# Calcareous nannofossils from the stratotype section of the Upper Cretaceous Mzamba Formation, Eastern Cape, South Africa

**Maria N. Ovechkina[1,2], Mike Watkeys[3] & Mike B. Mostovski[2,4]**

[1]*Joint Council for Geoscience and University of KwaZulu-Natal Marine Geoscience Unit*
*E-mail: movechkina@mail.ru / saccammina@gmail.com*
[2]*Paleontological Institute, Russian Academy of Sciences, 123 Profsoyuznaya Str., Moscow, 117997 Russia*
[3]*School of Geological Sciences, University of KwaZulu-Natal, Private Bag X54001, Durban, 4000 South Africa*
[4]*Natal Museum, Private Bag 9070, Pietermaritzburg, 3200 South Africa and School of Biological & Conservation Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, 3209 South Africa*
*E-mail: mmostovski@nmsa.org.za*

## Introduction

Cretaceous deposits are scattered along the eastern and southern margins of South Africa (Shone 2006), partially filling the accommodation space provided when the Falkland Plateau was withdrawn from the Natal Valley during Gondwana break-up (Watkeys 2006). The Mzamba Formation is an Upper Cretaceous shallow-marine succession, which crops out in a narrow, discontinuous coastal strip from the north-eastern Eastern Cape to southern KwaZulu-Natal; it is equivalent to the St Lucia Formation of the coastal plain of northern KwaZulu-Natal (Dingle *et al.* 1983). The fossiliferous Mzamba Formation has been studied since 1853 (for review of previous works on Mzamba fossils see, for example, Kiel & Bandel (2003) and McMillan (2008)), but its exact age remains debatable. Klinger & Kennedy (1980) described the (u)Mzamba Formation formally and suggested its Middle Santonian–Early Campanian age, with the Santonian/Campanian boundary established in the middle of the section at the level corresponding to the boundary between Greyling's (1992) Beds N16 and N17. Using sequence stratigraphy, Greyling (1992) delineated the Santonian/Campanian boundary at the base of her Bed N13, having noted that the identification of this boundary is impeded due to the paucity of leading macrofossils in the deposit. McMillan (2003) gave a comprehensive review of foraminiferal stratigraphy of the Cretaceous successions in South Africa, including the Mzamba Formation. He proposed an Early Santonian age for the lower half of the formation, and an Early Campanian age for its upper half; however, the stratigraphic position of the unconformity that should exist between the Early Santonian and the Early Campanian parts was not established precisely but was suggested to lie within the interval between the top of Klinger & Kennedy's (1980) bed A7 and the base of bed A15 which corresponds to Greyling's (1992) beds N15–16 and N25. Recently, McMillan (2008) re-evaluated foraminiferal assemblages of the Mzamba Formation type section and suggested the Middle to Late Santonian age for the lower half of the lower Mzamba succession up to and including Klinger & Kennedy's (1980) bed A8; the position of the Santonian–Campanian boundary remained unclear due to inaccessibility to the relevant part of the section, but was suggested to lie between the beds A9 and A12 (effectively A15). The analysis of the calcareous nannofossils presented here adds to this stratigraphic conundrum and offers another variant of zonal sequencing in the stratotype section.

## Materials and methods

The stratotype section (Greyling's (1992) sections N1 & N2, 31°06′13.6″S, 30°10′40.8″E; Fig. 1) was sampled on 11 May 2008 at low tide, which facilitated the access to the lowest beds. Samples were taken at 0.05–0.3–0.5 m intervals, except for the lowermost part of the succession that was covered with beach sand and the uppermost part, which was inaccessible at the time. Greyling's (1992) profile of the unit stratotype has been used to map samples (Fig. 2). The lowermost part of the sequence (samples 1/1–1/8) was sampled at an outcrop 60 m south of N1. Subsamples (*ca.* 100–200 g) were crushed and concen-

