Δελτίο της Ελληνικής Γεωλογικής Εταιρίας τομ. XXXX, 2007
Πρακτικά 11ου Διεθνούς Συνεδρίου, Αθήνα, Μάιας 2007

Bulletin of the Geological Society of Greece vol. XXXX, 2007
Proceedings of the 11th International Congress, Athens, May, 2007

CASPIAN SEA GEODYNAMICAL EVOLUTION EFFECT ON THE SEA LEVEL CHANGING ALONG THE QUATERNARY PERIOD

Khoshravan H.[1]

[1] *Head of coastal management group, Caspian Sea research & study center, Water Research Institute, Zaffar Alley, Emam Square, Sari, Mazandaran, Iran, H_khoshravan@yahoo.com*

Abstract

The Caspian Sea as the largest lake in the world has different characteristics considering geosciences (Fig. 1). In fact sea level changing is the most important happening in this region. Annually fluctuation impact on surrounding coastal area has serious damage and human society meet frequent destroyed phenomena. In this paper we are trying to reconstruct rapid Sea level changing in Holocene epoch by use paleontology evidences such as: Mollusks fossil and sedimentary facies record. In this research 254 Quaternary sediment core samples from exploring petroleum wells (M-1, G3-A) have been evaluated considering above mentioned and also more than 130 sea bottom recent sediments on view of biofacies and biostratigraphy studied. Our investigation results show that in the Caspian Sea basin at the Holocene epoch there are many periodic sea level fluctuations and climatologic impact is most important agent for sea level changing in this basin.

Data results are showing that in the studied area there were many periodic rapid sea levels changing during the Quaternary period. The Caspian Sea has several fluctuations along 10,000 years ago and its latest begin about 25 years ago. Finally we can conclude that Caspian Sea level fluctuation could continue at future similar past time and climatologic impact and tectonic movement are important agents for sea level changing in this region.

Key words: *biostratigraphy, gastropod, Caspian Sea, fluctuation, mollusc, Holocene epoch.*

Περίληψη

Η Κασπία Θάλασσα, η μεγαλύτερη λίμνη στο κόσμο, παρουσιάζει ποικίλα χαρακτηριστικά όσον αφορά τις γεωεπιστήμες (Fig. 1), με σημαντικότερο όλων τις διακυμάνσεις στις στάθμης της. Οι ετήσιες διακυμάνσεις της στάθμης έχουν πολλές φορές καταστροφικές επιπτώσεις στις παράκτιες περιοχές και τους πληθυσμούς που κατοικούν εκεί. Στην παρούσα εργασία γίνεται προσπάθεια αναπαράστασης των απότομων μεταβολών της στάθμης κατά το Ολόκαινο με τη βοήθεια απολιθωμένων μαλακίων και ιζηματογενών φάσεων. Αναλύθηκαν 254 δείγματα ιζήματος προερχόμενα από φρέατα εξόρυξης πετρελαίου (M-1, G3-A) καθώς και περισσότερα από 130 δείγματα επιφανειακών ιζημάτων πυθμένα. Σύμφωνα με τα αποτελέσματα της έρευνας, κατά το Ολόκαινο -και εν γένει το Τεταρτογενές- καταγράφονται πολλές περιοδικές διακυμάνσεις της στάθμης της Κασπίας Θάλασσας, οφειλόμενες κατά κύριο λόγω σε μεταβολές του κλίματος. Η τελευταία διακύμανση

που καταγράφηκε ξεκίνησε πριν περίπου 25 χρόνια. Τέλος συμπεραίνουμε ότι, οι διακυμάνσεις αυτές θα συνεχιστούν με παρόμοιο ρυθμό και στο μέλλον, ελεγχόμενες από κλιματικές διακυμάνσεις και τεκτονικές κινήσεις.
Λέξεις κλειδιά: βιοστρωματογραφία, γαστερόποδα, Κασπία Θάλασσα, μαλάκια, Ολόκαινο, διακυμάνσεις στάθμης.

