A Comparison of Pleistocene Gastropod Distribution in Both Open Shore and Lagoon at Ash Shaibah South Jeddah, Western Saudi Arabia

Abdu M. Almassari, Mohammed Gameil

ABSTRACT--- An exposed succession of raised beaches at the lagoon (5.5m) and the open shore (4.5m), at Ash Shu'aybah area, 80 Km south of Jeddah City was studied from the Paleontologic point of view. The focus was carried out on gastropods collected from two sites to study their diversity and abundance. The studied raised beach at the lagoon is divided into four distinct layers: dolomitic algal limestone layer (1m); calcareous mudstone layer (2.5m); argillaceous limestone layer (1m); calcareous sandstone layer (1m). The open shore raised beach is divided into four distinct layers: dolomitic limestone layer (2m decreasing northward to 1m); limestone layer (1m increasing northward to 2m); argillaceous limestone layer (1m); calcareous sandstone layer (0.5m). The calcareous sandstone layer has high diversity and abundance of gastropods. The study led to the identification of 80 gastropod species belonging to 58 genera, 29 families and 7 orders. The succession at the lagoon has more species (76 species) than the succession at the open shore (27 species), some species are common between the two sites. This is due to the difference in energy (currents and waves) and substrate type. The species Conus auricomus is recorded in the Red Sea for the first time.

Index Terms - Pleistocene, Macrofossils, Gastropods, Ash Sha'ibah, MIS 5e, Lagoon, Open shore, Conus auricomus sp.,

I. INTRODUCTION

A. Abbreviation:

Kyr: thousand years; BP: Before Present; Ma: million years; Km: Kilometer; m: meter; mm: millimeter; L1: Location 1; L2: Location 2; U/Th: Uranium-thorium dating; sp.: species; MIS: Marine Isotope Stages.

B. Previous Works:

In western Saudi Arabia particularly around Jeddah city, the marine terraces form a flat platform that is raised 3-6 m above sea level. It is poorly exposed because of a covering of fossil-rich sand, sabkha and alluvial deposits (Moore and Al Rehaili. 1989).

Manaa et al., (2011), carried out a U/Th dating of the Red Sea, they concluded that average age of coral ranges from 119.9 to 122 kyr BP, it is within the age of the last interglacial (MIS 5e at 128–116 kyr BP) when coastline was 6 m higher than now.

El-Sorogy, et al. (2014) studied two terraces of Late Pleistocene raised beaches in Rabigh area; It has a sequence of vertical coral reef layers. They identified 35 species of gastropods and 16 species of bivalves from the sequence. They conclude that the fossils similarity between this study area and what is currently living in Indo-Pacific and the Mediterranean Atlantic. About 78% of the fossils have a range from Pleistocene to Holocene.

Bantan et al. (2015), studied the lithology, fauna, and environmental conditions of the Pleistocene raised beaches of the Jeddah coastal plain. They concluded that the coastal plain of Jeddah consists of two featured strata. The lower part is white limestone bed rich in corals (*Porites* sp., *faviids* sp.) and foraminifers assemblage (*Amphistegina* sp., *Neorotalia calcar*). These species indicate that the sedimentation in a high-energy, open shore environment such as reef crest and fore reef, between 5–10 meters. The upper layer is calcareous clay bed is rich in molluscs, echinoids, branching corals, and the benthic foraminifera (*Elphidium striatopunctatum*, *Agglutinella robusta*, *Varidentella neostriatula*) suggesting sedimentation in back-reef, lagoonal environments. The top of the calcareous clay layer is truncated, but in some area, it was covered by fluvial sediments, which indicates a rapid regression in sea-level at the end of MIS 5e.

According to Manaa et al., (2016) the Late Pleistocene raised beaches has 5 km wide flat outcrops, along with the Saudi Arabia coast. The consistent elevation of these raised beaches is due to tectonic stability of the sea coast at the southern and central Saudi Arabia for at least 125 kyr BP, and the coral reef terraces are consistent with the Marine Isotope Stages (MIS 5e), which reached a peak of 6–9 m above present sea level.

Recently, Abu Zeid and Bantan (2018), studied the Pleistocene raised reefal limestone south Sharm Obhur, north of Jeddah city. They recorded 90 species of gastropods. They divided the section into two parts. The lower part is white limestone, and no specific species prevail in this layer. The upper part is calcareous mud rich in gastropods, that match to the last Marine Isotope Stages (MIS 5e). Between the two strata an erosional surface indicating regression of sea level through the deposition of the interval MIS 5e.

