

A review of the calcareous nannofossil biostratigraphy of the Al Athrun and Apollonia Formations, Cyrenaica, NE Libya

Ali Ahmed El Mehaghag*, Ali Daw El Mehdawi

Arabian Gulf Oil Company, Geological Laboratory, PO Box 263, Benghazi, Libya; *a_mehagnan@yahoo.com

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Abstract The Al Athrun and Apollonia Formations, exposed in the Wadi Al Athrun area of the Cyrenaica region of NE Libya, have been biostratigraphically reviewed. The studied section of the Al Athrun Formation is assigned to the lower to upper Upper Campanian (Nannofossil Biozones UC15d^{TP}-e^{TP} of Burnett (1998), corresponding to CC22c of Sissingh (1977) and Perch-Nielsen (1985). The studied section of the Apollonia Formation is assigned to the Upper Palaeocene (Nannofossil Biozone NP9) to Lower Eocene (NP10-11) of Martini (1971), equivalent to CP8-9 of Okada & Bukry (1980).

Keywords Al Athrun Formation, Apollonia Formation, Upper Campanian, Upper Palaeocene, Lower Eocene, Cyrenaica, NE Libya

1. Introduction

The Cyrenaica region is located on the NE Libyan coast (Figure 1). Carbonate rocks of Upper Cretaceous to Tertiary age are exposed in this region. An unconformity marks the boundary between the Upper Cretaceous Al Athrun and Tertiary Apollonia Formations. Both formations are characterised by the dominance of chalky limestone, deposited in a deep marine environment (Röhlich, 1974; Zert, 1974; Banerjee, 1980).

These formations are of particular interest because they have not been studied in any detail previously using calcareous nannofossils. In general, previous biostratigraphical investigations of the Al Jabal Al Akhdar sedimentary units were based on foraminifera, ostracoda, macrofossils and only partially on nannofossils (*e.g.*, Hay, 1968; Barr & Weeger, 1972; Barr & Berggren, 1980; Haq & Aubry, 1980; Abdulsamad & Barbieri, 1999). More recently, El Mehdawi (1991, 2004), El Mehaghag & Muftah (1996), El Mehaghag & Daw (2002), El Mehaghag & El Mehdawi (2002), El Mehaghag *et al.* (2002), Muftah *et al.* (2002), El Mehdawi & El Beialy (2004) and El Mehaghag & Ashahomi (2005) have revised the ages of the type-sections of some lithostratigraphic units exposed in the Al Jabal Al Akhdar area (*e.g.*, the Al Hilal, Al Athrun, Al Uwayliyah, Apollonia, Tukarh and Al Faidyiah Formations) using nannoplankton, foraminifera and palynomorphs. These studies have emended and refined the ages of those formations.

Barr & Hammuda (1971) originally assigned the Al Athrun Formation to the Upper Coniacian to Maastrichtian, based on planktonic foraminifera. Later, using nannofossils, El Mehaghag & Muftah (1996) determined the basal part of the Al Athrun Formation to be Lower Campanian (Nannofossil Biozone CC18a, following Sissingh, 1977, and Perch-Nielsen, 1985a), highlighting a significant discrepancy for the oldest age of the formation. Zert (1974) reported on planktonic and benthic

deep-sea foraminifera from the Apollonia Formation, exposed in Wadi Dernah, east of the study area, consequently determining the formation as being Middle Eocene (Lutetian) in age. Barr & Berggren (1980) and Haq & Aubry (1980) considered the typical Palaeocene foraminifera and nannoplankton encountered in the basal part of the Apollonia Formation in the Wadi Al Athrun section to be reworked.

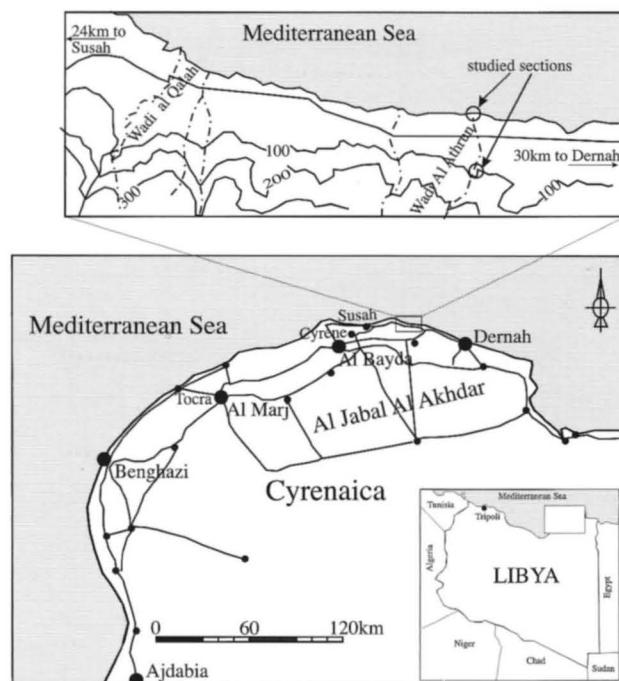


Figure 1: Location of the studied Al Athrun and Apollonia sections, Wadi Al Athrun area, NE Libya

