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A brief review on Oyster shells origin and sedimentary evolution for the formation of limestone

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Abstract

The shell waste biomineralization process has known a tremendous metamorphosis and also the nanostructure with the identification of matrix proteins in oyster shells. However, proteins are represented in minor shell components and they are the major macromolecules that control biocrystal synthesis. Aragonite and calcite were derived from molluscan shells and evaluated the source of carbonate minerals and it helps for the formation of limestone. The oyster shell wastes are large and massive. The paleoecological study of oyster beds has discovered a near-shore and thin Upper Rudeis formation with storm influence during the accumulation of oysters with highly altered by disarticulation, bioerosion, and encrustation. It is possible even in the Paleozoic mollusks provided sufficient carbonate entirely to the source of microcrystalline of limestone. The present review is to discuss paleoecologically a number of oyster shell beds accumulated and sediment to form the different types of limestone during the Middle Miocene time.

Key words : Oyster shell origin, Limestone formation, Sedimentation.

1. Introduction:

Late & Middle Jurassic climates occurred water source is very low and allowed to develop the carbonate rocks throughout the world [1-6]. However, these evolution periods are the most important for the development of carbonate rocks throughout the world [7-11]. In the period of the "Callovian interval," the production of carbonate occurred and it was recorded by stratigraphic gaps and the siliciclastic depositions are mainly carbonates [12-16]. Consequently, the reef was developed in the period of Middle Oxfordian along with the Tethys margins [17-19].

1.1. Paleoecological and Taphonomic suggestions.

In the oyster's lifecycle, biological factors and environmental factors are an influence upon the shell growth and its morphology [20]. Oyster shell waste sedimentation and fossil formation will occur after their taphonomic modifications. In the Middle Miocene period, the taphonomic processes occurred for the sedimentation of oyster shell waste.

Paleoecological studies

The oysters are lived near shore in the Miocene period, and most of the sedimented shell are found less than 35 m depth in low-level water-containing environments [21]. Oysters are naturally found in ti-

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dal creeks, estuaries, bays and brackish water to normal marine water [22]. Oyster occurs mainly in subtidal and intertidal areas and it has irregular shapes [23].

Ecological factors such as water turbulence, the nature of the substrate and crowding are strongly influenced by the oyster shells morphology [24]. The living oyster shell growth is high in warm condition with high energy environment than cold with lower energy environment [25]. But, oysters shell faster growth in variable salinity conditions than constant environment [26]. Alternatively, the growth of oyster shells with high thickness may occur in higher salinity with bioerosion.

Taphonomical studies

Some studies indicate oyster shell wastes are strongly deposited and densely packed in the Miocene period, and its occurrence to generated waves [27-33]. In the taphonomical process, the oysters after death shell waste were generated and sedimented finally preservation of these shells to fossil formation [34]. The taphonomic process explained the shell decomposition and dissolution process after that abrasion, bioerosion, and fragmentation was occurred [35,36]. In the Middle Miocene period the oyster shell waste displacement process bioerosion process and encrustation, are the major taphonomic characteristics.

2. Origin of Oyster shells:

The oyster shell originated from an ectodermic layer of the early stage developing animals, and it depends on the postembryonic developmental processes. In the shell formation process, the amorphous calcium carbonate was produced in the protoconch stage of oysters. Weiss et al, [37] and Auzoux-Bordenave et al. [38] suggested that different microstructural changes were occurred at growth stages of larval stage as well as in adult shells (e.g. Oyster, Manila clam and Abalone etc.), and the early mineralized layer probably amorphous calcium carbonate was showed below the periostracum layer.

2.1. Oyster shell calcification process:

Oyster shell formation process typically enters the biomineralization of the epithelium layer [39]. The animal organ secretes a layer is known as the mantle and the shell inner surface coated with the ciliated tegument. The Fig. 6, redrawn by Waller [40], describes the calcification of oyster shell at the tissue level. In these figure shows the shell growing border with bi-layers, thick internal and outer crossed-lamellar layers, these layers are formed with aragonite [41]. In the shell growing process involved the mantle layer, periostracum, an interface between the outer epithelium layer.