Revised Manuscript Received on May 29, 2019.

Abdu M. Almassari, Department of Petroleum Geology and Sedimentology, Faculty of Earth Sciences, King Abdulaziz University, Jeddah, Saudi Arabia. Saudi Geological Survey, Jeddah, Saudi Arabia.(E-mail: masary.am@gmail.com)

Prof. Mohammed Gameil, Department of Petroleum Geology and Sedimentology, Faculty of Earth Sciences, King Abdulaziz University, Jeddah, Saudi Arabia. (E-mail: mgameil@yahoo.com)

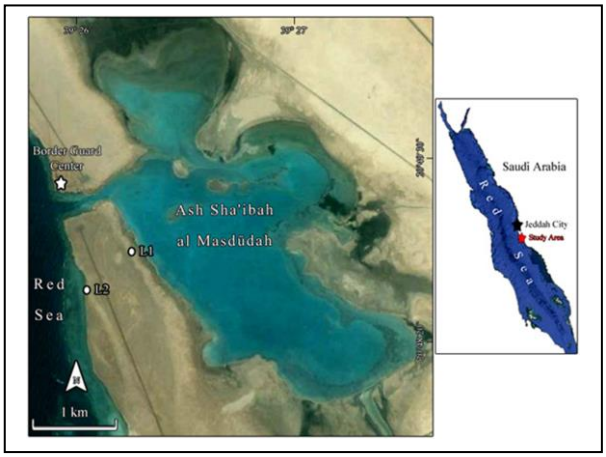

Figure 1: Map showing the location of the study area.

Many studies conducted the sedimentological, geomorphological and mineralogical aspects of raised beaches (Nesteroff 1960; Dawood et al. 2013).

The main aim of this work is to study Pleistocene gastropod distribution in two different localities, and the effect of environments on diversity and abundance of species, in Ash Sha'ibah al Masdūdah (open shore and lagoon), about 80 km south of Jeddah.

II. STUDY AREA

The area of the study is located south of border guard-center of Ash Sha'ibah al Masdūdah, 80 Km south of Jeddah City. Two sites were selected representing two different environments lagoon has coordinates (20° 48' 55" N and 39° 25' 53" E) and, open shore has coordinates (20° 48' 41" N and 39° 25' 35" E), the distance between the two sites is about 700 meters (Fig. 1). The area is composed of a carbonate platform that rises about 5.5 meters above the present shoreline. The thickness of the raised beaches varies between the two locations.

III. MATERIALS AND METHODS

Several field trips were carried out in the study area. About 535 gastropod specimens were collected from the exposed surface. The collected gastropods were washed and cleaned by water; they are later dried and studied from the taxonomic view point.

IV. RESULTS AND DISCUSSION

A. Lithology and Stratigraphy:

Previous studies dealt with the age dating of the coral reef terraces at the eastern part of Red Sea using the U/Th series, indicated an age of 140–110 kyr BP according to Plaziat et al. (2008); 235–128 kyr BP according to Dawood et al. (2013); 125–121 kyr BP according to Bantan et al. (2015); and 122–119 kyr BP according to Manaa et al. (2016). These ages belong to the last interglacial MIS 5e (Late Pleistocene).

The studied section at the lagoon of Ash Sha'ibah al Masdūdah (L1), consists mainly of four distinct layers with thickness about 5.5 meters, it is about 75 meters far from the current beach, it was measured at the coordinate (20° 48' 55" N and 39° 25' 53" E). The measured section is composed of (from bottom to top) hard algal limestone (1 m), it is grayish white color on the weathered surface, yellowish gray on the fresh surface, including small borings, Echinoid spines, and colonial corals at the top. The second layer is fine grained calcareous mudstone (thickness: 2.5 m) overlying the hard limestone, it is dark brown, rich in coral fragments and dominated by *Fungia* sp. and other colonial corals, bivalves and large gastropods at the top. The third layer is hard argillaceous limestone (1 m), it is grayish white, composed mainly of thinly branching *Acropora* sp., highly bored and cavernous, it is rich in bivalves dominated by *Tridacna* sp., *Spondylus* sp., and Oysters, the gastropods are found at the top. The fourth layer is calcareous sandstone (1 m), it is brownish gray, very rich in gastropods and thinly branching corals (fig. 2).

