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Integrated biostratigraphy, stage boundaries and Paleoclimatology of the Upper Cretaceous–Lower Eocene successions in Kharga and Dakhala Oases, Western Desert, Egypt

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ABSTRACT

The Upper Cretaceous–Lower Eocene succession in the studied sections is divided into four rock units that arranged from base to top: the Dakhla, Tarawan, Esna and the Thebes formations.

Detailed study of the foraminifera and calcareous nannofossils has led to the recognition of 58 and 82 species, respectively. Based on planktonic foraminifera and calcareous nannofossils 8 planktonic foraminiferal biozones (CF4, P2, P3, P4, E1, E2, E3 and E4) have been recognized as well as 8 calcareous nannofossil biozones (CC25b, NP3, NP4, NP5, NP6, NP7/8, NP9, and NP10).

At Gabal Teir/Tarawan section, Kharga Oasis, the Paleocene can be divided into three stages; Danian, Selandian and Thanetian. The Danian/Selandian boundary is placed at P3a/P3b zonal boundary (LO of *Igorina albeari*) which corresponds to the level of LO of *Lithoptychius ulii*, *Fasciculithus pileatus*, *Fasciculithus involutus and Lithoptychius janii* (upper part of Zone NP4). The Selandian/Thanetian boundary, on the other hand, can be traced within the foraminiferal Zone P4 (*Globanomalina pseudomenardii* Zone) and between the nannofossil zones NP6 and NP7/8 (LO of *Discoaster mohleri*).

At Gabal Ghanima section, the Paleocene/Eocene boundary is located within the lower part of the Esna Formation. It can be traced at the base of planktonic foraminiferal Zone E1 (LOs of *Acarinina africana*, *A sibaiyaensis* and *Morozovella allinsoensis*), and at the NP9a/NP9b subzonal boundary (LO of *Rhomboaster* spp). However, the lower Eocene succession seems to be condensed and punctuated by minor hiatus (absence of Subzone NP10a).

The dominance of cool water nannofossil species in the late Maastrichtian and early Danian interval suggests a gradual decrease in the surface water paleotemperature. However, a slight warming condition prevailed around the Danian/Selandian transition as evidenced by the warm water nannofossil species. At the P/E boundary interval, the high abundance of warm-water taxa (e.g. *Discoaster*, *Sphenolithus*, *Rhomboaster*, *Tribrachiatus* and *Pontosphaera* species) indicates a warm-water paleotemperatures.

1. Introduction

The Upper Cretaceous–Lower Paleogene successions of the Western Desert have attracted several studies with special emphasis on the general geology, stratigraphy and paleontology (e.g., Abdel-Kireem and Samir, 1995; Tantawy et al., 2000; EL-Azabi and Farouk, 2010). The surface geology of the Kharga Oasis has been the subject of numerous studies including those by Bassiouni et al. (1991), Faris (1993), Tantawy (1998), Faris et al. (1999), Ouda et al. (2004), Obaidalla et al. (2008), Tantawy (2006) and El-Azabi and Farouk (2010). Also, several studies have been published on the stratigraphy, of the Maastrichtian–Paleocene rocks exposed in the Dakhla–Farafra stretch of the Western Desert (e.g. Faris et al., 1999; Tantawy et al., 2001; Obaidalla et al., 2008; EL-Azabi and Farouk, 2010).

The aim of the present study is to integrate the data obtained from planktonic foraminifera and calcareous nannofossils to subdivide the Late Cretaceous–Early Paleogene into biostratigraphic units, as well as their biostratigraphic correlation, delineate and discuss some of the Paleocene and Early Eocene stage boundaries, shed light on the Paleocene hiatuses in the studied area and to predict the paleoecological conditions that prevailed during the deposition of the Cretaceous/Paleocene and Paleocene/lower Eocene succession in the area under consideration.

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2. Materials and methods

Three lithostratigraphic sections were measured and sampled (Fig. 1). A total of 92 rock samples were collected from Gabal Ghanima section (Kharga Oasis), 89 rock samples from Gabal Teir/Tarawan section (Kharga Oasis) and 44 samples from Gabal El-Qasr (Dakhla Oasis). Each of the studied sections was measured and sampled at intervals ranging from 50 cm to 2 m depending on the variation in lithology and/or bed thickness.

For planktonic foraminiferal study, the samples have been washed and picked and the different species have been examined and identified using a binocular microscope with maximum 40× magnification. The first and last appearances of a species, species richness and relative abundances were identified based on random representative splits with 300–400 individuals from the >63 μm size fraction. The remaining sample residue was investigated for rare species and any other vital observations.

For the calcareous nannofossil study, samples were processed by smear slide preparation from raw sediment samples. Samples were processed by using the standard preparation technique in Bown and Young (1998). At least 300 nannofossil specimens in each sample were counted along random traverse on the slide. Slides are generally examined beyond the 300 specimens count to uncover any rare species and to ensure that no biostratigraphic information was lost. The relative abundance of nannofossils determined as follows; A (abundant) = >5 specimens per one field of view, C (common) = 1–5 specimens per one field of view, F (frequent) = one specimen per 2–5 fields of view, R (rare) = one specimen per 6–10 fields of view, VR (very rare) = one specimen per >10 fields of view, and B (barren) = no specimen. For preservation of nannofossil taxa, the following letters are used; G (good) = little or no overgrowth and/or dissolution, M (moderate) = little or some overgrowth and/or dissolution, and P (poor) = abundant overgrowth and/or dissolution.

