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Petrographical and Paleontological Characterizations of the Quaternary Calcarenites along the Coastline of NE-Libya

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الملخص

ترسيبات الكالكارينيت (الرمل الجيري المتماسك) التابع للعصر الرباعي بمكن مشاهدتها بشكل متقطع غير مستمر على طول الشاطئ الليبي بمياه البحر المتوسط، وكذلك الشاطيء التونسي، والايطالي، والمالطي والقبرصي. يتواجد الكالكارينيت في اماكن محدودة بالجبل الاخضر مكونا صخور متوازية مع الساحل الليبي وعلى إرتفاعات متفاوته تصل أحيانا لمئات الأمتار فوق مستوى سطح البحر. تهدف هذه الورقة إلى وصف وتصنيف رسوبيات الكالكارينيت الرملي الكلسي في الحقبة الرباعية بالعصر الهلوسيني والبليستوسيني المتواجدة بالجبل الأخضر وبناء على النسيج الترسيبي. تم أخذ عينات صخرية من أربع مناطق شاطئية بالمنطقة الشرقية وهي: قاريونس، والحنية، والحمامة، وسوسة. وفي المجمل تتكون هذه الصخورمن رسوبيات بحرية بأعماق مائية مختلفة. وتتواجد هذه الصخور على شكل أحزمة متعاقبة كبيرة الحجم أفقية وعمودية وعلى هيئة أحواض مقعرة أو حادة من صخور ناعمة وأحيانا صلبة نوعا ما وبلون أبيض إلى كريم، مع تواجد قوالب الجذور والقواقع البرية في اماكن محدودة. اما الفتات الحيوي تمثله المنخربات القاعية الصغيرة الحجم التابعة للخزفيات والروتاليدات وكذلك التلازنيات، والاوستراكودات، وبقايا القنافذ البحري والرخويات والطحالب الجيرية الحمراء. بينما بموقع قاريونس فالصخور تتميز بتواجد غزير لصداف الرخويات المتمثلة في الكارديوم مع تخلل للمارل والطين الغني برخويات الأويستر.

الكلمات المفتاحية: الكالكارينيت ، الجبل الاخضر، النسيج الصخري، الساحل الليبي، الطبقية المتقاطعة.

Abstract

Quaternary calcarenites deposits can be traced sporadically along the Mediterranean coastlines including Libya, Tunisia, Italy, Malta and Cyprus. Quaternary calcarenites are cropping out at local places in Al Jabal al Akhdar forming the coastal rocks, few hundred meters above sea level. This paper aimed to describe and classify the Quaternary (Pleistocene and Holocene) calcarenites of Al Jabal al Akhdar based on the depositional texture and the manifested sedimentary structures. Four rocky beach localities are subjected to sampling for this study namely, Garyounis, Al Haniyah, Al Hammamah and Susah. They are mainly composed of marine deposited at more or less various water depths. The concerned calcarenites displayed an alternating band of soft and hard white to creamy, planar to festoon trough large scale cross bedded with local occurrences of root casts and land snails. The bioclasts are represented by small benthic foraminifers of miliolids, rotalids and textularids as well as ostracodes, echinoderm remains, mollusks and calcareous red algae. The calcarenite in the studied localities showed wide range of facies distribution on both lateral and vertical sense in terms of biofacies and lithofacies, the calcarenite grains in Susah region is bounded by calcite bridges filled fractured. However, the calcarenite in Garyounis area is characterized by the presence of highly molluskan shells concentration such as *Cardium*, with intercalated marls and clays enriched with *Ostrea*.

Keywords: Calcarenite, cross bedded, Quaternary, Susah, Garyounis, Al Jabal al Akhdar

1. INTRODUCTION

The Quaternary calcarenite rocks in Libya was intensively studied [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]. In general, the calcarenites are soft, highly porous sedimentary rocks formed by cementation of calcareous grains.

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The Quaternary calcarenite rocks are well distributed in many places along Cyrenaica shoreline and (Fig. 1). Four localities are subjected to sampling that are; Al Haniyah, Al Hammamah, Susah and Garyounis calcarenites (Fig. 1).They revealed that these selected measured sections are mainly composed of marine bioclasts that deposited at more or less at various water depths. The concerned calcarenites displayed an alternating bands of soft and hard light brown to creamy planar to festoon

trough large scale cross bedded with local occurrences of root casts and land snails. The hard beds of the Quaternary calcarenites were widely used in the era of Greek civilization in construction and that's adding historical event with a significant cultural value to this type of rock [15].

