

# A reservoir Scale Case Study: Facies Geometries, Cyclicity, and Depositional Environments of the Homogeneous Nummulitic Eocene sequence, Darnah Formation, Cyrenaica Platform, Northeast Libya



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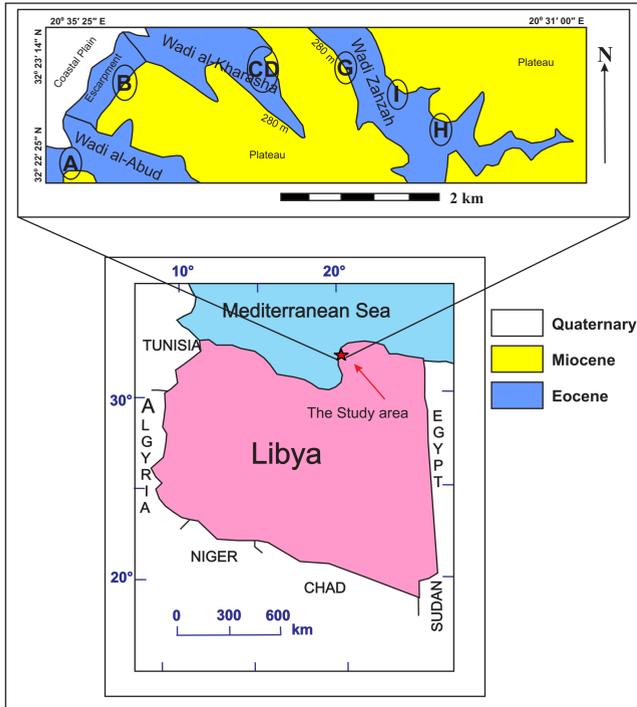


Figure 1 Location and geological maps of the Eocene sequence, Darnah Formation, Cyrenaica, NE Libya

## ABSTRACT

Six detailed field sections of 135 m maximum thickness, along 7 km distance were measured in the Middle to Late Eocene succession of Darnah Formation. Two depositional facies association were distinguished in the nummulitic Eocene shallowing upward sequence. The facies associations are: 1) nummulitic dominated rudstone associated with packstone, and 2) nummulitic dominated floatstone associated with packstone and some wackestone and mudstones.

The Nummulitic Eocene shallowing upward sequence comprises six cycles of sedimentation based on lithological, paleontological, and field observations. These six cycles of sedimentation include smaller subcycles. The cyclicity of these nummulite dominated successions formed due to the interchangeable deposition of fining-upward floatstone dominated facies and the coarsening-upward rudstone dominated facies.

The SW-NE stratigraphic cross section shows three different geometries at three different stratigraphic levels in the coarsening upward rudstone cycles, bioherm/banks. The Nummulitic bioherms/banks are of elongated lens shape in the lower part of the sequence that changed into a continuous mound shape in the middle, and then changed into a half-channel cross-section shape at the top. On the other hand, the fining upward floatstone dominated cycles are of blanket shape that covers the rudstone cycles. The bioherms of lenticular shape gradually thins and bench out from both sides, while the half-channel shape bioherms suddenly bench out and disappear against the fining upward floatstone dominated cycles. However, the bioherms of the mound shape are always laterally continuous. The datum for the stratigraphic cross section was the top surface of the Eocene sequence.

The nummulitic Eocene shallowing upward sequence shows a general trend of increase in the nummulite fossils size up in the section. In addition, the fining upward floatstone cycles are dominated by smaller size nummulites (1-5mm) associated with large bivalves and gastropods. The coarsening upward rudstone cycles are dominated by larger size nummulites (2-50mm) that always associated with smaller size bivalves and gastropods. The fining upward floatstone cycles are very hard, well cemented, and usually associated with brownish gray chert nodules of 15-30 cm in diameter. The chert nodules sometimes contain intact nummulite fossils inside them.

The nummulitic Eocene shallowing upward sequence deposited in a shallow neritic environment as indicated by fossils assemblage of Nummulites gizehensis, Nummulites incressatus, Nummulites chavanesi, Nummulites fabiani, and pelecypods. This case study covered only a small part of the nummulitic Eocene shallowing upward sequence that extends for more than 200 km along a dip profile, and its excellent 3-D exposure makes it an analogue for nummulitic carbonate reservoirs in the subsurface within the Mediterranean region and globally.