1. Introduction

Currently the use of recent evidences for historic phenomena reconstructing is occurred in the geology science. In the paleocimatology and pale geography studies, fossil and sedimentary petrography records are the best tools for the past events recognition. For instance some faunas which they leave to certain environment like the recent time help us to know about environmental conditions at the previous time. The last research on Middle and Upper Pliocene sediments in the Caspian sea southern basin (Chelken, Agchagile formation) showed that the Caspian sea was a real marine basin and with high biodiversity of molluscs (Mousavi 1994). On the basis of these elements we could recognize the environment conditions of the Caspian Sea at the Quateruary period and its fluctuation reconstructing. Therefore in tbis research we have used fossils and sediments petrography records for the Caspian Sea level changing evaluation. Among the Quaternary invertebrate fossils, Gastropod species are the most important indicator for environment analysis and pale climatology studies. Because biodiversity of their species is considerably in the Quaternary sediments and their adaptation to new environment considering sea bottom depth increasing and water salinity degree is very sensibility. Usually sedimentation processes in the Caspian Sea basin have regular condition. It means at the sea floor, the size of sediment grains decreased gradually with depth increasing. At the shallow water, the depth between 1 to 10 m sand sediments deposit when sea floor depths increasing, sediments vary to closer material and the percent of clayey matrix gradually increase. In the deep zone of the Caspian Sea, very fine sediment like mud and ooze has developed correctly (Khoshravan 1999). Therefore we could use above mentioned results for pale environment analysis and sea level reconstructing in the Caspian Sea basin.

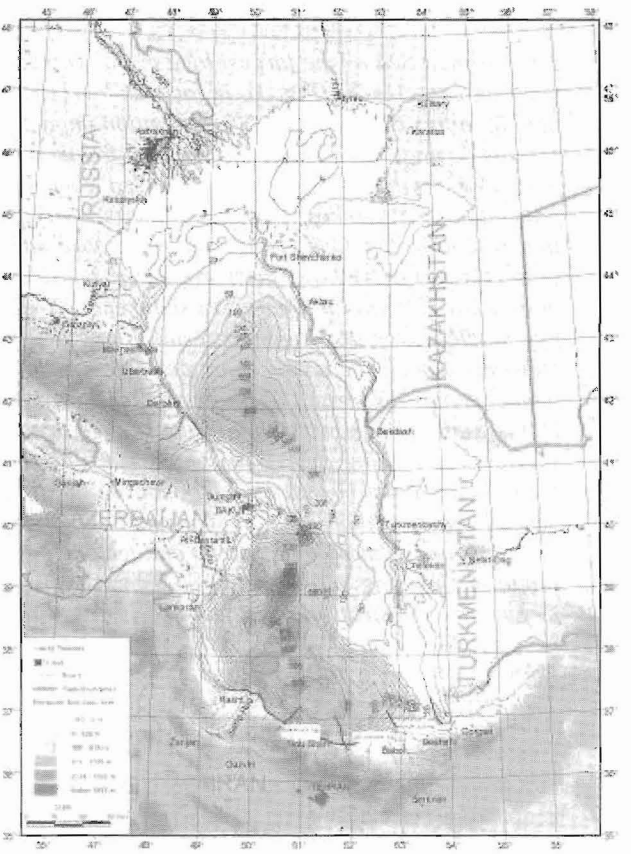


Figure 1 - The Caspian Sea Geographical location map

2. Method

In this research our investigation were programmed in two directions. At the first step we need to know which class of molluscs varied with depth increasing respectively. So we were sampling 130 sea bottom sediments at the 18 stations from shoreline to 400 m depth in the southern coasts of the Caspian Sea (5, 10, 20, 50, 100, 200, 400 and randomly 800 m depth) with grab sampler on the research vessel. After sample preparing stage, fossil determination was beginning. In general we found that gastropod species were most useful indicator for bathymetry of sea depth classification. Therefore with microscopy species determination we could classify the Caspian Sea floor in the southern part to five depth limitations. In fact today there are five assemblage zones of Gastropod species in the southern region of Caspian Sea from depth 5 to 400 m. So we should determine similar Gastropod species in the old sediments. Also we studied core sample from oil exploring wells in the southern coasts plain of Caspian Sea (M-1, G 3-A) (Fig. 2). About 254 core samples have been studied considering stratigraphy and palaeontology indexes. After gastropod fossil species determination and systematic classification we were trying to compare all of them with recent equivalent biota. Therefore with this method pale bathymetry of Quaternary sediments of the Caspian Sea has been done perfectly.

