

# Calcareous nannofossil biostratigraphy of the Upper Cretaceous–Lower Paleocene sequence of the Deramazan section, Sulaimani area, Kurdistan region of NE Iraq

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**Abstract** The nature of the Cretaceous–Palaeogene boundary in the Kurdistan region of NE Iraq is still under debate. Most studies have considered the Danian sediments to be mostly missing. Another hypothesis suggests that a conglomerate represents the contact between the Cretaceous and Paleogene. We examined the boundary succession of the Deramazan section in the Sulaimani area (NE Iraq) in order to determine the calcareous nannofossil assemblages and address the biostratigraphy around the boundary. The rock strata in the studied section are characterised by alternations of olive-green to greenish-grey sandstone, siltstone, shale and marlstone interlayers in both the Tanjero (Upper Campanian–Maastrichtian) and overlying Kolosh (Paleocene–Lower Eocene) Formations. The upper part of the section includes a thick conglomerate bed. We found that deposition across the boundary was essentially continuous, with no discernible break in sedimentation. The base of Zone NP1 (base of the Kolosh Formation) was identified by the bases of *Biantholithus sparsus*, *Cruciplacolithus* spp. and *Coccolithus pelagicus*, plus an acme of *Cervisiella operculata*, which seems to indicate no hiatus. There is some reworking of Cretaceous taxa above the boundary, into NP1 and NP2. The relative abundances of the nannofossil assemblages across the boundary reflect a productive marine environment.

**Keywords** Nannofossils, *Biantholithus sparsus*, Tanjero, Kolosh, K–Pg boundary, Sulaimani, Kurdistan, Iraq

## 1. Introduction

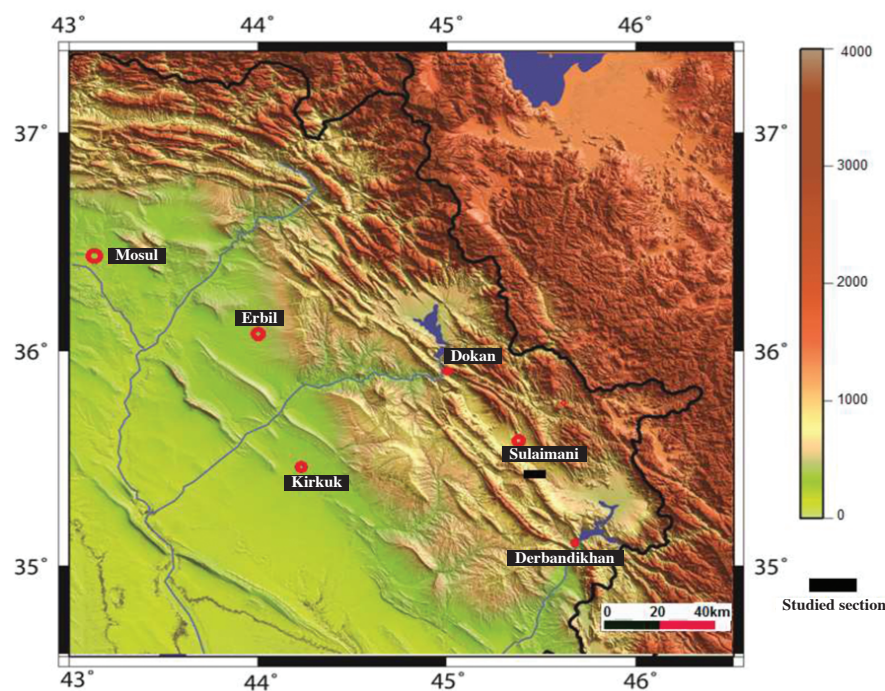
The Cretaceous–Palaeogene boundary (K–Pg) in NE Iraq has been studied by several authors, using planktonic foraminifera, such as Abdel-Kareem (1986) and Sharbazeri (2009). In our study, we examined the stratigraphic sequence across this boundary, at one locality, using calcareous nannofossils. This globally-important boundary is characterised in the study area by a sequence of flysch sediments of the foreland basin on the NE Arabian Plate (Al-Qayim et al., 2012). The flysch sediments are represented by the Maastrichtian Tanjero Formation and the overlying Palaeogene Kolosh Formation.

The Deramazan section, which is 300 m thick, was selected for a case study to sample and re-examine the age of the sequence. The section is located 200 m west of the village of Deramazan, between the Sulaimani–Qaradagh main road and the Tanjero River (35°23'56.0"N, 45°30'36.8"E; Figures 1, 2).

## 2. Geological setting

The study area is located within the High Folded Zone of the Zagros Orogenic Belt, which is characterised by numerous folds and faults that strike NW–SE. Most of the features and units are shown in Figure 1. The structures in this zone are linear, curvilinear, asymmetrical, doubly-plunging and high amplitude, and are arranged in an echelon pattern on the surface (Buday & Jassim, 1987). To the NE are the complicated, imbricate Zagros Suture Zones, whilst, to the SW, the folds become lower in elevation, with broader synclines in the Low Folded Zone (Jassim & Goff, 2006).

The study area represents the flysch stage of the Zagros Foreland Basin that followed pelagic carbonate sedimentation on the passive Arabian margin (Al-Qayim et al., 2012). The flysch sequence exceeds 2000 m in some places, and consists of alternating sandstones, siltstones and shales, with associated conglomerates and carbonates (Al-Qayim, 1994). The flysch sequence consists of two formations—the mainly Maastrichtian Tanjero Formation,



**Figure 1:** Relief map of NE Iraq/Kurdistan, showing the geographical location of the study area



**Figure 2:** Tilted image of the Deramazan section, showing the geography of the study area and the orientation of the sampled sequences (1–3). From Google Earth (2013)

with a proximal turbidite facies, and the Upper Paleocene–Lower Eocene Kolosh Formation, a distal turbidite facies.

