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Occurrence of Arctostrea: Existence of high energy Paleoenvironment in Cauvery basin, India during Late Cretaceous.

Riffin T.Sajeev

Abstract

The distribution of ammonites in Arogyapuram/Dalmiapuram, Ariyalur and Senthurai areas show a maximum abundance at Ariyalur and a decrease in its abundance from Ariyalur around 30-35 Km. An uplift which caused marine regression throughout Cauvery basin was proposed by earlier workers. In the present study author propose a terrain style at Cauvery basin with respect to Senthurai, Ariyalur and Dalmiapuram in early Cretaceous and after uplift in late Cretaceous. Hence the possibility of a shallow water basin in Dalmiapuram and senthurai regions cannot be ruled out. If it happens , there is enough chance to create a very deep canyon like terrain and water from both sides of Ariyalur accumulated in that region with a depth of more than 100 m. This favors the migration of ammonites from Dalmiapuram and Senthurai regions to Ariyalur region.

More than 30 samples of Arctostrea were collected by the author, The Rastellum (Arctostrea) genus in cavery basin may have originated in late Jurassic with adaptive modifications like high toothed commissure. The reason for such adaptation is the existence of high energy environment with heavy sedimentation. Arctostrea, comprising strongly elongated, slender, arcuate forms with high zigzag commissure were dominant during this time. These genera differ in their morphology of features externally and internally, but some representatives of genus Alectryonia (e.g., Al. rastellaris or Al. gregarea) are elongated and arched. Probably the Arctostrea originated from such forms.

Key Words : Cauvery Basin, Arcostrea , Cretaceous, Alectryonia, Ammonite, Al. rastellaris, ,Arogyapuram, Ariyalur

1.INTRODUCTION

The Cauvery Basin Extends along the Eastern Coast of India, bounded by 08º-12º′ North Latitude, 78º- 80º East Longitude. This basin was formed as a result of Gondwanaland fragmentation during drifting of India-Srilanka landmass system away from Antarctica/ Australia plate in Late Jurassic/ Early Cretaceous. The basin is endowed with 5-6 Km of sediments ranging in age from Late Jurassic to Recent (mainly thick shale, sandstone & limestone). The late Jurassic to early Cretaceous rifting between India/Australia and India/Antarctica resulted in the formation of a number of NE–SW-trending basins in the Indian Precambrian crystalline basement. The Cauvery Basin is the southernmost basin along the eastern margin of the Indian Sub-Continent, covering much of this part of India and extending a considerable distance offshore. The basin comprises several 'depressions', or sub-basins, with the Ariyalur–Pondicherry Depression in the north. The exposed successions are in the southern part of this sub-basin. Cretaceous tectonostratigraphy and the development of the Cauvery Basin studied by Matthew Watkinson.et.al (2007). It contains thick sedimentary sequences of around 6 Km, which were deposited on the Archaean basement (Rangaraju et al., 1993).The sedimentary rocks in the Cauvery basin are well exposed in five isolated areas, i.e., Pondicherry, Vridhachalam, Ariyalur, Tanjore and Sivaganga (Banerji, 1972).

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2.PREVIOUS WORKS

various studies in this area done by many researchers (Sastry et al., 1972; Sundaram and Rao, 1986; Ramasamy and Banerji, 1991; Govindan et al., 1996; Sundaram et al., 2001; Madhavaraju and Ramasamy, 1999a, 1999b, 2001, 2002; Nagendra et al., 2002; Madhavaraju et al., (2004, 2006). A

International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
ISSN 2229-5518

study on Seismic Expression of the Canyon Fill Facies and its geological significance on Ariyalur-Pondicherry Sub basin, was done by Roy Moulik and Prasad (2007). In this study they proposed that, at the end of Cretaceous Period, there was tectonic reorganization resulting in upliftment causing marine regression throughout the basin. This caused incision of exposed shelf and the formation of submarine canyon at the shelf edge. Subsequently the canyon was filled during late Paleocene times. Five different types of canyon fill facies have been identified based on the seismic expressions of the canyon fill. Integrating the available well data with seismic and lithological interpretation of different types of canyon fill facies has been made and presented diagrammatically in this work. Somewhere it is sand rich, at some places shale rich, and sometimes it consists of alternating sand and shale facies. A conceptual depositional model of these sands has been postulated. This model shows that sands were deposited in submarine canyon formed under the influence of gravity-driven mass transport processes like slumps/slides and debris flow.