2. SEDIMENTOLOGY AND STRATIGRAPHY

2.1 Garyounis Calcarenite Petrography

The best developed calcarenites outcrop in southwest of Wadi Al Qattarah, Benghazi plain. These calcarenites are unconformably overlies the Middle Miocene Benghazi Formation. The studied section is about 2 m thick, it consists of three main units [14] (Figs.2; 3 and 4).



Figure 1: Location map of the studied localities, NE Libya

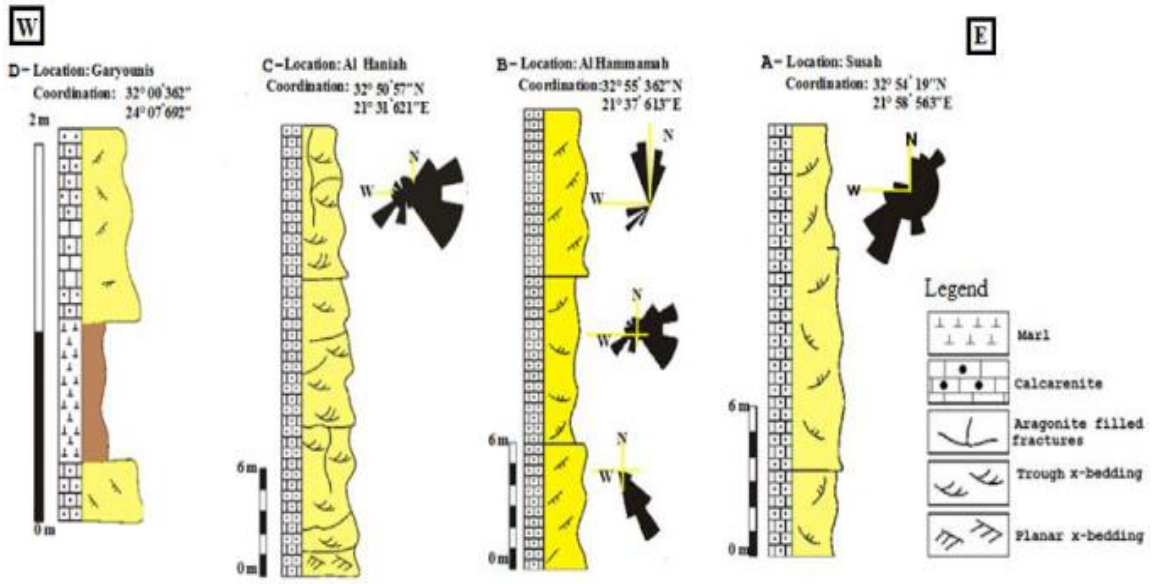


Figure 2: The stratigraphical columnar sections of the Quaternary calcarenite rocks; A- Sush, B- Al Hammamah, C- Al Haniyah and Garyounis area

Unit 1; consists of calcarenite, yellowish white in color, hard, thickly bedded (0.3 m), this unit also characterized by shell concentration made of *Cerastoderma edula*, calcareous red algae, bryozoans and foraminifera.

Unit 2; consists of marls and clays, yellow to gray in color, soft, friable, thickly bedded (0.75 m), this unit also characterized by shell concentration made of *Ostrea* sp., the washed residue of this unit is made of ostracodes, *Elphidium macellum* and *Ammonia* cf. *tepida*.

Unit 3; yellow to brown calcarenite, moderately hard to hard and very thick bedded (1m), this unit is also characterized by shell concentration made of *Cerastoderma edula* Linnaeus.

No fluid movement allowed due to lack of porosity because of dolomitization and cementation. The paleontological collections

from the Calcarenite in this study area are illustrated in Plate 1and 2 and were based on the collection of the authors and [14].



Figure 3: Typical section of the calcarenite with high concentration of Oyster in the middle part (clay & marl) at Garyounis area.