## INTRODUCTION

The study area located in the western part of Al-Jabal Al-Khdar, 70 km northeast Benghazi city along the coastal escarpment. Its boundaries are defined by the longitudinal lines 20°35' 25" E and 20°31'00" E and the latitudinal lines 32°22'25"N and 32°23'14" N. The main objectives of this study are to define depositional facies and their environment, facies cyclicity, facies geometries, facies homogeneity, and to make stratigraphic correlations based on high resolution field measured sections in this carbonate ramp setting.

## METHODS

Six detailed bed-by-bed field sections measured in the Eocene Darnah Formation. The measured data includes lithology, fossils identification and vertical variations, facies geometries and thickness variations, nature of bedding surfaces, facies vertical and lateral changes, and facies cyclicity.

## DISCUSSION

The SW-NE stratigraphic cross section delineated geometries of the facies associations and highlighted their vertical homogeneity. The top disconformity surface of the Eocene-Miocene was selected as a datum for this high resolution stratigraphic correlation. The studied Cyrenaican Eocene carbonate ramp is a shallowing upward sequence that comprises three shallowing upward sequences. The three shallowing upward sequences include six cycles of sedimentation that made up of two facies associations. The facies associations are: 1) nummulitic dominated rudstone associated with packstone, and 2) nummulitic dominated floatstone associated with packstone and some wackestone and mudstones. Each shallowing upward sequence is made up of a fining upward nummulitic-floatstone-dominated cycle (T.S.T) that topped by a coarsening upward nummulitic-rudstone-dominated cycle (H.S.T). The three shallowing upward sequences in this study are separated from each other by sharp surfaces (S.B) that topped immediately by very distinctive flooding mudstone beds (f.s) of the next sequence. The same three shallowing upward sequences pattern is noted in the Ras al-Hillal area in Cyrenaica and in the Borui field area (El-Hawat et.al, 2007). Although it is not a reefal setting, it must be mentioned that the rudstone and floatstone textures are used in the context of mud-free grain-supported and mud-contained grain-supported carbonate respectively that have dominant bio-grains larger than 2mm in size.

The nummulitic bioherm coarsening upward cycles form three distinctive geometries at three different stratigraphic levels. At lower part of the Eocene sequence the nummulitic bioherms form lense-shape bodies that up to 35 m thick and thinning laterally for less than a meter in a distance of 7 km. In the middle part of the Eocene sequence the nummulitic bioherms form a laterally continuous mound-shape body of up to 55 m thick and thins in the SW direction down to 15 m. At the upper part of the Eocene sequence the nummulitic bioherms form a half-channel-cross-sectional-shape of 33 m thick, and 3 km wide. It benches out suddenly to the NE, and thins out to 2 m and then disappears in the SW. The nummulitic fining upward cycles form blankets that cover the nummulite bioherms. These nummulite blankets increase in their maximum thickness upwards from 28 m thick at the base, to 35 m thick in the middle, to 65 m thick in the upper part of the Eocene sequence.

Sizes of the nummulite fossils show a strong trend of increasing upward in this Eocene sequence. In each one of the three complete shallowing upward, the nummulite sizes in the coarsening upward cycles are always larger than those in the fining upward cycles. Also, the nummulite fossils sizes are always larger than the associated bivalves and gastropods in the coarsening upward cycles, where in the fining upward cycles the nummulites are frequently associated with larger sizes bivalves and gastropods.

The nummulite fossil in the Darnah formation Eocene sequence are Numulites gizehensis, Numulites incressatus, Numulites chavanesi, Numulites fabiani, besides pelecypods, and gastropods. This fossils assemblage indicates the deposition of the Darnah formation in a shallow neritic to littoral environment in the ramp setting (El-Hawat et.al, 2007; Zert, 1974; and Rohlich, 1974).

## CONCLUSION

The Eocene Darnah Formation of the Cyrenaican has three main shallowing upward sequences, contains six cycles of sedimentation that made up of two facies associations. The two facies associations are the nummulitic rudstone bioherms that form as coarsening upward cycles, and the nummulitic floatstone blankets that form as fining upward cycles. The Eocene Darnah Formation sequence shows a gradual facies change vertically with repeated cyclicity. The nummulitic Eocene sequence was deposited in a ramp setting of a shallow neritic environment as indicated by the fossils assemblage.