The sedimentary rocks in the Ariyalur area divided them into three distinct groups, i.e., Uttatur, Trichinopoly and Ariyalur. Detailed lithostratigraphic classification of Cretaceous-Tertiary rocks was given by many workers (Srivastava and Tewari, 1969; Sastry et al., 1972; Banerji, 1972; Sundaram and Rao, 1986; Ramasamy and Banerji, 1991; Sundaram et al., 2001). The present study aimed to postulate the reason for adaptation on Alectryonia genera on the basis of the recovery of fossils of Rastellum (Arcostrea) genus from Dalmiapuram Formation of Uttatur group. The Cretaceous Uttatur Group has been subdivided into four Formations, i.e Terani Formation, Arogyapuram Formation, Dalmiapuram Formation and Karai Formation., The first three formations have been dated to be Early Cretaceous and the last formation to be Late Cretaceous. The Dalmiapuram Formation is well exposed in the Kallakudi limestone quarry in Dalmiapuram. Lithologically, the Dalmiapuram Formation consists of gray shale in the lower part and limestone in the upper part [Sundaram et al. (2001).].

3. Materials and Methods

The samples were collected from Dalmiapuram limestone quarry from a depth of 18-20 meters below the top soil. The samples were bedded with limestone and light brown colored marl. More than 30 samples collected But the present study is based on the occurrence of Arcostrea. From these 30 samples, the author could identify 9 species of Rastellum (Plate I & Plate II).

4. Morphology of Rastellum (Arcostrea)

All these fossil specimens were obtained almost full in size. In most specimens the curved ribs are clearly visible. Some of the fossil specimens of Arcostrea are obtained in the form of fragments and the tooth like commissures are clearly visible. When both valves joined together a zigzag pattern is revealed. The dimensions of these fragment with a length nearly 250mm in curved length and 90mm from upper valve rib to lower half rib.

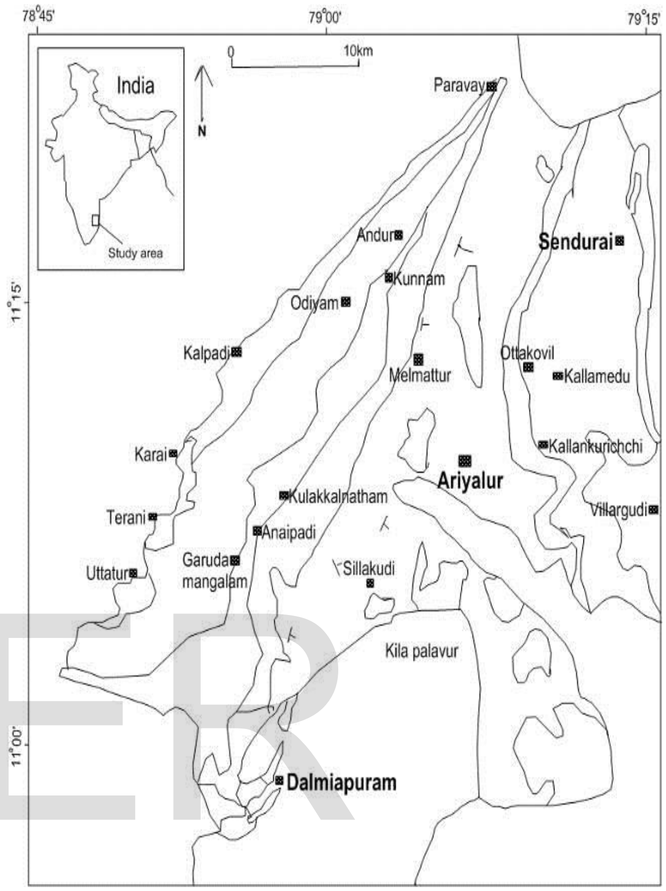

Fig.1. Location Map of study Area

The commissure is high-toothed; hinge with simple oyster structure bent backward. The high toothed commissure measured almost 50mm in length (Fig. 2).

