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MAASTRICHTIAN TO PALEOCENE FACIES EVOLUTION AND CRETACEOUS/TERTIARY BOUNDARY IN MIDDLE AND SOUTHERN EGYPT

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ABSTRACT

The sedimentary history and facies development of southern Egypt during the Latest Cretaceous and Early Paleogene is summarized. The *G. eugubina* Zone is reported for the first time from middle Egypt, where the conglomerate usually marking a disconformity at the Cretaceous/Tertiary boundary, is absent. The Uppermost Maastrichtian strata are attributed to the *M. prinsii* Zone, the Late Maastrichtian index foraminifer *Abathomphalus mayaroensis* (Bolli) was not recovered in the investigated samples.

Keywords: Maastrichtian, Paleocene, transgressive/regressive cycles, facies, K/T Boundary, Gebel Qreiya, southern Egypt, *G. eugubina* Zone.

RESUMEN

En la siguiente publicación se describen sintéticamente la historia de la sedimentación y el desarrollo de las facies en el sur de Egipto durante el Maastrichtiense y el Paleógeno basal. La Zona de *G. eugubina* es descrita por primera vez en el centro de Egipto, donde no está desarrollado el conglomerado que normalmente caracteriza el límite entre el Cretácico y el Terciario. Las capas superiores del Maastrichtiense están atribuidas a la Zona de *M. prinsii*, el foramínifero guía del Maastrichtiense superior *Abathomphalus mayaroensis* (Bolli) no se ha encontrado en las muestras investigadas.

Palabras clave: Maastrichtiense, Paleógeno basal, ciclos transgresivos/regresivos, facies, Gebel Qreiya, Egipto meridional, Zona de *G. eugubina*.

INTRODUCTION

The cratonic area of southern Egypt (stable shelf of Said, 1962) was affected by several marine transgressions during the Cretaceous and Paleogene. The early transgressive pulses, the majority of which coincide with eustatic sea level rises (Luger & Schrank, 1987), are dated as Aptian (Böttcher, 1982; Schrank, 1982) or Early Aptian respectively (Schrank, 1983), Late Cenomanian/Early Turonian (Dominik, 1985; Hendriks et al., 1987), Late Turonian and Middle or Late Coniacian (Klitzsch, 1986; Hendriks et al., 1987). Due to tectonic control most of these shallow transgressions did not flood all of southern Egypt, i.e. the Aptian is restricted to the Western Desert (Dakhla Basin) and the Late Turonian as well as the Coniacian to the Eastern Desert (see Hendriks et al., 1987). The largest transgression started during the Campanian and, although interrupted by minor regressive phases, lasted until the Early Eocene. During this transgression, which affected all of southern Egypt, more homogeneous sedimentary patterns developed over wide areas, resulting in the replacement of "Nubian-type" psammites by pelites and carbonates. Whereas detailed palaeontological investigations are still in progress, sufficient data are available to give here a brief review of the facies evolution during this transgressive cycle and to report on the occurrence of the *G. eugubina* Zone from a section in middle Egypt for the first time.

MAASTRICHTIAN FACIES EVOLUTION

In the Maastrichtian to Middle Paleocene strata of southern Egypt the following facies types may be distinguished: 1) calcareous marls of open marine, deep shelf origin (Hamama Marl Member and Beida

