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CALCAREOUS NANNOFOSSIL STRATIGRAPHY OF THE UPPER CRETACEOUS – LOWER PALEOCENE SEQUENCE FROM THE CHINAROK SECTION, SULAIMANIAH AREA, KURDISTAN REGION, NE IRAQ

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Key words: Tanjero and Kolosh Formations; K/Pg boundary; Nannofossils; Maastrichtian; Danian; Sulaimanyah; Kurdistan; Iraq

ABSTRACT

The Cretaceous/ Paleogene boundary in the Kurdistan region of Iraq is still under debate. Most studies consider the Danian sediments to be mostly missing. We examined the boundary succession of the Chinarok section in the Sulaimaniyah area of the Kurdistan Region to examine calcareous nannofossil assemblages as well as the biostratigraphy of the boundary. The rock strata in the study section are characterized by alternations of organic shale, marlstone, siltstone, fine- grained sandstone, and organic limestone interlayer within the Tanjero Formation (upper Maastrichtian) and the overlying Kolosh Formation (Paleocene – Lower Eocene). The study shows that deposition across the boundary is continuous with no break in sedimentation. The boundary is biostratigraphically delineated by the first occurrences *of Biantholithus sparsus, Cruciplacolithus spp. and Coccolithus pelagicus* plus an acme of *Thoracosphaera operculata* of biozone NP1 that indicate no hiatus; there is reworking of the Cretaceous taxa all above the Cretaceous/ Paleogene boundary into zones NP1 and NP2.

نانوستراتيكرافى الكلسى للتتابع الكريتاسى الأعلى – الباليوسين الأسفل في مقطع جناروك في منطقة السليمانية، إقليم كردستان، شمال شرق العراق

سوران عثمان خراجيانى، باسم عبد الخالق القيم و شيروود وايز

المستخلص

لاتزال الحدود الطباشيرية/ الباليوجينية في إقليم كردستان العراق قيد المناقشة. معظم الدراسات تعتبر أن رواسب الدانين هي في معظمها مفقودة. فحصنا تتابع الحد من مقطع جناروك في منطقة السليمانية، إقليم كردستان لدراسة تجمعات النانو الكلسية بالإضافة إلى دراسة نطاق الحيوي للحد. تتميز الطبقات الصخرية في مقطع الدراسة بتواجد صخر طفل العضوي، مارلستون، حجر الجيري، الحجر الرملي ذات الحبيبات الصغيرة، والطبقة من الحجر الجيري العضوية المتداخلة في تكوين تانجيرو (ماستريختان العليا) وتكوين كولوش (باليوسين – الإيوسين السفلي). هذه الدراسة تدل على أن الترسب عبر الحد الطباشيري/ الباليوجيني مستمر بدون انقطاع في الترسيب. تم تعريف الحد من خلال ظهور الأول لاجناس *Biantholithus sparsus*، *Cruciplacolithus* spp. و *Coccolithus pelagicus* بالإضافة إلى ذروة لظهور *Thoracosphaera operculata* من نطاق NP1 التي تشير إلى عدم وجود فجوة فى الترسيب. هناك اختلاط لترسبات العصر الكريتاشى فوق الحدود الطباشيري/ الباليوجيني إلتى وصل الى نطاقى NP1 و NP2.

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INTRODUCTION

The Cretaceous/ Paleogene boundary (K/Pg) in northeast Iraq has been studied by many authors using planktonic foraminifera such as the study of Abdel-Kareem (1986) and Sharbazheri (2009). Kassab (1974) analyzed the biostratigraphy of the Upper Cretaceous/ Lower Tertiary sequence of north Iraq. Al-Shaibani *et al*. (1986) analyzed the stratigraphy of the Cretaceous – Tertiary contact at the Dokan area, Sulaimanyah, North Iraq. Ghafor (1988) examined the planktonic foraminifera and biostratigraphy of the Aaliji Formation and its contact with the Shiranish Formation in Well Tel-Hajar No.1. Beside, Starkie (1994) studied calcareous nannofossil biostratigraphy and depositional history of the Late Cretaceous to Early Miocene sequence of Iraq.

Our study examines the stratigraphic sequence across this boundary at one locality using calcareous nannofossils. This globally important boundary is characterized in our area by a sequence of flysch sediments of the foreland basin on the Northeast Arabian Plate (Al-Qayim *et al*., 2012). The Maastrichtian Tanjero Formation and the overlying Paleogene Kolosh Formation represent the flysch sediments. The Chinarok section was selected for a case study to sample and re-examine the age of the sequence, which is 170 meters thick. The Chinarok section is inside Kani Kand Village, 250 meters north of the Chinarok resort at the toe of the northeast limb of the Haibat Sultan anticline (36° 07' 00'' N and 44° 40' 26'' E) (Figs.1 and 2).