The second section of the open shore at Ash Shu'aybah area (L2), consists mainly of four distinct layers with a thickness about 4.5 meters, it was measured at the coordinate (20° 48' 41" N and 39° 25' 35" E). The section is composed of (from bottom to top) hard dolomitic limestone, yellowish white color in the fresh surface, dark gray color in weather surface. It contains many echinoid spines and poorly preserved casts and molds of gastropods and bivalves. The thickness is 2 meters but decreases northward to 1 meter. The second layer is fine grained limestone dark brown color in the weathered surface, grayish white color in the fresh surface with algae, bivalves and large gastropods at the top. The thickness is 1 meter but increases northward to 2 meters. The third layer is hard argillaceous limestone with thickness 1 m; it is white in color, cavernous, and rich in poorly preserved fossils of gastropods and branching corals. The thickness is 1 meter. The fourth layer is calcareous sandstone (0.5 m); it is brownish gray in color, very rich in gastropods and colonial corals (fig. 3).

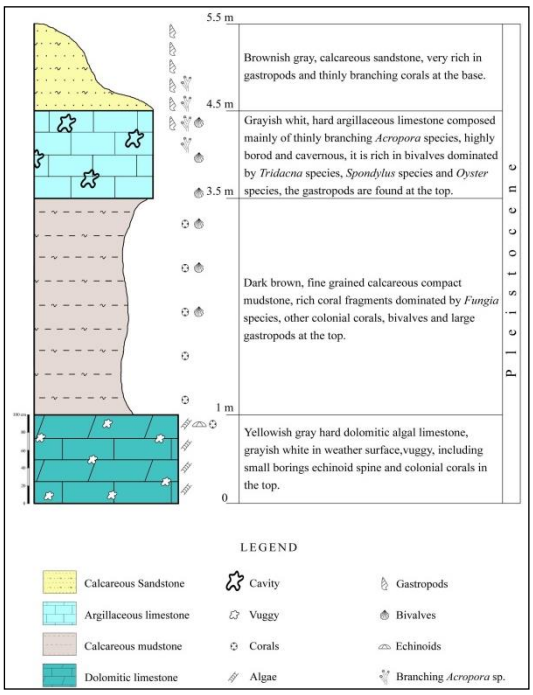

Figure 2: Stratigraphic column of location 1(lagoon).

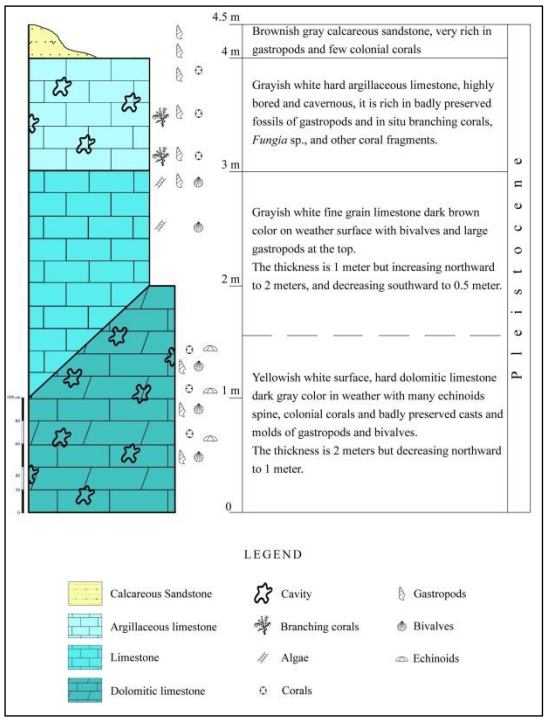

Figure 3: Stratigraphic column of location 2 (open shore).

In general, most fossils of the two locations are collected form of the upper two layers which are composed of argillaceous limestone and calcareous sandstone. Also, most of the small fossils in L2 are poorly preserved in the form of casts and molds.

B. Biodiversity and paleoenvironmental interpretation:

In the present study, 535 gastropod specimens were collected, 363 specimens are collected from L1 and 172 specimens from L2. These fossils belong to 4 subclasses, 7 orders, 16 superfamilies, 29 families, 58 genera, and 80 species. The species dominated in the two localities are *Gibberulus gibberulus albus* and *Rhinoclavis vertagus*.

23 species are common in the two locations and 53 species in the L1 only and 4 species in the L2 only (Table 1).

