Cretaceous Research 74 (2017) 120–136

Contents lists available at ScienceDirect

Cretaceous Research

journal homepage: www.elsevier.com/locate/CretRes

# Paucispecific macroinvertebrate communities in the Upper Cretaceous of El Hassana Dome (Abu Roash, Egypt): Environmental controls vs adaptive strategies

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ARTICLE INFO

*Article history:*
Received 5 October 2016
Received in revised form
5 February 2017
Accepted in revised form 12 February 2017
Available online 14 February 2017

*Keywords:*
Environmental control
Facies associations
Biotope reconstruction
Late Mesozoic
North Africa

## ABSTRACT

Based on rock and fossil data from the Upper Cretaceous of the El Hassana Dome (Abu Roash, Egypt), factors controlling facies architecture and the nature of biotopes are highlighted. The succession formed on a non-rimmed shelf, the architecture of which varied from an inner to an outer shelf setting upsection. Macrobenthic biotopes are reconstructed and their palaeoecological significance assessed using a novel ternary plot. Based on diversity and community structure (770 specimens assigned to 28 bivalve and gastropod taxa), four paucispecific associations are identified. These are: 1. the '*Cucullaea*' Assemblage, a low-energy, soft-substrate, oligotrophic outer shelf environment with reduced terrigenous input dominated by infaunal bivalves and hexactinellid sponges; 2. the '*Plicatula*' Assemblage, a low-energy, restricted inner shelf lagoonal setting with soupy substrates and dysoxia below the sediment-water interface dominated by plicatulid and ostreid bivalves, 3. the '*Durania*' Assemblage, a high-energy, high-temperature, shoal environment dominated by elevator rudists with minor numbers of echinoids, corals and bryozoans, which together form several biostromes. and 4. The '*Trochactaeon*' Assemblage, which share the same characteristics of the '*Durania*' Assemblage. The paucispecific nature of these biotopes is indicative of different stress factors. Consequently, the predominant taxa exhibit different degrees of adaptive strategies. In addition to global sea level, local tectonics have significantly affected facies distribution and biotope structure. The shallower facies during the early Turonian and the dysoxia spanning the Coniacian–Santonian were linked to synsedimentary tectonics, which formed many barriers and led to circulation restrictions.

## 1. Introduction

Cretaceous strata of the El Hassana Dome, Northwest Cairo (Western Desert, Egypt) have been studied previously (e.g., Hataba and Ammar, 1990; Hamza, 1993). Recently, the fauna has also received considerable attention (De Castro and Sirna, 1996; Abdel-Gawad, 2001; Abdel-Gawad and Saber, 2001; El-Sabbagh and El-Hedeny, 2003; Mansour, 2004; El-Hedeny, 2007; Zakhera, 2010; Abdel-Gawad et al., 2011; Badawy, 2015). A detailed geological summary was provided by Said (1962, 1990). The thickness of Cretaceous strata is highly variable (257 m [Jux, 1954], 495 m [Faris, 1948], 640 m [Hataba and Ammar, 1990]). Here the section studied is about 300 m (Fig. 1). These differences in thickness may be related to the occurrence of many faults which are indicated by repetitions of numerous decimetre-thick cycles. However, these strata may also represent a cyclothymic response to climatic controls. Therefore, detailed biostratigraphic/isotopic dating is needed to discuss this matter further.

During the Cretaceous, in contrast to scleractinian corals, rudist bivalves dominated the carbonate platforms occasionally in the Tethyan Realm (Skelton et al., 1997; Sanders and Baron-Szabo, 1997; Carannante et al., 1999; Di Stefano and Ruberti, 2000; Stanley, 2003; Özer and Ahmad, 2015; Moro et al., 2016). The hypothesis that rudists were more successful as reef builders than corals was rejected by Gili et al. (1995) for two reasons. First, corals and rudists have different autecologies, and secondly, unlike corals, rudists trap enormous amounts of sediment between their elevated conical valves and among individual shells. Therefore, rudists are not true reef builders, in contrast to corals. According to the same authors, the relative decline of coral frameworks during the Cretaceous was

