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## RESEARCH ARTICLE

# INTER-CONECTIONS BETWEEN NARMADA AND CAUVERY BASINS DURING TURONIAN (LATE CRETACEOUS) TIME

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**ABSTRACT**

During the Late Cretaceous times the Narmada Basin in the Central India and Cauvery Basin in South India received a thick pile of marine sediments as a result of the global Cenomanian marine Transgression. It is believed that Tethyan sea became narrower facilitating the formation of Indian ocean as a result the large part of the Indian Plate especially Kachchh, Narmada and Cauvery basin inundated. The Late Cretaceous sediments of Narmada Basin is popularly known as Bagh Beds which ranges in age from Cenomanian to Coniacian. In the Cauvery Basin Late Cretaceous sediments are known as Trichinopoly Beds and range in age from Middle Aptian to Maastrichtian. The Turonian sediments of Narmada Basin is grouped as Nodular Limestone Formation and in Trichinopoly region Maruvattar and Paravay formations. Both of these have more or less similar history, although affected by fluctuating sea levels, rate of local subsidence and rate of sedimentation resulting in different lithological framework. An attempt has been made to use Turonian bivalves of the two sub-basin to give further ascertain of the views of the faunal synochronisation in these parts of Narmada and Cauvery basins. The common bivalve divides in both these regions during Turonian those are *Modilous (Modilus) typicus, Acesta obliquistriata, Plicatula numidica, Pinna laticostata, Plicatula batnensis, Astarte similis, Opis concentricus, Cardium (Protocardia) hillanum, Mytiloides labiatus, Protocardia pondicherriensis, Pycnodonte(phygraea) vesicularis, Lopha(Actinostreon) diluviana, Agerostrea ungulate* etc. This may imply that an eastern area of sea could have inundated the lower Narmada Basin and further extended up to Cauvery Basin during Turonian time.



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## INTRODUCTION

Fossils act as a connecting bridge between separated part of continent. Both Cauvery and Narmada basins are quite productive in terms of Cretaceous bivalves. According to Moore (1969) 80 families of marine bivalves has been found during Cretaceous all over the globe. Blanford (1862) with massive collection in both basins however, it was impossible to given the systematic during that time due to exceptional preservation but Ferdinand Stoliczka completed by revealing diversity in composite fauna, its relationship with Narmada Basin is established on the basis of tectonic setting and bivalve faunal correlation. Cauvery Basin succession display from late Jurassic depositional history because during Late Jurassic-Early Cretaceous, Laurasia fragmented into Eurasia and North America whereas Gondwana land into South America, Africa, India, Antarctica, Australia and Newzealand. Since India separated in Valanginian, due to this Indian Ocean passive margin sedimentary system developed.

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According to Lister *et al*. model that represent shore sector subsidence by the ongoing extension and thermal inducement and consequently extensional architecture developed in form of horst and graben after 30Ma from fragmentation (Jafer, 1996). However, subsidence and deposition preceded contemporarily with sea floor spreading in Valanginian time. Cauvery Basin received marine water thoroughly in Aptian, Albian and till Turonian, Coniacian and Santonian most of the part were covered by sea. During this time Madagascar also separated from India so due to extensional force Narmada graben formed that received marine incursion by the invasion of extended Tethys arm. So for this favour Duncan (1865, 1887), Fourtau (1918) and Verdenburg (1907, 1908) found echinoides, ammonoid and bivalve distinguished as Mediterranean province. This is further improved by Chiplonkar and Badve (1968) suggested that only the Mozambique channel was migrated way but Dassarma and Sinha studied after detail taxonomical analysis that these species also allied from South India, Madagascar, South Africa and Australia. However, this is always questionable that where was the migration passage situated they migrated either from Arabian sea or bay of Bengal, on the basis of oscillatory tilting

of Indian plate suggest the bivalve fauna passage was Arabian sea.

## Geology of Cauvery basin

Lithostratigraphic succession of Cretaceous Cauvery Basin comprises complete shallow marine sequence with very rich macrofauna of Albian-Maastrichtian age(Acharya and lahari, 1991). While bivalve fauna occur throughout the all three groups Uttatur, Trichinopoly and Ariyalur(Chiplonker and Tapaswi, 1979) further bivalve affinity assign age Upper Albian to Middle Turonian for Uttattur Group, Upper Turonian to Santonian for Trichinopoly Group and Campanian to Maastrichtian for Ariyalur Group but as per correlation concerned only Turonian fauna are present in Narmada Basin and in Cauvery basin this stage is represented by top of Uttattur and bottom of the Trichinopoly groups. So for correlation purpose it is necessary to detail study of two formations.