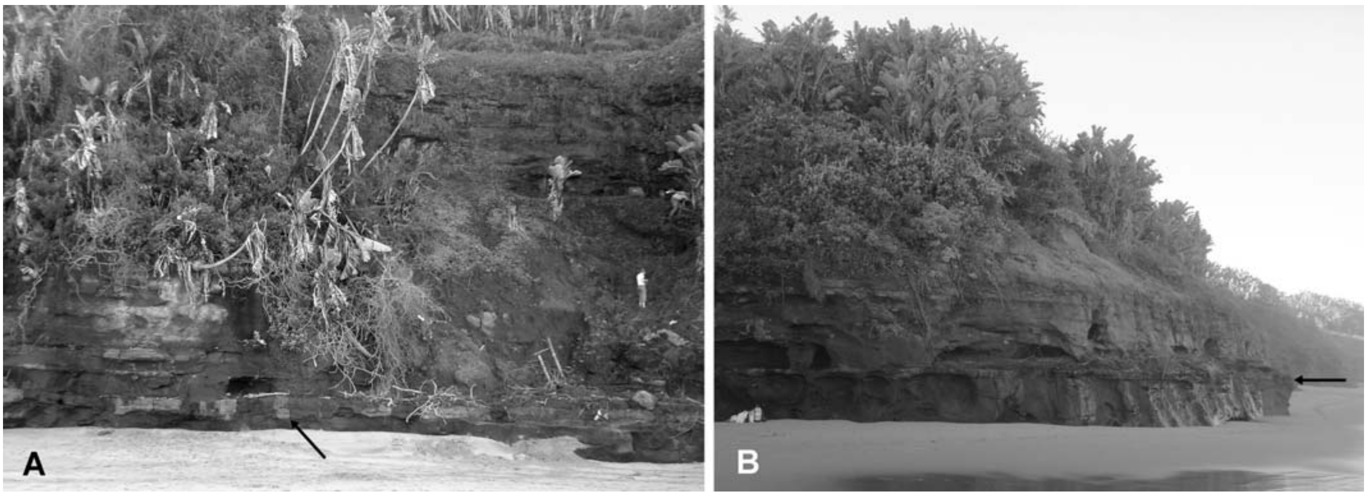

**Figure 1**. Cliff exposure of the lectostratotype of the Mzamba Formation: **A**, Greyling's N1 section; **B**, Greyling's N2 section. The level of Bed 7 is arrowed.

