



Lithofacies and biofacies characteristics and whales skeletons distribution in the Eocene rock units of Fayoum Area, Egypt



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ABSTRACT

At Wadi Al Hitan area, rapid lateral and vertical variation is observed among the exposed middle and upper Eocene rock units. The traditionally known formations (Gehannam, Birket Qaroun, Qasr El-Sagha formations) interfinger laterally and not chronologically stacked above each other in most areas. Fine siltstones and claystones characterize the Gehannam Formation, sandstones and calcareous sandstones are characteristic for Birket Qaroun Formation, dark gray claystones are attributed to Garet El-Naqb Formation and interbedded claystones are attributed to Qasr El-Sagha Formation, irrespective of their stratigraphic position. Within these formations large numbers of marine vertebrate and invertebrate fossils exist at different stratigraphic levels. Whales are classified into four species belonging to four genera, these include *Basilosaurus isis*, *Dorudon atrox*, *Saghacetus Osiris* and *Anclacetus simonsi*. *Basilosaurus isis* and *Dorudon atrox* are the most common whale species exist in these formations. No major break in sedimentation has been described within the Eocene formations in Fayoum region. Only a well marked low sea stand is indicated at the top of the Gehannam Formation where it overlain by Birket Qaroun Formation.

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1. Introduction

The study area lies around Wadi Al Hitan, Fayoum Area, at the northern part of the Egyptian Western Desert (Fig. 1). The Eocene rocks contain excellent skeletons of marine mammals belonging to whales and sea cows, in addition to turtles, shark and ray teeth. The discovery of such well preserved vertebrate fauna in this area especially Wadi Al Hitan (Valley of whales) led the UNESCO to declare this area as a World Heritage Area. The present study deals with the stratigraphic characteristics and stratigraphic distribution of the late Middle – Late Eocene formations in four studied sections in the Fayoum Area, and the characteristic vertebrate and invertebrate fossil content of each formation.

2. Location and aim of study

Wadi Al Hitan Area is a broad, flat area located between

latitudes 29° 15' and 29° 22' N and longitudes 30° 01' and 30° 11' E (Fig. 2). The bedrock strata, where exposed, are eroded continuously by wind and blowing sand. The isolated hills and escarpments which border the wadi are composed of carbonates of Bartonian–Priabonian age. These rocks are formally known as Gehannam Formation, Birket Qaroun Formation and Qasr El-Sagha Formation respectively.

Within these Eocene formations large numbers of marine vertebrates and invertebrates are commonly observed at different stratigraphic levels. Vertebrate fossils represented by numerous whale skeletons were first described by Beadnell (1905) and later described in detail by Gingerich (1992) who has documented more than 500 complete and partial vertebrate skeletons from an area of about 20 km². The most common whale fossils encountered in the area are *Basilosaurus isis* Andrews 1904 and *Dorudon atrox* Andrews 1906.

The present study aims to study the lithofacies and biofacies characteristics of the Eocene succession along four studied sections in the area. It focuses on the lithological and paleontological aspect of these strata, their lateral and vertical facies changes and the distribution of whale skeletons in these sections.

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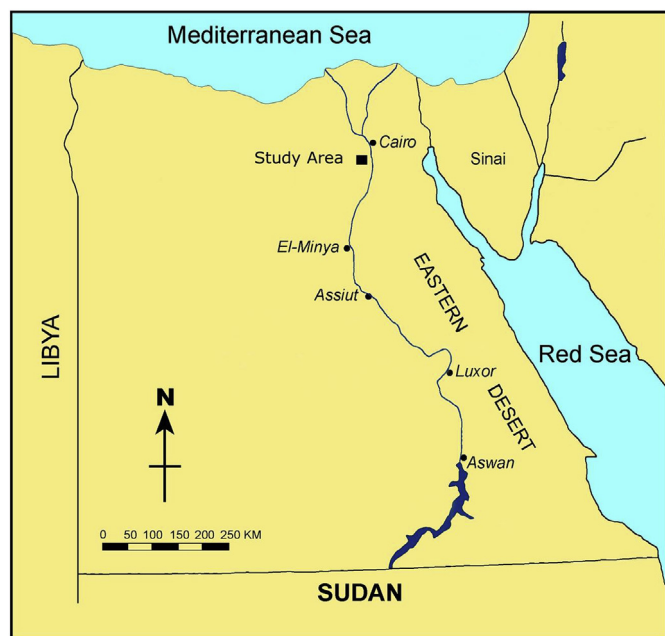


Fig. 1. Location map of the Wadi Al Hitan Area.

3. Stratigraphy

The stratigraphy of the Eocene rocks exposed at Fayoum area in general have been dealt with by many authors such as Beadnell (1901, 1905), Sandford and Arkell (1929), Ansary (1955), Said (1962), Bown and Vondra (1974), Strougo and Haggag, 1984, Bown and Kraus (1988), El-Anbaawy (1989), Kappelman (1991).