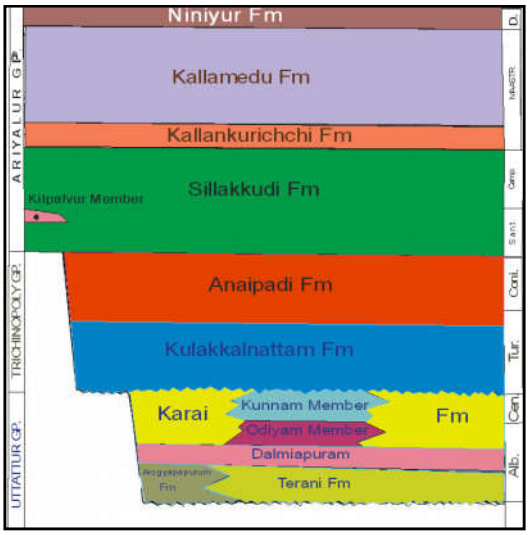


**Figure B. Stratigraphical map of the Cretaceous Cauvery Basin**

## Karai Formation

Uppermost sequence of Uttattur Group in which Upper contact represent a regional unconformity that is indicated by low angular discordance with overlying Kalakkalnattam Formation of the Trichinopoly Group. The lower and middle part of the formation contain ammonite of Late Albian and Cenomanian stage (Sastry *et al.,* 1968, Ayyasami, 1990). So on the basis of ammonitic assemblage and lithlogical variation that directly belongs to depositional environment, Karai Formation divide in two members. Lower one is Gypsiferous Clay Member and the Odiyam Sandy Clay Member, in stratigraphic order. Lower one Member has 275 meter thickness consist of deep marine gypsum rich silty clay and very thick to thin gypsiferous (synsedimentary) clay beds characterize by high stand depositional environment with continuity of transgressive trend apparent for the underlying Dalmiapuram Formation. During this time sea level was at its maximum after that it decline consequently simultaneously deposition of relatively coarser siliciclastics and the development of syngenetic gypsum ceased to continue, marking the end of the deposition of this member. Beds of this sequence contain of numerous micro and macro fauna *Gryphaea*, *Tubulostrum*, belemnites and foraminiferal assemblages belonging to *Rotalipora subticinensis* interval Zone to the *Praeglobotrancana helvetica* interval Zone are reported and demonstrate Cenomanian age for this member (Govindan *et al.,* 1996). The upper member which is 175 meter thick include sandy clay with silty clay due to shallowing of basin which is indicated by Load structures and syndepositional slump folds, the presence of *belemnites* is replaced by ammonites and other fossils are *Thalassinoides*, *Pecten*, *Exogyra*, *Alectryonia*, ammonites, foraminifers and serpulids and regarding the age Govindan *et al*. (1996) recorded a distinct faunal assemblage of species of *Rotalipora, Preaglobotruncana, Whiteinella* and *Hedbergella* and with help of *Whiteinella arahaeocretacea* (Passagno) Tewari *et al*. (1996) have found the similar age.

## Trichinopoly Group

This group comprises a discrete tectonostratigraphic assemblage, separated from the underlying Uttattur Group by a regional unconformity. The outcrop of the Trichinopoly Group are found in south of the Garudamangalam village and its exposure are present at Nala sectrion between Garudamangalam and Anandapuram. An angular unconformity near the Dalmiapuram locality creats separation from steeply dipping upper part of Uttattur group but according to Blanford (1862) angular unconformity is present at two localities Alundalippur and Varagur villages either these area other show paraconformity that is marked by abrupt change in lithology. We attribute the discordant relationship to rotational fault displacements associated with the progression in basinal subsidence. Biostratigraphy data indicate that the time break represented by the unconformity is small, occupying only a small part of the Turonian Stage. The unconformity is closely matched in time with the inception of a new spreading system of the Indian Ocean, assigned an age of 90 Ma by Powell *et al*. (1988), and may reflect a change in the stress field related to that change. Banerji (1972) introduced the Garudamangalam Formation for exactly the same succession assigned to the Trichinopoly Group by Blanford (1862), and Ramasayand Banerji (1991) subsequently proposed subdivision of the Garudamangalam Formation into three formal members. However, the Trichinopoly Group has precedence as do its component Kulakkalnattam and Anaipadi formations as defined by Sundaram and Rao (1986). The Trichinopoly Group is some 490 m thick.