Corals exist in the two locations, except for the calcareous sandstone that is rich in gastropods only. The base of the section is composed of dolomitic limestone containing no gastropods. A few poorly preserved specimens are found in L2 in the form of cast, and mold of gastropods and bivalves together with many echinoid spines.

The second layer is composed of calcareous mudstone in L1, dominated by *Fungia* and other colonial corals but they change to limestone in L2 with few algae and bivalves.

Location	Species
L1	*Cerithium nodulosum; Cerithium scabridum; Indomodulus tectum; Planaxis sulcatus; Monetaria annulus; Naria erosa; Nucleolaria nucleus; Staphylaea limacina; Cypraea pantherine; Palmadusta clandestina; Pustularia bistrinotata; Pustularia globulus; Pustularia marerubra; Pustularia margarita; Notocochlis gualtieriana; Strombus alatus; Terestrombus terebellatus; Bursa granularis; Gyrineum concinnum; Ranularia exilis; Euplica turturina; Pyrene splendidula; Fasciolaria scalarina; Latirus polygonus; Fusinus leptorhynchus; Fusinus rostratus; Nassarius arcularia; Nassarius clarus; Tritia nitida; Sycostoma bulbus; Volema pyrum; Pollia fumosa; Conus auricomus; Conus flavidus; Conus pennaceus; Conus terebra; Lophiotoma abbreviate; Nebularia pellisserpentis; Mitra turgida; Strigatella aurantia; Strigatella coronata; Nassa francolina; Bulla ampulla; Aliculastrum cylindricum; Nerita histrio; Nerita striata; Neritopsis radula; Haliotis rugosa; Trochus maculatus; Trochus noduliferus; Clanculus pharaonius; Turbo petholatus.*
L2	*Rhinoclavis aspera; Mammilla melanostoma; Nerita yoldii; Tectus dentatus.*
L1+L2	*Cerithium caeruleum; Rhinoclavis vertagus; Monetaria moneta; Erronea caurica; Mauritia arabica; Canarium mutabile; Conomurex fasciatus; Gibberulus gibberulus; Lambis truncate; Tricornis tricornis; Tibia insulaechorab; Monoplex nicobaricus; Malea pomum; Pleuroploca trapezium; Conus arenatus; Conus vexillum; Terebra subulata; Chicoreus virgineus; Vasum turbinellus; Nerita albicilla; Nerita textilis; Clanculus puniceus; Turbo radiatus*

Table 1: A table showing the distribution of gastropods species in the studied two locations.

The third layer is argillaceous limestone in two locations, but there is a significant difference in size, number, and quality of preservation of fossils. This layer in L1 is rich in thinly branching Acropora, bivalves dominated by Tridacna with large size, and gastropods. This indicates shallow and low energy marine environments in warm tropical waters (lagoon environments). The same equivalent layer in L2 contains poorly preserved gastropods, bivalves, and in situ dendritic corals. These indicate the shallow open marine environments in warm tropical waters.

The top most layer is composed of calcareous sandstone in the two sites, it is very rich in gastropods, and colonial corals in L2, but there is a difference in thickness of the layer.

The reason for the difference in diversity, abundance, size, and preservation of fossils between the lagoon environment and the open shore environment is due to the energy difference between the two localities.

C. Gastropods taxonomy

L1:

1. Genus: Cerithium

Cerithium nodulosum (Bruguière, 1792)

Elongated shell, the spire is rapidly ascending; at the dorsal of body whorl marked by spiral lines that appear in aperture and makes it distinctive. (Fig. 4 A)

2. Genus: Conus

a. Conus auricomus (Hwass in Bruguière, 1792)

The shell is a cylindrical shape, has a stain convex spire, and revolving striae at all shell. This species is common in the Indo-Pacific, but this is the first record in the Red Sea. (Fig. 4 B)

b. Conus nussatella (Linnaeus, 1758)

The shell is closely striated, the striae minutely granular, with many brown spots on the striae. The spire is short. (Fig. 4 C)

c. Conus pennaceus (Born, 1778)

The shell is conical shape, covered by minute white triangular spots. (Fig. 4 D)

3. Genus: Haliotis

Haliotis rugosa (Reeve, 1846)

Small oblong shell, convex, has many round holes. (Fig. 5 A)

