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# Encrusting foraminifera from the miocene reefs of Sinai, Egypt: A significant paleobiogeographic affiliation

Wafaa I. Shahat

*Geology Department, Zagazig University, 44519 Zagazig, Sharkia, Egypt*

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ABSTRACT

First attention is offered to encrusting foraminifera existing in the Miocene reefal deposits of Wadi Gharandal (Sinai, Egypt). The detected encrusting foraminifera are confined to typical reefal limestone development. They belong mainly to the acervulinid, planorbulinid and homotrematid groups; dominated entirely by *Tayamaia* and *Gypsina*. Moreover, other forms include *Neoplanorbulinella, Planolinderina, Borodinia, Discogypsina, Ladoronia, Sphaerogypsina* and *Sporadotrema*. Besides, they inhabit different paleoenvironments; reef-flat, fore-reef and back-reef lagoonal conditions. This encrusting assemblage shows close paleobiogeographic affinity to the West Pacific region that locates at the same paleolatitudinal position. Consequently, such strong affiliation and copious faunal exchange certainly require direct and short distance connection and water inroad of an assemblage likely indicative for warm temperate to tropical settings. Therefore, the prior marine connection that dubiously proposed by Rögl (1999) in the Early Oligocene, extending north of India, west-east direction from eastern Mediterranean passing through east Iran and expanded directly across Asia to West Pacific is proposed to be the best direct and shortest water connection to the W. Pacific realizing this rigorous faunal similarity. On consequence, this connecting sea is thought to continue open even during Aquitanian and its closure had started in Early Burdigalian time. This closure is synchronous with the analogous restriction of the central basins of Iran which is considered the entry passage to W. Pacific across the proposed connecting sea. The results significantly provide an evidence for interruption also during the Early Burdigalian.



## 1. Introduction

In Egypt, most efforts for studying the encrusting fossil reefal associations were greatly interested in the algal coralline assemblages 'the nullipores'. The term nullipores was first reported in Sinai (Wadi Gharandal) by Moon and Sadek [78]. Afterwards, the nullipores were dealt broadly for their prevalence and striking association with corals in the Middle Miocene reef accumulations by Souaya [107], Dullo et al. [37], Piller and Rasser [87], Rasser and Piller [93], Imam and Refaat [59] and Hamad [46]. Furthermore, during a detailed planktonic and benthonic foraminiferal biostratigraphic delineation of some Miocene exposures in Wadi Gharandal (Sinai, Egypt), it is observed, strictly plentiful encrusting and attached types of foraminifera are distributed among the reefal type assemblages.

Encrusting foraminifera constitute a group of organisms growing and adapting for attachment or cementation on various substrates. Within intricate structures of modern and ancient reefs individuals of encrusting foraminifera live either exposed or cryptic [71]. The cryptic types are getting hide either in (i) the lower surfaces of corals [14], (ii) cavity dwellers in and under coral rubble [29,41,42,77,92], and (iii) inside tubular chambers of another foraminifera in the deep sea [44]. The substrates of encrusting foraminifera are commonly hard skeletons of invertebrates (corals, bivalvia, echinoids and barnacles), decayed matter, sea grass, manganese nodules, debris material and others [7,66,68,73,79,80,95]. On such substrates, the encrusting foraminifera are found dwelling diverse bathymetries ranging from shallow to deep seas.

Stratigraphically, encrusting foraminifera are first known in the Late Ordovician. Their individuals have limited stratigraphic ranges, but some may extend and/or crowd the modern reef habitats. On modern or ancient reefs, the encrusting foraminiferal assemblages demarcate thoroughly different depth distributional patterns and actual variations along bathymetric gradients [14,72,79,86,93,112]. In modern environments, most experimental case studies have provided valuable information about this perception. This reefal type of foraminifera is considered as a secondary supplier in the reef building process and acts as frame-binder [14,71].

*Abbreviations:* C.N., Crossed Nicols; Gh, Gharandal; PPL, Plane Polarized Light; W. Pacific, West Pacific.

