



Stratigraphy of the Cretaceous/Paleogene Boundary in the Al Uwayliah Area, Al Jabal al Akhdar, NE Libya

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Abstract

The lithostratigraphic and biostratigraphic review of the Late Cretaceous/Paleogene (k/pg) boundary in the Al Uwayliah area with a comprehensive stratigraphic correlation is the aim of this study. The

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Upper Cretaceous rocks of Wadi Al Dukhan Formation at Al Uwayliah area is in general composed of microcrystalline dolostone and calcitic dolostone. The Wadi Dukhan Formation at surface exposures in Cyrenaica is of Maastrichtian age as indicated by rudistid pelecypoda. The Maastrichtian age is confirmed from subsurface sections (Well B7 and U2-6) based on larger foraminifers. The Underlying Paleocene deposits, on the other hand, are represented by the Landenian Al Uwayliah Formation which is cropping out near al Uwayliah village is made of chalky limestone alternating with foraminiferal wackestone. It has been dated Late Paleocene the Landenian age based on Globorotalia pseudomenardii Zone and Globorotalia angulata Zone. However, the Uwayliah Formation was assigned to the Planorotalites pseudomenardii Zone. Hence, the Al Uwayliah Formation represents only the late Paleocene (Landenian) with complete absence of Danian and Selandian age making unconformable contact ($\approx 11\text{Ma.}$) with the underlying Wadi Dukhan Formation. Elsewhere, at al Athrun area the stratigraphy is completely different as Apollonia Formation unconformably overlain the Athrun Formation with angular unconformity ($\approx 10\text{Ma. Missing}$) in response to severe tectonism.

Keywords: *Stratigraphy, Cretaceous, Paleogene boundary, Al Uwayliah, Al Jabal Al Akhdar, Libya.*

1. Introduction

The study area is located east to Al Uwayliah village at (Lat. $32^{\circ}33'12''$ N and Long. $21^{\circ}02'40''$ E). This study is performed on basis of the reviewing and integrating the previous results made by [3-8].

The Al Jabal al Akhdar lies in northern Cyrenaica, northeastern Libya, and has excellent surface exposures of upper Cretaceous-Cenozoic sedimentary sequences. Al Jabal al Akhdar has been interpreted as an anticlinorium [1]. However, the Al Jabal al Akhdar belt is a part of the

northern African-Arabian active margin following the opening of the Neo-Tethys. Al Jabal Al Akhdar is composed largely of carbonate rocks of the Late Cretaceous, Paleogene and Neogene age, their spatial distribution are illustrated in Figure (1). The upper Cretaceous rocks are strongly folded and faulted, whereas the Eocene, Oligocene and Miocene rocks are, slightly, folded and commonly with dip angles 10° [1]. According to [2], the exposed rock units of Al Jabal al Akhdar are stratigraphically divided into fourteen rock units (Fig. 2). All the above-mentioned rock units are separated from each other by unconformity surfaces, with the exception of Apllonia/Darnah boundary which is gradational (Fig. 2).

The present study aims to: i) review the nature of the Cretaceous/Paleogene boundary in the Al Uwaliyah area; ii) comprehensive correlation with the Athrun area; iii) to produce a composite lithological column.

