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A shell concentration of the Middle Miocene *Crassostrea gryphoides* (Schlotheim, 1813) from Siwa Oasis, Western Desert, Egypt

Ahmed M. El-Sabbagh [a], Magdy M. El Hedeny [a, b, *]

[a] Department of Geology, Faculty of Science, Alexandria University, Alexandria 21568, Egypt
[b] Deanship of Scientific Research, King Saud University, Riyadh, Saudi Arabia

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ABSTRACT

A concentration of heavy, thick-shelled, large-sized, and elongated population of the oyster *Crassostrea gryphoides* (Schlotheim, 1813) was recorded in shallow-marine deposits of the basal Oasis Member of the Middle Miocene Marmarica Formation exposed at Siwa Oasis, Egypt. The oyster assemblage is resedimented as a lens-shaped bank up to 80–100 cm thick and about 220 m long. *Crassostrea gryphoides* specimens are embedded in a yellowish green, soft marl matrix. This is the first documented occurrence of this lens at Siwa Oasis. The lensoid structure is bounded by a lower marl and an upper shale beds of about 2 m and 1.5 m thick, respectively. Assemblage within this lens is characterized by extreme variations of *Crassostrea gryphoides*, forming an almost monotypic assemblage. The shell packing was dense (shell percentages higher than 75%) at the base and the center of the lens, whereas it exhibits loose packing at the top and right and left sides of the lens (shell percentage less than 15%). Valves are poorly sorted and randomly orientated (both in surface and cross section views). Encrustation and bioerosion have observed on both sides of the left and right valves. The relatively limited varieties of encrusters together with moderate frequency of borings indicate moderate to high sedimentation rate. On the other hand, the low abundance of fragmented and abraded shells indicates good preservation and minimal transport. The studied lens concentration is interpreted as proximal tempestites assemblage.

1. Introduction

Benthic macrofauna is known to be sensitive to environmental conditions such as temperature, salinity, substrate characteristics, energy, nutrients, etc. (e.g. Sanders, 1968; Fürsich, 1981; Staff and Powell, 1988; Pickerill and Brenchley, 1991; Kownacki et al., 2000; El-Hedeny, 2005). They exhibit signs of environmental stresses, such as high mortality, low diversity, shell abnormality, dwarfism, etc. (e.g. Fürsich, 1981; Röhl, 1998). Among benthic macrofauna, oysters represent an outstanding opportunistic example that tolerate a wide range of a highly dynamic and stressful environmental conditions (i.e. r-strategists; El-Sabbagh et al., 2011). Their concentrations are often mono-to pauci-specific and characterized by large-sized shells (e.g. Fürsich and Werner, 1986; El-Ayyat and Kassab, 2004). The response of their tolerance could also be observed in their morphological features, including general shape and outlines, ligamental area, beak, shell-thickness, beak orientation, etc. (e.g. Newell and Boyd, 1970; Abdel Aal and El-Hedeny, 1998; El-Hedeny, 2005; Pufahl and James, 2006; El-Hedeny and El-Sabbagh, 2007).

Shell concentrations are common phenomena of shelf and coastal areas (Kidwell et al., 1986; Fürsich, 1995; El-Ayyat and Kassab, 2004; Bressan and Palma, 2010; El-Sabbagh et al., 2016). Their formations are greatly affected by many biostratinomic processes. Accordingly, detailed biostratinomic analysis is essential for understanding of their formation (e.g. Brett, 2003; El-Qot et al., 2009; El-Sabbagh et al., 2016).

