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Discussion

Comments on "Paleoecology and paleobiogeography of Paleocene ostracods in Dineigil area, south western Desert, Egypt." by Youssef et al., Journal of African Earth Sciences, 131 (2017) 62–70



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ABSTRACT

In their recent paper, Youssef et al. (2017) published a quantitative study of Paleocene ostracod distributions in the Southwestern Desert of Egypt and recognized regional ecozones within a paleobiogeographic concept. To understand the significance of this ecozonation, a solid stratigraphic framework is required, though the authors only provided limited information. We demonstrate that fundamental aspects of their data representation and stratigraphic interpretation are incorrect, and thus not warrant utilization of the reported age of the ostracod record. For that reason, we stress that basic geological aspects of correlation between outcrops and creation of composite sections should be described in full detail upon publication. Based on our detailed reconstruction, the composite sequence at Bir Dungul spans calcareous nannoplankton Zones NP5-NP7/8, and mostly Thanetian in age, contrasting the observations of Youssef et al. (2017). The lowermost part of the sequence, suggested to comprise NP4 by Youssef et al. (2017) and thus Danian in age, cannot be dated because of lack of calcareous nannofossils and planktic foraminifera. Accordingly, there is no evidence in this sequence for the Latest Danian Event (as proposed by Youssef, 2014) either, and the potential relationship with the Mid Paleocene Biotic Event should be assessed critically. Consequently, accurate stratigraphic analysis, including biostratigraphy, remains essential to safeguard future paleobiogeographic interpretations along the edges of the Tethyan Ocean.

1. Introduction

The relationship between Paleogene transient climate events and the development of ostracod communities are not well understood due to scarcity of well-dated records. Most research is devoted to the Paleocene-Eocene thermal maximum (PETM), which exerted significant influence on the paleobiogeography and composition of Tethyan ostracod faunas (e.g. Speijer and Morsi, 2002; Morsi et al., 2011). These studies indicate that ostracod distributions across the PETM are closely linked to distinct biosphere changes on a large scale by migration and interspecies competition across the Tethyan shelf. Marginal marine sequences are expected to contain comparable biotic indications of other, less extreme, early Paleogene climate events, yet their impact is unresolved as only very few elaborated data sources are available (e.g. Van Itterbeeck et al., 2007). Therefore, new data sets with trustworthy detailed stratigraphic framework are essential to understand the sensitivity of Tethyan ostracod communities to the early Paleogene climate

evolution.

During the early Paleogene, marine transgressions reached the intracratonal areas of southern Egypt. This enabled widespread deposition of fine-grained marine sediments, offering excellent opportunities to record the regional expression of climate changes in this marginal setting. Youssef et al. (2017) reported a continuous sedimentary succession without any stratigraphic discontinuities, starting from uppermost Danian marly shales to upper Thanetian white chalks at the top. They differentiated two main ostracod assemblages and argued that the turnover was mainly controlled by rising sea level during the late Selandian. Yet the authors did not discriminate the potential role of climate-related turnovers and only limited biostratigraphic information is provided by the authors. Judging from the GPS coordinates and the composition of the sedimentary sequences, it is clear that the sections described by Youssef et al. (2017), labelled BD-A to BD-E, and the investigated samples are identical to our own. This is not surprising, considering that we investigated and sampled the area together with

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the first author in 2009. Yet, their reported stratigraphic representations and timing of biotic events are incompatible with our mutual field-based observations and newly generated, more precise biostratigraphic zonations. Our proposed composite section, based on a thorough lithostratigraphic correlation, highlights the need of detailed and trustworthy stratigraphic descriptions in support of published microfossil distribution data. This will safeguard future paleobiogeographic interpretations along the edges of the Tethyan Ocean.

2. Lithostratigraphic correlation

The Dineigil area, previously investigated by Luger (1985), Bassiouni and Luger (1990) and Elewa et al. (1999), exposes the Kurkur and the Garra Formations near Bir Dungul, respectively of Danian to Selandian and Selandian to Ypresian in age. The Kurkur Formation (Fm.) is mainly composed of shales and limestones with sandstone intercalations. In most areas, the Garra Fm. overlies unconformably the Kurkur Fm. and comprises a thick succession of calcareous shales and marls, grading upwards to more massive limestone beds. In their paper, Youssef et al. (2017) did not provide the detailed description (logs) of the various parts of the sedimentary succession that was available through our joint fieldwork. Fig. 1 shows the actual outcrops near Bir Dungul and detailed lithological descriptions of the individual sections are shown in Fig. 2. Both figures highlight the discontinuous exposure between the investigated outcrops, and the presence of some distinct marker beds. In our point of view, mutual field observations are misrepresented or omitted by Youssef et al. (2017), despite the available preliminary stratigraphic evidence in Košťák et al. (2013).