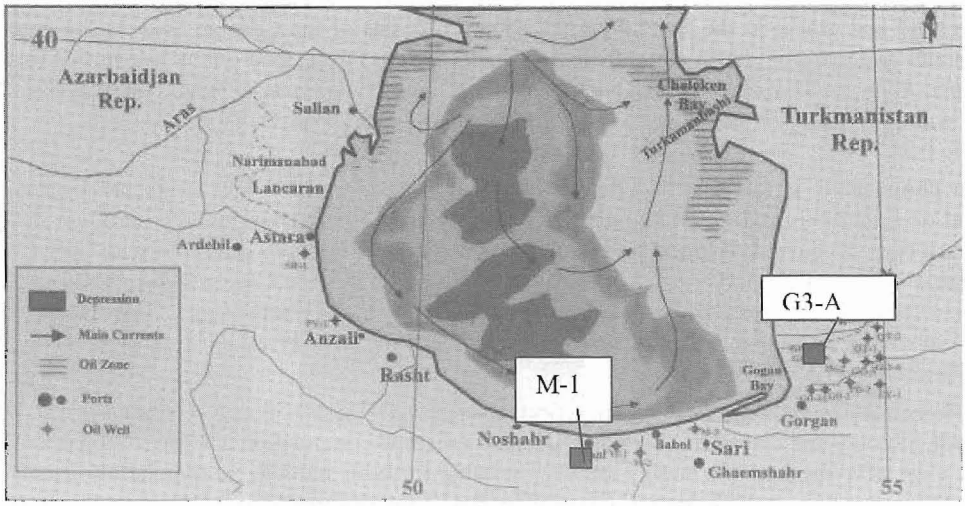


Figure 2 - Mazandaran petroleum exploring wells location map

3. Caspian Sea recent Gastropod assemblages' distribution on depth zone

Gastropods are more abundant than any other group of molluscs at the present day; they also occupy a greeter range of habitat. The majorities are aqnatic, and of these most live in shallow seas; they are also widespread in freshwater and on dry land. Modern examples include the marine limpets, winkles and whelks, and the terrestrial snails and slugs.

Gastropods are classified by features of the soft part, but these leave few clues in the empty shell. Accordingly, fossil shells are classified by comparing them with similar modern shells. There are three subclasses: Prosobranchia, Opistobranchia and Pulmonata (Murray 1985). Only the prosobranchs are most important indicator and are discussed in more detail here.

The prosobranchs are fully torted and are divided into three orders: Archeogastropoda (Cambrian-Recent), Mesogastropoda (M. Ordovician-recent), and Neogastropoda (Cretaceous-recent) (Moore 1969). In the Caspian Sea Archeogastropoda and Mesogastropoda species have developed perfectly on the sea floor (Khoshravan 1995). *Theodoxus pallasi* from Archeogastropoda and other species from Mesogastropoda are frequent in this area. The structure of gastropods shell consider-

ing thickness and size in the Caspian Sea vary to other open marine biota. Often they are so small and have very tinny shell. The distributions of several species of gastropods on sea bottom in the Caspian Sea southern basin have been classified to five zones. Each zone contain special fossil of gastropods they are live together at the certain depth on sea bottom (Table 1). Sea bottom substrate sediments composition and biodiversity accumulation of gastropod species change into each zones. So those are introduced as below table.

Table 1 - Caspian Sea bottom depth classification with Gastropod assemblages

Coastal Environment	Depth(m)	Gastropods	Sediments	Indicator index
Beach zone	0	Pulmonata	Sand-Gravel	Without Marine Element
Near shore zone	5-10	Clessionella	Sand-Silty Sand	%Clessionella> Caspiella
Offshore	10-50	Caspiella	Silty Clay-Clay	%Caspiella> Clessionella
Inner Shelf	50-200	Caspia	Clay – Marl-Mud	Caspia> Caspiella%
Outer Shelf	200-400	Micromelania	Ooze-Mud	%Micromelania> Caspia

1- Beach zone: This zone is located in beach zone and corresponding with shoreline, sediments include sand and gravel in the several part of southern coasts of the Caspian Sea. At the near of river mouth and marginal basin some fresh water and dry land gastropod genus live in this region like *Helix*, *Radix* and *Planorbis* genus and always there are much plants debris on the shore line of course without marine elements. Also mucb rework bivalve shell accumulated on the beach zone (Plate 1: 1-3).