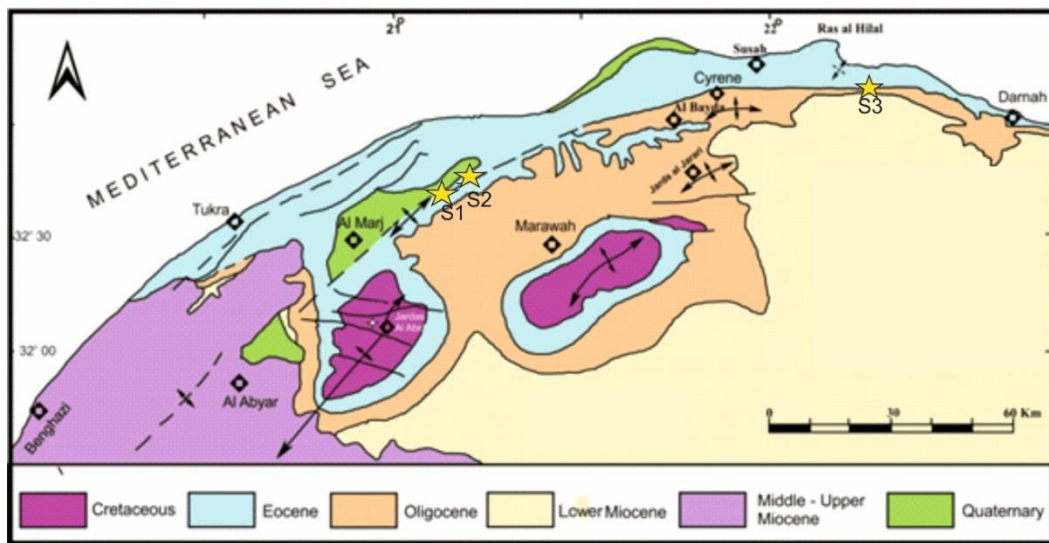


Fig. (1): Geologic surface map of Al Jabal al Akhdar after [12]. the studied localities are indicated by Stars (*1: Statah Quarry; *2: Al Uwaylian village; *3: Al Athrun village).

PERIOD	EPOCH	STAGE	AL JABAL AL AKHDAR
NEOGENE	MIOCENE	Messinian	Wadi Al Qattarah Fm.
		Tortonian	
		Serravalian	Benghazi Fm.
		Langhian	
		Burdigalian	Al Faiadiyah Fm.
PALEOGENE	OLIGOCENE	Aquitanian	
		Chatian	Al Abraaq Fm.
	EOCENE	Rupelian	Al Baydah Fm.
		Priabonian	
		Bartonian	Darnah Fm.
		Lutetian	Apollonia Fm.
		Ypresian	
		Thanetian	
	PALEOCENE	Setandian	Al Uwayliah Fm.
		Danian	
Maastrichtian		Wadi Dukhan Fm.	
CRETACEOUS	LATE	Campanian	Al Majahir Fm.
		Santonian	
		Coniacian	Al Banyah Fm.
		Turonian	Hilal Fm.
		Cenomanian	Qasr Al Abid Fm.

Fig. (2): Stratigraphical chart of the exposed rock units of Al Jabal al Akhdar after [4].

2. Lithostratigraphy

Wadi Dukhan Formation

The Wadi Dukhan Formation is exposed in the Jardas al Abid area with a 610m section [3]. It consists of hard, grey to brown, micro-crystalline dolomite and calcitic dolomite to dolomitic limestone. Although no diagnostic fossils were reported, a tentative age (Late Cretaceous to Early Tertiary) was given based on stratigraphic position [3]. However, [4] reported poorly preserved rudists in the lower part and poorly preserved *Nummulites*-casts in the upper part of the formation. Accordingly, they are considered the Wadi Dukhan Formation Paleocene(?) – Maastrichtian in age. The presence of *Nummulites*-casts in the upper part of the formation as suggested by [4] is not accepted herein, as it is a form of tracefossil (casts) with no internal details. Therefore, the closely similar morphology genus *Amphestigina* is the most likely as this genus is commonly reported in association with the reefal habitat,

accordingly the Paleocene is surely eradicated, meanwhile, the Maastrichtian age is confirmed.

[3] and [4] reported that the Wadi Dukhan Formation conformably overlies the Jardas Formation (Cenomanian to Campanian) and is unconformably overlain by the Apollonia Limestone, Darnah Formation or Al Bayda (syn. Cyrene) Formation in the Jardas al Abid and al Marj areas. Other exposures of the Wadi Dukhan Formation in the proximity of Jardas al Jarrari, with thickness ranging from 40-100 m have been reported by [9]. However, The contact of the Wadi Dukhan Formation with Al Uwayliah Formation (Paleocene) in the vicinity of Jardas al Jarrari was observed by [9]. An exposure of Wadi Dukhan Formation at Wadi Stata in Stata village (Fig. 3), close to Uwayliah city, displays the upper Cretaceous Wadi Dukhan and Upper Paleocene Al Uwayliah formations along the opposite side of the North - West Jardas Fault (NWJF) [10]. The former also mentioned earlier in the field guide books of [11, 12]. The spatial distributions of the (Cretaceous and Paleogene) exposed rock units namely Wadi Dukhan, Al Uwayliah and Darnah formations in the Al Uwayliah area however are shown in Figure (4).