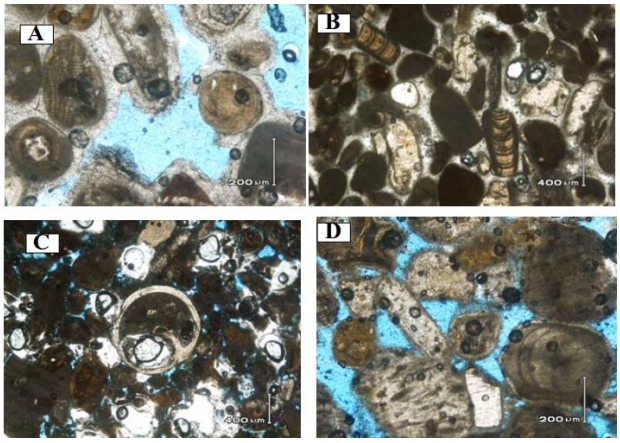


Figure 4: The lower calcarenite (A & B); A) highly porous with thick layer of isopachous cement; B) Red algae; and the upper part (C & D); C) large thick-shelled gastropod; D) highly porous with thin layer of isopachous cement [14].

2.2 Petrography of Al Haniyah Calcarenite

The base of the Al Haniyah calcarenite overlies unconformably a pitted erosion surface of hard, white limestone bioturbated sediments with land snails. Two types of cross bedding, the lower one is planar and the upper one is festoon cross bedding (trough x-bedding). It composes of elongate semi ellipsoidal plunging trough or scoop likes structures or hummocky cross bedding with total thickness of 24 m (Figs. 2 and 5). Thin sections show that there are three types of cement; isopachous, meniscus and the pore filled is blocky or drusy (Fig. 6). Mimetically, euhedral to anhedral dolomite crystals were observed (2 to 8 % max.), it occurs both as fabric selective replacement of the carbonate mud matrix and as a cement. Quartz, gypsum and iron minerals are also observed. Some of small benthic foraminifers are retrieved from this section such as *Lobatula lobatula*, *Elphidium crispum*, *E. advenum*, *E.* cf. *jenseni*, *Ammonia beccarii*, *Triloculina plicata*, *T.* sp., *Quinqueloculina* cf. *bosciana*., *Q. vulgarism*, *Spiroloculina angulosa*, *S. dilatata*, *Adelosina* sp., *Cibicides* cf. *reflunens*, *Cibicidella variabilis*, *Rosalina bradyi*, *R.* cf. *macropora* and *Planorbulina mediterranensis*. This assemblage is associated with rare ostracodes and small sized *Cerithium* sp., bryozoan fragments and echinoderm spines. However, polychaetes serpulids are encrusted on some beds with terrestrial *Helix* sp.



Figure 5: Hummocky and Swale cross beddings in Al Haniyah calcarenite

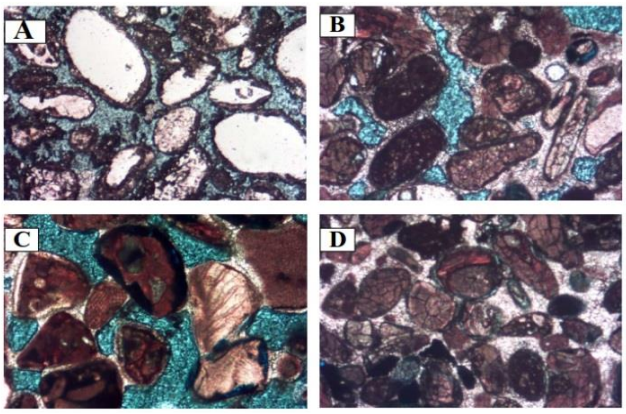


Figure 6: A; shows micrite envelopes developed in algal peloids; there are three cement generations; B) isopachous cement; C) meniscus cement; and D) drusy or blocky cement, (40 x; PPL).

2.3 Al Hammamah Calcarenite

Al Hammamah calcarenite is unconformably overlies the Eocene carbonate rocks, bioclastic, and sandy limestone, brown to creamy in color. It consists of two types of cross bedding; planar (Figs. 2 and 7) and festoon cross bedding (trough x-bedding), with total thickness of 20 m (Fig. 8) with land snails (*Helix*) and root casts or molds (Fig. 9).Thin sections show that there are three types of cement; isopachous, meniscus and pore-filling as blocky or drusy (Fig. 10). Euhedral to anhedral dolomite crystals were observed (8 to 10 % max.), it occurs both as fabric selective replacement of the carbonate mud matrix and as cement (blocky cement is totally replaced by dolomite crystals). Quartz, gypsum and iron minerals are also observed. Al Hammamah in its type section is fossiliferous, notably of benthic foraminifers include *Quinqueloculina* spp., *Elphidium advenum*, *E. crispum*, *Rosalina bradyi*, *Ammonia beccarii* and *Cibicides* cf. *reflungen*. This assemblage is associated with common small sized *Cerithium* with echinoderm spines and some terrestrial *Helix* sp. Present as well in places.