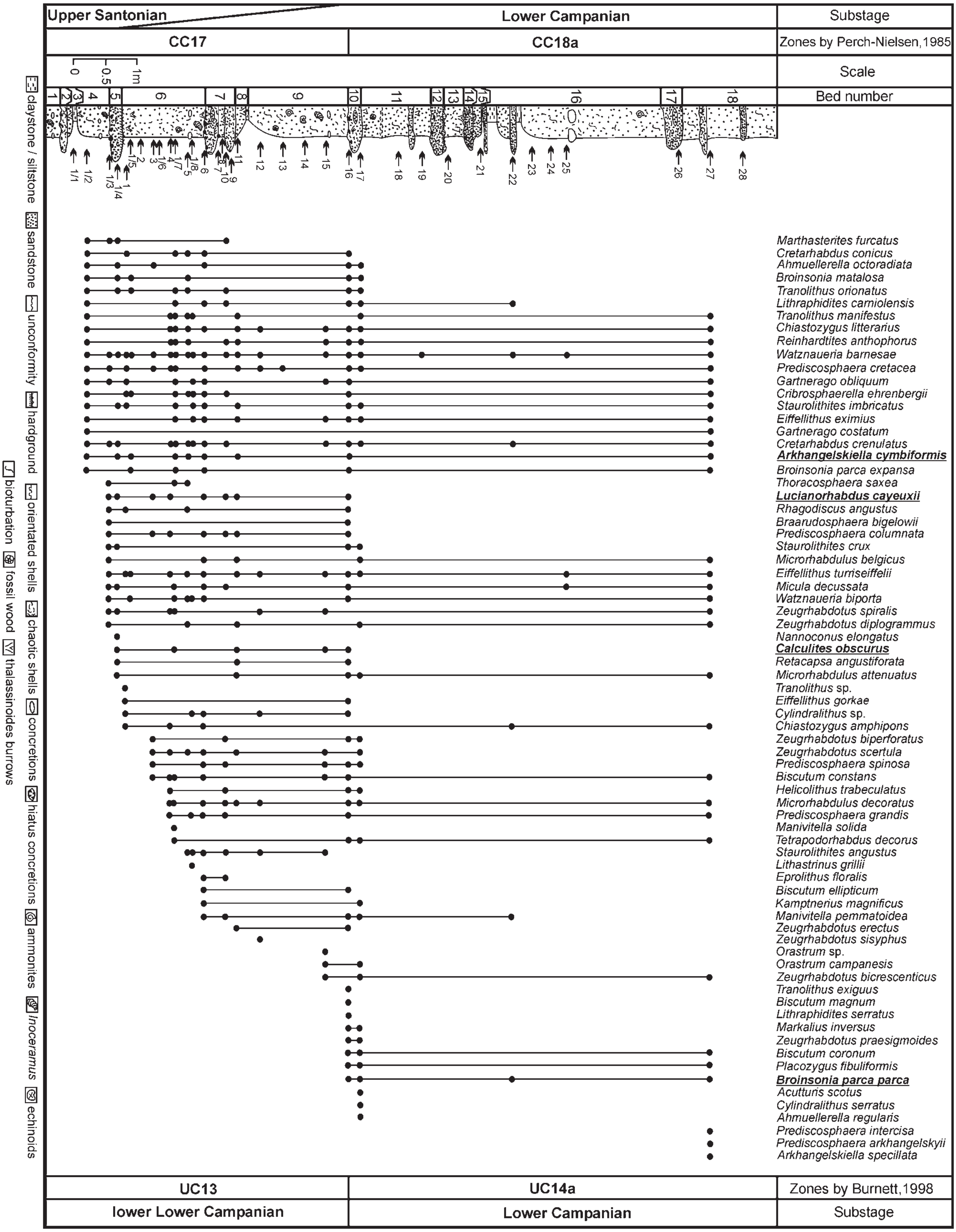


**Figure 2**. Distribution of calcareous nannofossils from the stratotype section of the Mzamba Formation. The unit stratotype profile is re-drawn after Greyling (1992).

trated, and smear slides (22 × 32 mm) were made in Canada Balsam (Ovechkina 2007). The slides were systematically examined for nannoplankton which was then identified and photographed using light microscope (Zeiss Axioskop) with crossed Nicols at ×1200–1920 magnification with immersion.

The calcareous nannofossil assemblage identified in the stratotype section of the Mzamba Formation includes 73 species (Figs 2–4). Nannofossils are well preserved but extremely rare throughout the section (1–5 specimens of each species per one smear slide). Samples 1/1, 1/6, 2, 7–9, 14, 18, 20, 21, 23, 24, 26, 28 yielded no nannofossils.