The Tanjero Formation was first described by van Bellen et al. (1959) from the type section in the Sirwan Valley, 70 km SE of the study section, and comprises two divisions. The lower division is a pelagic marl, with occasional beds of argillaceous limestone, and with siltstone beds in its upper part. The upper division contains silty marls, sandstones, conglomerates and sandy or silty, organic detrital limestones. The thickness of the formation is highly variable, reaching 2018 m in the type section.

Beneath the Tanjero Formation is the Shiranish For-

mation, with its gradational and conformable contact. The overlying sequence is the Kolosh Formation, which was deposited in a deep marine trough with flysch sediments (Buday, 1980). Karim (2004) stated that the environment of this formation was highly variable, with the depth ranging from continental to deep marine, while the salinity ranged from that of fresh-to-brackish riverine to marine waters.

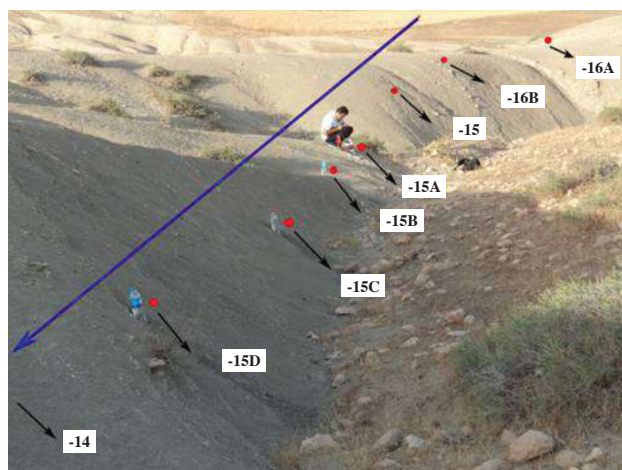
The Kolosh Formation was first described by van Bellen et al. (1959) at the village of Krozh, north of the town of Koya (SW of the city of Sulaimani). The formation consists of 777 m of alternating shales and sandstones. Al-Qayim (1994) studied the petrography of this formation, determining that the sandstones were recycled from the orogenic province, and developed as part of the foreland system. In the Sirwan Valley, van Bellen et al. (1959) found that the Tanjero Formation was unconformably overlain by the Kolosh Formation. The unconformity is marked by a total faunal change, with no transitional elements, while the Kolosh Formation is overlain by the red beds of the Gercus Formation.

### 3. Material and methods

Several field trips were conducted to examine, measure and describe the stratigraphy of the section. Ninety rock samples were collected, and standard smear-slides were prepared for studying the calcareous nannofossils, with a focus on the K–Pg transition.

Three sampled sequences are indicated in Figure 2. The first sampled interval yielded 40 rock samples from a clastic unit previously considered to contain the K–Pg boundary, although the nannofossils indicated an age of

Middle–Upper Paleocene. The second interval included 25 samples from a sedimentary succession previously thought to be close to the boundary, but this was actually found to be Upper Maastrichtian. The third attempt was performed on a sequence located between the previous two sampled intervals, and a further 25 samples were collected. The sample numbers of the latter section are, from oldest to youngest, -23 to -2, as shown in Figures 3 and 4. The nannofossil marker-species place the K–Pg boundary between Samples -15B and -15A, as shown in Figure 4b. The nannofossil study, and its resulting biostratigraphy, were based on the examination of smear-slides using cross-polarised-light microscopy, at magnifications of 400x and 1000x, as well as scanning electron microscopy.



**Figure 3:** Part of the studied K–Pg section near Deramazan. The boundary lies between Samples -15B and -15A

#### 4. Lithostratigraphy of the study section

The studied section was located 200 m west of the southern part of the village of Deramazan, between the main Sulaimani–Qaradagh road and the Tanjero River (Figure 2). The section consists mainly of the Tanjero, Kolosh and Sinjar Formations (Maastrichtian to Middle Paleocene). The samples were taken parallel to a line that connected the villages of Deramazan and Zirgwez. About 303 m of the section, which had all been previously assigned to the middle of the Tanjero Formation, were measured. The sequence was generally characterised by alternations of yellow, medium-grained sandstone beds, with black shales, marlstones and marly limestones, cropping out from the Deramazan section down to the Tanjero River (Figure 3). These beds dip toward the SW at 30–35°.

Superficially, this succession appears to be similar to the beds of the Shiranish Formation, or perhaps a tongue

of that formation, but closer up, it is clear that they are different, as this succession contains sandstone beds that are usually absent from the Shiranish Formation. Towards the top of this unit, the lithology of the Tanjero Formation becomes more clastic, with the sandstones becoming thicker, coarser-grained and darker in colour up-section.

The upper part of the Tanjero Formation consists of a greenish-grey, medium- to thickly-bedded horizon of sandstone (2–5 m), with medium- to thinly-bedded black shale beds. The uppermost part of the unit becomes a coarse and granular sandstone of polygenetic origin. The lithologies then become coarser upwards, changing from organic-rich shales and silty marlstones to siltstones and sandstones. Locally, pebbly sandstones are sandwiched between dark, medium- to thickly-bedded marlstones, sandstones and siltstones (Figure 4).