The Cretaceous biostratigraphic zonation is evaluated here based on the Cretaceous Foraminiferal (CF) zonal scheme of Li and Keller (1998a,b) which replaced the last Upper Cretaceous biozones of Caron (1985) by refined nine biozones (CF1–CF9), where's the Paleocene and Early Eocene biozones are based on the zonal scheme of Berggren and Pearson (2005).

Nannofossil biostratigraphic framework is applied according to the biozonation scheme of Sissingh (1977) and Perch-Nielsen (1981) for the Late Cretaceous. Meanwhile, the Lower Paleogene rocks comprise many zones from NP1 to NP10 according to the Zonal Scheme of Martini (1971). Furthermore, the subdivisions of the Paleocene biozones proposed by Romein (1979) have been followed.

3. Lithostratigraphy

The Kharga Oasis lies in the Western Desert of Egypt, longitude 30°32′33″–30°54′25″E and latitude 25°27′52″–25°46′44″N. Dakhla Oasis is located to the west of the Kharga Oasis, longitude 28°15′–29°40′E and latitudes 25°00′–26°00′N. The lithostratigraphic subdivisions of the studied sections in both Kharga and Dakhla oases throughout the Late Maastrichtian–Early Eocene interval are based mainly on field observations, lithology, and stratigraphic position. A detailed lithostratigraphic description of the measured sections is summarized in Figs. 2–4. The Upper Maastrichtian–Lower Eocene successions along the studied sections are differentiated into four lithostratigraphic units of wide distribution. The following is a brief account on each of these rock units arranged from bottom to top.

3.1. Dakhla Formation: (Said, 1962)

The Dakhla Formation at Gabal Ghanima section consists of multicolored shale interbeded with thin phosphatic bands. At Gabal Teir/Tarawan section, it is made up of multicolored shale in its lower part and varies into grey calcareous shale in the upper part. While at Gabal El-Qasr section it is made up of multicolored

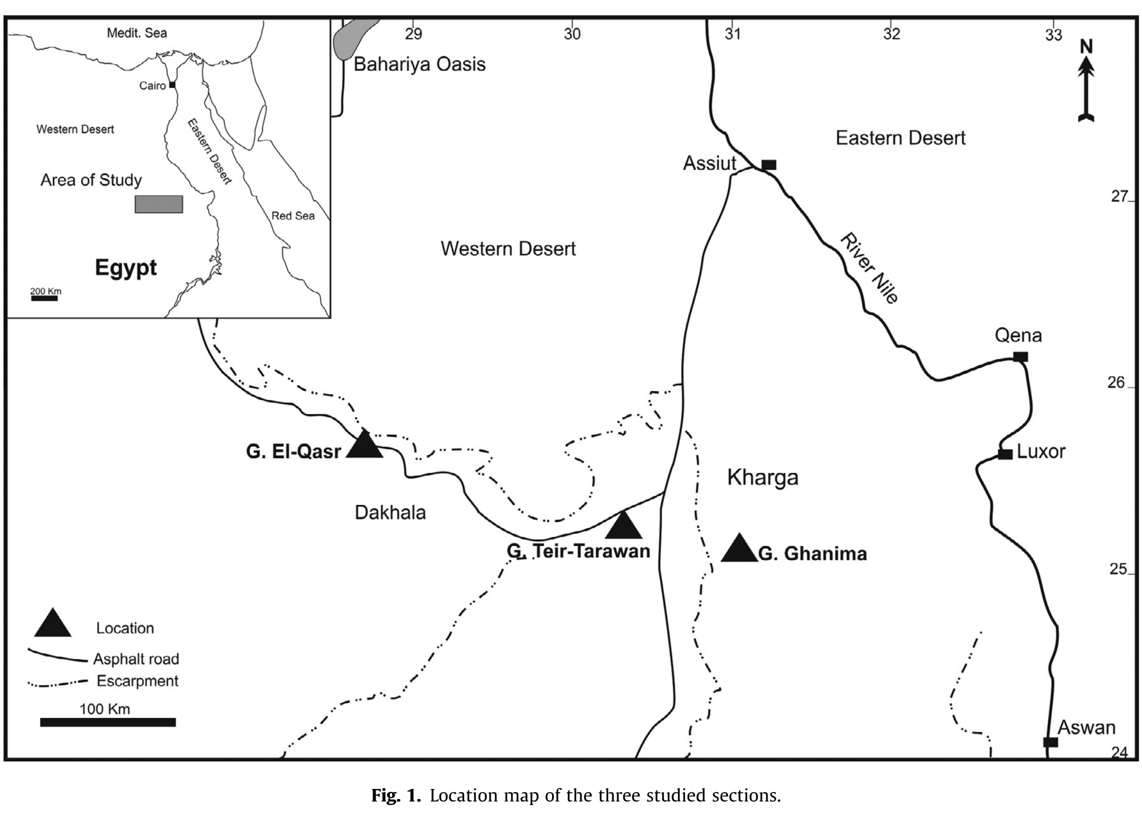

Fig. 1. Location map of the three studied sections.