
XVI Indian Colloquium on
Micropalaeontology and Stratigraphy
Organized by
Post Graduate Department of Geology
Institute of Science, Aurangabad


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Post Graduate Department of Geology


Institute of Science, Aurangabad
(A Post Graduate Teaching and Research Institute of Govt. of Maharashtra)
and Stratigraphy


18th - 20th December 2015
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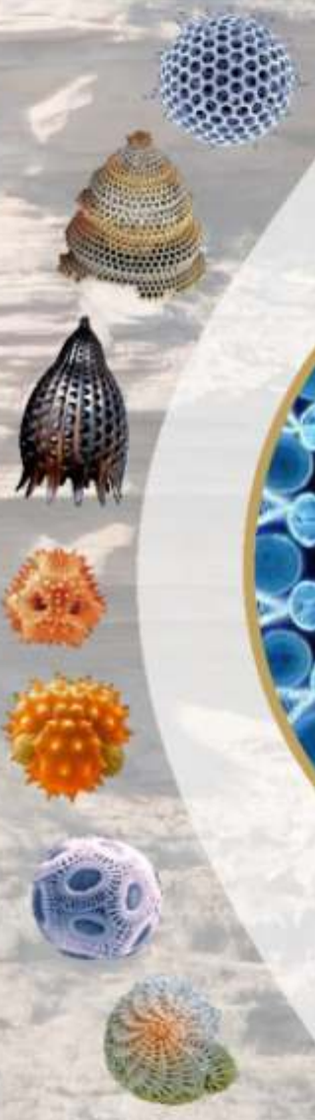
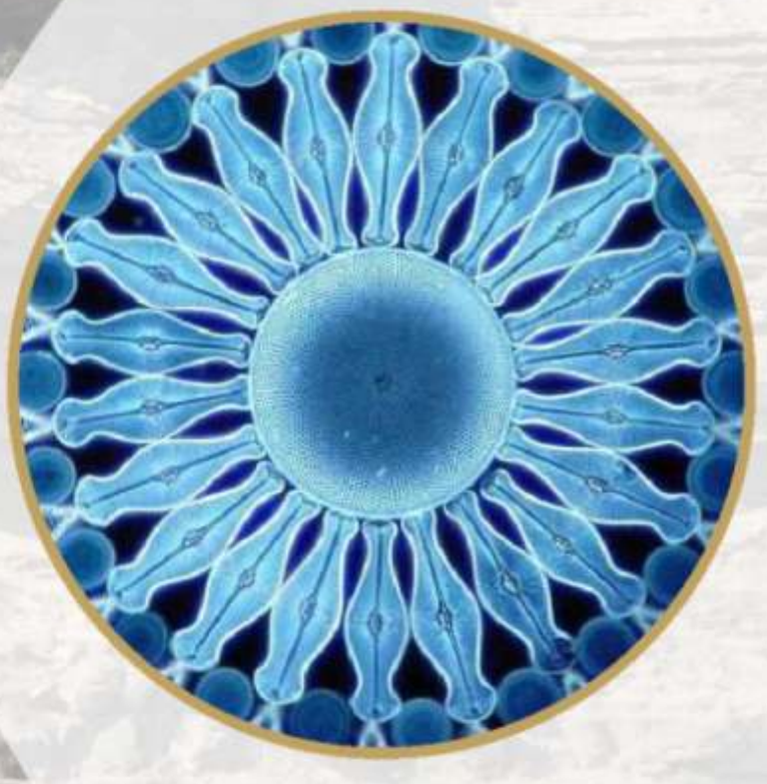
ABSTRACTS

XXV Indian Colloquium on Micropalaeontology and Stratigraphy

18th - 20th December 2015





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XXV Indian Colloquium on Micropaleontology & Stratigraphy

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XXV- ICMS-2015

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18-20 December-2015

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MESSAGE

I am pleased to learn that Post Graduate Department of Geology, Institute of Science, Aurangabad is organizing a National level conference i.e., "XXV Indian Colloquium on Micropaleontology & Stratigraphy" (i.e. XXV ICMS-2015) on 18-20th December 2015 in association with Paleontological Society of India, Lucknow, Geological Society of India, Bangalore and Gondwana Geological Society, Nagpur.

The silver jubilee event of this colloquium is being organized to understand paleoclimate, paleoenvironment, hydrocarbon exploration potential. The issues of Stratigraphy and Micropaleontology and their relations will be discussed, which is the broad theme of this colloquium.

I am sure that the colloquium will provide an excellent forum to micropaleontologists and stratigraphers to deliberate issues resolving future prospects of explorationof hydrocarbons and pertinent needs of the country. I am sure this is a great learning opportunities for the faculty as well as the students.

I extend my best wishes for the success of colloquium.

Professor **B. A. Chopde**
Vice-Chancellor

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MESSAGE

I am delighted that Post Graduate Department of Geology, this Institute is organizing 25th Indian Colloquium on Micropalaeontology and Stratigraphy" during 18-20 December 2015.

In this age of Science and Technology, I hope that, some new aspects of palaeoenvironmental analysis and hydrocarbon exploration will be discussed in this national colloquium. I am confident that, the invited talks by learned researchers and the papers which are going to be presented will be of immense use for research students, scientists and society. I offer my best wishes for effective and successful conduct of colloquium.

(Dr. Mrs. H. J. Wankhede)

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20	2005	Dept. of Geology, Vishakhapatnam University, Vishakhapatnarn	Dr. T.Y. Naidu
21	2007	Birbal Sahni Institute of Palaeobotany, Lucknow	Dr. R.ahul Garg
22	2009	PG and Research Department of Geology, National College, Trichy	Dr. V.Kumar
23	2011	Dept. of Geology, Bangalore University, Bangalore	Dr.N.Malarkodi & Dr. P.C.Nagesh
24	2013	Wadia Institute of Himalayan Geology, Dehradun	Dr. Kishor Kumar and Dr (Mrs) Meera Tiwari
25	2015	Institute of Science, Aurangabad	Dr. K.M. Wanjarwadkar and Dr. M.A. Sonar

Contents

XXV Indian Colloquium on Micropalaeontology and Stratigraphy

Cretaceous Oceans - Inferences and Its Contribution in Sourcing Hydrocarbons in Indian Basins

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Our knowledge about Cretaceous oceans and climate are mostly based on comparison with the present. This comparison may not be valid, since, the differences between these are far and wide. The surface circulation of the modern ocean is triggered by low latitude easterly, mid latitude westerly and easterly polar winds. The circulation pattern results in low to mid latitude, anti cyclonic gyres and high latitude cyclonic gyres. In the Cretaceous the lack of polar ice resulted in unstable and reversing winds. Today nearly 60% of the earth's surface lies in the 3 major interconnected ocean basins with communication only at high southern latitude. Deep marginal seas occupy 6% of earth surface and shallow sea and shelf regions, along the continental margin occupies only 4% of the earth's surface.

This is in contrast at the Cretaceous sea level high stand, about 90Ma in late Cretaceous, the Cretaceous sea water covered 78% of the planet. The Panthalassa – eastern Tethys a large ocean basin of that period, covered nearly 50% of the planet surface, much greater than the Pacific. It seems nearly 10% of the sea floor that existed in the Cretaceous has been lost in subduction. The remaining water bearing surface was covered 11% as deep basins and 16% as shallow seas. The western Tethys and north Atlantic formed latitudinal sea way for tropical surface waters. In the Cretaceous marginal seas between 20° and 40° are in the high evaporation areas. The area of shallow seas and shelves was 4 times greater. Some of these Cretaceous seas are probably large enough to generate the volumes of dense water required to form homogenous ocean deep waters. Open ocean formations of intermediate waters were less likely at the beginning of Cretaceous.

In the Cretaceous there were episodes of wide spread ocean anoxia with deposition of organic rich black shales which were deposited in a range of marine setting shelf sea to open ocean globally at selected stratigraphic levels. These Cretaceous oceanic anoxic events have been documented globally as OAE-1 (Aptian/Albian); OAE-2 (latest Cenomanian/Turonian) and OAE-3 (Turonian/Coniacian). The imprint of global OAE-1 is well documented in the deeper part of the

Cauvery basins in many wells. The foraminiferal fauna is well represented in black shales by agglutinated foraminifera, rare planktic *Hedbergella planispira* and well preserved radiolarians at this stratigraphic level. In modern oceans, high concentrations of radiolarian tests in the sediments is related to high flux of siliceous tests to the sea floor due to high productivity in surface waters. The dominance of *Nassellaria* in these samples demonstrate the contribution of Cretaceous oceanic water for the presence of *Dictyomitra multicostata*, *D. somphedia* and other taxa. These are also recorded in the Albian sediments of hydrocarbon producing basins of Brazil. Overall Pre-Albian/Albian black shales in the Cauvery basin are source rich and are capable of generating hydrocarbons. Relatively high TOC values of 2-3.5% are recorded at this level in many wells. These sediments are reported as good source from geochemical analysis capable of generating oil and gas accumulation in this basin as well as in other Indian east coast basins. The prevalence of agglutinated foraminifera recorded at this level may be related to sediment properties associated with restricted bottom water circulation or rapid deposition of fine grained clastic sediments (low O_2, low Ph, high CO_2, positive or intermittently negative Eh) which lead to reducing substrates and high organic contents. The subsurface history of the wells in this basin also indicates faster rates of deposition keeping pace with the subsidence of the sea floor at that period.

The Cretaceous period in this region also indicates oceanic red beds under oxic environment in late Cretaceous. These reddish brown claystone cored at shallower depths (45-50m subsurface) in Kunnam-Ariyalur area yielded rich foraminiferal fauna assignable to *Dicarinella asymmetrica* Zone of Santonian age. These marine red beds have also been noticed further south east at greater depths at Ramnad sub basin. The reports of marine red beds in Tibet Himayalan region from *D. asymmetrica* Zone as seen in the Cauvery basin confirms wide spread oxygenated ocean bottom water circulation in the eastern Tethyan and adjoining regions during late Cretaceous. Some of the factors resulting oxic bottom water environment in the Cauvery basin could have been its high south paleolatitudinal position and warmer climatic condition during Santonian. During Cretaceous the climate was much warmer than in present with temperature maxima at middle Turonian.

KEY WORDS: CRETACEOUS OCEAN, INFERENCES, ANOXIC, OXIC, ENVIRONMENT, HYDROCARBON, CAUVERY BASIN

Recent advancements on the studies of fossil calcareous algae

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Skeletal remains of calcium-carbonate depositing benthic red and green algae i.e., calcareous algae make up a high proportion of carbonate sediments accumulating in tropical marine shelf environments. Marine calcareous algae are important in micropaleontology as they can be used in the interpretation of palaeoenvironments. Calcareous algae have been quantitatively significant producers of carbonate sediments and influential in sedimentological processes, such as the construction of reef frameworks and in trapping and binding of fine-grained sedimentary particles. Carbonate-secreting habits have been developed namely by three families of marine green algae, the Halimedaceae, Udoteaceae and Dasycladaceae. Amongst the calcareous algae, coralline red algae are the most abundant carbonate producers. Encrusting corallines are important binders and encrusters in present-day and fossil reefs. In addition to their binding function in coral reefs, encrusting coralline red algae may also form algal reefs. However, not all of the taxa need stable substrate. Coralline algae may also form unattached nodules i.e., rhodoliths and their branches may form thick sediment accumulations i.e., marl. Coralline red algae are important carbonate producers in present-day and fossil environments and are supposed to be valuable facies indicators.

Taxonomy and identification of corallines are indeed complicated. The identification of fossil coralline red algae bears several problems and the intraspecific variability is very high. As an outcome of major studies by various phycologists remarkable changes in the taxonomy of living species of coralline red algae (Corallinales, Rhodophyta) have taken place. The taxonomy of fossil coralline red algae is under the process of revision and modification since 1993. Prior to 1993 it was believed that several diagnostic characters used in present day coralline red algae were unpreservable in fossil coralline algae. Several palaeoalgologists opined that fossil and Recent coralline algae have to classified in different manners and consequently different diagnostic characters were used for the identification of fossil and Recent coralline algae. Traditionally the generic and suprageneric taxonomy of Recent coralline algae was based upon the characteristics of tissues and reproductive structures. On the other hand, taxonomy of fossil coralline algae was solely dependent upon the calcified characters with high fossilization potential. Diagnostic supra-generic criteria followed by the earlier workers for fossil coralline red

algae are: i) type and location of conceptacles ii) character of hypothallium (core or primigenous filaments in recent literature) iii) character of perithallium (peripheral or postigenous filaments in recent literature) and iv) presence or absence and arrangement of heterocysts (trichocytes). Later, some important questions were raised by several workers regarding the preservation of taxonomic characters and relationships between fossil taxa and groups of Recent taxa. As a result, reassessment and revision of well-known fossil taxa along with detailed measurements and statistical analysis became essential because many of the fossil coralline taxa were suffering from excessive splitting only on the basis of very few characters. Interfilamental cell-connections is an important taxonomic criterion for characterizing subfamilies of Recent coralline algae and later on, use of this important character in both suprageneric and generic taxonomy of Recent corallines by a number of renowned phycologists and was widely accepted by the phycologists all over the world working. Apart from this, some other diagnostic features e.g., shape of epithallial cells, number of epithallial cells and pattern of cell elongation as significant features at generic and suprageneric level were employed for the taxonomy of coralline algae. Many of these characters were not utilized prior to 1993 in the taxonomy of fossil coralline algae. However, since 1993 extensive work by the palaeoalgologists led to the view that some key feature e.g., cell-connections, cell-fusions, characteristics of epithallial cells and meristems can also be recognized in fossil corallines using light microscopic study as well as using appropriate SEM techniques. It has been widely accepted by the palaeoalgologists that unification of taxonomy for Recent and fossil corallines is essential for accurate interpretation of phylogeny, palaeoecology and palaeobiogeography. It may be mentioned here that phylogenetically the corallines are very important as it represents a major evolutionary line within red algae as evidenced by the studies on 18S rRNA gene sequences. Woelkerling (1988) extensively analyzed the genera and subfamilies of Recent coralline red algae and proposed a classification scheme based on number of diagnostic features. Many of those features can be observed in fossil material with bright field and Scanning Electron Microscopy. Based on the key features Woelkerling (1988) classified subfamilies of Corallinaceae into Amphiroideae, Corallinoideae, Metagoniolithoideae, Chreonematoideae, Lithophylloideae, Mastophoroideae and Melobesioideae. Amongst these Amphiroideae, Corallinoideae and Metagoniolithoideae were considered as geniculate corallines and rest of the subfamilies as non-genicultae corallines. Verheij (1993) instituted the family Sporolithceae to separate the genus *Sporolithon* from rest of the corallines. Fossil record of this family is represented by the genera *Sporolithon, Kymalithon* and *Hemiphyllum*. Later on, Harvey & Woelkerling (1995) erected a new subfamily Austrolithoideae (nongeniculate coralline) belonging to the family Corallinaceae. 18S rRNA gene sequence analysis (Bailey, 1999) recommended

close affinity of the geniculate Amphiroideae and the non-geniculate Lithophylloideae. Broadwater et al. (2000) re-evaluated coralline algal taxonomy using ultrastructural studies and their studies also support that Amphiroideae and Lithophylloideae should be included in a single subfamily Lithophylloideae. Harvey et al. (2003) based on rDNA phylogenetic study emended the family Hapalidiaceae that includes the subfamily Melobesioideae. Studies on nuclear 18S rRNA gene sequence analysis, Bailey et al. (2004) opined that the Mastophoroideae (Corallinaceae, Rhodophyta) is a polyphyletic taxon. Considering all these findings a modified scheme has been introduced by Ghosh & Sarkar (2010) after the contributions (on supra-generic taxonomy) of Woelkerling (1988), Verheij (1993), Harvey & Woelkerling (1995), Bailey (1999), Braga (2003), Harvey et al. (2003) and Bailey et al. (2004). In this classification, three subfamilies of Corallinaceae viz., Metagoniolithoideae, Austrolithoideae and Chreonematoideae have not been recorded as fossils till date. In recent years a number of publications on fossil corallines, palaeoalgologists all over the world highlighted the application of newly proposed taxonomic criteria for the fossil species following the taxonomy applied to present day corallines based on gene sequence analyses (Kato et al. 2011, 2013; Woelkerling, & Harvey, 2012; Hind & Saunders, 2013; Bittner et al. 2011).

Indian sedimentary basins have lots of potential areas for the study of Calcareous fossil algae. Limestone deposits in different formations of Mesozoic and Cenozoic sequence potentially contain skeletal remains of calcareous algae. Extensive exposures of are known to occur in Cauvery Basin, Kachchh Basin, Deccan Intertrappean beds, Bagh beds, Andaman-Nicobar Basin, N-E India (South Shillong Plateau) and also in the offshore of different Cenozoic basins.

In recent years the concepts of fabric analysis and facies analysis have been successfully applied on coralline algae dominated carbonates. The diversity of coralline algae, growth form analysis and taphonomic signatures are useful for the determination of limestone fabric. These parameters also form the basis for facies analysis and have been applied on algal rich facies of Palaeogene and Neogene carbonate rocks of India. These studies are also useful for palaeoecological interpretation.

The coralline algae are globally distributed benthic primary producers in wide range of environments ranging from arctic to tropics. They have received much attention due to their importance in ecology and potential vulnerability of their high-Mg Calcite skeletons in the context of ocean acidification. As a matter of fact, coralline algal ecology and physiology may be significant to understand their responses to global climate change. Corallines are photosynthetic; however, they can thrive in water depths from intertidal down to 250 m in low light intensity owing to presence of phycoerythrin pigments and also can grow both high and low nutrient conditions.

Coralline algae have a high-Mg Calcite skeleton which exhibits distinct banding patterns similar to tree rings. Since long growth banding patterns in trees and corals have been used to reconstruct palaeoclimatic variability. Recently calcite chemistry of coralline algal growth bands has also been used as a proxy of past environmental conditions.

Algal rich facies have provided porous and permeable reservoirs for hydrocarbon accumulations through various ages. In Alberta (western Canada) Devonian carbonate deposits containing oil is well developed. Calcareous algae are important constituents in the late Devonian Leduce reefs. Reef facies of Redwater Field in central Alberta contain abundant alga *Renalcis* along with tubular stromatoporoids through intervals of porous and permeable

carbonates of several meters thick. Late Palaeozoic phylloid algal limestones in the United States are important petroleum reservoirs. From the Paradox Basin of southeastern Utah and Colorado and in west Texas and New Mexico petroleum production is from buildups of lenses of bioclastic limestone composed mainly of the phylloid alga *Ivanovia*. Major oil fields producing from Cretaceous and early Cenozoic carbonates occur in the Sirte Basin of Libya. Reefs and other carbonate accumulations of Palaeozoic age are the principal oil and gas reservoirs. However, it is yet to be established in our country.

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Sequence Stratigraphic Analysis of Tide Affected Transgressive to Wave Dominated Highstand Systems Tract of Lower Part of Sandhan Formation, Kutch, India

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The Cenozoic sediments of Kutch basin is deposited in passive margin sag-basin are well exposed along western part of Kutch as a wide continuous belt of coastal plain trending NW-SE. Their sedimentation was primarily controlled by relative interaction between sea-level fluctuations vis-à-vis siliciclastic supply. The terminal Cenozoic sediment of Sandhan Formation is siliciclastic dominated succession exposed as discontinuous outcrop along cliffs and banks of Kankawati River (type section). The formation has an unconformable contact with underlying Chhasra Formation and has gradational contact with overlying Quaternary/Sub-recent sediments. The detailed stratigraphic and sedimentary facies analysis of Sandhan Formation suggests that lower part of formation (135m) is deposited in a shallow marine environment and upper part of the formation (~157m) is deposited in a fluvial setting. This study is aimed at the process based sedimentary facies and sequence stratigraphic analysis of lower part of Sandhan Formation.

The process based sedimentological analysis of the succession led to identify the following nine Facies Associations as follow in stratigraphic order: Conglomerate (unconformity), Cross-bedded sandstone (backshore), Cross-stratified and planer laminated sandstone (upper shoreface), Interbedded sandstone and siltstone (lower shoreface), Compound cross-stratified sandstone (intertidal zone), Intercalated siltstone and mudstone (tidal flat), Fossiliferous muddy limestone (shallow inner shelf), Inclined graded beds-horizontally laminated sandstone (beach complex), and Laminated shales (lagoon).

The field based stratigraphy and sedimentary facies analysis of siliciclastic-dominated shallow marine Sandhan Formation suggests that its deposition took place in transgressive environment followed by normal regression. The facies association from conglomerate to inner shelf muddy limestone (up to 95m) represents tide affected fining upward succession is regarded as transgressive systems tract. The coastal onlap of Sandhan Formation over Chhasra Formation as inliers can be observed near Mothala Village is a characteristic feature of shoreline transgression. The base of the transgressive systems tract is characterized by an erosional unconformity between Chhasra and Sandhan Formation can be traced

at basin-wide-scale and indicates a large shift of depositional environment across the unconformity from limestone dominated Burdigalian to siliciclastic dominated post Burdigalian successions. The fossiliferous muddy limestone rich in oysters, pecten and shallow benthic foraminifera is identified as maximum flooding surface and indicates the end of shoreline transgression. The prominent coarsening-upward succession above MFS is characterized by laminated shales (lagoon) and beach barrier complex (up to 40m) is interpreted as normal regression of highstand systems tract. The coarsening and thickening upward, horizontal laminations, sharp and erosional base of individual units and abundant trough and tabular cross-stratification indicate wave dominated setting during HST. The highstand systems tract is bounded at top by basal surface of forced regression is characterized by abundant fluvial channel lags occurring at top of beach barrier complex. The sedimentation of siliciclastic dominated Sandhan Formation deposited in passive margin-sag basin provided an exceptional opportunity to document classical example of tide affected transgressive systems tract and wave dominated highstand systems tract.

Keywords : Tide affected TST, Wave dominated HST, Siliciclastic sequence, Beach barrier complex, Tidal flat.

Palaeoenvironmental studies in Lingala-Koyagudem Coalbelt of Godavari graben, South India.

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In order to reconstruct the palaeoenvironment of Mamakannu succession in Lingala-Koyagudem Coalbelt of Godavari Graben, palynofacies analysis were conducted on 380.00m deep core. Six categories of Dispersed Organic Matter (DOM) were observed and an attempt has been made to decipher palaeoenvironmental setting based on the existing lithological and palynofacies data. Total four (A—D) palynofacies have been identified in the complete succession, representing the different palaeoenvironments. Palynofacies Association A, (dominated by structured terrestrial) has been interpreted as proximal to fluvio-deltaic source in oxic environment; Palynofacies Association B (dominated by degraded terrestrial) reflects low energy dysoxic-anoxic (fresh water swamp) palaeoenvironmental conditions; Palynofacies Association C (dominated by charcoal) indicative of deposition in oxic environmental conditions due to either its proximity to terrestrial source or redeposition of organic matter from fluvio-deltaic sources; Palynofacies Association D (dominated by terrestrial palynomorphs) has been attributed to the suboxic-dysoxic (fresh water peat) environmental conditions in lower energy settings. The succession of the four distinct palynofacies types indicates the oxic, fluvio-deltaic, fresh water low energy settings in Permian, fluvio deltaic and suboxic-dysoxic conditions were slightly higher in Barakar Formation while, dysoxic-anoxic conditions were slightly higher in Barren Measures Formation. The purpose of present investigation is to reconstruct the palaeoenvironment of non-marine sequences with the help of palynofacies analysis.

Key words : Palynofacies, Palaeoenvironment, Permian, Mamakannu area, Godavari Graben.

Impact of Metal Concentration and Pollen Preservation in the Soil of Kukrail Reserve Forest, and its implications on the Geo-environment, Central Ganga Plain (CGP), Lucknow, Uttar Pradesh, India

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Lucknow district is a part of Central Ganga Plain (CGP) in the state of Uttar Pradesh covering an area of 2 ,528 km^2 and lies between North latitudes 26°30' and 27°10' and East longitudes 80°30'and 81°13'. The average elevation from mean sea level is ranging from 80 to 134 meters. Increasing urbanization and growth in vehicular density has become a growing concern in recent years. Road dusts in urban areas are indicators of heavy metal contamination and they are also affecting the top layer of the soil. The dusts primarily consist of soil derived minerals and also contain some potentially toxic pollutants like heavy metals, originating from a wide range of anthropogenic sources. The total of 10 top soil samples were pollen analysed to trace the effect of heavy metal concentration in relation to the pollen preservation in the *Kukrail Reserve Forest, Lucknow (U.P.). The metal concentrations analysed in the field using Liica Hand held XRF and the observation showed* that concentrations of cadmium, iron and manganese in soil were recorded above the permissible limits set by WHO while other heavy metal concentrations particularly Cu, Cd, Zn, Fe, Ni, Mn, K, Ca and Pb are within the permissible limit. *The study reveals* the occurrence of higher frequency of fungal spores, hyphae, fruiting body of Microthyriaceae along with degraded pollen/spores which is indicative of biodegradation and destruction of microbiota in mineralized condition which is unconducive for pollen preservation too.

Keywords: CGP, Soil and Road Dust, Plants, Heavy metals, Hand held XRF, Pollen structure

Holocene vegetational history around Hamtah and Chhatru glaciers, Lahaul-Spiti, India

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The Quaternary Period is characterized by repeated climatic changes marked by glacial and interglacial phases; the Holocene climate has been even more variable. Climate change is the governing factor for periodic vegetational shifts in a particular region. The vegetational sequence and climate of the past, within a definite time-frame, can be specifically achieved through pollen analyses. Hence, for the reconstruction of vegetational history and corresponding climatic changes during the Quaternary, palynology is considered one of the best parameters. The present study is an effort to understand the vegetational and climatic changes during the Holocene, from around the Hamtah and Chhatru glaciers, Lahaul-Spiti, Himachal Pradesh, India.

The Hamtah Glacier is a north-westerly flowing valley glacier and is the trunk glacier of the Hamtah Basin. It is approximately 6 km long with an average width of 0.50 km; the snout is located at an altitude of ~4020 masl. The glacier is approachable from Chhatru, the nearest road head, through a 8 km long foot/mule track along the Hamtah *Nala* (stream) joining the Chandra River. The Chhatru Glacier is located nearby (32º19'8" N: 77º21'47" E) on the opposite side of the Hamtah Glacier and has a southern orientation. The glacier is comparatively small which has presently receded to its cirque. The Chhatru Glacier can similarly be approached from Chhatru by a 2 km long track along the Chhatru *Nala*. The area is a cold, high-altitude desert characterized by alpine, steppe type of vegetation.

Palynological studies have been undertaken around Hamtah and Chhatru glaciers from surface and sub-surface sediments. In order to understand the pollen-vegetation relationship, pollen analyses of the surface samples collected from the outwash plains of the two glaciers were carried out. The pollen assemblages are characterized by an overall predominance of arboreal taxa, especially conifers, over the non-arboreal taxa. A trial trench of 90cm was dug on the outwash plain of the Hamtah Glacier to reconstruct the palaeoclimate and vegetational history. On the basis of changing frequencies of arboreal/non-arboreal pollen ratio, different climatic phases have been recorded since the last 4783 yrs BP to present.

Keywords: Holocene, Palynology, Alpine vegetation, Climate-Change, Lahaul-Spiti

Large sized prokaryotic microfossils from the Salkhan Limestone (>1600 MA), Semri Group Vindhyan Supergroup.