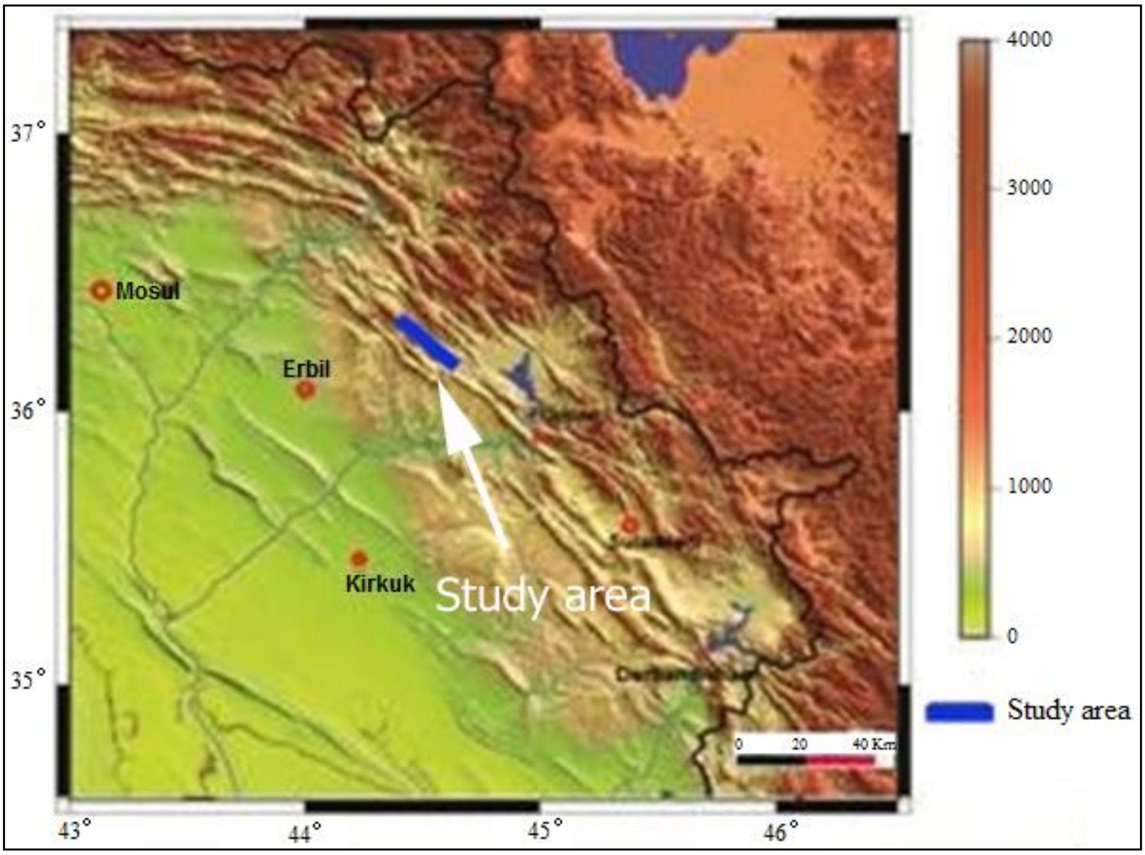

Fig.1: Relief map of northeast Iraq/ Kurdistan Region, shows the geographic location of the study area

Fig.2: Aerial photograph of the Chinarok section (tilted image, Google earth). The green arrow denotes the measured section

GEOLOGICAL SETTING

The study area is located within the High Folded Zone of the Zagros orogenic belt, which is characterized by numerous folds and faults that strike northwest-southeast. The most of the features and units are shown in Fig.1. The structures in this zone are linear, curvilinear, asymmetrical, doubly-plunging, high-amplitude, and arranged in an en-echelon pattern on the surface (Buday and Jassim, 1987). To the northeast are the complicated, imbricate Zagros Suture Zones, whereas to the southwest the folds become low in elevation with broader synclines in the Low Folded Zone (Jassim and 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). Bellen *et al*. (1959), from the type section in the Sirwan Valley, first described the Tanjero Formation; it comprises two divisions. The lower division is pelagic marl and occasional beds of argillaceous limestone with siltstone beds in its upper part. The upper division is silty marl, sandstone, conglomerate, and sandy or silty organic detrital limestone. Beneath the Tanjero Formation is the Shiranish Formation with a gradational and conformable contact. The overlying sequence is the Kolosh Formation. The formation was deposited in a deep marine trough with flysch sediments (Buday, 1980).

The Kolosh Formation was first described by Bellen *et al*. (1959) at the village of Krozh, north of the town of Koya (southwest of the city of Sulaimanyah). The Formation consists of alternating shale and sandstones. At the Sirwan Valley, Bellen *et al*. (1959) found that the Kolosh Formation unconformably underlies the Tanjero Formation. The unconformity is marked by a total faunal change without transitional elements, while the red beds of the Gercus Formation cover the overlying formation.

MATERIAL AND METHODS

Five field trips were conducted to examine, measure, and describe the stratigraphy of the section. 52 rock samples were yielded and standard smear slides were prepared to study the calcareous nannofossils with particular focus on the Cretaceous/ Paleogene transition. The sample numbers start from older (1) to the younger (52). The nannofossil study and its biostratigraphy are based on the examination of smear slides prepared from rock samples using cross-polarized light microscopy at magnifications of 400X and 6300X. In addition, scanning electron microscopy (SEM) provided high- resolution nannofossil photography.

LITHOSTRATIGRAPHY OF THE SECTION

140 meters from the stratigraphic succession of the section at Chinarok are studied; the section lies near Kani Kand village. It is at the foot of the northeast side limb of Haibat Sultan anticline (Figs.2 and 3). The main stratigraphic units of the area belong to the Shiranish, Tanjero, Kolosh, Khurmala, Gercus and Pila Spi Formations; they range from the Campanian to the upper Eocene.

Fig.3: The Cretaceous/ Paleogene boundary along the Chinarok section

The lithology of the studied sequence at Chinarok (Fig.4) consists of dark organic shale, organic limestone, marlstone and fine-grained sandstone of the Tanjero Formation. At the top of the beds, the color of the argillaceous shale and marl becomes brown due to iron-rich minerals. It appears at the tops of the hills in the area as horizons; this succession is designated as Unit A, and its thickness is more than 125 m. The same sequence repeats itself, but the marlstones become more calcareous and the sandstones become thicker, contain chalk, and are regarded as Unit B (50 m thick). The Tanjero Formation passes gradually into the Kolosh Formation with a similar lithology, except for the presence of thick, friable sandstone and light green to gray, thin beds of marly limestone and pinkish red claystone in the lower part of the Kolosh Formation.