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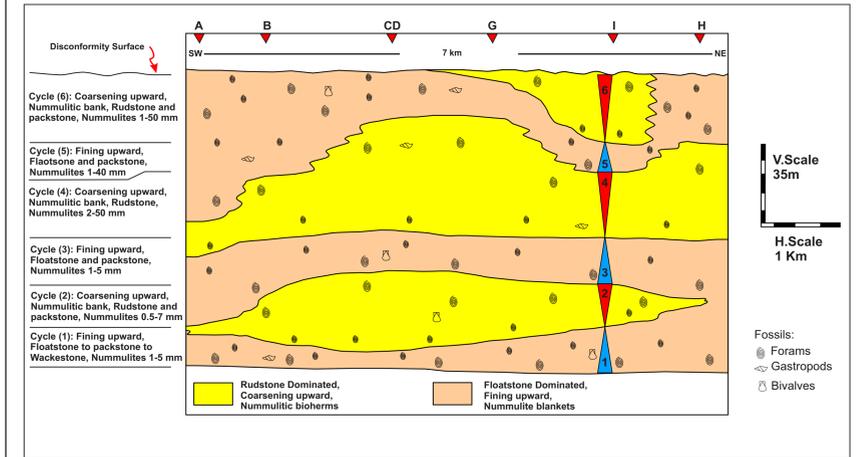


Figure 2 The stratigraphic cross section of the Eocene carbonate sequence, Darnah Formation, Cyrenaica, NE Libya

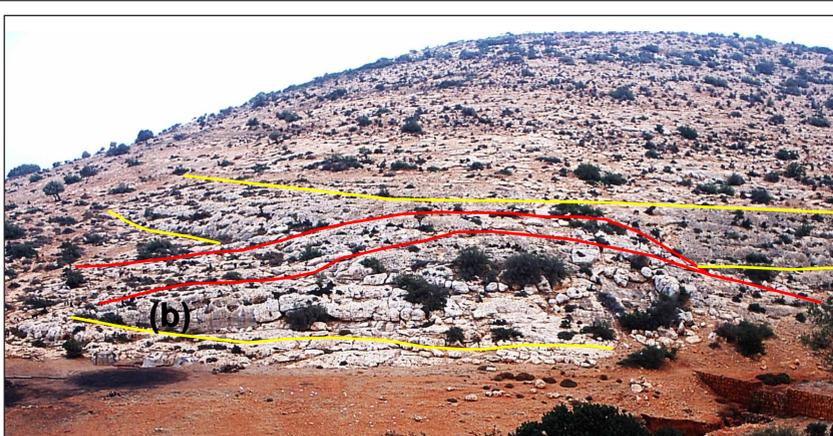


Figure 4 Field photos of the nummulitic lense-shape bodies, and closeup view of the nummulitic banks of the Eocene sequence, Darnah Formation, Cyrenaica, NE Libya

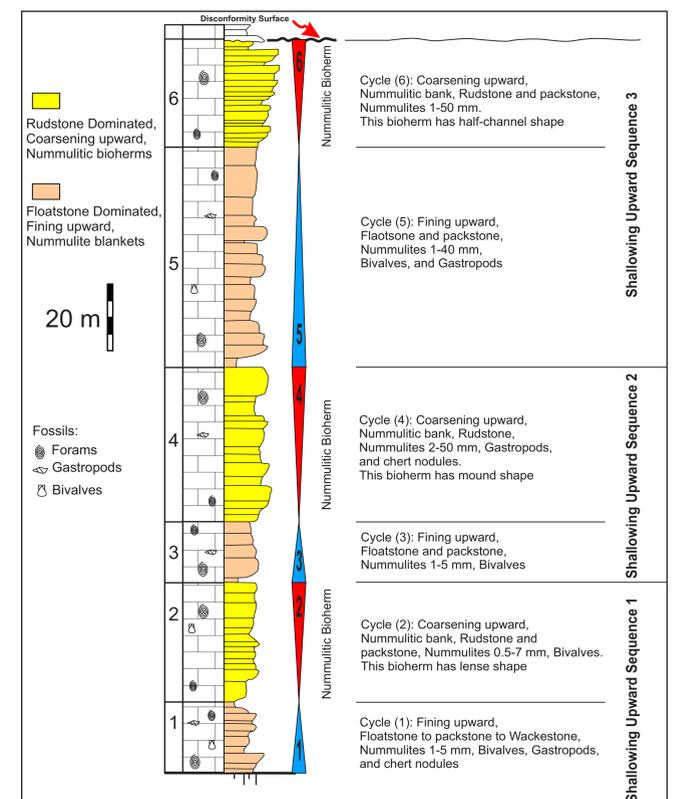


Figure 3 The ideal carbonate Nummulitic shallowing upward sequences of the Eocene, Darnah Formation, Cyrenaica, NE Libya