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The late Palaeoproterozoic to early Mesoproterozoic Salkhan Limestone (>1600 Ma) is well exposed in the Son Valley area, Uttar Pradesh and Nauhatta area Bihar. Both stromatolitic and massive carbonates constitute the Salkhan Limestone a 90 meter thick succession of carbonate and chert unit. The chert has been differentiated into Bedded chert, stromatolitic chert and cherty stromatolites. Well preserved microfossils have been documented in these three different cherts types. Well preserved large sized coccoidal microfossils have been recovered from the sporadically found black chert of the Salkhan Limestone. These microfossils are the subject matter of the present study. More than 200 such specimens are studied. *Mor*phology and size criteria have been discussed to consider the nature of these large sized cells and their affinity. These forms are assigned to three genera and five species. *Gloeodiniopsis lamellosa and Gloeodiniopsis micros are grouped under cyanobacteria.* Four species are being recorded for the first time from the Salkhan Limestone. Among these, *l*arge sized coccoids*, Kheinjuasphaera vulgaris, Phanerospherops magnicellularis and P. capitaneus* are grouped under *incertae sedis and their taxonomic positions are reconsidered.* The main purpose of this study is to document their mode of occurrence, describe morphology and to discuss their palaeobiological affinity and their significance in understanding the evolution. Palaeobiological implications are also discussed to understand the large size coccoidal microfossils which have been assigned to large sized prokaryotes preserved during the Late Palaeoproterozoic to Early Mesoproterozoic.

Palynodebris based depositional environment studies of Yingkiong Group of the east and upper Siang Districts, Arunachal Pradesh.

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The present study was carried out along the Yamne river section of the East and Upper Siang Districts of Arunachal Pradesh. The area presents the Eocene Yingkiong Group of sediments exposed in the road and river sections from the north of Ranaghat up to Yingkiong. The dominating rock types encountered are sandstone, limestone, shale, carbonaceous shale and streaks of coal. The palynological study reveals the scanty occurrence of palynofossils and foraminiferal linings. The palynodebris assemblage is dominated by charcoal and degraded black debris along with considerable amount of amorphous organic matter and well preserved woody structures. Presence of charcoal and degraded black debris indicate oxidizing environment at the time of deposition of the sediments while amorphous organic matters with well preserved woody structures point that the study area experienced recurrence of reducing environment. From the occurrence of foraminiferal linings, the depositional environment can be envisaged to be shallow marineThe palynodebris assemblage together with coal occurrence indicates a tropical to sub-tropical climate with high humidity and heavy rainfall prevailed in the area of deposition.

Key words : Palynodebris, Depositional Environment, Yingkiong Group, Arunachal Pradesh

Subsurface Stratigraphy and Palynology of Prang Limestone Member of Oil Field Areas of Upper Assam Petroliferous Basin

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The present study reveals abundance of well preserved miospore and pollen grains together with dinoflagellates in the palynological assemblage of the subsurface Prang Limestone Member. The pollen assemblage is dominated by grains of Palme family. Miospore assemblage is dominated by Lycopodiaceae. On the other hand, the occurrences of dinoflagellates in the fossil assemblage leads to the conclusion that The Prang Limestone Member was deposited in a shallow marine condition under humid tropical climate during Middle Eocene time.

Keywords : Miospore, Pollen, Dinoflagellate, Stratigraphy, Depositional Environment, Upper Assam Petroliferous Basin.

Palynology and Source Rock Potential of the Barail Group of Rocks along Tuli-Merengkong Road-Section, Mokokchung District, Nagaland

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A diversified Palynofloral and Palynodebris assemblages have been recorded from the Barail Group of rocks of Mokokchung District, Nagaland. The Palynofloral assemblage is represented by Pteridophytic spores, Gymnosperm and Angiosperm pollens like *Podocarpidities sp.*, *Meyeripollis nahorkotensis, Striapollis bellus, Magnastriatities sp., Palmaepollenities sp., Polypodisporities sp. etc.* The prolific presence of structured and amorphous organic matters together with mangroove and shoreline pollen grains indicate deltaic environment with tropical to subtropical humid climate during the deposition of the Barail Group. The Palynofossil assemblage suggests Upper Eocene-Lower Oligocene age. Source rock analyses suggest presence of type III kerogen and low hydrocarbon generation potential of the formation.

KEY-WORDS : Palynology, Source Rock Potential, Barail Group, Nagaland, India.

Biofacies analysis of Pleistocene limestones from Neil West Coast Formation, Neil Island, Ritchie's Archipelago of South Andaman

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The type area of Neil West Coast Formation is situated in the west coast of Neil Island. The formation is divided into two litho-units *viz.,* a lower Silty Mudstone Member and an upper Limestone Member. The lower unit is evidenced in few outcrops whereas, the Limestone Member of Pleistocene age is exposed all along the West coast and comprised of fine to medium, compact to porous, buff, foraminiferal-algal limestone with moderately sorted, broken fragments of foraminifera, corals, algae and polycrystalline quartz grain. Earlier, based on planktic foraminiferal biostratigraphy (*Globorotalia tosaensis i.e., N21* Zone to *Globorotalia truncatulinoides* i.e., N22 Zone) late Pliocene to Pleistocene age has been assigned for the Neil West Coast Formation. As observed in the field the formation is overlain by recent to sub-recent deposits comprising shell limestone with boulder and pebbles, coral rags and beach sands. The samples were collected from the type section of the Limestone Member (Pleistocene) of Neil West Coast Formation (11°49.919´ N, 93°00.843´ E) exposed near the natural bridge. Petrographic thin section analysis of the samples yielded fairly preserved coralline red algae, benthic and planktic foraminifers, coral fragments, echinoid spines and gastropod shells. The coralline red algae are represented by both non geniculate and geniculate forms. The non geniculate forms belong to mastophoroides and melobesiodes. The geniculate forms are represented by species of *Corallina* and *Amphiroa*. However, the diversity and abundance of coralline algal forms are less in comparison to the benthic foraminifers those are represented by *Ammonia*, *Amphistegina*, *Lepidocyclina*, *Operculina*, *Operculinella* and texularids. Planktic foraminifera like *Globigerinoides* and other biogenic components viz., coral fragments, echinoid spines and gastropod shells are also common. The texture of the facies is basically grain-supported grainstone and poorly sorted. Only a single foraminiferal-algal grainstone facies has been recognized as observed in the field as well as in thin section analysis. The overall assemblage of the biogenic components and biofacies analysis indicate a near shore environment of deposition with high energy condition and increased hydrodynamic activity.

Recovery of biogenic silica crash during early Pliocene: Evidence from siliceous microfossils of Car Nicobar Island, North East Indian Ocean

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The present contribution deals with the analysis of siliceous microfossils from Sawai Bay Section of Car Nicobar Island, North East Indian Ocean. The outcrop is the type section of Sawai Bay Formation and is lithologically characterised by moderately hard, highly calcareous, light to bluish-grey mudstone. The age of this formation ranges from late Miocene to middle Pliocene. For the present study, samples collected from the Sawai Bay Section, Car Nicobar Island yielded well preserved diatoms, radiolarians, silicoflagellates and sponge spicules. Qualitative and quantitative analysis of the recovered microfossils have been done. Twenty five species belonging to 16 genera of diatoms along with 16 radiolarian taxa have been identified in the studied samples. The diversity of diatoms is quiet fair; however, their abundance is poor in comparison to radiolarians. The significant diatom taxa are represented by *Triceratium favus*, *Azpeitia nodulifera*, *Plagiogramma tessellatum*, *Coscinodiscus radiatus* and *Stictodiscus nankoorensis*. The important radiolarian taxa are *Rhopalastrum profunda*, *Semantis* sp., *Stylochlamydium asteriscus* and *Stylochlamydium* sp. The diversity of silicoflagellates is comparatively less with regard to sponge spicules. Silicoflagellates are dominated by *Dictyocha fibula* and the sponge spicules by Astrophorids. Occurrence of radiolarian taxon *Didyomocyrtis avita* in the top of the studied section is significant as it is common globally in middle Pliocene sediments from latitude lower than 40°. Other radiolarians and diatoms clearly indicate the age of the sequence as early to middle Pliocene. The abundance and diversity of diatoms along with other siliceous microfossils in the Sawai Bay Formation exposed in Car Nicobar Island is remarkably less in comparison to the late Miocene sequence exposed in Neil East Coast and Cave Point localities of Neil Island. The concentration of $CaCO_3$ is comparatively less in the lower part of the studied outcrop; however it is remarkably enhanced in the upper part where the silicates gradually declined. The reduced abundance and diversity of siliceous microfossils may be due to nutrient deficit condition and poor sediment influx from terrigenous sources. It also may be correlated with the biogenic silica crash at about 6 Ma owing to closure of Indonesian Through flow (ITF). However, the early Pliocene may be earmarked as the recovery phase of biogenic silica as evident from the present analysis.

Micropaleontogical and geochemical study of Valia Lignite mine, Western India

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A preliminary study of microfaunal assemblage, representative palynofloral elements and geochemical characteristics of the subsurface beds of the Eocene Cambay shale Formation exposed in Valia Lignite Mine section, Western India was undertaken to infer the paleoenvironment and paleobathymetry of the succession.

The Vastan and the adjacent open cast lignite mines (latitude 21° 30' 52' N, longitude 73° 12' 20.5" E) situated about 30 km northeast of Surat (Cambay basin) in Gujarat have provided lots of data on well preserved plant fossils, including pollen and spores, invertebrate fossils as well as vertebrate fossils comprising a diverse assemblage of terrestrial mammals such as aryiodactyls, perissodactyls, creodonts, tillodonts, primates, rodents and bats. The Valia lignite mine which is situated to the north of the Vastan mine has a lignite sequence, which is broadly similar to that in Vastan, but differs in that it has up to four productive lignite seams and conspicuously lacks molluscan shell beds.

The Valia mine section consists of lignite, light and dark grey shales, brown shale, lignite pinching, pebbly coarse sandstone. Six assemblage zones have been recognized in Valia Mine Section on the basis of fossil availability-

UNIT – 1 Valia 1- 7 (exposed base level to 7.6 meter upward)

UNIT - 2 Valia 8-11 (higest level of Valia 7 to 4 meter upward)

UNIT – 3 Valia 12-15 (higest level of Valia 11 to 10 meter upward)

UNIT – 4 Valia 16-20 (higest level of Valia 15 to 4.5 meter upward)

UNIT – 5 Valia 21-24 (highest level of Valia 20 to 7 meter upward)

UNIT – 6 Valia 25- 27 (highest level of Valia 24 to 3.5 meter upward)

The microfaunal remains consist mostly of foraminiferids both plaktic and benthic (e.g., *Rhabdammina, Pyrgo, Sigmoilopsis, Reophax, Orbulina, Globigerinoides)* and some ostracods among invertebrates anda few fish verteibrae among vertebrates. The assemblage suggests that

the paleo-environment of the middle to upper Valia section is shallow marinewith high oxygen supply. The lithology and overall fossil assemblage of the Cambay shale Formation suggest a freshwater to brackish water and inner shelf deposition.

The microfloral remains consist of pollens, spores (e.g., *Acanthotricolpitesbulbospinosu, Triporopollenitesparviannulatus, Phragmothyriteseocaenica, and Tribrevicolporiteeocaenica*), and some poorly preserved dinocysts. The pollen and spores assemblage suggest a tropical – subtropical moist or wet forest environment. The habitat and present day distribution of the modern comparable taxa in the fossil assemblage recorded from Valia Mine are indicative of a terrestrial lowland environment. The dinocysts study also reveals the same paleoenvironment.

From the geochemical analysis (bulk rock XRD and clay mineralogy) of samples from the Valia mine section it can be inferred that the rocks of the Valia section mineralogically comprise kaolinite, siderite, quartz, smectite and chlorite (very low). Kaolinite abundance is very high throughout the succession which is also an indicator of chemical weathering and high erosional environment.

The fossil assemblage suggests that the succession of Valia mine section ranges in ranges in age from the middle Eocene to Miocene.

Keywords : Valia ,lignite, Eocene, kaolinite ,shallow-marine, microfaunal, foraminiferids

Changes in the NW Arabian Sea Oxygen Minimum Zone (OMZ) during the Holocene as recorded in benthic foraminifera at ODP Hole 723A

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This study attempts to analyze 11ka record of deep-sea benthic foraminifera at Ocean Drilling Program (ODP) Hole 723A (Leg 117), located at the core of an oxygen minimum zone (OMZ) in the northwestern Arabian Sea, with the main aim of understanding the changing intensity of the Arabian Sea OMZ and its links to variability in the Indian monsoon.

A 3.2m long core was studied at contiguous 1 cm interval with an average time resolution of 33years per sample (based on 12 AMS ^{14}C calibrated dates). The samples were washed and dried, and benthic foraminiferal census data was generated from an aliquot of ~300 specimens, from 125 µm+ size fraction. The species diversity of benthic foraminifera was calculated in terms of Information Function (H) and Equitability (E). The number of species (S) were also counted from each sample. The dysoxic and oxic species of benthic foraminifera were identified following Kaiho (1994), Caulle et al. (2014) and Singh et al. (2015). The species diversity of benthic foraminifera, abundance of dominant/ecologically important benthic foraminiferal species, and oxic-dysoxic assemblages were studied, along with published records of stable isotope analyses of *Uvigerina peregrina* and population abundance of *Globigerina bulloides* - a well-established southwest monsoon wind proxy (Gupta et al. 2005, 2008).

The H, E and S values show stable trend in the early Holocene between 11,500 and 8,200 yrs. The H values start increasing in the beginning of the middle Holocene (8.2 kyr), peaked at 6,400 cal yrs BP and then show a continuous decreasing trend. The H, E and S values increase again during the Medieval Warm Period. The E shows an almost similar trend as the H but vary in magnitude. The S remains unchanged up to middle Holocene and thereafter shows slight decrease during the late Holocene.

The dysoxic assemblage, thriving in severely oxygen deficient conditions, comprise 20 percent or more of the benthic population. The oxic assemblage is comparatively more dominant during the early Holocene, although it reached highest abundance of only 8 percent of the total benthic assemblage. It continues in low abundance till 5,500 yrs BP, after which it completely disappears. The dysoxic assemblage shows a corresponding increase in abundance, reaching up

to 50% of the total benthic population, after 5,000 yrs BP with highest abundances during 4,200 to 1,500 yrs BP. The study shows that the Arabian Sea OMZ was weak at intermediate depths during early Holocene; the OMZ intensified similar to the present day conditions during the middle to late Holocene.

Keywords: Oxygen Minimum Zone, Holocene, benthic foraminifera, Arabian Sea.

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Ichnology of a Paeogene fluvial meandering channel –levee complex: Insights from Mohamad ki Dhani Sandstone , Jaisalmer Basin, India.

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Ichnological signatures are regarded as storehouses of pristine information regarding the Paleo-depositional environments and palaeoecological reconstruction. Such stored information becomes more significant, in situations where there is lack of other proxy like body fossils etc. for reconstructing paleo-environment and palaeoecological conditions. The Paleogene in Jaisalmer basin is represented by a fluvial succession belonging to Mohamad-ki-dhani sandstone Member of Sanu Formaiton. In the outcrop, the succession is sandstone dominated characterize by fine to medium grained argillaceous sandstones that shows fining up sequence. The present study explores several sections that exposes as continuous succession from lower part of the Mohamad-ki-dhani sandstone member to the overlying Early Eocene marine succession of shale-limestone alterations belonging to lower part of Khuiala Formation. The studied Paleogene succession shows two well-developed cycles of Fining upward sequence interpreted as meandering channel system topped by laminated siltstones belonging to levee plain. Channel sands are strongly bioturbated with presence of *Egadiradixus rectibrachiatus, which are* vertical tapering down root network. In contrast, the levee sediments shows well preserved trace fossils like *Arenicolites* isp, *Skolithos linearis*, *Camborygma eumekenomos*. The Ichnofabric analysis reveals that the levee sediment shows cross cutting and tiering of two distinct trace fossil community, one dominated by soft sediment like *Arenicolites* and *Skolithos* while other dominated by deep tiered, firmground trace fossil like *C. eumekenomos*. Thus paper will discuss the potential of using Ichnofabric analysis in understanding non-marine paleoecology and paleodepositioanl control.

Benthic foraminiferal record from the mud bank region off Alleppey, Kerala-SW coast of India

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The mud bank off Alleppey is a seasonal phenomenon which forms during monsoon. It occurs as patch ofcalm coastal waterswhen the coastsat other places are under massive erosion. Benthic foraminiferal response to the formation of mud bank is recorded from the area. From 5 to 15 m water depth surface sediment samples were collected during both pre-monsoon and monsoon season; covering the mud bank and adjacent non-mud bank areas. During pre-monsoon season within the mud bank area the Total Foraminiferal number/ gm sediment (TFN), Total Benthic foraminiferal Number/ gm sediment (TBN) and Total Living foraminiferal Number/ gm sediment (TLN) was found lowest. The abundance increased outward- north and south- in the non-mud bank area. While during monsoon TFN, TBN and TLN increase from north to south as a whole.Both in the pre-monsoon and monsoon season foraminifera population is dominated by agglutinated fauna. In Benthic foraminifera on an average percentage of agglutinated fauna is 0-73% and in living foraminifera the average percentage of agglutinated fauna is 46-99%. Overall decrease in the living agglutinated fauna is observed during monsoon and a drastic decrease of ~ 25% is noted within the mud bank area. Whereas, the percentage of dead agglutinated fauna increases in the mud bank region from pre-monsoon to monsoon on an average by 10% and shows a general decrease in non-mud bank area. The changes observed in the faunal distribution and abundance pattern is most likely due to seasonal changes in bottom water physiology that occurs as a result of mud bank formation. The different pre-monsoon pH (8.23 to 8.264) and monsoon pH (7.707 to 7.762) suggests terrestrial influence in the area during monsoon. The Dissolved Oxygen (DO) of bottom water is very low off Alleppey during monsoon (average ~ 0.3mg/l) as compared to that in pre-monsoon (average ~ 5.08mg/l) points towards high productive nature acquired by the region during the existence of mud bank. The complicated relationship between faunal distribution pattern and characteristic ocean bottom physiology of the mud bank off Alleppey shall be addressed in future with detailed study.

Keywords: Mud bank, Alleppey, Benthic foraminifera, Agglutinated foraminifera, Living foraminifera

Ecology, ostracod diversity and sediment characteristics of sub-surface samples of Marakkanam backwaters, Villupuram District, Tamil Nadu, SE coast of India.

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To study the ostracod environment, one core sample has been collected from the Marakkanam backwaters at the depth 1m and it sub-sampled by 5 cm intervals and totally 20 samples were obtained, samples are subjected to standard micropaleontological and sedimentological analyses. A total of 29 ostracod taxa belonging to 18 genera, 13 families, 2 superfamilies and 1 suborder of the order Podocopida have been identified. In the study area the calcium carbonate content of the sediment is one of the important parameter which governs the population of Ostracoda, especially its vertical distribution of the core sediments. Here, the calcium carbonate content is generally found to be directly proportional to the population size. The impact of organic matter content on the distribution of ostracod fauna in all the sub-sample is insignificant and *the higher diversity values are noticed in middle segment of the core. The relatively higher diversity index encountered in the samples is attributed to the nature of substrate, sand and siltysand it is* more accommodative substrate for the population abundance. The following species in the core sample indicate that the sediments are deposited under normal oxygenated, shallow and brackish water environment: *Hemicytheridea reticulata, L. megapora indica, L .tekkaliensis and Jankeijcythere mckenzii.* The distribution of carapaces and open valves, for all the samples put together, reveals that the closed carapaces are outnumbered open valves and its concluded that a faster rate of sedimentation prevails in the Marakkanm backwaters. In the study area, almost all the carapaces are light yellow and white in colour, supporting the fact that the sediments were deposited under normal oxygenated environment. From the type of sediment in the core, it is inferred that the deposition of sediment in the Marakkanam backwater is observed to the under medium to high energy conditions.

Keywords : Ecology, Ostracoda diversity, sediment characteristics, Marakkanam backwaters, Tamil Nadu, India.

Distribution of diatoms in the subsurface samples of Pulicat lagoon, Tamil Nadu, southeast coast of India: implications on paleoenvironment.

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Diatoms are one of the most important and abundant components of fresh, brackish and marine phytoplankton with two valves (frustules), composed mainly of silica (SiO2). Diatoms are very important tool for paleoclimate reconstruction and inhabit in all aquatic environment. Many researches have been carried out in the Pulicat Lagoon such as Hydrogeochemistry, sedimentology, Micropaleontology. But the sedimentological and Diatom study are very scare in the area. So, it is an attempt to study about the relationship between Diatom and the sedimentological parameters in the subsurface samples of Pulicat Lagoon and to interprete the implications of paleoenvironment.

To access the paleoclimatic reconstruction, one core sample has been collected from the Pulicat lagoon, Tamil Nadu, the second largest lagoon in India. A total of 66 diatom taxa belonging to 32 genera, 21 families, 18 orders, 4 subclasses and 2 classes have been identified. They are represented mostly pennate forms. *Grammatophora oceanica* Ehr., *Cocconies heteroidea*, *Cocconies scutellum* are abundant species throughout the core.

Distribution pattern of individual taxon were examined and their relationship used to determine for ecologic/environmental interpretation. Sedimentological parameters such as $CaCO_3$, organic matter and sand-silt-clay ratios were estimated and their distribution were discussed throughout the core. Downcore variation of sand-silt-clay ratio,CaCO3 and organic matter reveales depositional events with the influence of freshwater and marine water. The core data shows , increase in the marine taxa as well as rate of sedimentationin the Pulicat lagoon.

Benthic Foraminifera Biostratigraphy of Lakadong Limestone exposed in Amtapoh Quarry, Jaintia Hills, Meghalaya

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The South Shillong Plateau Sylhet Limestone Formation is sub-divided into following lithounits namely, Lakadong Limestone Member, Lakadong Sandstone Member, Umlatdoh Limestone Member, Nurpuh Sandstone Member and Prang Limestone Member in ascending order of their age. The present study was carried out in a quarry exposing a thick section of Lakadong Limestone sandwiched between underlying Therria Formation and overlying Lakadong Sandstone Member. The study confirm presence of two numbers of Taxon Range Zone viz. Miscellanea Juliette Taxon Range Zone and Miscellanea miscella Taxon Range Zone and one Concurrent Range Zone (Miscellanea Juliette - Miscellanea miscella Concurrent Range Zone) in the Lakadong Limestone Member Jaintia Hills, Meghalaya. Correlation of these biozones with global standard zonation scheme of benthic foraminifera suggest that they can be compared with SBZ 3 Zone (Early Thanetian) which is equivalent to P4 Zone of Planktonic Foraminifera.

Larger benthic foraminiferal response to palaeoenvironmental fluctuation during Eocene of Meghalaya, NE India.

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Eocene is very significant time period as it involves many large and small scale paleoclimatic changes, plate reorganisation as well as paleogeographic changes. Shillong Plateau, being the north easternmost extension of the Indian Peninsula bears signatures of all the climatic changes in its southern fringes that occurred during Eocene time. Larger benthic foraminiferal assemblage of Umlatdoh Limestone Member of Sylhet Limestone Formation exposed in Mawlong village of East Khasi Hills district, Meghalaya (Latitude N 25°12′25.2″- N 25°12′6.3″ Longitude E 91°41′25.8″-E 91°41′5.3″) were studied to unveil the climate induced syndepositioinal changes in the basin. The study suggested that deposition of the limestone was started in a comparatively less stable environmental setup with considerably high kinetic energy and more wave action followed with a comparatively stable less agitated basinal condition. During deposition of middle part of the limestone unit, the basin attained a maximum quiet condition which was again followed by almost similar basinal condition that prevailed during early phase of the limestone formation in the basin.

Biotic response to the global warming event PETM: evidences from the Subathu succession of the type area, Himachal Pradesh, NW Sub-Himalaya

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The Paleocene-Eocene Thermal Maximum (PETM) was a prominent global warming event that occurred close to the Paleocene/Eocene (P/E) transition. It lasted for ~170–200 kyrs and brought about noticeable geochemical and biotic changes which are manifested in the global sedimentary archives of that time. The biotic changes include extinction, appearance, blooming, and or diversification of various ocean and land-dwelling organisms. In the NW sub-Himalaya, the late Paleocene to middle Eocene (~56–45 Ma) interval is represented by the richly fossiliferous Subathu succession (=Subathu Group), which is a largely shallow marine deposit and continental conditions began only towards its terminal stage. It has been established by the foraminiferal biostratigraphy that the organic rich lower part of the Subathu succession spans the P/E transition (Mathur and Juyal, 2000). The geochemical and isotopic signatures of the PETM in the basal part of the Subathu succession have also been recorded recently (Gupta and Kumar, 2015).

The present work, focussed in the basal part of the Subathu Group of the type area in Himachal Pradesh (NW sub-Himalaya), is aimed at studying the composition and preservational features of biotas occurring in the beds preceding the PETM, during the PETM and following the PETM event, thus highlighting the overall biotic response to the warming event. The studied section has yielded diverse fossil assemblages comprising larger as well as smaller benthic foraminiferids (LBFs and SBFs) and planktic foraminiferids apart from dinoflagellates and other fossils, including vertebrates. Since the basal part of the Subathu succession of the type area comprises mostly recrystallized limestone and limited shale, the study of foraminiferids was undertaken mostly through thin sections of fossiliferous samples, while the dinoflagellates were recovered using the palynological processing.

In the studied section the thin sections of the late Paleocene beds have yielded well preserved LBFs, such as *Daviesina*, *Lockhartia*, and rotalids. The preservation of these forms deteriorates gradually due to carbonate dissolution near the P/E boundary and they are completely missing in the PETM beds. The dissolution of LBFs is attributed to the warming event.

In the earliest Eocene beds when the warming peaked foraminiferids are absent. As the warming slowed down the SBFs reappeared first while the LBFs reappeared little later when the basin condition became more stable. Thus the PETM caused a lot of stress to biotas living in the shallow marine environment of the Subathu basin. The stresswas accelerated further due to the India-Asia collision which was operational around the same time. The LBFs may not have been able to survive in the Subathu basin during the early part of the early Eocene due to rise in temperature and carbonate dissolution. Thus arrival of the early Eocene LBFs and their turnover, in the Subathu basin, was delayed till the basin conditions became stable. After the conditions stablized the early Eocene beds became dominated by the LBFs, such as *Nummulites* and *Assilina* (Mathur and Juyal, 2000). In the studied section, *Apectodinium* (dinoflagellate) acme (including *A. parvum, A. homomorphum*and *A. quinquilatum*) has been observed close to the P/E boundary and in the PETM beds.The bloom of *Apectodinium* is usually interpreted as an indicator of rise in temperature, sea level, and nutrient influx (e.g., Crouch and Brinkhuis, 2005; Sluijs *et al.*, 2005). The availability of ample nutrients and conducive environment in the basin at the onset of the PETM must have led to *Apectodinium* acme in the studied section.Thus the biotic response to the PETM in the shallow marine Subathu basin was heterogenous in nature—the major biotic changes in the studied section include the dissolution and disappearance of larger benthic foraminiferids and bloom of *Apectodinium.*

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Key words: NW Sub-Himalaya, Subathu succession, biotic reponse, disappearance of larger benthic foraminiferids, *Apectodinium* acme.

