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RESEARCH ARTICLE

SHELL WALL STRUCTURE OF PHYLUM MOLLUSCA OF ABHOR, JEDDAH, KINGDOM SAUDI ARABIA

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ABSTRACT

Fourty thin sections were prepared for the study of the shell wall microstructure of the molluscan shells were collected from Abhor, Jeddah, Kingdom Saudi Arabia. The studied shells comprise: *Arca imbricate*, *Anadara* (*Anadara*) *antiquate*, *Tellina rugosa*, *Spondylus* (*Spondylus*) *gaederopus Tridacna gigas*, *Chama pacifica*, *Cardites antiquate*, *Dosonia* (*Dosonia*) *radiate*, *Barbatia barbata*, *Turbo argyrostomus*, *Nerita polita*, *Cerithium ruppelli*, *Strombus gibberulus*, *Strombus fasciatus*, *Bursa granularis*, *Cypraea staphylae*, *Conus virgo*, *Nassarius arcularis*, and *Terebra nebulosa*.The detailed microscopic examination has revealed many observations of shell wall microstructures.

INTRODUCTION

The Red Sea has length of about 2100 km. It's southern end is connected to the Gulf of Aden and opens into the Indian Ocean, while its northern end bifurcates into: the Gulf of Suez and the Gulf of Aqaba (Fig. 1). The maximum width of the Red Sea is about 270 km, while its maximum depth is about 2900 km. The surface water temperature varies from 18° C in winter to about 31° C in summer, while the water salinity varies from 41% in winter to about 43% in summer. The purpose of this study is to investigate the Pleistocene beachrock, its formation, composition geochemistry and also to study the systematic classification, distribution, and shell wall structure of phylum Mollusca, in addition to, their relation to the paleoenvironment

PREVIOUS WORK

Many of researchers studied shell wall structure begging by Bogglid (1930); Lowenstam (1954): Stenzel (1968); Dodd (1964); More *et al*. (1969); Kennedy *et al*. (1970); Flags (1972); Maslov (1973); Taylor *et al*. (1973); Omeri *et al*. (1976); Carter and Tavez (1978); Waller (1980); Hegab and Kenawy (1982); Hegab (1983); Adbel Aal and Frihy (1984) Al-Aasem and Veizer (1986); Abdel Aal *et al*. (1987); and Abdel Aal and El-Hedeny (1989). The last researches of this subject are as follows:- Abdel Aal (1991) concluded that the Eocene and Pre-Eocene oyster shells are composed of crossed-lamellar, complex crossed-lamellar, foliated and prismatic structure without any organic material in between these types, while the Miocene and Post-Miocene oyster shells are composed of foliated calcite with organic materials in between the foliae. The difference in the shell wall structure of the Pre-Miocene and Post-Miocene oysters could have depended upon the change in the mantle which builds up the shells. El-Sabbagh (1992) indicated that the shells of shells of *Glycymeris juxtadentata* are completely composed of calcitic crossed-lamellar, the shells of *Vulsella crispate*, *Mimachlamys heluanensis*, *Plicatula polymorpha* and *Spondylus aegyptiaca* are composed of foliated calcite, the shells of *Ostrea multicostata* are composed of two layers, the external is foliated calcite while the internal is crossed-lamellar. Finally, he concluded that the wall structure of oysters, Plicatulidae and Spondylidae depends upon the paleoecology and histological characters with age. Marei (2003) concluded that the shells of *Oscillopha dichotoma*, *Curvostrea heinzi*, *Pycnodonte costei*, *Pycnodonte vesiculare*, *Gryphaea roachensis*, *Nicaisolopha tissati*, and *Nicaisolopha lyonsi* are composed of regularly foliated and cross foliated layers. Ahmed and Abdel Aal (2003) stated that the fresh water bivalve shell *Corbicula angasi* and the gastropod shell *Viviparus vivipara* are composed of an external prismatic layer and an internal nacreous layer. The shells of *Acanthocardia tuberculata* and *Cardium edule* are completely composed of cross foliate aragonite. The shells of *Lima lima* and *Barbatia barbata* are composed of foliated aragonitic with lenticular chambers. The shells of *Turritella communis* and *Turitella triplicate* are composed of aragonitic prisms

MATERIALS AND TECHNIQUE

Forty thin sections were prepared in the laboratories of College of Science, King Saud University. These sections were

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prepared parallel to the ventral margin and muscle scars of the bivalvian shells, and though the body whorl of the studied gastropod shells. Skeletal structure is more varied in the mollusks than in any other group of organisms. Skeletal structure has been studied more extensively in the mollusks. The microstructure analysis of well preserved fossil shells allows for the interpretation of physiology, ecology and diagenesis.

