National Seminar
on
EFFECTS OF PALEO AND ANTHROPOGENIC EVENTS ON EARTH SYSTEM

and

ANNUAL GENERAL MEETING (AGM)- 2018 OF GEOLOGICAL SOCIETY OF INDIA

19-21 September, 2018

ABSTRACTS

Organised by
DEPARTMENT OF GEOLOGY
PERIYAR UNIVERSITY
Salem – 636 011, Tamil Nadu, India

in association with
GEOLOGICAL SOCIETY OF INDIA

Sponsors

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www.epaevents2018salem.com

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प्रकाश जावडेकर
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सत्यमेव जयते

मंत्री
मानव संसाधन विकास
भारत सरकार
MINISTER
HUMAN RESOURCE DEVELOPMENT
GOVERNMENT OF INDIA

MESSAGE

I am glad to learn that Periyar University, Tamil Nadu is going to conduct a National Seminar on *"Effects of Paleo and Anthropogenic events of Earth System"* and AGM of the Geological Society of India during 19th to 21st September, 2018.

This seminar will focus on the following major themes: Marine Transgression and Regression; Coastal Geomorphology; Boundary Events; Mass Extinctions; Anoxic Events; Climate Change; Sustainable Development of Mining and Industry; Overexploitation of Groundwater; Ecosystem and Pollution; Agriculture and Deforestation.

I extend my best wishes to the organisers, participants and the awardees from different regions of India representing Industries, Institutions, Universities and Colleges, besides 100 M.Sc., Applied Geology Students from Periyar University Departments and affiliated Colleges.

(PRAKASH JAVADEKAR)

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PERIYAR UNIVERSITY
State University
Salem - 636 011
Tamil Nadu, India

Professor P. KOLANDAIVEL
Vice Chancellor

Date: 06-09-2018

Message

I am happy that Department of Geology, Periyar University is organizing a National Seminar on "*Effects of Paleo and Anthropogenic events of Earth System*" and also host the Annual General Meeting(AGM) of the Geological Society of India during 19-21 September 2018 at Salem which is a *Geologist's Paradise*, known for its mineral wealth and mining industries.

I hope that this seminar will focus on Marine Transgression and Regression; Coastal Geomorphology; Boundary Events; Mass Extinctions; Anoxic Events; Climate Change; Sustainable Development of Mining and Industry; Overexploitation of Groundwater; Ecosystem and Pollution; Agriculture and Deforestation.

These topics are very important in the national and international scenario. I learnt that good number of delegates from Tamil Nadu and other States are participating in the Seminar. It is a great moment and opportunity for young students of the Department of Geology, Periyar University and other institutions to attend this seminar and to meet and discuss with eminent scholars of Geology.

I would like to congratulate the organizing secretary and committee members for organizing this seminar. Further, I thank the members of the Geological Society of India for conducting their Annual General Meeting (AGM) at Periyar University.

I wish the national seminar and Annual General Meeting (AGM) of the Geological Society of India a grand success.

P. Kolandaivel

[P.Kolandaivel]

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MESSAGE

I am happy to learn that a National Seminar on the "*Effects of Paleo and Anthropogenic Events of Earth System*" is being held at Periyar University from 19th to 21st September 2018. It is a privilege to be part of the revered institution of national repute.

Over the past several billion years our planet has undergone complex interactions, swinging through periods of intense heat and extreme cold, coupled with plate tectonic events. The inquisitiveness of Earth Scientists to delve into the sequences, causes and consequences have led to the pursuit of mineral resources, bountiful within Mother Earth. In this quest, while harnessing the resources, conserving the biosphere is of utmost importance. It is indeed pleasing to know that the Seminar will focus on themes ranging from Tectonic History, Biodiversity, Paleoenvironment, Geomorphology, Marine Transgression and Regression to Sustainable Development of Mining Industry. The conglomeration of Academicians, Industry Professionals and Students will provide a forum for exchanging experiences and knowledge on the various aspects of Earth Science and Sustainable Development.

"What we have learned is like a handful of earth; what we have yet to learn is like the whole world." Knowledge grows as you share. Seminars of this magnitude provide a platform to share knowledge, exchange ideas and provide a great impetus to overall development of the country.

I take this opportunity to wish the participants and the organizers all the very best for the event.

(P. Chandrasekaran)

PREFACE

Earth is the only known planet to support life. The physical features of the Earth have evolved and shaped by different geological processes. The earth has witnessed many natural events involving geological and extra-terrestrial in the past and more recently by anthropogenic factors. The nature of earth processes creates a dynamic setting that has recorded paleo events/ past environmental events, climate variations and paleo landscapes. Understanding of these processes is important for extraction of mineral, hydrocarbon and water resources, mitigation of natural hazards besides protection of environment.