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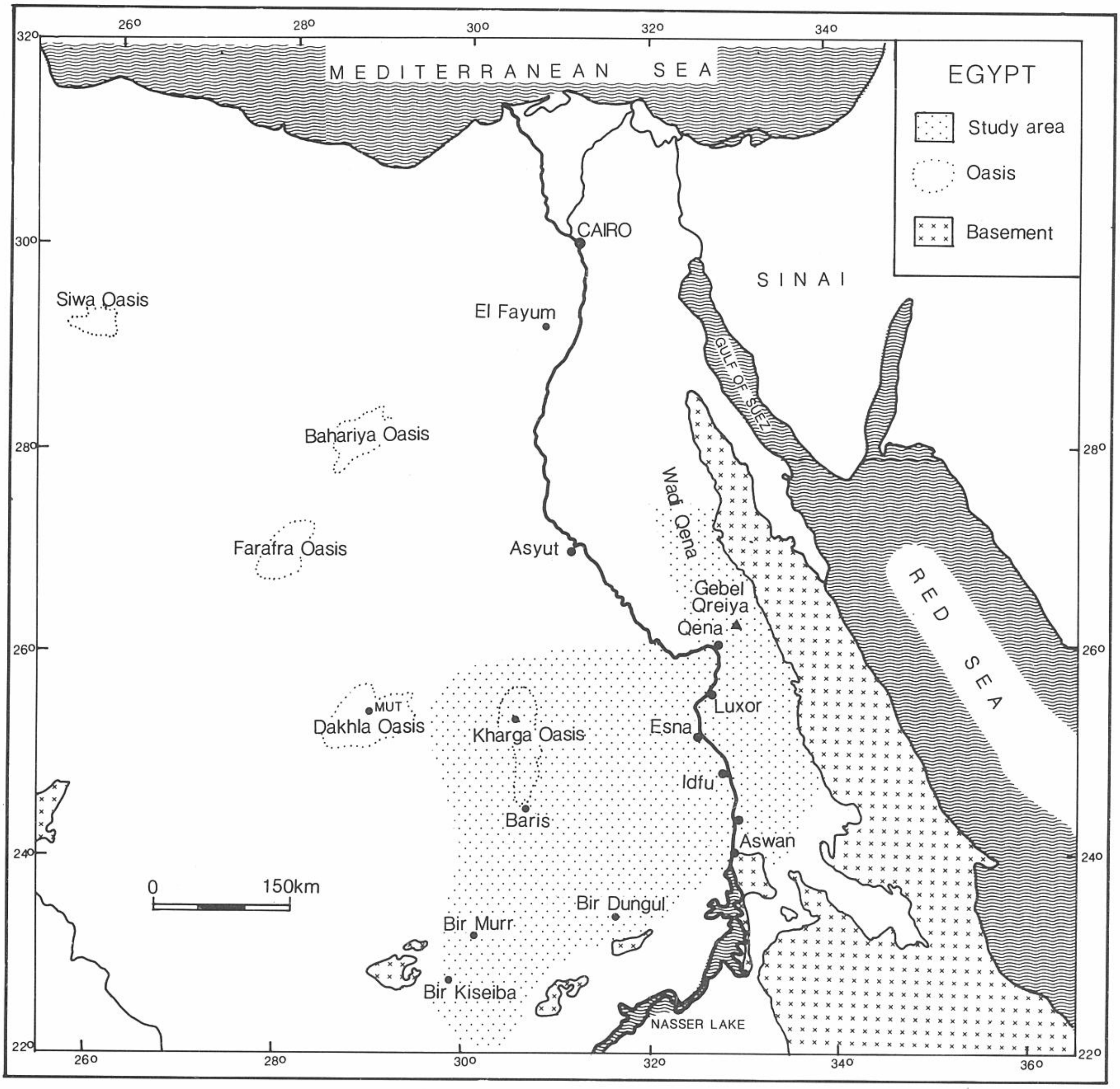

Figure 1. General map of Egypt showing the area of study.

Shale Member of Dakhla Formation, Asyut Basin, Eastern Desert); 2) clayey marls with intercalations of claystone, siltstone and sandstone, predominantly of open marine, deep shelf origin (Dakhla Shale Member of Dakhla Formation, eastern Dakhla Basin, Western Desert); 3) highly fossiliferous siltstones, sandstones and limestones of open marine, shallow shelf origin (Ammonite Hill Member of Dakhla Formation, western Dakhla Basin, Western Desert and, partially, Kurkur Formation, southern Upper Nile Platform, Southwestern Desert); 4) intercalations of sandstones, siltstones and claystones of mixohaline deltaic to shallow shelf origin with few calcareous open marine intercalations (Shab Member of Kiseiba Formation and, partially, the Kurkur Formation, southern Upper Nile Platform, Southwestern Desert). Interfingering of Facies 4 with Facies 1 occurs in an area from the southern Nile Valley near Kom Ombo to the southeastern part of the Western Desert in the region of Bir Dungul; interfingering of Facies 4 with Facies 2 is observed in the southern Western Desert between Baris and Bir Murr (see Figs. 1-3A).

During the Middle to Late Campanian the Tethys Sea gradually transgressed southward onto southern Egypt. A first transgressive peak was reached during deposition of Upper Campanian shallow shelf phosphoritic, chert-bearing limestones of the upper Rakhiyat Formation in the north and the Duwi Formation in the south (Hendriks & Luger, 1987). Upper Campanian strata of relatively deeper marine origin, indicated by the occurrence of planktonic foraminifera, are only known from the central part of the Dakhla Basin (Qur-el-Malik Member of Dakhla Formation, Barthel & Herrmann-Degen, 1981).