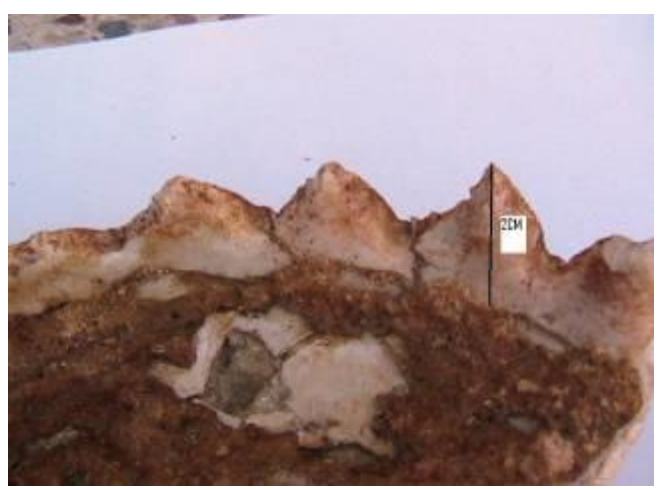

Fig.2: High toothed commissure of Rastellum (Arcostrea) Dilluviana

International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
ISSN 2229-5518

5. DISCUSSION

The author examined three formations on the cavery basin, namely Arogyapuram/Dalmiapuram, Ariyalur and Senthurai. The road distance from Dalmiapuram to Ariyalur is nearly 35 Km and the distance from Ariyalur to Senthurai is nearly 25 Km. From intense field work on these areas we could notice that ammonites are abundant in Ariyalur area. But strangely, no ammonite fossils were found at the Arogyapuram/Dalmiapuram limestone quarry sites. Instead of ammonites there are a great number of fossils like those of Exogyra, Pycodonte, Griphea, Ostrea, Echinoderms, Rastellum (Arcostrea) genus etc.. At the same time in the Senthurai area, the Cretaceous sea bed is revealed within 20 ft of digging. On this rocky substrate we can see a number of ostredae species bedded with it. From this area the author could find numerous fragments of Ostrea and shells of gastropods. Surprisingly, we could not find any ammonoid species. Hence we propose the possible reasons for the absence of ammonites in Dalmiapuram/Arogyapuram & Senthurai areas or formations.

Kale et al. (2000) reported a rich assemblage of palyno fossils in Dalmiapuram .This Formation exposes the planktonic forminiferal Zone (Govindan et al., 2000). Ostracods, bryozoans, gastropod fragments have also been observed in this Formation (Tewari et al., 1996). But Krishnan Ayyasami (2006) Identified eight oyster zones in Dalmiapuram with two unnamed zones where no characteristic ostreiid has been collected. These are: Agerostrea ungulate Zone, Pycnodonte (Phygraea) vesicularis Zone, Ostrea zitteliana Zone, Exogyra(Costagyra) fausta Zone, Rhynchostreon suborbiculatum Zone, Pycnodonte vesiculosa Zone, Exogyra (Costagyra) costata Zone and Rastellum (Arcostrea) carinata Zone. The ranges of these zones compare well with that of ammonite zones. Stephane Reboulet et.al (2003) interprets abundance variations of ammonoid in terms of taphonomic processes, sedimentary dilution, and paleoenvironmental factors; most variations in ammonoid absolute abundance are not the result of post-mortem shell transport. High abundance is related to a maximum-flooding stage. Ammonites are vertical migrants and have moved up when tropic conditions prevailed in surface waters, and down in order to avoid oligotrophic surface waters. Roy Moulik et.al (2007) in a study on the cavery basin with its depositional history on the basis of sea level changes of the Cauvery Basin proposed that Dalmiapuram formation as a gray shale member with a thickness of 7 m and aged as Barremian to Albian. According to this, Dalmiapuram is principally grey shale with frequent interbeds of fossiliferous grey limestone (the thickness of which increases upwards) and to a minor extent it is composed of a significant admixture of silt-sized siliciclastics.

formation which shows around 38.5 m depth with a granite gneiss of Archean age. From that up to 3.5 m gray shale member is present. Followed by 12 m of coral algal limestone member and a marl bedded lime stone member of about 13.5 m. This lithography shows just below the top soil there is a marl bed with 7.5 meters depth in Dalmiapuram formation.