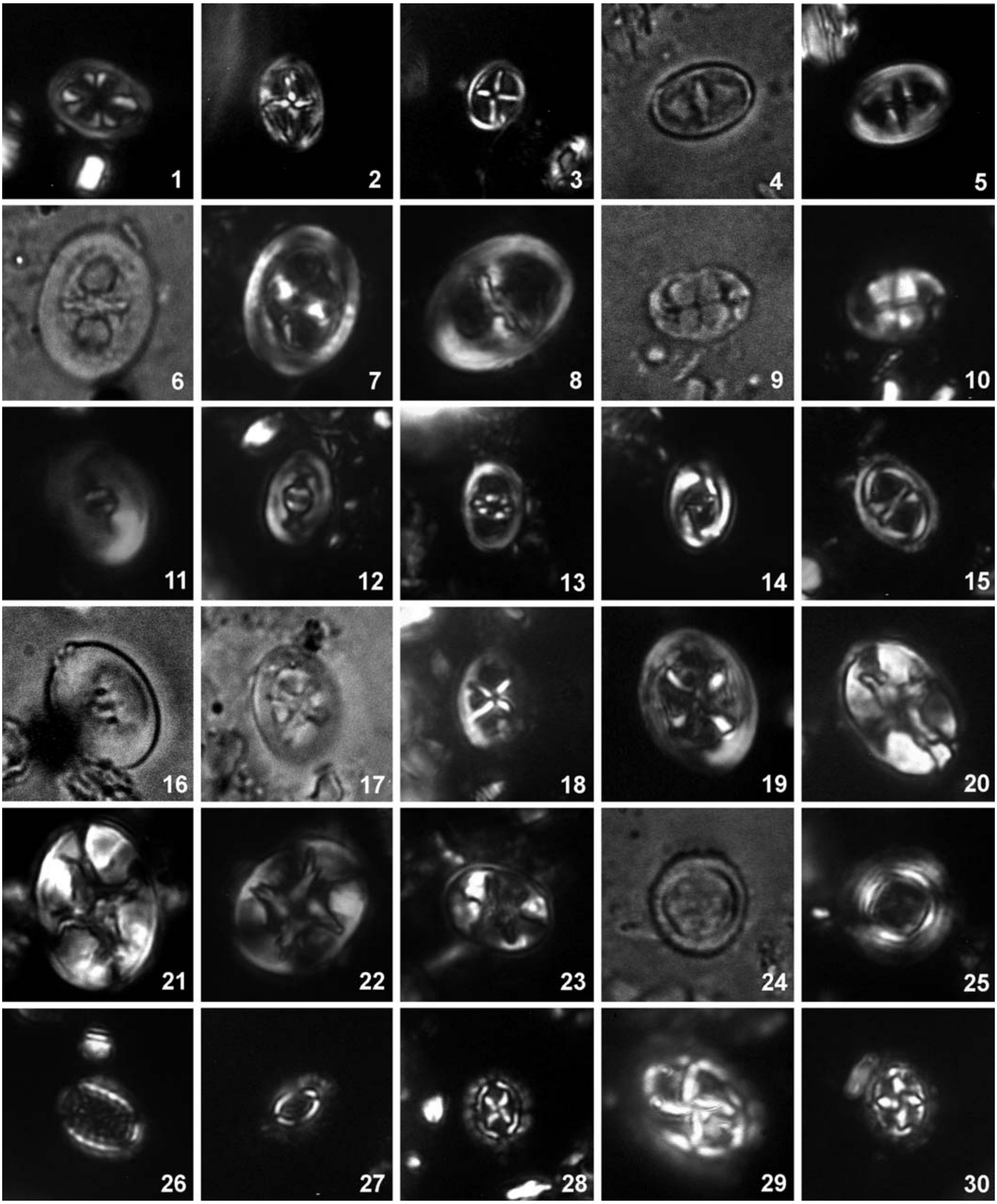

**Figure 3**. Calcareous nannoplankton from the Mzamba Formation. All illustrations are light micrographs. Abbreviations 'pol' and 'tr' denote polarized and transmitted light, respectively. The magnification for all images is ×2300. **1**, *Ahmuellerella octoradiata,* sample 16, pol; **2**, *Staurolithites imbricatus,* sample 17, pol; **3**, *S. crux,* sample 16, pol; **4**, *Tranolithus manifestus,* sample 17, tr; **5**, *T. manifestus,* sample 17, pol; **6**, *Reinhardtites anthophorus,* sample 16, tr; **7**, *R. anthophorus,* sample 16, pol; **8**, *Zeugrhabdotus scertula,* sample 15, pol; **9**, *Tranolithus orionatus,* sample 16, tr; **10**, *T. orionatus,* sample 16, pol; **11**, *Zeugrhabdotus biperforatus,* sample 17, pol; **12**, *Z. bicrescenticus,* sample 17, pol; **13**, *Z. erectus,* sample 16, pol; **14**, *Z. spiralis,* sample 15, pol; **15**, *Placozygus fibuliformis,* sample 17, pol; **16**, *Zeugrhabdotus biperforatus,* sample 17, tr; **17**, *Chiastozygus amphipons,* sample 27, tr; **18**, *Ch. amphipons,* sample 27, pol; **19**, *Ch. litterarius,* sample 17, pol; **20**, *Eiffellithus eximius,* sample 16, pol; **21**, *E. eximius,* sample 17, pol; **22**, *E. turriseiffelii,* sample 15, pol; **23**, *E. gorkae,* sample 16, pol; **24**, *Cylindralithus serratus,* sample 17, tr; **25**, *C. serratus,* sample 17, pol; **26**, *Cribrosphaerella ehrenbergii,* sample 10, pol; **27**, *Biscutum magnum,* sample 16, pol; **28**, *Prediscosphaera cretacea,* sample 6, pol; **29**, *P. grandis,* sample 16, pol; **30**, *P. spinosa,* sample 10, pol.