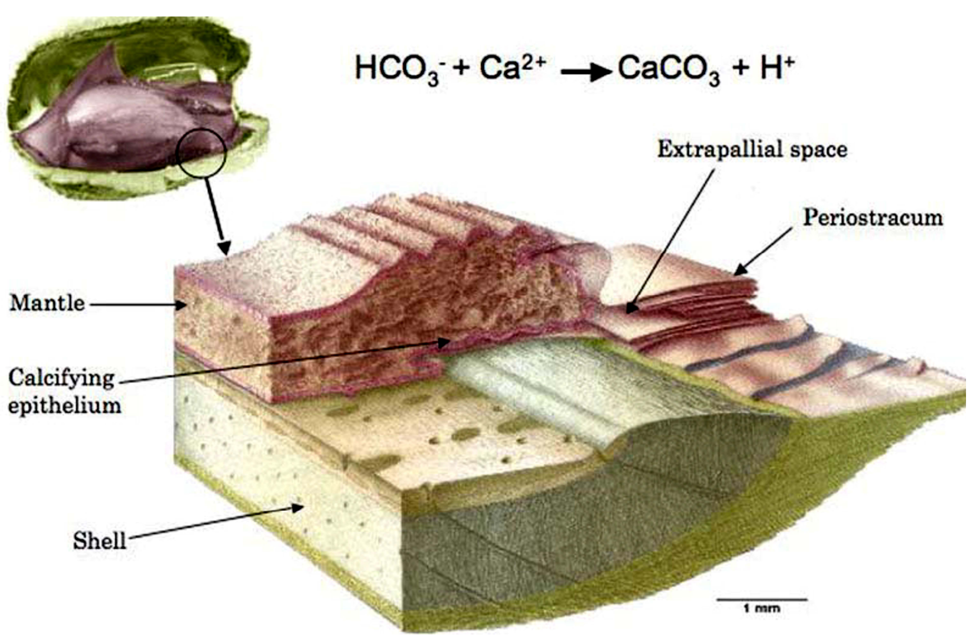

Fig. 1. Physiology of the shell calcification of the shells [40].

2.2. The formation of oyster shell:

In the shell formation process, calcium ions are the main source for the shell formation. The calcium ions are uptake from food and diffusion throughout the body, and it transporting with hemolymph and stored in the mantle layer, and it will help for the calcifying the epithelium layer for the formation of the shell. Simultaneously, bicarbonate ions are available from the hydrated CO_2 ions present into the site of the mantle epithelium layer. The calcium and bicarbonate ions are reacted for the formation of calcium carbonate in the extrapallial space of the epithelium layer, and the process self-assemble controlled manner for the production of the $CaCO_3$, and it was suggested by this equation. This process describes the shell calcification at the cellular level [42]

$$Ca^{2+} + HCO_3^- \rightarrow CaCO_3 + H^+$$

2.3. Overview of Oyster Shell with chemical composition.

Oyster shells are composed predominantly of low-magnesium calcite, and the bulk of modern Crassostrea and Ostrea shells are composed of stacked layers of foliated calcite locally interrupted by layers or lenses of chalky calcite [43-45]. The chalky calcite can be porous or denser and with pronounced lamination, but the significance of the amount and structure of chalky calcite in oyster shells is not clear; it has been variously suggested as (a) the most efficient way to adjust the shell outline during growth [46], (b) an adaptation to living in soupy sediment [43], although porous chalky calcite is also found in oysters [45], or (c) adaptation to less optimal environmental conditions. MacDonald [45] noted that the volume of chalky calcite was larger in estuarine than in marine oyster shells. It has been suggested that the more dense and laminated prismatic structure of the chalky calcite in many fossil specimens is caused by cement that precipitated in the pores of the originally porous honeycomb structure [43]. The schematic diagram of oyster shell inner surface and vertical section of the shell as referred by Chinzei [43]. The scheme of oyster shell with the extension of myostracum and it contains 5～35μm thickness, the major component of this myostracum is aragonite. The myostracum surrounded by the layer is called folia, it has 100～200μm thickness was present and the major composition of folia is calcite. In between the myostracum and folia organic matrix are present.

2.4. Sedimentation of oyster waste shells for the formation of limestone:

In the Phanerozoic period, many mollusks shells, are generated with the major composition of aragonite and some of the calcite. The less amount approximately 10% of molluscan shells are composed with calcite, including with low level of Mg-calcite [48]. The different mollusks shells produce calcium carbonate molecules as shown in Table 1, the calcium carbonate synthesis from different mollusks [49].