In the lower part of the Kolosh Formation, the beds consist of cyclic alternation of marly chalky limestone (2 meters thick) and medium beds of dark gray sandstone, they are interbeded with the shale and marlstone beds. In addition, within the same sequence, thick beds of pinkish red claystone are interbeded with the shale and marlstones. The sandstone beds become thicker toward the upper part; that is specified as Unit C (30 m thick). The red claystone might be due to a connection of the sedimentary basins of the Kolosh Formation and the contemporaneous Red Bed Series or simultaneous deposition of both units. Unit D is the beginning of the Danian sediments and the lower part of the Kolosh Formation. It consists of cyclic alternations of thinly bedded, laminated, graded bedded sandstone, thin chalky marly limestone and black silty calcareous shale. The sandstones become thicker toward the upper part.

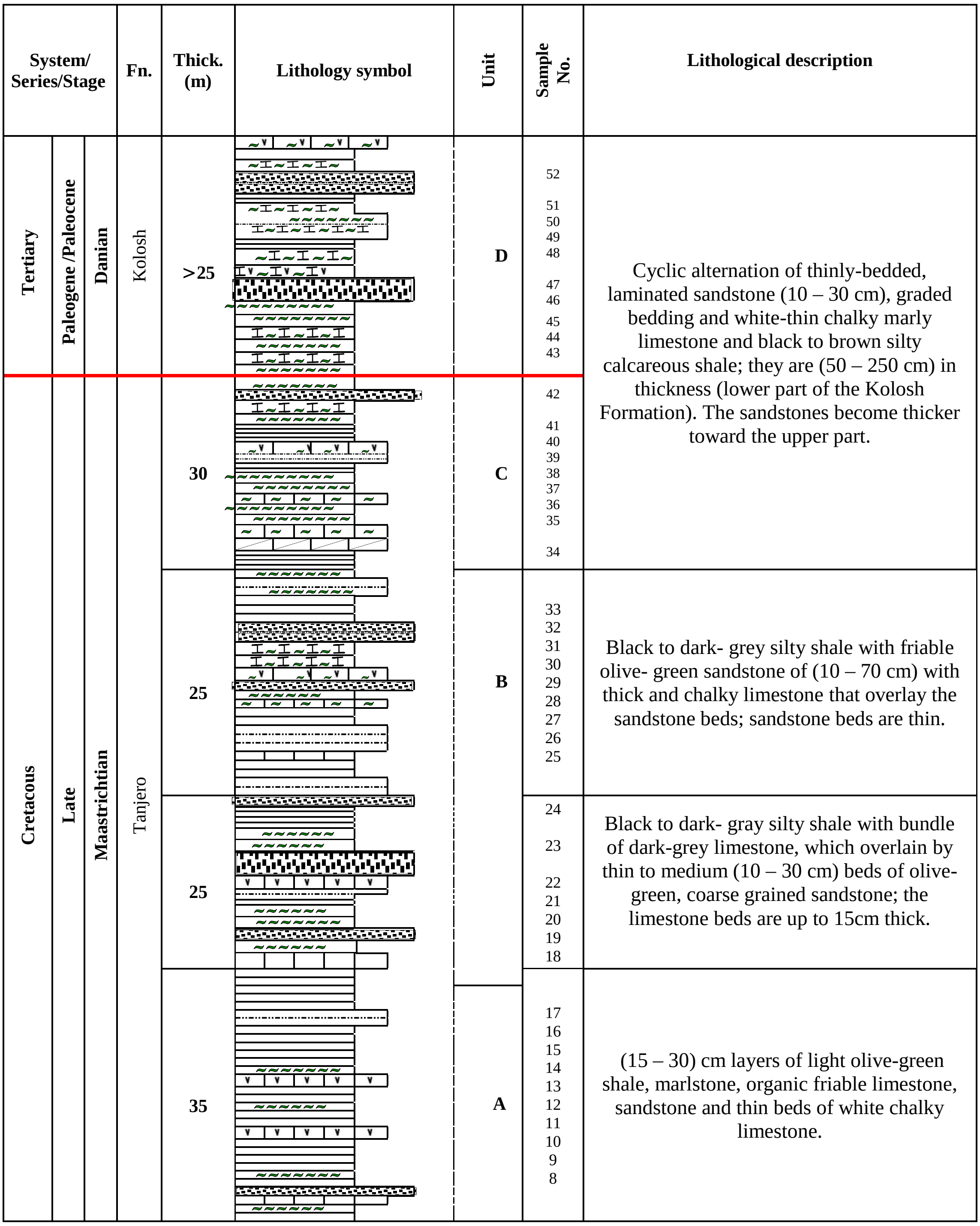

Fig.4: Lithostratigraphic column of the Chinarok section

BIOSTRATIGRAPHY

The zonation schemes for calcareous nannofossils used here follow Perch-Nielsen (1985a and b) (Fig.5).