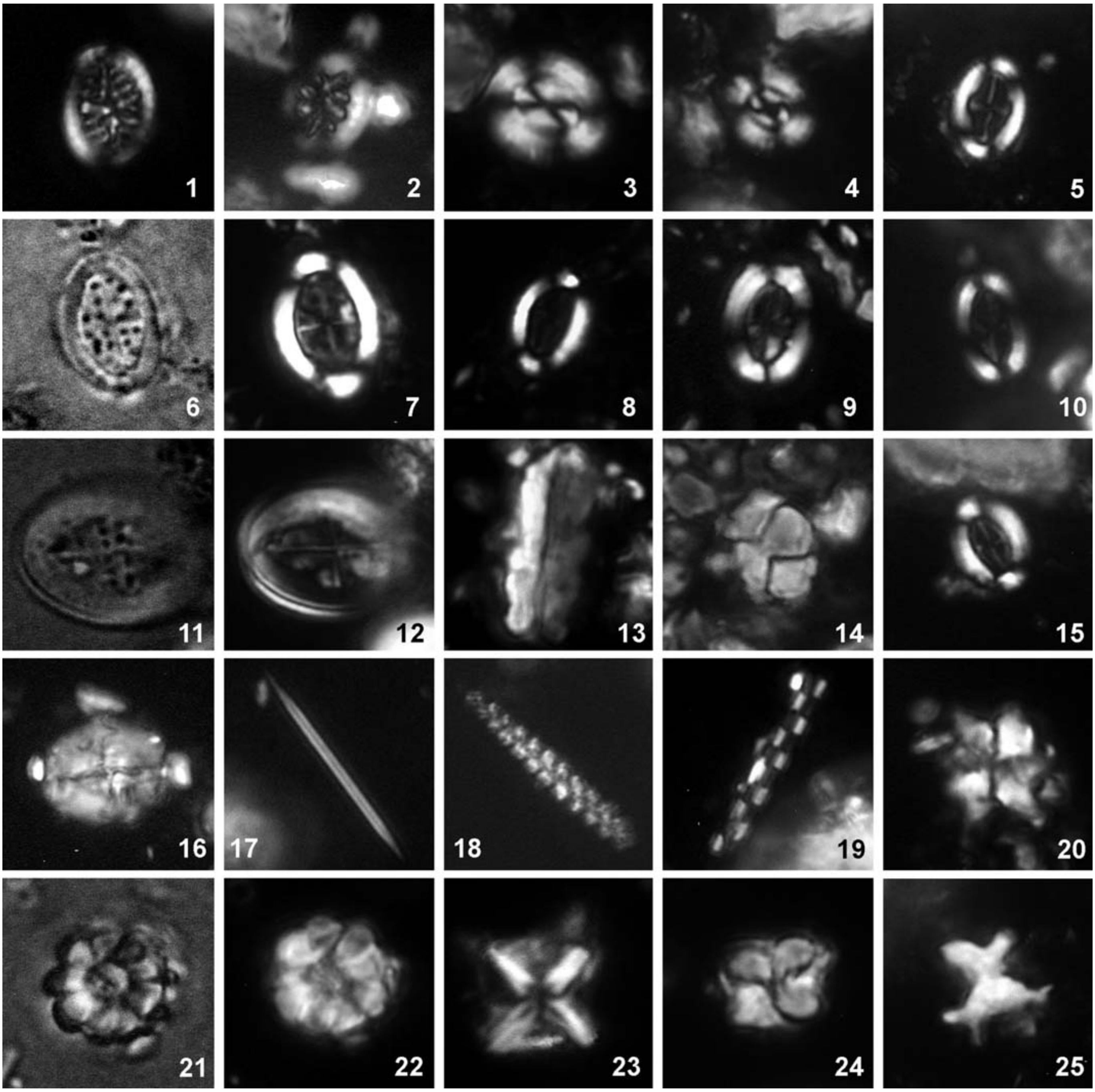

**Figure 4**. Calcareous nannofossils from the Mzamba Formation. Abbreviations as in Fig. 3. The magnification for all images is ×2300. **1**, *Cretarhabdus crenulatus,* sample 16, pol; **2**, *Retacapsa angustiforata,* sample 16, pol; **3**, *Watznaueria barnesae,* sample 27, pol; **4**, *W. biporta,* sample 16, pol; **5**, *Broinsonia matalosa,* sample 16, pol; **6**, *Arkhangelskiella cymbiformis,* sample 6, tr; **7**, *A. cymbiformis,* sample 6, pol; **8**, *Broinsonia parca expansa,* sample 1/7, pol; **9**, *B. parca parca,* sample 16, pol; **10**, *B. parca parca,* sample 16, pol; **11**, *Gartnerago obliquum,* sample 6, tr; **12**, *G. obliquum,* sample 6, pol; **13**, *Lucianorhabdus cayeuxii,* sample 10, pol; **14**, *Calculites obscurus,* sample 11, pol; **15**, *Broinsonia parca parca,* sample 17, pol; **16**, *Orastrum campanensis,* sample 17, pol; **17**, *Lithraphidites carniolensis,* sample 17, pol; **18**, *Microrhabdulus belgicus,* sample 17, pol; **19**, *M. decoratus,* sample 10, pol; **20**, *Lithastrinus grillii,* sample 1/8, pol; **21**, *Eprolithus floralis,* sample 6, tr; **22**, *E. floralis,* sample 6, pol; **23**, *Micula decussata,* sample 27, pol; **24**, *M. decussata,* sample 6, pol; **25**, *Marthasterites furcatus,* sample 1/3, pol.

**Stratigraphy**

The standard nannoplankton zonation by Sissingh (1977) with additions by Perch-Nielsen (1985) and the zonal scheme by Burnett (1998) have been used for biostratigraphic sequencing of the Mzamba succession.

According to Perch-Nielsen (1985), the lower part of the section (samples 1/2–1/8 & 1–15; Beds 4–9) may be referred to the transitional Upper Santonian–Lower Campanian Zone CC17, which lower boundary is demarcated by the first occurrence of *Calculites obscurus* (Fig. 4.14). The first record of this species in the Mzamba section has been detected at the level of sample 1/4. This species is absent from samples 1/2 and 1/3, which, however, may be explained by the rarity of nannofossils in the section. Alternatively, the lowermost part of the section (prior to sample 1/4) can be assigned to Upper Santonian Zone CC16, but we refrain from doing so at this stage: although *C. obscurus* has not been found in this part of the section, *Arkhangelskiella cymbiformis,* which usually appears later, has been recorded in sample 1/2.


ISSN 0078-8554 *Palaeont. afr.* (December 2009) **44**: 129–133