Table 1. The calcium carbonate production from different mollusks.

location with reference	$CaCO_3$ synthesis (g CaCO3 m^{-2} a^{-1})
Wadden Sea - German (*Mytilus edulis*) [50]	2000-6500
Oyster reef (*Crassostrea virginica*) [51]	23400
Cretaceous period -Oyster shell layers [49]	4000-28500
Bay of Florida - USA [52]	7-64
Bay of Biscayne - USA. [53]. Subtidal Intertidal	3.74-18.17 309
Bay of Kailua - Hawaii (Molluscan ‘sediment production) [54]	0-120
French Polynesia lagoons (*Cardium fragum*) [55]	200
Molluscs-aragonitic shells (bivalves, gastropods, chitons) [56]	20-24
Dutch Wadden Sea -bivalves (*Macoma balthica*) [57]	9-13

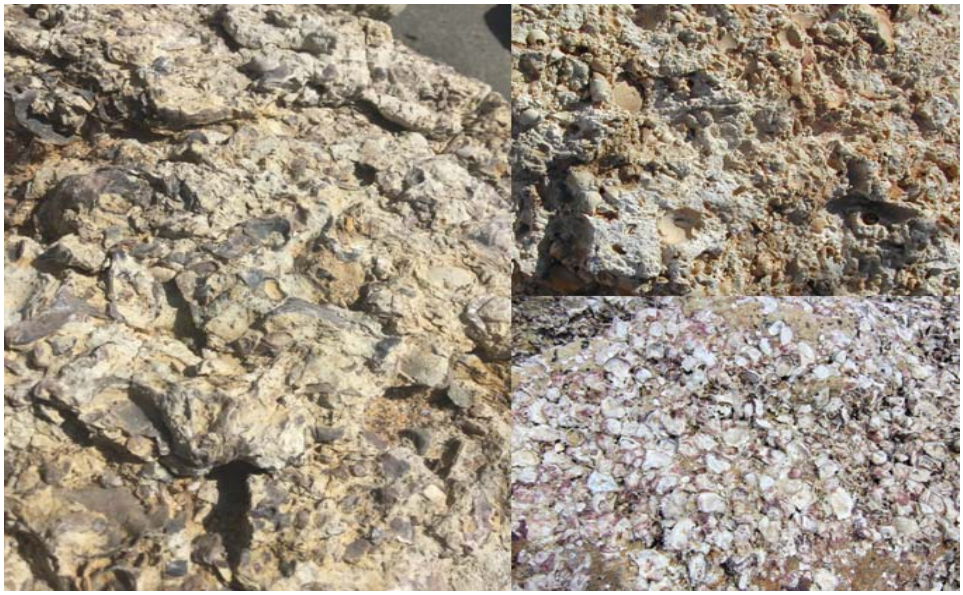

Fig. 2. Different shells sedimentation and forming into the limestone

While a number of studies have applied paleoecological and sedimentological methods to elucidate the evolution and distribution of Miocene coral reefs and heterozoan carbonates in the Mediterranean area [58-64], there is a paucity of supporting geochemical analyses [65]. In the Phanerozoic period, the marine deposits of the oyster shell are accumulated over millions of years and this chemical deposition is helpful for the formation of limestone during this period and built up the sediment limestone layers are formed in the Middle Eocene period and Pleistocene period. in Fig 2. Oyster shells sedimentation and forming the limestone.

Oysters belonging to the 'secondary soft-bottom dwellers' group often form spectacular shell beds in the fossil record [66-71]. With some notable exceptions where specimens are still preserved in life position [70,72,73], oysters in shell beds have usually been reoriented due to reworking by hydrodynamic agents. Reconstructed life positions of such displaced oysters provide valuable information for deciphering the sedimentary and ecologic dynamics of oyster beds [74-78]. This, in turn, may help in the placement of oyster beds within the more general environmental framework, and within that of sequence stratigraphy [79].

3. Limestone origin:

Limestone made largely with calcium carbonate ($CaCO_3$), usually in the form of calcite. Organic limestone formed from fragments of calcareous animal remains such as shells and coral. The most important and abundant of all sedimentary rocks that are employed commercially is usually of organic origin. Fossiliferous, marine sediments in oceans and fresh bodies of water, consisting of shells and skeletons of plants and animals, were gradually accumulated through deposition, layer on layer, to form in some case, massive beds of limestone.

In the limestone formation proposes, the dissolution of aragonite from the oyster shell and reprecipitation of carbonate with calcium ions under limestone layers [80,81]. During this ‘differential diagenesis’ [82] aragonite fragments such as calcium and carbonate ions are re-precipitated as microcrystalline form and preserved within the limestone bed. The dissolution of molluscan aragonite shells and re-precipitated for the formation of limestone referred by the schematic diagram of Munnecke and Samtleben [82].

The aragonite containing oyster is required for the formation of limestone beds in Ordovician and Silurian periods. In the Fig. 3, shows the aragonite production by oysters and to evaluate the limestone formation in the Ordovician period [83].