All sections, excluding BD-A, are situated along one flank of a long escarpment and enable a rather straightforward lateral lithostratigraphic correlation between the different outcrops. The lowermost section BD-E exposes non-calcareous shales with black nodules and sporadic remains of plant fragments. A thick sandy fossiliferous limestone bed with reworked red-colored clasts was found two meters below the base of BD-E, which can serve as a local marker bed. Approximately 5 m of presumed shales or marls are not exposed below the base of the overlying BD-D section. This non-sampled interval is covered by weathered debris, including numerous black nodules, suggesting a continuation of similar shale deposits. Section BD-D exposes less weathered shales and marls, intercalated with more indurated, brownish glauconitic marls, which are not observed in other sections. Remarkably, only 7 m of the BD-D section are represented in the composite figure of Youssef et al. (2017), contrasting the 10 meter-long sampled exposure with three distinct beds (Fig. 2). Note that also the total number and position of these beds varies in the presented figures by the main author (Youssef, 2014; Youssef et al., 2017). Youssef (2014) reported an acme of Neoeponides duwi approximately 3 m above the base, whereas we observe the acme of this characteristic benthic foraminifera at 4.5-5 m above the base. The BD-D section is thus misrepresented by artificially reducing the length and falsely omitting the lowermost glauconitic bed in the composite section of Youssef et al. (2017).

Section BD-B is the upward continuation of section BD-D, but the transition is not exposed and covered by debris. Sediments of this section are composed of more calcareous shaley marls at the base, gradually developing to marls with intercalating thin beds of marly chalks. The top of the BD-B section is formed by a distinct white marly chalk bed (Fig. 1), which is used to correlate with the nearby BD-C section to obtain a more complete and continuous sequence. Section BD-C exposes white chalks and appears to be most affected by diagenetic alteration of the calcareous content, resulting in a clear whitish appearance (see Fig. 1). Although the BD-C section spans about 22 m, only the lowermost 7 m were sampled, because the upper part is not well exposed. As section BD-A is located at the opposite site of the escarpment, thus prohibiting direct visual correlation, the exact lithostratigraphic relationship with the BD-B and C sections was unresolved during the field

trip.

Strangely, our mutual field observations are significantly distorted by Youssef et al. (2017), as the original BD-C section is a direct upward continuation of the BD-B section, thus younger in age, whereas this section is placed below the BD-A and BD-B sections in their composite section. Equally problematic is the representation of more than 10 m of sediment in their top section as only 7 m of the uppermost section were sampled during the field trip. In addition, their BD-C section is 7 m thick and directly positioned above section BD-D. This is in conflict with field observations of a 10-m-thick complete sequence overlying section BD-D and the presence of an unexposed intermediate interval. This suggests that sections BD-D and C are erroneously interchanged by Youssef et al. (2017), however they recognized the lower part of calcareous nannofossil zone NP5 in their BD-C section. This biostratigraphic zone is incompatible with our much younger age estimate of the entire BD-B and BD-C succession, and thus strongly questions the reliability of their biostratigraphic evidence (see biostratigraphy section and Fig. 2). The combined total thicknesses of the three sections (31 m), as represented in the lithologic composite log in Youssef et al. (2017), matches our field observations (14 m at BD-A and 17 m at BD-B to C). Therefore section BD-A seems to be randomly inserted into the BD-B to C sequence, near the base of the more indurated interval with marly chalks (BD-B 7 m). Youssef et al. (2017) thus falsely interrupted a continuously exposed sequence (BD-B and C sections), based on an arbitrary lithologic correlation, which is incompatible with our presented bio- and lithostratigraphic evidence.

Section BD-A is the best-exposed outcrop and less affected by surface weathering, and the lithostratigraphic interpretation of this section is a key aspect to understand the lateral extension of the investigated sequences. An enigmatic brown fossiliferous limestone bed with redcolored clast occurs several meters below the base of this section and contains a rich mollusk fauna. Section BD-A exposes shaley marls at the base, alternating with more marly intercalations, but without glauconitic beds. Two characteristic brown beds around 7 m and similar brownish beds are encountered in the basal part of the BD-D section (Figs. 1 and 2). The shaley marls turn into more calcareous marls with thin limestone beds towards the top of section BD-A. White marly chalks are visible in smaller parallel outcrops above this level (Fig. 1). This resembles the lithologic succession in the BD-B section, including a thicker distinct marly chalk bed used as a reference level. Although this lithologic transition is not investigated in detail in the BD-A section, the expected stratigraphic overlap of both sections is confirmed by calcareous nannofossil biostratigraphy (see below).