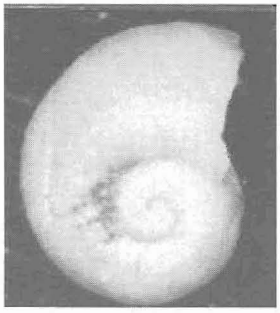
2- Near shore zone: In this zone, the depth of sea water is between 1 to 10 meters and on view of physical oceanography indexes, this position is located in the near shore zone where waves surf and swash currents have developed. Sediments include fine sand to very fine sand with little silt to clay matrix. The most important gastropods fauna in these depths are *Clessionella, Pygohydrobia* species. Often the thickness of their shell is very thin and crystal shape as fragile material. The percent of *Clessionella* and *Pygohydrobia* species population density is more than others in this zone (Plate 1: 4-9).

3- Offshore zone: Offshore environmeut with tbe depth between 10-50 m include sediments with sandy silt, silt clay and clayey unarl deposit. Usually substrate composition and environment condition on view of hydrodynamic energy are very suitable for biota habitat. So population density of gastropods in this zone is high degree. *Caspiella, Clessionella genuses* are the most important gastropods but they have different abundance on sea bottom. Bio indicator index of Gastropod species determined with the high population of caspiella species ratio others. *Oxypyrgula* and *Clessionella sp.* have low population density (Plate 2: 1-9).

4- Inner Shelf: The depth of water in this zone is between 50-200 m. Sediments contain: Marley clay and carbonate mud with dark color. Gastropods assemblage includes different species of *Caspia* and *Oxypyrgula genuses*. The increasing of *Caspia* species accumulation ratio to *Caspiella sp.* is good indicator for this zone recognition in the old sediment of Quaternary. The shell of gastropods has developed with certain thickness and the number of whorls have been increased (Plate 3: 1-8).

5- Outer Shelf: Several gastropods live at the depth between 200-400 m, Sediments include: carbonate ooze with sulfide minerals (Pyrite and Sphalerit). Anaerobic condition has developed in the deepest sea bottom. The most important gastropods Genus in this zone contain: Planorbis, Micromelania, Abeskunus species. The increasing of Abeskunus and Micromelania species population ratio others is a good indicator for this depth zone finding in the old sediments (Plate 4: 1-6).

Plate 1 - Size scale of each fossil shell ×12. 1-*Planorbis* sp., 2-*Helix* sp., 3-*Radix* sp., 4-*Clessionella martensi*, 5-*Clessionella triton*, 6-*Clessionella variabilis*, 7-*Pygohydrobia eichwaldi*, 8-*Pygohydrobia oviformis*, 9-*Pygohydrobia gemata*



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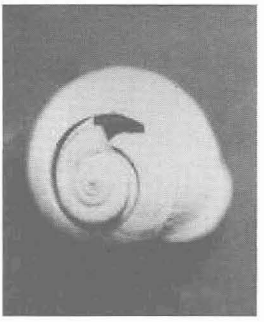

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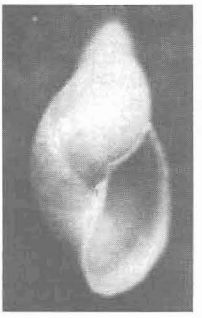

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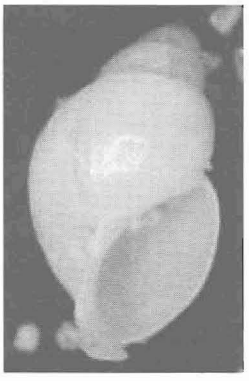

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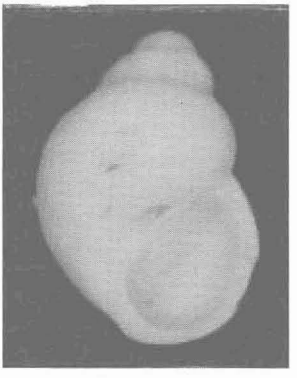

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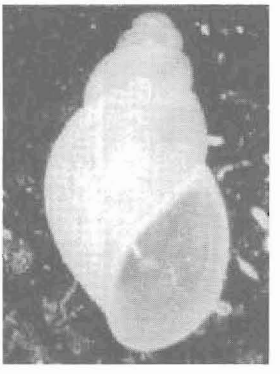