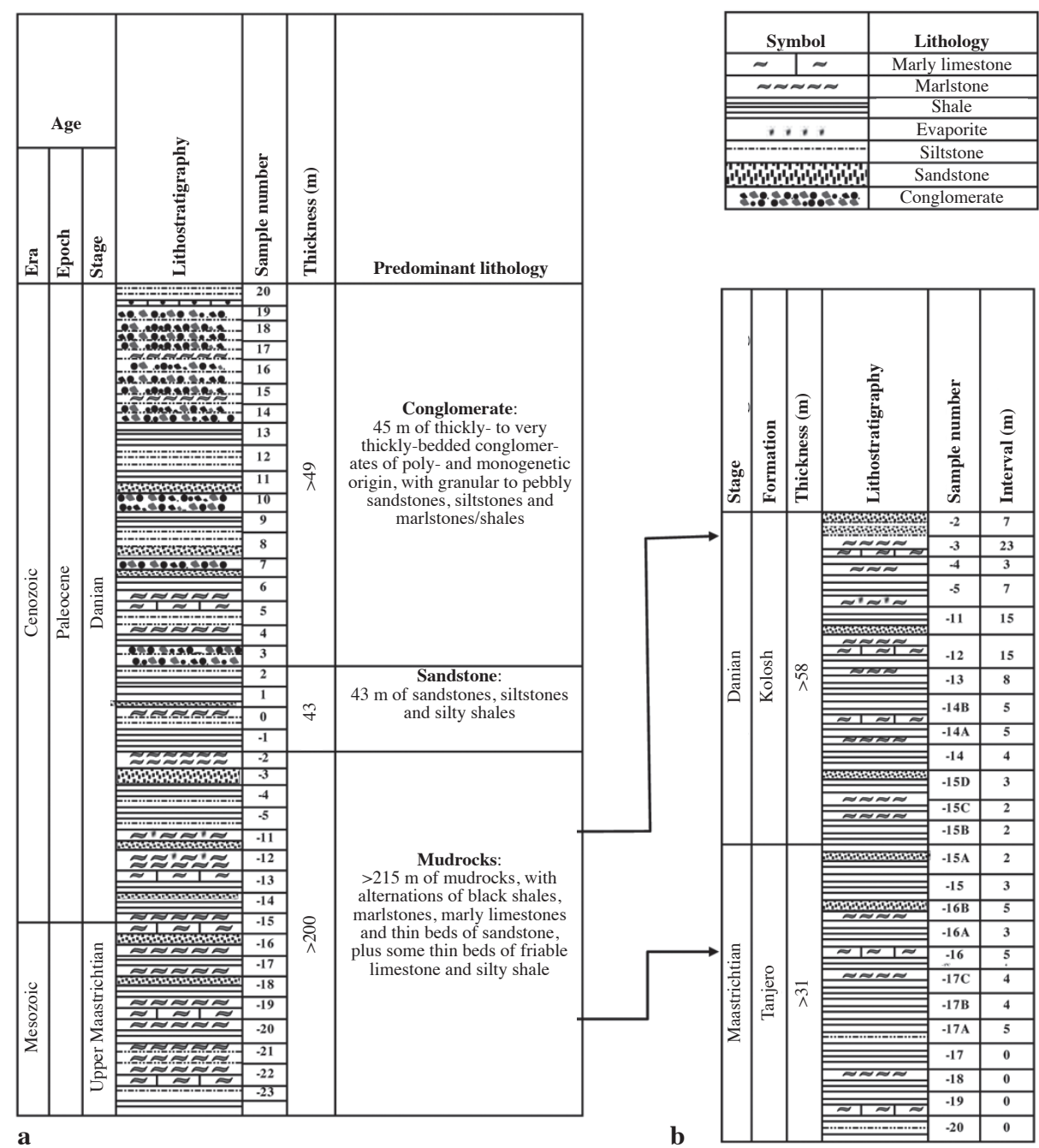
The underlying part of the section exhibits a clearer cyclic pattern. The clastics in these cycles are primarily cemented with calcareous materials. Each cycle is repeated up to the appearance of the first conspicuous conglomerate bed (3 m thick). These contain poorly-sorted, rounded clasts and are mainly composed of organic-rich limestones. Three other conglomerate beds succeed the first, representing repetitions of fining-upwards clastic materials (Figure 4). The conglomeratic sequence is mainly composed of medium- to coarse-grained, grey to light green sandstones and conglomerates of igneous and metamorphic rocks. The hard and compacted sandstones are well bedded, well rounded and cemented by calcite. The lithostratigraphy is illustrated in Figure 4.

#### 5. Nannofossil assemblages

##### 5.1 Cretaceous

The Cretaceous calcareous nannofossil assemblages from the uppermost Maastrichtian are moderately to well preserved. Figures 5 and 6 show the relative abundances of selected taxa. The most abundant taxa were *Microrhabdulus undosus* (Plate 1, figs 16–18) and *Watznaueria* spp., including *W. biporta*, *W. ovata*? (Plate 1, fig. 23) and *W. barnesiae* (Plate 1, figs 21, 24). *Micula* spp. were also abundant, including *M. staurophora* (Plate 2, figs 1, 2), *M. praemurus* (Plate 2, figs 3, 4), *Micula murus* and *M. premolisilvae*. *Lithraphidites quadratus* (Plate 2, fig. 23) and *L. praequadratus* were frequent in the assemblages, and *Arkhangelskiella cymbiformis* (Plate 2, fig. 15) was variably abundant. The presence of *L. quadratus*, *M. prae-*





**a**

**b**

Figure 4: (a) Lithostratigraphy of the Deramazan section  
(b) Detailed stratigraphic log of the K–Pg boundary interval

*murus* and *M. murus* indicate the Upper Maastrichtian.