Figure 7: Planar cross beddings in Al Hammamah road-cut



Figure 8: Trough cross stratification in Al Hammamah area.

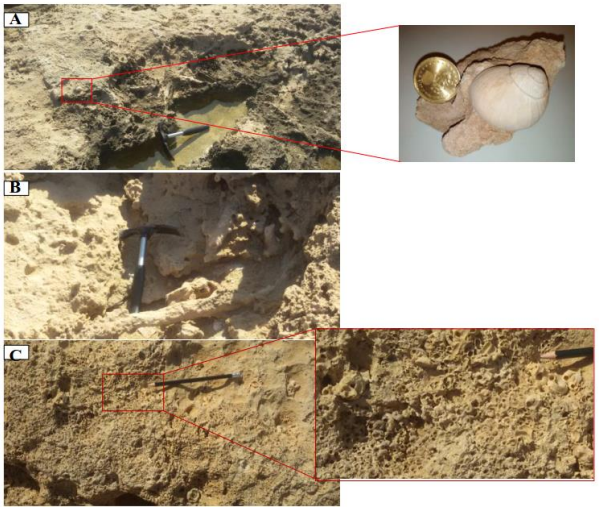


Figure 9: A) Horizontal Rhizoconcretion with Helix sp.; B) Tangential Rhizoconcretion (calcareous root concretions); C) encrusted Serpulid worm tubes; at Al Hammamah calcarenite.

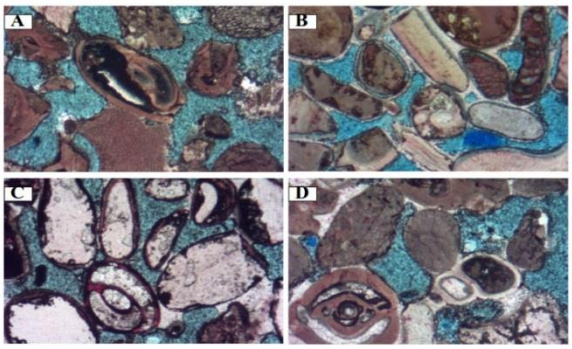


Figure 10: A, B, C & D Shows meniscus cement in; B) isopachous cement; C) micrite envelopes developed in algae and some in miliolids, (40 x; PPL).

2.4 Susah Calcarenite

Susah calcarenite overlies unconformably an erosional surface of Eocene Apollonia rocks, bioclastic, and sandy limestone, brown to cream in color with total thickness of 18 m (Fig. 11). It consists of rhizoconcretions are parallel to the cross beddings (Figs. 2 and 12). Three types of cross bedding, planar and festoon cross bedding (trough x-bedding); large dune of hummocks have inside gently curve lamination which are convex up in the hummocks and there are also concave up lamination called swales between the hummocks (Fig. 13). Thin sections show that there are two types of cement; isopachous and meniscus (Fig. 14), euhedral to anhedral dolomite crystals were observed (of about 10 %), it occurs both as fabric selective replacement of the carbonate mud matrix and as a cement. Quartz, gypsum, anhydrite and iron minerals are also observed.



Figure 11: A and B) Cross bedding in Susah calcarenites; C) Hard beds of the Quaternary calcarenite were widely used in city construction of Greek civilization.

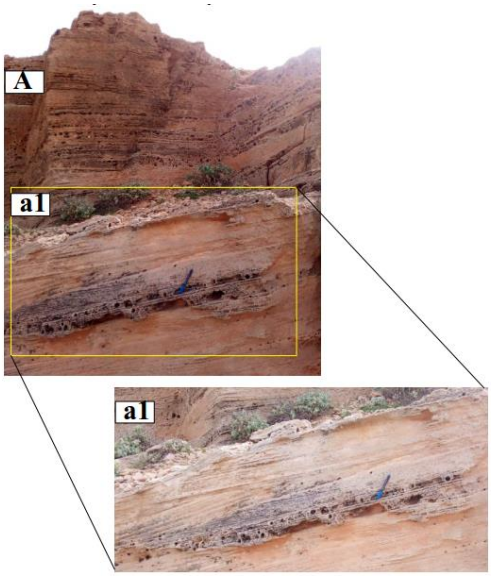


Figure 12: A & a1) Rhizoconcretions (biogenic), and plant root casts or molds are parallel to the cross stratifications.