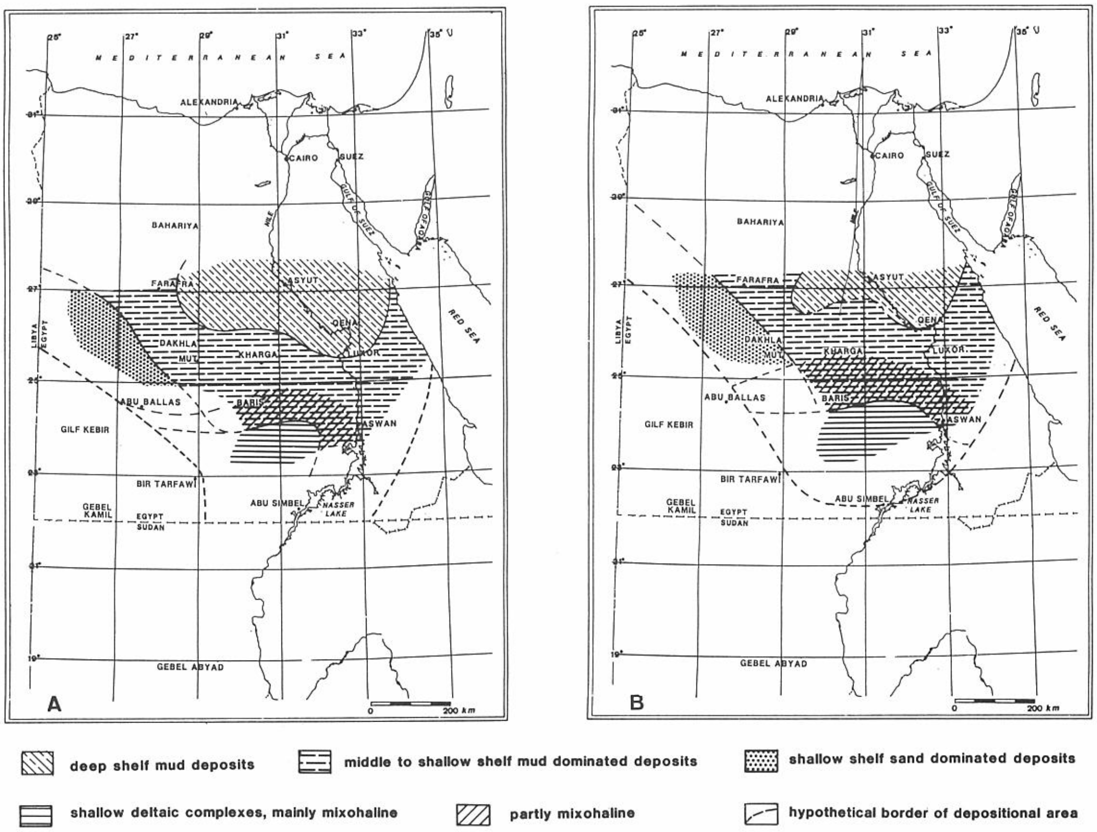

Figure 2. Generalized facies maps for the Maastrichtian of central and southern Egypt. A: Transgressive period (late Early, Middle and? Late Maastrichtian). B: Regressive period or stillstand of transgression (early and late Middle Maastrichtian).

