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Paleocene stratigraphy in Egypt

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ABSTRACT

The Egyptian Paleocene is widely distributed with vertical and lateral facies changes geographically separated and subject to different tectonic and sedimentary regimes. Five coeval facies associations of the Paleocene outcrops are identified and named from south to north: Garra El-Arbain, Nile Valley, Farafra, Sinai, and Southern Galala. Ten Paleocene third-order depositional sequences (Ds Da1 to Ds Th9) are tentatively distinguished in Egypt. These are bounded at their base and top by ten sequence boundaries (Eg.Da-1, Eg.Da-2, Eg.Da-3, Eg.Da-4, Eg.Da-5, Eg.Da-6, Eg.Se-7, Eg.Th.-8, Eg.Th.-9, and Eg.Eo-10). The relative ages and correlation of the Paleocene depositional sequences are based on planktonic foraminiferal biostratigraphy. Comparison of identified Paleocene sequences in and outside Egypt are referred to eustatic sea-level changes and partly to regional tectonics events, which have caused hiatuses of variable durations and different configurations of Paleocene sedimentary regimes from place to place.

1. Introduction

The Paleocene successions of Egypt have long been recognized as continuous outcrops of hemipelagic sediments, as well as more continuous sequences containing abundant diverse microfossil assemblages. Previous authors have presented numerous stratigraphic and paleontological studies, focusing more attention on the Egyptian Paleocene than on any other Paleocene succession in the Middle East. The number of such studies increased sharply after the assignment of the global stratotype section and point (GSSP) for the base of the Eocene at the Dababiya Quarry, Qena district, Egypt (Aubry et al., 2007).

The Egyptian Paleocene successions are characterized by distinct facies variations from deep to shallow facies associations, depending on tectonic setting and province. Most previous works have dealt with the hemipelagic facies, which is characterized by uniform lithologies and condensed successions. They lack physical boundaries, and this poses a problem for sequence stratigraphy, in that they represent systems tracts in hemipelagic settings that cannot be easily distinguished by conventional methods (e.g. Lüning et al., 1998; Dupuis and Knox, 2013). On the other hand, cyclic changes in foraminiferal assemblages, including planktonic/benthonic (P/B) ratio, diversity, faunal turnovers and faunal breaks can provide important clues to relative sea-level changes (e.g., Speijer, 2003; King, 2013; Farouk and El-Sorogy, 2015). Paleocene relative sea-level change and sequence stratigraphic frameworks have been introduced in separate areas of Egypt (e.g. Lüning et al., 1998; Kuss et al., 2000; El-Azabi and Farouk, 2011; King, 2013), but are in need of more detailed regional and extra-regional biostratigraphic and sedimentological data from both proximal and distal settings (King, 2013). Unfortunately, there are significant inconsistencies within the stratigraphic data that have yet to be resolved, leaving unanswered questions about the Paleocene shallower and deeper water facies and their relationships. Planktonic foraminifera have proved to be a useful tool for long–range correlation and high resolution biostratigraphy, taking in consideration the discrepancies of planktonic bioevents across different paleo-latitudes. The present study employs this methodology on ten measured Paleocene sections in different parts of Egypt, representing a range of facies types. In addition, regional correlations of the Paleocene sequences, based on chronostratigraphic and paleoenvironmental interpretation, may reveal details of the interplay between relative and eustatic sea-level change, tectonic events, palaeotopographic and palaeoenvironmental changes.

The aims of this paper are: (1) to establish a lithostratigraphic, biostratigraphic and chronostratigraphic framework for the Paleocene, based on measured stratigraphic sections that cover most facies variations and tectonic provinces; (2) to correlate between shallow and deep water Paleocene successions in Egypt; 3) to compare the depositional sequences of this study and their boundaries, with previously published studies from Egypt and abroad; and 4) to outline the relationships between relative and eustatic sea-level changes for the Paleocene.

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2. Geological setting

During the Paleocene, Egypt was part of a vast epicontinental shelf at the edge of the southern Tethys Ocean on the northwestern margin of the Arabian-Nubian massif (Aubry and Salem, 2013). Tectonics played an important role in controlling the configuration of the Egyptian Paleocene depositional environment, leading to great complexity in the facies distribution and thicknesses. This, in turn, has led to complications in the regional stratigraphic correlations between Paleocene deeper and shallower marine environments. Said (1962) distinguish between the stable and unstable tectonic zones in Egypt, the deformed 'Unstable Shelf' to the north and the nearly horizontal and less deformed 'Stable Shelf' to the south. Several E–W trending ridges were uplifted along the North African Tethyan margin during the Paleocene, while folding developed in the Negev, and thrusting continued in the Palmyrides (Guiraud and Bosworth, 1999). These deformations may be synchronous with the major tectonic episode described in Western Europe as the 'Laramide event' (Ziegler, 1990).

The Egyptian Paleocene sequences were deposited in diverse sedimentary environments with distinct vertical and lateral facies changes reflecting frequent epeirogenic movements.

3. Materials and methods

This study is based on detailed logging of 10 key sections in the Paleocene succession of Egypt. Five sections were selected in the Sinai: sections 1. Gebel Sahaba, 2. Themed, 3. Matulla, 4. Markha and 5. Gebel Qabilyat. Two sections were measured in Farafra Oasis: sections 6. NW Ain Maqfi and 7. northern slope of El-Quss Abu Said. One section was chosen in Kharga Oasis (section 8. Naqb Assiut), and two sections in the Nile Valley (section 9. South Luxor), and Aswan (section 10. west Kom Ombo) were selected (Fig. 1). In each section rock samples were taken along a profile normal to bedding and each sample was taken from an interval less than 30 cm thickness. The samples were prepared for foraminiferal analysis using standard methods to disaggregate, wash and sieve the samples through a 63 μm sieve. In addition, thin sections were prepared from suitable rock samples and non-fossiliferous intervals to assist in the interpretation of palaeoenvironments.