Beds 10–18 (samples 16–27) belong to the Lower Campanian Subzone CC18a due to the presence of *Broinsonia parca parca* (Figs 4.9, 4.10, 4.15), the first occurrence of which is recorded in sample 16.

According to Burnett (1998), the lower part of the section (samples 1/2–1/8 & 1–15; Beds 4–9) should be referred to the lower Lower Campanian Zone UC13 due to the presence of *Arkhangelskiella cymbiformis* (Figs 4.6, 4.7), the first appearance of which delineates the lower boundary of this zone. In the Boreal Province and Boreal-intermediate Province, Burnett subdivides this zone into two subzones and delineates their boundary by the consistent first occurrence of *Orastrum campanensis.* However, this species has not been found at low or high-southern palaeolatitudes (Burnett 1998; Lees 2002), and Burnett (1998) recognized no subzones in UC13 for the Tethyan-intermediate Province. We have detected *Orastrum campanensis* in samples 15 & 17 (Fig. 4.16), which is the first record of this species in southern hemisphere. Its first occurrence (sample 15) is situated below the level of the first occurrence of *Broinsonia parca parca,* which does not contradict Burnett's (1998) scheme for the Boreal and Boreal-intermediate provinces.

The upper part of the section (samples 16–27; Beds 10–18) refers to the Lower Campanian Subzone UC14a due to the first appearance of *Broinsonia parca parca* in sample 16.

Thus, according to available data from calcareous nannofossils the Santonian–Campanian boundary is either absent from the section at all, or situated within the interval between the visible base of the section and the base of Greyling's (1992) Bed 10. In both cases its position is lower than the boundary drawn by Greyling (1992) and considerably lower than the position of the boundary proposed on the basis of research done on ammonites (Klinger & Kennedy 1980) and foraminiferans (McMillan 2003, 2008).

**Palaeoenvironments**

Despite the species diversity and good preservation, nannofossils are extremely rare throughout the section, with 14 samples being entirely empty. This suggests that palaeoenvironmental conditions were generally unfavourable for the development of the calcareous nannoplankton. This assumption corroborates well with the hypothesis offered by McMillan (2008), who interprets the general setting at Mzamba to be within the mud belt and in proximity of active river systems.