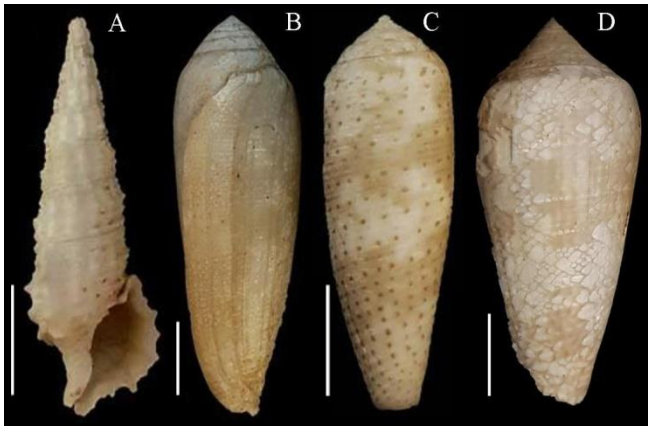

Figure 4: A *Cerithium nodulosum* (Bruguière, 1792), B *Conus auricomus* (Hwass in Bruguière, 1792), C *Conus nussatella* (Linnaeus, 1758), D *Conus pennaceus* (Born, 1778). Scale bars 10 mm.

4. Genus: Mitra

Mitra turgida (Reeve, 1845)

The shape of the shell is ovoid, distended in the middle, has the short spire, many spirally grooved, and three ridges from columella. (Fig. 5 B)

5. Genus: Turbo

Turbo petholatus (Linnaeus, 1758)

The shell is smooth and solid. Characterized by a circular aperture, which is approximately half the size of the shell. The inner lip is sharp. (Fig. 5 C).

L2:

1. Genus: Rhinoclavis

Rhinoclavis aspera (Linnaeus, 1758)

The shell is elongated slender; it has a sharp spire. At the surfaces shown radial sculpture, axial ridges, and nodules. (Fig. 5 D)

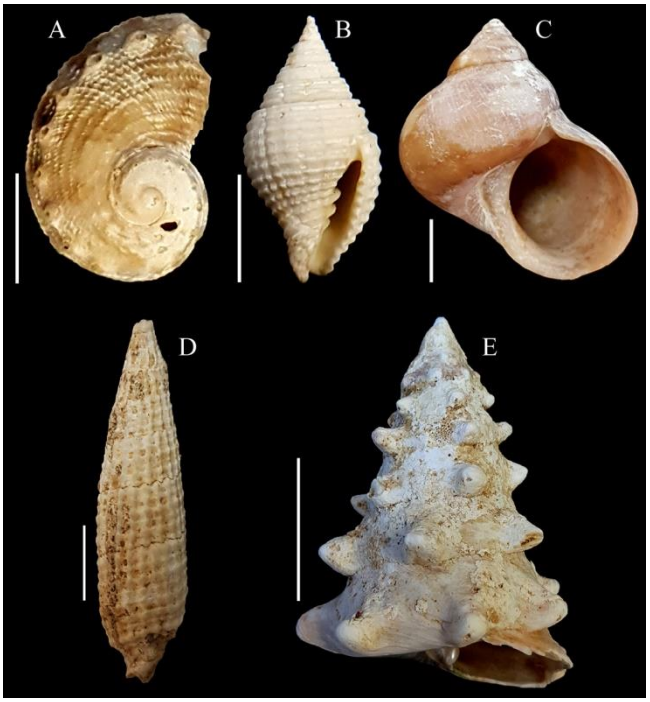

Figure 5: A *Haliotis rugosa* (Reeve, 1846) Scale bars 5 mm, B *Mitra turgida* (Reeve, 1845) Scale bars 5 mm, C *Turbo petholatus* (Linnaeus, 1758) Scale bars 10 mm, D *Rhinoclavis aspera* (Linnaeus, 1758) Scale bars 10 mm, E *Tectus dentatus* (Forskål in Niebuhr, 1775) Scale bars 50 mm.