- **Nannofossil assemblage of the Late Maastrichtian**

– ***Nephrolithus frequens* Zone (CC26):** In the Chinarok section, the nannofossils are well preserved and the overgrowth of calcite crystals is very low; calcite crystals remain without overgrowth (diagenesis). Most of the Maastrichtian genera are reworked into the Danian. The nannofossil assemblage of Zone CC26 here includes: *Micula staurophora* Gardet, 1955 (Fig.6.10), *Micula prinsii* Perch-Nielsen, 1979 (Figs.6.11, 24 and 39), *Micula premolisilvae* Lees and Bown, 2005 (Fig.6.12), *Micula swastica* Stradner and Steinmetz, 1984 (Fig.6.15), *Micula murus* Martini, 1961 (Fig.6.16), *Lithraphidites quadratus* Bramlette and Martinii, 1964 (Fig.6.40), *Lithraphidites alatus* Thierstein *in* Roth and Thierstein, 1972 (Fig.6.29), *Arkhangelskiella cymbiformis* Vekshina, 1959 (Fig.6.31), *Arkhangelskiella confusa* Burnett, 1998 (Fig.6.34), *Arkhangelskiella maastrichtiensis* Burnett, 1998 (Fig.6.14), *Uniplanarius trifidus* Stradner in Stradner and Papp, 1961 and Hattner and Wise, 1980 (Fig.6.35), *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968 (Fig.6.23), *Watznaueria barnesiae* Black in Black and Barnes, 1959 and Perch-Nielsen, 1968 (Fig.6.28), *Microrhabdulus undosus* Perch-Nielsen, 1973 (Fig.6.17 and 26), *Zygodiscus plectopons* Bramlette and Sullivan, 1961 (Fig.6.27), *Placozygus spiralis* Bramlette and Martini, 1964 (Fig.6.19), *Placozygus banneri* Lees, 2007 (Fig.6.33), *Cribrosphaerella santacruzensis* Perch-Nielsen, 1973 (Fig.6.22), *Cribrosphaerella ehrenbergii* Arkhangelsky, 1912 (Fig.6.30), and *Retecapsa ficula* Stover, 1966 (Fig.6.32). The identified survivor species are *Neocrepidolithus cohenii* (Perch-Nielsen, 1968) (Fig.6.13) and *Thoracosphaera operculata* Bramlette and Martini, 1964 (Fig.6.25). Plate A shows the genera/ species of the assemblages and Fig.7 represent the range chart of the Maastrichtian and early Danian and their boundary. Fig.8 shows the relative abundances of selected individual species based on counting method. It shows the dominance of species of *Watznaueria, Micula murus, Cyclagelosphaera alta* and *Arkhangelskiella* over all other species. Also, *Thoracosphaera* spp. are dominant, whereas most of the Maastrichtian taxa are reworked into the Danian.

- **Nannofossil assemblage of the Early Danian**

The assemblages of the Early Danian of the Chinarok section are well preserved, and the calcite crystals have low to moderate overgrowth and are widely distributed. The species *Biantholithus sparsus* appears in sample CHO43 and is regarded as the boundary between late Maastrichtian and Early Danian (K/Pg). See lithostratigraphic column in Fig.4. The identified taxa are: *Biantholithus sparsus* Bramlette and Martinii, 1964 (Figs.6.20 and 36), *Coccolithus pelagicus* (Wallich, 1877) Schiller, 1930 (Figs.6.2 and 4), *Prinsius martini* (Perch-Nielsen, 1969), Haq, 1971. (Fig.6.3) *Chiasmolithus danicus* Hay and Moller 1966 (Fig.6.5), *Praeprinsius tenuiculus* Varol and Jakubowski 1989 (Fig.6.1), *Praeprinsius dimorphosus* (Perch-Nielsen, 1969 (Fig.6.38), *Cruciplacolithus tenuis* Stradner, 1961 (Fig.6.6 and 9), *Cruciplacolithus intermedius* Van Heck and Prins, 1987 (Figs.6.7 and 37), *Cruciplacolithus primus* Perch-Nielsen, 1977 (Fig.6.21), and *Cruciplacolithus asymmetricus* Van Heck and Prins, 1987 (Figs.6.8 and 41).

– ***Markalius inversus* Zone (NP1):** The bloom or acme of the genus *Thoracosphaera* is here recorded above the boundary a few meters before the first occurrence of *Biantholithus sparsus*. The first occurrence of *Biantholithus sparsus* is in sample number CHO43; samples CHO43 to 44 represent the early Danian (NP1).

– ***Cruciplacolithus tenuis* Zone (NP2):** The *Cruciplacolithus* spp. are developed and well preserved within this sequence. The first occurrences of *Cruciplacolithus* spp. such as *Cruciplacolithus primus*, *Cruciplacolithus tenuis* and *Cruciplacolithus intermedius* are identified in samples CHO45 and above; where they represent zone NP2.

- **Biostratigraphic zonation**

The zonation schemes for calcareous nannofossils used here follow Perch-Nielsen (1985a) for the Maastrichtian as shown in Fig.5. According to Perch-Nielsen (1985a) the uppermost zone for the late Maastrichtian is the *Nephrolithus frequens* Zone (CC26). The boundary is based here on the first occurrence of the marker species *Biantholithus sparsus* is used (also seen in Figs.6 and 7) with an increase in the percentage of Danian forms above the boundary.

– **Late Maastrichtian** Zone

- ***Nephrolithus frequens* Zone (CC26):** This zone is defined by the first to last occurrence of *Nephrolithus frequens*, works well in high latitudes where *N. frequens* is relatively common. Problems arise with the top of this zone since *N. frequens* is found reworked into the overlying Paleocene. In low latitudes, *N. frequens* is very rare and here the first occurrence of *Micula murus* and the subsequent first occurrence of *Micula prinsii* can be used to subdivide the interval between the first occurrence of *Lithraphidites quadratus* (base of Zone 25c) and the top of the Maastrichtian (Figs.5 and 7). Since our study area is located within the low latitudes, *N. frequens* is not observed and the *Micula* spp. are reworked into the Paleocene, thus at the top of this zone it is difficult to determine the last occurrence of the Cretaceous specimen. We, therefore, used the first occurrences of early Danian taxa at the boundary. Some reworked Upper Maastrichtian species show high abundances compared to the Danian species as shown in Figs.6 and 7.

