.

Pearsonia gen. nov.
Type species: Pearsonia ecclesiata gen. et sp. nov.  
Derivation of name: After Prof. Paul Pearson (Cardiff University), TDP co-chief and Cenozoic micropalaeontologist on the TDP team. Diagnosis: Cavate holococcoliths with thin rims and small spines, which act as a single crystal in XPL.

Pearsonia ecclesiata gen et sp. nov.
Pl.11, figs 29-42.  
Derivation of name: From the Latin 'ecclesia', meaning 'church', and 'atus', meaning 'like-ness to', referring to its resemblance to a church with a spire in side view. Diagnosis: A very small species of Pearsonia with a church-plus-spire-shaped outline in side view. At 0°, the liths are dark in XPL, becoming bright when rotated, with the base-plate and spine behaving as a single crystal. Holotype: Pl.11, figs 29-32. Holotype dimensions: H = 3.08µm, L = 2.64µm. Paratype: Pl.11, figs 34, 35. Type locality: Matandu Bridge, west of Kilwa Kivinje, coastal Tanzania. Type level: PP04-K1; UC9a, Middle-Late Turonian. Occurrence: Matandu Bridge (Kilwa), Middle-Late Turonian (UC9a); TDP15, Early Turonian (UC6b).

Petrobrasiella venata Troelsen & Quadros, 1971
Pl.9, figs 25-28
Russellia bukryi Risatti, 1973
Pl.10, figs 28-32
Russellia laswellii Risatti, 1973
Pl.13, figs 26-29

Thecatus varolii gen. et sp. nov.
Type species: Thecatus varolii gen. et sp. nov.  
Derivation of name: From the Latin ‘theca’, meaning ‘box’, and ‘atus’ meaning ‘like’, referring to the boxy, cavate shape of this holococcolith in size view. Diagnosis: A cavate, box-shaped holococcolith. At 0°, in side view in XPL, the rim is relatively tall and the proximal plate thin. A bipartite structure/short spine sits atop the rim, completing the box shape. The spine is not visible on rotation.

Tanzanella bownii gen. et sp. nov.
Pl.13, figs 46, 47.  
Derivation of name: After Dr. Osman Varol (Varol Research, Llandudno), seasoned calcareous nanofossil biostratigrapher and taxonomist. Diagnosis: As for the genus. This species is small. Holotype: Pl.13, figs 46, 47. Holotype dimensions: H = 3.08µm, W = 3.52µm. Type locality: TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. Type level: TDP15/29-1, 10cm; UC6b, Early Turonian. Occurrence: TDP15, Early Turonian (UC6b).

5.3 Nannoliths

Family BRAARUDOSPHAERACEAE Deflandre, 1947

Braarudosphaera bigelowii (Gran & Braarud, 1935) Deflandre, 1947
Pl.2, fig.28

Gonolithus fluckigeri Deflandre, 1957
Pl.2, figs 29, 30

Micrantholithus? nicholissii sp. nov.
Pl.2, figs 23-27. Derivation of name: After Dr. Chris Nicholas (Trinity, Dublin University), co-chief, general geologist and lithostratigrapher on the TDP team. Diagnosis: Possible segments of pentaliths of Micrantholithus, each segment having a median depression, bordered by ridges, occupying the central third of the segment. The expression of this depression at the outer edge of the segment creates a very shallow ‘w’-shape. Differentiation: This new species is composed of distinctively-shaped segments with a ridge-bordered central depression and crenulated outer edge that has not been seen in any other species. Remarks: Although no entire pentaliths have yet been found, the segment angles suggest a pentalith structure, and so this new species is questionably placed into Micrantholithus. Holotype: Pl.2, fig.27. Holotype dimensions: Central lith point to outside edge = 4.40µm, point to point across outside edge = 3.96µm. Paratype: Pl.2, fig.25. Type locality: TDP15, Maghreda Swamp, NW of Kilwa Kivinje, coastal Tanzania. Type level: TDP15/15-1, 10cm; UC6b, Early Turonian. Occurrence: TDP15, Early Turonian (UC6b).
Family **MICRORHABDULACEAE** Deflandre, 1963