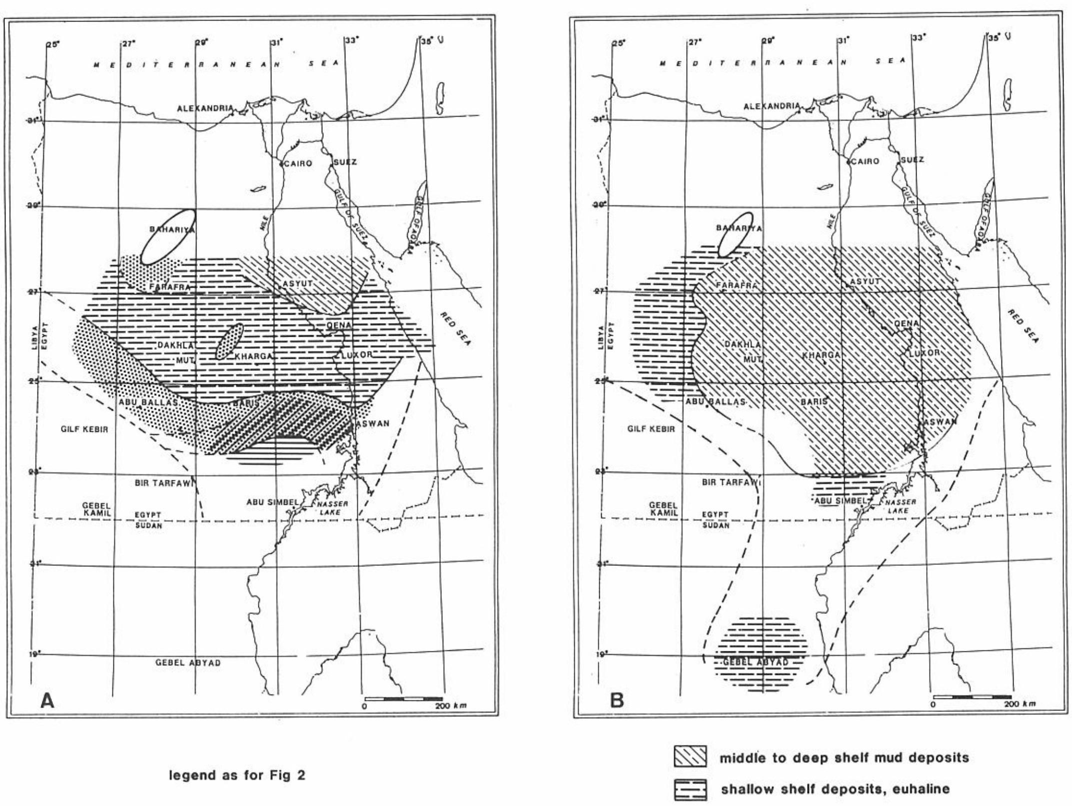

Figure 3. Generalized facies maps for the Paleocene of central and southern Egypt. A: Late Early to early Middle Paleocene. B: Late Paleocene (Sudanese occurences after Barazi, 1985 and Barazi & Kuss, 1987).

In the Eastern Desert (Wadi Qena to Kom Ombo) the Maastrichtian strata unconformably overlie the Upper Campanian Duwi- and Rakhiyat Formations. The phosphoritic basal conglomerate of the Dakhla Formation rapidly grades into well-bedded marls, rich in foraminifera. The planktonic foraminifera favour an assignment of the base of this transgressive sequence to the later part of the *G. falsostuarti* Zone, in the late Early Maastrichtian. In the basinal sections (Gebel Qreiya, Asyut Basin) the foraminiferal assemblages suggest deposition in middle to outer shelf environments (Hendriks & Luger, 1987).

In the central parts on the Asyut Basin (e.g. Gebel Qreiya) the entire Maastrichtian part of the Dakhla Formation (Hamama Marl Member) is exclusively made up of calcareous marls without significant lithological variation (see Fig. 4). Further to the south, between Esna and Idfu, the basal marls of the Dakhla Formation grade upwards into nearly unfossiliferous claystones (Lower Sharawna Shale Member, El Naggar, 1966). These claystones are overlain by an intraformational conglomerate with reworked megafossils (e.g. *Exogyra overwegi* von Buch), followed upwards by calcareous marls, again rich in microfossils (Sharawna Marl Member). This transgressive sequence occurs in the *G. gansseri* Zone. Further up-section the carbonate content decreases and the Upper Maastrichtian consists of almost unfossiliferous claystones of a restricted marine facies. The Cretaceous/Tertiary boundary is marked by a disconformity documented by a conglomeratic horizon containing reworked Maastrichtian macrofossils, which is overlain by microfossil-rich marls of the later *G. pseudobulloides* Zone; the basal Paleocene is missing (El Naggar, 1966), see Fig. 5.

Towards the SW, along the Bir Murr (W)-Bir Abu el Husein (SW)-Bir Dungul (E) stretch of the southern Western Desert, the clay-dominated strata are replaced by contemporaneous "Nubian-type" sandstone/siltstone/claystone intercalations of mixohaline deltaic facies (Shab Member of Kiseiba Formation, Luger, 1985) and the open marine deposits thin out gradually. From Bir Murr (S) towards Baris (N) the deltaic complexes again interfinger with open marine deposits of the Dakhla Formation (see Fig. 2). The deltaic, marginal marine facies prograded twice into the basinal facies during the Maastrichtian and thus, as in the Esna-Idfu region, the Upper Maastrichtian claystones of the Kharga-Baris region are of a restricted marine facies devoid of planktonic foraminifera. The Cretaceous/Tertiary boundary here is marked by a disconformity and a conglomerate, locally rich in reworked Maastrichtian macrofossils (e. g. *Libycoceras* sp.), the lowermost Paleocene deposits are attributed to the *G. trinidadensis* Zone (Luger, 1985), see Fig. 5.

Towards the west into the Dakhla Basin the influence of the deltaic complexes decreases and the thickness of the clayey deposits increases. A Maastrichtian to Middle (?) Paleocene euhaline shallow water facies is documented by the Ammonite Hill Member of Dakhla Formation interfingering with the Dakhla Shale Member from West to East (see Fig. 2). Again, in the Dakhla Basin the Cretaceous/Tertiary boundary is also marked by a hiatus and a conglomerate containing reworked Late Maastrichtian foraminifera and macrofossils together with planktonic foraminifera of the *G. pseudobulloides* Zone (Barthel & Herrmann-Degen, 1981), see Fig. 5.

THE CRETACEOUS/TERTIARY BOUNDARY

The Cretaceous/Tertiary boundary in southern Egypt is usually formed by a conglomerate marking a hiatus of varying extent (lowermost Paleocene: *G. pseudobulloides*- to *G. trinidadensis* Zone). The absence of a conglomerate at the K/T boundary was recently reported from a section west of Qena (Asyut Basin) by Mahmoud Faris et al. (1986), who also documented the occurrence of the latest Maastrichtian *Micula prinsii* Zone (calcareous nannoplankton) and placed the lowermost recorded Paleocene into the *M. trinidadensis* Zone.