*E-mail address:* wafaaibsh@yahoo.com

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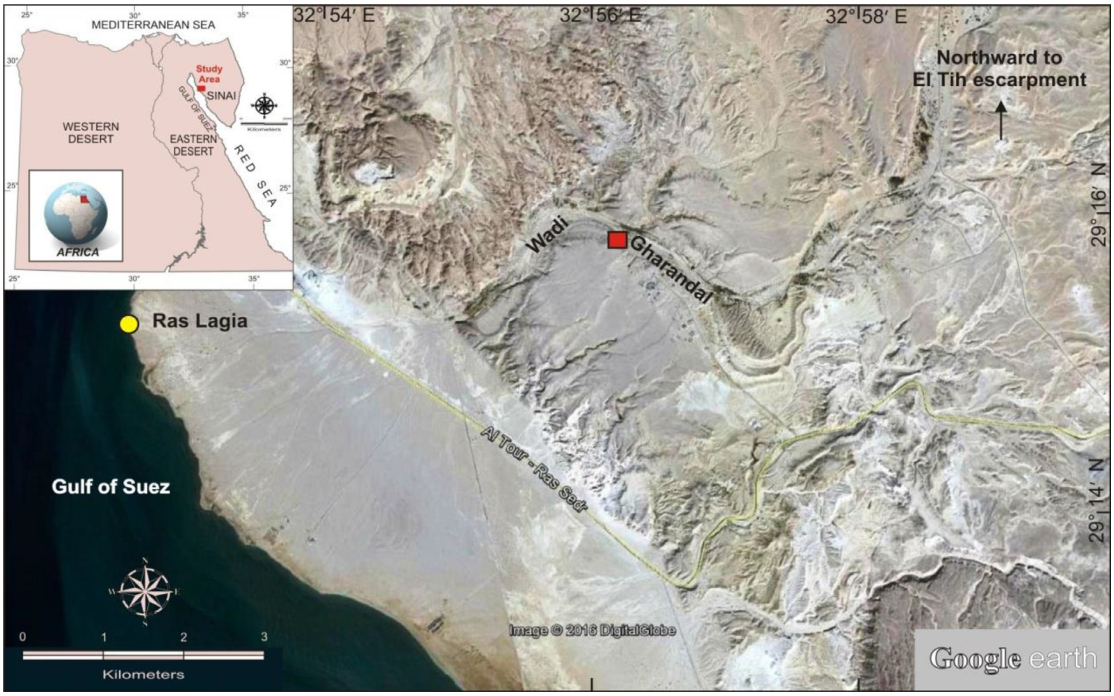


**Fig. 1.** Geographical location of the studied section in the western extremes of Wadi Gharandal, Sinai.

In comparison with the ancient records, the modern reefal systems show a global distribution, e.g. Sinai and the W. Pacific island's occurrences. Accordingly, the reefal encrusting formainefera signify paleoecological and paleogeographical important implications. In Sinai, encrusting foraminifera, the subject of the present study, are a principal component of Miocene reefal constitutions. The encrusting foraminifera reveal accompanying intergrowths with other encrusting organisms including coralline red algae and bryozoans, with bivalves, echinoids, and barnacles. These taxonomically variant taxa are known to live together forming a symbiotic 'consortium'. Scholle and Ulmer–Scholle [102] reported the consortium for the Late Paleozoic and some Mesozoic reefal deposits. On the other hand, the intended Miocene reefal interval in Sinai shows another younger record of such livelihood.

As no attention offered before to the Miocene encrusting foraminifera of Sinai, this paper focuses on studying this type of reefal taxa including paleoecological and/or paleogeographical clarifications in the fossil reef reconstruction. Moreover, their identification, taxonomic classification, description and stratigraphic and geographic distributions are studied. Such reefal taxa are abundant and, accordingly, their role in reef building process ought not to be undervalued.

## 2. Study area and geologic setting

Wadi Gharandal is one of the famous valleys in Sinai. It starts up at El Tih escarpment near the center of Sinai and extends widely across ridges of Eocene–Cretaceous rocks [101]; westward direction, it runs narrower and ends its course facing Ras Lagia at the Gulf of Suez (Fig. 1).

The ground surface of Wadi Gharandal area is covered with adjacent, well exposed, moderate and low relief successions. In this location, facies generally exhibit a monotonous character, mostly formed of soft clastics, and few successions are seemed different. One of the dissimilar successions exhibits reefal facies criteria and has been selected for the present study.

The selected succession is located in the southern flank of Wadi Gharandal, near the west extremes of the valley (Fig. 1) at longitude 32° 56′ 10″ E and latitude 29° 15′ 56″ N. It attains a total thickness of 41 m. In the field, this succession is demarcated easily due to the characteristic configuration of its embedded outcrop. It consists of closely spaced successive embankments of limestone and much fewer sandstones (Fig. 2A and B); these banks are continuous even or undulating and have small thicknesses. The bedding planes and their geometry are hardly defined in most parts.

This distinctive succession (Fig. 2A–C) has been found particularly suitable for the present study; its crystallized, massive, limestone constitution is dominated with growths of in-situ attached or encrusting organisms. Encrusting foraminifera are the most prominent in successive intervals of this reefal succession. The section parts are composed of a talus slope of reef debris as fore-reef deposits, defined by their original dip and another flat to embedded limestone geometry corresponding to back-reef deposits. It is an actual example of typical reefal limestone development without a true solid framework.

## 3. Material and methods

This study is based on thin sections derived from a stratigraphic succession of special facies characters in the southern margin of Wadi Gharandal course trend. In the field, this infrequent section of the reefal structure was hardly offered the opportunity for studying its bedding geometry and limitations. The lithologic features of some markers such as conglomerate and evaporitic beds facilitate its division. A large number of rock samples is therefore collected in order to trace the barely expected change in lithology. A number of 63 rock samples are used for megascopic description and petrographical analysis and finally succeeded in constructing a stratigraphic column consisting of three successive different intervals (interval I, interval II and interval III). The hard rock matrix in the recognized succession have succeeded in preparing good thin sections but failed to allow specimens of encrusting foraminifera to be freed from their encasing sediment. Therefore,