**Lithraphidites acutus** Verbeek & Manivit in Manivit et al., 1977
Pl.2, figs 21, 22

**Lithraphidites carniolensis** Deflandre, 1963
Pl.2, figs 1-3; Pl.2, figs 4-7 – thick form

**Rhabdolithus aquaticus** Manivit, 1971
Pl.2, figs 8-20

Family **INCERTAE SEDIS**

‘*Anacanthoica mitra*’ Varol, 1989
Pl.12, figs 9, 18

Remarks: As Bown (2005, p.38) remarked, these forms may be fragments of a calcisphere test.

**Ceratolithina capitanea** (Burnett, 1997a) stat. nov.
Pl.2, figs 31-34
1997a *Ceratolithina cruxii* Perch-Nielsen, 1988 subsp. capitanea Burnett: p.59, pl.1, fig.4 (holotype).


**Ceratolithoides ohalloraniae** sp. nov.
Pl.2, figs 35-40. Derivation of name: After Ms. Aoife O’Halloran (Trinity, Dublin University), sedimentologist/clay mineralogist and geochemist on the TDP team.

Diagnosis: A small species of *Ceratolithoides* with an almost equilateral-triangular outline and a shallow inter-horn angle. The cone extends halfway down the length of the nannolith and is bright at 45°. Differentiation: This new species is smaller than the majority of *Ceratolithoides* species. Its almost equilateral-triangular outline distinguishes it from all other species. Holotype: Pl.3, figs 7. 8. Holotype dimensions: Cone-tip to inter-horn angle = 3.08µm, side = 5.06µm, horn-point to horn-point = 4.40µm. Paratype: Pl.3, figs 9, 10. Type locality: TDP5, Machole, south of Kitulo Hill, near Lindi, coastal Tanzania. Type level: TDP5/9-3, 55-57cm; UC15eTP, Late Campanian. Occurrence: TDP5, Late Campanian (UC15eTP); TDP9, Early Maastrichtian (UC17); Kitulo Hill (Lindi), Early Maastrichtian (UC18).

**Singanoa** gen. nov.

Type species: *Singanoa scapus* gen. et sp. nov. Derivation of name: After Dr. Joyce Singano (TDPC, Dar-es-Salaam), micropalaeontologist, general facilitator and ‘mother’ of the TDP team. Diagnosis: Nannolith of various lengths, comprising four narrow blocks, arranged end-to-end in two pairs. Diagonal blocks go into extinction together, and a dark extinction area in the centre gives the appearance of a constriction in the nannolith (like a scroll tied at the middle).

**Ceratolithoides dongenii** sp. nov.
Pl.3, figs 5-10. Derivation of name: After Dr. Bart van Dongen (Stockholm University), organic geochemist on the TDP team. Diagnosis: A medium-sized species of *Ceratolithoides* with an almost equilateral-triangular outline, a prominent cone, almost entirely enclosed by the horns, occupying half the length of the ceratolith, and an inter-horn angle approaching 90°. Differentiation: This new species has a shorter, broader cone (e.g. Pl.3, fig.5) and a more equilateral-triangular shape than *C. aculeus*. It somewhat resembles *C. prominens*, but the cone is entirely enclosed by the horns, the outline is triangular, rather than subtriangular, the inter-horn angle is more acute, and the cone is less prominent in the new species. The cone in *C. sagittatus* Lees & Bown, 2005 is not enclosed by the horns, and the cone divides into two elements, which distinguishes this from the new species. Holotype: Pl.3, figs 7, 8. Holotype dimensions: Cone-tip to inter-horn angle = 3.08µm, side = 5.06µm, horn-point to horn-point = 4.40µm. Paratype: Pl.3, figs 9, 10. Type locality: TDP5, Machole, south of Kitulo Hill, near Lindi, coastal Tanzania. Type level: TDP5/9-3, 55-57cm; UC15eTP, Late Campanian. Occurrence: TDP5, Late Campanian (UC15eTP); TDP9, Early Maastrichtian (UC17); Kitulo Hill (Lindi), Early Maastrichtian (UC18).