In a section measured by the author in 1985 at the Gebel Qreiya, about 50 km E of Mahmoud Faris et alii's (1986) Qena locality, the K/T conglomerate also proved to be absent and continuous sampling in 5 to 10 cm intervals over .. total column of 2.5 m in the upper part of the Hamama Marl Member of Dakhla Formation yielded samples of true *G. eugubina* Zone (see Fig. 4).

The Upper Maastrichtian strata consist of calcareous marls; the basal Paleocene is made up of clayey marls (30 cm thick), the carbonate content increases up-section. There are no signs of reworking or of any high-energy bed, nor are there iron-enriched horizons or colour changes at the boundary. A boundary clay, present in all complete K/T sections, was not observed at the Gebel Qreiya.

Whereas detailed paleontological/biostratigraphical investigations are still in progress (Luger & Boldt in prep.), the following points can be stated:

The uppermost Maastrichtian strata yield a moderately diverse planktonic foraminiferal assemblage with *Globotruncana aegyptiaca* Nakkady, *G. arca* Cushman, *G. esnehensis* Nakkady, *Globotruncanita conica* (White), *G. stuartiformis* (Dalbiez), *Globotruncanella havanensis* (Voorwijk), *Globotruncanella* sp., *Rugoglobigerina rugosa* (Plummer), *R. macrocephala* Brönnimann, *R.* cf. *reicheli* Brönnimann, *R. scotti* (Brönnimann), *Plummerita hantkeninoides* (Brönnimann), *Globigerinelloides volutus* (White), *Heterohelix striata* (Ehrenberg), *Planoglobulina brazoensis* Martin, *Pseudotextularia elegans* (Rzehak), *Pseudoguembelina* sp. and *Racemiguembelina* sp.