Anthropogenic events have accelerated the changes in environment and are most important reasons for the global warming, failure of monsoon and natural calamities including floods faced by mankind in recent years. Dealing with Climate change requires adequate knowledge and understanding of past changes on the interactions among earth-ocean-atmospheric system and their impact on ecosystem.

The National Seminar on "Effects of Paleo and Anthropogenic Events on Earth System" or "EPAEVENTS2018SALEM organized by the Department of Geology, Periyar University focus and kindle awareness among people about the importance of protecting our mother earth. About 120 participants representing Industries, Institutions, Universities and Colleges are participating in the Seminar of National importance at Salem – a "Geologist's Paradise", known for its mineral wealth and mining industries.

It has been planned to highlight the evolving and dynamic nature of the Earth involving geological, extra-terrestrial and more recently anthropogenic factors. This was evident in the geological past through changes in coastal geomorphology by marine transgressions and regressions, boundary events characterised by mass extinctions due to catastrophic events like meteoritic impacts, volcanism, anoxic events and major climate changes as evidenced by glacial and warmer periods.

After the advent of the humans on the Earth and with the progress of the civilisation, an exponential increase in the exploitation of natural resources has taken place often ignoring sustainability issues and the impact on environment. The consequences have been all too well-known. Over-exploitation of groundwater, deforestation, haphazard mining and agricultural practices has had severe impacts on global ecosystems. Pollution levels have reached an all time maximum, more so in rapidly developing societies like ours. A holistic approach is required for urgent remedial measures, where social and economic factors also play important roles. The role of science and new technologies occupy paramount importance in mitigating the present scenario. The seminar, it is hoped will provide a forum for wide-ranging discussions on all the relevant issues from the Earth Science perspective with special focus on the following themes: Marine Transgression and Regression; Coastal Geomorphology; Boundary Events; Mass Extinctions; Anoxic Events; Climate Change; Sustainable Development of Mining and Industry; Overexploitation of Groundwater; Ecosystem and Pollution; Agriculture and Deforestation.

This Seminar is duly supported/ Sponsored by SERB, MoES, OIL, ONGC, CSIR, Union Bank of India and Leica Microsystems India. We express our sincere thanks for their valuable contribution and support for the successful conduct of this Seminar. The Organising Committee is thankful to the authorities of Periyar University and the Council, Geological Society of India for their support at every stage of the seminar to achieve this magnitude. The Convener is also thankful to Scientific Advisory Committee, members of Local Organising Committee, well-wishers, non-teaching staff, scholars and students of Periyar University for their timely support in organization of the seminar.

It is sure that the three days seminar will deliberate many important geological problems/ issues, recent developments in geological sciences and will be a memorable one.

It is intended to publish the peer reviewed papers as a Special publication of the Geological Society of India.

Salem
19th September 2018

Prof. Dr. R. Venkatachalapathy
Convener - EPAEVENTS2018SALEM

HIGHLIGHTS OF THE NATIONAL SEMINAR ON EPAEVENTS2018SALEM

"EFFECTS OF PALEO AND ANTHROPOGENIC EVENTS ON EARTH SYSTEM" AND ANNUAL GENERAL MEETING OF GEOLOGICAL SOCIETY OF INDIA

19-21 SEPTEMBER, 2018

Organised by : Department of Geology, Periyar University, Salem - 636 011, Tamil Nadu

Sponsors : SERB, MoES, OIL, ONGC, CSIR

Venue : Grand Ball Room at Hotel Radisson, NH-7 Bangalore Highway, Mamangam, Salem

PROGRAMME

Day 1: Wednesday, 19th September 2018

08.30-09.30 : Registration

10.00-11.15 : **Inaugural Function**

11.15-11.30 : TEA BREAK

11.30-01.15 : **Technical Session–1: Special Session for Keynote Addresses**

Chairpersons : **Prof. Harsh K. Gupta and Prof. Hema Achyuthan; Rapporteur: Dr. R. Suresh**

11.30-12.15 : **Keynote 1 : Geosciences in Energy Security**
- **Dr. P. Chandrasekaran,** Director (E&D), OIL

12.15-12.45 : **Keynote 2 : The Indian Mega-Sequences: Salient Features & Major Events**
- **Prof. Dr. Jai Krishna,** HoD (Rtd.) Banaras Hindu University - p.1

12.45-01.15 : **Keynote 3 : An Insight into Petroleum Exploration & Exploitation**
- **Shri. P. Raja,** Ex. Executive Director, ONGC

01.15-02.00 : **LUNCH BREAK**

02.00-03.15 : **Technical Session–2 : Invited Talk & Society Endowment Lecture-1**

Chairpersons : **Dr. M. Prithviraj and Dr. K.Anbarasu; Rapporteur: Dr. N. Vijayakumar**