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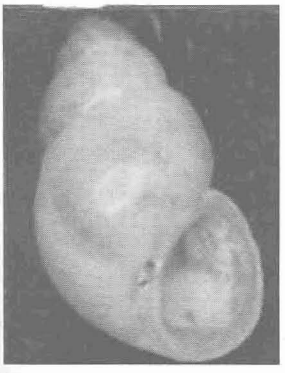

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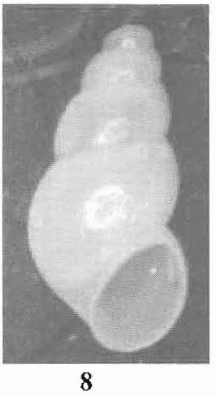

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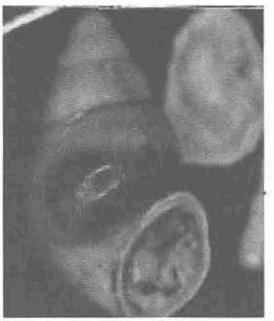
Plate 2 - Size scale of each fossil shell ×12. 1-*Caspiella ulski*, 2-*Caspiella laveli*, 3- *Caspiella baeri*, 4- *Caspiella derbentina*, 5- *Caspiella klensnikoviana*, 6- *Caspiella triavilis*, 7- *Caspiella conus*, 8- *Caspiella ovum*, 9- *Caspiella eichwald*



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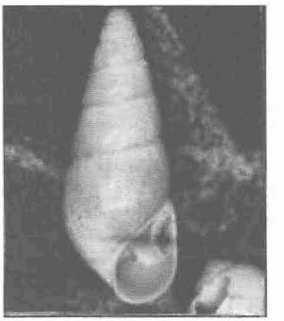

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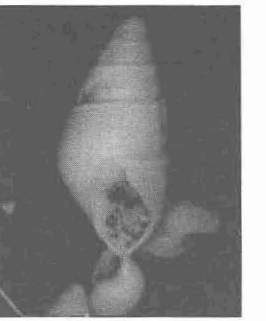

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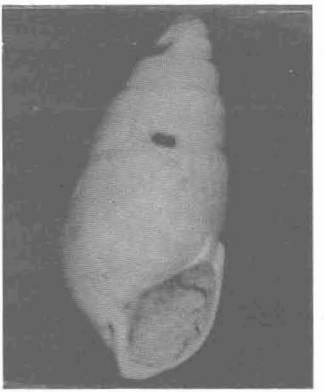

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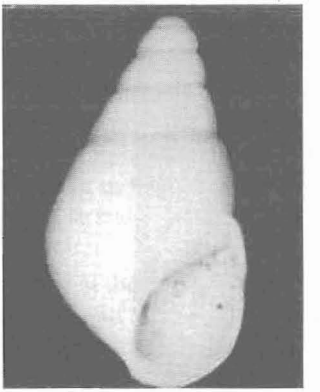

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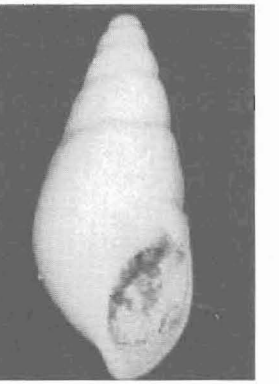

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On the basis of above mentioned we have five gastropod assemblage indicators in the southern coasts of Caspian Sea which help us to do paleobathyometery evaluating on Quaternary sediments and Caspian Sea level fluctuation reconstructing. Continuously as follow we are trying to investigate Quaternary sediments considering above characteristics and finally we will introduce Caspian Sea level fluctuation at the Quaternary period.