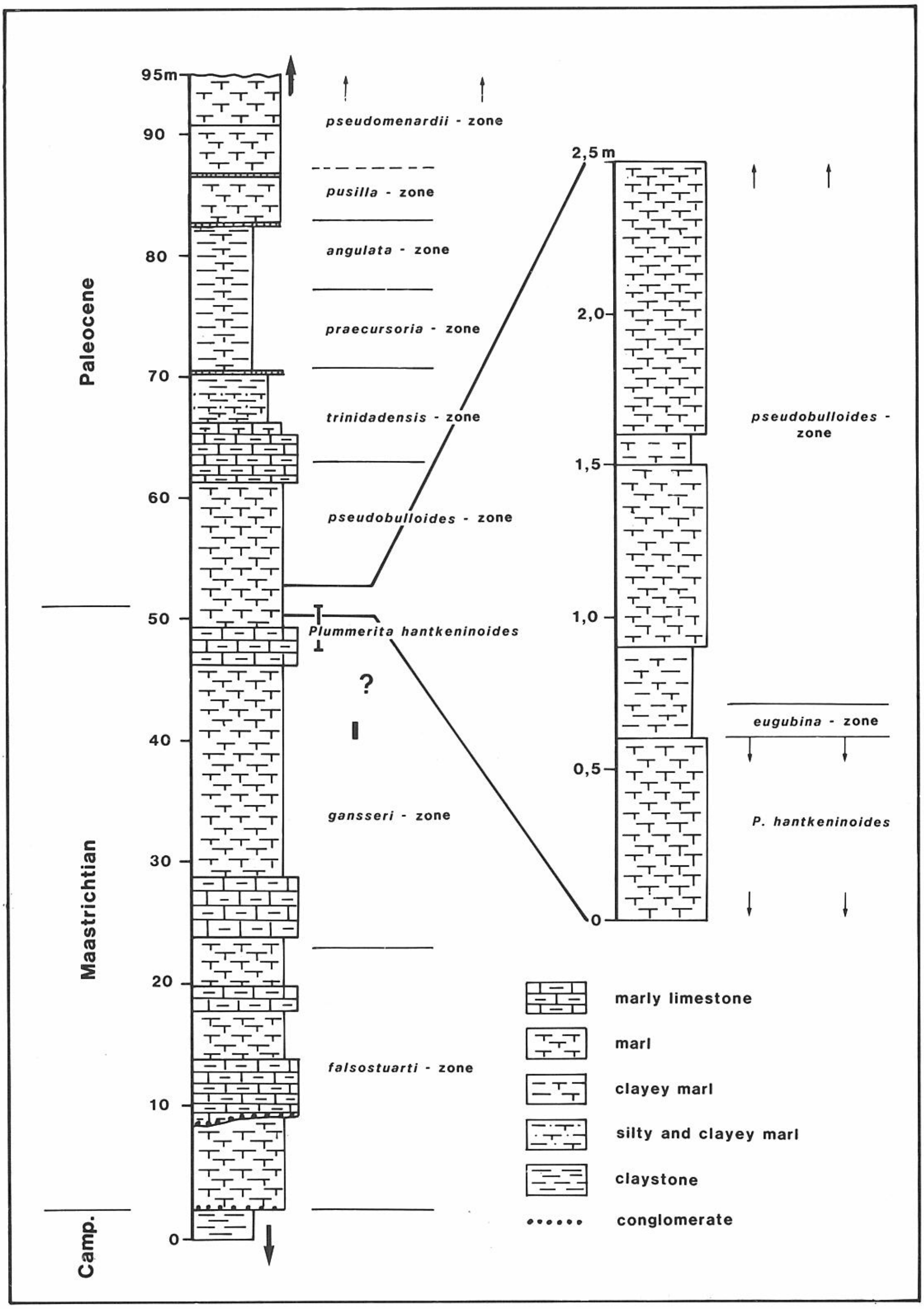

Figure 4. Litho- and biostratigraphy of the Maastrichtian to Paleocene part of the Gebel Qreiya section, about 50 km ENE of Qena.

Abathomphalus mayaroensis, the Late Maastrichtian planktonic foraminiferal index species, was not found in my samples (nor in other Upper Maastrichtian samples from southern Egypt collected by the Berlin group, Barthel & Herrmann-Degen, 1981 and Herrmann-Degen, pers. comm.). Regarding planktonic foraminifera, a Late Maastrichtian age could only be stated if *Plummerita hantkeninoides* (morphotype with spines on all chambers), which is present only in the upper 3 m of the Maastrichtian, was accepted an index fossil for the Late Maastrichtian (disputed, see Robaszynski et al. 1984). However, additional investigations on calcareous nannofossils of the same samples yielded *Micula prinsii* (det. M. Boldt), the Latest Maastrichtian index species. In the section under investigation *M. prinsii* has its first occurrence about 13 m below the *G. eugubina* Zone.

The *G. eugubina* Zone (about 10-15 cm thick in the investigated section) as well as the lower part of the *G. pseudobulloides* Zone, here are characterized by very large numbers of reworked Late Maastrichtian foraminifera (up to 95 % in the *G. eugubina* Zone). The very small-sized *G. eugubina* (< 0.1 mm) and *Guembelitria* sp. (partly probably also reworked) are the only Paleocene constituents of the planktonic foraminiferal assemblage and therefore the only forms considered to be autochthonous in the *G. eugubina* Zone. The high percentage of Maastrichtian forms (relatively large globotruncanids, heterohelicids, rugoglobigerinids) in the *G. eugubina* Zone is considered to be reworked. These forms lack in equivalent horizons of undisturbed sections, where the boundary clay is well developed (e.g. Caravaca, Smit 1977). The situation thus is similar to the Lattengebirge (Herm *et al.*, 1981) and the Sopelana sections (Lamolda *et al.*, 1983), where Maastrichtian foraminifera found in the basal Paleocene were shown to be reworked. In the section under investigation, reworked Maastrichtian foraminifera are also met up-section in decreasing quantities until the earlier *G. pseudobulloides* Zone; they probably derived from neighbouring areas where the regression around the K/T boundary caused reworking of sediment and the boundary-conglomerate is developed. Due to the presence of reworked Late Maastrichtian foraminifera of all size-classes in the *G. eugubina* Zone, it is not possible to decide if there is survivorship of Maastrichtian forms in the basal Paleocene in the Qreiya section.

The occurrence of *G. fringa* has not yet been proved. Investigations of the calcareous nannoplankton showed that the lowermost sample containing *G. eugubina* yielded exclusively rare *Thoracosphaera*, while the next sample (about 5 cm above) yields a rich spectrum of coccoliths, consisting of reworked (?) Maastrichtian forms (det. M. Boldt).

The Maastrichtian to Paleocene facies evolution in southern Egypt reveals several transgressive/regressive periods, resulting in the land- or basinward shift of facies belts due to changes of overall water-depth. The stratigraphical column of one locality (e.g. the Gebel Qreiya) therefore comprises deposits of different paleoenvironments (here: open shelf deposits of different water depths) even if there are no significant lithological changes. An estimation on the extinction pattern among planktonic foraminifera inevitably requires stable paleoecological conditions in the investigated interval or at least sufficient knowledge of the paleoenvironmental changes in order to differentiate between extinction and exodus (e.g. caused by shallowing of the water column). This is particularly needed for the present Late Maastrichtian shelf assemblages, characterized by a high percentage of rugoglobigerinids and heterohelicids and scarceness of large globotruncanids, probably indicating a moderately deep shelf environment. Therefore a discussion on extinction rates among the present Late Maastrichtian planktonic foraminifera has to be postponed until the required paleoenvironmental parameter (P/B rations, composition and diversity of planktonic and benthonic associations) are fully elaborated.