Strougo and Faris (2008) made a biostratigraphic analysis of the Eocene rocks of Northern Egypt using Nannoplanktons. Peters et al. (2009, 2010) tried to interpret the presence of a deeply incised channel within the lower Qasr El-Sagha Formation, in terms of sequence stratigraphic analysis and sea level changes. Abdel-Fattah et al. (2010) interpreted the stratigraphic relationships of the exposed rock units at Sandouk-El Borneta in terms of sequence stratigraphic analysis. Abdel-Fattah et al. (2011) studied the depositional environments and sequence stratigraphy of the exposed rock units.

Little biostratigraphic studies have been carried out on the area, the first detailed biostratigraphy was done by Strougo et al. (2013), using Planktonic foraminifera and calcareous nanofossil of the middle to late Eocene rocks at Wadi Al Hitan. King et al. (2014) made a litho- and biostratigraphic revision of the Eocene formations around Wadi Al Hitan Area.

Paleontologic studies concerning vertebrate fossils of the area were carried out by Beadnell (1901), Simons and Wood (1968), Gingerich (1992) and Peters et al. (2009). Underwood and Ward (2011), Underwood et al. (2011) studied the shark and ray faunas in the middle and late Eocene of the Fayoum Area.

As mentioned above, the upper Middle and Upper Eocene strata in Wadi Al Hitan area are divided into four formations namely the Gehannam, Birket Qaroun and Qasr El-Sagha formations in addition to a new formation erected by King et al. (2014) and introduced in the present work called Garet El-Naqb Formation.

In the present study four stratigraphic sections (Fig. 3) were investigated from the Lithologic and paleontologic point of view, particularly whale occurrences and their preservation. These sections include Qaret Gehannam section, Minqar El-Hut section,

Sandouk El Bornetta section and the North of Wadi Al Hitan section (Figs. 4–7).

Generally, the Gehannam Formation is composed of fine-grained claystones and siltstones, with marls and argillaceous limestones in the lower part. Its upper part interfingers with the Birket Qaroun Formation (fine bioturbated sandstones). This formation is overlain by Qasr El-Sagha Formation, which is composed of interbedded claystones, bioturbated sandstones and shelly calcareous sandstone. The Garet El-Naqb Formation as introduced by King et al. (2014) includes a distinctive dark claystone unit overlying the Gehannam Formation and extending proximally to interfinger with the Birket Qaroun Formation. These formations are characterized by the existence of marine mammals like whales, sea cows and terrestrial mammals like Proboscideans, in addition to micro- and macro-invertebrates (Gingerich et al., 2012). Correlation of the studied sections in Figs. 8–11 shows the lateral extension and whale fossil distribution in the exposed formations.

3.1. Gehannam Formation (Bartonian – early Priabonian)

The Gehannam Formation is composed of claystones and siltstones at the upper part, with marls and argillaceous limestones at the lower part. Beadnell (1905) named this rock unit as Ravine beds because it is exposed under the alluvium succession at the deep-water channels or Ravine in Fayoum Depression. It forms the floor of much of the cultivated Fayoum lands. The type section of Gehannam Formation designated by Said (1962) is exposed at Qaret Gehannam (West of Fayoum Depression), the main section of the “Ravine Beds” described by Beadnell (1905).

The sandstones previously described as representing the upper part of the Gehannam Formation are separated by Gingerich (1992) and included in the Birket Qaroun Formation. Moreover fine clastics similar to those of the Gehannam Formation are exposed North and Northwest of Qaret Gehannam, although at higher levels, they are included in the Gehannam Formation (King et al., 2014). In Wadi Al Hitan the Gehannam Formation is extensively exposed at the northern part of the valley, in numerous buttes and in the lower part of the Birket Qaroun escarpment.

At Qaret Gehannam section (Pl 1, Fig. 1), the maximum thickness of the Gehannam Formation is about 50 m. The Gehannam Formation is composed at the base of calcareous, yellowish gray to grayish green, laminated mudstone, which grades upward to calcareous, bioturbated sandstone that contains plant roots and many whale skeletons especially *Basilosaurus isis* and *Dorudon atrox*. This sandstone is followed by pale yellow siltstone and fossiliferous limestone containing bivalve fossils like *Lucina* sp. and many whale bone fragments. The limestone is overlain by yellow fossiliferous marls containing whale skeletons of *Basilosaurus isis*. The topmost part of the succession is formed of calcareous, fossiliferous, nummulitic limestone with *Thalassinoides* (what so called mangrove layer) rich in whale bone fragments, which forms the contact between the Gehannam and the Birket Qaroun formations.

At Minqar El-Hut section (Pl 1, Fig. 2), the Gehannam Formation is best exposed. It is formed at the base of grayish yellow, calcareous, fossiliferous, fine-grained mudstones that contains echinoids and whale skeletons especially at its top. Some whale skeletons are nearly complete while others are disarticulated and fragmented. *Basilosaurus isis* is the most common type of whales. Some scattered bones of *Dorudon atrox*, sea cow and shark teeth also exist. This sandstone is followed by yellow marls and grayish green claystone, containing plant roots. The formation ends with marl containing echinoids, shark teeth, and whale bones with *Thalassinoides* (? mangrove roots), the latter lies at the contact with the overlying Birket Qaroun Formation.

At Sandouk El Bornetta section (Pl 1, Fig. 3), the Gehannam

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