Other Maastrichtian species found included *Ceratolithoides arcuatus* (Plate 2, figs 18, 19), *C. kamptneri* and *C. self-trailiae* (Plate 2, fig. 20). Less abundant species found in the Maastrichtian sequence included *Retecapsa angustiforata* (Plate 1, fig. 25), *Retecapsa crenulata* (Plate 2, fig. 16), *Cribrosphaerella ehrenbergii* (Plate 2, figs 5, 8?), *Chiastozygus* sp. (Plate 2, fig. 10) and *Tetrapodorhabdus decorus* (Plate 2, fig. 14).

Two species that are generally considered to have survived the K–Pg boundary event were found below the boundary—*Neocrepidolithus neocrassus* (Plate 1, fig. 19) and *Lapideacassis bispinosa* (Plate 1, fig. 20). Plate 2 illustrates the more common species from the Upper Maastrichtian, whilst Figures 5 and 6 show selected distributions and relative abundances of some of the common taxa (including Samples -17 to -15A) in Zone CC26.



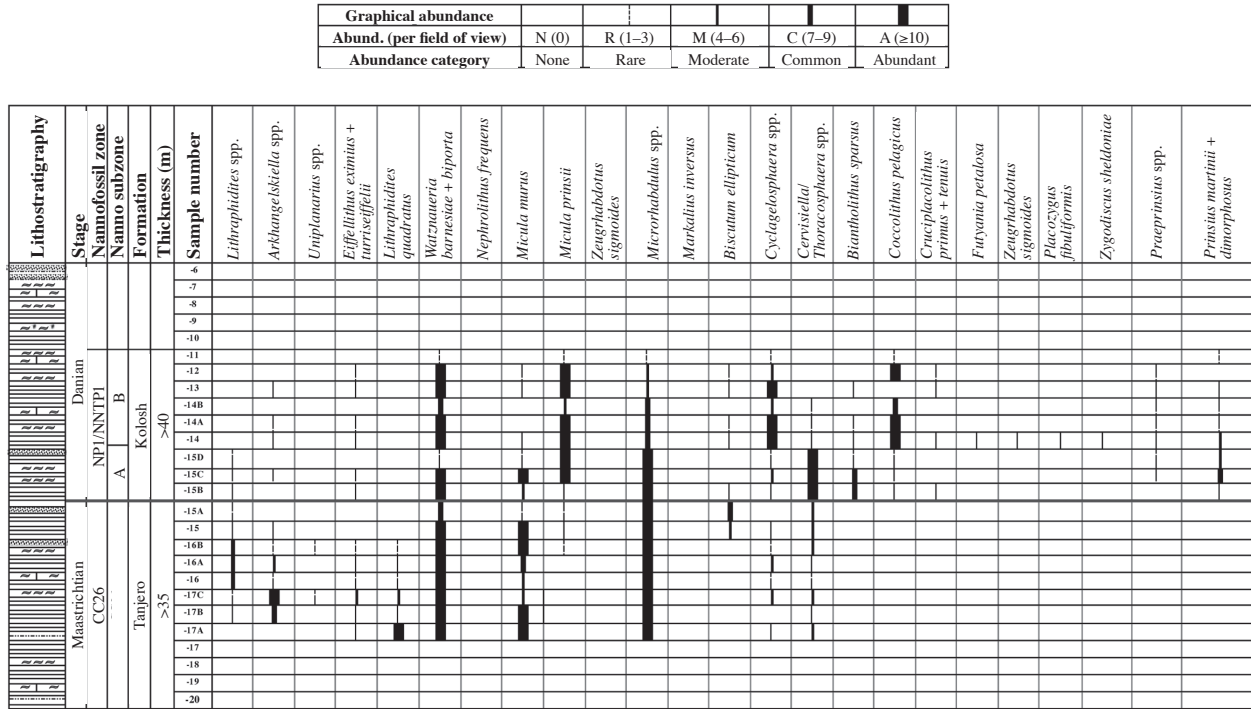


Figure 5: Calcareous nannofossil biostratigraphic zonation of the Deramazan section