2. Materials and methods

The studied part of the Wadi Al Athrun area represents

one of the exposed Cretaceous/Tertiary boundary sections in the Al Jabal Al Akhdar region, in which the Upper Cretaceous Al Athrun Formation is unconformably overlain by the Tertiary Apollonia Formation. The type-section of the Al Athrun Formation is c.45m thick, comprising white, chalky limestones, with very thin marls in parts. The lower and upper parts of the formation were sampled (Figure 2). Ten samples (ATS1 to ATS10), taken at 0.5m intervals from the highly contorted bedding exposed in a c.4.5m-high sea-cliff at the mouth of Wadi Al Athrun, were examined. A further eight samples (AT1 to AT8) were taken at 1m intervals from the uppermost part of the formation, below the unconformity that separates it from the Apollonia Formation. Eight samples (AP9 to AP16), taken at variable sampling intervals, were collected from the 4m of pale-coloured, fine-grained siliceous limestones of the Apollonia Formation.

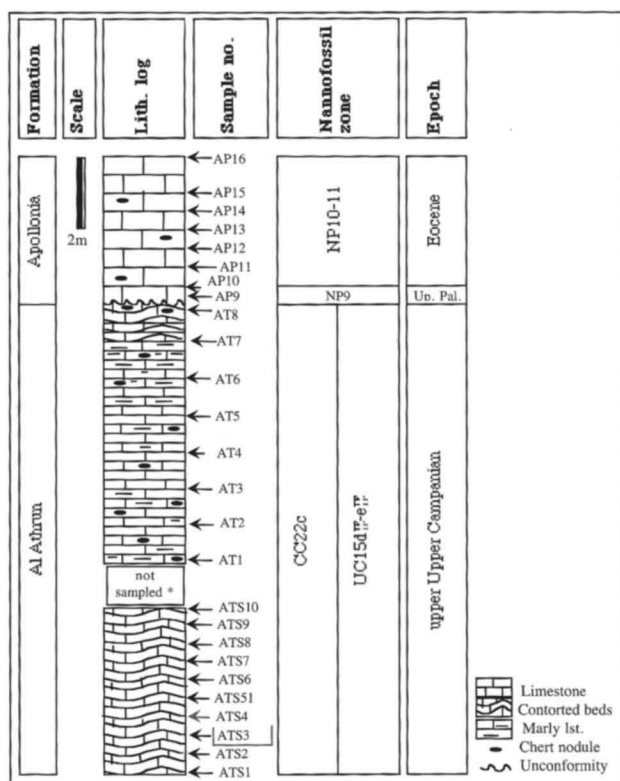


Figure 2: Lithostratigraphy and sample levels, Al Athrun and Apollonia Formations; *not to scale

Smear-slides were prepared loosely following the pipette strew-slide method described in Bown & Young (1998). The surface of each sample was trimmed with a blade until a fresh surface was obtained. The sample was crushed in a paper towel, to avoid contamination, and the powder was then placed in a beaker and immersed in distilled water. The suspension was stirred and left for a short time to allow the sediments to disintegrate. A small amount of the suspension was decanted into a test-tube and diluted with distilled water. A labelled glass slide was flooded with the suspension and dried on a hot-plate. A

coverslip was then attached, using an optical mounting medium.

All slides were examined with an Axio Plan 2 Universal Zeiss microscope at 1000x and 2000x magnification. Each slide was examined under cross-polarised and transmitted (bright field) light. Estimation of the relative abundances of species present per field of view was based on three traverses. The slides are kept in the Geological Laboratory of the Arabian Gulf Oil Company (AGOCO), Benghazi, Libya.

3. Results

The 26 investigated samples from the Al Athrun and Apollonia Formations yielded moderate to high richness of moderately- to well-preserved specimens. Fifty-one Campanian and Eocene taxa were recorded. All taxa can be found, fully-authored and referenced, in Perch-Nielsen (1985a, b) and Bown (1998). The biostratigraphy is shown in Table 1. The biozonation schemes of Sissingh (1977), as modified by Perch-Nielsen (1985a: CC zones), Burnett (1998: UC zones), Martini (1971: NP zones) and Okada & Bukry (1980: CP zones) were applied.