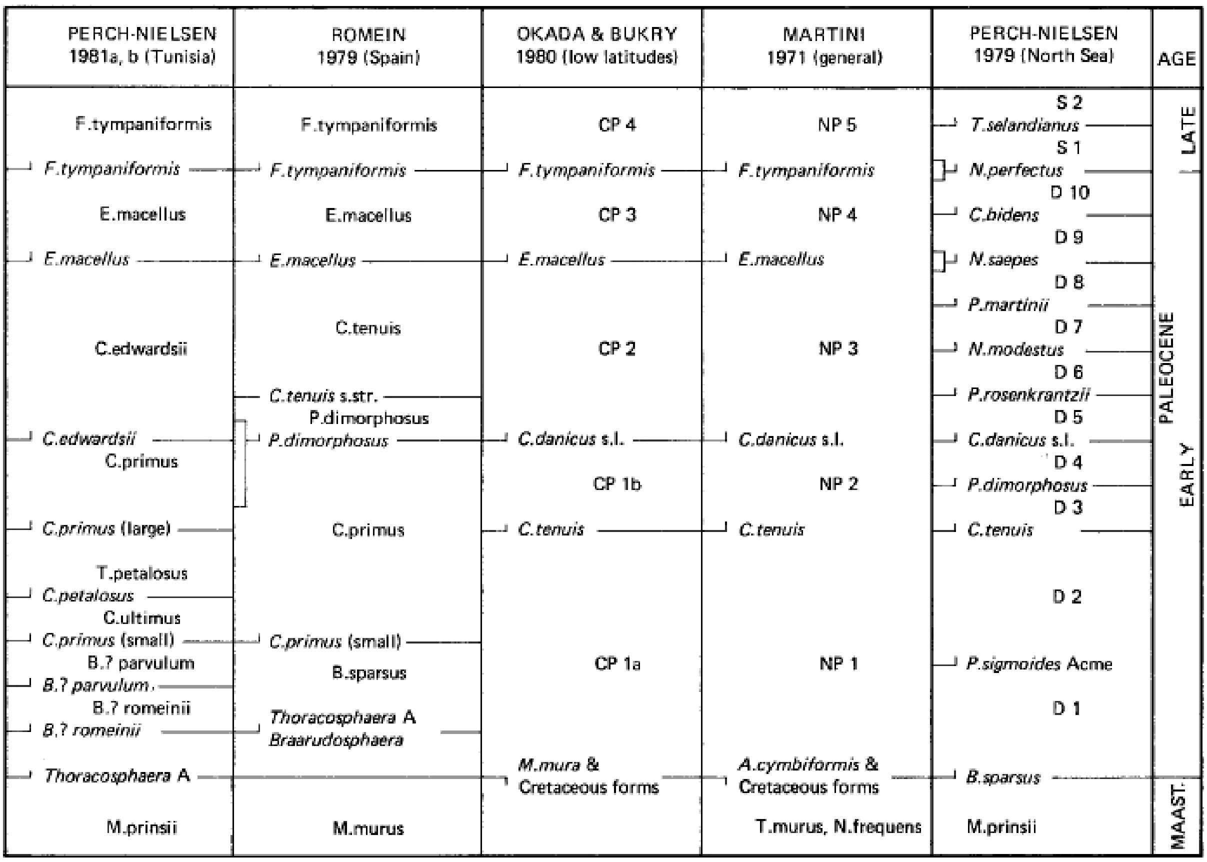

Fig.5: Definition and correlation of zones and subzones in the early Paleocene (From Perch-Nielsen, 1985b)