4. Paleocene facies distribution

Based on differences in lithological and faunal content and tectonic provinces, the Paleocene exposures of Egypt may be classified from south to north into Garra El-Arbain, Nile Valley, Farafra, Sinai, and Southern Galala facies associations (Figs. 1–3). A brief description for Paleocene facies associations is given below, from south to north.

4.1. Garra El-Arbain facies associations

In southern Egypt, on the Abu Tartur Plateau, and south of latitude 25°N down to northwest Sudan, a wide carbonate platform was well developed during Paleocene times, represented by the Garra El-Arbain Facies (Issawi, 1968) consisting of the Kurkur, Garra, and Dungul formations. The Kurkur Formation (Danian – Selandian age) unconformably overlies the Maastrichtian Dakhla Shale Formation, and underlies the Garra Formation (Figs. 2 and 3). It ranges in thickness from 10 to 20 m and consists of molluscan packstone, floatstone or rudstone intercalated with shale in the middle part, reflecting hyposaline nearshore to shallow subtidal environment. A scree of huge carbonate blocks covers the foot slopes of the mountains in the localities of the Garra El-Arbain facies, resulting in some previous workers not recognizing the Kurkur Formation (Hewaidy and Soliman, 1993; Youssef, 2003). The Garra Formation (Thanetian age) is unconformably overlain by the Dungul Formation, which begins with a nummulitic shale, known as the Abu Ghurra Shale Member (Ouda, 2003). In the present study, the Garra Formation marks the top of the scarp as well as a part of the plateau surface, and has a measured thickness of 30 m in the west Kom Ombo section (Fig. 4A).

4.2. Nile Valley facies associations

These facies associations are widely distributed in the central part of the Western Desert, Nile Valley, and Safaga-Quseir region along the Red Sea coast. They consist of the Dakhla Shale, Tarawan Chalk and Esna Shale formations. The Nile Valley facies association is represented in the study area by two sections measured in the eastern Nile Valley (South Luxor section), and the Kharga Oasis (Naqb Assiut section).

The Dakhla Shale Formation (Dakhla Shale of Said, 1961; Dakhla Formation of Awad and Ghobrial, 1965) displays distinctive lateral facies and thickness changes related to deposition on an irregular shelf with submerged structural highs and lows (Farouk and El-Sorogy, 2015). It is classified into three formal subdivisions (Awad and Ghobrial, 1965), namely, the Early Maastrichtian Mawhoob Shale, the Late Maastrichtian Beris Mudstone, and the Late Maastrichtian – Paleocene Kharga Shale members. The Kharga Shale Member is divided by (Luger, 1985) into two informal units, the Lower and Upper Kharga Shale, separated by a distinct palaeoenvironmental change corresponding to the Cretaceous/Paleogene (K/Pg) boundary. The Maastrichtian Mawhoob Shale and Beris Mudstone members pass laterally into the Khoman Chalk Formation north of latitude 27° 00″ N in the Western Desert, and into the Sudr Chalk Formation in the North Eastern Desert and Sinai (Fig. 2).

Dupuis and Knox (2013) noted that the terminology and divisions of the Dakhla Formation of Awad and Ghobrial (1965) in its type locality can not been applied to the exposures in the Nile Valley or Eastern Desert areas, and they considered that the terminology of Abd El Razik (1972) was more appropriate. Abd El Razik divided the Dakhla Shale Formation of the Red Sea, Eastern Desert and Nile Valley areas into two members: a lower Hamama (Marl) Member and an upper Beida (Shale) Member. In the present study, the Danian-Selandian Dakhla Formation is equivalent to the Upper Kharga Shale Unit in Dakhla-Kharga oasis or Beida (Shale) Member in most parts of Egypt (Fig. 2). In the Dakhla-Kharga oases, the Upper Kharga Shale Unit begins with the Bir Abu Munqar Horizon (Bartherl and Herrmann-Degen, 1981). It consists of ~30 cm to 1 m layer of phosphatic conglomeratic marl, equivalent to the basal Paleocene (Fig. 4B and C). This part is succeeded by calcareous shale and mudstone rich in foraminifera.

The Tarawan Chalk Formation ('Chalk' of Said, 1961; Tarawan Formation of Awad and Ghobrial, 1965) in the Nile Valley facies association has a Thanetian age. It is composed of pale yellow gray to medium gray, massive, thick-bedded chalky and argillaceous limestone (Fig. 4D). It yields a high diversity of well-preserved planktonic and benthonic foraminifera (Fig. 4E). The Tarawan Chalk Formation in the Nile Vally Facies is vary in thickness from 1 to 20 m, with decreasing thickness towards the south.

The Esna Shale Formation unconformably overlies the Tarawan Chalk Formation and shows vertical facies changes from a predominately carbonate succession upwards to a calcareous shale. It is classified into the late Thanetian El Hanadi, earliest Eocene Dababiya Quarry, early Eocene Mahmiya and Abu Had members (Aubry et al., 2007) (Fig. 4F). The Dababiya Quarry Member is typified by argillaceous limestone with varies thickness range from 0.5 to 1 m. It contains much debris of coccoliths, and forms a