The conglomerate at the Cretaceous/Tertiary boundary in southern Egypt usually contains well preserved open marine Maastrichtian megafossils, and in some cases also Late Maastrichtian planktonic foraminifera (Barthel & Herrmann-Degen, 1981). In many places (especially along the Kharga-Baris transect) it overlies claystones of a restricted marine (?mixohaline) facies. This indicates that here during the Late Maastrichtian open marine conditions prevailed and that is was rather a transgressive than a regressive period. The Upper Maastrichtian strata in their majority must have been reworked later, probably during the Early Paleocene.

PALEOCENE FACIES EVOLUTION

In the areas which were affected by the widespread Early Paleocene regression (Dakhla Basin, Upper Nile Platform), open marine conditions were re-established rapidly. Whereas in the Asyut Basin open marine sedimentation had continued since the Maastrichtian, in the Dakhla Basin (upper Dakhla Shale Member, Barthel & Herrmann-Degen, 1981) and in the Esna - Idfu region (Owaina Shale Member of Dakhla Formation, El-Naggar, 1966; Luger unpubl. data) a deeper shelf facies developed during the late *G. pseudobulloides* Zone, as indicated by foraminifera. On the Kharga Uplift (between Kharga and Baris) these conditions were reached during the late *G. trinidadensis* Zone (Upper Kharga Shale Member of Dakhla Formation, Luger, 1985). This open marine phase lasted until the *G. angulata* Zone.

The southernmost part of the Upper Nile Platform (Bir Murr-Bir Kiseiba-Bir Dungul stretch) remained, as in the Maastrichtian, an area of a marginal marine facies. After a first short shallow marine phase during the Early Paleocene, documented by glauconitic oyster limestones and coquinas (lower transgressive sequence of Kurkur Formation, Luger 1985), shallow deltaic complexes prograded northwards into the basinal facies (middle regressive sequence of Kurkur Formation, loc. cit.), see Fig. 3A. The progradation of the deltaic complexes, which have a far smaller areal extent than their Maastrichtian precursors, is related to a minor regressive phase between the *G. angulata-* and the *P. pseudomenardii* Zones.

In most of southern Egypt an erosional unconformity is observed between the Dakhla Formation and the overlying chalky limestones of the Tarawan Formation (*P. pseudomenardii* Zone). The resulting hiatus is of varying extent (see Fig. 5). In the Dakhla Basin it comprises mainly the *G. pusilla* Zone, in the Kharga-Baris stretch also the later *G. angulata* Zone is included. The hiatus is less pronounced in the southern Nile Valley between Esna and Idfu,