Our field observations, which includes unexposed parts between the outcrops, markers beds and lithostratigraphic overlap between the sections, are completely disregarded by Youssef et al. (2017). Unfortunately, the lithologic transition between the base of section BD-A and the underlying thick fossiliferous limestone bed was covered by thick layers of recent wind-blown sand. This prohibited an accurate lithostratigraphic interpretation and correlation with the limestone bed below the base of the BD-E section. Their geometric positions suggest that they are probably two unrelated beds (Fig. 2) and thus represent two distinct discontinuities. If so, it is reasonable to assign the BD-E section to the Kurkur Fm., whereas the BD-D section probably represents the glauconitic base of the Garra Fm., as a distinct shell bed at the base of this formation was previously reported at this location (e.g. Luger, 1985; Bassiouni and Luger, 1990). This lithostratigraphic interpretation contrasts the inclusion of section BD-D in the top part of the Kurkur Fm. by Youssef et al. (2017), who placed similar lithologies in two different formations as the base of section BD-A (Garra Fm.) is biostratigraphically correlatable to the top of section BD-D.

3. Biostratigraphy

The stratigraphic framework of Youssef et al. (2017) is based on the identification of Paleocene planktic foraminiferal and calcareous



Fig. 1. Outcrop photographs displaying the non-continuous nature of the various studied Bir Dungul sections and encountered variations in lithology and weathering phenomena: 1) The uppermost BD-C section, starting from the 10 m reference level (marly chalk bed) and exposing lower Thanetian white chalks. 2) The BD-B section exposes lower Thanetian shaley marls and marly limestones, with a distinct white marly chalk marker bed at the top, which enables direct field correlation to BD-C (see text). 3) The BD-A section exposes upper Selandian to lower Thanetian shaley marls with limestones beds near the top. Note that thicker limestone beds are visible in the background, including a white marly chalk, which is thought to correlate with the marker bed at the top of section BD-B. 4) A thick brown fossiliferous limestone bed crops out several meters below the base of section BD-A. 5) A lowermost fossiliferous limestone is present two meters below the base of section BD-E. 6) Sections BD-D and BD-E are mainly composed of shales with varying carbonate content and different degrees of weathering. A late Danian age can be neither proven nor excluded for the lowermost part, but the upper part is of Thanetian age. Thanetian shaley marls are visible in the background, correlative with the nearby BD-B section.



Fig. 2. Geographical map of the studied area (A) with positions of the studied sections (B). Detailed lithologic description with profile lengths in meter (diamond symbols represent sample positions) are presented for section BD-C (1), section BD-B (2), section BD-A (3), section BD-D (4) and section BD-E (5). This figure reflects our proposed stratigraphic correlation of the studied Bir Dungul sections according to distinct marker beds and calcareous nannofossil biozonations (NP zones). This geometric arrangement highlights the unexposed intervals that were covered by weathered debris and displays the stratigraphic overlap of section BD-A with the sedimentary sequences in the BD-B and BD-D sections.

nannofossil biozones. They reported nannoplankton zones NP4 to NP7/ 8 and planktic foraminiferal zones P3a to P5, and concluded that the main part of the investigated sequences, including the entire BD-A section, was deposited during the Selandian (their Fig. 3). This is in disagreement with previously reported biostratigraphy of this area (Košťák et al., 2013). Therefore, we investigated additional samples to better constrain and subdivide the calcareous nannofossil biozones of the individual sections at Bir Dungul. This zonation is based on observations in coeval strata of the Aquitaine Basin (Steurbaut and Sztrákos, 2002) and other Tethyan locations (Storme et al., 2014). We avoid the application of planktic foraminiferal biozonations, as planktic foraminifera are too rare in the BD-D section and the reported P3a zonation of Youssef et al. (2017) must be discarded, as no planktonic foraminifera are present in this interval (see Youssef, 2014). The rarity of unambiguous specimens of *Globanomalina pseudomenardii* in Egypt does not warrant a chronostratigraphic interpretation of the planktic foraminiferal Zone P4 in this region. This explains the enigmatic coexistence of the calcareous NP7-8 nannoplankton zone with the planktic foraminiferal Zone P5 in the top part of the sequence as indicated by Youssef et al. (2017).