## Kulakkalnattam (Paravay) Formation

The Kulakkalnattam Formation is named after the village Kulakkalnattam that lies about 18 km to the west of Ariyalur. Nearly 2.5 Meter exposure of kulakkalanattam Formation are present in the Nala About 1 km east of Kulakkalnattam south of the Pilimisai Road. The same rocks have also received the name Paravay Formation (Narayanan, 1977). The type area for this unit lies to the west of Kulakkalnattam Village from which the name is derived. It is located between 78°56’22”–78°57’06” E; 11°07’22”–11°22’23” N in exposures along the Karai Kulakkanattam road and elevation is 103m. The formation is some 230 m thick. Basal sandstone, pebbly sandstone and conglomerate passing up to interlayered mudstone, shale, variably cemented sandstone and coquinite.

**Table 1. Common Bivalve species representing occurrence from different horizons of both basins**

| Bivalves Species | Narmada Basin | Cauvery Basin |
|---|---|---|
| *Modilous(Modilus)typicus* Forbes | Upper part of Nodular Limestone | Siliciclastic Sandstone, Kulakkalnattam |
| *Plicatula numidica* (Coquand) | Deola-ChirakhanMarl &Coralline Limestone | Kilpalvur Member, Sillakkudi Formation |
| *Plicatula batnesis* CHIPLONKER | Upper Nodular Limestone | Kilpalvur Member, Sillakkudi Formation |
| *Acesta Obliquistriata*(Forbes) | Nodular L.stoneDeola-Chirakhan Marl | Siliciclastic Sandstone, Kulakkalnattam |
| *Protocardia hillana*(Sowerby) | Lower NodularLimestone | Siliciclastic Sandstone, Kulakkalnattam |
| *Protocardia* pondicherriensis d'Orbigny | Upper Coralline Limestone | Siliciclastic Sandstone, Kulakkalnattam |
| *Pinna laticostata* | Deola-Chirakhan Marl& Nodular Limestone | Kilpalvur Member, Sillakkudi Formation |
| *Pycnodonte(phygraea)vesicularis*(Lamarck) | Upper Nodular Limestone | Kilpalvur Member, Sillakkudi Formation |
| *Lopha(Actinostreon)diluviana*(Linne) | Deola-ChirakhanMarl&CorallineLimestone | Siltstone, Karai Formation |
| *Agerostrea ungulate*(Schlotheim) | Upper Nimar Sandston | Siltstone, Karai Formation |
| *Mytiloides labiatus* | Lower NodularLimestone | Siltstone, Karai Formation |
| *Astarte similis* DASSARMA&SINHA | Deola-Chirakhan Marl | Kallankurchchi Formation, Ariyalur G |
| *Nicaniella(Nicaniella)trigonoides* STOLICZKA | Lower NodularLimestone | Kilpalvur Member, Sillakkudi Formation |
| *Opis concentricus* DASSARMA& SINHA | Deola-ChirakhanMarl &CorallineLimestone | Siliciclastic Sandstone, Kulakkalnattam |

Conglomeratic and pebbly horizons are particularly characteristic of the formation in the southern part of its distribution. Fossiliferous sandstone beds ranging to sandy coquinite with current-orientated disarticulated bivalve shells and locally with cross-lamination and small-scale basal scours are developed throughout the formation but these specially represent upper part . Fossil drift-wood occurs in the basal part of the formation at several localities in north of the type area. The Kulakkalnattam Formation is unconformable on the Karai Formation and conformably succeeded by the Anaipadi Formation. The basal part of the unit contains ammonites referred to the *Romaniceras* (*Yubariceras*) *ornatissimum* Zone by Ayyasami and Banerji (1984) and assigned a Turonian age.

**Narmada Basin**

First time Blanford (1869) has studied the Upper Narmada Basin in form of Bagh Beds and divided but on the basis of lithology and geographical occurrence Bose (1884) gave formal nomenclature for these lithic units as Nimar sandstone, Nodular Limestone, Deola-Chirakhan Marl and coralline Limestone in ascending order. Thereafter many experts classified the Bagh Beds although lithofacies varies laterally within this beds and highly condensed succession, include hardground and major hiatuses (Taylor and Badve, 1995; Gangopadhyay and Bardhan, 2000; Tripathi and Lahiri, 2000).

**Nimar Sandstone Formation**

It is the lowermost formation of Bagh Group succeeded with Bijawar Gneiss in form of loosely oriented pebble conglomeratic bed Near the Mahakal($22^0$ $21^{'}$ $68^{''}$: $74^0$ $48^{'}$ $47^{''}$) and it become hard and compact as advancing toward Aliraj Pur. As South-West form near the Bamkua ($22^0$ $20^{''}$ $68^{''}$:$74^0$ $47^{'}$ $00^{''}$) is fresh water succession whereas conglomeratic beds pinch in between yellowish gray brittle sandstone and greenish color sandstone. Bose (1884) subdivided this formation into Lower member and upper member. However, repetitive cycle of 30 ft section include 6 beds those are lithologically distinguish from each other. Lowermost is brownish gray contains vertebrate bones which is overlain by greenish loosely packed sandstone contains nodules near Chikli village and this bed is succeeded by grayish black, coarse grained with cross bedding , tightly bound sandstone and yellow brittle sandstone overlie by calcareous brownish sandstone.