In our recent study of the Middle Miocene benthic macroinveretbrates in Siwa Oasis, Western Desert, a lens concentration of the large shells of *Crassostrea gryphoides* (Schlotheim, 1813) is recorded for the first time in an outcrop, about 7 km north of the Siwa City (Fig. 1). *Crassostrea gryphoides* reefs were widespread and common along the Miocene circum-Tethyan coasts (Hoşgör, 2008; Harzhauser et al., 2015). Certainly, because of their abundance and higher fossilization potential of their shells, the present lens could provide significant paleoecological information as well as detailed

* Corresponding author. Department of Geology, Faculty of Science, Alexandria University, Alexandria 21568, Egypt.
E-mail address: mmelhedeny@gmail.com (M.M. El Hedeny).

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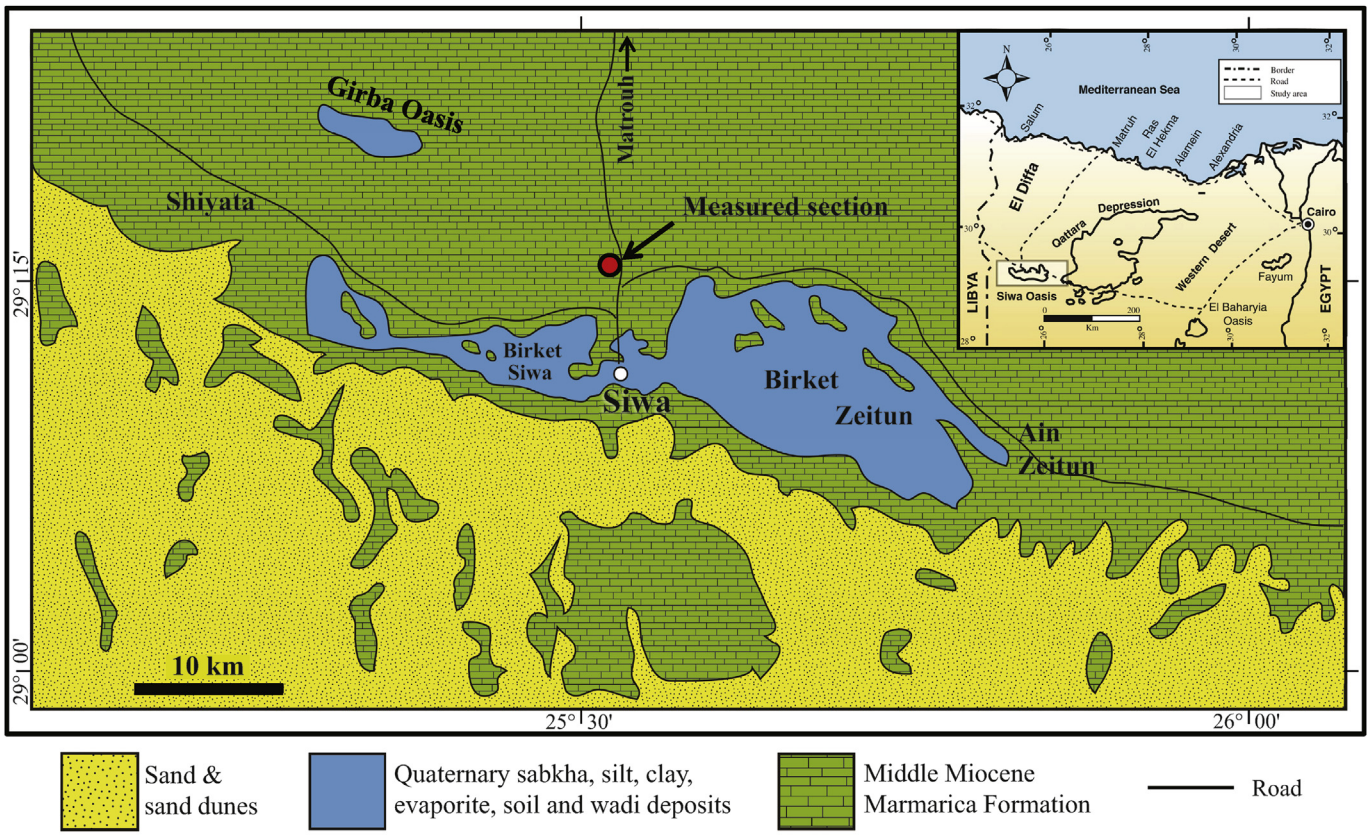

Fig. 1. A Simplified geological map of the Siwa Oasis showing the section analyzed (modified after CONOCO and EGPC, 1988). The key map is modified after Abdel Fattah et al. (2013).

data on the paleoenvironment in which they were deposited (e.g. Brett, 2003; El-Sabbagh et al., 2015).