Fig. (3): A general view of Wadi Dukhan Formation at the abandoned quarry, Stata village. A close up view of Rudists (arrowed).

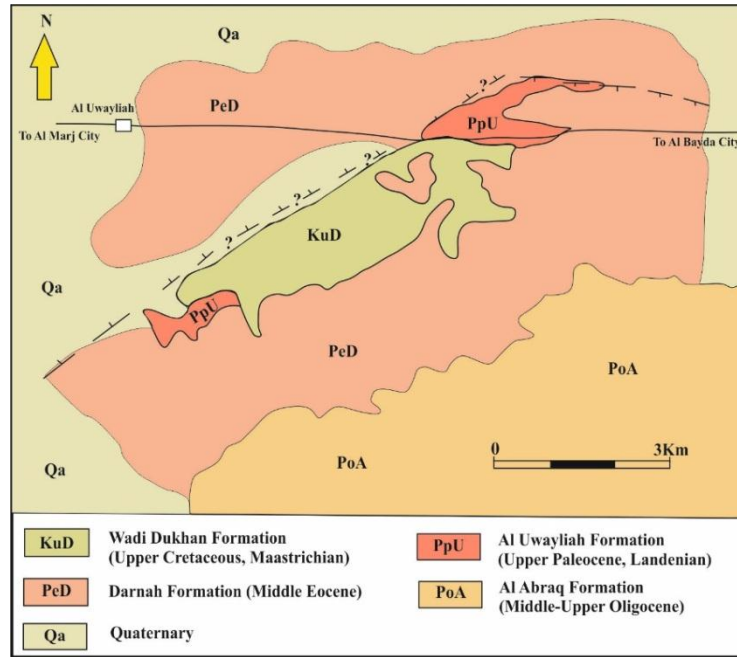


Fig. (4): Geologic map of Al Uwayliyah area after [12].

The Wadi Dukhan Formation has been subdivided on a petrographical basis into four units at the measured section of Wadi Stata, (Fig. 5), from bottom to top: reefoidal calcitic dolostone (Fig. 6, A), coarsely crystalline dolostone (Fig. 6, B), brecciated dolostone (Fig. 6, C), and finely crystalline dolostone (Fig. 6, D), reflecting a progressing-up sequence from reef-bearing shallow warm marine to shallower subtidal settings [8].