Significance of diatoms to evaluate climatic variability in watershed of Navegaon Bandh Lake, Maharashtra and its Trophic Statusduring the past three centuries

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The present study mainly deals with the investigation of diatoms from the sediment core of the Navegaon Bandh Lake, Gondia district of Maharashtra, India. The objectives of the present study are to determine the changes in the past climate particularly the wet and dry periods and to understand the paleo-trophic conditions of the lake affected by the varying intensities of the monsoon in a semi arid region. The ^{210}Pb dating divulges that the sediment core recovered from this lake bears the sedimentation history of approximately two and half centuries with the mean sedimentation rate of 0.9307 cm/ year and was calculated by assuming the constant accumulation rate down the core. The enlarged peaks of organic matter may be the result of eutrophication i.e. increased lake productivity in the Navegaon Bandh Lake. The common source of P may be the synthetic fertilizers used in the agricultural lands in the watershed. The clear distinction has been made in the precipitation at the Navegaon Bandh Lake using the diatoms supported by the other proxies like particle size analysis, magnetic susceptibility and the chemical weathering Index (CWI). The diatom analyses of the sediment core of the Navegaon Bandh Lake revealed the presence of 62 diatom taxa, of which 20 attained a maximum abundance of >1% in at least one sample. The planktonic and benthic (P/B) ratio of the Navegaon Bandh Lake clearly shows fluctuations in the dominance of *Aulacoseira granulata* and *Rhopaloidea musculus* indicating changing trophic status. The dominance of *A. granulata* indicates increased nutrient levels with high phosphorus and nitrogen content and highly eutrophic waters amid wet period and less swampy conditions, whereas, the prevalence of *R. musculus* suggests mesotrophic, alkalibiontic waters and with slight swampy state. The slight swampy conditions may be due to longer dry period / less rainfall prevailed in the watershed of the lake. The recent years i.e. during ~2007 – 2012 AD, *R. musculus* and *A. granulata* both decreased drastically with predominance of the small sized centric diatom taxa *Discostella stelligera,* which point nutrient less, oligotrophic, alkaline lake waters with comparatively less rainfall (i.e. dry period). The size disparities in diatom frustules of the core sediments also indicate the fluctuating wet and dry periods in the watershed. Thus, the overall investigation of the sediment core clearly point out the changing climatic and trophic conditions in the entire history of the Navegaon Bandh Lake.

***Key-words*:** Diatoms, paleoclimate, trophic status, Navegaon Bandh Lake, Gondia District.

Diatoms as indicator of precipitation and changing trophic status for the last century at the Pandharabodi Lake, Nagpur District, Maharashtra

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The diatoms recovered from the sediment core of the Pandharabodi Lake of the Nagpur district, Maharashtra have been used as indicator to interpret past rainfall fluctuations and its trophic status for the last century. The core sediments of this lake divulged 71 species belonging to 35 genera. The seven diatoms zones and twelve subzones were recognised from the Pandharabodi Lake based upon major species using constraint cluster analysis. Out of total 71 diatoms taxa of the sediment core of the Pandharabodi Lake, 14 taxa have attained a maximum abundance of > 1% in at least one sample. Diatom assemblages were categorised as 1) Planktonic diatoms such as *Cyclotella ocellata*, *Aulacoseira granulata*, *Discostella stelligera*, *Stephanodiscus minutulus*, *Aulacoseira ambigua*, *Aulacoseira distans*, *Stephanodiscus niagarae*, *Thallassiosira australis* and *Cyclotella gordonensis* and 2) with benthic diatoms such as *Achnanthidium minutissimum*, *Synedra ulna*, *Tryblionella levidensis*, *Nitzschia microcephala* and *Navicula microcephala*. The stratigraphic profiles of the biotic indicators, Hill's N2, benthic and planktonic diatoms percentage and mean linear diameter (MLD) of diatoms for the Pandharabodi Lake were investigated to understand past precipitation and trophic status. The maximum flux rate of diatoms for the Pandharabodi Lake was 1497 x 10^5 valves m^2 $year^1$ during ~1958- ~1959 A.D. The planktonic and benthic (P/B) ratio of Pandharabodi Lake shows predominance of planktonic assemblages during ~1992 - ~2012 A.D. During ~1965- ~1991 A.D. the planktonic diatoms were again dominated in the core. During ~1951- ~1964 A.D. benthic diatoms were dominated over planktonics. During ~ 1911- ~1915 A.D. the planktonic diatoms again dominated in the core. The Hill's N2 ratio for the Pandharabodi Lake was also fluctuating and maximum peaks were noted during ~1939- ~1951 A.D, ~1988- ~1990 A.D, ~2001 - ~2008 A.D and ~2009- ~2012 A.D. The increased *C. ocellata* along with high values of *A. granulata* suggest meso-eutrophic environments with high nitrogen during ~1992- ~2012 A.D. During ~1996- ~1991 number of *C. ocellata* has gone down with minor increase in *A. granulata* and dominance of *D. stelligera*. Thus,

this period suggest moderate to less nutrients oligotrophic, alkaline waters coinsiding with the existence of dry period/ less rainfall. During ~1958 -~ 1985 A.D *C .ocellata*was dominating with low number of *A. granulata* (complete disappearance during ~1975-~1985 A.D). Thus, this period represents deep water diatoms assemblage with mesotrophic to Eutrophic pelagic waters. During ~1955- ~1956 A.D *Trybionella levidensis* was dominated. However, no ecological data supporting the species is available. But dominance of *C.ocellata* in this period suggest mesotrophic water condition. During, ~1937- ~1954 A.D the number of *C.ocellata* has declined whereas *A. granulata* was increased along with presence of *D. stelligera* in minor level indicating oligo-mesotrophic water condition. During, ~1911- ~1936 A.D, *C. ocellata* has increased in number with decline in *A. granulata* with meager presence of *D.Stelligera* indicates mesotrophic deep water assemblage of the lake. Decline in large sized diatoms during ~1933- ~1992 A.D indicates dominance of dry period/less rainfall. The actual rainfall and mean summer rainfall data also supports this finding. During ~1992- ~2012 large sized diatoms along with small sized diatoms were prevalent supporting the existence of wet period in the watershed of Pandharabodi Lake. Thus, amount of dry and wet periods along with variations in aquatic habitats may have resulted in change in diatom responses in the Pandharabodi Lake. The Pandharabodi Lake also clearly exhibits varying diatom species diversity since last 102 years with maximum diversity during ~1923-~1956 A.D. The Pandharabodi Lake shows relative dominance of small, medium, large and very large diatoms during ~1992-~2012 A.D with minor fluctuations in between indicating predominance of wet period with small episodes of dry period. During ~1965-~1992 A.D overall small sized diatoms were predominates whereas during ~1983- ~1989 A.D large sized diatoms were common indicating moderately wet period. During ~1951-~1965 A.D small sized diatoms were very common indicating existence of dry period. Thus, it can be surmised that changes in the diatom species diversity in this lakes would be in response to fluctuations in wet and dry period present in the watershed.

***Key-words*:** Diatoms, precipitation, trophic status, Pandharabodi Lake, Nagpur District.

Distribution of foraminifera and ostracoda and their ecological conditions in the beach sands of Tuticorin, Tamil Nadu, SE coast of India.

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In order to study the distribution of Foraminifera and Ostracoda in the beach sands of Tuticorin Coast, Tamil Nadu, a **total of 18 beach sand and water samples were collected along the coast of Tuticorin, from** Palayakayal to Tuticorin Old Harbour. The microfauna were separated from the sediments by using standard micropaleontological techniques.

Water and sediment parameters were measured in both field and lab from the collected samples. In the present work, a total of 31 species of foraminifera belonging to 22 genera and 16 Ostracoda species belonging to 15 genera were identified. Sand is the only substrate recorded in the study area and it is appears congenial for the population abundance. Predation on foraminiferal tests and change in their color has also noticed in few species. Occurrence of few broken and abraded tests indicates the high amplitude of tidal agitation and comparatively low deposition of sand in the beach environment of Tuticorin coast.

Keywords : Foraminifera, Ostracoda, Distrubution, Tuticorin, Beach, Tamil Nadu

Ultrastructures of fossil serpulid tubes from the Vinjhan Formation (Miocene): first evidence of preserved lamello-fibrillar structure

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Calcareous tubes of serpulids are extremely common in Mesozoic and Cenozoic benthic communities. However, the group is poorly studied, mainly due to the fact, that fossil tubes cannot be adequately classified in terms of taxonomy of recent forms, which is based on soft body characters. Accordingly, no analogues with recent species and genera can be drawn for making any detailed paleoecological interpretations based on actualistic observations. Potentially, this problem could be solved by the ultrastructural studies of fossil tubes, as serpulids demonstrate outstanding variability of this character (Vinn et al., 2008; Ippolitov et al., 2014). However, up to date there are just few cases of recognition of specific ultrastructures in fossils among published papers, while in the majority of cases fossilized tubes were considered recrystallized. The problem is caused by diagenetic alteration of primary structures, which erases the specific characters of structures to some uncertain degree. The second point is that among structures, recognized in fossils, most belong to group of consolidated oriented prismatic structures, which are most resistant to recrystallization, while certain highly ordered types are more subjected to alteration because of somewhat crumbly constitution, and were never recorded in fossils.

We collected and studied a large collection of serpulid tubes from the Vinjhan formation in its stratotypic section at Kachchh. Serpulid complex here includes two main morphotypes of the tubes – medium-sized tricarinate tubes, assignable to *Hydroides*, and two species with subtriangular tubes having pronounced median keel and assignable to *Spirobranchus.* Both mentioned genera are “problematic” for recognition in fossil record because of nonspecific morphology and their determination in fossils is always probabilistic (Ippolitov et al., 2014), however, they form the background of all shallow-water serpulid assemblages in recent seas. SEM analysis, conducted for several specimens of each species, revealed well-preserved multi-layered walls with lamello-fibrillar structure, specific for both genera, in the inner half of the wall. Outer half of the wall showed combination of irregularly oriented prismatic structure and spherulitic prismatic structure. The different degree of alteration, observed in different specimens, allows to connect the original structures with their derivates and see how they can look after partial recrystallization. Our study also fixes for the first time the finds of genera *Hydroides* and *Spirobranchus* in fossil record by means of ultrastructures, showing that principal type of the wall for both genera was similar to Recent already in Miocene.

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Keywords: ultrastructures, Serpulidae, tubeworms, Miocene, Vinjhan

New finds of megateuthids from the Middle Jurassic of Kachchh and their significance for the evolutionary history of Gondwanian belemnites

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Belemnite assemblages of Middle Jurassic of Gondwana in general and India, in particular, are known to be represented mainly by members of the belemnite family Belenopseidae Naef, 1922 (genera *Hibolithes* de Montfort, 1808 and *Belemnopsis* Bayle, 1878). Unusual conical rostra, falling out of such assemblage, were first described from India by Spath (1927, 1933), who figured a single rostrum of "*Megateuthis* sp. indet.?", represented by longitudinal section imbedded into rock. This find remained the only record of non-belemnopseid belemnites from the Jurassic of India for ages.

During winter season of 2014 the authors manage to collect abundant rostra, similar to Spath's specimen, from the Coral Limestone Member exposed in Jumara Dome (Middle Bathonian age). Abundant material, counting over 60 specimens, allows us to re-evaluate this enigmatic species and to add some more details to the evolutionary history of belemnites in the Southern hemisphere.

The present Jumara belemnites are the youngest finds of megateuthid belemnites in Gondwanian seas. Certain megateuthids were previously recorded from the Bajocian of Argentina only. Our finds are roughly contemporary with latermost megateuthid species, known as *Paramegateuthis* spp. from the Boreal realm in Northern hemisphere. Careful examination of outer morphology of Jumara specimens and comparative material led us to conclusion that Indian material, along with previous finds/reports from the Bajocian of Argentina studied in the La Plata Museum in Argentina, belongs to a separate, isolated lineage within megateuthidid belemnites.

Remarkably, megateuthidids in both hemispheres decline synchronously during the Middle-Upper Bathonian, being replaced by unrelated families (cylindroteuthidids in the Boreal realm and belemnopseids in the Tethyan realm Gondwanian epicontinental seas and North Tethyan margin). Such type of decline and replacement by differential families in both hemisphere might be explained by late Bathonian global sea level rise, that led to the formation of large epicontinental seas. This resulted in rapid evolution and diversification of more progressive belemnites in new habitats and final edgeding out megateuthidids especially during this time. The decline of megateuthidids in the central part of Tethys during the end of Late Bajocian indicates that neaby the equator this occurred even earlier, while in high latitudes in both hemispheres remained the refugia for megateuthidids during the Bathonian time.

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Keywords : Megateuthididae, belemnites, Kachchh, Middle Bathonian, biogeography

Discovery and revision of the age of Indonesian ammonite *Macrocephalites keeuwensis* Boehm [m] and its biostratigraphic and biogeographic implications

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Abstract

Recently, the presence of typical Bathonian Indonesian ammonites in Kachchh have enabled better biostratigraphic correlation between the South Tethyan (Indonesia, Nepal, Jaisalmer, Kachchh and Madagascar) and European localities (Jain, 2014). Here we additionally record the first occurrence of the Indonesian ammonite *Macrocephalites keeuwensis* **Boehm** 1912 **Var. A and B** [m] in the core of the Jara Dome in marl and marlstone intercalations (Point 48; 23°44'32" N: 68°59'00" E). Another fragmentary specimen (**Var. *forma flexuosa* [m]**) is now also recorded from the Jumara Dome, 12 km west of Jara. These ash-gray carbonate sediments (at both Jara and Jumara) have recently been well dated as *Late Bathonian* based on the presence of the *characteristic* **Indonesian ammonite** *M. mantataranus* **Boehm [M] (Jain and** Desai**, 2014).**

Based on this recent discovery, now, the age of the more cosmopolitan *M. keeuwensis* **Boehm [m] (from Indonesia, India, Madagascar, and Germany), previously straddling the Bathonian-Callovian boundary, rests comfortably within the Late Bathonian NW European Orbis Zone.** Similarly, the record of *M. mantataranus* **Boehm [M] from Kachchh now enables to date the** M. apertus-mantataranus Association of Central Nepal (bed 11 of unit Q2) as a **definite Late Bathonian rather than the earlier proposed and straddling the Bathonian-Callovian interval**.

These two species records, now also suggest that the age of the top of the pervasive ammonite-bearing ash-gray carbonate marker bed (= Sponge Beds; **bed A8 of Jain et al., 1996**) is Late Bathonian (=Orbis Zone, *Epistrenoceras histricoides* Horizon). Interestingly, a**t Jumara, the same Sponge bed (A8) has also yielded the** dimorphic pair of *Sivajiceras congener* (Waagen), an endemic species that closely resembles the European *Procerites imitator*;

P. *imitator* spans from Middle to Late Bathonian sediments. Based on the close morphologic and stratigraphic similarity of the Indian form with the European one, the former is considered as a geographic subspecies of the latter (Callomon, 1993).

The evolution of Genus *Macrocephalites* has recently been discussed in light of new discoveries from early Middle Bathonian sediments from Kachchh with its roots still firmly placed in Sula Island (Indonesia; see Westermann and Callomon, 1998; Jain, 2014). Globally, the Late Bathonian (early Discus Zone) is marked by a transgression (T11 of Hallam) and it is plausible that the entry of the more cosmopolitan *M. keeuwensis* **Boehm** *[m] from* **Indonesia to Kachchh (Jara and Jumara) and Madagascar (South Tethys) and on to Germany (Europe)** is likely to have been facilitated by this sea level rise.

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A new mid-Early Tithonian *Hildoglochiceras* assemblage from Western India

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A well-constrained and rare mid-Early Tithonian ammonite assemblage of *Hildoglochiceras* [*H*. *latistrigatum* (**Uhlig**), *H*. *kobelliforme* (**Oppel**), and *H*. *nodosum* **Prasad**] associated with *Aulacosphinctoides* is described from the Rupsi Shale Member of Jaisalmer Formation (western Rajasthan), western India. Based on the abundant and restricted occurrence of *H*. *kobelliforme* (**Oppel**), the Kobelliforme Zone is proposed. This zone is delimited below by the occurrence of the Earliest Tithonian genus *Virgatosphinctes* and above by the Late Tithonian index *Himalayites* aff. *seideli* (**Oppel**). The Kobelliforme zone is equated with the mid-Early Tithonian Tethyan Semiforme Zone. This new *Hildoglochiceras* assemblage now not only enables correlation of mid-Early Tithonian sediments within the Himalayan province (Nepal, Spiti, Kumaon and Pakistan) but also with the larger Indo-Malagasian (Kachchh and Madagascar) and beyond to Argentina (South America). Interestingly, an earlier recorded coeval-occurring specimen of *Hildoglochiceras* from the Tethyan Himalaya had yielded dinoflagellate cysts containing *Aldorfia aldorfensis*, *Broomea simplex, Pareodinia* sp. and the acritarch *Nummus similis*. The presence of *Broomea simplex* heralds the late Early Tithonian *Omatia montgomeryi* Zone, a dinoflagellate cyst event that is noted both within the Indo-Pacific realm (in Papua New Guinea and Australia) as well as in the Himalayas, Madagascar and Mexico, and corresponds with the standard ammonite Zones of Semiforme and Ponti of mid-Early Tithonian age. The present ammonite-based *Hildoglochiceras* assemblage recorded here also demonstrates a similar but more constrained age (restricted to the Semiforme Zone). Thus, it appears that within western India (Kachchh and Jaisalmer Basins), *Hildoglochiceras* is of mid-Early Tithonian age and well-correlated with the Tethyan Semiforme Zone. From here, it most likely spread to the Tethyan Himalayas on one hand and on the other to Madagascar and beyond to Argentina. Possibly, the almost world-wide sea level highstand within the Semiforme Zone enabled its migration to newer shallower niches. This hypothesis would also entail that the center of *Hildoglochiceras* evolution probably lies in western India, itself.

Key words:*Hildoglochiceras, Early Tithonian,* Late Jurassic, **Jaisalmer Basin, Western India**

Current status of ammonite biozonation in Kachchh (South Tethys) and correlation with the Standard Western European (North Tethyan) biozonation

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This contribution refines the Middle Jurassic (Bathonain-Oxfordian) ammonite biostratigraphy of Kachchh, based on a collection of 648 specimens belonging to 44 genera from Jumara Dome, a classical locality that exhibits not only the most expanded Callovian sequence for the basin but also for the entire northern periGondwana margin. Additional recordsof new species from KachchhMainland and Island beltshave also been incorporated.However, Jumara Dome in the Mainland Kachchhremains the most prolific and the best ammonite exposure with a deposition of 422 m thick sedimentary sediments.

However, it must be kept in mind that faunastically, Kachchh is marked by patchy and dominating occurrences of differing ammonite species even at coeval time intervals, with only a few species having a pan-basin distribution. This has resulted in the erection of multiple Zones, Subzone and Horizon levels. Hence, instead of single species dominance, an assemblage criteria is used in building biozones and correlated with the Standard European Zones.

Twelve ammonite Zones and four subzones are identified(see Table 1) and correlated both within the basin and with the standard Zones of the Submediterranean and Subboreal provinces. The identified Kachchh zones/subzone include: early Middle Bathonian (Arkelli Zone; Jain, 2014); early Late Bathonian (**ProceritesZone); Latest Bathonian (TriangularisZone); Earliest Callovian (MadagascariensisZone), mid-Early Callovian (Dimerus-Diadematus andFormosus Zones), late-Early Callovian (SemilaevisandOpis Zones); early-Middle Callovian (Anceps: Ramosa andKleidos subzones);late**

Discovery of a double-winged aptychus of latest Early Callovian index ammonite *Subkossmatia opis* (Sowerby) from Kachchh (western India)

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The present contribution records the first aptychus of the index ammonite *Subkossmatia opis* (Sowerby) (Family Sphaeroceratidae Buckman, 1920) from latest Early Callovian sediments of Jumara, Kachchh (western India). *S*. *opis* (Sowerby) transcends latest Early to earliest Middle Callovian interval and the present specimen is the earliest record of this species (Bed B35; Formosus Zone; Jain, 1996, pl. 18, fig. 3; Jain and Pandey, 2000). It is associated with *Bullatimorphites (Kheraiceras) bullatus, Parapatoceras tuberculatum, Macrocephalites subcompressus, M. lamellosus, M. dimerus and M. formosus*; the former two also mark their last appearance *(*Jain and Pandey, 2000). From this Formosus Zone, earlier Cariou and Krishna (1988) had also recorded *Collotia oxyptycha* and *Hecticoceras proximum*, index of Western Tethyan Proximum Horizon (Patina Subzone, Gracilis Zone).

The coupling of ammonite genera with the corresponding aptychus and the position of the aptychus within the body chamber (at 145 mm; phragmocone measures 108 mm) is an indication that the present aptychus belongs to the associated shell of *S*. *opis*. **Engeser and Keupp (2002) analyzed function and calcification of aptychi and distinguished uni- or single-valved horny anaptychi and calcified rhynchaptychi and aptychi with distinct two valves (thin-walled synaptychi and thick-walled diaptychi). The present specimen falls with the latter two-valved thin-walled synaptychi group. But the most unusual part of the specimen is its un**ornamented (smooth) nature, unlike the normally present concentric ornamentation. More such finds might necessitate erection of a new species.

Keywords: Aptychus, *Subkossmatia opis* (Sowerby), latest Early Callovian, Kachchh, Western India

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Middle Jurassic Kachchh Species Diversity: A Preliminary Analysis

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Preliminary Kachchh species diversity of both body fossils (ammonites, corals, and gastropods) and microfossils (ostracods and foraminifers) follow broadly similar trends with an initial low in Late Bajocian, increase in Bathonain, peak in Early Callovian, and reduction thereof until the Oxfordian. Early Callovian peak corresponds to a transgressive phase and correlates with the global Callovian radiation that co-occurred with a rapid relative sea-level rise from Bullatus to Gracilis Zones (equivalent to Madagascariensis-Formosus Zones in Kachchh). Locally, this increased species diversity also corresponds to higher nutrient content in the basin (=higher Phosphorus content). The beginning of the latest Early to early Middle Callovian regressive phase (from Opis to Anceps Zones) is marked by reduced species diversity corresponding with increased terrigenous content and high humidity. Preliminary analysis by this study suggests that species diversity in Kachchh is not monocausal but is a composite function of regional tectonics (opening up of new habitats and migration routes), the intensity of transgression, changes in clay content (reflecting changes in humidity and substrate), and rates of sedimentation, and above all changes in the relative sea level. However, which of these had a major role to play can only be borne out by more high resolution studies and by incorporating datasets of belemnites, bivalves, and brachiopods.

Keywords: Species diversity, Body fossils, Microfossils, Middle Jurassic, Kachchh, Western India

New Data on the Occurrence of rare Genus *Pachyerymnoceras* and *Phlycticeras* from the Indian Subcontinent

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Of the six widely known western Tethyan genera of family Pachyceratidae, only three - *Erymnoceras*, *Pachyerymnoceras* and *Pachyceras* have so far been described from the Indian subcontinent. *Erymnoceras* comes from Middle Callovian sediments and both *Pachyerymnoceras* (Kachchh, western India and Central Nepal) and *Pachyceras* (Kachchh) from Late Callovian sediments. However, elsewhere, family Pachyceratidae ranges from Middle Callovian to Middle Oxfordian. On the other hand, the occurrences of Genus *Phlycticeras* (Family Stringoceratidae Buckman, Subfamily Phlycticeratinae Spath) have mostly been noted in passing with few detailed and illustrated Early to Late Callovian records.

Here, two new Late Callovian Macroconch [M] species of *Pachyerymnoceras* (*P*. *vimlayii* and *Pachyerymnoceras* sp.) are recorded from the “Athleta beds” of Jumara and Ler (Kachchh, western India). The common occurrence of *Peltoceras* (*P*.) *ponderosum* at Jumara, Ler, Jara, Keera and Habo and the co-occurrence of *P*. *lalandeanum* in the Keera and Jara along enables correlation of *P. vimlayii* [M] with the Poculum subzone (mid-Athleta Zone) of the Submediterranean province. *Pachyerymnoceras* sp. occurs associated with *Collotia fraasi* and is here correlated with the Collotioformis subzone (early-Athleta Zone) of the Submediterranean province, assigned to an early Late Callovian age. Outside Kachchh and within the Indian subcontinent, *Pachyerymnoceras leave* from Central Nepal also comes from the Athleta Zone associated with *Collotia fraasi*. Thus, in Kachchh, Genus *Pachyerymnoceras* is restricted to the

Athleta Zone. However, globally, the earliest record of the Genus is from the earliest part of the Athleta Zone (Trezeense subzone) from the Arabian Province. Available data suggests that *Pachyerymnoceras* appeared first in Western Algeria and possibly migrated to Kachchh and then elsewhere during Mid to Late Callovian times.

This contribution also records the earliest occurrence of Genus *Phlycticeras* from the entire south of Tethys. *Phlycticeras polygonium* (Zieten) [M] is now recorded from latest Early Callovian sediments of Jumara and correlated with the Submediterranean Proximum subzone (Gracilis Zone). In light of new taxonomic data, the previously recorded *P*. gr. *pustulatum* (Reinecke) [M] from early Middle Callovian sediments is re-described as *P*. *polygonium* (Zieten) var. *nodosum* (Quensteadt) [M] and its occurrence is correlated with the Submediterranean Tyranniformis subzone of the Anceps Zone. New collections form the adjoining Jara Dome have also yielded both *P*. *polygonium* (Zieten) [M] and *P*. *polygonium* (Zieten) var. *nodosum* (Quensteadt) [M]. Thus, Genus *Phlycticeras* in Kachchh and in the Indian subcontinent ranges from latest Early Callovian (in Jumara: Semilaevis Zone = Proximum subzone) to the earliest Late Callovian (in Keera: Depressum subzone = Collotiformis subzone; Athleta Zone). The present record of *Phlycticeras polygonium* Zieten [M] from the latest Early Callovian sediments of Jumara is the earliest record from the entire south of Tethys.

Keywords: Kachchh, Middle Jurassic, Callovian, *Pachyerymnoceras*, *Phlycticeras*.

Record of Gondwana Plant fossils (Permian and Jurassic-Cretaceous) in Nimugudem area, Telangana, India: palynodating and palaeoenvironmental interpretation.

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Abstract:

We record Permian (Lower Gondwana) and Late Jurassic -Early Cretaceous (Upper Gondwana) palynomorphs in megafossils bearing beds in Nimugudem area of Godavari subbasin, Telangana State, India. Detailed palynological studies were carried out on outcrop samples from the exposure in nala of Nimugudem area where Leaf impressions of plant megafossils were also observed. Leaf impressions of *Ptilophyllum* and *Pterophyllum* recorded in this section indicates Upper Gondwana affinity for these sediments. Presence of different species of palynomorphs of Upper Gondwana affinity *viz. Callialasporites* spp. (*C. indicus, C. barragoanensis, C. dampieri, C. discoidalis, C. microvelatus, C. monoalasporous, C. reticulates, C. segmentatus, C. triletus, C. trilobatus, C. turbatus, C. variens*), *Araucariacites australis, A. fissus, Alsophyllidites kerguelensis, Biretisporites eneabbaensis*, *Cicatricosisporites* sp., *Classopollis classoides, Foveosporites cf. canalis*, *Laricoidites magnus, Podocarpidites ellipticus, Podocarpidites rarus, Podocarpidites typicus, Stereisporites antiquasporites* in sandstone beds indicate Late Jurassic-Early Cretaceous (Tithonian–Barriasian) age for these sediments. It is equivalent to Kota/ Gangapur Formation of Godavari Graben. The coal exposure yielding Late Permian palynomorphs viz. *Striatopodocarpites* spp. *Faunipollenites* spp., *Crescentipollenites*, *Strotersporites, Densipollenites Falcisporites, Lundbladispora, Densipollenites magnicopus, Marsupipollenites sp., Klausipollenites etc.*, belongs to Raniganj Formation.

Key Words – Palynology**,** Permian, Jurassic, Cretaceous, Mesozoic.

Palynological Analysis of Terminal Cenozoic Succession (Sandhan Formation) Western Kutch and their Implication on Age

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Palynomorphs are acid resistant organic walled microfossils that are encountered in palynological preparation. Their occurrence in geological records is dependent on environment of deposition, organic source, grain size, and hydraulic conditions. The spore and pollens are especially important as they occur in both marine and continental environments and can be used as a correlation tool for marine to continental shift of depositional milieu. Their study is highly requisite if succession is unfossiliferous/lacking age diagnostic fauna. This study is aimed at spore and pollen analysis of Sandhan Formation for its paleoenvironment, paleoecology and its age implications.