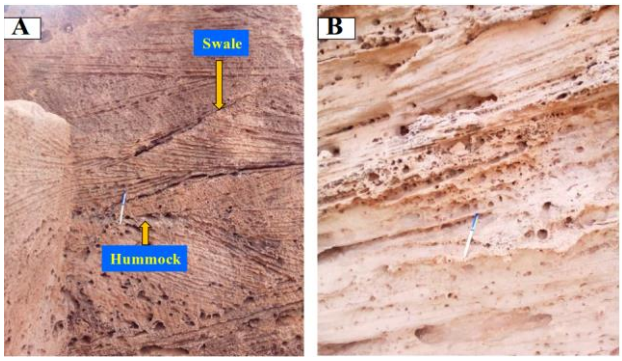


Figure 13: A) Hummocky and Swale cross stratifications; B) Rhizoconcretions (biogenic), and plant root casts or molds

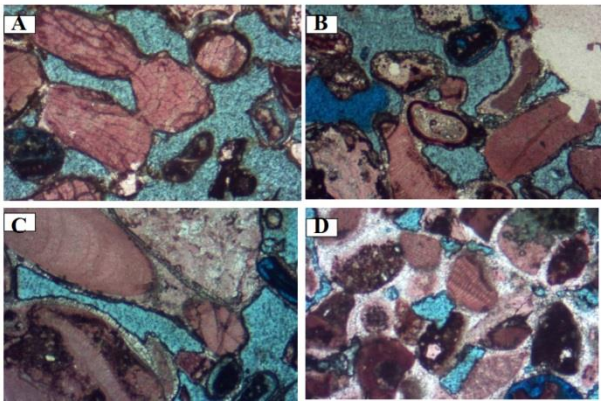


Figure 14: A, B & C) Red algae fragments, slightly compacted with meniscus cement; D) Isopachous cement, (40 x; PPL).

These Quaternary calcarenites are Pleistocene in age (Early Calabrian – Late Tarantian) according to. [16] using ($^{87}Sr/^{86}Sr$) radiometric dating of the crystalline calcites from different localities.

3. DEPOSITIONAL ENVIRONMENT

Due to high diversity of bioclasts such as foraminifera (Plate 1), pelecypods (Plate 2), gastropods, bryozoans, echinoids, and algae, the studied calcarenites are deposited in-situ at shallow marine carbonate environments (Fig. 15).

Al Haniyah, Al Hammamah and Susah are all generated by strongly sea water storm wave in the lower sea floor of shore-face. Most the calcarenites in NE Libya are subjected to meteoric water diagenesis and dissolution occurs in the phreatic environment; isopachous cement is formed below the water table, pores are totally filled with water and cementation continued and formed the drusy mosaic or blocky cements. The meniscus cement can precipitated particularly in the upper part of beach, occurred in the vadose environment. In the lagoon only mollusks, algae and foraminifera are noted. No fluid movement allowed due to lack of porosity because of dolomitization and cementation.

4. CONCLUSION

The Al Haniyah, Al Hammamah, and Susah calcarenites overlies unconformably a pitted erosional surface of Eocene limestone, while the Garyounis calcarenite overlies unconformably an erosion surface of middle Miocene of Benghazi carbonate rocks. Calcarenites may have been deposited on shallow banks with temporal periods of strong storm wave, and subsequently uplifted, they alternatively suggested as an aeolian deposit. The geographical matching similarity in Libyan coastal Quaternary outcrops, suggesting that Quaternary Cyrenaican calcarenite outcrops at Al Haniyah, Al Hammamah, and Susah could be stratigraphically assigned to Gergaresh Formation, however, Garyounis calcarenite stratigraphically assigned to Agedabia Formation. Al Haniyah, Al Hammamah and Susah were deposited by storm wave in the lower sea floor of shore-face shallow marine shelf.