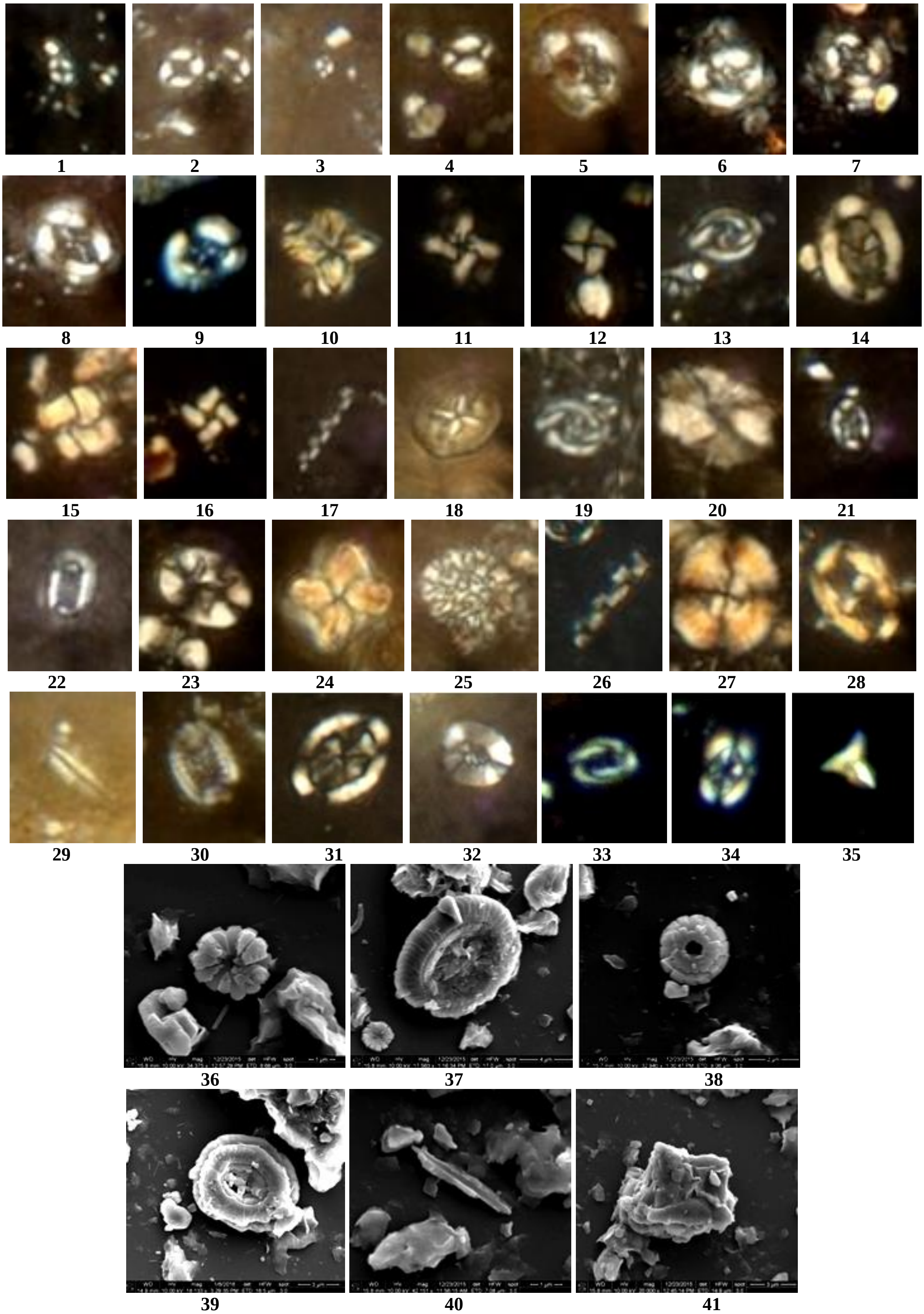

Fig.6: Selected calcareous nannofossil from the Chinarok section.
The figure frames represent five micrometers except the last 6 SEM photos

Cont. Fig.6:

1) *Praeprinsius tenuiculus* (sample CHO51);
2) *Coccolithus pelagicus* Wallich, 1877 Schiller ???, (sample CHO51);
3) *Prinsius martini* Perch-Nielsen, 1969 (sample CHO51);
4) *Coccolithus* sp. (sample CHO51);
5) *Chiasmolithus danicus* Hay and Mohler, 1967 (Sample CHO51);
6) *Cruciplacolithus tenuis* Stradner, 1961(Sample CHO51);
7) *Cruciplacolithus intermedius* Van Heck and Prins, 1987 (sample CHO51);
8) *Cruciplacolithus asymmetricus* Van Heck and Prins, 1987 (sample CHO51);
9) *Cruciplacolithus tenuis* or *intermedius* (sample CHO51);
10) *Micula staurophora* Gardet, 1955 (sample CHO49);
11) *Micula prinsii* Perch-Nielsen, 1979 (sample CHO47);
12) *Micula premolisilvae* Lees and Bown, 2005 (sample CHO47);
13) *Neocrepidolithus cohenii* Perch-Nielsen, 1968 (sample CHO47);
14) *Arkhangelskiella maastrichtiensis* Burnett, 1998 (sample CHO47);
15) *Micula swastica* Stradner and Steinmetz 1984 (sample CHO46);
16) *Micula murus* Martini, 1961 (sample CHO46);
17) *Microrhabdulus undosus* Perch-Nielsen, 1973 (sample CHO46);
18) *Chiastozygus* sp. (sample CHO45);
19) *Placozygus spiralis* Bramlette and Martini, 1964 (sample CHO45);
20) *Biantholithus sparsus* Bramlette and Martinii, 1964 (sample CHO45);
21) *Cruciplacolithus primus* Perch-Nielsen, 1977 (sample CHO43);
22) *Cribrosphaerella santacruzensis* Perch-Nielsen, 1973 (sample CHO43);
23) *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968 (sample CHO43);
24) *Micula prinsii* Perch-Nielsen, 1979 (sample CHO43);
25) *Thoracosphaera operculata* Bramlette and Martini, 1964 (sample CHO43);
26) *Microrhabdulus undosus* Perch-Nielsen, 1973 (sample CHO42);
27) *Watznaueria barnesiae* Perch-Nielsen, 1968 (sample CHO42);
28) *Zygodiscus plectopons* Bramlette and Sullivan, 1961 (sample CHO40;
29) *Lithraphidites alatus* Thierstein 1971 (sample CHO40);
30) *Cribrosphaerella ehrenbergii* Arkhangelsky, 1912 (Sample CHO39);
31) *Arkhangelskiella cymbiformis* Vekshina, 1959 (sample CHO36);
32) *Retecapsa ficula* Stover, 1966 (sample CHO36);
33) *Placozygus banneri* Lees, 2007 (sample CHO36);
34) *Arkhangelskiella confusa* Burnett, 1998 (sample CHO33);
35) *Uniplanarius trifidus* Stradner *in* Stradner and Papp, 1961 (sample CHO32);
36) *Biantholithus sparsus* Bramlette and Martinii, 1964 (sample CHO51);
37) *Cruciplacolithus intermedius* Van Heck and Prins, 1987 (sample CHO50);
38) *Praeprinsius dimorphosus* Perch-Nielsen, 1969 (sample CHO49);
39) *Cruciplacolithus asymmetricus* Van Heck and Prins, 1987 (sample CHO48);
40) *Lithraphidites quadratus* Bramlette and Martinii, 1964 (sample CHO37);
41) *Micula prinsii* Perch-Nielsen, 1979 (sample CHO37).