The Sandhan Formation occurs as discontinuous outcrops along cliff and banks of Kankawati River (Type section). The formation has an unconformable contact with underlying Chhasra Formation and has gradual contact with the overlying Quaternary/Sub-recent sediments. Based on stratigraphic and process based facies analysis, Sandhan Formation can be sub-divided into lower marine (135m) and upper fluvial (157m) succession. The marine succession is characterized by tide to wave dominated shallow marine environments representing shoreface, tidal flat, beach and lagoonal environment, whereas fluvial succession is characterized by multi-story/multi-lateral channels, overbank fine and floodplain of braided river system.

This study is carried out on 14 samples form marine and 8 samples form fluvial sediments. The palynological analysis of samples suggests diverse occurrence of spores and pollens, amorphous organic matter and fungal spores were also recorded. Their occurrence at different stratigraphic-levels is useful to interpret depositional environment and paleoecological conditions; however,

most of the species are long ranging and are inappropriate for biostratigraphy.

The presence of marine species such as *Meliapollis sp., Retritricolpites sp., Triporopollenites sp., Palmaepollenites sp., Tricolpites sp., Polyporina sp.* indicate deposition of sediments under a coastal marine settings in tidal to wave dominated shallow shelf environment in a humid and warm climate. *The terrestrial species are characterized by Polypodiaceaesporites sp., Pinuspollenites sp., Scabratricolpites sp., Verrumonoletes sp., Disaccites sp.* These species are exclusively occurring in finer sediments of fluvial successions especially in channel fills, overbank fines and flood plains and suggests arid climatic. The abundance of reworked Jurassic and Cretaceous palynomorphs is significant in this part of the formation.

The Sandhan Formation overlies Chhasra Formation (Burdigalian) through an unconformity. Its age is not established because of the absence of age diagnostic fauna. Intuitively, the Pliocene age is designated to the Sandhan Formation because of prominent break in sedimentation above Burdigalian (Miocene) and order of superposition. The marine assemblage of spore and pollens shows an affinity to Late Miocene-Pliocene age which suggests that deposition of Sandhan Formation was initiated in Late Miocene instead of onset of Pliocene. However, upper age limit of Sandhan Formation is not delineated because of the long ranging character of palynomorphs in the fluvial part. The analysis corroborates to the field observation and environment shift from marine to fluvial conditions. The palynomorph occurrence from the marine part of the formation indicates that deposition took place in a warm and humid climate whereas, assemblage from fluvial part indicates dry and arid climate. Increase in abundance of reworked Cretaceous and Jurassic palynomorphs in the fluvial part of the succession suggests Mesozoic sediments acted as a possible provenance for the upper part of the Sandhan Formation.

Keywords : Palynology, Sandhan Formation, Marine to fluvial transition.

Palaeoenvironmental, palaeoecological and palaeobiogeographical implications of the fresh water Late Cretaceous ostracods, charophyte and distinctive residues from coprolites of the Lameta Formation at Pisdura, Chandrapur district (Maharashtra), Central India

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The coprolites of four types i.e. Type A, B, Ba and C belonging to the titanosaurid sauropods have been recorded in large number from the red silty clays of the Lameta Formation of Pisdura, Chandrapur District, Nand-Dongargaon Basin, Maharashtra, central India**.** The only access that scientist today have in understanding the digestive physiology of large plant eating dinosaurs is either through uniquely preserved stomach contents or through the plant contents in expelled material. **The coprolitic material known from Pisdura has received attention worldwide in the last fifteen years** because a variety of plant and animal material has been recovered pointing to an herbivorous nature for these producers. In order to understand the detailed micropalaeontological studies **of the coprolites of Type A, which are** are 80-100 mm in diameter and were haphazardly broken **by the hammer and were macerated with 10-15%** H_2O_2 **and then treated with 10% Hcl for few hours and then sieved. The putative coprolites from Pisdura have yielded** a varied microbiota, represented by the ostracods like *Paracypretta* sp., *Gomphocythere* sp., *G. paucisulcatus, Cypridopsis* sp., *Cypridea* (*Pseudocypridina*) sp., *Eucypris* sp. and ?*Mongolianella* sp., a charophyte (*Microchara* sp.) and numerous unique plant fossils showing well-preserved microstructure. The other macerated micro fauna studied under scanning electron microscope includes plentiful siliceous microfossils, sponge spicules and diatoms. Apart from fauna, micro flora comprises gymnosperm seed-like structures and scales, twigs with needle-like leaves, woody tissues, plant cuticles with imperative longitudinal ridges, chrysophyte resting spores, probable fungal hyphae mineralized in a void, and possible leaf laminae replaced with silica. In the present study, I am focusing mainly on the systematics of ostracods and a charophyte. Palaeoecologically, the ostracod assemblage includes poor swimmers (*Cypridea* and *Gomphocythere*) and active swimmers (*Paracypretta* **,** *Cypridopsis, Eucypris* and *Mongolianella*). The non-marine, low energy aquatic *Paracypretta* sp. dominate the recovered

assemblage of 7 species from the Pisdura coprolites. The genus *Gomphocythere* has been considered as low energy aquatic, epibenthonic walker/crawler. The taxa such as *Cypridopsis and Mongolianella* favoured to subsist in enduring waters (ponds and lakes) that would permit to move away to the deeper parts of the water body. The genus *Eucypris* lived in temporary water bodies. The bulk of the ostracod fauna and charophyte points to a freshwater, arid terrestrial environments that included shallow, alkaline, lacustrine, low energy aquatic, palustrine environments for the Lameta Formation of Pisdura. Palaeobiogeographically, the biotic assemblage illustrates an assorted pattern ensuing from the accumulation of Indian endemic forms, Gondwanan elements to Laurasian taxa. The ostracod fauna from the Pisdura infratrappeans is rather endemic to Indian subcontinent. The Pisdura fauna includes endemic ostracod taxa for example *Paracypretta and Gomphocythere* .On the whole the Pisdura ostracod taxa, such as *Mongolianella, Cypridopsis* and *Eucypris* emerge to have diffused out from India to assorted parts of the Maastrichtian world. The presence of dinosaur skeletal material and eggshells indicates Gondwanan affinities. Thus *Microchara* sp. from Pisdura shows affinities with the Late Cretaceous and early Paleogene of Mongolia and China and while *Microchara* sp. emerges to be endemic to peninsular India and also has an extensive allocation in Laurasia. Apart from charophytes, other previously recorded biota from peninsular India for instance some pollen, alligatorid crocodiles, anguimorph lizards, pelobatid and discoglossid frogs, and troodontid dinosaur show affinities of Laurasian origin. The endemic ostracods probably originated during the complete isolation and the northward drift of the Indian plate during the late Cretaceous period. The dispersal route for the Laurasian biota can be persuasively elucidated by way of sweepstakes routes from Asia to the Indian subcontinent while the biota with Gondwanan affinities may reflect vicariance.

Keywords: Late Cretaceous, Pisdura Coprolites, Ostracods, Charophyte, Palaeoenvironment, Palaeoecology, Palaeobiogeography.

Distribution and Ecology of Recent Ostracods from the sediments of Serthalaikadu Creek, Tamil Nadu, South East Coast of India.

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Ostracods are successful inhabitants of almost every aquatic environment. Hence, in order to understand the ecology of the sediments from Serthalaikadu Creek, South East coast of India, surface sediments samples were collected from 20 localities covering entire creek area and additionally salinity, temperature measurement were taken at the time of sampling for comparative study. A total of 24 marine ostracod species were identified from the Serthalaikadu Creek and the distribution of these ostracods were predominantly controlled by salinity, nature of substrate, depth and organic matter etc. Among these species, *Neomonoceratina iniqua* is a dominant and persistent taxon (70% and above) followed by *Hemicytheridea Paiki* (10%), *Stigmatocythere Indica* (10%) and other species constitute the remaining <10% in the entire population. The most abundant ostracod species *Neomonoceratina iniqua* is found to be restricted to tropical to sub-tropical environment and it is widely reported from east coast of India. Further, *Neomonoceratina iniqua, Hemicytheridea Paiki and Stigmatocythere indica* were earlier recorded from the east coast of India under the temperature range (25.6° C to 33.5° C) and salinity range (31.8 to 34.9 ppm).

Keywords : Ostracoda, Surface sediments, Neomonoceratina iniqua, Serthalikadu Creek

Palynostratigraphy, palaeovegetation and depositional environments of the Bhuj Formation (Early Cretaceous) of northwestern Kutch, India

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Kutch, a major sedimentary basin of northwestern India comprising unique late Gondwanic sediments, of which the youngest sedimentary succession of Bhuj Formation is analyzed to define palynoflora, palynozones (cenozones), palaeovegetation and depositional environments. A 25 m thick sedimentary succession of carbonaceous shale, clay, siliceous clay/shale, thin coal seam and sandstone etc. is exposed near Trambau village embodies palynoflora *viz*., abundant megaspores, microspores, gymnosperm pollen grains, dinoflagellate cysts and colonial alga *Botryococcus braunii* etc. The quantitative and qualitative analyses of recorded palynoflora exhibit dominance of *Minerisporites kutchensis* megaspores in the basal part (0-4.5 m) followed by dominance of *Araucariacites australis* pollen grains in the upper part (4.6 – 25 m) of the sedimentary succession. The palynoflora occur in the *Minerisporites kutchensis* cenozone are - *Minerisporites institus, M. auriculatus, M. reticulates, Paxillitriletes batenii, P. maheshwarii, Cyathidites australis, Concavissimisporites variverrucatus, Murospora florida, Contignisporites cooksonii, Retitriletes nodosus, R. astroclavatus, Ruffordiaspora loodbrokiae, Asterisporites chlonovae, Araucariacites australis, Tsugaepollenites* sp., *Cycadopites grandis* etc. with dinoflagellate cysts *Coronifera oceanica, Oligosphaeridium pulcherrimum, Prolixospaeridium parvispinum* and *Botryococcus braunii*. Occurrence of megaspores, microspores, conifer pollen grains, dinoflagellate cysts and colonial alga in the cenozone identified in the basal part of the succession indicate their deposition in peat-mire habitat situated along the cost during Late Aptian to Albian. The overlying *Araucariacites australis* cenozone contains rich conifer pollen grains followed by pteridophytic spores, few megaspores; *Botryococcus braunii* and no dinoflagellate cyst suggest their deposition in fresh water lake through fluvial channels. The botanical affinity of megaspores with heterosporous Lycopsides, Isoetales, water ferns, microspores of tree ferns, ferns, other pteridophytes and pollen grains of conifers indicate prevalence of subtropical warm humid climate during the development of vegetation and their burial in the sediments. The recorded palynoflora also show relationship with other contemporaneous late gondwanic deposits of the southern hemisphere.

Keywords - Palynostratigraphy, depositional environments, early Cretaceous, Kutch

Influence of substrate characteristics on the diversity and abundance of Recent Benthic Foraminifera from the inner shelf sediments of northern part of Gulf of Mannar, southeast coast of India.

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To inventory the influence of subtract characteristics on the diversity and abundance of Recent benthic foraminiferal fauna from the inner shelf of northern part of Gulf of Mannar, systematic collection of sediment samples, along three almost equispaced traverses, off the coast of Keelakarai, Muthupettai and Mandapam has been made. Samples were collected from 7 stations in each traverse and thus 21 samples were collected for each of the three seasons viz. pre monsoon, post monsoon and summer. Each field collection was followed by a systematic study of foraminiferal population, and estimation of various sediment parameters using standard procedures.

Systematic study of the samples collected leads to the identification of 126 foraminiferal species belonging to 60 genera, 40 families, 20 super families of 5 suborders. Among the 126 living species, the following species are considered widespread and abundantly occurring viz. *Ammonia beccarii, Ammonia tepida, Asterorotalia inflata, Nonionoides boueanum, Nonionoides*

grateloupi, Quinqueloculina seminulum and Spiroloculina communis.

The population size both living and total (living + dead) in each of the stations during different seasons reveals that the maximum living population size and higher diversity are found in stations between 3 and 6 during all the collections and the living population is maximum in summer (April) and is minimum during monsoon (October).

The spatial distribution of heavy metal concentration reveals that they are more concentrated in stations 2-6. Deformities in *Helinina perlucida, Nonionoides boueanum, N. grateloupi, Pararotalia nipponica, Peneroplis planatus, Quinqueloculina polygona, Spiroloculina costifera, Sorites orbic*ulus, *Ammonia dentata, Asterorotalia trispinosa and Operculina ammonoides* are attributed to the concentration of the heavy metals in the sediments.

In general, the favourable substrate characteristics for the diversity and abundance of living population of the study area are higher $CaCO_3$ content and optimum (0.8 – 1.0 %) organic content of the substrate. The accommodative substrate for the species is siltysand.

Key words: Recent Benthic Foraminifera, shelf sediments, Gulf of Mannar, **s**ubstrate characteristics

Microinvertebrates from Early Eocene to Middle Miocene of Kachchh Offshore Basin, India

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The Kachchh Basin is the westernmost pericratonic rift basin situated at the northern end of the western seaboard of India and this basin represents the earliest rift during the break up of Africa and India. The Kachchh Basin in Onland and Offshore is filled with sediments ranging in age from the middle Jurassic to Recent. Due to easy access and well preserved Cenozoic sequence in the Onland portion of Kachchh Basin, voluminous work has been done on different mega fossils and microfossils from this portion. However, core samples from the Cenozoic sediments of Offshore portion of Kachchh Basin are not easily available and hence limited work has been done on the Cenozoic sediments of Offshore portion of Kachchh Basin.

The sediments of the Kachchh Offshore Basin are ranging in age from the early Cretaceous to the Recent and these sediments are divisible into eleven formations, which in order of superposition are: Bhuj Formation (middle to late Cretaceous); Mundra Formation (middle to late Cretaceous)/Naliya Formation (middle late Cretaceous); Deccan Trap (late Cretaceous); Nakhtarana Formation (late Paleocene); Jakhau Formation (early Eocene); Fulra Limestone (late middle Eocene); Tuna Formation (early Oligocene); Narayansarovar Formation (late Oligocene); Godhra Formation (early Miocene); Chhasra Formation (early middle Miocene) and Kandla Formation (middle Miocene to Recent).

The present author was lucky to get core samples from ONGC Ltd. of sediments ranging in age from early Eocene to middle Miocene of Offshore portion of Kachchh Basin and in a series of papers he has documented different microfossils. While early Eocene Jakhua Formation has

presence of only Foraminifera: *Assilina sp., Nummulites sp., Operculina sp., and Quinqueloculina sp.* (Kundal, 2014a). The late middle Eocene Fulra Formation has presence of Foraminifera: *Nummulites, Lockhartia, Globorotalia, Operculina*, *Rotalia, Textularia* and *Linderina* (Kundal, 2014b). The early Miocene Godhara Formation has presence of Foraminifera: *Ammonia*, *Operculina*, *Miogypsina* and *Textularia* (Kundal, 2014b), Bryozoa: ?*Crassimarginatella* sp., *Thalamoporella* sp. and *Vincularia* sp. (Kundal, 2014c) and Calcareous Algae: *Arthrocardia cretacica* Raineri, *Calliarthron antiquum* Johnson, *Corallina grandis* Rao, *C. hayasaki* Ishijima, *C. raoi* Chatterji and Gururaja, *Jania guamensis* Johnson, *J. sripadaraoi* Kundal and Humane and *Subterraniphyllum thomasii* Elliott (Kundal and Humane, 2012) while the early middle Miocene Chhasra Formation has presence of Foraminifera: *Textularia, Globorotalia*, *Sphaerogypsina*, *Operculina*, *Planolinderina*, *Spiroloculina*, *Miogypsina*, *Biloculina*, *Austrotrillina howchini, Pseudotaberina malaberica*, *Sorites orbicularis*, Miliolids, Rotalids (Kundal, 2014b), Bryozoa: ?*Margaretta* sp., *Steginoporella* sp., ?*Thalamoporella* sp. and *Vincularia* sp. (Kundal, 2014c) and Calcareous Algae: *Corallina* viz. *C. crassa* Ishijima, *C. delicatula* Johnson and Ferris, *C. elliptica Ishijima, C. grandis* Rao, *C kachchhensis* Kundal and Humane, *C. marshallensis* Johnson, *C. matansa* Johnson, *C. otsukiensis* Ishijima, *C. prisca* Johnson, *C. raoi* Chatterji and Gururaja and *C. typica* Ishijima (Kundal, 2015a), *Lithothamnion valens* Foslie, *Mesophyllum roveretoi* Conti, *Phymatolithon calcareum* (Pallas) Adey and Mckibbin, *Melobesioideae* gen. et spec. indet. and *Lithoporella melobesioides* Foslie (Kundal et al., 2015), *Arthocardia indica* Kundal and Humane, *Jania indica* Kundal and Wanjarwadkar (Kundal, 2015b).

This paper records for the first time Echinoid Spines from late middle Eocene Fulra Limestone Formation and early middle Miocene Chhasra Formation; Ostracod shells from early Miocene Godhra Formation and early middle Miocene Chhasra Formation; Gastropod shell from early Miocene Godhra Formation and early middle Miocene Chhasra Formation; while Corals from early Miocene Godhra Formation from Kachchh Offshore Basin, Western India.

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Calcareous Algae from the Late Pleistocene Miliolite Formation of Kachchh, Gujarat, India

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The Quaternary sediments of the Kachchh area, Gujarat, India are represented by Mahuva Formation, Mohadi Formation, Chaya Formation, Miliolite Formation and Kothara Formation. A rich assemblage of calcareous algae dominated by Coralline algae is documented from the Late Pleistocene Miliolite Formation of Kachchh, Gujarat. The nongeniculate coralline algae are represented by 6 *species, namely Lithophyllum incrustans Philippi, Lithophyllum sp.1, Lithoporella melobesioides Foslie, Lithothamnion sp.1 and Lithothamnion. sp.2.* The geniculate coralline algae are represented *6 species, namely: Amphiroa anchiverricosa Johnson and Ferris, A. fortis Johnson, A. rigida Lamouroux, Corallina grandis Rao, C. prisca Johnson and C. typica* Ishijima. The calcareous algal assemblage is represented by a solitary species *Ovulites* sp. belonging to the Udoteacean algae. *The present algal assemblage indicates that the sediments (containing algae) of the Miliolite Formation were deposited in nearshore / beach marine environment. Later on, these sediments were windblown to form aeolian Miliolites.*

Will increasing greenhouse gas concentration induced ocean acidification cause benthic foraminiferal extinction by the end of the current century ?

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The persistent increase in greenhouse gas concentration in the atmosphere is causing ocean acidification. The ocean acidification affects calcareous marine organisms, including foraminifera. Recently, based on the absence of benthic foraminifera near natural volcanic vents, it was suggested that the projected ocean acidification levels will cause extinction of benthic foraminifera by the end of this century. The conditions around volcanic vents, however, may not exactly mimic those under greenhouse gas induced ocean acidification. Therefore, we tested the response of benthic foraminifera to extreme levels of carbon dioxide, much higher than that expected by the end of this century, under controlled laboratory conditions. The entire benthic foraminiferal assemblage along with the sediments collected from coastal waters off Goa were subjected to different CO_2 concentrations (1000 ppmv, 2000 ppmv, 3000 ppmv, 4000 ppmv) by modulating ambient air. All the sets were maintained at constant temperature (27°C), salinity (35 ‰) and food. The media was continuously aerated. The physico-chemical parameters (pH, salinity and dissolved oxygen concentration) were measured routinely. A minor increase in salinity was noticed with fairly constant dissolved oxygen throughout the experiment. Initially a drop in pH was observed, immediately after inoculating the cultures in CO_2 stabilized media but later, the pH stabilized. The experiment was conducted for 125 days. At the end of experiment, the sediment samples were processed following standard procedure. Both the living and fossil benthic foraminifera were picked. Benthic foraminiferal abundance deceased with increasing CO_2 concentration. Interestingly, the abundance of infaunal benthic foraminifera increased and that of epifaunal forms decreased with increasing CO_2 concentration. The calcareous benthic foraminiferal population decreased and that of agglutinated benthic foraminifera increased with increasing CO_2 concentration. The most significant finding of this work was that benthic foraminifera survived at as high as 4000 ppmv CO_2 concentration, which is many fold higher than the projected levels by the end of this century. Therefore, we prove that it is unlikely that benthic foraminifera will get extinct by the end of this century under the influence of greenhouse gas induced ocean acidification.

Orbitoidal/Orbitoidiform Larger Benthic Foraminifera of Upper Cretaceous Shallow Marine Sequences of the Trichinopoly, Cauvery Basin, Southeast India : A biometric approach and paleobiogeographic synthesis

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The late Cretaceous orbitoidiform benthic foraminifera are very common in late Cretaceous sediments of the Ariyalur region in Cauvery Basin. Stoliczka (1873) was the first to name the orbitoidiform foraminifera from the Cauvery Basin. He assigned these foraminifera to *Orbitoides faujasi* (Defrance, 1823). Vredenburg (1908) was the first to assign the Cauvery Basin orbitoidiform assemblages to *Lepidorbitoides minor* (Schlumberger, 1901). After Vredenburg (1908), some new taxa have been erected from the late Cretaceous outcrops that are mainly exposed near Ariyalur region in Cauvery Basin. These taxa are represented by *Lepidorbitoides blanfordi* (NarayanaRao, 1941), *Lepidorbitoides inornata* (NarayanaRao, 1941), *Orbitocyclina ariyalurensis* (NarayanaRao, 1941). Thus, the occurrence of more than one genus (two genera) in the late Cretaceous sediments of the Ariyalur region in the Cauvery basin. The morphological changes observed in the central part of orbitoidiform foraminifera allow the distinction of successive species/subspecies based on the numerical characterization of evolutionary parameters. Biometric study has been carried out for an accurate description of the taxa. Thus, an accurate description and characterization of these foraminifera depend on the studies of the foraminifera shell in oriented sections and application of biometric procedures, which were developed in the last several decades of the last century. The world-wide distribution of these groups and their paleobiogeographic synthesis suggest that Orbitoides and Lepidorbitoides are very common in Tethys spanning from West Europe to Himalayas and West Pacific.

Key Words : Foraminifera, Upper Cretaceous, Cauvery Basin, Biometric, Palaeobiogeography

Ecology and distribution of *Asterorotalia in the western Bay of Bengal*

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The foraminiferal species abundance is a function of its adaptive response to changing environmental conditions. *Asterorotalia*, a benthic foraminifera has been reported from varied substrates with a preference for hyposaline conditions. The effect of various physico-chemical properties of seawater on its distribution and abundance is, however, debated. In view of this, a total of 97 surface sediment samples from the riverine influx dominated western Bay of Bengal have been collected from water depths of ~25 m to ~3000 m, covering the entire shelf, slope and a part of the abyssal region. The samples were analyzed for benthic foraminiferal abundance and *Asterorotalia* was found in 33 samples. The relative abundance of living as well as total (living and dead) *Asterorotalia* ranges from being absent to a maximum of ~32%. The highest abundance of *Asterorotlia* (living and total) is noted very close to the river mouth and the abundance decreases away from the river mouths. The living *Asterorotalia* abundance is lowest in between two major river systems, viz. Ganga-Brahmaputra-Mahanadi and Krishna-Godavari, being as low as ~2%. The Principal Component Analysis (PCA) and simple correlation was carried out to understand the relationship of *Asterorotalia* with environmental variables. Out of all the environmental variables, *Asterorotalia abundance* is strongly positively correlated with temperature. On the other hand, $\%C_{org}$ and salinity are negatively correlated with both the total and living *Asterorotalia* abundance. The abundance of *Asterorotalia* also correlates well with the pH of the ambient seawater. Therefore, the spatial variation in *Asterorotalia* abundance is attributed to terrigenous and freshwater influx and resultant change in physico-chemical conditions. This study provides a better understanding of the ecology of *Asterorotalia.* The findings can be used to reconstruct paleo-monsoonal fluctuations from the east coast of India.

Key words: *Asterorotalia*, ecology, western Bay of Bengal, paleomonsoon, riverine influx

Palynostratigraphy and palaeoecological interpretation of the early Miocene sediments of Amarpur, Tripura, India.

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A rich and moderately diversified palynological assemblage comprising 124 species belonging to 97 genera described from surface samples of Amarpur representing the middle Bhuban Formation of Tripura basin. The palynoassemblage dominated by pteridophytic spores (16 genera 32 species), angiosperms pollen grains (37 genera 44 species), fungal remains (14 genera 14 species), gymnosperms pollen (4 genera 9 species), dinoflagellate cyst 11 genera and 10 species and other reworked pollen grains (15 genera 15 species). The palynoflora of Amarpur subdivides the sediments into three cenozones, namely *Pteridacidites vermiverrucatus* cenozone, *Malvacearumpollis bakonyensis* cenozone and *Albertipollenites crassireticulatus* cenozone respectively. The assemblage is typically indicative of a tropical to subtropical warm humid climate with high rainfall in a delta distributary channel under shallow marine influence. The terrestrial elements of upland flora and low land vegetational flora tend to merge with fresh water constituents. The dominant pollen elements (*Spinizonocolpites, Palmaepollenites, Malvacearumpollis*) suggest evidence of brackish water mangrove swamp along the coastal line. The stratigraphically significant taxa such as *Clavaperiporites jacobii, Proteacidites triangulus, Spinizonocolpites echinatus, Pteridacidites vermiverrucatus, Retitrescolpites typicus, Malvacearumpollis bakonyensis, Albertipollenites crassireticulatus* suggest an early Miocene (Aquitanian – Burdigalian) age. A comparison of the present palynoassemblage with other contemporaneous Tertiary assemblages of India reveals closed similarity with floras of Bengal, Mizoram, Assam, Meghalaya and Kerala basins. Moreover, palaeoclimates and environment of deposition have also been discussed on the basis of palynotaxa.

Key- words- Palynostratigraphy, Bhuban Formation, Amarpur, Tripura, India.

Ostracode fauna from Katrol Formation, Mainland Kachchh, Gujarat, India

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The Mesozoic of Kutch has drawn major attention on global scale in fields like lithostratigraphy, biostratigraphy, paleoecology and palaeoenviornmental interpretations in last few decades but the scarcely fossiliferous Katrol Formation has received less attention compared to other fossiliferous stratigraphic units. Although a broad statigraphical background has been presented for the Formation by several workers, detailed micropaleontological work is yet to be carried out. The lithology of the Formation comprises of predominantly dark grey to black shales, interbedded with ferruginous sandstones and laminated micaceous siltstone. Sandstone yields a rich assemblage of trace fossils. The present work deals with ostracode fauna from Katrol Formation. 21 samples were collected from two sections exposed around 1/2km North of Jadura village (23° 09' 51.7" N: 69° 41' 32.1" E). Nine samples were collected from Section I exposed along Jadura-Bhuj road and 12 samples were collected from Section II exposed along the eastern flank of a nala cutting about 100m west of Jadura-Bhuj road. All the samples from Section I have yielded a well preserved ostracode fauna represented by 21 species while Section II is devoid of Ostracodes.

Of 21 species, 5 species- *Eucytherura guillaumeae* Ballent and Whatley, *Majungaella perforata kachchensis* Khosla, Jakhar and Mohammed, *Macrodentina* sp. *cf. M. (M.) cicatricose* Malz, *Pirileberis tenuisculata* Mette and Geiger, *Trichordis jaisalmerensis* (Kulshreshtha, Singh and Tewari) - are assigned to already known taxa and 16 species - *Bairdia* sp., *Cytherella* sp., *Cytherelloidea* sp., *Eucytherura* sp. 1, *Eucytherura* sp. 2, *Fabanella* sp. 1 *Fabanella* sp. 2, *Fabanella* sp. 3, *Fabanella* sp. 4, *Fabanella* sp. 3, *Lophocythere*? sp., *Monoceratina* sp. 1, *Monoceratina* sp. 2, *Monoceratina* sp. 3, *Paracypris* sp., *Schuleridae* sp.- are left under open nomenclature.