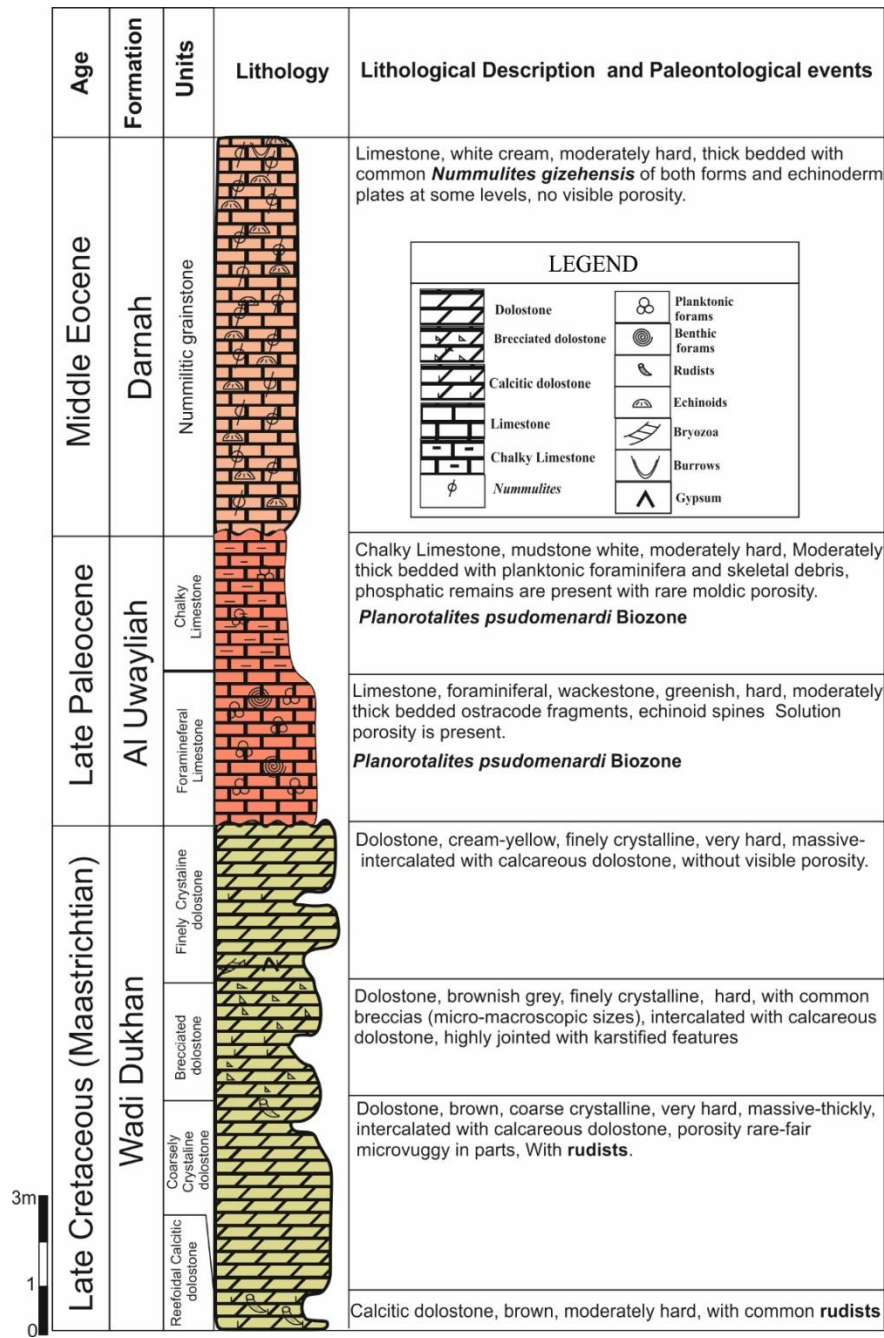


Fig. (5): Composite stratigraphic column of the rock units and the main units exposed at Al Uwayyah area.