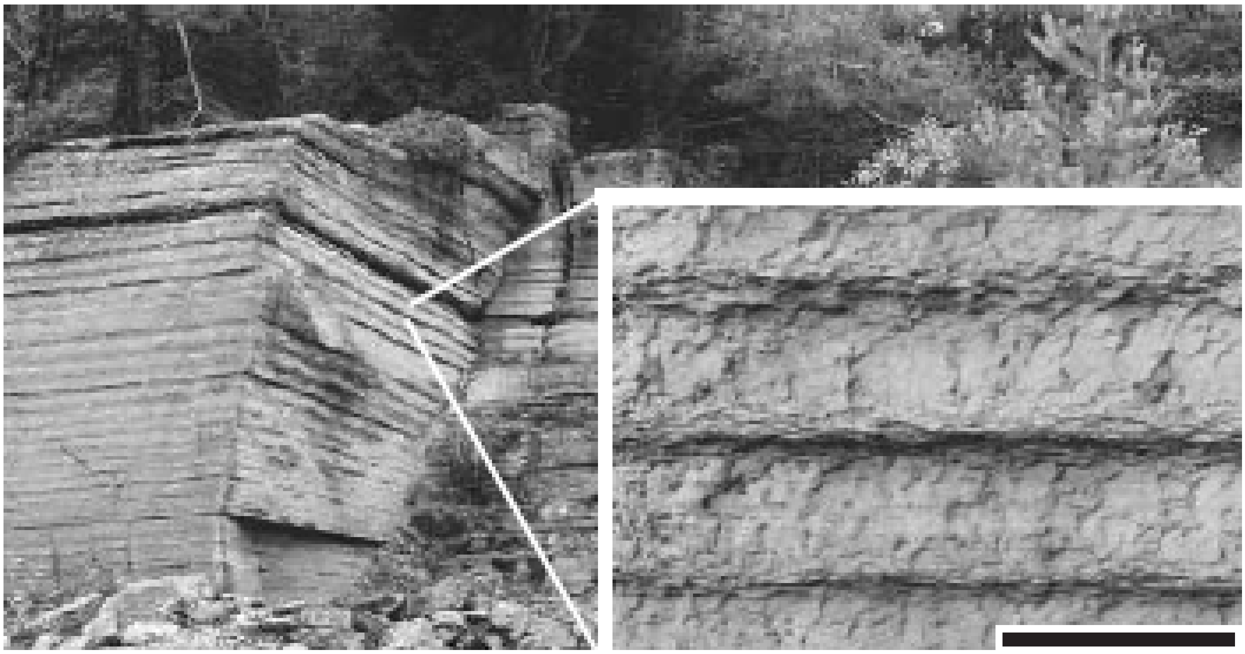

Fig. 3. Field photographs of limestone formation in the Ordovician period.

Limestone sediments are deposited by natural chemical reactions, in these process the dissolution of calcium carbonate fossils through the solvent action of carbon dioxide to form calcium bicarbonate, which was subsequently reprecipitated in carbonate form. Sometimes this carbonate precipitation process occurred with plant and animals organisms acting as the intermediary.

Huge coral reefs are gradually accumulated in this manner over thousands of years, and in the millions of years of geologic ages that have reshaped the geography of the world, they have formed mountains in the interior of continents and many mountains in Europe and North America are coralline in Origin. Pressure and heat have supplemented chemical precipitation in consolidating the minute carbonate particles into these imposing compact masses. In the crystalline form of limestone depends on oyster shells grains that are deposited. More quality limestone formation occurs more often in the thickest masses or beds of up to several hundred feet thick. However, frequently these thick beds contain strata of relatively impure stone. Contamination of the stone with soil usually occurred at the commencement of deposition, but in some instances, impurities were absorbed through pores and interstices during deposition. These impurities occur both vertically an laterally in the bed, but usually, a change in purity is much more gradual laterally than vertically.

The limestone is not of organic origin include stalactites and stalagmites in caves and some oolitic limestone, travertine, and calcareous tufa. However, the presence of fossils in varying degrees is apparent in mostly commercial limestone, and this enables the geologist to determine from which geologic age it was derived. Often the prehistoric fossils are found intact in the stone in an almost perfect state of preservation.

4. Conclusions:

In this review has implicated for understanding the evolution and distribution of heterozoan and protozoan carbonate deposits in the Mediterranean during the Miocene, and these results suggested that the deposition of calcium carbonate and evolution of limestone formation from oyster shells waste. The oyster shells aragonite to provide the calcium and carbonate source for microcrystalline formation in Paleozoic periods. Oysters shells, aragonite, and calcite is the main source for the formation of sedimentary limestone. Sedimentation rates can be inferred from reconstructed oyster life positions. Together with the taphonomic data, this offers valuable insights into the sedimentary dynamics of oyster shell beds, allowing to distinguish between different sedimentary regimes, e.g., between those of dynamic bypassing and starvation.

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