**Singanoa** scapus gen. et sp. nov. Derivation of name: From the Latin ‘scapus’, meaning ‘a scroll’, referring to the scroll-like appearance of the nannolith. Diagnosis: As for the genus. May be medium-sized to very small. Differentiation: The short form of this species bears a slight resemblance to the birefringent blades of *Lithraphidites? charactozorro* Self-Trail, 1999, as seen in XPL. *S. scapus* is distinct, however, in not having the tapering ends possessed by that species, and in being much smaller. Holotype: Pl.4, figs 11, 12. Holotype dimensions: L = 6.16µm, W = 0.88µm. Paratype: Pl.4, figs 7-10, 13-18. Type locality: TDP9, Nangurukuru junction, SW of Singino Hill, near Kilwa Kivinje, coastal Tanzania. Type level: TDP9/15-1, 21cm; UC17, Early Maastrichtian. Occurrence: TDP9, Late Campanian-Early Maastrichtian (UC15eTP-UC17).

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References


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Plate 2

Microrhabdulaceae, Braarudosphaeraceae, incertae sedis

Lith. carniolensis Nguru-99-2-065/064 (BF) 066
Lith. carniolensis thick Nguru-99-3-004/008
Lith. carniolensis thick Nguru-99-5-172/173
Rhab. aquitanicus TDP15/49-2, 62 cm-010/011/009
Rhab. aquitanicus TDP15/35-1, 10 cm-029/028
Rhab. aquitanicus TDP15/35-1, 10 cm-034/033
Rhab. aquitanicus TDP15/15-1, 10 cm-063/062
Rhab. aquitanicus TDP15/15-1, 10 cm-005/004
Rhab. aquitanicus TDP15/15-1, 10 cm-068/069
Lith. acutus Nguru-99-1-096/097
Mic.? nicholasi TDP15/15-1, 10 cm-043
Mic.? nicholasi TDP15/15-1, 10 cm-044
Mic.? nicholasi TDP15/15-1, 10 cm-047
Mic.? nicholasi TDP15/15-1, 10 cm-072
Mic.? nicholasi TDP15/15-1, 10 cm-073
Brac. bigelowii TDP5/8-2, 2-3 cm-025
Gon. fluckigeri TDP5/6-3, 36-37 cm-021/025
Cerato. ohallorianae Lindi-99-9a-010/011
Cerato. ohallorianae Lindi-99-3-002/001
Cerato. ohallorianae TDP9/9-2, 39 cm-030/031

paratype
paratype
paratype
holotype
holotype
holotype
Plate 3

Incertae sedis, placoliths (uncertain affinity), Kamptneriaceae, Rhagodiscaceae

New Late Cretaceous calcareous nannofossils...Tanzania
Plate 4

Rhagodiscaceae, incertae sedis, Stephanolithiaceae, Axopodorhabdaceae
Plate 5

Biscutaceae, Cretarhabdaceae, Prediscosphaeraceae

Bisc. ellipt. Nguru-99-5-121
Bisc. ellipticum coccosphere Nguru-99-1-028/030/029
B. ellipt. c’sphere TDP15/9-1, 10cm-007/008

Bisc. ellipticum coccyocylinder TDP15/33-1, 10cm-020/021/022/023
Disc. ignotus TDP9/48-2, 20cm-041

Bisc. ellipticum coccosphere TDP15/35-1, 10cm-009/010
Bisc. ellipticum coccosphere Nguru-99-5-112/113
Disc. ignotus Nguru-99-5-132
Disc. ignotus TDP15/25-1, 10cm-010