Geographically, *Crassostrea gryphoides* (Schlotheim, 1813) is a long lived species. In the entire Western Tethys, it is appeared in the Oligocene and extended up to the Pliocene (Schultz, 2001). Other studies recorded it in higher stratigraphic levels (e.g. Pliocene-Pleistocene, Khalil, 2011; Recent, Siddiqui and Ahmed, 2002; Ganapathi Naik and Gowda, 2013). The purposes of this paper are: 1) to register the occurrence of *C. gryphoides* in the Middle Miocene sediments of Siwa Oasis, 2) to describe and discuss the recorded *C. gryphoides* concentration, and 3) to interpret the post-mortem alterations and the paleoenvironmental conditions prevailed during the formation of this concentration.

2. Location and stratigraphic context

Siwa Oasis, a depression of about 10–17 m below sea level, is situated on the west of the Qattara Depression between latitudes 29° 02′ and 29° 28′ N and longitudes 25° 12′ and 26° 02′ E (Fig. 1). In the north, it is bounded by a Middle Miocene escarpment that rises about 100 m above the depression floor while it is bounded on the south by a low Middle Miocene scarp of about 20–25 m above the depression floor.

The Marmarica Formation is widely exposed in this region. It was first introduced into the Egyptian lithostratigraphy by Said (1962) for a Middle Miocene sequence of about 78 m thick, at the northern scarp of Siwa Oasis. It is composed of alternating carbonate beds and greenish, bluish, and blackish shales and marls. The carbonates are made up of cross-bedded coquina and other organoclastic limestone. The rocks of the Middle Miocene Marmarica Formation unconformably overlie the Lower Miocene Moghra Formation (Said, 1962).

The studied section is located north of the Siwa City, at longitude 25° 31′ 22.1″ E and latitude 29° 16′ 24.6″ N (Fig. 1). At this area, the Marmarica Formation (about 78 m thick) is subdivided into three units. They are: a lower unit of marl, carbonate and shale, a middle unit of chalky and argillaceous limestone, and an upper unit of fossiliferous and non-fossiliferous chalky limestone. Based on the classification suggested by Gindy and El-Askary (1969), these units are named the Oasis, Siwa Escarpment and El Diffa Plateau members, respectively (Fig. 2). A remarkable feature of the studied rock unit is the predominance of carbonate rocks. They progressively decrease from top to bottom as shale and marl increase. Also, sandstones are completely absent.

The Oasis Member attains a thickness of about 41 m. It is composed of fissile shale, marl, cross-bedded limestone, argillaceous limestone and coquina beds (Fig. 2). In places, shale and marl occurred as lenses that interfingering with limestones and coquinas. The cross-bedded carbonate rocks are tabular and mainly composed of mixed organic debris derived from several marine faunas (i.e. coquina). In case of well developed cross-bedding, the coquina composed of well-sorted fine to medium grains. In the other case, sorting and fabric of the cross-bedded rocks become complex, containing fragments of large fossils. In tops of some shale-marl beds, traces of horizontal bioturbation (mainly *Thalassinoides* isp.) and/or lag deposits of reworked shale/marl clasts are recorded. The Siwa Escarpment Member (about 21 m thick) consists mainly of thick beds of chalky limestones as well as thin beds of shale, marl and argillaceous limestone. Some bored hardground surfaces and lag deposits occur. Within this member, as