SHELL MICROSTRUCTURE OF THE STUDIED SPECIMENS

The detailed microscopic examination of the shell wall microstructure has revealed the following observations:

Wall structure of bivalvian Shells

The shells of *Arca imbricata* (Pl. 3, Figs. 1 - 2) are composed of two layers. The external one is crossed-lamellar calcite formed of adjacent lames packed together side by side so as to form an array of roughly parallel vertical sheets, these sheets making an angle of about 60° - 65° with the shell surface. The internal layer is formed of aragonitic nacreous structure, it consists of parallel sheets of minerals, but it is finner, more regular and with luster (Pl. A, Fig. 1).

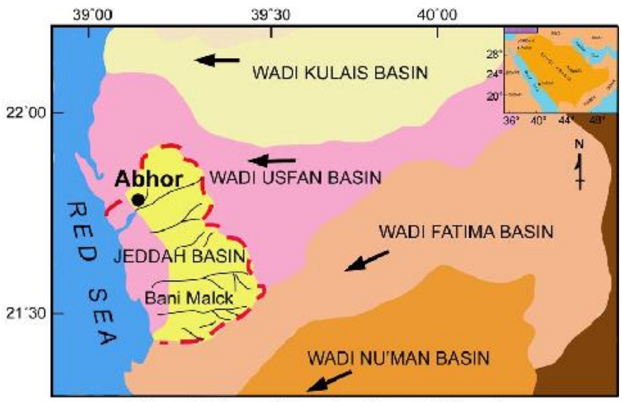

Figure 1: General Location Map of Abhor Area

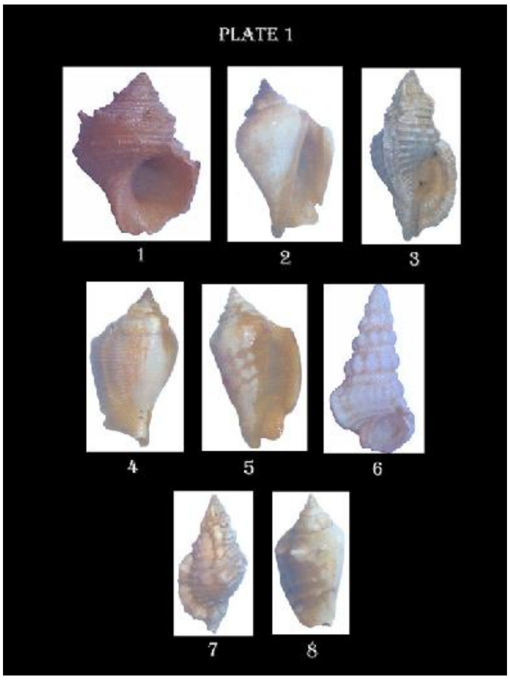

PLATE 1

1 – *Turbo argyrostomus* LINNE (X 1.5), aperture view.
2 – 4 - *Strombus gibberulus* LINNE (X 2), 2 = aperture view, 4 = opposite view.
3 – 7 – *Bursa granularis* RODING (X 1.3), 3 = aperture view, 7 = opposite view.
5 – 8 – *Strombus fasciatus* BORN (X 2) 5 = aperture view, 8 = opposite view.
6 – *Cerithium ruppelli* PHILLIPPI (X 1.5), aperture view.