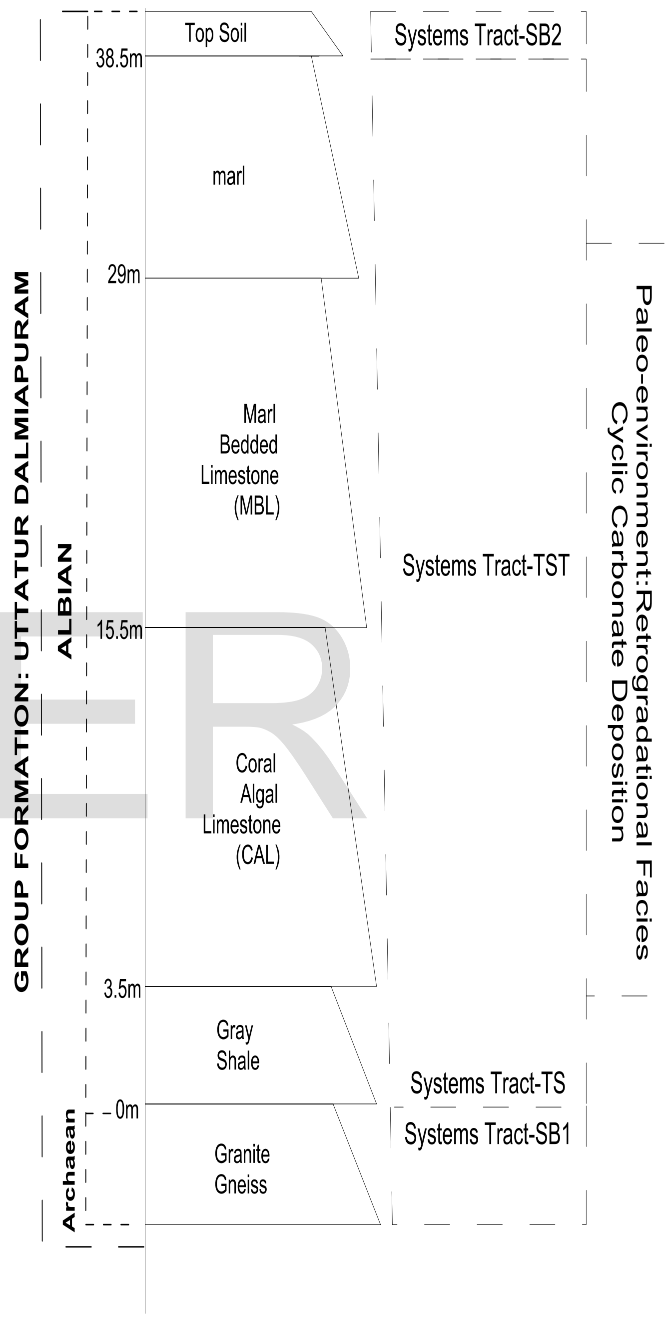

Fig.3: Lithography of Dalmiapuram [Modified after Madhavaraju et.al (2009)]

The observation on abundance of fossils of ammonites from Arogyapuram/Dalmiapuram, Ariyalur and Senthurai areas show maximum abundance at Ariyalur and it decreased to both sides from Ariyalur around 30-35 km. This led to the fact that, the uplift causing a marine regression throughout cauvery basin as proposed by Roy Moulik et.al have happened not uniformly but uniquely. We proposed a

International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
ISSN 2229-5518

terrain style at cauvery basin with respect to Senthurai, Ariyalur and Dalmiapuram in early Cretaceous and after uplift in late Cretaceous like in Fig. 4.

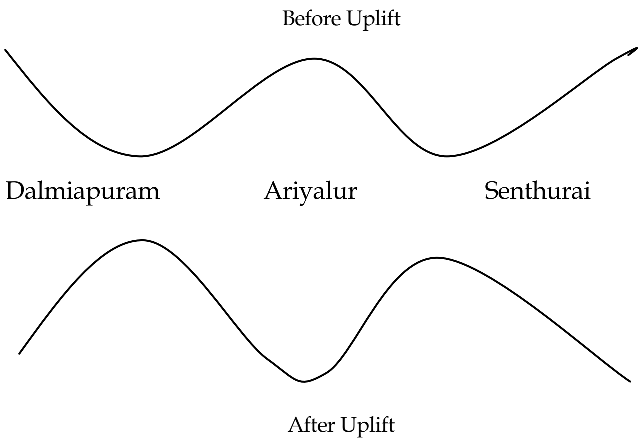

Fig.4: Proposed Depth variation due to tectonic reorganization in late cretaceous

An accurate lithographical pictorisation of Dalmiapuram was given by Madhavaraju et.al (2009) on the basis of geochemistry. He proposed a depth wise narration of this. The absence or rare presence of ammonites may be based on this lithology and the modification of this formation can be explain on the basis of tectonic reorganization on this area at the end of Cretaceous Period, which results in uplift causing marine regression throughout the Cauvery basin. We propose that the uplift has happened in a wavy nature which separates Ariyalur, Senthurai and Dalmiapuram areas. Our proposal matches well with the data given by Ramkumar (2004).