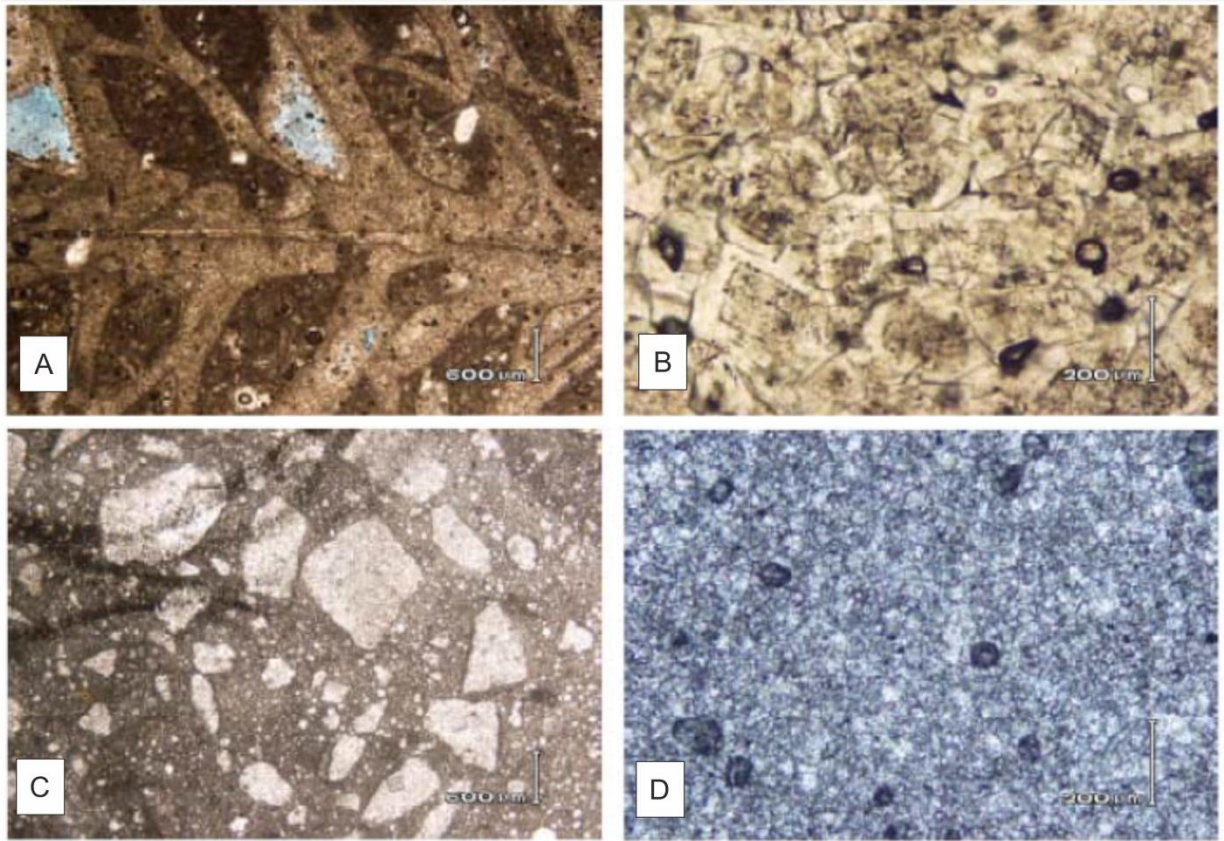


Fig. (6): Thin sections photomicrographs of A-Reefoidal calcitic dolostone unit, B-Coarsely crystalline dolostone unit, C- Brecciated dolostone unit, D -Finely crystalline dolostone unit of Wadi Dukhan Formation in Al Uwayliah area, after [8].

Al Uwayliah Formation

The Paleocene rocks in Al Jabal al Akhdar were deposited during marine transgression, which began during the Danian. The tectonic unrest of the area and the subsequent erosion played an important role in the limitation of Al Uwayliah outcrop distribution in the area [11]. The measured and studied section described previously by [13] from the al Uwayliah locality is the holostratotype, which represents the upper part of the Al Uwayliah Formation and is composed of whitish chalk and

greenish marl (in the middle part of the facies). The present studied section is made of 6m thick, the upper boundary of this formation with the overlying Darnah Formation is exposed at the type locality. However, the lower boundary with the underlying Upper Cretaceous Wadi Dukhan Formation is not exposed at the type locality (Figs. 5 and 7). According to [6] two lithological units have been recognized in the exposed Al Uwayliah Formation (Fig.5 and 8).