3.1 Al Athrun Formation

Eighteen samples from the Al Athrun Formation yielded 34 species of early to late Late Campanian age. The lower 10 samples (ATS1-10) and the upper eight samples (AT1-8) are assigned to Nannofossil Biosubzones UC15d^{TP}-e^{TP} (lower to upper Upper Campanian), based on the co-occurrence of *Uniplanarius trifidus* and *Eiffellithus eximius*. The two subzones cannot be separated due to the absence of the subzonal marker *Eiffellithus parallelus*. This corresponds to CC22c, based on the co-occurrence of *Reinhardtites levis* and *E. eximius*.

3.2 Apollonia Formation

The eight samples (AP9-16) from the lowermost part of the Apollonia Formation revealed 17 Late Palaeocene and Early Eocene taxa. Sample AP9 is assigned to NP9 (Upper Palaeocene), corresponding to CP8, on the basis of the presence of *Discoaster multiradiatus* in AP9 and the first occurrences (FO) of *Discoaster diastypus* and *Tribrachiatus bramlettei* in Sample AP10. Samples AP10-16 are assigned to NP10-11 (Lower Eocene), equivalent to CP9, on the basis of the presence of *D. diastypus* and *T. bramlettei* and the absence of *Discoaster lodoensis*.

4. Discussion

The Al Athrun Formation was assigned to the Coniacian to Maastrichtian by Barr & Hammuda (1971), based on planktonic foraminifera. The present study, and that of El Mehaghag & Muftah (1996), restrict the age to the Campanian. An Early Campanian age was reported by El Mehaghag & Muftah (1996) for the lowermost part of the formation, exposed in Wadi al Qalah, based on the assignment of the *Globotruncana elevata* Planktonic Foraminifera Zone and Nannofossil Subzone CC18a. The

present study assigns the uppermost part of the formation to UC15d^{TP}-e^{TP}, here equivalent to CC22c, of early to late Late Campanian age.

The Apollonia Formation was assigned to the Eocene by Zert (1974), Barr & Berggren (1980) and Haq & Aubry (1980). Barr & Berggren (1980) and Haq & Aubry (1980) studied the same section, Haq & Aubry (1980) interpreting NP9 for the lowermost part of the formation but considering the nannofossils to be reworked, based on Barr & Berggren's (1980) interpretation. Barr & Berggren (1980) reported, in their lowermost sample only, typical Palaeocene planktonic foraminifers of Biozone P4, including *Planorotalites pseudomenardii*, *Morozovella velascoensis*, *Subbotina velascoensis* and *Acarinina mckennai*. In their next sample (60cm above the first), they recorded Lower Eocene Biozone P6, characterised by the presence of *Morozovella subbotina*, *M. marginodentata*, *Acarinina coalingensis* and *A. soldadensis*. Consequently, they referred the presence of the Palaeocene microfauna to reworking, but considered the absence of the Eocene microfauna from the same sample as puzzling. They suggested a paraconformity between their lower two samples, separating the Upper Palaeocene (P4) from the Lower Eocene (P6).

In the present study, only a typical Palaeocene nannoflora was recorded from our lowermost sample (AP9), which was collected from c.25cm above the Cretaceous/Tertiary transition, with the first indication of the Lower Eocene (NP10) being recognised in the next sample, 15cm above the first. This evidence suggests that the Upper Palaeocene microfauna and nannoflora present in the lowermost part of the formation, and originally reported by Barr & Berggren (1980) and Haq & Aubry (1980), are *in situ*, and not reworked as previously suggested. Furthermore, since Nannofossil Biozones NP9 and NP10 are present consecutively in the section, this would suggest that the paraconformity interpreted by Barr & Berggren (1980), separating the Upper Palaeocene P4 from the Lower Eocene P6, cannot be proved.

5. Conclusions

Results from the current study, combined with those of El Mehaghag & Muftah (1996), confine the age of the Al Athrun Formation to the Early to Late Campanian (CC18a-22c; UC14a-15d^{TP}/e^{TP}). The age of the Apollonia Formation in the Wadi Al Athrun section ranges from Late Palaeocene (NP9) to Early Eocene (NP10-11). This conclusion is supported by the presence of typical Palaeocene taxa, in the absence of Eocene species, in the basal part of the formation, followed without obvious interruption by typical Early Eocene species. This contests the previously-held views of Barr & Berggren (1980) and Haq & Aubry (1980) that the base of the Apollonia Formation is Eocene.

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Table 1: Nannofossil biostratigraphy, Al Athrun, and Apollonia Formations. R = rare (1-2 specimens per field of view), C = common (3-10 specimens per field of view); *interpreted as reworked

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