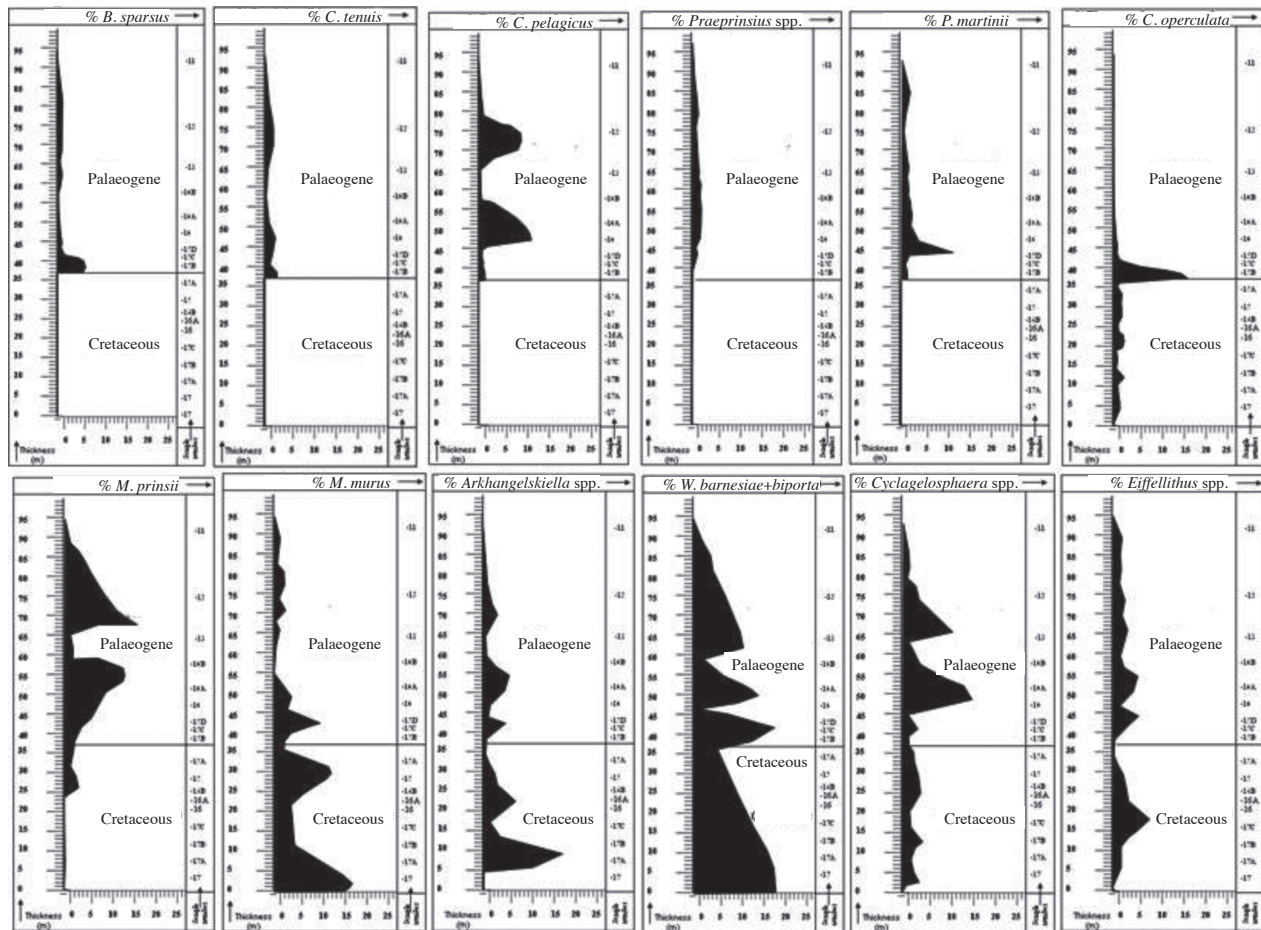


Figure 6: Percent abundance of selected nannofossil species across the K-Pg boundary in the Deramazan section, 0-95 m

## 5.2 Palaeogene

Plate 1 illustrates some of the common Lower Danian species from the Deramazan section, whilst Figures 5 and 6 present plots of the distributions and relative abundances in Zones NP1 and NP2. The Lower Danian assemblages of NP1 are moderately well preserved. *Biantholithus*, the first genus to evolve in the Palaeogene, is common, and represented by *B. sparsus* (Plate 1, figs 12–15), which is common in the lower part of NP1. Other Palaeogene taxa in the sequence are *Coccolithus pelagicus* (Plate 1, fig. 11; Plate 2, fig. 21), *Cruciplacolithus primus* (Plate 1, fig. 7), *Prinsius martinii* (Plate 1, fig. 8), *Praeprinsius dimorphosus* (Plate 1, figs 9, 10) and *Cyclagelosphaera alta* (Plate 1, fig. 2). Some species that evolved in the Late Cretaceous, and are considered to be K–Pg survivors were present, include *Cervisiella operculata* (Plate 1, fig. 6), *Zeugrhabdotus embergeri* (Plate 1, fig. 3) and *Z. sigmoides* (Plate 1, fig. 4).

The Lower Danian sequence encompasses Samples -14B to -11. The Upper Danian is not included here. Reworked fragments and whole specimens of Upper Maastrichtian nannofossils that were observed in the Lower Danian may have resulted from Early Danian turbidity currents or tsunami-induced redeposition resulting from the K–Pg bolide impact (Kristan-Tollmann & Tollmann, 1994).

## 6. Biostratigraphy

### 6.1 CC26 (Upper Maastrichtian)

According to Perch-Nielsen (1985a), the uppermost Maastrichtian zone is CC26 (of Sissingh, 1977), based on the base of *Nephrolithus frequens* and the extinct of most Cretaceous taxa. This works well at high latitudes, where *N. frequens* is relatively common. Problems arise at the top of this zone because Cretaceous taxa are often found reworked into overlying Paleocene deposits. At low latitudes, *N. frequens* is very rare, and the bases of *M. murus* and then *M. prinsii* can be used to subdivide the interval between the base of *L. quadratus* (base CC25b) and the top of the Maastrichtian, which is what we did here. Using the extinct of Cretaceous taxa to determine the top of the Maastrichtian was unfeasible due to reworking. We therefore used the bases of Lower Danian taxa to locate the boundary. Note that some reworked Upper Maastrichtian taxa occurred in higher abundances in the Danian than the in-situ Danian species (Figures 5, 6).

### 6.2 NP1 (Lower Danian)

According to Perch-Nielsen (1985b), the lowest nannofossil zone in the Palaeogene (Paleocene) is NP1 (of Martini, 1971), the base of which is defined by the top of Cretaceous taxa and the base of an acme of *Cervisiella operculata*. The base of the following zone (NP2) is defined by the base of *Cruciplacolithus tenuis*. According to Burnett et al. (1998, fig. 6.8), NP1 can be divided into two sub-zones—NNTp1A and NNTp1B (of Varol, 1989).

#### 6.2.1 NNTp1A

The base of this subzone is defined by the top of Cretaceous taxa and base of *B. sparsus* and/or *C. alta*. The top is defined by the base of the following subzone. In this study, we found the base of *B. sparsus*, accompanied by relatively abundant *C. operculata*, in Sample -15B, and so this was designated the base of NP1/NNTp1A.