Given the scarcity of the calcareous nannoplankton in the discussed deposits in general, noteworthy is its distribution within the type section. Species occur more frequently in the lower part of the section (samples 1/2–1/8 & 1–17, except for samples 13 & 14; Beds 4–10). This part is followed by a 'gap' with few nannofossils (samples 18–26; Beds 11–17). The reappearance of a rich assemblage has been detected in sample 27 (bottom part of Bed 18). This distributional pattern is intriguing, since it does not coincide with the detected zonal boundaries at the level of sample 16. It must have an explanation in the depositional environment or in diagenetic processes involved (Liu & Greyling 1996), and needs further investigation.

The staff of SEM and Microscopy Units of the University of KwaZulu-Natal (Westville campus) is acknowledged for facilitating access to the relevant equipment. M.O. was funded through a NRF post-doctoral bursary and Marine Geoscience Unit, and thanks the Directorate of the Natal Museum for the access to the sophisticated Zeiss microscope. We thank an anonymous reviewer for useful comments on the manuscript.

**REFERENCES**

BURNETT, J.A.1998. Upper Cretaceous. **In**: Bown, P.R. (ed.), Calcareous nannofossil biostratigraphy, 132–198. British Micropalaeontological Society Publication Series. London, Chapman and Hall.

DINGLE, R.V., SEISSER, W.G. & NEWTON, A.R. 1983. *Mesozoic and Tertiary Geology of Southern Africa.* Rotterdam, A.A. Balkema.

GREYLING, E.H. 1992. *The Mzamba Formation (Cretaceous) of the Transkei – Stratigraphy, sedimentology and palaeontology.* Unpublished M.Sc. thesis, University of Durban Westville, Durban.

KIEL, S. & BANDEL, K. 2003. New taxonomic data for the gastropod fauna of the Umzamba Formation (Santonian–Campanian, South Africa) based on newly collected material. *Cretaceous Research* **24**(4), 449–475.

KLINGER, H.C. & KENNEDY, W.J. 1980. The uMzamba Formation at its type section, uMzamba estuary (Pondoland, Transkei), the ammonite content and palaeogeographical distribution. *Annals of the South African Museum* **81**(6), 207–222.

LEES, J.A. 2002. Calcareous nannofossil biogeography illustrates palaeoclimate change in the Late Cretaceous Indian Ocean. *Cretaceous Research* **23**, 537–634.

LIU, K.W. & GREYLING, E.H. 1996. Grain-size distribution and cementation of the Cretaceous Mzamba Formation of Eastern Cape, South Africa: a case study of a storm-influenced offshore sequence. *Sedimentary Geology* **107**(1–2), 83–97.

McMILLAN, I.K. 2003. Foraminiferally defined biostratigraphic episodes and sedimentary pattern of the Cretaceous drift succession (Early Barremian to Late Maastrichtian) in seven basins on the South African and southern Namibian continental margin. *South African Journal of Science* **99**(11/12), 537–576.

McMILLAN, I.K. 2008. Reappraisal of foraminiferal assemblages of the Santonian–Campanian Mzamba Formation type section, and their correlation with the stratigraphic succession of the KwaZulu Basin. *African Natural History* **4**, 25–34.

OVECHKINA, M.N. 2007. Calcareous nannoplankton of the Upper Cretaceous (Campanian and Maastrichtian) of the south and east of the Russian Platform. *Transactions of the Paleontological Institute, Russian Academy of Sciences* **288**, 1–352.

PERCH-NIELSEN, K. 1985. Mesozoic calcareous nannofossils. **In**: Bolli, H.M., Saunders, J.B. & Perch-Nielsen, K. (eds), *Plankton Stratigraphy,* 329–426. Cambridge, Cambridge University Press.

SHONE, R.W. 2006. Onshore post-Karoo Mesozoic deposits. **In**: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (eds), *The Geology of South Africa,* 541–552. Johannesburg, Geological Society of South Africa & Pretoria, The Council for Geoscience.

SISSINGH, W. 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie en Mijnbouw* **56**(1), 37–65.

WATKEYS, M.K. 2006. Gondwana break-up: a South African perspective. **In**: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (eds), *The Geology of South Africa,* 531–539. Johannesburg, Geological Society of South Africa & Pretoria, The Council for Geoscience.