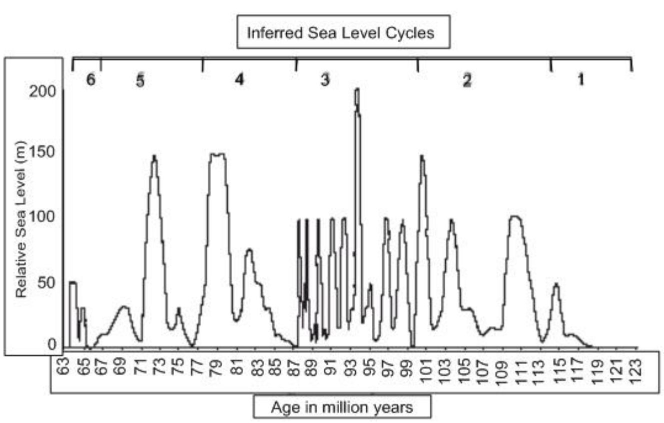

Fig.5: Sea level fluctuation through various era till late cretaceous: after Muthuvairvasamy Ramkumar (2004)

The living habitats of ammonites show that many ammonites probably lived in the open water of ancient seas, rather than at the sea bottom. This is suggested by the fact that their fossils are often found in rocks that were laid down under conditions where no bottom-dwelling life is found. The living depth of ammonites is suggested to be varied from 50-250 m. But some researchers like Geraghty and Westermann (1994) suggest that, ammonites are predominantly epifaunal suspension feeding community living at depth maximally 50-90 m. So before Cretaceous period the depth of the sea around Dalmiapuram and Senthurai regions are deeper than Ariyallur region which may be less than 50 m. This goes well with the study of Ramkumar et.al [2004]. The sea level changes for various eras noted by them are shown in fig. 5. The above proposal shows that from Jurassic to beginning of late Cretaceous, the sea level maintained average of 100-150 m.

According to Moulik et.al, in Cretaceous period, there was tectonic reorganization resulting in uplift causing marine regression not throughout the basin. but, it happens with reorganization of the sea bed which uplifted each region with creation of shallow region in Dalmiapuram and Senthurai But, the depth of the Ariyallur region became more than 100 m. Hence the possibility of creation of shallow water in Dalmiapuram and senthurai cannot be ruled out. If it happens , there is enough chance to create a very deep canyon like terrain and water from both sides of Ariyallur accumulated in that region with a depth of more than 100 m. This might have favored the migration of ammonites from Dalmiapuram and Senthurai to Ariyallur. After the uplift and reorganization of the terrain in Cauvery basin there was filling of canyon by deposition of mud/sand/slump gravitationally and may be due to high energy environment of sea bed in different regions. After Cretaceous period, due to marine regression, Ariyallur region may have continued as water filled canyon and subsequently due to deposition on canyon depth of this region reduced and due to heat, water evaporated and the canyon became dry land and the fossils of the ammonites were exposed to open land. Krishnan Ayyasami (2006) also noticed the absence of ammonites in Arogyapuram Formation. In this study he reported the presence of various species of Rastellum (Arcostrea) in Dalmiapuram formation. The presence of Rastellum Carinata shows an evolution from alectryonia in that region due to heavy sedimentation and a high energy muddy environment.

Commissure is an important taxonomic feature with other peculiarities determines a specific range. Arctostrea is characterized by high zigzag Commissure, but several species of Alectryonia exhibit a commissure developed in similar way and such a commissure together with arched shell shape, character of ribs and of umbo determines the specific classification. The fossil of Arcostrea from Dalmiapuram formation has a well defined high zigzag

International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
ISSN 2229-5518

commissure. The problem of oxygen and food supply is particularly important to the development of oysters. Passive mode of life on the basin floors of muddy and often turbid waters and gregarious occurrence did not create good living conditions. In response to difficult environmental regime the oysters have developed highly advanced functional adaptations which are reflected first of all in structural peculiarities of the shell. These are: arcuate shape, zigzag commissure, lobe-like enlarged posterior edge of umbo, promyal chamber and also marginal denticles and pedal retractor muscle scar (Fig.6).