Keywords: Ostracode fauna, Katrol Formation, Gujarat

Ostracode fauna from Karai Formation, Uttatur Group, Tiruchirapalli

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Exposed upper Albian-early Turonian Karai Formation, a marine, fossiliferous sedimentary sequence of Ariyalur area in Cauvery basin, have long been known for its lithological and faunal diversities. Comprehensive studies have already been carried out owing to rich, varied macro-and microfossil assemblages. As far as ostracodes are concerned, researchers have not been given much emphasis on the fauna from the Formation. In the present work, an attempt has been made for a relook into the Karai shale Formation based on its ostracode fauna. The formation has been divided into two members namely, in ascending order, Gypsiferous clay Member and Odiyam Sandy Clay Member, and composed predominantly of silty and sandy claystone; and has been known for its occurrence of ammonites, belemnite rostrum, Gryphaea, Foraminifers, thalassinoides and serpulids. Nineteen samples have been systematically collected from different locations of the formation covering both the members (14 samples from Gypsiferous clay Member and 5 samples from Odiyam Clay Member). All the samples yielded a well preserved ostracode fauna and are represented by 13 species. The checklist of the recorded fauna is as follows - *Bairdia* sp. 1, *Bairdia* sp. 2, *Bairdia* sp. 3, ***Bythocypris* sp., *Cythereis* sp., *Rehacythereis* sp. 1**, ***Rehacythereis* sp. 2, *Schuleridea* sp. 1, *Schuleridea* sp. 2, *Cytherella* sp. 1, *Cytherella* sp. 2, *Cytherelloidea* sp. 1, *Cytherelloidea* sp. 2.**

Keywords: Ostracode, Karai Formation, Turonian

Distribution of recent benthic ostracoda assemblages off Kurusadai Island, Gulf of Mannar, Southeast coast of India.

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The main objective of this study is to provide information about the ecological preferences of recent shallow marine Ostracoda from the twenty two bottom sediments and water samples around Kurusadai island that were collected during different seasons, namely, Fair weather season (May 2013), Southwest monsoon (2013) and Northeast monsoon season (December 2013). The distribution of Ostracoda and their population for the said seasons are presented. The sediment and water parameters were found and compared with the population of Ostracoda. The seasonal assemblages of benthic Ostracoda and its distribution in marine environments depend on many factors, but the sediment parameters like, type of substrate, calcium carbonate, organic matter and water parameters such as depth, Dissolved Oxygen, temperature, salinity along with species that has affinity to Mangroves and Corals with special reference to thickness of shells. The development of either a single species or an Ostracoda assemblage is influenced by physico–chemical characters of waters (salinity, temperature, pH, dissolved oxygen and nutrients) and hydraulic conditions. The dynamics of water significantly affect the nature and distribution of sediments around Kurusadai island that influence the assemblages of Ostracoda.

Key words: Recent benthic Ostracoda, Seasonal assemblage, Mangroves, Corals, Kurusadai island, Gulf of Mannar.

A comparativestudy of benthic foraminifera and geochemical assessment of Arasalar and Thirumalairajanar esturies, Karaikal, Southeeast coast of India.

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Foraminifera are a group of single celled, almost exclusively marine micro-organisms. They are either planktonic or benthic in habit. They are excellent paleoecological indicators because they are short-lived protists with rapid generation times, and thus are generally more sensitive to changing environmental conditions. They respond to these changes by adapting, perishing, multiplying, diversifying, or by changing the chemical composition of their tests, etc. Benthic foraminifera occupy a wide range of marine environments, from brackish estuaries to the deep ocean basins and occur at all latitudes. Many species have well defined salinity and temperature preferences making them particularly useful for reconstructing past trends in ocean water salinity and temperature.

An estuary is a partially enclosed body of water along the coast. Where freshwater from rivers and streams meets and mixes with salt water from the ocean and the lands surrounding them are places of transition from land to ocean and freshwater to salt water. Each estuary is unique with respect to physical, chemical and biological characteristics, but estuaries share many common features. For example, rivers provide a continuous input of sediment into the estuary. In the present study areas are Arasalar and Thirumalairajanar estuaries in Karaikal region is embedded in Nagapattinam and Thiruvarur Districts of Tamil Nadu state. Totally 24 surface sediments and water samples were collected from each estuary. Both sediment and water samples were collected at all locations for micropaleontological, sedimentological, ecological and hydrogeochemical studies.

Based on the foraminiferal studies, a total of 60 species of foraminifera were recorded from both estuaries. Out of which 38 species of foraminifera, belonging to 22 genera, 12 families and 6 sub-orders were recorded from Arasalar estuary, and 22 species of foraminifera were observed from the sediment samples of Thirumalairajanar estuary. They belonged to 14 genera, 8 families and 3 sub-orders. Seven species were common in both estuaries. Thirty one and fifteen species

were found to be unique in Arasalar and Thirumalairajanar estuaries respectively. The species belonging to sub-orders Textulariina, Miliolina, Lagena, Globigerina and Rotaliina are seen in Arasalar estuary. And the sub-orders Textulariina, Miliolona and Rotaliina are only noticed in Thirumalairajanar estuary, compared to the Arasalar estuary they are shows higher abundance. Among the living foraminiferal population in both the estuaries, calcareous forms are found to predominant. In both the area living foraminiferal population belonging to the genus Ammonia (especially *A. beccarii, A. tepida* and *A. dentata*) are found to be predominant. *Quinqueloculina patagonica, Haynesina depressula, Nonion commune and Ammonia convexa* are newly identified species in Thirumalairajanar estuary.

Various sedimentological parameters such as organic matter, calcium carbonate and sand-silt-clay were determined in each estuary. The organic matter contents are higher in amount in the eastern and western side of the estuarine sediments, the foraminiferal distribution also higher in amount in those locations. The abundance of organic matter depicts that the sediments are immature and appears to have been derived from marine sources. In addition to the above, other controlling factor may be rate of sedimentation, which is variable in different areas of the river. The high inorganic sedimentation will dilute the environment of organic matter in sediments and increase of organic matter with decreasing the grain size has been reported from many areas, all over the world, and is attributed to co-sedimentation of particles. In the present study areas, a direct relationship was observed between the calcium content and abundance and diversity of foraminifera. The species belonging to sub-orders Miliolina and Rotaliina were abundant on the east coast of these two estuaries, where calcium content was more. The very high abundance and diversity of foraminifera found at eastern part of the Arasalar and Thirumalairajanar estuary are correlated to the presence of high amount of fine sand and clay in the sediment composition.

The trace element studies are also carried out in the samples. The results also indicate that the Arasalar and Thirumalairajanat regions is more contaminated with Co and Pb. Based on the comparative levels of metals in the studied area to other areas, the levels of metals content are lower than in other areas. The extractable metals indicate that the sediments of these study area were relatively unpolluted. But compared to the Arasalar estuary, Thirumalairajanar estuary is slightly polluted with reference to some locations. Broken species are noticed in some locations in Thirumalairajanar estuary, where the trace elements concentration is slightly higher in these regions this is also one of the reasons for the morphologic deformative abnormal study in this regions. The results from scientific literature indicate that benthic foraminifera are excellent indicators to monitoring the marine-coastal environments.

Palynological studies from Chorabari Glacier, Kedarnath: Implications to Holocene climate change

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The highly revered Kedarnath temple is situated at an altitude of 3440m in the outwash plain of the Chorabari Glacier. The glacier is located in the Rudraprayag District of Uttarakhand. The typical U-shaped glacial valley was carved out by the glacier during its current phase of retreat. The outwash plain of the Chorabari Glacier is well developed and is about one km long and half a km wide; where, over the years, a small township has come up around the temple. The Chorabari and adjoining Companion glaciers are presently in a state of retreat as evidenced by the kame terraces, wide U-shaped valley andrelict moraines.

The region experiences temperate climate and receives precipitation mainly from Southwest Summer Monsoon. Most of the rainfall is receivedduring the months of June to September by Southwest Summer Monsoon, while during winters there is heavy snowfall due to the Western Disturbances. The vegetation around Kedarnath is basically an alpine meadow, characterized by high-altitude herbaceous taxa. During June2013, the area suffereda catastrophic toll of life and propertydue to flash floods and landslides . The spilling of water from the channels, morainic boulders from the glaciers and debris from the unstable slopes overwhelmed all the existing landforms and obliterated the geomorphology of the region. The massive devastation witnessed in Kedarnath was basically due to the fact that the area was not conducive to support so much of population and construction activities.

Palynological studies have been taken up around Kedarnath from surface and sub-surface sediments to decipher the pollen-vegetation relationship and interpret the past vegetation and climatic fluctuations in the region. In the context of the valley glaciers, the expansion and evolution of vegetation in proglacial environment is considered to be an implication of accelerated deglaciation.The climatic oscillations are manifested by the relative changes in the proportions of arboreal and non-arboreal vegetation which is an index of advance or retreat of the glacier during different climatic phases.

Keywords: Chorabari Glacier (Kedarnath), palynological studies, Holocene, climate change.

Application of tree-rings in reconstruction of drought variability over Kumaun Himalaya, India and its relationship with crop productivity

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Kumaun Himalaya covers tropical to alpine vegetation depending on orography from lesser to higher Himalaya. Many conifers growing in Kumaun are known to produce datable growth rings. The Himalayan cedars known to grow very old in the western Himalaya are limited to some patches in Kumaun Himalaya, spread from plantations near the temples. We used Himalayan cedar samples from two localities in Kumaun Himalayan region to explore its potential in drought variability. The chronologies developed extend back to AD 1536 and AD 1668, respectively. Using these chronologies of Himalayan cedar prepared from two ecologically homogeneous settings in Kumaun region, we reconstructed Standardized Precipitation Index (SPI), a metric of drought. The principal component regression approach was adopted to develop 7-month SPI of May extending back to 1720-2012 CE. The reconstruction model, capturing 60% of variance in the observed SPI series, is the strongest so far from the Indian region. On achieving such a robust tree-ring calibration we are of the opinion that SPI could provide a better option to develop long-term drought records for the data scarce Himalayan region. The SPI reconstruction revealed high year-to-year variability with 1816 (SPI -1.92) and 1737 (SPI +2.33) the driest and the wettest years respectively. The five year mean of reconstructed SPI revealed multiyear droughts in 1920-1924, 1782-1786, 1812-1816, 1744-1748, 1964-1968. We observed that wheat-barley production data of Almora in Kumaun, close to our tree ring sites, has strong relationship with 7-month SPI of May. The wheat and barley crops sown in October-November in high elevation regions of the western Himalaya are usually harvested in May when Himalayan cedar trees are in peak of seasonal growth. We noted that most of the droughts recorded in our reconstruction (SPI <1) were associated with famines related to rabi crop failures. The findings endorse that 7-month SPI of May developed from tree rings should serve as a base line data to quantify the impact of droughts on forest as well as rabi crop productivity in hilly regions of Kumaun, western Himalaya, India.

Small archosauriform teeth from the Late Triassic of India: implications on early radiation of the dinosaurs

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Vertebrate microfossils are bones, teeth and scales that are less than 12.5 mm in diameter, though the entire organism could be of greater size. The relative abundance of microfossils reflects the abundance of living animals that originally dwelled in that locality in the geologic past and provide useful information about the paleoenvironment and palaeoecosystem. The different Gondwana basins of peninsular India are rich storehouses of highly diverse vertebrate fossils. The focus of the current study is the Late Triassic Tiki Formation, which is a mud-dominated succession with subordinate amount of quartzofeldspathic sandstone and well-developed palaeosol profiles.

Several microsites are prospected for microfossils by bulk sampling and screen washing of sediments, which have yielded more than 300 isolated teeth having recurved and serrated or smooth crowns. All the teeth are triangular in labial and lingual view, with elliptical and oval asymmetric crown bases. Based on distinct characteristic features, several morphotypes of teeth are identified as belonging to different types of archosauriforms. This is corroborated by quantitative assessment, which was based on several measured parameters of these teeth and that of known Late Triassic archosauriform teeth. Principal Component analysis (PCA) was applied to the variance-covariance matrix of the logarithmically transformed data to show that most of the archosauriform teeth collected from the Tiki Formation show similarity with those

known from the Tecovas Formation of the Chinle Group, USA. However, these teeth are found isolated, without being associated with any other skeletal elements, and it is not possible for higher resolution of their taxonomic position.

In addition, several morphotypes of saurischian teeth, especially that of the theropods are identified based on recurved crown and rectangular denticles attached perpendicular to the crown margin. It may be noted that Tiki Formation has yielded fragmentary remains of a basal saurichian dinosaur, which has been identified as a possible herrerasaurid whereas a basal saurischian dinosaur, *Alwalkeria maleriensis*, is known from the Maleri Formation of the Pranhita-Godavari basin. Hence, the discovery of isolated theropod teeth from the Tiki Formation augments the diversity of Late Triassic dinosaurs in India, which along with saurischian-finds from the Santa Maria Formation of southeastern Brazil and the Ischigualasto Formation of northwestern Argentina suggest that the Late Triassic dinosaurs originated in the Gondwanan countries.

Keywords: Chorabari Glacier (Kedarnath), palynological studies, Holocene, climate change.

Indian Record of Drilling Predation by the Predatory Gastropods and its Global Significance

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Keywords: Ecological interaction, naticid gastropod, spatio-latitudinal predation gradient, Cretaceous, Miocene, sampling bias.

It has been argued that we still need more samples from the less-studied parts of the world to make a 'true' global compilation for testing any macroevolutionay hypothesis (Jackson and Johnson, 2001). For example, for drilling predation by the gastropods of the family Naticidae and Muricidae, most of the data comes from the USA and Europe, while data from India – a less studied part of the world – is severely lacking. To test how new Indian data are influencing the global pattern of drilling predation (quantified from drilling frequency, DF), we have collected DF values of bivalves and gastropods from the previously published literatures for two time intervals: the Cretaceous, when the drilling gastropods diversified; and the Miocene, when DF assumed modern high (Huntley and Kowalewski, 2007). Moreover, because DF can vary with latitude, it is required to compare DFs within same latitudinal bin. Because India belonged to 30°-40° latitudinal bin in the Cretaceous and 20°-30° bin in the Miocene, DFs of drilled species with at least ten individuals were statistically compared between the global data excluding Indian records and data exclusive of India (i.e., India–only data) for these two intervals.

Our results show that although the medians and distributions of global and India-only DFs were statistically indistinguishable ($p > 0.05$), the India-only data showed higher average DF in the Cretaceous (DF=29.3%, n=5777) and lower average DF in the Miocene (DF=8.6%, n=874.5) than that of the global averages (DF=7.9%, n=88.38; and DF=23.1%, n=256, respectively) when

compared in the same latitudinal bins (Fig 1). These variation in DFs cannot be attributed to sampling size as both the dataset have sufficient number of specimens (i.e., 'n'). For both intervals, the global data already includes data from the latitudinal bin where India used to belong during the respective time intervals, and therefore DFs of them were statistically similar. However significant differences in average DF values between India-only and the global data for both the time periods in the same latitudinal bin suggests that there is a need to obtain more data from different biogeographic locations with their own localized intrinsic biological constraints, as data from these underrepresented locations may change the overall global patterns. For example, new drilling data from the Jurassic of Kutch and the Cretaceous of Rajahmundry showed that drilling intensities were distinctly higher than the previous reported values, at least in some clades, from the respective time periods (Bardhan et al., 2012; Mallick et al., 2013). Sampling, therefore, is not robust enough, and Indian fossil records need more attention and documentation.

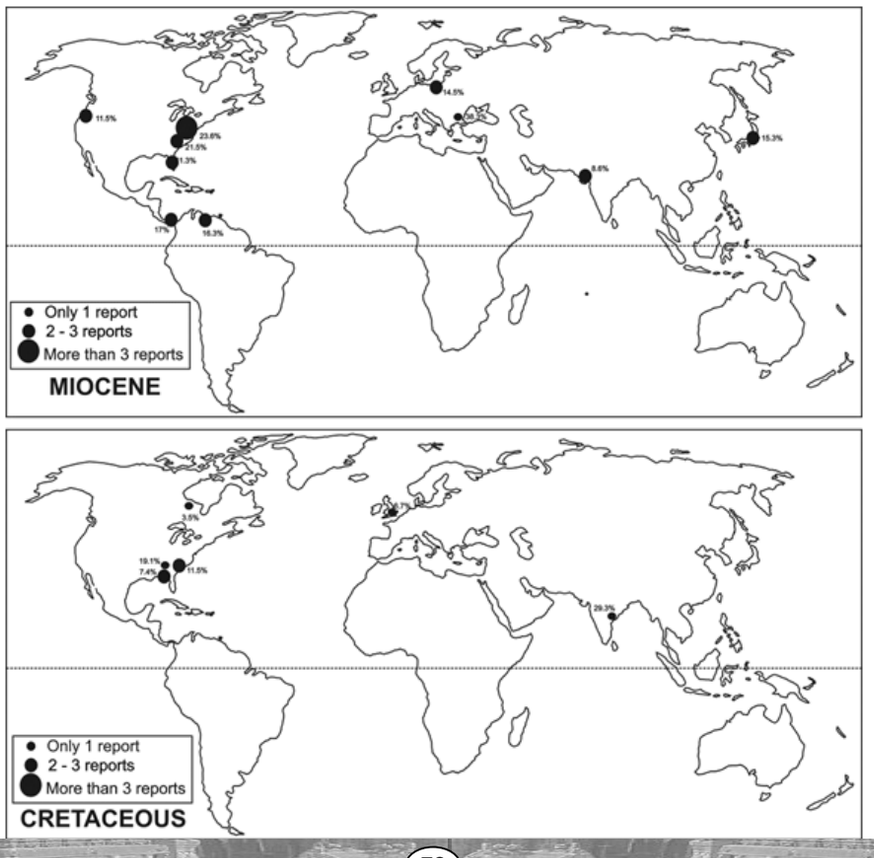

Fig 1. Global distribution of DF and no of published reports during the Cretaceous and the Miocene show poor spatio-latitudinal coverage.

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Study of Diatoms from Core samples of Mastani Lake, Pune

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Diatoms play a significant role in paleo-environmental and paleo-climatic studies. The Mastani Lake (18° 25'9"N; 73° 59'55"E) is located in the Wadaki village of the Pune District, Maharashtra, at the base of Dive Ghat. The core samples have been collected for study of fossil diatoms. The present paper documents 14 species of diatoms, namely, *Surirella spp; Synedra spp*; *Denticulata Subtilis; Synedra sp; Nitzscia spp; Fragilaria spp*; *Frustulia spp*; *Fallacia spp*; *Pleurosigma spp*; *Cymbella spp; Sellaphora spp*; *Pinnularia spp*; *Melosira spp* and *Eunotia Curvata.* The present association of diatoms and geochemical analysis of core sample reveal that the ecological status of the Mastani Lake is Oligotropic to Hypereutropic.

Key Words : Fossil diatoms, Geochemical analysis, Mastani lake, Ecological status

Latest Cisuralian plant remains from the Jarangdih colliery, East Bokaro Coalfield, Damodar Basin, Jharkhand

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The East Bokaro coalfield is one of the major repositories of medium-coking coal in the peninsular Gondwana basins of India. It occupies an area of about 237 sq. km between latitudes 23º 44' N and 23º 49' N and longitudes 85º 42' E and 86º 04' 30 E'. The coalfield contains a number of thick and thin seams belonging to Barakar and Raniganj formations. The East Bokaro Coalfield comprises sedimentary succession from Talchir to Supra-Panchet (Mahadeva) formations. Scattered exposures of Talchir Formation unconformably overlie the basement rocks in the north-eastern part of the coalfield around Chapri area and to the west of Gomia, in the north-western part of the coalfield. The eastern part of the basin is occupied by Barakar Formation, whereas, the crescent-shaped outcrops of the Barren Measures are exposed in the central and western parts. Successively overlying Raniganj and Panchet formations also follow the same crescent pattern further towards west. Supra-Panchet Formation, occupies the higher elevations in Lugu hillock at the westernmost part of this coalfield (after C. S. Raja Rao, 1987).

The investigation of the continental sediments from Jarangdih coal mine, near Kathara were carried out for qualitative and quantitative palynological analysis. One palynoassemblage has been identified which is characterized by the dominance of striate bisaccate palynomorphs mainly *Faunipollenites* and non striate bisaccate pollen grain *Scheuringipollenites.* The other stratigraphically significant palynotaxa are *Striatopodocarpites, Verticipollenites, Crescentipollenites, Striatites* and *Arcuatipollenites*.

In addition to the above palynoassemblage, a diverse macrofloral assemblage has also been identified from these sediments. The flora includes elements of Glossopteridales (*Glossopteris*, *Vertebraria indica*, stem casts) and Equisetales (*Phyllotheca indica*, *Schizoneura gondwanensis* and *Paraclamites* sp.). The genus *Glossopteris* dominates the assemblage with 7 species viz. *G*. *angustifolia*, *G. communis, G. barakarensis, G. giridihensis, G. churiensis, G. tenuinervis* and *G. tenuifolia.* Floral composition is devoid of fructifications. The group Lycopodiales, Coniferales, Sphenophyllales and Filicales are altogether absent in the megafloral assemblage.

The recovered palynocomposition and megafloral assemblage suggest the late early Permian (Kungurian) age for these sediments.

Key words : East Bokaro, Jarangdih, palynoassemblage, *Glossopteris*, early Permian

Distribution and Relative abundance of Biserial and Triserial forms of Benthic Foraminifera from the surface sediments of Continental Shelf off Pentakota, Andhra Pradesh, Central East Coast of India: Implications for Paleo - sedimentary depositional environments.

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Foraminifera is a protozoan belongs to kingdom protista which comes under calcareous walled microfossil group. Benthic Foraminifera is occurring from Cambrian –Recent in age and distributed from as shallow as tidal pool to deep sea environments. They have many applications such as in the study of Biostratigraphy, Paleoecology, Paleobathymetry, Paleoclimate, and monitoring coastal pollution etc. besides hydrocarbon exploration.

Eleven surface sediment samples were collected using the Van-Veen grab from the continental shelf off Pentakota located towards north of Godavari delta, Andhra Pradesh, Central East Coast of India. These samples were analyzed for foraminiferal studies following the standard procedures and relative abundance of some of the biserial and triserial benthic foraminifera such as Bolivina, Brizalina, Bulimina and Uvigerina at generic level are only considered to deduce the bathymetric distribution in the present investigation. Based on the Relative Abundance(R.A),the distribution of these genera are categorized in to nil/absent, poor, common, abundant, and very abundant in the inner, middle and outer shelf regions.R.A of Bolivina is higher i.e abundant in the inner and middle shelf where as very abundant in the outer shelf when compared to other three genera. R.A of Brizalina is nearly common in the inner shelf , poor in middle shelf and common to abundant in the inner outer shelf but absent in the outer- outer shelf. The distribution of Bulimina is

almost nil in the inner shelf, poor in the middle shelf, though still poor but slightly improved in the outer shelf. R.A of Uvigerina is almost common in the inner shelf and nearly poor in the middle shelf and common to abundant in the outer shelf. As a whole it was observed that inner and outer continental shelf regions are favorable, still outer shelf is more favorable. It appears that the middle shelf environment is not much favorable. In general as the distribution of these Benthic Foraminifera are controlled by substrate, organic matter content, depth, dissolved oxygen which are mostly depth related factors, so that these observations will help in deciphering paleo sedimentary depositional environments during hydrocarbon exploration/ riverine input specially in sub crop delta as these sample locations are situated towards the north of modern Godavari delta in particular and also sedimentary basins present elsewhere in the world.

Holocene brackish water trace fossil assemblage from AllahBund, Great Rann of Kachchh, India

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The Great Rann of Kachchh (GRK) is well known for its Quaternary tectonic activity and sea level changes. The most famous is the formation of the 80 Km long ridge along the northern part of the GRK known as Allah bund formed during 1819 earthquake. It exposed a vast area of marine silty clay and sandy horizons all along the northwestern GRK. The present study is aimed at studying ichnology of Allah bund sediments with the intention of understanding its origin. Integrated Sedimentological and ichnological analysis along a selected section in the western part of Allah bund (the relict Nara River) and its vicinity were studied in detailed. The sediment succession comprised of fine sand, clay and silt alternation with fossil rich horizons. The detailed ichnological analysis suggested low diversity suite and *r*-selected trace fossils like *Paleophycus*, *Skolithos* and *Thalassinoides.* The sediments shows distinct trace fossil assemblages namely (a) *Skolithos- Thalassinoides* (b) *Skolithos* (c) *Paleophycos- Skolithos.* The *Skolithos-Thalassinoides* forms the part of fine grained sand units with scattered bivalve and gastropod shells. *Skolithos* occurs with clay-silt alternation, and the *Paleophycos-Skolithos* occurs at several levels within the sequence. Most of the burrows show ferruginous halo surrounding the burrows, indicative of partial oxygenation of sediments. Thus, low diversity trace fossils, dominance of infaunal and *r*-selected organism indicates prevalence of brackish water conditions during the Holocene time in Allahbund-Nara River area.

Modern pollen rain studies from mangroves of Sundarbans, Ganges-Brahmaputra Delta

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Pollen analysis was carried out on surface sediments collected from various plant communities of mangroves in Sundarbans to examine the relationships between vegetation and present-day pollen. The paucity of modern pollen-rain data from the Sundarbans is a significant barrier to understanding Late Quaternary vegetation history of this globally important Ganges-Brahmaputra Delta. The palynological assemblages revealed that local vegetation (i.e. mangroves) represented 75% of the pollen spectra, while the regional one (i.e. hinterland forests) represented 20% of it. Amongst the mangrove taxa, *Rhizophora* and *Bruguiera* constitute on average 35.9 % of the pollen in the total pollen rain, whereas the average contribution of peripheral mangrove taxa is only 10.5%. Among the herbaceous taxa, Poaceae has a relatively high frequency, whereas, Chenopodiaceae/Amaranthaceae, Cyperaceae, Brassicaceae, and Caryophyllaceae reflect the agriculture activities in the study area. Occurrence of aquatic taxa such as *Typha angustifolia*, *Potamogeton* and *Nymphoides* are recorded in moderate values. Trilete and monolete fern spores are also recorded in good frequencies which are indicative of humid climatic conditions. High percentages of mangrove types can be indicators of the mangrove vegetation in general. Thus, the analysis of pollen rain data corroborates existing floristic and structural characterisation of different mangrove types of Sundarbans, Ganges-Brahmpaputra Delta. Hence, the present study confirms that mangrove pollen spectra can be accurately used to describe different mangrove environments for fossil based palaeoecological reconstructions.

Keywords **:** Modern pollen rain; mangroves; pollen analysis; Sundarbans, Ganges-Brahmaputra Delta

Study of trace fossils from the Sillakudi Formation to decipher its palaeoenvironment

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Cauvery Basin is a pericratonic rift basin situated in the southernmost part of the East Continental Margin of India. The depositional history of this basin is dominated by two phases- the syn-rift and the post-rift phase. In the post-rift phase, the Uttatur and Trichinopoly Group represent the early part where the passive margin had begun to develop. During the Campanian (Ariyalur Group) fully established passive margin depositional conditions, represented by the rocks of the Sillakudi Formation, are found. The Sillakudi Formation is a sandstone dominated sequence bounded at both contacts by unconformities. It represents the oldest unit of the Ariyalur Group.

The present study is an attempt to interpret the environment of Sillakudi Formation based on its trace fossil content. Detailed sedimentological and ichnological observations were undertaken in two main traverses across the Sillakudi Formation, viz. Varagur-Nallarikkai and Saradmangalam-Sillakudi railway cutting.