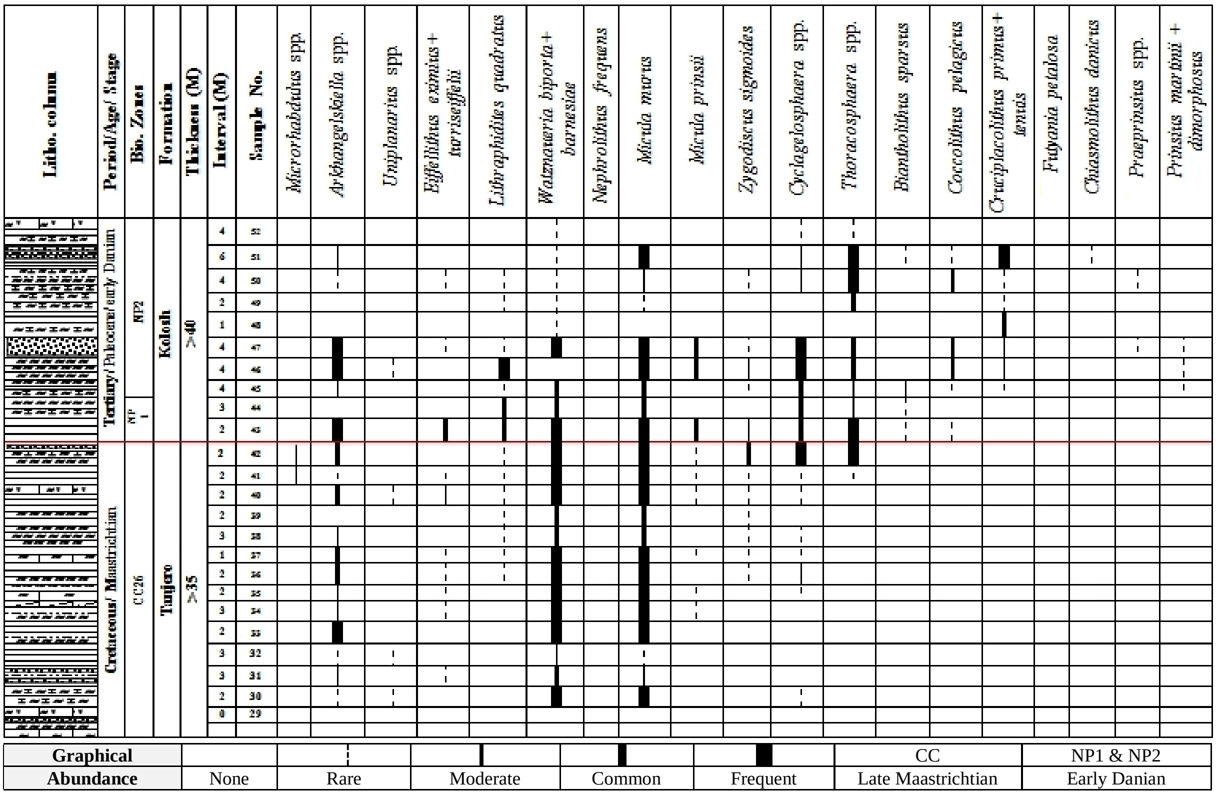

Fig.7: Calcareous nannofossil biostratigraphic zonation chart of the Chinarok section

– **Early Danian zones:** The Paleocene/ Early Danian was a time of rapid evolution after the very heavy ‘casualties’ at the Cretaceous/ Paleogene boundary. According to Perch-Nielsen (1985b), the zonation of calcareous nannofossils for the early Paleogene (Paleocene) starts with the *Markalius inversus* Zone (NP1).

A. ***Markalius inversus* Zone (NP1):** The zone NP1 is defined by last occurrence of the Cretaceous nannofossils or the first occurrence of the acme of *Thoracosphaera* to the first occurrence of *Cruciplacolithus tenuis.* The base is defined by the last occurrence of *Micula murus* and other Cretaceous species. The *Biantholithus sparsus* is defined as the interval from the massive occurrence of *Thoracosphaera operculata* to the first occurrence of the *Cruciplacolithus tenuis* (Fig.5); Samples 43 – 44 represent NP1. *Biantholithus sparsus* is the incoming species contemporaneous with the *Thoracosphaera operculata* (Bown, 1998).

B. ***Cruciplacolithus tenuis* Zone (NP2):** The zone NP2 is defined by the first occurrences of *Cruciplacolithus tenuis* to *Chiasmolithus danicus.* The lower boundary is NP1 as discussed above. Most authors put the base of NP2 at the first occurrence of any *Cruciplacolithus*, usually *Cruciplacolithus primus*, a small form of the genus (Fig.5). Sample 45 and above are included in this zone.

- **The Cretaceous/ Paleogene Boundary**

The massive change in calcareous nannofossil assemblages at the Cretaceous/ Paleogene boundary was first noted and illustrated by Bramlette and Martini (1964) and has since been described in detail (Perch-Nielsen, 1969, 1979a and b, 1981c; Percival and Fischer, 1977; Romein, 1977; in Perch-Nielsen, 1985a). The diverse Maastrichtian assemblage disappears suddenly, probably over a few thousands of years after mass mortality at the boundary. At low latitudes, *Thoracosphaera* bloomed shortly after the boundary after being quite sporadic during the Cretaceous. In high latitudes, *Thoracosphaera* first occurred above the boundary and did not bloom until after NP1. As Winter and Siesser (1994) stated, coccolithophores were quite abundant in both coastal and oceanic waters in both polar and equatorial waters, but the vast majority of species in the diverse coccolithophore community became extinct at the end of the Cretaceous. Here we noted the bloom of *Thoracosphaera* sp. at Sample 42 accompanied by the first occurrence of *Biantholithus sparsus*, which is where we placed the boundary.