Section BD-E and the basal part of the BD-D section are completely devoid of calcareous nannofossils; therefore, a late Danian age can be neither proven nor excluded. Nannofossils indicate that the remaining part of the BD-D section is entirely of early Selandian age. This is based on the co-occurrences of *Fasciculithus tympaniformis* and an acme of *Lithoptychius* aff. *bitectus* (previously documented as *Lithoptychius janii*, see Storme et al., 2014), indicating nannofossil zone NP5. The top part of the BD-D section is assigned to zone NP6, based on the lowest



Fig. 3. Reassessment of the ostracod distribution in the Dineigil area (excluding section BD-E with no ostracod occurrences), which is based on the stratigraphic correlation between the studied sections, as proposed in the present paper and previously discussed in Košťák et al. (2013).

occurrence of *Heliolithus kleinpellii* (NP5/NP6 boundary marker), which is recorded at a much lower level than reported by Youssef et al. (2017). The nannofossil associations from the BD-B and BD-C sections show signs of moderate to strong dissolution and recrystallization. Although clearly biased in favor of the more solid forms in most of the samples, they retain sufficient characteristics for accurate age dating. *Heliolithus mohleri*, marker of Zone NP7, is recorded at the base of section BD-B and *H. kleinpellii* is consistently present in the basal part. The remaining parts of the BD-B and BD-C sections are assigned to an undifferentiated upper NP7 to NP8 biozone. No further subdivision is feasible due to the disappearance of *H. kleinpellii*, and the absence of *Heliolithus riedelii*. This NP7/NP8 boundary marker taxon is extremely rare to absent at low latitudes, including Egypt, and the absence of *Discoaster multiradiatus* (marker for zone NP9) implies deposition during the early Thanetian.

The nannofossil associations from the BD-A section are rather well preserved and more diversified compared to the other sections. The following biohorizons have been identified in section BD-A: lowest occurrence (LO) of *H. kleinpellii* at ~1.5 m, LO of *Discoasteroides bramlettei* at ~3 m, LO of *Fasciculithus clinatus* at ~4 m, LO of *Discoaster mohleri* at 5 m and the highest consistent occurrence of *H. kleinpellii* at 6 m. The uppermost interval (7–11 m) contains similar associations, including *D. mohleri*, but without *H. riedelii* and the absence of characteristic *Discoaster* taxa (*D. nobilis*, *D. okadai* and *D. multiradiatus*), which are all known from other sites in Egypt in younger strata. Consequently, the BD-A section covers the upper part of NP5 (lowest 1.5 m), NP6 (2–4.5 m), the lower part of NP7 (5–6 m) and an undifferentiated upper NP7 to lower NP8 interval (7–11 m). This clearly indicates an assignment to upper Selandian to lower Thanetian for this interval, contrasting a middle Selandian attribution by Youssef et al.

(2017). In addition, the recognition of these nannoplankton biozones indicates a significant stratigraphic overlap between the different studied sections (Fig. 2). As an example, *D. mohleri* is already recorded at the base of section BD-B, indicating a direct correlation with a level \sim 5 m above the base of section BD-A. Such evidence based on biostratigraphic data is completely absent in the record presented by Youssef et al. (2017).

4. Towards a correct composite section and ecozonation interpretation

It is obvious from our litho- and biostratigraphic observations (Figs. 1 and 2) that the different sections have a significant stratigraphic overlap and are partly covered by weathered material. Our data integration indicates that the BD-A section is almost completely correlated with the interval spanning the BD-D and BD-B sections. Youssef et al. (2017), however, incorrectly positioned the BD-A section in an intermediate stratigraphic position within the BD-B to BD-C sequence, but provided no stratigraphic evidence. Our field observations, including several distinct beds that can be traced along the entire cliff, demonstrate that the BD-B and BD-C sections compose one continuous sedimentary sequence. We thus strongly disagree with the authors' claim that their composite section is based on a thorough stratigraphic investigation as they failed to represent the simple geometry between the studied sections correctly. Accordingly, the proposed composite section of Youssef et al. (2017) is incorrect and the reported ostracod distributions are significantly misrepresented by a doubling of data and invalid biostratigraphic assignments.