Bisc. notaculum TDP5/5-1, 66-67cm-018/017
Bisc. notaculum TDP9/14-1, 36cm-017/018
Cruci. hayi Lindi-99-11-016/015

Cruci. salebrosum? TDP15/15-1, 10cm-052/053
Cruci. salebrosum? TDP15/9-1, 10cm-009/010
Cruci. salebrosum? TDP15/35-1, 10cm-019/020
Cruci. salebrosum? TDP15/1-2, 15cm-025/026

Mira. bergentii Lindi-99-11-017/020/018/019

Pred. mgayae TDP9/19-1, 30cm-015/016

Mira. bergentii Lindi-99-3-003/004/005
Pred. mgayae Lindi-99-11-007/008
Pred. mgaya Lindi-99-11-025/026
Plate 6

Eiffellithaceae, Chiastozygaceae, Kamptneriaceae

1. Eiff. lindiensis Lindi-99-2-004/005
2. Eiff. lindiensis TDP5/9-3, 36-37 cm-020/019
3. Eiff. lindiensis TDP5/9-1, 48-49 cm-055/054
4. Eiff. lindiensis TDP5/9-3, 55-57 cm-004/005
5. Eiff. lindiensis TDP5/9-2, 20 cm-039/040
6. Eiff. lindiensis TDP9/49-2, 62 cm-019/018
7. Stauro. halfanii TDP15/35-1, 10 cm-032/031
8. Stauro. halfanii TDP15/45-1, 10 cm-005/006
9. Stauro. halfanii TDP15/3-1, 10 cm-002/003
10. Stauro. halfanii TDP15/31-1, 10 cm-001/002/003
11. St. nguru. TDP15/15-1, 10 cm-023/022
13. St. ngurumanahuntaensis Nguru-99-5-135/136
14. Stauro. handleyi TDP9/49-2, 62 cm-003/004
15. Stauro. handleyi TDP9/41-1, 36 cm-015/016
16. Stauro. handleyi TDP9/29-1, 99 cm-008/007/009
17. Stauro. handleyi TDP9/9-2, 39 cm-001/002
18. Gari.? coxalliae PP04-K19-002/001
19. Gari.? coxalliae TDP8/10-2, 15-16 cm-039/038
20. Amph. brooksii TDP5/3, 55-57 cm-036/037
21. Amph. brooksii TDP9/29-1, 99 cm-008/007/009
Plate 9
Chiastozygaceae, Calyptrosphaeraceae

Zeug. bicrescenticus Nguru-99-9-047/048
Zeug. cf. Z. bicrescenticus PP04-K19-054/055
Zeug. cf. Z. bicrescenticus PP04-K19-005/006
Zeug. cf. Z. bicresc. PP04-K17-019
Zeug. biperforatus PP04-K9-051/052
Zeug. cf. Z. biperforatus TDP8-2, 2-3cm-003/004
Zeug. xenotus TDP15-45-1, 10cm-010
Chi. spissus Nguru-99-2-049/050
Chi. spissus Nguru-99-2-109/110
Zeug. xenotus Nguru-99-1-052/051
Zeug. erectus? TDP9/19-1, 30cm-018/019
Zeug. erectus Lindi-99-2-014/013
Zeug. erectus TDP15/13-1, 10cm-006/007
Petro. venata TDP15/15-1, 10cm-116/117/118/119
Calc. obscurus TDP5/5-1, 66-67cm-001/002
Calc. obscurus TDP5/5-1, 66-67cm-001/002 PP04-K1-022/023
Calc. axosuturalis PP04-K1-037/038
Calc. axosuturalis? PP04-K9-019/020
Plate 10

Calyptrosphaeraceae


Calc. cyclops TDP15/15-1, 10cm-054/055 Calc. cyclops TDP15/15-1, 10cm-011/012 Calc. cyclops? TDP15/17-1, 10cm-020/021 Calc. cyclops? TDP9/9-2, 39cm-028/029