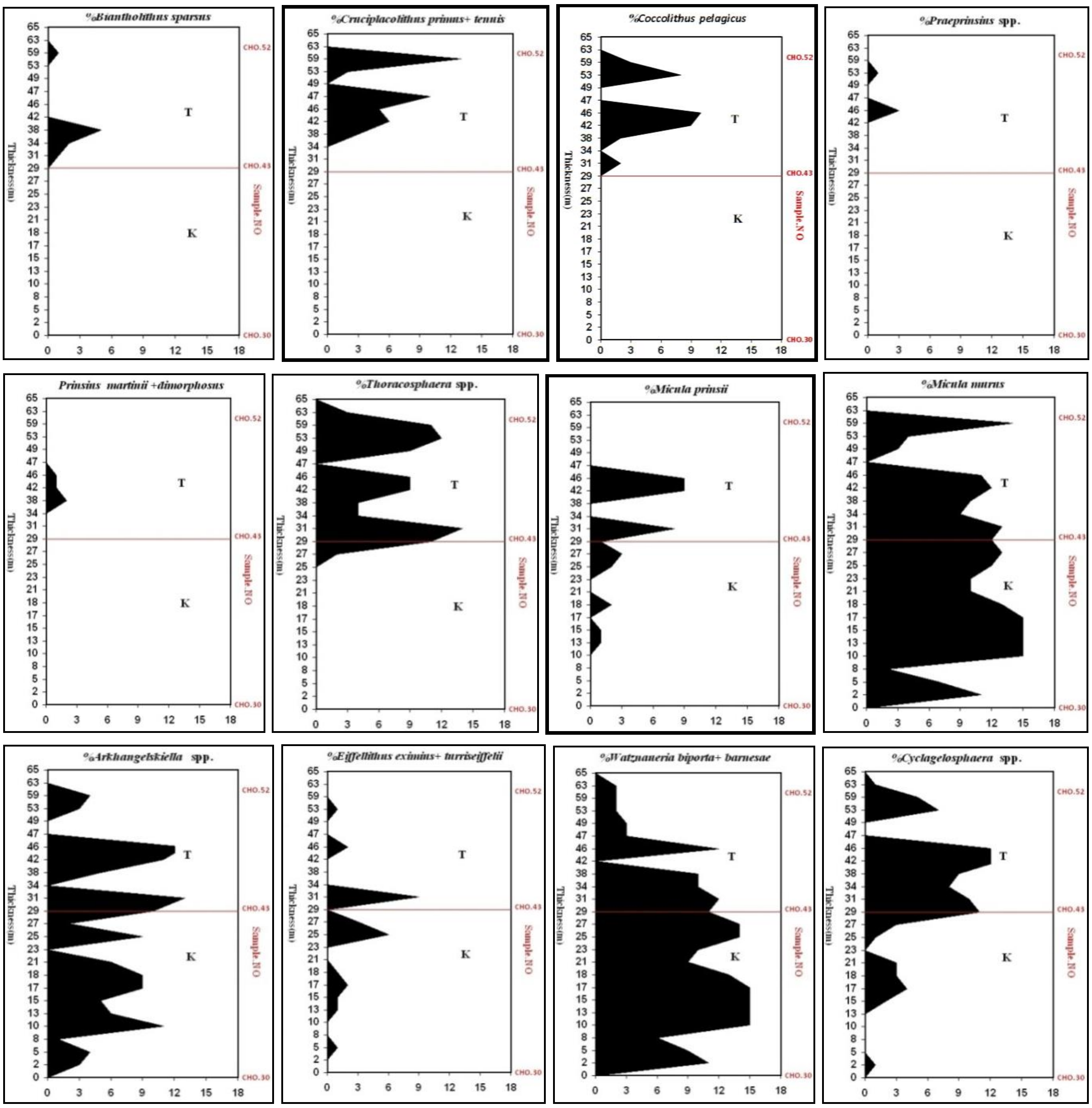

Fig.8: Percent abundance of selected calcareous nannofossil species across the Cretaceous/ Tertiary boundary at the Chinarok section

DISCUSSION

Figures 7 and 8 show nannofossil marker species like *Biantholithus sparsus*, *Cruciplacolithus tenuis*, and *Coccolithus pelagicus* are accompanied by *Praeprinsius* spp., such as *Prinsius martinii* and *Prinsius dimorphosus* with the acme of *Thoracosphaera operculata* at the beginning of the Paleogene (early Danian); they appear in Samples 43 to 52. Species like *Micula murus, Micula prinsii, Arkhangelskiella* spp., *Uniplanarius* spp., *Eiffellithus eximius, Lithraphidites quadratus, Watznaueria barnesae* and *Microrhabdulus* spp. indicative the latest Maastrichtian appear below Sample 43 (they also appear in all samples above the boundary due to reworking).

The lithostratigraphy and calcareous nannofossil assemblages recognized in this study clearly show that deposition was continuous and the boundary between the Cretaceous and Paleogene is lithologically gradational. The result of this study does not match the previous idea, which stated that there is a break between the boundary of Cretaceous and Paleogene. Specifically Bellen *et al*. (1959) stated that during the Tertiary/ Paleogene break, the environmental controls on facies distribution changed considerably, and it is unusual to find Maastrichtian rock-units on any particular facies overlain by precisely similar rock units of Paleocene age; i.e., the Tanjero Formation underlies the Kolosh unconformably. The unconformity is marked by a total faunal change without transitional elements. Buday (1980) also described both formations and he concluded that the lower contact of the Kolosh Formation is clearly unconformable and transgressive; in the type area the Tanjero Formation underlies the Kolosh Formation; whereas in other areas it is underlain by the Shiranish Formation. Fauna and fragments of the Cretaceous taxa/ species reworked into the Paleocene are considered to have been transported by turbidity currents during the early Danian.

The results of our current study also do not match the study of Starkie (1994), who studied the Cretaceous, to early Miocene calcareous nannofossils of Iraq oil wells. He states that this succession lay unconformably on the Upper Cretaceous and spans 3.7 – 6.1 Million years (NP1 to NP3). He believed the unconformity probably was the result of the tectonic processes active during the final closure of the Tethys Ocean during the Late Cretaceous. The presence of CC26 and NP1 Biozones are heterogeneous from the surroundings. Senemari and Azizi (2012) determined CC26-NP1 Biozones in Iran. In Jordan, Farouk *et al.* (2014) stated that the K/Pg boundary is marked by a major depositional hiatus that differs in magnitude from place to place.

Another previous hypothesis considered the Danian sediments in Kurdistan to be absent, whereas others considered a conglomerate bed to be the K/Pg boundary. But through this study, it is proved that the Danian sediments exist and a conglomerate bed is not the K/Pg boundary, because sedimentation of mud rocks and sandstone were continuous during that time.

CONCLUSIONS

The biostratigraphic analysis of calcareous nannofossil assemblages across the K/Pg boundary at the Chinarok section of the city of Sulaimanyah, Kurdistan Region of Iraq documents the presence of biozones CC26 of the Late Maastrichtian, and NP1and NP2 of the Early Danian. These zones indicate a transition in deposition with no break or hiatus. The changes are in the assemblages where the Late Cretaceous calcareous nannofossils are topped by new taxa and species of the Danian.

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