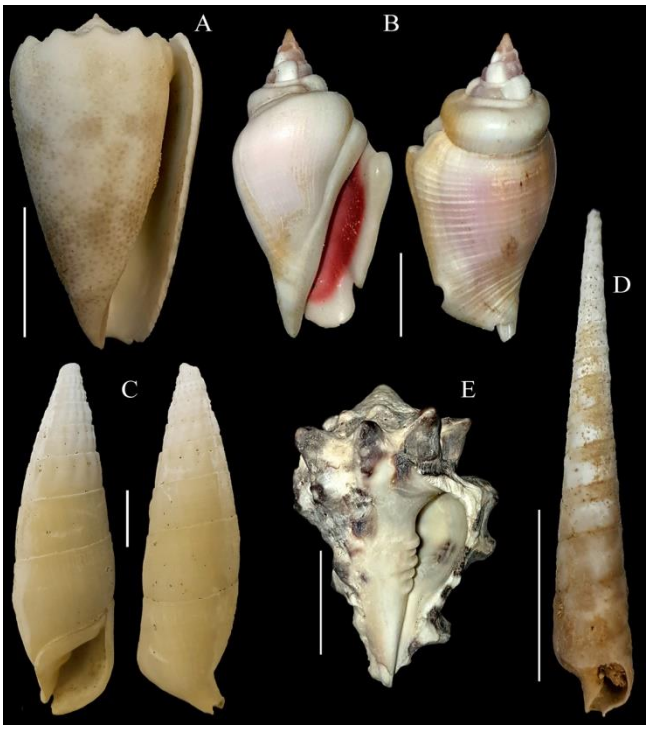

Figure 6: A *Conus arenatus* (Hwass in Bruguière, 1792) Scale bars 20 mm, B *Gibberulus gibberulus* (Linnaeus, 1758) Scale bars 10 mm, C *Rhinoclavis vertagus* (Linnaeus, 1767) Scale bars 10 mm, D *Terebra subulate* (Linnaeus, 1767) Scale bars 30 mm, E *Vasum turbinellus* (Linnaeus, 1758) Scale bars 20 mm.

2. Genus: Gibberulus

Gibberulus gibberulus (Linnaeus, 1758)

The shell is gibbous, smooth in the frontal, and grooved in the dorsal. The aperture is scarlet pigment. (Fig. 6 B).

3. Genus: Tectus

Tectus dentatus (Forskål in Niebuhr, 1775)

It is large conical turret shape, has rhomboidal aperture and rounded protrusions. (Fig. 5 E)

L1+L2:

1. Genus: Conus

Conus arenatus (Hwass in Bruguière, 1792)

The shell is a conical shape, covered by minute brown spots. The spire is low and crown at the top. (Fig. 6 A)

2. Genus: Rhinoclavis

Rhinoclavis vertagus (Linnaeus, 1767)

The shell is a fusiform shape. Characterized by axial plaits at the top of whorls, and sharp inner lip. (Fig. 6 C)

3. Genus: Terebra

Terebra subulate (Linnaeus, 1767)

The shell is very elongate, well rounded whorls and a sharp spire with a small aperture, and two rows spots at whorls but the body whorls has three rows. (Fig. 6 D)

4. Genus: Vasum

Vasum turbinellus (Linnaeus, 1758)

The shell is widely conical such as vase shape with low spires. The shell has thick and large knobs, appear five plaits on the columella. (Fig. 6 E).

CONCLUSIONS

Generally, the studied sections are composed of limestones. It occurs at Ash Shu'aybah, 80 Km southern Jeddah city which raised about 5 m above the current sea level.

Lithologically, the lagoon section is divided into four distinct layers: dolomitic algal limestone layer; calcareous mudstone layer; argillaceous limestone layer; calcareous sandstone layer. This section is very rich in gastropods which are represented by 76 species. The open shore section is divided into four distinct layers: dolomitic limestone layer; limestone layer; argillaceous limestone layer; calcareous sandstone layer. This section has rare gastropods where 27 species are only identified, compared to the other section. 23 species are common in the two locations.

The different number of species between lagoon (L1) and open shore (L2) is due to the difference in depositional environments, and the intensity of sea currents and waves.

These gastropods belong to 4 subclasses, 7 orders, 16 superfamilies, 29 families, 58 genera, and 80 species. The species dominated in the two localities are *Gibberulus gibberulus albus* and *Rhinoclavis vertagus*.

The calcareous sandstone layer (top layer in sections) has higher diversity and abundance of gastropods than the other layers which may be related to the last interglacial marine isotope stage 5e (MIS 5e).

The most important result of this study was the first record of *Conus auricomus* in the Red Sea; this species is common only in the Indo-Pacific.

ACKNOWLEDGMENT

I would like to thank Prof. Mohammed Gameil for his supervision, efforts, observations, and review of this work. I would like to thank the head of Petroleum Geology and Sedimentology Department Dr. Faisal Al-Kahtani for offering facilities to work in the department. Special thanks to the Saudi Geological Survey for their scientific and administrative facilities to its junior staff to carry out postgraduate studies.

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