4. Caspian Sea level fluctuations in the Quaternary period

In this research we could recognize Caspian Sea level fluctuation in the Quaternary period with comparing recent bio indicators with similar old fossil and sediment petrography evidences. In the Fig. 3 you can see Caspian Sea levels fluctuation periodically curve that has been reconstructed with use bio indicator. In fact this curve describes sea level changing during Quaternary period about 2.5 million years ago till now. At the X axis, thickness of layers and on the Y axis depth of water is located. So the condition of curve line shows us that there are many sea levels periodically changing with passing of time. For instance at the point A on the curve line at the late Quaternary sediments (Apsheronian Stage) the Caspian Sea at the point station (M-1 Well) has moderate to high depth but with beginning of regression phase rapid sea level changing had been occurred rapidly. Sometimes uncertain agents caused the sea level randomly decrease but this condition in the Bakovian stage changed and depth of water immediately increased and progression phase started (point B). This process continued till lower late khazarian sediments and at the late khazarian stage all at once Caspian Sea level rapidly decreased. In fact this event was beginning of regression phase in the Caspian Sea basin after Bakovian (point C). In the khovalynskian stage progression phase again caused sea level raised and the depth of sea increased (point D). But in the late Neocaspian stage the second fall at the curve line apparent regression phase as all at once and rhythmic fluctuation continued till present time (point E). What we could result from this curve is the presence of three kind of fluctuation rhythms in the Quaternary period. Those were a long time sea level changing, moderate time and short or rapid sea level fluctuation period. But in the Holocene epoch Caspian Sea level fluctuation has Rapid condition. There are many regression and progression phases in that time. In fact at the late Neocaspian stage Caspian Sea has a moderate depth in studied area and periodically sea level change so the depth of water some times increased and some times decreased (Fig. 4). After this time at the early Neocaspian stage Caspian Sea level decrease and regression phase happened. For example from 10000 years ago till now there were so many fluctuations in this basin and now we could feel the last period progression of it.

1- Long time sea level fluctuation

This kind of sea level changing was created with tectonic movements. It has low velocity and unfeeling events. During Quaternary period, The Caspian Sea has two real sea level rises in Bakovian and khovalynskian. Apparently about 400000 years it would be taken and two most important regression phases also in khazarian and Neo Caspian happened. So for this event, tectonic movement is most important factor.