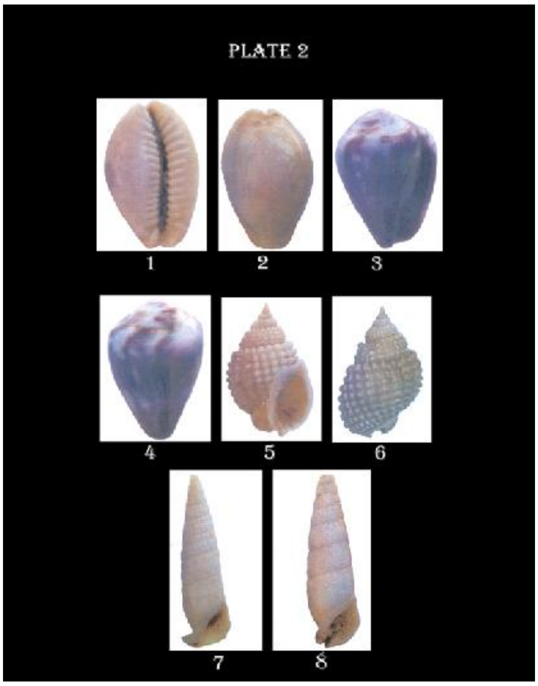

PLATE 2

1 – 2 – *Cypraea staphylaea* LINNE (X 1.2), 1 = aperture view, 2 = opposite view.
3 – 4 – *Conus virgo* LINNE (X 1.2), 3 = aperture view, 4 = opposite view.
5 – 6 – *Nassarius arcularis* LINNE (X 1.5), 5 = aperture view, 6 = opposite view.
7 – 8 – *Terebra nebulosa* SOWERBY (X 1.2), 7 = aperture view, 8 = opposite view.

The shells of *Barbatia barbata* (Pl. 3, Figs. 3 - 4) are completely composed of crossed-lamellar calcite. The lamels are crossing each other in different parts with different angles (Pl. A, Fig. 3).

The shells of *Anadara antiquate* (Pl. 3, Figs. 5 - 6) are composed of three layers. The external layer is formed of crossed-lamellar calcite, while the middle layer is formed of nacreous aragonite. The inner layer is formed of composite prismatic layer, the prisms lie side by side with their long axes perpendicular to the shell surface (Pl. A, Fig. 2).

The shells of *Gylcymeris pectunculus* (Pl. 4, Figs. 3 - 4) are composed of two layers. An external one is formed of calcitic prisms lie with their long axes perpendicular to the shell surface. The internal layer is formed of crossed-lamellar structure, consists of subunits, each one extends in opposite direction with respect to the adjacent another one (Pl. A, Fig. 4).

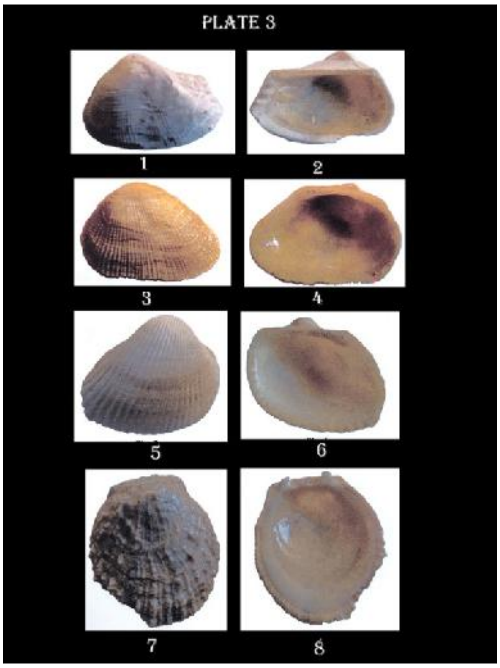

PLATE 3

1 – 2 – *Arca impricata* BRUGUIERE (X 2), 1 = external view, 2 = internal view.
3 – 4 – *Barbatia* (*Barbatia*) *barbata* LINNE (X 1.5), 3 = external view, 4 = internal view.
5 – 6 – *Anadara* (*Anadara*) *antiquata* LINNE (X 1), 5 = external view, 6 = internal view.
7 – 8 – *Spondylus* (*Spondylus*) *gaederopus* LINNE (X 1), 7 = external view, 8 = internal view.

The shells of *Spondylus gaederopus* (Pl. 3, Figs. 7 - 8) are formed of three layers. The external layer is formed of crossed-lamellar calcite. The middle layer is formed of calcatic prisms, the prisms are very thin and long, lie side by side with their long axes perpendicular to the shell surface. The internal layer is formed of nacreous structure (Pl. B, Fig. 1).