It extended from Sitapuri to Rajpipla whereas it directly overlie on the conglomeratic sandstone. Upper Nimar member which start from oyster bed included with trace fossils is the signature of first marine incursion and somewhere it is covered by brownish calcareous sandstone containing with fragment of *ostrea*, *turritella* and *Astarte* fossils.

**Nodular limestone-Deola-Chirakhan Marl**

Calcareous nature of upper part of Nimar Sandstone and this formation favors the continuous deposition. Although Nodular Limestone makes sharp contact with Nimar Sandstone in many localities but at Zeerabad it directly overlies the metamorphic which support the paraconformity (Singh and Srivastava, 1981). Nodular Limestone Formation comprises of basically two litho-unit which are not present throughout in the Bagh Group. Nodular Limestone Formation consist of mostly five beds include two members Karondia and Chirakhan(Jaitly and Ajane, 2012). Lowermost thickest part is arenaceous, gray color and contains two levels of *Inoceramus,* Three levels of *Ammonites* with other invertebrate faunas and its upper part is highly rich for *Thalassinoids* burrow, ripple marks and nodular appearance. However, near Kosdana and Kherwan it is directly overlain by Coralline Limestone but at Dhar cement factory, Karondia section it is succeeded by Chirakhan Marl member. It seldom cover all the nodular exposure, at some localities it directly overlies on the lower bed of Coralline Limestone. Uppermost bed of nodular limestone consist of *Oyster* at Kosdana, Chakrur whereas it also underlain by Coralline Limestone.

**Coralline Limestone**

It is yellow or reddish brown in color with few meter thickness. According to Jaitly and Ajane (2013) coralline limeston do not contain corals but presence of bryozoans exhibit coralline appearance. Chiplonker (1939) suggested two horizon of coralline limestone, one below the Deola-Chirakhan Marl and other above it. The freshly broken samples have granular appearance. Abraded and rounded bioclastic sandstone consist of trough cross bedding, ripple cross bedding and falser bedding indicates shallow marine condition of open circulation and normal salinity (Akhtar and Khan, 1997). However, it is equivocal to discriminate between upper and lower coralline where the Deola-Chirakhan Marl has eroded.

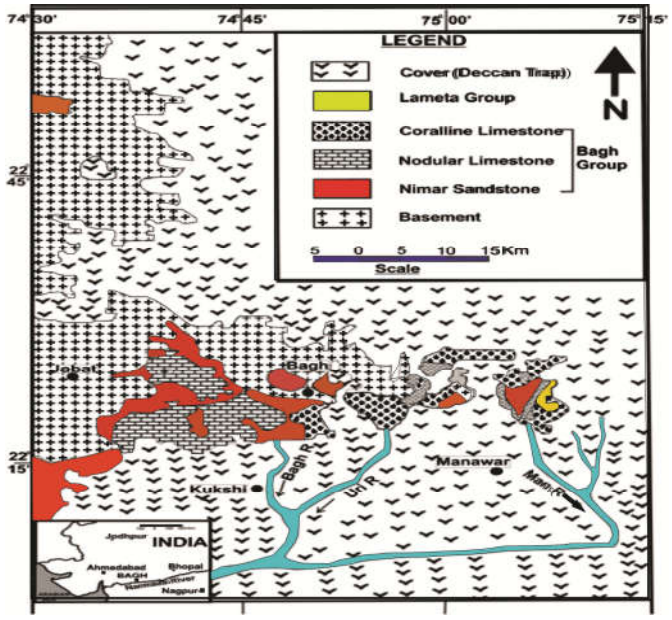


**Fig. C. Geological Map of Bagh Group (modified after Jaitly and Ajane, 2013)**

## Conclusion

Common forms of bivalves establish the interconnection between both basins but some of these species also have come from other regions like North Africa, South Europe and Malagasy. However, as per age concerned these are not much suitable. Although some short range species of Inoceramidie family have been used as age representation tool in some basins. Predefined formations of Cauvery Basin those are contemporary formations in Narmada Basin still exhibiting the 14 common species. Table 1 Common Bivalve Fauna from Both Basins

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