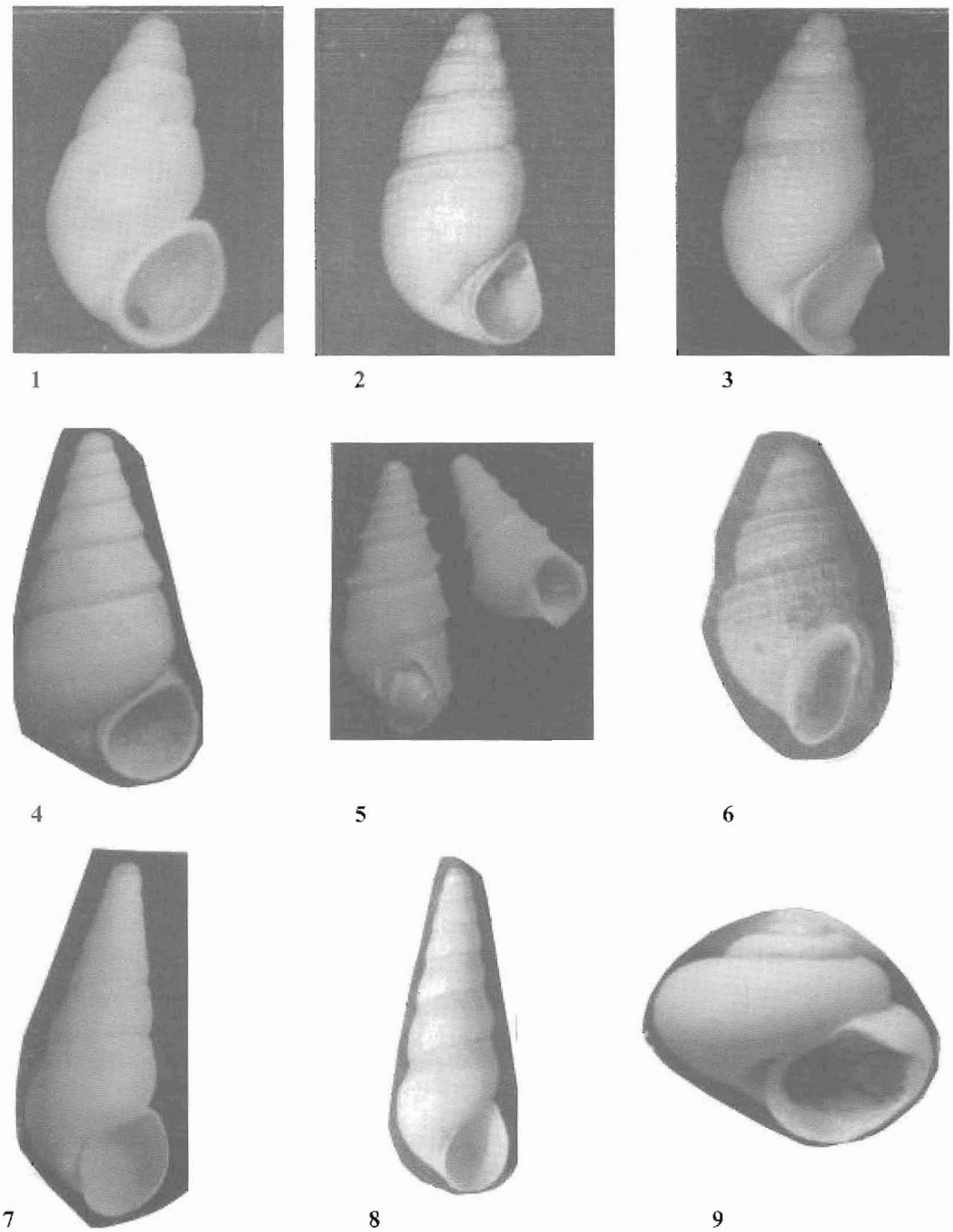
2- Moderate time□sea level fluctuation

This natural changing on sea level has been happened at glacial and interglacial phases. In Quaternary period there were many glacial phases which were effected sea level changing.

3- Short time sea level fluctuation

These processes at the little time and with high velocity cause rapid sea level changing. Climatologic agent was most important for rapid sea level change in the Caspian Sea basin during the early of Quaternary in Holocene epoch.

Plate 3 - Size scale of each fossil shell ×12. 1-*Caspia baeri*, 2- *Caspia pallasi*, 3- *Caspia gemelini*, 4- *Caspia pseudobacuana*, 5- *Caspia pseudodimidiata*, 6- *Oxypyrgula bogatscheviana*, 7- *Laevicaspia eburnean*, 8-*Abeskunus brusiana*



At the present we can observe some sediment sequences at the margin of beach in the southern coasts of Caspian Sea which contain sea level changing record especially at the end time of Quaternary period.

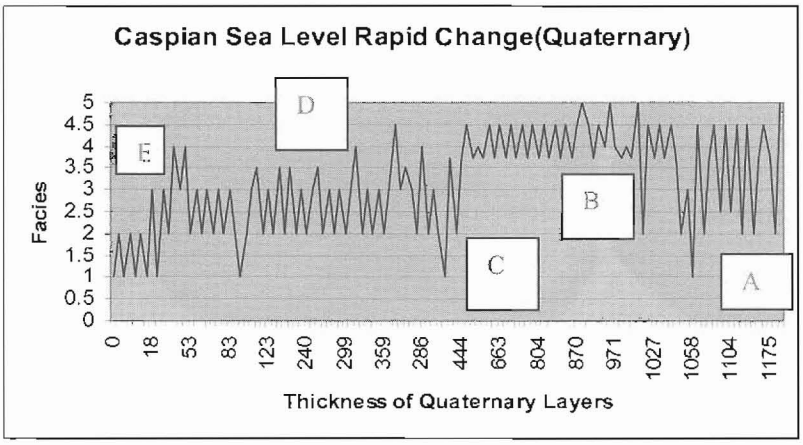


Figure 3 - Caspian Sea level rapid change in the Quaternary period

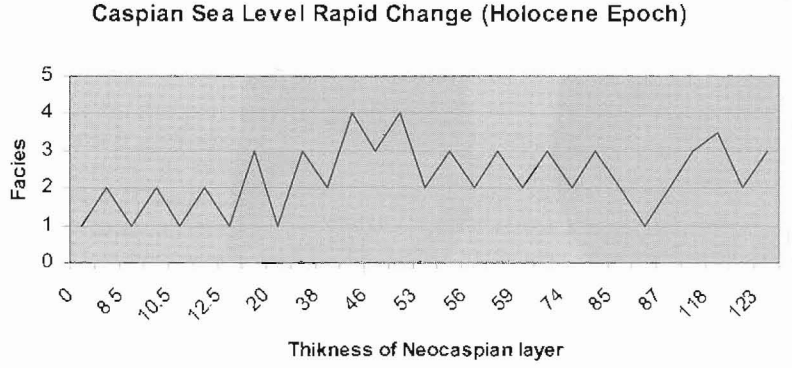


Figure 4 - Caspian Sea level rapid change in the Holocene Epoch

5. Conclusion

1- On the whole during the Quaternary period the Caspian sea basin has periodic sea level changing with different duration(long, moderate, short).