PLATE 4

1 – 2 – *Chama pacifica* BRODERIP (X 1.5), 1 = external view, 2 = internal view.
3 – 4 – *Glycymeris pectunculus* LINNE (X 1), 3 = internal view, 4 = external view.
5 – 6 – *Dosinia* (*Dosinia*) *radiata* REEVE (X 1.2), 5 = internal view, 6 = external view.
7 – 8 – *Cardites antiquata* LINNE (X 1.3), 7 = external view, 8 = internal view.
9 – 10 – *Tellina rugosa* BORN (X 1), 9 = external view, 10 = internal view.

The shells of *Chama pacifica* (Pl. 4, Figs. 1 - 2) are completely composed of crossed-lamellar structure with lenticular chambers. The lenticular chambers are hollow cavities of lenticular outline surrounded by normal shell material. These chambers are originally empty or filled with chalky deposits (Pl. B, Fig. 3).

The shells of *Cardites antiquate* (Pl. 4, Figs. 7 - 8) are completely composed of crossed-lamellar calcite (Pl. B, Fig. 2).

The shells of *Tridacna gigas* (Pl. 5, Figs. 1 - 2) are composed of three layers. The external one is prismatic calcite lie with their long axes perpendicular to the shell surface. The middle layer is prismatic calcite differs from the external layer in that the prisms lie with their long axes parallel to the shell surface and radiating from the umbo, so, they appear as network of polygons in a cross section parallel to the ventral margin. The internal layer is formed of aragonitic nacreous structure; it consists of parallel sheets of minerals (Pl. B, Fig. 4).

PLATE 5

1 – 2 – *Tridacna gigas* LINNE (X 1.3), 1 = external view, 2 = internal view.

The shells of *Dosinia radiate* (Pl. 4, Figs. 5 - 6) are completely composed of crossed-lamellar calcite, in some parts organic materials were found in between the lamels (Pl. C, Fig. 1).

The shells of *Tellina rugosa* (Pl. 4, Figs. 9 - 10) are composed of two layers. The external one is formed of prismatic calcite, while the internal layer is formed of crossed-lamellar calcite (Pl. C, Fig. 2).

Wall structure of gastropod shells

The shells of *Turbo argyrostomus* (Pl. 1, Fig. 1) and *Nerita polita* (Pl. 4, Fig. 2) are completely composed of composite prismatic calcite, formed of alternating two series of prisms, the first one lies side by side with their long axes perpendicular to the shell surface, while the second series lies with their long axes parallel to the shell surface, so, they appear as a network of polygons in a cross section parallel to the ventral margin (Pl. D, Figs. 1 – 2).

The shells of *Cerithium rupelli* (Pl. 1, Fig. 6) are composed of three layers. Both the internal and external layers are composed of aragonitic nacreous layer, while the middle layer is formed of prisms perpendicular to the shell surface, the prisms are long, and forming thick layer, attaining about 0.65 of the thickness of the shell (Pl. E, Fig. 1).

The shells of *Strombus gibberulus* (Pl. 1, Figs. 2 - 3) are composed of four layers. The external layer is formed of simple prisms, the second layer is formed of composite prisms, the third layer is formed of simple prisms, and the fourth layer is formed of composite prisms (Pl. E, Fig. 2).

The shells of *Strombus fasciatus* (Pl. 1, Figs. 5 - 6) are composed of three layers. The external layer is formed of simple prismatic calcite, attaining about half the shell thickness, lie with their long axes perpendicular to the shell surface. The middle layer is formed of aragonitic nacreous structure; it consists of parallel sheets of minerals, but they are finner and more regular. The internal layer is formed of composite prisms (Pl. F, Fig. 1).

The shells of *Bursa granularis* (Pl. 1, Figs. 3 - 7) are composed of four layers. The external layer is formed of simple prisms. The second one is formed or aragonitic nacreous structure. The second layer is separated from the first layer by organic materials. The third layer is formed of composite prisms. The fourth layer is formed of simple prisms (Pl. F, Fig. 2).

The shells of *Cypraea staphylae* (Pl. 2, Figs. 1 - 2) are composed of four layers. The external layer is formed of aragonitic nacreous structure, the second one attain about 0.60 of the shell thickness and formed of simple prisms. The third layer is formed of very thin aragonitic nacreous structure. The fourth layer is formed of simple prisms (Pl. G, Fig. 1).