According to our observations, the Sillakudi Formation can be sub-divided into four sandstone litho-units/bedsets beginning with 1. glauconitic, alternating medium to coarse sandstone beds with ripple cross lamination and planar cross-stratification, 2. pebbly to very coarse grained massive sandstones, 3. Thinly bedded siltstones alternating with medium grained calcareous sandstones, 4. Gritty to coarse grained fossiliferous sandstones.

Unit 1 is dominated by vertical *Ophiomorpha nodosa, O. annulata, Thalassinoides* isp. and

Skolithos linearis, indicating constant reworking of sediment hindering colonization of other fauna. Such conditions typify modern intertidal environments. Unit 2 on the other hand showed a monogeneric colonization of vertical or U-shaped burrows, *Skolithos* isp. and *Arenicolites* isp.; indicating rapid colonization in an event bed. Unit 3 consisted of the most diverse ichnoassemblage comprising of *Trichichnus* isp., *Scolicia prisca* var. *laminites, S. ?prisca*, *S. vertebralis, Palaeophycus tubularis, Planolites beverleyensis, P. montanus, Taenidium* isp., *Thalassinoides suevicus, Ophiomorpha* isp., *Chondrites* isp. and *Phycodes* isp., pointing towards deposition in calmer, possibly anoxic outer shelf or slope environments. Unit 4 sandstones exhibited development of networks of *Thalassinoides* isp. and *Ophiomorpha* isp. indicating shallow sub-tidal to intertidal conditions of deposition.

Overall, the sequence shows a gradual deepening trend followed by rapid shallowing.

Key words - Sillakudi, trace fossils, palaeoenvironment, sea level changes

Biostratigraphy and biogeography of the Agnostids from the Cambrian successions of the Zanskar basin, Ladakh Himalaya, India

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The sedimentary Cambrian sections studied in the Zanskar Basin rests over the metasedimentary rocks of Neoproterozoic age. The Cambrian sediments of this area are fossiliferous comprising trilobites, trace fossils, hylothids, and brachiopod, etc. Among them the trilobites constitute the most significant group of fossils in Cambrian succession and are useful not only for the delimination of various biozones but also for the reconstruction of the Cambrian paleogeography of the region.

The Zanskar basin together with the Spiti basin forms not only the largest basin of the Tethyan sequences in the Himalaya, but also exposes one of the best developed sections. The complete successions of rocks ranging in age from Precambrian to Eocene are exposed in the Zanskar area of Ladakh Himalaya. In Zanskar basin the Phe Formation is more or less similar to the Kunzum La Formation of Spiti, although Zanskar may have been located in a slightly more distal setting. The Formation is succeeded by the Karsha Formation, which contains trilobites in its upper Teta Member. The Karsha Formation is conformably overlain by the Kurgiakh Formation which contains similar lithofacies to the Kunzum La Formation, and also bears Cambrian trilobites. The Kurgiakh Formation is unconformably overlain by the Ordovician molasse deposits of the Thaple Formation the lithological equivalent of the Thango Formation of the Parahio Valley. These relationships, along with the constraints provided the biostratigraphy based on trilobites, it also suggests that in this zone of the Himalaya the Ordovician unconformity cut to deeper stratigraphic levels toward the southeast.

The Cambrian sediments in this basin are exposed in Karsha, Purni-Phuktul, Tangzee, Kogma, Tangzee yogma, Kuru and Kurgiakh sections of the Suru Valley. In recent studies the authors have collected a variety of tracefossil and few fragmentary remains of trilobites from the Karsha section of the Zanskar Valley. Beside this a various polymerid and agnostid trilobite with

few brachiopods were collected from the different sections. On the basis of the faunal studies of ichnofossils and on polymerid as well as agnostid trilobites, various faunal assemblage zones have been worked out from these sections. In recent studies a variety of agnostid taxa have been reported from the Cambrian successions of the Zanskar basin. Agnostids constitute the most important index fossils for the global correlation of Cambrian successions. In the Zanskar Himalayan belt, the agnostid fauna is well preserved in the Middle Cambrian succession of Tangzee-Kuru-Purni-Phuktul and in the Kurgiakh sections of Lingti and Suru valleys. Preliminary studies reveal the presence of *Baltagnostus*, *Calavagnostus*, *Proagnostus*, *Utagnostus*, *Peronopsis*, *Hypagnostus*, *Diplagnostus*, *Lejopyge* and *Goniagnostus* a characteristic taxa of Hsuchuangian to Changhian stages of the Middle Cambrian. It has been observed that the biostratigraphic distribution of the Cambrian trilobite fauna in the Zanskar is restricted to certain stratigraphic levels. The restriction of the majority of taxa to a stratigraphic interval reflects the paleoenvironmental history of the basin.

In almost all well preserved Cambrian successions of the world most of the workers find the Middle – Late Cambrian boundary in between *Lejopyge laveigata* Zone and *Agnostus pisiformis* biostratigraphic Zone. In as Zanskar basins, therefore, this boundary can be marked on the basis of the occurrence of genus *Diplagnostus* in association with *Lejopyge*.

Early Cambrian fauna is well preserved both in the Lesser as well as Tethyan Himalayan Successions. Whereas, the middle to early Late Cambrian fauna so far is known from the Tethys Himalayan succession of Zanskar – Spiti, Kashmir and Bhutan. The biostratigraphic zonation based on the trilobite fauna collected so far from these regions. The trilobite fauna do not indicate any significant environmental change during the Cambrian period. So far no fossils have been reported from the upper part of Late Cambrian, whereas latest part of Late Cambrian is marked by an angular unconformity in the Zanskar – Spiti region and by the facies variations in Kashmir. The trilobite fauna ranges in age from Stage 4, Series 2 of the Cambrian system and extends up to the top of the Series 3 of the Cambrian System. The fauna shows close affinity with that of South China, North China, Siberia and Kazakhstan.

Ichnology of Early Cretaceous Delta Plain-Abandonment Sequence, Bhuj Formation, Kachchh, Western India.

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The Kachchh basin of western India is well known for its Cretaceous sedimentary sequences. Well known as Bhuj Formation. The Bhuj Formation was traditionally interpreted as deposited in deltaic environment during early Cretaceous times. The Bhuj formation has been extensively studied for its Sedimentological analysis however very few work was done for understanding the ichnology of the Bhuj Formation. Analysis of ichnological data provides precise information regarding the depositional environment and various factors governing it. To evaluate the deltaic model proposed for Bhuj Formation, ichnological data along with Sedimentological data were systematically analyzed along with short distance lateral facies mapping. The data suggested that the central part of the Kachchh basin constituted of delta plains with various phases of abandonment surfaces. In general, the lower Member of the Bhuj formation is characterized by cyclic highly bioturbation events interrupted by discontinuity and omission surfaces. Following deltaic sub-environments are identified. (1) Deltaic Channels comprises of low diversity trace fossils with low bioturbation (2) Flood plains also comprises of low diversity of trace fossils (3) Interdistributary bays are characterized by mixed depauperate Cruziana/Skolithos ichnofacies. (4) The mouth bars occurs as stacked sand bodies that are highly bioturbated with depauperate Skolithos ichnofacies. Several discontinuity surfaces separate deltaic plain sequence. Two dominant types of discontinuity are identified (1) abandonment surfaces indicating overlapping of root traces and rooted horizons over the Skolithos ichnofacies –indicating total abandonment of the depositional site (2) minor discontinuity surfaces characterized by Glossifunguites ichnofacies surfaces indicative of pausing of active sedimentation. The occurrence of the trace fossils and associated discontinuity surfaces indicates proximal part of the delta system with brackish water condition. Thus the identification of various depauperate integration of the ichnology and ichnological surfaces have successfully emphasized on the need ichnology in delineating deltaic sub environments in the lower part of Bhuj Formation.

Late Quaternary climate change from southwestern Madhya Pradesh (central India) based on loss-on-ignition study

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Loss-on-ignition (LOI) study, a widely used method to estimate the organic carbon (C_{org}) and inorganic carbon (CO_3^{--}) content of sediments, of a 2.4-m deep lacustrine sedimentary profile, collected from Nitaya Lake situated at Nitaya village, Hoshangabad District of southwestern Madhya Pradesh, central India, has been carried out in order to reconstruct the palaeoclimate during the last 12,700 cal. yrs. The study revealed that between ~12,700 to ~7150 cal. yr BP (NL-I), there is uniform moisture content, slightly increase in C_{org} and more or less uniform CO_3^{--}content, depicting cool and dry climate (partially matches with the Younger Dryas event). Between ~7150 and ~4650 cal. yr BP (NL-II), the increasing trend of moisture, C_{org} and decreasing trend of CO_3^{--} content show warm and humid climatic conditions (corresponds with the period of Climatic Optimum). Between ~4650 and ~2807 cal. yr BP (NL-III), decreasing trend of moisture & C_{org} content and relatively increasing trend of CO_3^{--} indicate warm and less humid climatic conditions during the time of deposition. Subsequently between ~2807 and ~1125 cal. yr BP (NL-IV), abrupt decrease in moisture & C_{org} content and highest value of CO_3^{--} content portray that climate was relatively warm and more humid than the preceding zone. Since ~1125 cal. yr BP to Present (NL-V), increasing moisture & C_{org} content and decreasing CO_3^{--} content point towards a warm and relatively less humid climate equivalent to that exists today. The LOI-based palaeoclimatic inferences are in agreement with the results of pollen-based palaeoclimatic study, which could be helpful in understanding the natural variability of the climatic system and simultaneously in **simulating the climatic models to understand the trends of future climate changes, relevant to the society.**

Keywords: Loss-on-ignition (LOI), Pollen, Late Quaternary, Climate change, Younger Dryas (YD), Period of Climatic Optimum, Southwestern Madhya Pradesh (central India)

Early Jurassic age calcareous nannofossils from western India: its palaeogeographical implications.

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The earliest marine Mesozoic sedimentary succession lacking macrofossils from two western Indian basins (the Kachchh and the Jaisalmer) have yielded calcareous nannofossils and precise age, environmental and palaeogeographical interpretations are drawn which are as follows:-

The Kachchh Basin is a small sedimentary basin situated on the eastern fringe of the southern extension of the Neotethys at a palaeo-latitude of around 33° S during Early-Middle Jurassic times (Dercourt et al. 2000). After a phase of terrestrial sedimentation in the Late Triassic (Koshal 1984), marine sedimentation is thought to have started during the Early Jurassic (Earliest Bajocian) in response to the opening of the Arabian Sea. This date was based on the earliest ammonite record of *Calliphylloceras heterophylloides* from the ?Earliest Bajocian (~171.6 Ma; Pandey et al. 2013), recorded from the Dingy Hill Member (Pachchham Island). A moderately diversified late Early Aalenian age calcareous nannofossil assemblage with reworked Early Jurassic Pliensbachian-Toarcian interval nannotaxa from the middle part of the Dingi Hill Member of Kaladongar Formation exposed at Point 16 hillock at Kuar Bet in Pachchham Island is recorded by Rai & Jain (2013). This assemblage includes the marker species *Lotharingius contractus* and *Triscutum sullivanii* of late Early Aalenian age which co-occurs with reworked nannotaxa of *Biscutum finchii*, *Bussonius prinsii*, *Crepidolithus granulatus*, *C. pliensbachensis*, *Discorhabdus criotus*, *D. striatus* and *Mitrolithus elegans* of Pliensbachian-Toarcian interval.

Calcareous nannofossils recorded from the oldest marine sediments exposed in Kuar Bet area of Pachchham Island, Kachchh Basin help to decipher the earliest epeiric transgressive event in western India in response to the opening of the Ethiopian gulf (Rai & Jain 2013).

The adjoining Jaisalmer Basin is a pericratonic Basin situated in the western India, comprising of sediments from Early Jurassic to Cretaceous age. DasGupta (1975) classified the sucession into Lathi, Jaisalmer, Baisakhi, Bhadasar, Pariwar and Habur formations in ascending order ranging in age from Lias (Singh 2006) to Albian (Rai *et al.*, 2013).

Singh (2006) presented both surface and subsurface Mesozoic lithostrtigraphy of Jaisalmer Basin. Pandey *et al* (2012) provided an overview of Mesozoic sediments of Jaisalmer Basin. The lowermost Jurassic horizon in the Jaisalmer Basin is represented by the Lathi

Formation which is underlain by the Malani Igneous rocks and meta-sedimentaries of Randha - Birmania formations of Palaeozoic age. The term “Lathi Beds” can be traced back from Oldham(1886) who first designated it after Lathi village on Pokaran–Jaisalmer road and considered it a continental deposit due to prevalence of silicified fossil woods. It was later designated as Lathi Formation (Swaminathan et al. 1959). Narayanan (1964) indicated that the Lathi Formation rests unconformably on Pre-Cambrian or lower Paleozoic rocks and contains abundant silicified fossil woods, leaf impressions and some silicified gastropods. Lower Jurassic microflora and some unidentified fragmentary foraminifers were also recorded (……). A conformable contact with the overlying Jaisalmer Formation and an intertonguing relationship between the two was suggested (Pandey et al. 2012). The outcrop sections were considered deltaic deposit and down the dip sediments were considered marine deposit due to presence of broken foraminifers from middle and lower part of Lathi Formation. Lucose (1971) assigned Liassic age to these sediments on the basis of palyno-assemblage. Maxium thickness of the Lathi Formation is considered ca. 600m (Pareek, 1980).

Datable but depauperate calcareous nannofossil assemblage from several sections of Lathi Formation (covering the lower Odania and upper Thaiat members) of precise Pleinsbachian-Aalenian age (Early Jurassic) is recovered (Rai et al. in press). A shallow epeiric sea or multiple such episodes inundated the south-western part of Indian craton encompassing the pericratonic shelf basin of Jaisalmer on the northwestern slope of the Indian peninsular shield during ?Pliensbachian – Aalenian time which was covered by thick and luxuriant gymnospermous forest proliferated during early-middle Jurassic time in the coastal areas.

Dominance of sandy sediments did not allow preservation of invertebrate macrofossils in the lower part of the Lathi Formation, however giant tree tunks in Odania Member and foot prints of dinosaurs from lower Thaiyat member (Pieńkowski et al. 2015) have been used for its fluvial to tidal environment interpretation. The present study thus provides precise Early-Middle Jurassic age (Pliensbachian – Aalenian extending upto ?Bajocian) for the entire Lathi Formation and presence of calcareous nannofossils in both its lower and upper members attest coastal marine depositional environment.

The recorded nannofossil assemblage from both Kachchh and Jaisalmer basins has wider palaeogeographical implications. It appears that after rift and drift of the Indian plate in its western margin, the transgressive event took place at least during the Pliensbachian. This transgression is ~11 Ma older than the previously proposed Early Bajocian ammonite or coral -based (*Isastrea bernardiana*) dates (Pandey et al. 2013). In this context, the record of coeval Late Pliensbachian

nannofossils from the Masirah Island (Sultanate of Oman, Arabia; Von Salis & Immenhauser 1997) and?Aalenian-Bajocian (NJ8b Zone) age nannofossils from Kuwait (Kadar et al. 2012) further strengthens the present evidences.

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Lithostratigraphy and paleoclimate of Meso-Proterozoic Badami Group, Kaladgi Basin, Karnataka, India

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The Badami Group comprises of two formations namely Kerur and Katageri formations. In the study focus on only Kerur formation with its lower two members namely Kendur conglomerate and Cave Temple arenite are represented. These sediments comprises coarse clastics of arenite and conglomerate, trending E-W with 10° to 20° dip towards north, and rest nonconformably over the basement rocks consisting of quartz-chlorite-sericite schist/meta-basic rock of the Chitradurga Group. A distinct unconformity separates the overlying Badami coarse clastics from the underlying Chitradurga Group of metasediments. In the study area, the unconformity surface is obscured by thick soil cover and a thin veneer of Deccan basalt towards south, which is under soil cover. The following four litho units, with distinct lithological characters, are identified. They are basal arenite, lower conglomerate, quartz arenite and upper conglomerate. **The petrofacies in Q-F-R ternary diagrams suggest mainly continental provenance of cratonic interior and quartzose rock type undergone weathering in a humid climate. Perhaps the paleoclimate during the deposition of lower units such as basal arenite and lower conglomerates was of semi-arid types which resulted in retaining feldspar grains in the framework. However towards the upper horizons with the occurrence of quartz arenites and upper conglomerates the climate become moisture rich and humid leading to destruction and elimination of feldspars.**

Keywords: Lithostratigraphy, paleoclimate, proterozoic sediments, Kaladgi Basin.

Equatorial Forest Vegetation and Depositional Environment at the Early Eocene Climate Optimum: Palynological evidences from lignite bearing sequences of western India

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During Early Palaeogene time, Indian subcontinent was moving northward as an isolated landmass and crossed various latitudinal and longitudinal positions which resulted into peculiar flora and fauna, particularly, the tropical rain forest elements. In the early Eocene time, the Indian plate was situated in an equatorial, high precipitation zone resulting in the formation of very thick peats preserved as lignites and coals in western and north eastern India. This was a time of several hypothermal events which are believed to have triggered an active radiation of mammals and angiosperms including the spread of the *Shorea* forests. During this period. Palm genera appeared, Caesalpinoidae diversified, Bombacaceae became abundant, swamp forest developed and the entire continent was covered by multi-storied rain forests.

The lignite bearing early Palaeogene sedimentary successions in western part of India (Kutch. Cambay, Barmer and Bikaner areas) provide unique opportunity to study floral diversity during events of extreme global warming. Here, we present the results of dinoflagellate cysts spore-pollen assemblages from lignite succession of Vastan Lignite Mine (Cambay Basin) and Panandhro Lignite Mine (Kutch Basin). The palynological data allows reconstruction of vegetational history, depositional environment and age determination.

Key-words: Palynology, Depositional environment, Early Eocene, Vastan (Cambay) and Panandhro Lignite Mines (Kutch), western India.

Indian summer monsoon changes over the last ~8.5 Kyr record as seen in sediments of the northeastern Arabian Sea

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In this study, 100 sediment samples have been analyzed for benthic and planktic foraminifera as well as total organic carbon (TOC) from marine sediment core ABP-25/03, off Gujarat in the northeastern Arabian Sea. In total 197 species belonging to 91 genera of benthic foraminifera along with 8 species of planktic foraminifera, characteristic of specific environments to understand early Holocene monsoonal variability are reported in this study. The main objective is to reconstruct the early Holocene history of the Indian monsoon system. The modern Arabian Sea sustains an intense oxygen minimum zone due to high surface productivity and low oxygen intermediate water makes it one of the most interesting regimes for paleoceanographers to examine paleoproductivity and organic carbon content in the sediments. The planktic foraminifera species *Globigerina bulloides* and mixed layer species (MLS) which is known as upwelling indicators from this study core ABP-25/03 collected from northeastern Arabian Sea. **This study** analyzed benthic and planktic foraminifera from >125 µm and >149 µm size fractions which were split into suitable aliquots of ~300 specimens, identified and counted. Seasonal changes in the oceanography are reflected in benthic and planktic foraminiferal productivity. We have identified here on oceanographically very important benthic foraminiferal species such as *Bolivina spathulata, Bolivina dilatata, Bolivina erlandii, Bolivina silvestrina, Bulimina aculeate, Bulimina gibba, Bulimina marginata, Bulimina costata, Cassidulina modeloensis, Discopulvinulina bertheloti, Gyroidinoides nitidula, Hyalinea balthica, Sigmoilopsis schlumbergeri, Uvigerina proboscidea,* etc. This core ABP-25/03, a major change in benthic foraminifera occurs during ~8.5 to 6 Kyr BP indicates a stronger summer monsoon whereas during 4 to 2 Kyr BP the summer monsoon was weakest. The northeastern Arabian Sea benthic foraminifera are good proxies to understand southwest monsoon variability during the early Holocene. The higher population of

mixed layer species (MLS) *Globigerinoides ruber, Globigerinoides sacculifer, Globigerinoides obliquus and Globigerinoides extremus* coincides with low *Globigerina bulloides* abundances a well documented Indian summer monsoon proxy. The upwelling indicator of planktic foraminifera species *Globigerina bulloides and Globigerinita glutinata* suggests phases of strong summer monsoons during the early to mid Holocene and a weak summer monsoon during the late Holocene. The eastern Arabian Sea upwelling induced productivity was higher during the early Holocene. The Total Organic Carbon (TOC wt. %) results document a great complexity when combined with *Globigerina bulloides* data at core ABP-25/03, a vital proxy for surface productivity. This core records high Total Organic Carbon (TOC) from ~6.5 to 4 Kyr and over the last 2 Kyr and low Total Organic Carbon (TOC) values during ~8.5 to 6.5 Kyr and 4 to 2 Kyr. This is a deep water (abyssal) core and planktic foraminiferal species might have suffered dissolution at this core. The IC values show a brief increase at ~8.3 to 7 Kyr and thereafter a continuous decrease in the younger interval during early to late Holocene. Total carbon (TC) values show opposite trend than TOC ranging from 5-12 Wt % while inorganic carbon (IC) values range from 2-8 Wt %. The TC and IC values show roughly match each other an overall opposite trend to the TOC values in this core ABP-25/03.

Keywords: Benthic and Planktic foraminifera, Total Organic Carbon (TOC), Upwelling, Indian monsoon, Northeastern Arabian Sea, Early Holocene.

Ecology and distribution of agglutinated benthic foraminifera in the western Bay of Bengal

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Agglutinated benthic foraminifera are abundant in carbonate poor environments prevailing in both the riverine influx dominated shallow shelf as well as waters below carbonate compensation depth. Additionally, they can also survive under depleted oxygen induced low pH conditions. All of these conditions are present in the western Bay of Bengal. The distribution of agglutinated benthic foraminifera, has, however, not been studied from this region. In view of this, a total of 100 core-top samples (67 multicore and 33 spade core top) collected from depths ranging from 27 m to 2540 m, covering the entire shelf-slope and upper abyssal region of the western Bay of Bengal were studied for agglutinated benthic foraminifera. Half of the sediments from the top section (0-1 cm) of each sample was stained by rose Bengal. The samples were processed by following a modified freeze drying procedure, which helps in easy processing of even clay and organic matter rich sediments, as well as quantification of absolute abundance of foraminifera in sediments. Both the living (stained) and fossil agglutinated benthic foraminifera were picked from all the samples. The absolute as well as relative abundance of agglutinated benthic foraminifera was calculated and compared with the ambient physico-chemical parameters. Abundance of living and total agglutinated foraminifera vary from being totally absent to a maximum of 87% (living) and 98% (total), at 2098 m water depth. Large regional differences are observed in the abundance of agglutinated benthic foraminifera. Interestingly, a considerable progressive increase in agglutinated benthic foraminiferal abundance, from shallow marine to deeper locations is observed in the central western Bay of Bengal. This region falls in-between Mahanadi and Krishna-Godavari river systems. The stations with higher agglutinated benthic foraminiferal abundance are marked by very low dissolved oxygen and moderate organic matter content. Therefore, we suggest that the agglutinated benthic foraminiferal abundance in the central western Bay of Bengal is controlled by dissolved oxygen as well as organic matter content of the sediments.

Keywords: Agglutinated benthic foraminifera, western Bay of Bengal, dissolved oxygen, organic matter.

Petrographic Constitution of the Coal Seams from Belampalli Coalfield, Godavari Valley, Telangana.

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The presented research output incorporates the coal petrographic analysis of three sub-surface coal seams encountered in Bore-hole No. A-146, from Belampalli Coalfield of the Godavari Valley, Telangana. This study has indicated that the topmost Index Seam contains considerably high proportion of mineral matter association and therefore the coal is shaly in nature. The Middle Seam however, has shown a wide range variation in its maceral constitution as depicted by the existence of vitric, fusic and mixed coal types. The Bottom Seam is marked by the presence of fusic coal. Similarly, from the random vitrinite reflectance (R_o mean %) study, it is inferred that the Bottom Seam has reached high volatile bituminous C stage of rank whereas, the Middle Seam contain coal with rank variation from sub-bituminous B to high volatile bituminous C stage. The facies diagram advocate regarding the prevalence of alternate oxic and anoxic moor conditions during the deposition of the Middle Seam while, the Bottom Seam has witnessed both the wet moor with intermittent moderate to high flood as well as alternate oxic and anoxic moor conditions.

Keywords : Belampalli, Godavari Valley, Telangana, Reflectance, Maceral, Depositional Environment.

A 8 kyr history of paleo productivity in the South Eastern Arabian Sea

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Climate of the Indian subcontinent is controlled by the monsoon winds that changes direction with the season.Arabian Sea is one of the highest productivity is the world ocean and it is ruled by reversing seasonal monsoon wind-driven upwelling.The detailed account of upwelling-induced productivityin the south eastern Arabian Sea is not well understood. In this present study we used marine sediment cores from SE Arabian Sea to understand the upwelling induced productivity during Middle - Late Holocene. Here we present a continuous record of centennial-millennial time scale of Indian monsoon variability during the Mid-late Holocene from rapidly accumulating sediments in the SE Arabian Sea. we studied 299 marine sediment samples from site SK-291 and GC-13 (14° 42.5'N, 74° 00.82'E, 25m water depth) that time span past 8kyr. BP for $\delta^{18}O$ of benthic foraminifera and total organic carbon (TOC) contents, which are shown to mainly vary in concert. Ages of these samples ^{14}C dates obtained from Woods Hole Oceanographic Institution, US. The abrupt changes in the SW Indian monsoon are well documented in numerous previous studies using$\delta^{18}O$, benthic foraminifera faunal data and total organic carbon (TOC) as a proxy. In this study we used abundance of benthic foraminiferal data, and Total Organic Carbon (TOC) to understand the effects of past climate on relative upwelling phenomenon strength of the monsoons and associated responses such as sedimentation history, productivity, ?uvial input of detritus etc. The three proxy profile records of core SK-291, GC-13indicate similar productivity variations ~5.5 to 2.5 kyr BP. with higher values prevailing during this time period rapid fluctuation occurred due to the weakening the SW monsoon. The abundance of benthic foraminiferal faunal data shows similar trend, particularly opportunity species *Nonion cf. asterizans*(%) shows continuously increasing trend ~7.0 to 0.5 kyr that maintained a high abundance along with opportunistic species in this region and *A.gaimardii* (%), *A.beccarii* (%) abundanceindicateshigh organic supply and brackish to shallow, inner neratic environment with high productivity. The high TOC shows better preservation potential of organic matter produced by enhanced surface paleoproductivity. The TOCcontent fluctuated between 4.1 % (at age 3.1 kyr) and 1.7 % (at age of 7.8 kyr). This study area holdshigh TOC %, indicating high productivity.

Keywords:South EasternArabian Sea; SW Monsoon; Benthic foraminifera; Total Organic Carbon (TOC);

Progress in understanding the enigmatic middle eocene larger foraminifera *nummulites obtusus* (Sowerby), 1840 form b: new insights from SEM study

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Shallow marine Middle Eocene rocks of Kutch, western India are excellent repository of diverse larger foraminifera. With distinctive morphology, abundant occurrence, wide geographic distribution and narrow stratigraphic range, *Nummulites obtusus* (Sowerby), 1840 constitutes one of the key Middle Eocene larger foraminiferal species of Kutch. The B Form of this species, in sharp contrast to the morphologically simple A Form counterpart, exhibits highly complex morphology. Presence of septal filaments instead of marginal cord and chambers at the periphery along with large orifices and linear feature on the lateral surface of adult B Form tests of *N. obtusus* are some of the morphological attributes that have remained enigmatic since erection of the species. In order to understand the true nature of such enigmatic features, the present authors examined the B Form tests of *N. obtusus* under the scanning electron microscope (SEM). The examined specimens were collected from the upper part of Harudi Formation (Middle Eocene) in western Kutch.