2- At the Holocene epoch most natural changing in the Caspian Sea basin related with climatologic changing and rapid sea level changing happened gradually and alternative phenomena.

3- Bio indicators are useful tool for reconstructing of sea level changing in the Caspian Sea.

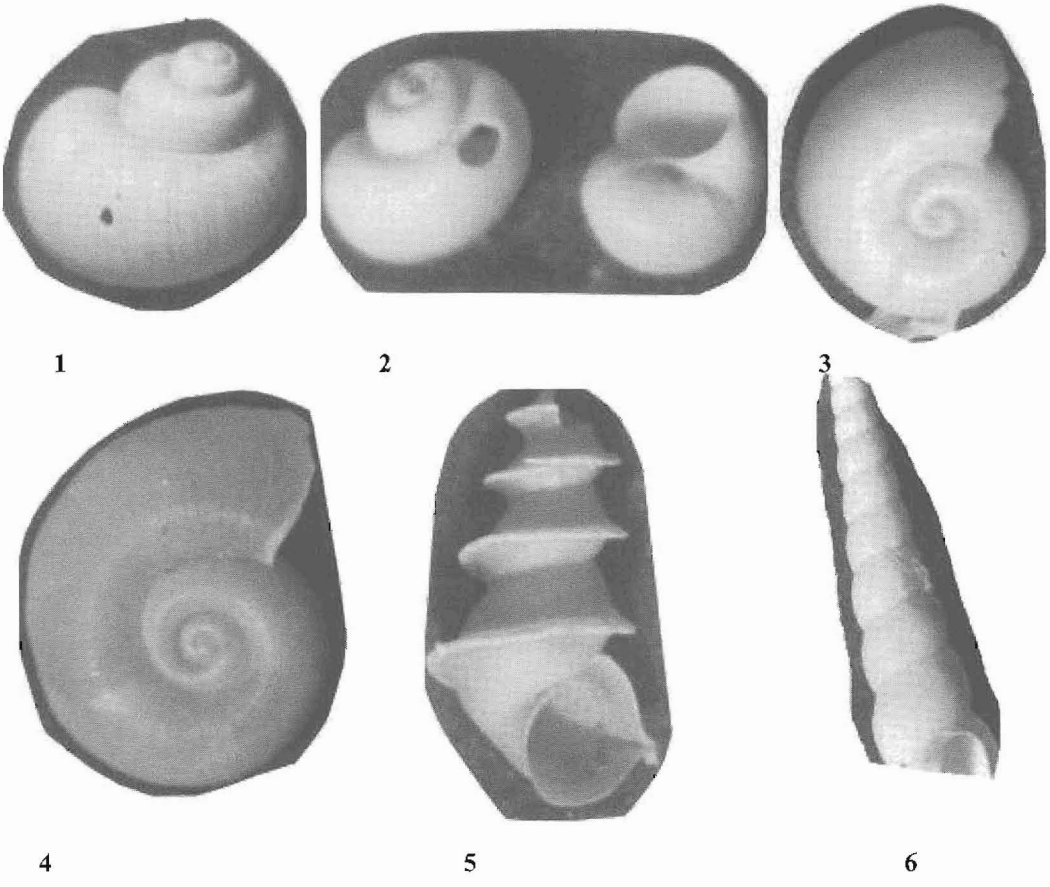
4- Gastropod is most important indicator for bio environment recognition and sea level changing analysis.

5- Tectonic movement, glacial activities and climatologic impact are the most important agents for Caspian Sea level fluctuation.

6. Acknowledgements

This work is part of the Caspian Sea national research & study center. We acknowledge the all colleagues who organized and participated to the sea cruise (September 1997), during which the

Plate 4 - Size scale of each fossil shell ×12. 1-*Abeskunus sphaerion*, 2-*Abeskunus depressispira*, 3-*Planorbis djalalus*, 4-*Planorbis eichwaldi*, 5-*Micromelania laticarinata*, 6-*Micromelania turricula*



sediment sample was collected by fishery research institute of Iran. The sub-surface sample was made available thanks to Mr Mousavi Rohbakhsh (N.I.O.C). We are grateful to Mr Arsalan Mansouri (Head of CSNRSC) and others for their helpful comments.

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