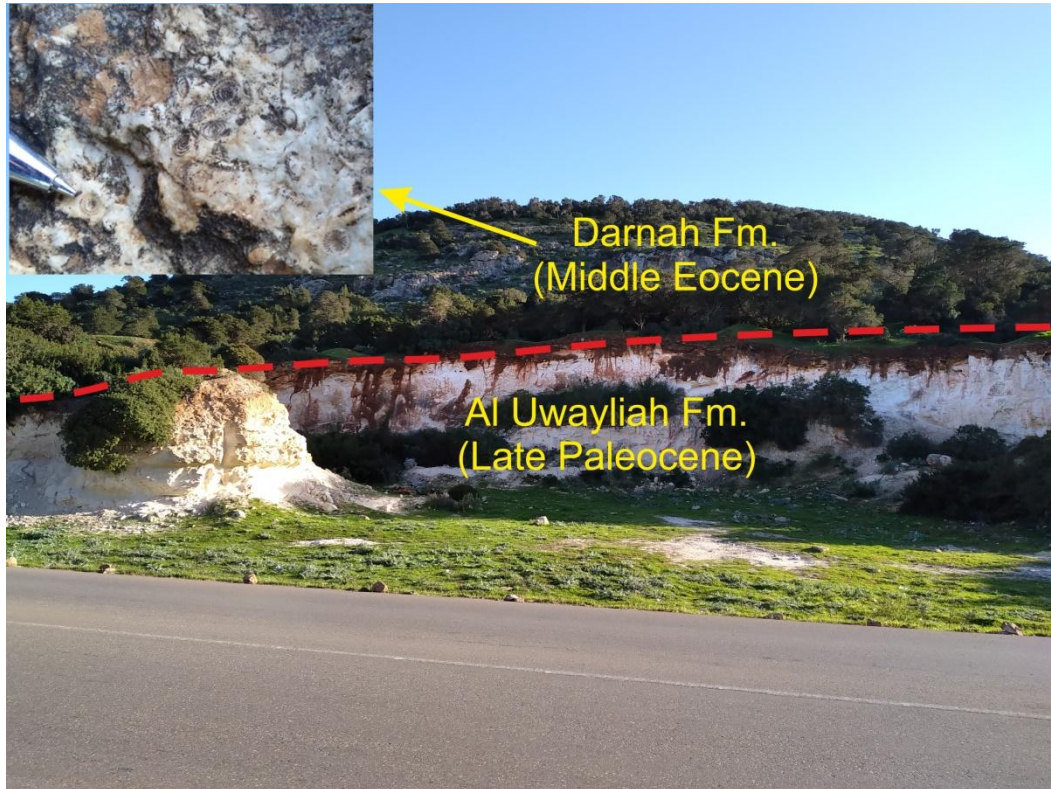


Fig. (7): Al Uwayliah Quarry section showing the Boundary (dashed line) between the chalk limestone of Al Uwayliah Formation below and Nummulitic limestone of Darnah formation above. The arrow shows a close up view of *Nummulites gizehensis* (megalospheric-Form) assemblage.

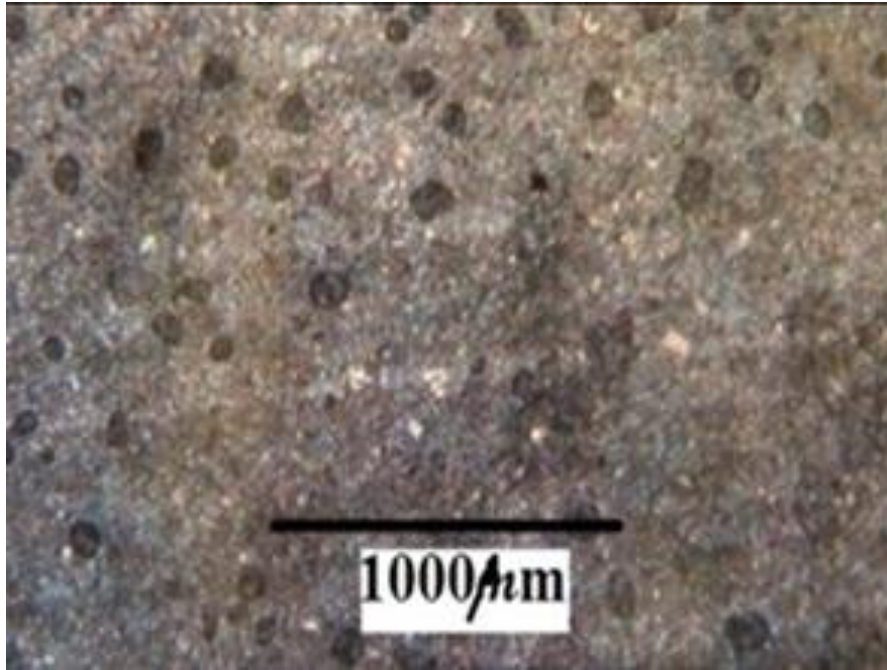


Fig. (8): Thin sections photomicrographs of Chalky mudstone of Al Uwayliah Formation.