Calc. maghredaswampensis TDP15/7-1, 10cm-020/021 Calc. maghredaswampensis TDP15/8-1, 10cm-018/017 Calc. maghredaswampensis? TDP15/7-1, 10cm-015/014 Calc. maghredaswampensis? TDP5/6-3, 36-37cm-016/015

Russ. bokriyi TDP5/8-2, 2-3cm-022/023/024 Russ. bokriyi TDP5/9-2, 97-99cm-001/002 Calc. turonicus TDP15/25-1, 10cm-047/048 Calc. turonicus TDP15/1-2, 15cm-010/011


Calc. percennis Nguru-99-1-112/113 Calc. percennis TDP15/46-2, 70cm-007/006 Calc. percennis Nguru-99-5-008/007 Calc. percennis TDP15/15-1, 10cm-051/050


Oraost. perspicuum biperf. Nguru-99-5-140/139 Bif. mcanae TDP5/8-2, 2-3cm-005/006 Bif. mcanae TDP5/9-1, 48-49cm-040/039 Bif. mcanae side view TDP5/19-1, 30cm-028/030
Plate 11
Calyptrosphaeraceae
Plate 12

Calyptrosphaeraceae

Owenella hillii small form
TDP15/1-1, 10cm-027/028

Owenella hillii large form
Nguru-99-2-084/085

Owenella hillii small form
TDP58-2, 2-3cm-038/037

Owenella hillii small form
Nguru-99-1-014/013

Owenella hillii small form
Nguru-99-1-085/056

Owenella hillii small form
Nguru-99-1-084/085

Owenella hillii large form
Nguru-99-5-152/153

Owenella hillii large form
Nguru-99-5-151/150

Owenella hillii large form
Nguru-99-5-145/144

Owenella hillii small form
Nguru-99-5-076/077/078

Owenella hillii small form
TDP15/1-2, 15cm-024/023/022

Tanzania? bownii
Nguru-99-1-121/122/123

Tanzania? bownii
Nguru-99-1-151/149/150

Tanzania? bownii
Nguru-99-1-127/128

Lucas? tabernus
Nguru-99-5-023/024/025

Owenella cf. O. hillii
TDP15/1-2, 15cm-030/029
Plate 13
Calyptrosphaeraceae

Otto terraezii
TDP9/48-2, 20cm-017/018/019

Musa lesierte
Nguru-99-2-075/074

Musa. Kelly
TDP5/6-3, 36-37cm-018/017

Musa. Kelly
PP04-K9-017/016

Musa. Kelly
TDP9/9-2, 39cm-016/015

Musa. Kelly
TDP9/19-1, 30cm-011/010

Musa. Kelly
TDP5/8-2, 2-3cm-002/001

Calc. rosaviiae
TDP5/1-1, 66-67cm-001/002

Calc. juliae
Nguru-99-9-043/044

Bilap. wadeae
PP04-K1-010/009

Bilap. wadeae
Nguru-99-2-016/017

Bilap. wadeae
TDP15/5-1, 10cm-020/051

Bilap. wadeae
TDP15/5-1, 10cm-010/009

Bilap. wadeae
TDP15/25-1, 10cm-035/036

Duo. learine
Nguru-99-1-140/141/142

Duo. learine
Nguru-99-5-179/180/181/182

Duo. learine
Nguru-99-5-117/118

Duo. sianiae
TDP15/5-1, 10cm-023/024

Duo. sianiae
TDP15/9-1, 10cm-035/036

Duo. sianiae
TDP15/15-1, 10cm-076/077

Holococcolith indet.
TDP5/7-2, 2-3cm-019/020/021

Holococcolith indet.
TDP5/15-7-1, 10cm-002/003/004

Nichol. baileyi
PP04-K1-040/041

Nichol. baileyi
Nguru-99-10-10

Nichol. baileyi
TDP15/33-1, 10cm-015/016