#### 6.2.2 NNTp1B

The base of this subzone is defined by the top of *Biantholithus hughesii* and/or base of *C. primus*. It contains the first common occurrence of *Zeugrhabdotus sigmoides* (Sample -14; Plate 1, fig. 4), which is a Cretaceous survivor species.

### 6.3 NP2 (Lower Danian)

This zone extends from the base of *C. tenuis* to the base of *Chiasmolithus danicus*. Some authors use the base of any *Cruciplacolithus* species—usually *C. primus*, a small form of the genus—to determine the base of NP2. The detailed zonation of NP2 was not studied.

## 7. Discussion

The lithostratigraphy and calcareous nannofossil assemblages clearly indicate that deposition was essentially continuous across the K–Pg boundary. This finding differs from those of earlier studies, which have proposed a significant break at the boundary. For example, van Bellen et al. (1959) determined that, during the K–Pg interval, the environmental controls on facies distribution changed considerably, and that it was unusual to find Maastrichtian rocks overlain by sediments of Paleocene age. They also noted that the unconformity between the Tanjero Formation and the overlying Kolosh Formation was marked by a complete faunal change, with no transitional elements. Buday (1980) also described both formations, concluding

that the lower contact of the Kolosh Formation was clearly unconformable and transgressive. In the type area, the Tanjero Formation underlies the Kolosh Formation, but in other areas, the Kolosh Formation is underlain by the Shiranish Formation.

The results of our study also do not match with those of Starkie (1994), who studied the Cretaceous to Lower Miocene calcareous nannofossils from Iraqi oil wells. He found that the Cenozoic succession lay unconformably above the Upper Cretaceous, determining that 3.7–6.1 Myr (NP1 to NP3) were missing. He thought the unconformity was probably the result of the tectonic processes that were active during the final closure of the Tethys Ocean during the Late Cretaceous.

Other hypotheses have considered the Danian sediments of Kurdistan and Iraq to be absent, and that a conglomerate bed marks the K–Pg boundary. The results of this study, however, prove that Danian sediments do exist in this region, and that the conglomerate bed is not at the K–Pg boundary.

## 8. Concluding remarks

Our biostratigraphic analysis of calcareous nannofossil assemblages across the K–Pg boundary from the Deramazan section near the city of Sulaimani, Iraq documents the presence of CC26, indicating the Upper Maastrichtian, and NP1–NP2 (including NNTp1A and NNTp1B), indicating the Lower Danian. The completeness of these zones—with uppermost Maastrichtian species giving way to lowermost Danian species—suggests a depositional transition with no significant break or hiatus.

## Acknowledgments

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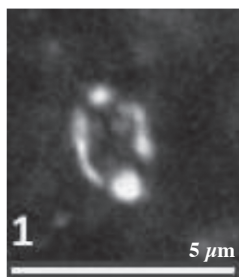
Jalil for his assistance during the fieldwork. We are grateful to two reviewers for their comments on the manuscript.

## References

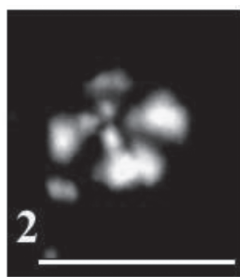
- Abdel-Kareem, M.R. 1986. Planktonic foraminifera and stratigraphy of the Tanjero Formation (Maastrichtian), Northeastern Iraq. *Journal of Micropaleontology*, **32**(3): 215–231.
- Al-Qayim, B.A. 1994. Evolution of flysch basin along the north-eastern margin of the Arabian Plate. *Geology of Jordan and Adjacent Areas*. Geocom III, Amman: 347–372.
- Al-Qayim, B.A., Omar, A. & Koyi, H. 2012. Tectonostratigraphy overview of the Zagros suture zone, Kurdistan region, Northeast Iraq. *Geoarabia/Gulf Petrolink, Bahrain*, **17**(4): 109–156.
- Buday, T. 1980. *Regional Geology of Iraq, Volume 1. Stratigraphy*. Geological Survey of Iraq, Baghdad: 445 pp.
- Buday, T. & Jassim, S.Z. 1987. *Regional Geology of Iraq, Volume 2. Tectonism, magmatism and metamorphism*. Geological Survey of Iraq, Baghdad: 352 pp.
- Burnett, J.A., Gallagher, L.T. & Hampton, M.J. 1998. Upper Cretaceous. In: P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontological Society Series. Chapman & Hall/Kluwer Academic Press, Amsterdam: 132–199.
- Jassim, S.Z. & Goff, J.C. 2006. *Geology of Iraq*. Dolin, Prague and Moravian Museum, Brno: 341 pp.
- Karim, K.H. 2004. *Basin analysis of Tanjero Formation in Sulaimaniya area, NE Iraq*. Unpublished PhD thesis, University of Sulaimani, Iraq: 135 pp.
- Kristan-Tollmann, E. & Tollmann, A. 1994. The youngest big impact on Earth deduced from geological and historical evidence. *Terra Nova*, **6**(2): 209–217.
- Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. In: A. Farinacci (Ed.). *Proceedings of the Second Planktonic Conference, Roma, 1970*, **2**: 739–785.
- Perch-Nielsen, K. 1985a. Mesozoic calcareous nannofossils. In: H.M. Bolli, J.B. Saunders & K. Perch-Nielsen (Eds). *Plankton Stratigraphy*. Cambridge University Press, Cambridge: 329–426.
- Perch-Nielsen, K. 1985b. Cenozoic calcareous nannofossils. In: H.M. Bolli, J.B. Saunders & K. Perch-Nielsen (Eds). *Plankton Stratigraphy*. Cambridge University Press, Cambridge: 427–554.
- Sharbazheri, K.M. 2009. Biostratigraphy of the Cretaceous/Tertiary boundary in the Sirwan Valley (Sulaimani region,