Lithostratigraphic Correlation

The two sections under investigation at the Al Uwayliah area (Al Uwayliah quarried section, Wadi Dukhan quarried section) at Stata area have been laterally correlated with the previous studied wadi al Athrun section at Athrun area. The correlation aimed to verify the lateral lithofacies changes and to link the Cretaceous/ Paleogene boundary in the two areas (Fig. 9). The correlations revealed that, at Al Uwayliah Quarried section, the Late Paleocene Al Uwayliah Formation is represented by chalky limestone and unconformably overlain by the Middle Eocene Darnah Formation, which is characterized by nummulitic rich-limestone of 9m thick. The Early Eocene Apollonia Formation at this section is completely missing with a hiatus of about 11 Ma. Nearby 1.5

Km away eastwards at Statah quarried section, the Middle Eocene nummulitic limestone Darnah Formation is preserved with a thickness of 11m, and at this section, is unconformably underlain by the Maastrichtian Wadi Dukhan Formation of about 12m thick sequence of dolostone with different microfacies devoid of any fossils except some poorly preserved Rudists sp. This section shows the complete missing of Al Uwayliah and Apollonia formations with hiatus equals to 21 Ma. This long hiatus may be attributed to an instability episode in the Uwaylian inlier development. *Further to the east, about 120 km, the Wadi Al Athrun section, which was studied by [14] Darnah Formation shows a highly nummulitic rich-limestone of packstone and grainstone texture with a remarkable increase in thickness, which underlain by Early Eocene Apollonia Formation with interfingering relationship. Apollonia Formation at this section is well preserved and reaches a thickness of 30m, with two unconformities of short hiatus, have been reported by [14], this as well indicating the instability of Al Jabal Al Akhdar during the Early Eocene times at this area. The Campanian-Maastrichtian Al Athrun Formation at this locality unconformably underlain the Apollonia Formation shows several structural elements (Joints, microfaults and folded strata). The presence of the angular unconformity which delineates the contact between Al Athrun Formation and the Early Eocene Apollonia Formation is strong evidence of the Al hilal anticline [15]. The Paleocene deposits at this section is debatable, a very thin marly unit containing reworked pebbles of Paleocene age [2, 14].*

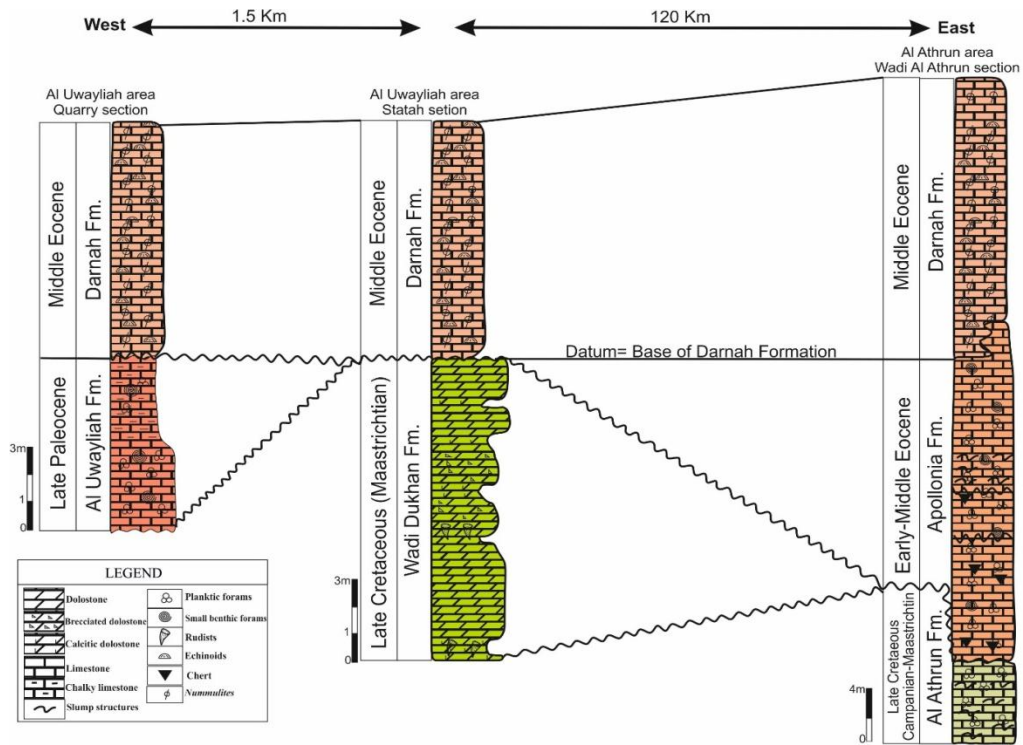


Fig. (9): Lithostratigraphic correlation of sections at Al Uwayliyah and Wadi Al Athrun areas.