Fig. 6: Muscle scar of Rastellum Dilluviana specimen

The most common arcuate shape of shell reflects an adaptation of efficient respiration, which is best illustrated in the shell morphology of species of Arctostrea. Those shells are extremely long, in vertical axis, narrow and strongly arcuated. Broadly convex anterior margin guarantees a good oxygen supply to the gills and high, with sharply cut typical zigzag commissure external valve margin even increases the current inflow. The water current, besides of oxygen supply, furnishes also minute feeding particles, which are then directed by means of complicated internal current to the pelecypod mouth. The gills are strongly arcuated, of large inhalant surface and play also the role of directing the feeding particles thus being a very important organ taking part in the basic living functions. On the other hand, the enlarged inflow surface endangers internal organs with penetrating of sediment particles from the muddy, turbid environment. In such cases, the zigzag commissure acts as an adaptative organ impeding the penetration of larger inorganic particles. A slightly open shell turns the zigzag commissure into a kind of sieve which eliminates the larger feeding particles and sediment. Zigzag commissure plays a well adapted protective function acting jointly with a strongly muscled mantle margin, which bears sensory appendices. Most probably the environment, in which alectryonias lived, must have been more convenient and they lived possibly in waters which were better aerated. Pervinquiere (1910) proposed to separate from Alectryonia new genus, Arctostrea, with type species Ostrea carinata Lamarck, comprising strongly elongated, slender, arcuate forms with high zigzag commissure. These genera differ in a number of features in external and inner structures, but some representatives of genus Alectryonia (e.g., AL rastellaris or AL gregarea) are rather elongated and arched. Probably the Arctostrea originated from such forms.

I proposed The Rastellum (Arcostrea) genus in cavery basin geological area may have originated in late Jurassic with adaptive modifications like high toothed commissure. The reason for such adaptation is the existence of high energy environment with heavy sedimentation. Hence the possibility of various adaptations on the alectryonia cannot be ruled out. The functional importance of high toothed commissure was broadly discussed by Carter (1968) on the Cretaceous representatives of Arctostrea.

Halina Pugaczewska (1971) suggests that, the alectryonia and liostrea originated around upper Triassic and passed through various era. But the derivation of arcostrea happened in the late Jurassic due to the high energy muddy environment in the seabed. The adaptations like high toothed commissure shows that, the sedimentation and particle density in the water were very high. In cavery basin such situation may sustained from late jurassic. Then oyster families that lived in that area accepts various adaptations and becomes a new genus named Rastellum (arcostrea). The genus arcoatrea extinct in the late cretaceous, but the genus alectryonia continued further.

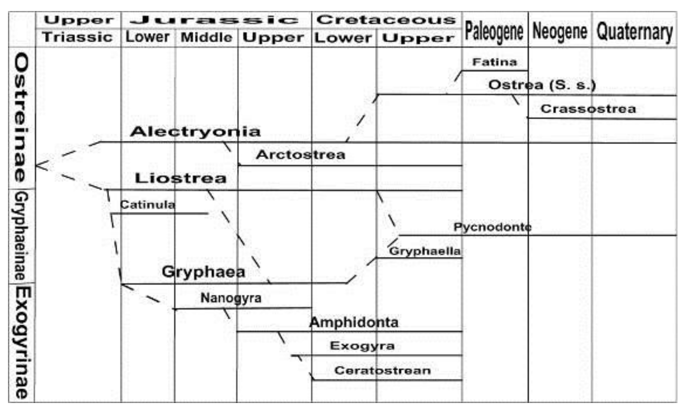

Fig. 7: evolution tree of Ostridae; after Halina Pugaczewska (1971)

Conclusion

The abundance of ammonites in various formations studied on the basis of the uplift happened in the late cretaceous in the area of cavery basin, south India. The uplift suggested as not uniform throughout the basin but it creates an upside down terrain structures which creates canyons in the area of ariyallur. At the same time, deeper areas become shallow.

International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
ISSN 2229-5518

Then the migration of ammonite species occurred due to shallow environment. The authors also studied the evolution of Arcostrea species from the Alectryonia due to heavy muddy particle density and the existence of high energy environment in the area of dalmiapuram region through various eras till late cretaceous.

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International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
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International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
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Plate I

A) Rastellum (Arcostrea) Carinata

B) Rastellum (Arcostrea) Dilluviana

C) Rastellum (Arcostrea) Sp. 1

D) Rastellum (Arcostrea) Sp. 2

E) Rastellum (Arcostrea) Sp. 3

F) Rastellum (Arcostrea) Sp. 4

International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
ISSN 2229-5518

Plate II

G) Rastellum (Arcostrea) Sp. 5

H) Rastellum (Arcostrea) Sp. 6

I) Rastellum (Arcostrea) Sp. 7

J) Rastellum (Arcostrea) Sp. 8

K) Rastellum (Arcostrea) Sp. 9

International Journal of Scientific & Engineering Research Volume 4, Issue 12, December-2013
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