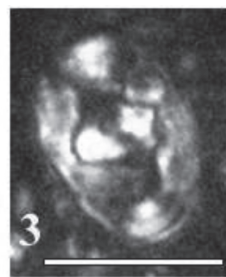
# Plate 1



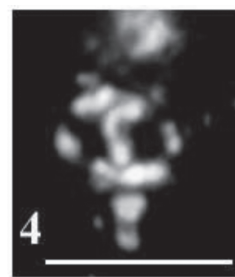
*Cruciplacolithus* sp. (-6)



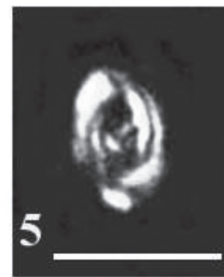
*Cyclagelosphaera* *alta* (-11)



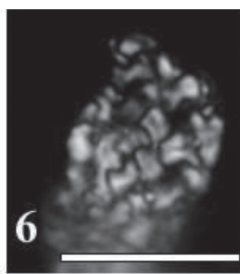
*Zeugrhabdotus* *embergeri* (-14)



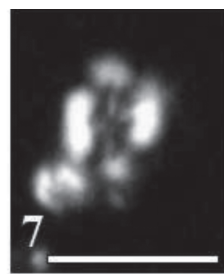
*Zeugrhabdotus* *sigmoides* (-14)



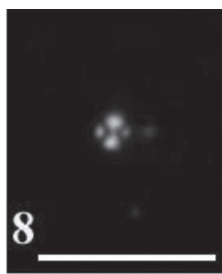
*Placozygus* *fibuliformis* (-14)



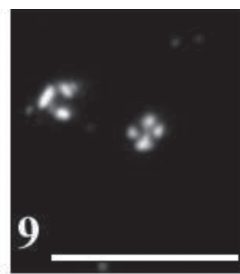
*Cervisiella* *operculata* (-15D)



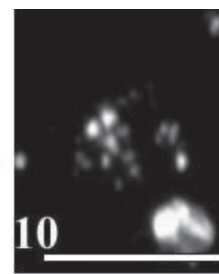
*Cruciplacolithus* *primus* (-11)



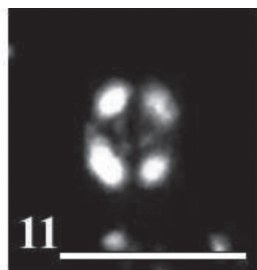
*Prinsius* *martinii* (-14)



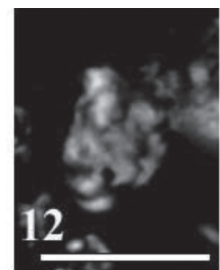
*Praeprinsius* *dimorphosus* (-15C)



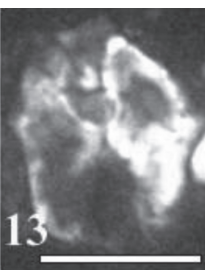
*P. dimorphosus* (-14A)



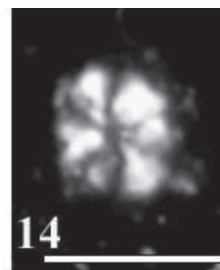
*Coccolithus* *pelagicus* (-15C)



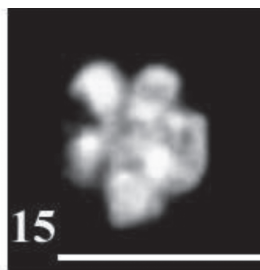
*Biantholithus* *sparsus* (-13)



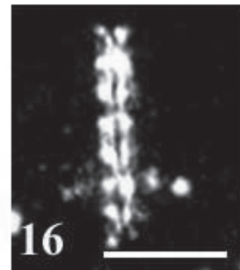
*B. sparsus* (-13)



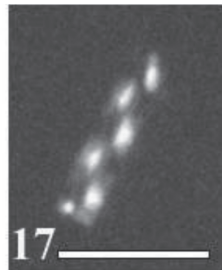
*B. sparsus* (-14A)



*Biantholithus* *sparsus* (-15B)



*Microrhabdulus* *undosus* (-15B)



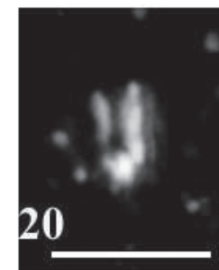
*M. undosus* (-15B)



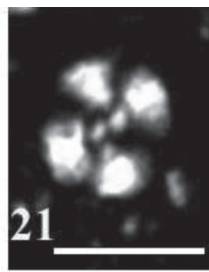
*M. undosus* (-16A)



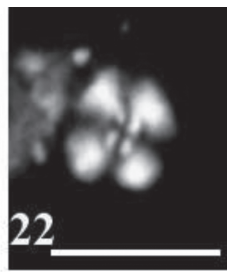
*Neocrep. neocrassus* (-15A)



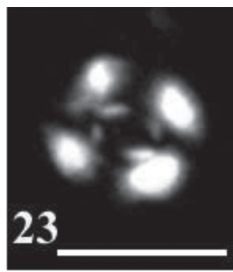
*Lapideacassis* *bispinosa* (-15A)