3. Biostratigraphy

Wadi Dukhan Formation (Maastrichtian)

[16] reported planktic foraminifera characterized by conical shape of the genus “*Globotruncana*” from the lower part of Wadi Dukhan Formation which represents the only report of foraminifera from this formation. [7] confirmed the Maastrichtian age of Wadi Dukhan Formation based on the reported larger foraminifers *Omphalocyclus macroporous*, *Siderolites* cf. *S. calcitrapoides* and *Orbitoides* cf. *O. media* from the dolomitic limestone intervals of Well B7-41 (8370'-8600') and Well U2-6 (7950'-8100') in Cyrenaica and northeastern Sirt Basin respectively. According to [8] Wadi Dukhan Formation at Stata section in

The different ages of Al Uwayliah type locality at Al Uwayliah exposed section was studied micropaleontologically by some workers including [13, 9, 5, 6], (Fig. 10). The last published work by [6] confirms the presence of *Planorotalites pseudomenardii* zone of Late Paleocene (Landenian) age. The documented foraminiferal assemblage at this formation by [6] is rich and diverse with the heavily ornamented taxa of *Morozovella velascoensis*, *M. aequa*, *M.cf. M. angulata*, *M.cf. M. quetra*, *M. oculosa*, *Acarinina mckannai*, *A. nitida*, *A. primitiva*, *Subbotina triloculinoides*, *S. cf. S. inaequospira*, *S. triangularis*, *S. velascoensis*, *Planorotalites chapmani*, and *P. pseudomenardii*. This zone represents almost the whole measured section of the Al Uwayliah type rock unit and it is corresponding to the nannofossil biozone (NP9) of [17]. The foraminiferal species reported by [13, 5], and the calcareous nannofossils and foraminifers recorded by [6] from the holostatotype and by [9] from the parastratotype (the upper and lower parts of Al Uwayliah Formation, respectively). It seems that at least the uppermost part of the Danian Stage (foraminiferal Zone P2 which represents *Morozovella unicata* Zone) and the lower part of the Selandian Stage (the lower part of the foraminiferal Zone P3 which represent *Morozovella angulata* and *Planorotalites pusilla pusilla*) are not represented in either part of the formation [7].

4. Conclusion

The upper Cretaceous rocks of the Wadi Al Dukhan Formation are composed of microcrystalline dolostone and calcitic dolostone and according to [8]. It is divided petrographically into four units from bottom to top: reefoidal calcitic dolostone; coarsely crystalline dolostone; brecciated dolostone; and finely crystalline dolostone. The Paleocene deposits, on the other hand, are represented by the Al Uwayliah

Formation which is made of chalky limestone alternating with foraminiferal wackestone according to [6]. [7] confirmed the Maastrichtian age of Wadi Dukhan Formation from subsurface successions in Well B7 (Cyrenaica region) and U2-6 (Sirt Basin) based on the reported larger foraminifers *Omphalocyclus macroporous*, *Siderolites* cf. *S. calcitrapoides* and *Orbitoides* cf. *O. media*. However, Wadi Dukhan Formation at surface exposures in Cyrenaica. [8] confirmed the Maastrichtian age due to the presence of rudists which is called herein *Durinia* sp.

The reported *Nummulites* casts in Wadi Dukhan as suggested by [4] is not accepted herein, as it most likely represents *Amphestigina* instead and the Paleocene questionable age made by them has been erased.

On the other hand, the age of Al Uwayliah Formation at Al Uwayliah area is dated to Late Paleocene by [5, 9, 13] the former reported the diagnostic Landenian species *Globorotalia pseudomenardii* Zone and *Globorotalia angulata* Zone. Whereas, [6] Muftah et al., (2002) assigned this chalky limestone to the *Planorotalites pseudomenardii* Zone which is corresponding to calcareous nannofossils *Discoaster multiradiata* = NP9 Zone of [17]. Hence, the Al Uwayliah Formation represents only the late Paleocene (Landenian) with complete absence of Danian and Selandian age making unconformable contact with the underlying Wadi Dukhan Formation.

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