02.00-02.30 : **Invited Talk-1 : Understanding the Evolution of early life on the earth**
- **Prof. Mukund Sharma,** Banaras Hindu University

02.30-03.00 : **Endowment Lecture-1: "R. Prahaladrao Endowment Lecture"**
- **Shri. D.V. Pichamuthu**

03.00-03.15 **TEA BREAK**

03.15-05.00 : **Annual General Meeting of Geological Society of India & Society Awards**

05.00-06.00 : Special Interactive Session for Scholars, Students with Experts and Awardees

07.00-08.45 : Cultural Programme

09.00-09.30 : **DINNER**

Day 2: Thursday, 20th September 2018

09.00-11.00 : **Technical Session–3: Tectonic History, Major Boundary Events & Mass Extinction**

Chairpersons : **Prof. Jai Krishna and Shri. P. Raja; Rapporteur : Dr. K. Anbarasu**

09.00-09.20 : **Special Paper-1** : Precambrians of Southern India : Need for Resolving Divergent and Conflicting Views - **Prof. K. R. Subrahmanya -** p.11

09.20-09.30 : Initiation of the Indian Ocean at 159 Ma late Middle Oxfordian Orientalis Zone Schilli Subzone MFS event - **Jai Krishna** - p.4

09.30-09.40 : Environmental effects of Deccan volcanism on biotic changes and K/Pg mass extinction in the Indian sub-continent: Organo-molecular evidences - **Sucharita Pal, Surabhi Srivastava and J. P. Shrivastava -** p.5

09.40-09.50 : Petrology of mafic intrusives associated with the Semris of the Vindhyan Supergroup in the eastern part of the Son Valley, Central India: Implications for bimodal volcanism - **Mageswarii G., Meenal Mishra and J. P. Shrivastava** - p.8

09.50-10.00 : Mass disappearance of radiolarians in the Central Indian Ocean Basin: Response to Paleo-events - **Ankeeta Amonkar and Sridhar D. Iyer** - p.8

10.00-10.10 : A tectono-sedimentary model of evolution of Paleoproterozoic Kolhan Basin - **Rohini Das and Subhashish Das** - p.13

10.10-10.20 : The Morphometric Classification and Geologic Implications of Kolhan Basin, Jharkhand, India: A Geospatial Approach - **Smruti Rekha Sahoo and Subhasish Das** - p.14

10.20-10.30 : Melt-clast relationship of deformed pseudotachylytes: An insight from clast size analysis and roundness study - **Abinash Bal, Rudra Mohan Pradhan and T. K. Biswal** - p.14

10.30-10.40 : Occurrence of an ambiguous rock near Putteti Alkaline Igneous Suite, Kanyakumari District, Tamil Nadu, South India - Is it Peperite? - **Anjana A.V. Panicker and N. Kumar** - p.15

10.40-10.50 : Paleostress analysis from Gangavalli (southern India): Inferred from pseudotachylyte Emplacement and fracture data - **Bhuban Mohan Behera and T. K. Biswal** - p.16

10.50-11.00 : Questions & Discussions

11.00-11.10 : **TEA BREAK**

11.10-12.30 : **Technical Session–4: Bio-events and Paleoenvironment**

Chairpersons : **Prof. S.P.Mohan and Prof. S.G.D. Shridhar; Rapporteur: Dr. V. Thirukumaran**

11.10-11.20 : Biostratigraphy of Early Cretaceous Sediments of Krishna Godavari basin - **Ashish Kumar Mishra, N. Malarkodi, Arun Deo Singh and Vandana Prasad** - p.22

11.20-11.30 : Palaeoenvironmental and Palaeoecological implications of freshwater and marine mixed biota from Early Cretaceous succession of Jaisalmer Basin, Western India - **Neelam Das, Raj Kumar, Krishna Kumar, Abha Singh, Binddhyachal Pandey and Neeru Prakash** - p.23

11.30-11.40 : Bio-events and Paleoenvironment of Albian Foraminifera in the Uttattur Group, Southern India - **Venkatachalapthy, R. and Harini, L** - p.23

11.40-11.50 : Age and paleoenvironment of Cretaceous sediments exposed in Karai to Kulakkanatham Traverse, Uttatur Group, Tamil Nadu - **Venkatachalapathy, R. and Kathirvel, P.** - p.24

11.50-12.00 : Study of Late Cretaceous Foraminifera from the exotic limestone of Naothalung area in Hungpung Village, Ukhrul District, Manipur State, NE India - **Venkatachalapathy, R. and Pemmaya Kasomva** - p.24

12.00-12.10 : Rupelian (Early Oligocene) calcareous nannofossils and dinoflagellate cysts from Lumpy clay Member of Maniyara Fort Formation, Kutch - **Poonam Verma and Abha Singh** - p.27