The shells of *Conus virgo* (Pl. 2, Figs. 3 - 4) are composed of four layers. The external layer is formed of simple prisms. The second layer is formed of composite prisms. The second layer is formed of composite prisms. The third layer is formed of simple calcitic prisms. Finally, the fourth layer is formed of aragonitic nacreous layer (Pl. G, Fig. 2).

The shells of *Nassarius arcularis plicatus* (Pl. 2, Figs. 5 - 6) are composed of four layers. The external and third layers are composed of aragonitic nacreous structure, while the

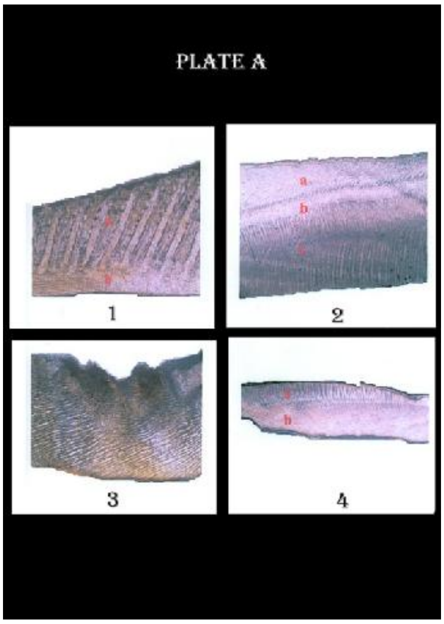

PLATE (A)

1 – Axial section in *Arca imbricate* BRUGUIERE (X 40)
a = crossed-lamellar calcite
b = aragonitic nacreous layer
2 – Axial section in *Anadara* (*Anadara*) *antiquata* LINNE (X 40)
a = crossed-lamellar calcite
b = aragonitic nacreous layer
c = composite prismatic layer
3 – Axial section in *Barbatia barbata* LINNE (X 40), is composed of crossed-lamellar calcite
4 – Axial section in *Glycymeris pectunculus* LINNE (X 40)
a = calcitic prismatic layer
b = crossed-lamellar calcite

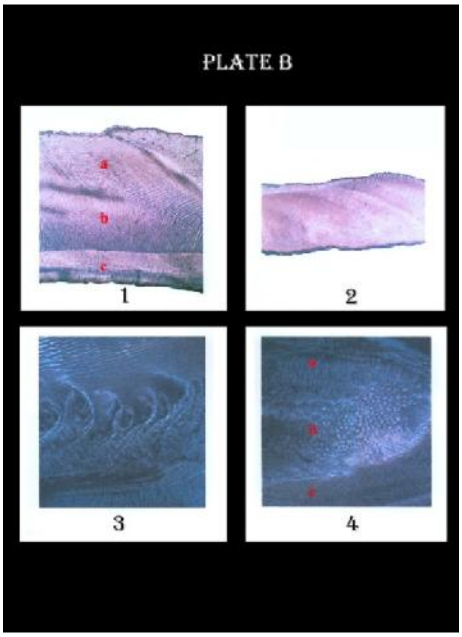

PLATE (B)

1 – Axial section in *Spondylus* (*Spondylus*) *gaederopus* LINNE (X 40)
a = crossed-lamellar calcite

b = calcitic prisms
c = nacreous layer
2 – Axial section in *Cardites antiquata* LINNE (X 40), is composed of crossed-lamellar calcite
3 – Axial section in *Chama pacifica* BRODERIP (X 40), is completely composed of crossed-lamellar structure with lenticular chambers
4 – Axial section in *Tridacna gigas* LINNE (X 40)
a = prismatic calcite
b = prismatic calcite
c = aragonitic nacreous