Ultrastructural examination revealed occurrence of low surface ridges in the outer whorls of the tripartite spire. These ridges constitute linear zones of inflated spiral laminae that are devoid of pores. Similar ridges were earlier reported in *N. vredenburgi* Prever by the present authors. The surface ridges recorded as 'trabeculae' in some earlier literatures must be annulled in the context of the present SEM data. True trabeculae have not been encountered in *N. obtusus* Form B. Regular array of the closely spaced surface ridges reminds us of the metabolism enhancing cell-size compartmentalization of the cameral space in some living and fossil foraminifera. Solid hyaline wall of the surface ridges strengthened the thin spiral laminae of the outer whorls and facilitated light transmission to the test interior for symbiosis.

Radially disposed resorption cavities extend across the surface ridges to connect the adjacent whorls on one hand and the septal filament canals on the other hand. Similar resorption cavities were earlier documented in *N. vredenburgi* Prever by the present authors. Outer ends of the resorption cavities appear as large orifices on the test surface. Resorption

cavities acted as conduits for the internal circulation of protoplasm and also for the extrusion of protoplasm from the orifices located on the test surface.

The most striking morphological modification of the outer whorls is the development of septa and septal filaments in the lateral and peripheral parts of the test respectively. This is contrary to the usual partitioning of the spiral cavity in *Nummulites*. Until now, chambers and canals were not recorded from the outer whorls of *N*. *obtusus* Form B, and as such, ontogenesis of the terminal part of the test remained enigmatic. Present SEM data from the outer whorls revealed definite evidence of chambers and canals in the lateral part of the test for the first time. It is envisaged that protoplasm emanation from the orifices and canals facilitated chamber development in the outer whorls. Above findings favor modification of the generalized rotaliid growth model as means of ontogenesis of the outer whorls of *N*. *obtusus* Form B.

Key words: Larger foraminifera, Middle Eocene, Kutch, *Nummulites obtusus* (Sowerby), ultrastructure

Palynostratigraphy of subsurface Triassic sediments in Johilla Coalfield, South Rewa basin, Madhya Pradesh, India.

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The South Rewa Gondwana Basin (SRGB) of central India exhibits full development of Gondwana sediments spaning from Asselian (early Permian) to Albian (early Cretaceous) in age. The basin is divided into two parts -the **eastern part includes Singrauli, Ramkola-Tatapani, Jhilimili** and **Sonhat** coalfields, while the **western part comprises Sohagpur**, Umaria, Johillla and Korar coalfields. Johilla Coalfield is one of the major coalfields, located in the Umaria District of Madhya Pradesh, India.

In the present communication, palynological analysis of a sedimentary sequence of borehole JNN-1 (6.60-514.05), located ~2 km north of Nowrozabad Railway Station (lat. 23º20' 48" N and long. 81º 04' 59" E) of Umaria district, Madhya Pradesh has been analyzed. Rich and diversified palynofloras of middle -late Triassic age are recorded in the subsurface sedimentary section of this area. In all, seventy five species belonging to forty genera are identified. The stratigraphically important species recorded in the assemblage are represented by—*Triplexisporites playfordii,* ***Carnisporites mesozoicus,*** *Lundbladispora willmotti,* ***Cingulizonates rhaeticus, Densoisporites velatus,*** *Osmundacidites senectus, Uvaesporites verrucatus, Ceratosporites helidonensis,* ***Tikisporites balmi,*** *Dubrajisporites bulbosus,* ***Aratrisporites granulates, Goubinispora morondavensis, Brachysaccus eskensis,*** *Minutosaccus crenulatus, Samaropollenites specious, Rimaesporites aquilonalis,* ***Klausipollenites schaubergeri, Staurosaccites marginalis, S. quadrifidus, S. densus, S. ovalis, Alisporites opii, Lunatisporites*** *pellucidus, Chordasporites magnus, Lueckisporites virkkiae, Infernopollenites janarensis, Triadiasporites plicata* and *Duplicisporites granulates.* Two

distinct palynological assemblage zones are recognized on the basis of quantitatively dominance palynotaxa and Last Appearance Datum (LAD) of certain stratigraphically significant palynomorph species. The zones in descending order are: i) *Minutosaccus crenulatus- Enzonalasporites ignacii* zone and ii) *Samaropollenites speciosus- Rimaesporites potoniei* zone. Palynological assemblages of these zones closely resemble with those of the Tiki Formation (late Triassic) of the Janar Nala Section, South Rewa Basin. The middle to late Triassic palynofossil assemblages recorded here represent the Onslow type palynofloras resemble the northwestern Australia and northern Madagascar.

Lithologically, the subsurface sediments of this segment has been assigned to the Late Triassic (Carnian - Norian) Parsora Formation. This palynoflora can be equated with that of the Tiki Formation. Therefore, it is suggested that Pali and Tiki beds are coeval litho-units and they should be grouped together as Pali- Tiki Formation to solve the ambiguity of Pali and Tiki formations. The Parsora Formation is a separate litho unit and younger than the Pali-Tiki Formation.

Sedimentary Facies and Architectural Element Analysis of Fluvial System of Upper part of Sandhan Formation, Western Kutch, India

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The siliciclastic dominated Sandhan Formation represents terminal Cenozoic succession is well exposed along cliffs and banks of Kankawati River (type section). The field based stratigraphic and facies analysis suggests that lower part (135m) of the formation is marine and upper part (157m) is fluvial deposits. The study aims at facies analysis and identification of fluvial architectural elements of upper part of Sandhan Formation. The process based facies analysis of the succession led to identify the following facies Medium to coarse grained sheet sandstone facies: dominated by stacked fining up sheets of planer to crossstratified sandstones with granular to pebbly lags. Medium grained planar laminated tabular sandstone facies: dominated by mediumcoarse grained poorly sorted tabular sandstones. Tabular crossstratified coarse to medium grained sandstone facies: dominated by finingup tabular crossstratified sandstones with small scale ripples. Trough crossstratified coarse grained sandstone, often pebbly facies: characterized by large scale crossstrata in poorly sorted sandstone. Thick compound trough crossstratified sandstone facies: characterized by low angle troughs, coarse granule to pebble sized grains at the bottom of foresets with fining up units. Massive pebbly sandstone facies: characterized by very coarse poorly sorted pebbly sandstone. Trough crossstratified gravel facies: dominated by trough crossstratified gravel with the foresets consisting of coarse granule to pebbles, set thickness 2025cm. Coarse grained poorly sorted massive matrix supported gravel facies: crudely bedded, poorly graded, massive, occurs as an elongate lobe, thickness of lobe 75cm. ?Mudstone interbedded with fine silt facies: dominated by tabular bodies of laminated mud interbedded with rippled fine silt. Paleosol facies: dominated by fine mud deposits,

abundant root penetration structures, calcrete layer and pedogenic features are common.

The importance of architectural analysis is to identify and understand the type of fluvial system, following Miall (1985) classification six architecture element of fluvial system are identified: Channel element CH – stacked sheet sand bodies, Sandy Bedform SB – tabular sand bodies dominated by planar laminations and tabular crossstratification, Downstream accretion element DAE – consists of cosets of trough crossstratified sandstones interspersed with coarse grained gravel deposits, Compound bar element CBE – amalgamation of unit bars, dominated by coarse troughcross sandstones finingup to tabular sand bodies, Overbank fines OF – represent fine sediments deposited on top of bars and banks, Gravel bars and bedforms GB – represented by troughcross stratified and planar crossstratified gravel.

The succession is dominated by poorly sorted granular, often pebbly, medium to coarsegrained sandstones and coarse granular and pebbly gravel deposits interbedded with minor gravity flow, hosts variety of sedimentary structures. The facies analysis suggests that the fluvial system is characterized by multistory/multilateral channels, compound bars, overbank fines, and paleosol. The architectural element analysis suggests that high energy braided fluvial system for upper part of Sandhan Formation. The occurrence of braided river system over shallow marine sediments indicates an abrupt fall in relative sea-level or a local tectonic resulted base level fall which triggered the initiation of fluvial system.

Key words : Fluvial architectural element, Facies analysis, Sandhan Formation, Channel shift, Braided river system

Cyanobacteria from the Cherts of Birmania Basin, Western Rajasthan

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Birmania Basin of western Rajasthan is considered to be a part of the Marwar Supergroup. Divided into lower Randha and upper Birmania formations, this basin is exposed around villages Randha, Barsinga and Beermani. The lower Randha Formation mainly consists of medium to coarse siliciclastic rocks where the beginning of depositional cycle is gritty, overlain by parallel to cross-bedded sandstone. Sandstone is overlain by compact, reddish-brown to buff coloured shales. Exposures around Barsinga Village are parallel bedded, moderately thick, grey colouredolomitized carbonates. Light to dark grey, resinous bands, lenses and large nodules of chert occur deeply embedded within these calcareous rocks. The lithology around Beermani Village shows dolomitized carbonates with siliceous content. The area shows multiple folds and deformation of bedding at outcrop level. The dolomites grade into thin to parallel bedded carbonates, siltstone and phosphorite beds.

Birmania Basin had been considered unfossiliferous till very recently when remnants of *Wengania exquisita* and other algal thalli were reported from the thin sections of phosphorite (Hughes et al., 2015). The present study, from the thin sections of chert occurring around the Beermani Village, has revealed an assemblage of cyanobacterial filamentous forms. The simplest forms occur as tubular sheaths belonging to different species of *Siphonophycus.*Some forms are doublewalled while some are thick walled or multilayered, with an outer membranous sheath. A few filaments are lamellated. Cross-section of the filaments is mainly circular. Dark organic matter occurs within some of the tubular sheaths. The filaments occur both in clusters and as individual entities. The cherts yielding these cyanobacterial forms are lithostratigraphically older than the Birmania phosphorites from which *Wengania exquisita* has been reported. The assemblage in itself does not throw any significant light on the age of the succession other than its being Precambrian. In the light of the present record of these cyanobacteria, detailed palaeobiological study is required to understand the position of Birmania Basinvis-à-vis other Precambrian Basins of India.

Palynodebris an lysis of Barsingsar Lignites, Bikaner District, western Rajasthan, India

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The present paper deals with the palynodebris analysis of lignites from Palana Formation at Barsingsar Lignite Mine in Bikaner, Rajasthan. In the present study, dispersed organic matter recovered from the lignite was estimated under transmitted light microscope to interpret depositional environment of the basin at the time of its deposition. The overall dominance of the organic matter in the Barsingsar section is shown by structured terrestrial organic matter followed by Black organic matter and Biodegraded terrestrial organic matter, which suggest partial oxidizing conditions prevailing in the basin during its deposition. Abundance of grey amorphous organic matter in some of the samples in the section reflects deposition under reducing conditions and cyclicity of the terrestrial and amorphous organic matter suggests fluctuations from shallow to short lived deep water conditions in the basin. The present investigations show the dominance of Structured Terrestrial Organic matter which suggests thick woody rain forests prevailing in the vicinity during sedimentation. Adequate amount of Resin documented in the samples is indicative of marginal marine environment. Significant frequency of Arecaceae pollen points to coastal-deltaic conditions during depositional regime in the basin. Hence the overall palynodebris spectrum delineated suggests marginal marine to coastal-deltaic environment of deposition for the Palana Formation of Barsingsar area, Bikaner District, Rajasthan.

Ecology and distribution of *Uvigerina* in the northern Indian Ocean

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The stable isotopic and elemental ratio of infaunal benthic foraminifera *Uvigerina* has often been used to infer past deep water conditions. The absolute and relative abundance of *Uvigerina* has also been used as a proxy for bottom water temperature, oxygenation as well as phytodetritus content in the northern Indian Ocean. Studies on surface distribution of *Uvigerina*, however, are limited from the northern Indian Ocean. Here we document the factors affecting distribution of *Uvigerina* in the northern Indian Ocean. A total 43 surface samples (38 multicore top and 5 grab samples) samples collected from the Gulf of Mannar and Lakshadweep Sea were used. Half of the surface sediment was stained by using Rose-Bengal, immediately after collection. The stained samples were processed following the standard procedure for processing of foraminifera. A minimum of 300 living stained benthic foraminifera were picked from each samples, wherever possible. The absolute as well as relative abundance of *Uvigerina* was calculated. The abundance was compared with bottom water dissolved oxygen, organic matter content ($\%C_{org}$), temperature and salinity. The relative abundance of *Uvigerina* varies from being absent at several stations in the upper slope and deeper depths to as high as 35% in the slope region. Both the relative and absolute abundance of *Uvigerina* is comparatively high between ~250 m and ~2000 m. This depth zone is marked by low dissolved oxygen as well as high $\%C_{org}$. The temperature and salinity of the ambient water does not appear to strongly influence *Uvigerina* abundance. Based on this work we demonstrate that in the northern Indian Ocean, *Uvigerina* prefers both the low dissolved oxygen as well as high $\%C_{org}$. The findings will help in improved application of *Uvigerina* to infer past deep water conditions in the northern Indian Ocean.

Keywords : *Uvigerina*, Rose Bengal stain, multicore, dissolved oxygen, organic carbon

Paleoceanographic significance of late Quaternary deep sea benthic foraminifers of the Japan Sea - a preliminary result

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Japan Sea is a semi marginal sea consisting of three major basins: the Japan Basin to the north, the Yamato Basin to the southeast, and the Tsushima (Ulleung) Basin to the southwest. By virtue of its geographic constraints the Japan Sea is connected with other seas by shallow, narrow straits such as Tsushima Strait (130 m water depth) in the South, the Tsugaru Strait (130 m water depth) in the east, and the Soya (55 m water depth) and Mamiya (20 m water depth) Straits in the north. The presence of these shallow straits makes the Japan Sea sensitive to glacially driven sea level changes.

These glacial driven changes cause variations in oxygen concentration, flux in organic matter and nutrient availability in the deeper part of the Japan Sea. Benthic foraminifers are one of the most widely used and reliable proxies to understand these variations.

During this study we have analysed late Quaternary benthic foraminifers from IODP Expedition 346 Sites U1423 and U1426 to understand their paleoceanographic significance in the Japan Sea. Site U1423 is in the northeastern part of the Japan Sea at 41°41.95'N, 139°4.98'E and 1785 mbsl, northwest of the entrance of the Tsugaru Strait. Site U1426 is in the south-central part of the Japan/East Sea at 37°2.00'N, 134°48.00'E and 903 mbsl, near the top of the Oki Ridge that bounds the southern margin of the Yamato Basin. Preliminary results show that benthic foraminifera are poorly preserved in the late Quaternary sediments of Site U1423 dominated by *Bolivina pacifica* and *Epistominella pulchella*. The major benthic species observed at Site U1426 are *Cassidulina norcrossi, Trifarina angulosa and Uvigerina peregrina*. The variations in these species are linked with changes in primary productivity and a sustained flux of organic matter into the Japan Sea driven by sea level changes.

Key Words : Japan Sea, Benthic foraminifera, sea level changes, Expedition 346

Palynofacies and hydrocarbon source rock of the Kopili Formation (Eocene), Jaintia Hills, Meghalaya.

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The present investigation reports the palynofacies distribution and Rock Eval in Kopili shale (lower section) from Umphyrluh, Jaintia Hills, Meghalaya to support reconstruction of the hydrocarbon source potential. The present palynotaxa are mainly composed of Dinoflagellate cysts. The source rock potential of Kopili shale recorded the different types of organic matters such as charcoal, partly biodegraded terrestrial organic matter, amorphous, black debris, spore and pollens (dinoflagellates). Based on the palynofossils investigations, the sediments were deposited under a shallow marine environment having inner shelf relatively deeper relatively and open marine influence and absence of brackish water environment. Rock-Eval and TOC analysis of the Kopili shale indicates that all the samples have poor organic richness (TOC<0.5%) and poor hydrocarbon generation potential (S_2<0.5mgHC/g rock). The type of kerogen is predominantly of type III and type IV. The T_{max} and productive index (PI) values support the findings of visual kerogen analysis. Most of the samples are in the mature stage. A few of them are immature and post-mature. The amorphous organic matter is more dominant than other organic matter. From the Van-Krevelen diagram almost all the samples are in mature stage. The source rock potential for the Kopili Formation at Umphyrluh area appears

poor potential of hydrocarbon.

Keywords: Kopili shales, Rock Eval, Dinoflagellate cyst, Hydrocarbon, Umphyrluh.

Tappania bearing Organic-Walled microfossils association in Proterozoic Chhattisgarh Supergroup, Central India

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In southern part of Central Indian Tectonic Zone (CITZ), a mixed sequence of siliciclastic and carbonate rocks of Proterozoic Chhattisgarh Supergroup host a *c.* ~2300 meter thick and unconformably overlies the Bastar craton that has received intermittent attention globally. Earlier studies in the entire succession mostly concentrated on establishing the stratigraphy and depositional history except biostratigraphic development. Although, the Meso-Neoproterozoic depositional time frame for the entire succession has been postulated based on various dating technique of tuffs and detrital zircon. But, the age control of Chhattisgarh sedimentation is still in controversy with respect to other Purana basins in global prospect. Additionally, less number of palaeobiological evidences pertains to more restrained picture. It is believed that fossil microorganisms acritarchs are being used as authentic records for age assessment, sedimentary history of strata similar to geochronological constraints before the dawn of Cambrian.

In the present study, well-preserved organic-walled microfossils (OWMs) are recorded from the carbonaceous shales belonging to the Saraipali Formation, Singhroa Group (1500 – 1400 Ma) – the lower most stratigraphic succession of Chhattisgarh Supergroup, exposed in Baradwar Subbasin situated in Mahasamund District, Chhattisgarh. Such types of fossil entity are identified as *Tappania* Yin Le-ming - a vesicle (up to 160 µm in diameter) with numerous hollow cylindrical spiny processes and a neck like tubular extension. *Tappania* is the most ancient morphologically complex demonstrably eukaryotic microfossils globally known from the precisely dated Palaeo -Mesoproterozoic sediments of Australian Roper Group (1492±3Ma); Ruyang Group (>1600Ma) of China; Yurubchen Formation of Siberia (1060±20 Ma); Bahraich Group of Ganga Basin and Semri Group, Vindhyan Supergroup of India.

Comparison with available global records, the occurrence of *Tappania* from the Singhora Group suggest early Mesoproterozoic age (~1500-1400 Ma) for the lower part of Chhattisgarh Supergroup that favors the available geochronological database. The present finding provides a new perspective to the lithostratigraphy and age of Chhattisgarh Basin.

High Resolution Foraminifera Records of Indian Summer Monsoon Variability from the Southeastern Arabian Sea

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Foraminiferal studies provide a vital contribution to our understanding of past and future ocean and climate systems. Understanding the past climate systems will help us to predict the future climate systems. Planktonic foraminifera are widely used for paleoclimatic and paleooceanographic reconstructions. In this meeting, we want to discus on oceanographically important foraminiferal abundance profile and its relationship with Indian summer monsoon variability(ISM). In the present study, A 4.82 m gravity core was collected from the southeastern Arabian Sea during the 313th Cruise of *O.R.V. Sagar Kanya* has been used for this study. The sediment core was sub-sampled at 1 cm intervals for the top 1 m and 2 cm interval for the rest of the core. Totally 291 sediments samples were analyzed using standard procedures. We focused here on following oceanographically important planktonic species, *Globigerina bulloides*, *Neogloboquadrina dutertrei, Globigerinoides ruber.* The percentage data of most abundant species are plotted against age in ka. Our results, shows that in the Arabian Sea, all the above studied species can be indicators of wind-driven upwelling, mean annual sea surface hydrographic conditions and the thermocline variability, respectively, our data favor an increased upwelling and a shoaling of thermocline due to increased Indian summer monsoon since the early Holocene to Present.

Key words: Southeastern Arabian Sea, Marine core, Foraminifera Abundance, Holocene, ISM

Foraminiferal investigation on Valinokkam Creek sediments.

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Creeks are very important marginal marine environments for micropaleontological studies as they are capable to record the sea level changes besides the evolution of the coast. Valinokkam creek is located in the Ramanad district, Tamil Nadu a part of South East Coast of India. In order to find out the of the foraminifera presence in the study area, two core samples were collected. 68 subsamples were separated from the core samples at 2.5 cm interval. Analyses were carried out to find out sand silt clay ratio, $CaCO_3$ and organic matter in the sediments. Foraminiferal investigation on all the subsamples was carried out. Calcareous benthic foraminifera are common and abundant at the surface. Juvenile forams are rich in the surface sediments. Near mouth core, foraminifera shows decreasing trend of population towards depth. Reworked foraminifera recorded at the middle of the core. Plant remains found at the bottom. Suborder ROTALIINA constitutes 70% of total foraminifera, suborder MILIOLIINA constitutes 29 % and 1 % of foraminifera belong to suborder TEXTULARIA found in the sediments. The creek sediments yielded low fauna may due to the discharge from salt pans adjacent to the study area. Preliminary investigations present a fair scope for further work on Valinokkam creek of the east coast.

Shell chemistry of Cytheridae, Schizocytheridae and Krithidae family, Recent benthic Ostracoda, off Rameswaram, Tamil Nadu, Palk Bay, Southeast coast of India

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The area under investigation is off Rameswaram in eastern transect of the shallow inner shelf region. From the bottom sediment samples that were collected from October 2010 to September 2011, during four different seasons that exist in the study area, benthic Ostracoda from its different family Cytheridae, Schizocytheridae and Krithidae, namely, *Hemicytheridae reticulata, Hemicytheridae sp., Neomonocetina iniqua, Neomonocetina porocostata, Jankeijcythere mckenziei, Spinoceratina spinosa, Hemikrithe peterseni* and *Hemitrachyleberis sp.,* were identified and their shell chemistry were determined using SEM-EDAX. The following elements were found to be present in the above mentioned seven species in different percent: C, O, Na, Mg, Al, Si, Cl, and Ca. The percentages of these elements in each species are discussed and their sources were arrived at.

Keywords: *Shell chemistry, Recent benthic Ostracoda, Family Cytheridae, Schizocytheridae and Krithidae, off Rameswaram*.

Paleoceanographic study during the Holocene over off Saurashtra NE Arabian Sea.

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To understand and reconstruct the variation of climate during Holocene, most commonly used proxy from the eastern Arabian Sea sediments is foraminifera. A quantitative analysis of planktonic foraminifera abundance studies were carried out on a 3.4 m long sediment core SK-240/485 recovered from off Saurashtra region to understand the productivity and sea level changes during Holocene time. Six radiocarbon ages place the core in the time interval 12-1 cal Ka BP. The results divide the whole 3.4 m core into 3 zones of different time periods of sea level variability viz. Zone-1(1-4 Ka) ,Zone-2(4-8 Ka) and Zone-3(8-12 Ka). Present study on the planktonic-benthic foraminiferal ratio suggests that, initially the sea level was low up to 8 Ka. Thereafter, during 8-5 Ka, the sea level raised which was again followed by consistence in sea level after 5 Ka. The increase in sea level during mid-Holocene (8-5 cal Ka BP) results are consistent with other studies as well from the coastal area. Moreover, the dominance of pellet carbonate mass in the time span of Zone-3 suggest the possible presence of aragonite sand dominated Fifty Fathom Flat which resulted in less foraminiferal abundance during the corresponding time span. The results are strongly supported by average sand percentage, planktonic and benthic foraminiferal abundance per gram, planktic-benthic ratio as well as %$CaCO_3$ data of the corresponding time period.

Keywords: Holocene, Foraminifera, off Saurashtra, Sea level, Productivity.

Synecological aspects of palaeogene larger foraminifera of Kutch – a preliminary assessment.

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Diverse larger foraminifera occur in the shallow marine Palaeogene rocks of Kutch, western India. In the past 175 years, these foraminifera received considerable attention in the fields of systematics, stratigraphy and stable isotope analysis. Synecological studies involving documentation of organic activities of other benthonic taxa (OBT) upon larger foraminifera of the '*obtusus* bed', Harudi Formation (Middle Eocene), were undertaken by the present authors from limited localities of Kutch. Subsequently, additional samples from the remaining 3 Palaeogene marine fossiliferous formations (Naredi Formation, Fulra Limestone and Maniyara Fort Formation) were collected across the entire Kutch basin for detailed synecological analysis. Temporal interval of the above study corresponds to the period of greenhouse to icehouse transition of the earth.

The examined larger foraminiferal genera include *Nummulites* Lamarck, *Assilina* d' Orbigny, *Discocyclina* Gümbel, *Alveolina* d' Orbigny, *Dictyoconoides* Nuttall and *Lepidocyclina* Gümbel. Organic activities of the OBT primarily include bioerosion and faunal growth upon the foraminiferal tests. Bioerosion comprises *Oichnus simplex* Bromley, *O*. *paraboloides* Bromley,*O*. cf. *paraboloides* Bromly, *O*. *ovalis* Bromley, *O*. cf. *ovalis* Bromley, cf. *Oichnus* Bromley, *Trypanites helicus* Nielsen and Görmüş, cf. *Trypanites* Mägdefrau, *Gastrochaenolites* Leymerie, *Rogerella* Saint-Seine *sensu* Bromley and Alessandaro, cf. *Radulichnus* Voigt and cf. *Ichnoreticulina* Radtke and Golubic. New bioerosion *Brevisulcichnus* ichnogn. nov., comprising ***B. spectabilis ichnosp. nov.,***

B. *neglectus* ichnosp. nov. and *B*. *kutchensis* ichnosp. nov., have been erected. Bryozoan encrustation of the foraminiferal tests includes cheilostomata taxa *Therenia* David and Pouyet, *Heteropora* Lang, *Lebioporella* Harmer, *Orbiculipora* Guha and Gopikrishna along with cyclostomata taxa *Stomatopora* Bronn, '*Proboscina*' Audouin, *Voitopora* Basser. Growth of solitary scleractinian coral *Trochocyathus* Edward and Haime and ostreid bivalve *Flamingostrea* Vredenburg have been recorded on the foraminiferal tests. Several bivalve specimens appear in shades of pink indicating original shell pigments. Annelid moulds and serpulid tubes have been also recorded on the foraminiferal tests. Instances of embedment of unclassified foraminifera within the microspheric tests of reticulate *Nummulites* have been collected.

The organic activities of OBT vary in time, being most abundant in the Harudi Formation (Middle Eocene), followed by Fulra Limestone (Middle Eocene), Maniyara Fort Formation (Oligocene) and Naredi Formation (Lower Eocene) in the decreasing order of abundance. Bioerosion had been the most dominant OBT activity recorded in all the formations. Some of the plausible bioeroders include worms, gastropods, green algae and acrothoracican cirripeds. The actual list of bioeroders is likely to include other taxa to account for the conspicuous diversity of the observed traces. The aforementioned documentation reveals: (a) information on the soft bodied OBT with low preservation potential; (b) live-live faunal interactions (viz. predation and embedment) involving the larger foraminifera; (c) part reconstruction of the Palaeogene benthic community; (d) uptake of sunlight and nutrients by symbiont-bearing larger foraminifera and OBT respectively; (e) prevalence of low sedimentation regime and bioclast accumulation during the Palaeogene; (f) transformation of 'soft' micritic to 'hard' shelly bottom due to bioclast accumulation; (g) bearing of substrate change upon foraminifera and OBT; (h) selective use of larger foraminiferal tests as hard substrate by the OBT.