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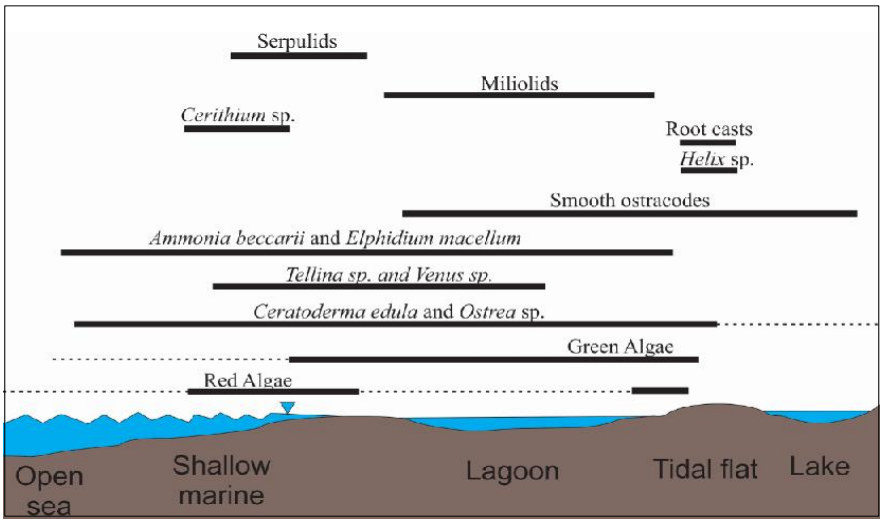


Figure 15: Depositional schematic setting of the studied Quaternary calcarenites

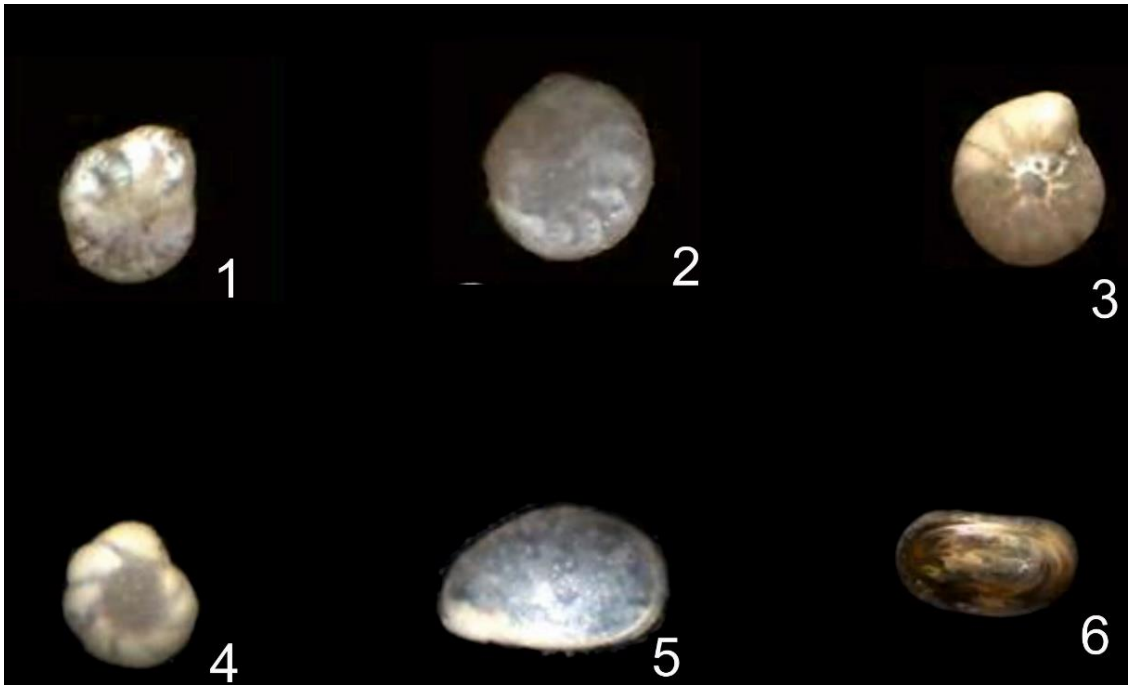


Plate 1: 1*) Elphidium macellum* 60-70X*;* 2) *Elphidium advenum* 60-70X*;* 3*) Ammonia* cf. *beccari* 60-70X; 4) *Ammonia* cf. *tepida;* 5-6) Ostracod G1- spp. 60-70X. based on biota (after [14])



Plate 2: 1-2) *Venus* sp.; 3-4) *Tellina* sp.; 5-8) *Cerastoderma edula;* and 9-12) *Ostrea sp.*

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