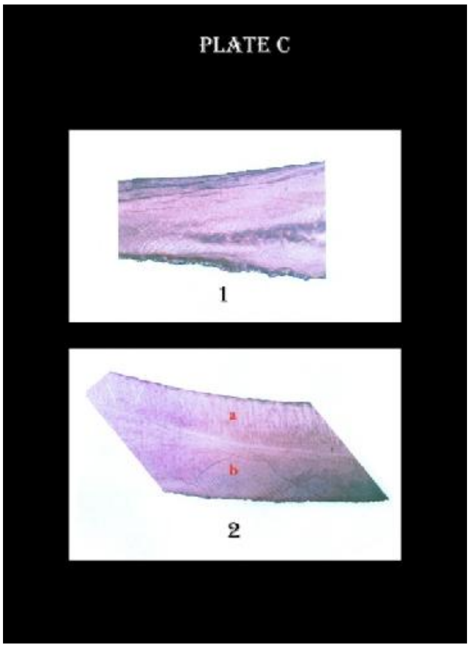

PLATE (C)

1 – Axial section in *Dosinia* (*Dosinia*) *radiata* REEVE (X 40), is composed of crossed-lamellar calcite
2 – Axial section in *Tellina rugosa* BORN (X 40)
a = calcitic prismatic layer
b = crossed-lamellar calcite

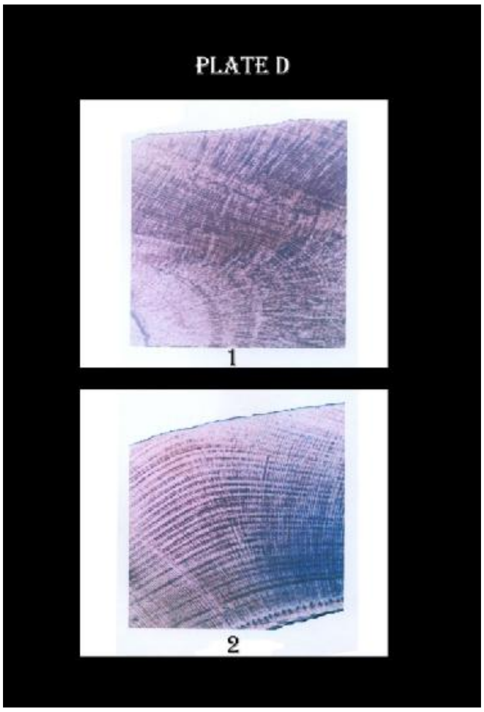

PLATE (D)

1 – Spiral section in *Turbo argyrostomus* LINNE (X 80) completely composed of composite prismatic calcite
2 - Spiral section in *Nerita polita* LINNE (X 80) completely composed of composite prismatic calcite

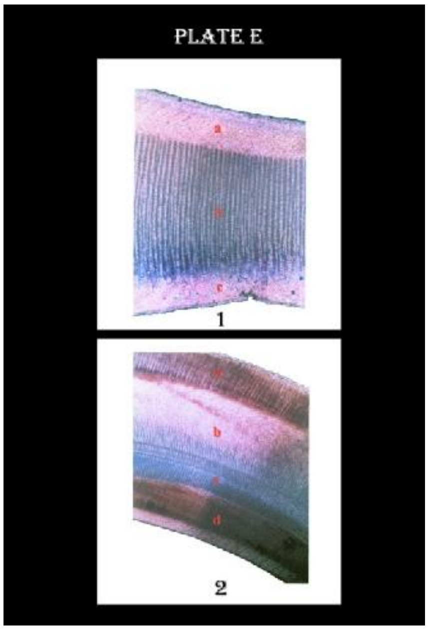

PLATE (E)

1 – Spiral section in *Cerithium ruppelli* PHILLIPPI (X 80)
a = aragonitic nacreous layer
b = prismatic layer
c = aragonitic nacreous layer
2 – Spiral section in *Strombus gibberulus* MORCH (X 80)
a = simple prisms
b = composite prisms
c = simple prisms
d = composite prisms

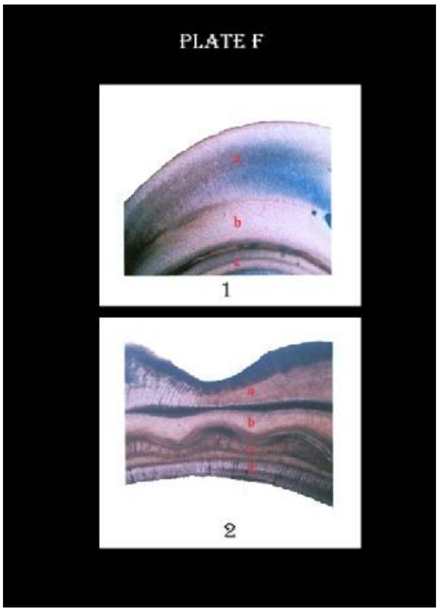

PLATE (F)