Key words: Larger foraminifera, Palaeogene, Kutch, synecology, bioerosion, faunal growth, encrustation, embedment

A comparison of living and dead benthic foraminiferal assemblages from the western Bay of Bengal

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Benthic foraminiferal abundance and distribution depends on food availability and oxygen content. The influence of these parameters on the benthic community however, varies from region to region. With this in consideration, benthic foraminiferal distribution was studied in 46 surface samples (35 multi-core and 11 spade core) collected from a water depth of 25 m to 2494 m from the western Bay of Bengal, covering Krishna-Godavari and Pennar river complex. The top 0-1 cm sediments from these samples were analysed for living (rose Bengal stained) and dead benthic foraminiferal assemblages. Based on the external morphology, the total assemblage was divided into two morpho-groups, viz. Rounded Symmetrical Benthic foraminifera (RSBF) and Angular Asymmetrical Benthic Foraminifera (AABF). Additionally, a few other groups were also identified based on test composition, (agglutinated and calcareous foraminifera) and abundance (*Uvigerina, Bulimina,* and *Asterorotalia*). Both, the total dead benthic foraminiferal number and total living benthic foraminiferal number increased with increasing water depth, decreasing dissolved oxygen (DO) and increasing organic carbon ($\%C_{org}$). The living and dead assemblages were comparable and show similar trend indicating limited transport and re-working of the sediments. The relative abundance of different morpho-groups, AABF, RSBF, agglutinated, calcareous benthic foraminifera, *Uvigerina*, *Bulimina*, *Asterorotalia*, were compared with the physico-chemical parameters of the ambient seawater. AABF, *Uvigerina* and *Bulimina* were relatively more abundant in the deeper oxygen poor cold water with higher $\%C_{org}$. RSBF and *Asterorotalia* were more abundant in the shallow well oxygenated, warmer water having low $\%C_{org}$. The agglutinated foraminifera were more abundant in the deeper regions of the western Bay of Bengal. The study area has a distinct hydrography and the wide depth range of collected samples will provide more meaningful understanding of the limiting physico-chemical factors affecting benthic foraminiferal abundance. These findings can eventually be applied in sub-surface samples to understand paleoclimatic changes in the area.

Keywords : Benthic foraminifera, ecology, living foraminifera, morpho-groups, western Bay of Bengal, paleoclimate.

Deep Sea benthic foraminifera and Total Organic Carbon from gas hydrate sequence of IODP Hole 1325B at Cascadia Margin during the Quaternary

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This study reports distribution of deep sea benthic foraminifera and total organic carbon from Cascadia Margin during Quaternary period. Benthic foraminifera considered to be the important component of marine community are abundant in modern oceans and good indicators of methane releases. Some of the species prefer to feed on rich bacterial food sources at methane seeps showing their potential as indicators of methane release in the geological record. *Bolivina spathulata (39.95%), Cassidulina carrinata (16.33%), Gavelinopsis lobatulus (7.52%), Pleurostomella alternans (15.68%), Uvigerina peregrina (11.83%) and Uvigerina probocidea (13.41%)* are few species found to be dominant over the analyzed samples in the mentioned region. The weight percentage of Total Organic Carbon (TOC) analysis is one of the most common geochemical proxies for ancient sediments which provide clues for methane rich seep zones. The samples analyzed from Hole 1325B of Expedition 311, measures the rate of deposition of total organic carbon during 2.6 to 0.01 Ma. The highest and lowest values of TOC, TC and IC shows quite fluctuating trends ranging from 2.371 to 0.004 wt%, 3.248 to 0.014 wt% and 0.940 to 0 wt% at study area respectively. The Study of benthic foraminifera has shown that distribution patterns are closely tied to the organic carbon flux and organic carbon content of the sediment in Cascadia Margin. The average organic carbon weight percentage results at 0.55% describe the species richness, abundance and biomass due to oxygen depletion, where the organic matter in the sediments serves as the major food source for benthic fauna. Therefore the study has a great potential in gas hydrate exploration in the marine sediments during the Quaternary.

Keywords: Benthic foraminifera, Gas Hydrates, Total Organic Carbon, Cascadia Margin

Sponge larvae in Chert-phosphorite Member of Tal Formation, Lesser Himalaya, India: a new tool to search evolution of metazoan life

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The Chert phosphorite Member of Tal Formation of Krol Belt contains abundant microfossils includingsmall shelly fossils, sponges, algae and acritarchs. During analysis of microfossilspresent inthin sections of chert of the Chert-phosphorite Member,exposed near Kauriala, Garhwal syncline, Lesser Himalaya,well-preserved characteristic microstructures with dense hair-like structures on the outer surface and solid spicular structures inside the body are observed for the first time. These structures are very peculiar in that they are superficially similar to large acanthomorphic acritarchs due to their large size and presence of processes on the outer surface. Thepresence of internal spicular structure marks the difference between the two. Although acritarchs of Cambrian affinity have been reported from Chert- phosphorite Member of Tal Formation, their size and morphology is quite different from the present microfossils.Based on the detailed observation of morphology and microstructures, it is considered that these microstructures with external hair like processes/cilia and interior spicules probably belong to sponge larvae. Sponges are known to be the earliest known metazoans. The study of sponge larvae will provide new windows for understanding early metazoan evolution. The aim of this study is to discuss these complex and enigmatic structures being reported for the first time.These complex early life evolutionary material needs the attention of paleobiologists to discuss such material to get a reasonable conclusion.

Closing of Indonesian seaway during early Pliocene: evidence from Western Tropical Pacific Ocean and South East Indian Ocean deep sea sediment cores.

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Ongoing tectonic collision between Indo-Australian oceanic plate with Pacific oceanic plate have resulted into emergence of large number of micro-continents and archipelago in the Indonesian seaway region. Presence of Indonesian archipelago result in tectonically constricted passage of Pacific Ocean tropical waters to enter Indian Ocean. Due to restriction of free passage Pacific Ocean waters starts pilling up east of Indonesia resulting in well-developed oceanographic feature known as Western Pacific Warm Pool (WPWP) maintaining annual sea surface temperature of ~28?C (Yan et al., 1992) and deep atmospheric convection. WPWP is observed to fluctuate under the influence of ENSO (El Niño southern oscillation). Several workers in last decades have been investigating using multiple proxies to understand how and when in geological history Indonesian seaway became restricted and resulted into development of modern day WPWP. Studies have revealed confusing and contradictory results suggesting closing of this leaky barrier is not a onetime event and been tectonically closing since late Miocene with estimate ranging from ~17 to ~3Ma ago (Kennett et al., 1985; Wei, 1995; Nishimura and Suparka, 1997; Srinivasan and Sinha, 1998,2000; Cane and Molnar, 2001; Sato et al., 2008; Nathan and Leckie, 2009). Thus this study aims to understand the geological process and timing of closing of Indonesian seaway which led to the formation of modern Western Pacific Warm Pool in the

Western Equatorial Pacific region. ODP hole 807A (Ontong Java Plateau, Western Tropical Pacific Ocean) (present study) and ODP site 763A (Exmouth Plateau, South East Indian Ocean) (Sinha and Singh, 2008) are ideally located for comparison of late Neogene planktic foraminifera biogeography and paleoceanographic records of tropical indo-pacific oceans. In this study total of 677 deep sea samples from ODP hole 807A (Ontong Java Plateau, Western Tropical Pacific Ocean) was analysed thoroughly to identify planktic foraminifera events (FO and LO). These events are used to erect biostratigraphic scheme for ODP hole 807A. Planktic foraminifera taxonomy is followed after Kennett and Srinivasan, 1983. A precise chronology is developed for ODP hole 807A to compare interoceanic stratigraphic ranges of planktic foraminifera species. Detailed planktic foraminifera events and biochronology for ODP hole 763A (S.E. Indian Ocean) is erected by Sinha and Singh, 2008. Biostratigraphic schemes from both the ODP sites are compared to understand late Neogene planktic foraminifera assemblages. It was observed that assemblages of planktic foraminifera at ODP 807A and ODP 763A are mostly comparable up until the commencement of the Pliocene Epoch (5.2 Ma) when the faunal record shows divergence. A important variance is observed while comparing biostratigraphic scheme from Indo-Pacific is that planktic foraminifera species *Pulleniatina spectabilis* evolved from *Pulleniatina primalis* in the equatorial Pacific region at about 5.2 Ma whereas in the S.E. Indian Ocean region *Pulleniatina spectabilis* is completely absent. Complete absence of *Pu. spectabilis* from ODP 763A (S.E. Indian Ocean) and presence at ODP 807A (Pacific Ocean) suggests closing of Indonesian Seaway during early Pliocene from 5.18Ma to 4.05Ma ago. During this time interval Indonesian seaway became an effective biogeographic barrier to thermocline dwelling planktic foraminifera of Pacific to enter S.E.Indian Ocean at the commencement of the Pliocene.

Zoogeographic Distribution, Diversity and Provincialism of Recent Freshwater Ostracoda from Karnataka, India

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There is a comparative variation in the geographical bio-geographical and climatological aspects of our State. As Northern part is covered with rock terrains and dry weather, Western side with deciduous forests, rivers and coastal plains and, Eastern and Southern part possess normal and pleasant cool climate with much greenery. Distribution of Ostracoda in local, regional and global dimensions helps us to know the extent of their survival, diversity and provincialism. It is with this idea an attempt is being made to understand the zoogeographic distribution, diversity and provincialism of ostracoda from Karnataka, India. About 50 ostracodes from ponds, streams and lakes have been recorded from Dharwad, Alnavar, Hospet, Mysuru and Bengaluru. Of these most of them are cosmopolitan and endemic. The diversity/distribution of micro crustaceans has an impact due to climatological changes, pollution (water and mining), rocky out crops and anthropogenic activities in the regions. The facts pertaining to the provincialism are also discussed very well in the present paper.

Key words : Ostracoda, Diversity, Biogeography and Provincialism,

Application of Diatoms in Assessment of Ecological Status of Freshwaters: Overview

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Diatoms are one of the popular tools in monitoring and assessment/ evaluation of surface water bodies across the world. Diatoms can be found in almost all aquatic habitats and are used as valuable indicators of environmental conditions in aquatic systems. Volumes of work on diatoms are progress in Europe, America and Australia and in some south Asian Countries like China, Japan and Korea. Though the studies on Diatoms are not new to India, their applications in Earth and Environmental sciences especially on the assessment, monitoring and recovery of surface waters are limited. In recent years, an attempt has been made to assess the **environmental conditions of surface water bodies in parts of Cauvery River, Yercaud Lake, Kodaikanal Lake, Lakes in Salem, Tamil Nadu and Loktak Lake in Manipur State in NE India and the results were compared with other areas.** The study of Diatom taxa and their assemblage reflects the gradient of water quality and environmental conditions. **The Diatoms** were highly useful in **assessment of the anthropogenic effects on water quality. As the** diatoms are sensitive to environmental changes, they were used to assess the quality of surface waters. It is noteworthy that the Biological Diatom Indices (IBD) of river Cauvery increase with heavy inflow of water resulted in rejuvenation of river to normal conditions as per IBD standards.

This paper discusses the Biological Diatoms Indices (IBD) and Water Quality Index (WQI) values and their use in assessment of ecological status of Cauvery River and Yercaud Lake. The study on Diatoms Indices (DI) reveal that water qualities of Cauvery River are good quality (Oligo-Mesotrophy) at Mettur, where as it is heavily polluted (eutrophic) at Bhavani. The Cauvery River at

Diversity and historical biogeography of Cretaceous vertebrates of the Cauvery Basin, southern India

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The Cretaceous vertebrate fauna of India has significant implications in terms of evolution and palaeobiogeography because of its position relative to the rest of Gondwana at a time of dispersal of the Gondwanan continental masses. The vertebrate fauna from the Cretaceous succession of the Cauvery Basin, south India has been known since 1845. However, it received only little attention as compared to the vertebrates already documented from the Upper Cretaceous sedimentary sequences associated with the Deccan traps of peninsular India. The Cauvery Basin is a large basin with an approximate aerial extension of 25,000 km^2, consisting of well-preserved shallow marine sedimentary sequences of the Albian to Maastrichtian age, deposited along the eastern coast of the Tamil Nadu state, southern India. The basin is classified into three groups such as the Uttattur, Trichinopoly and Ariyalur. Recent fossil discoveries from the Uttattur and Ariyalur groups of the Cauvery Basin appear to support the emergence of significantly diverse marine and non-marine vertebrate faunas, respectively, consisting of fishes, frogs and reptiles including ichthyosaurs, plesiosaurs, turtles, crocodiles and dinosaurs have revived the interest in the fauna of the basin as it has significant implications for understanding the palaeobiogeography of India. The latest Albian to Turonian Uttattur marine vertebrates such as sharks, ichthyosaurs and plesiosaurs show a wide geographic distribution and marine territory, while sharks are typically cooler water fauna of high palaeolatitude. The latest Maastrichtian Ariyalur non-marine vertebrates especially turtles, crocodiles and dinosaurs are considered to show mixed Gondwanan and Laurasian affinities thus providing new evidences in favour of a latest Cretaceous biotic links between India and the neighbouring continents.

Keywards: Cauvery Basin, India, Cretaceous, Vertebrates, Diversity, Palaeobiogeography

Palynology, palaeoecology and palaeodepositional environment of Late Palaeocene to Early Eocene lignites and associated sediments of Matanomadh Lignite Mine, Kutch Basin, Gujarat.

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The transition of Indian subcontinent through palaeoequatorial position during Palaeocene –Eocene time caused significant palaeobiological and paleogeographical changes. The western Indian lignites and associated sediments /successions treasured the signatures of extreme global climate changes and their effect on livestock. In present study, palaeofloral diversity has been recorded from Matanomadh lignite Mine deposits, western Kutch, Gujarat to reconstruct palaeovegetation and palaeoenvironment of the region during Palaeocene-Early Eocene time.

The Matanomadh Lignite mine palynological assemblage is diverse and rich, containing 71 genera and 107 species, out of these, algal remains (15 genera and 25 species, including dinoflagellate cysts); fungal remains (6genera and 10 species), pteridophytic spores (15 genera and 22 species) and angiospermous pollen grains (35 genera and 50 species). Qualitative and quantitative analyses reveals that the assemblage is dominated by angiospermous pollen grains followed by pteridophytic spores/dinoflagellate cysts. The important genera are: *Operculodinium, Cordosphaeridium, Polysphaeridium, Glaphyrocysta, Lejeunecysta, Lygodiumsporites, Dandotiaspora, Todisporites, Biretisporites, Polypodiaceaesporites, Retimonosulcites, Proxapertites, Neocouperipollis, Spinizonocolpites, Acanthotricolpites, Lakiapollis, Tricolporopollis, Dipterocarpuspollenites, Albertipollenites, Triangulloritesm, Retistephanocolpites,* and *Polybrevicolporites.*

The assemblage has been compared to modern taxa and found 30 extant families. Out of these, 5 families are restricted to tropical to subtropical; 5 are tropical, 1 cosmopolitan; 1 marine; 1fresh water and 1 tropical-temperate. Pteridophytic spores are

represented by the families of Osmundaceae (*Osmundacidites, Todisporites*), Schizaeaceae (*Lygodiumsporites, Schizaeoisporites*) and Polypodiaceae (*Polypodiaceaesporites, Polypodiisporites*) collectively indicate the prevalence of perennial water in their close vicinity, and warm and humid climate. The fungal remains present in the assemblage supports the view. The dominant population of the palynoflora is represented by 20 families of angiosperms, of these, Arecaceae (Monocot) is the most abundant. Palms referable to the family Arecaceae are predominantly pantropical, and restricted to evergreen and semi-evergreen forests. The diversity of *Spinizonocolpites* (*Nypa)* complex in the present study appears presence of various brackish water habitats. The dominance and variety of palm pollen is sufficient for interpreting the climate as definite tropical. Pollen grains belonging to Bombacaceae (*Lakiapollis ovatus and Tricolporopollis matanomadhensis)* are also abundant in this assemblage and it supports tropical climate. Tropical rain forest elements belonging to the families Dipterocarpaceae (*Dipterocarpuspollenites)*, Oleaceae (*Retitrescolpites*) and Ctenolophonaceae (*Retistephanocolpites* and *Ctenolophonidites*) also occur in the section. The overall assemblage indicates a warm and humid climate of a coastal zone, with a dense tropical rain forest in the vicinity of the site of deposition. An analysis of ecological groups represented by Matanomadh Lignite mine deposits reveal that the costal elements are dominant over fresh water swamp and water edge/terrestrial and marine elements. *T*he presence of dinoflagellate cysts (*Polysphaeridium, Operculodinium, Glaphyrocysta, Cordosphaeridium* and *Lejeunecysta*) and mangrove elements (*Spinizonocolpites* and *Spinomonocolpites*) elements in the palynoflora indicates an influx of brackish water during the deposition. It is concluded that the deposition of the Matanomadh Lignite Mine succession took place in coastal marshy lagoonal environmental conditions.

Palynoflora from two new intertrappean localities near Shibla village in Yavatmal District and Shankar Lodi village in Chandrapur District of Maharashtra: age implications.

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The Deccan continental flood basalt (DCFB) province extends in an area of about 500,000 km^2 in central and western India. The study of flora of the Deccan volcanic associated sediments is significant to understand the floral composition during Late Cretaceous-Early Paleocene. To know the palynoflora of intertrappean beds of central India palynological study of intertrappean beds associated with Ajanta Formation were studied. Of the studied intertrappean localities one near Shibla village and another near Shankar Lodi village in Yavatmal and Chandrapur districts respectively were found to be rich in palynomorphs. The Shibla intertrappean is about 2 m thick and lithologically composed of variegated chert in the lower part and tuffaceous shale in the upper part. Both chert and shales are associated with gastropods (*Physa*) and plant fossil woods. The palynological study indicated presence of palynomorphs of three genera of pteridophytes, one genera of gymnosperm and six genera of angiosperms. Of these *Proxapertites operculatus* and *Gabonisporis vigourouxii* are the most dominating followed by pollen of *Sparaganiaceaepollenites* sp. and *Incrotonopollis neyvelii.* Megaflora in this intertrappean is represented by seeds of family Vitaceae (Manchester et al, 2013) and fossil wood of dicot plants.

The intertrappean of Shankar Lodi is about 1 m thick and composed of fossiliferous black chert. The palynoflora is represented by six genera of pteridophytes, one genera of gymnosperm and eight genera of angiosperms. Of these palynomorphs of *Gabonisporis vigourouxii, Cyathidites*

australis, Azolla cretacea, Incrotonipollis nyvelii and *Retitricolpites reticulatus* are the dominant taxa. The other taxa which are common in this intertrappean are *Periporopollenites demarcatus*, *Proxapertites operculatus* and *Lygodiumsporites lakiensis*. Although qualitatively diversity of palynotaxa in both these intertrappean is less however they have good number of age marker taxa such as *Azolla cretacea*, *Aquilapollenites bengalensis* and *Gabonisporis* vigourouxii which suggest Maastrichtian age for the deposits. The presence of pollen grains of genus *Periporopollenites demarcatus* in the intertrappean sediments of Shankar Lodi is significant as the pollen of this species are comparable with the pollen grains of extant family *Caryophyllaceae.* Till date the fossil record of this family starts from Paleogene onwards therefore, record of the pollen grains this family from Maastrichtian intertrappean sediments is the oldest record known so far.

Key words : *Deccan volcanism, intertrappean, palynomorphs, Maastrichtian*

Taphonomic analysis of Campanian-Maestrichtian Shell accumulations, Kallankurichi Formaiton Kallankurichi, South India.

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Shell accumulations are important events to understand and decode Taphonomic and paleoecological changes occurring during its deposition. Upper Cretaceous (Campanian-Maestrichtian) sediments of the Kallankurichi Formation are rich is shell accumulations. The Shell accumulations are dominated by large and thick shelled bivalves with varying degree of preservation and commonly encrusted by bryozoans etc and bored by various types of borings. Three basic types of shell accumulations are identified (a) dispersed, well preserved shells with borings and encrustations, (b) fragmented with dominantly convex up arrangement (c) closely packed randomly oriented partially well preserved shells. Systematic lateral analysis in the Kallankurichi mines reveals most of the shell accumulation types were deposited in low sedimentation input which favored encrusters and borers alternating with high energy conditions favoring in-situ reworking. Such alternation of low sediment input with high energy conditions are usually found in shallow marine condition especially in between normal wave base and storm wave base conditions during Campanian -Maestrichtian times

Key Words: Shell accumulations, Campanian-Maestrichtian, Taphonomy, Kallankurichi Formation, South India.

Geo-environmental significance of Subrecent and Recent Molluscan fauna along the west coast of Ratnagiri District, Maharashtra.

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Area around Ratnagiri stretching over 20 to 25 km.covering localities from Mirya Jetti in the North to Kurli beach in the South is covered under present study. This stretch includes locations like Bhagvati temple,Mandvi,Bhate bridge, Bhatye coast, Zari Vinayak, and Kurli beach. Present study aims to find out geo-environmental significance and its effect on Molluscan fauna. In all 6 water samples have been collected from Mirya Jetti, Mandvi beach south end of Bhatye bridge Zari Vinayak and Kurli beach. Similarly surface sand samples were collected. Parameters like pH ,EC, RSC, DO, BOD,COD, TS, TSS, TDS were investigated for water and sand samples. Like wise from flame photometric method, spectro photometric method, Silver Nitrate method were considered to find out various parameters like Ca + Mg, Na, S, Cl, etc. were considered for analytical work. pH of the sample appears to be within the prescribed limit, while EC is on higher side. Similarly Ca + Mg , Na, S, and Cl found to be high and unsafe for any use especially for agriculture. Faunal elements from these six areas have been found quite variable .Kurli area is dominated by Turritella species while at Bhatye beach and Zari Vinayak localities abundance of bivalves is noticeable .In remaining areas few gastropods occur along with bivalve fauna ***Perna viridis*** i.e. common and dominant species while ***Paphia Texalena*** is dominant among bivalves. Similarly specimens of ***Crocostrea*** have been collected from Bhatye Mirya area.

Key Words: Molluscan fauna, significance, Subrecent and Recent, geo-environment, Ratnagiri district, Maharashtra

Paleo-philately: A Unique mode of education in Geosciences

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Paleo-philately is the hobby of collecting and studying postal stamps and related material on fossils. In recent time this discipline has proved one of the unique mode of education in geosciences .The aim and objective of this paper is to assess and analyse the Philatelic collection pertaining to Paleontology and to find out whether this can be addressed to highlight the diversity and classification of fauna.

Fossils being the most fascinating objects are the centre of attraction for many. They get easy attention of the specialists and non specialists and as such interest to common man. They are found in sedimentary rocks of all the ages and of all the environments and hence very useful and significant. Fossils are commonly preserved in most favourable conditions such as rapid burial.

A critical analyses of the stamp collection enable the author to classify the fossil diversity into four kingdoms namely Monera, Protista, Animalia-and Plantae. Besides there are stamps devoted to Ichnofossils.

The diversity of the fauna can be used in precise understanding of the evolution and it has immense application in sedimentary processes .This includes the exploration of fossil fuel, paleoecology , paleoclimate and paleoenvironment etc.

Key Words: Geosciences, Unique mode, Palaeo-Philately, education

Study of Late Cretaceous foraminifera from the exotic limestone of Hungpung Village, Ukhrul District, Manipur State, NE India

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Forty five geological samples are collected from two exotic limestone blocks namely Hungpung North band and Hungpung Lower band from the ophiolite mélange zone in Hungpung (erstwhile Hundung) village lies within 94º20'12? and 94º20'43? longitudes and 25º20' and 25º20'12? latitudes of Ukhrul District, Manipur, Northeast India. The samples are processed for the study of foraminifera using micropaleontological technique developed by Zolnaj (1979). They have yielded rich variety of planktic and benthic foraminifera include twenty six planktic foraminifera and three benthic foraminifera as follows:

Planktic foraminifera: *Contusotruncana contusa, Contusotruncanita plicata, Globigerinelloides ultramicra, Globotruncana arca, Globotruncana bulloides, Globotruncana dupeublel, Globotruncana falsostuarti, Globotruncana lapparenti), Globotruncanav linneiana, Globotruncana pseudoconica, Globotruncana ventricosa, Globotruncanella havanensis, Globotruncanita angulata, Globotruncanita calcarata, Globotruncanita pettersi, Globotruncanita stuarti, Globotruncanita stuartiformis, Globotruncanita subspinosa, Hedbergella flandrini, Heterohelix globulosa, Heterohelix pulchra, Heterohelix reussi, Heterohelix striata, Marginotruncana pseudolinneiana, Rugoglobigerina rugosa, Rugoglobigerin amacrocephala;* Benthic foraminifera: ***Dentalina catenula, Gavelinella cenomanica and Oolinaa piculata.***

The presence of marker planktic foraminiferal species *Globotruncana calcarata* and *Globotruncana ventricosa* indicate Middle to Late Campanian age for the Hungpung North band; whereas the presence of *Globotruncana ventricosa* indicate Middle Campanian age for the Hungpung Lower band. The study of foraminiferal assemblage indicate open marine environment for the study area.

Keywords: Late Cretaceous foraminifera, Exotic Limestone, Campanian

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The Geological Society of India

The Geological Society of India was established in a modest way on 28th May 1958 about 57 years ago to promote the cause of advance study and research in all branches of earth system science. The Society has gained recognition nationally as well as internationally as a leading earth science organization in India. The Journal of the Geological Society of India is its flagship publication. The Society also started co-publishing the electronic version of the Journal with Springer India. The Society is also publishing "Episodes", the quarterly Journal of IUGS since 2009. In addition Society also publishes Special Publications (covering the papers presented at conferences/seminars etc.) Memoirs, Field Guides and books in regional languages, Text books on geology of individual states of the Indian union. Most of the Indian states have been covered and this textbook series has become popular among the students of geology. In addition the Society organizes monthly talks and special lectures by eminent scientists in different branches of Earth System Science.

The Society has three classes of membership (1) Fellows (Annual and Life Membership); (2) Honorary Fellows and (3) Corporate Members. In order to recognize and encourage outstanding talent, the Society has instituted several awards and Gold Medals through voluntary donors in different branches of Earth System Science.

The Society celebrated its Golden Jubilee in the year 2008. It has successfully organized the 10th International Kimberlite Conference in the year 2012 and also conducted the 7th International Earth Science Olympiad (IESO) in the year 2013. These two international events have show-cased the Society's progress. It also conducts Workshops / Symposia / Seminars with leading universities and research organizations. Recently Workshops on Orthomagmatic ore deposits, Source Rocks of Diamond, Fluid Inclusion studies etc., have been conducted successfully to meet the requirement of the scientific community. Society also conducts annual events such as Foundation Day, Earth Day etc., regularly. Brief reports on all these events are regularly published in the Journal. These activities are supported monetarily by Department of Science and Technology (DST), Ministry of Earth Sciences (MoES) etc.

Bhavani areas are grossly polluted due to the discharge of untreated sewage disposal, industrial effluents directly into the river and anthropogenic impacts. The analysis of Biological Diatom Indices (IBD) for Yercaud Lake, Tamil Nadu show low quality to moderate quality i.e. Eutrophy–Mesotrophy conditions in Yercaud lake.

In Cauvery River the dominant presence of *Eunotia bilunaris*, *Eunotia intermedia*, *Achnanthidium minutissimum* diatom taxa are generally associated with good water quality; whereas medium to bad water quality are characterized by pollution tolerant diatoms species such as *Gomphonema parvulum*, *Nitzschia palea* and *Synedra ulna.* As pollution increases from Siluvampalayam to Bhavani in Cauvery River the low-pollution tolerant diatom species *Aulagosira granulate* and *Gomphonema angustatum* were replaced by pollution tolerant species of *Gomphonema parvulum*, *Nitzschia palea* and *Synedra ulna*. The dominance pollution tolerant diatom taxa *Fragillaria intermedia, Gomphonema parvulum, Melosira granulate and Synedra ulna were recorded* at the Inlet of the lake I-6 during summer seasons indicate sewage pollution in the lake where high BOD and COD values were recorded. This may be due to the dumping of garbage, sewage, illegal discharge of slaughter house waste and surface runoff to Yercaud Lake.

This paper also stresses the importance of Diatom studies and their applications.

Keywords: Diatoms, Surface Waters, Ecological Status

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