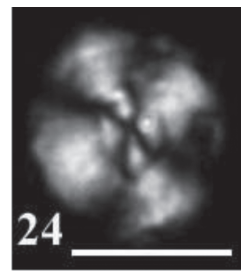
*Watznaueria* *barnesiae* (-15A)



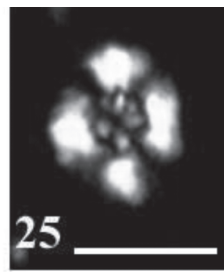
*W. barnesiae* (-15A)



*Watznaueria* *ovata*? (-14A)

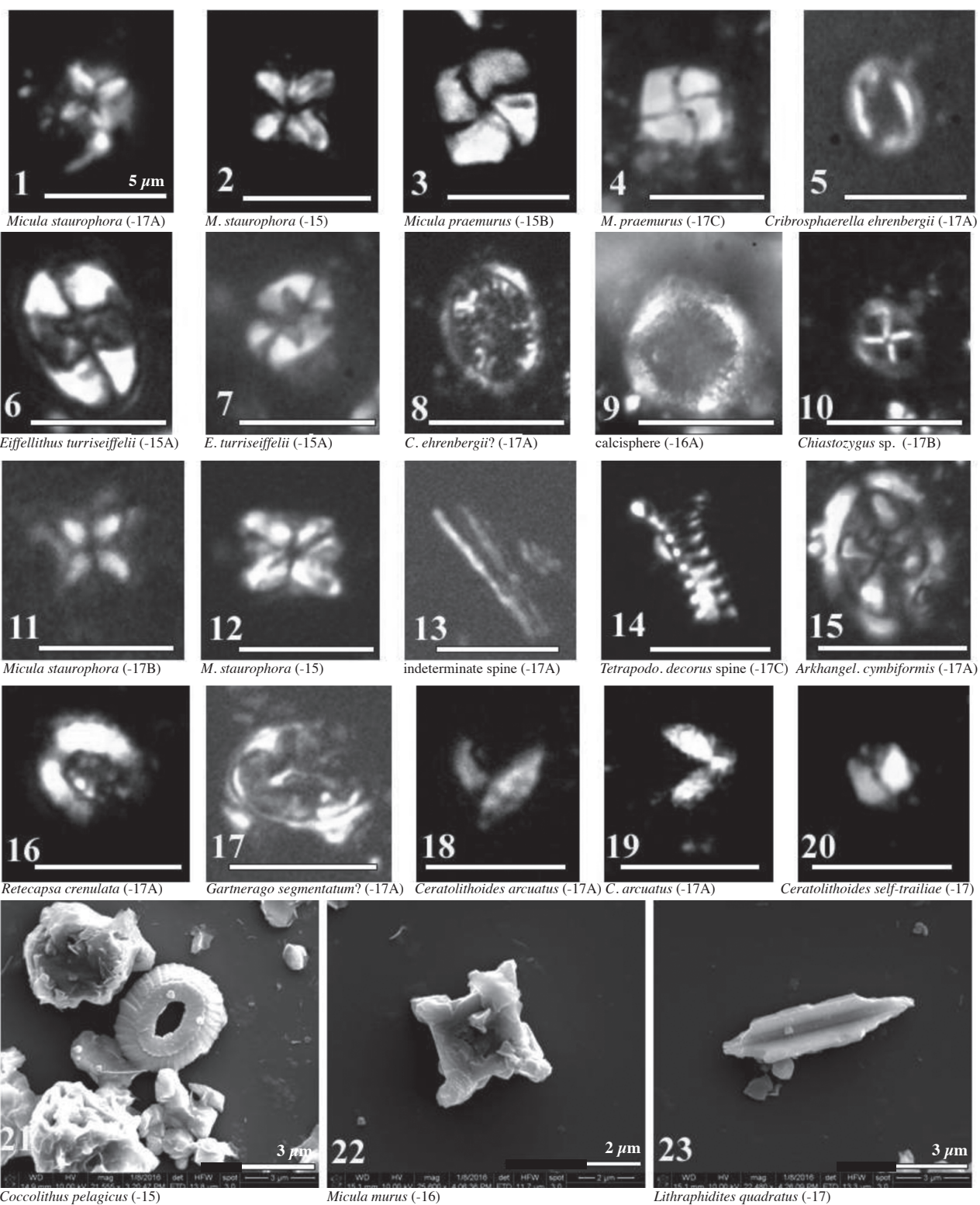


*W. barnesiae* (-15)



*Retecapsa* *angustiforata* (-15A)

# Plate 2



- Kurdistan, NE Iraq). *Geologica Carpathica*, **60**(5): 381–396.
- Sissingh, W. 1977. Biostratigraphy of Cretaceous nannoplankton. *Geologie en Mijnbouw*, **56**: 37–65.
- Starkie, S.P. 1994. *Calcareous nannofossil biostratigraphy and depositional history of the Late Cretaceous to Early Miocene sequence of Iraq*. Unpublished PhD thesis, University College London, UK: 325 pp.
- van Bellen, R.C., Dunnington, H.V., Wetzel, R. & Morton, D. 1959. *Lexique stratigraphique international, Asie (Iraq)*. Iraq International Geological Congress Commission on Stratigraphy, 3: 333 pp.
- Varol, O. 1989. Palaeocene calcareous nannofossil biostratigraphy. In: J.A. Crux & S.E. van Heck (Eds). *Nannofossils and their applications*. British Micropalaeontological Society Series/Ellis Horwood Limited, Chichester: 267–310.
- Winter, A. & Siesser, W.G. 1994. *Coccolithophores*. Cambridge University Press, Cambridge: 242 pp.