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http://dx.doi.org/10.1016/j.cretres.2017.02.014
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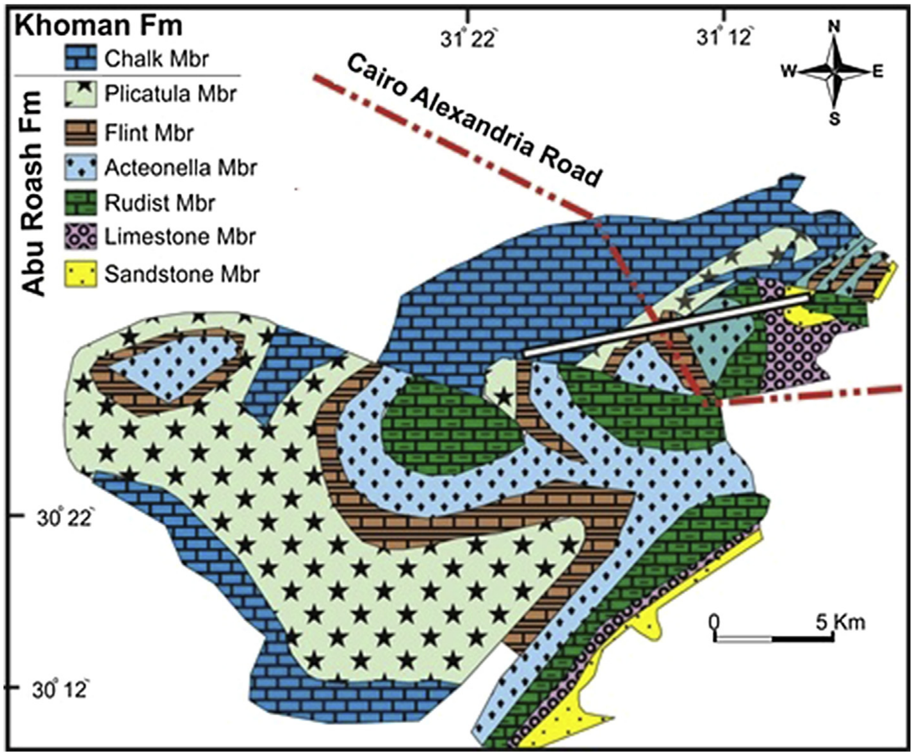

**Fig. 1.** Schematic geological map (modified after Said, 1962) of the El Hassana Dome showing the measured section (oblique white bar).

independently caused; the raised water temperature probably was the underlying agent (Huber et al., 2002, P.A.; Wilson et al., 2002; Bice et al., 2003).

According to Zakhera (2010), the family Radiolitidae is the most diverse in Cretaceous rocks of Egypt. Occasionally, elevator radiolitids became the dominant species in Turonian successions, which was the time of the greatest rudistid diversity (see also Aly et al., 2005; Saber et al., 2009). In the Cretaceous succession of the El Hassna Dome, the rudists form several biostromes, together with other benthic groups such as scleractinian corals, dasycladacean algae, in addition to minor bryozoans and sponges. The age of these rudists probably is Turonian (El-Hedeny, 2007; Zakhera, 2010; Abdel-Gawad et al., 2011).

A detailed biostratigraphical and sedimentological framework of Cretaceous strata in Abu Roash has recently been introduced (e.g., Abdel-Gawad et al., 2011). However, great uncertainties still exist, especially with respect to biotopes and their depositional environments. Here we aim to clarify environmental controls of biotopes of the El Hassana Dome discussed and to highlight decisive factors behind the paucispecific nature of macroinverbrate communities and the impact of tectonics and climate on facies architecture.

## 2. Palaeogeography

The opening of the Atlantic Ocean between Africa and America, in addition to the isolation of India and Madagascar in the Indian Ocean, are the main features of the earth during the Cretaceous (Fig. 2A; Scotese, 2001). The configuration of the continents was the main driver of Cretaceous climate. The opening of the Atlantic gateway could have contributed to the Cretaceous thermal maximum (Poulsen et al., 2003). The Cretaceous thermal maximum was a major turning point in the history of Earth's climate. These climatic features had an influence on the marine fauna; occasionally reef buildups of this period were very distinctive from their Mesozoic relatives, which consisted essentially of scleractinian corals. However, the important factor on a regional scale was the sinistral/dextral rotation of the North African plate relative to Laurasia, which had a strong effect on sedimentary basins that originated in northeast Africa and in particular the Western Desert of Egypt (Said, 1990). During the Cenomanian, the Abu Roash area was positive (land); from the Turonian onwards it was submerged and sea level rose until the end of the Maastrichtian (Said, 1990, Fig. 2B).

## 3. Structural setting

Rifting and normal faulting dominated the northern part of Africa during the Jurassic and continued into the Early Cretaceous (Said, 1990). During the Late Cretaceous to Eocene, tectonic activity was rejuvenated, resulting in widespread minor normal faults occasionally during the Santonian–Campanian. This is followed almost immediately by a period of compressive tectonics (Syrian Arc deformation; Fig. 1), in which many of the Jurassic and Cretaceous normal faults were reactivated as reverse faults. Transpressional tectonics was associated with strike-slip faulting and often with inversion tectonics, which characterises much of the structural style during the Syrian Arc event (Ayyad and Darwish, 1996; Sedek and Al Mahdy, 2013).

During the Triassic and Jurassic, many half graben basins were formed in North Africa (for details see Abdelhady, 2014). By the Cretaceous, inversion of the older half graben system due to the collision of Africa and Eurasia formed a series of palaeohighs (Moustafa and Khalil, 1990; Ayyad and Darwish, 1996; Lüning et al., 1998). Consequently, the Upper Cretaceous facies in the El Hassana Dome is related to uplift and tectonic inversion which continued into the early Paleogene (Strougo, 1986). Therefore, the global eustatic sea level signal is obliterated by