1 – Spiral section in *Strombus fasciatus* BORN (X 40)
a = simple prisms
b = aragonitic nacreous
c = composite prisms
2 – Spiral section in *Bursa granularis* RODING (X 40)
a = simple prisms

b = aragonitic nacreous structure
c = composite prisms
d = simple prisms

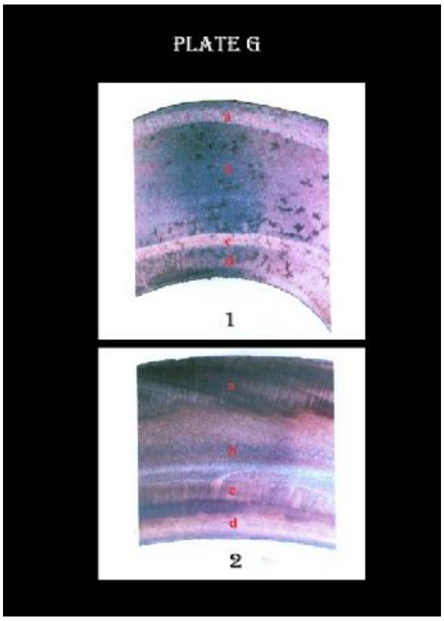

PLATE (G)

1 – Spiral section in *Cypraea staphylae* LINNE (X 40)
a = nacreous layer
b = simple prisms
c = aragonitic nacreous layer
d = simple prisms
2 – Spiral section in *Conus virgo* LINNE (X 60)
a = simple prisms
b = composite prisms
c = simple prisms
d = nacreous layer

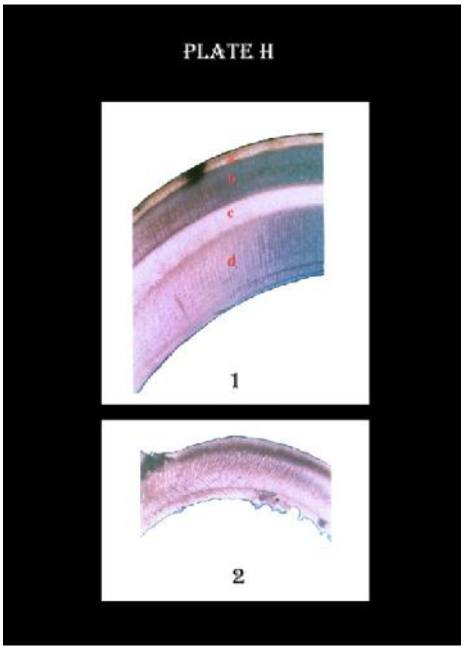

PLATE (H)

1 – Spiral section in *Nassarius plicatus* RODING (X 40)
a = nacreous layer
b = simple prisms
c = nacreous layer
d = simple prisms

2 - Spiral section in *Terebra nebulosa* SOWERBY (X 40) completely composed of crossed-lamellar calcite

Conclusion

The present study deals with stratigraphical, shell well structure and paleoecological of the Pleistocene section exposed at Abhor area, Jeddah, Kingdom Saudi Arabia. The Pleistocene section is composed of sandstone covered by reefal limestone. The microfacies of the beachrock is formed of grainstones, reflects the local geology. Systematically, the studied species are identified and belonging to Phylum Mollusca. The studied thin sections were prepared to study the shell well and microstructure of the molluscan shells. The most shells are composed of crossed-lamellar calcite and aragonitic nacreous structure, and prismatic calcite. The other shells are composed of calcitic prismatic and crossed-lamellar structure. Some shells are completely composed of prismatic calcite. The heavy metals in the recent shells are higher than in their equivalent Pleistocene shells which lived in a pristine environment. The increase of heavy metals due to the pollution of human activated as oil resulting from the oil industries, shipping, tourism activities and the construction materials of the new tourism villages along the Red Sea Coast.

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