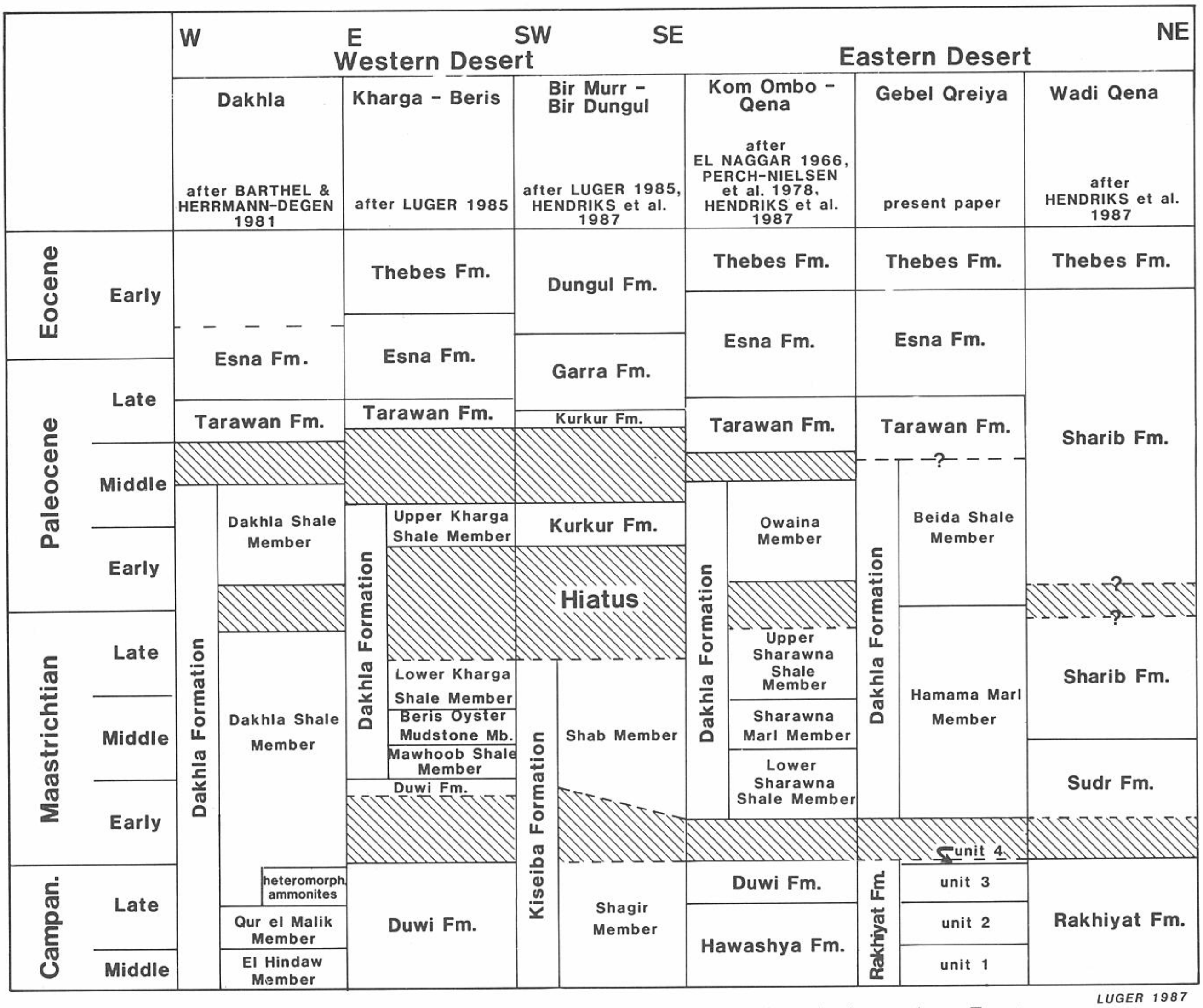

Figure 5. Correlation of the Late Campanian to Early Eocene lithostratigraphic units in southern Egypt.

where it has been shown to comprise the calcareous nannoplankton zones NP5 and possibly NP6 - NP8 (Perch-Nielsen et al., 1978). The hiatus cannot be traced by planktonic foraminifera in the central parts of the Asyut Basin (West of Qena, Mahmoud Faris et al., 1986 and Gebel Qreiya). However, it is interesting that the *G. angulata*/*G. pusilla* Zone and *G. pusilla*/*P. pseudomenardii* Zone boundaries are marked by thin intervals of reworking in the Gebel Qreiya section (see Fig. 4).

The new transgression during the time represented by the *P. pseudomenardii* Zone, accompanied by tectonic activity (Strougo, 1986: "*velascoensis*-event"), led to conspicuous changes of the sedimentary regime. During the *P. pseudomenardii*- and the *M. velascoensis* Zones almost all of southern Egypt underwent strong subsidence and open, deep marine conditions were established (Tarawan Formation, lower part of Esna Formation). The southern part of the Upper Nile Platform (Bir Kiseiba-Bir Dungul area) now also became part of a very broad shelf sea. This is indicated by the transition of glauconitic coquinoid limestones (upper transgressive sequence of Kurkur Formation) to calcareous marls, highly rich in microfossils of a middle shelf facies (Garra Formation, Luger, 1985). During that time this open shelf sea reached as far south as the Abyad Plateau in the northern Sudan (Barazi, 1985), see Fig. 3B.

CONCLUSIONS

From Campanian time onwards to the Late Paleocene southern Egypt underwent increasing subsidence. Transgressive peaks, which affected most of the area, are documented in the Late Campanian, late Early Maastrichtian (higher part of *G. falsostuarti* Zone), Middle Maastrichtian (*G. gansseri* Zone), Late Maastrichtian (equivalents of the *A. mayaroensis* Zone), late Early to early Middle Paleocene (*G. trinidadensis*- to *M. angulata* Zone) and Late Paleocene (*P. pseudomenardii*- to early *M. velascoensis* Zone). During the Maastrichtian open marine sedimentation was twice interrupted by phases during which deltaic complexes prograded northwards into the open marine facies on the southern Upper Nile Platform (Shab Member of Kiseiba Formation). These progradations were not necessarily related to sea level changes, but could as well have been induced by stillstands during overall transgression. Regressive peaks during which reworking took place in vast areas, are assumed for the basal Maastrichtian (early *G. falsostuarti* Zone), Early Paleocene (?early *G. pseudobulloides* Zone) and Middle Paleocene (*P.? pusilla* Zone).

The Early Paleocene regression did not affect the central part of the Asyut Basin in middle Egypt as documented by the presence of the *G. eugubina* Zone in the Gebel Qreiya section, where it overlies the latest Maastrichtian calcareous nannoplankton *M. prinsii* Zone without noticeable disconformity. The Cretaceous/Tertiary boundary in the Gebel Qreiya section apparently lacks the "boundary-clay"; the *G. fringa* Zone of Hillebrandt (in Herm et al., 1981) has not yet been identified; thus this section seems to be not entirely complete.

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