Secondly, their reported ostracod ecozones should have been detected in both the BD-A and BD-B to DB-C sequences. A revised distribution chart of the published ostracod data of Youssef et al. (2017) is presented in Fig. 3, based on the correct correlation of the studied sections. This figure highlights that a more diverse assemblage is recorded in section BD-A and an ostracod faunal transition is present in its upper part. This section is less influenced by weathering and less diversified assemblages are recovered in coeval, more indurated, strata of the other studied sections Therefore, the reported faunal change is less pronounced in section BD-B due to a lack of data around this level. Youssef et al. (2017) provided no details about varying preservation states or total abundances, and thus neglected this taphonomic and quantitative bias. The discussed ecozonation cannot be pinpointed exactly in the BD-A section and rather reflect a gradual faunal transition in response to regional sea-level changes as taxa with an outer neritic affinity become more common. As a result, the published record does not warrant future data utilization as the sea-level rise associated with the gradual faunal transition was dated wrongly and the compositional data cannot be applied to understand the paleobiogeographic distribution of Tethyan ostracods in detail.

We demonstrate that the reported data of Youssef et al. (2017) can result in an incorrect interpretation of climate-related biosphere developments during the early Paleogene, due to inadequate stratigraphic analysis. The Latest Danian Event (LDE) is extensively described in various Egyptian shelf settings and linked to a repopulation event by the benthic foraminifera Neoeponides duwi in response to severe oxygen depletion at the sea floor (e.g. Sprong et al., 2012). A late Danian age cannot be excluded for the basal levels, but the lowermost interval with ostracod occurrences is clearly of Selandian age (occurrence of F. tympaniformis in absence of F. clinatus, see Košťák et al., 2013). This evidence an assemblage in a stratigraphically younger position than the Latest Danian Event (LDE), although this climate event was previously postulated at this level, based on a paleoecological interpretation of the N. duwi acme (Youssef, 2014) in the BD-D section. High abundances of N. duwi are not uncommon in this region (Hewaidy, 1994; Schnack, 2000), and thus reflect the normal distribution of this shallow-water dwelling species, rather than the biotic expression of the LDE.

Another important event is the Mid Paleocene Biotic Event (MPBE), which represents a climate event preceding the Selandian-Thanetian stage boundary (Schmitz et al., 2011) and is biostratigraphically situated in the lower part of nannoplankton zone NP6. In the discussed Dineigil area, the reported ostracod faunal transition was incorrectly positioned by Youssef et al. (2017) in the Selandian middle NP6 zone. This late Selandian age assignment could lead to the assumption that the MPBE is related to this assemblage change. Our stratigraphic data indicate that the faunal transition, which is approximately situated around 10 m in the BD-A section, occurred within the Thanetian undifferentiated upper NP7 to NP8 zone, thus clearly postdating the MPBE. The MPBE cannot be further discussed due to a lack of data in the corresponding stratigraphic interval (Fig. 3) and no explanation for varying ostracod abundances is provided by Youssef et al. (2017). The reported low-resolution ostracod data of the Dineigil area thus mimics lithologic changes with no obvious link to Paleocene climate events. The faunal transition, interpreted as an ecozonation by Youssef et al. (2017), most likely represent the regional biotic response to gradual sea-level rise during the Thanetian, as the deposition of a more chalky interval suggests maximum sea level in this area, corresponding with data from other parts in Egypt (Luger, 1985; Speijer and Schmitz, 1998; ...).

5. Conclusion

Paleobiogeographic distributions of microfossils, in this case Paleocene ostracods, are useful to understand the interaction between biotic evolution and environmental change, but this can only be based on solid stratigraphic data. We stress that basic geological aspects of correlation between outcrops and creation of composite sections should be described in full detail and must be supported by available data upon publication. Based on field observations and biostratigraphic analysis, we reject the proposed composite section of the Dineigil area, as described by Youssef et al. (2017). The authors disregarded that parts of the sequence were obscured by weathered debris, omitted characteristic indurated limestone marker beds and fail to recognize a significant stratigraphic overlap between the sections. Consequently, large parts of their proposed litho- and biostratigraphic subdivisions are incorrect. Our composite section reflects a correct field-based lithostratigraphic correlation, strengthened by an accurate calcareous nannofossil biozonation, and we demonstrate that the reported ostracod data need to be carefully assessed. Our clarifications provide a more robust and reliable basis for reconstructing paleobiogeographic compilations, and accurately linking biotic and environmental change in the ostracod record of this region.

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