12.10-12.20 : Pleistocene deep-sea benthic foraminiferal diversification from Cascadia Margin (IODP Hole 1325B), NE Pacific Ocean - **T. Thena, K. Mohan and M. Prakasam** - p.29

12.20 - 12.30 : Evolutions and Extinction of Planktic Foraminfera in defining the Cenomanian and Turonion Stages in India - **R. Venkatachalapathy** - p.29

12.30- 12.40 Questions & Discussions

12.40 - 01.20 POSTER PRESENTATIONS

01.20 - 02.00 **LUNCH BREAK**

02.00-03.40 Technical Session–5: Paleoenvironment and Paleobiogeography

Chairpersons : **Prof. R. Neelakantan and Prof. R. Krishnamurthy; Rapporteur: Mr. V. Thirumurugan**

02.00-02.20 : **Special Paper-2 :** Ichnoassemblages and Tiering in Cretaceous Giumal Formation, Spiti Himalayas: Implications for understanding colonization of turbidite sequence in deep sea environment - **Bhawanisingh G. Desai and Rajendra Dutt Saklani** - p.31

02.20-02.30 : Trace fossils and Ichnofabric analysis in Early – Middle Miocene Inglis Formation: Insight from ichnology of forearc basin, Andaman Subduction zone, Andaman and Nicobar Islands, Northeast Indian Ocean - **Bhawanisingh G. Desai** - p.31

02.30-02.40 : Palaeoecological analysis of gastropods from the Eocene of Kutch, Gujarat reveals storm induced concentration in shell bed within a quiet marginal marine setting - **Sayoni Banerjee, Shrestha Das and Kalyan Halder** - p.32

02.40-02.50 : Sandstone Petrography, Heavy Mineral Analysis and Grain Size Analysis in a Lithostratigraphic Sequence : A Case Study from the Proterozoic Kolhan Group, Odisha and Jharkhand - **Rakshanda Jena and Subhasish Das** - p.33

02.50-03.00 : Early Cretaceous Marine signatures in Palar basin and its equivalents in east coast of India - **P. Kumaraguru and R.Sivakumar** - p.34

03.00-03.10 : Source rock characterization of Disang sediments in parts of Naga Hills North East India - **Vekhoto Shijoh and N. Pandey** - p.35

03.10-03.20 : Tidal facies characterisation of Palaeogene sediments of Tiru valley, Mon District, Nagaland - **K.Chiezou and N. Pandey** - p.36

03.20-03.30 : Megafossils from the Rajmahal Basin, Jharkhand, India - **Arun Joshi** - p.37

03.30-03.40 : Questions & Discussions

03.40-03.50 : **TEA BREAK**

03.50-06.00 : **Technical Session–6: Paleoclimate and Climate Change**

Chairpersons : **Prof. R. Venkatachalapathy and Prof. Nilesh Bhatt; Rapporteur : Dr. A. Thirunavukkarasu**

03.50-04.00 : **Invited Talk-2: "Climate Change and its Impact with Reference to Chennai City" - Prof. R. R. Krishnamurthy** - p.61

04.00-04.10 : Record of Permian Tethyan transgression in Sikkim-Darjeeling Himalaya with special reference to the Paleoclimatic event-**Raj Kumar Priya, V.C. Tewari & Rakesh Ranjan** - p.53

04.10-04.20 : Effects of climate change and other geological events on the evolution of palaeobiogeographic distribution pattern of Paleogene bivalves - **Aniket Mitra and Kalyan Halder** - p.53

04.20-04.30 : Carbon capture and long-term storage in basalt of the Deccan volcanic province: A possible device to control climate change - **Amit Kumar and J. P. Shrivastava** - p.54

04.30-04.40 : Paleoclimatic and Paleoceanographic variation in the Sulu Sea since LGM: Planktic foraminiferal abundance and stable isotopic records - **Ashutosh K Singh , Vikram Pratap Singh and Brijesh Singh** - p.55

04.40-04.50 : Palynofloristic and Palaeoclimatic Investigations of Lower Gondwana Sediments from West Bokaro Coalfield, Jharkhand, India - **Chanchal Lakra, Bacha Ram Jha & Neha Aggarwal** - p.55

04.50-05.00 : Quaternary fluctuations in Agulhas leakage and surface water hydrography of Southern Ocean - **Nirmal B and Mohan K** - p.56

05.00-05.10 : Imprints of Holocene climate instability on Indian Summer Monsoon – An overview - **Upasana S. Banerji and D. Padmalal** - p.57

05.10-05.20 : Last Glacial Maximum to Holocene abundance pattern of Uvigerina spp. in the Eastern Arabian Sea - Implication to paleoproductivity - **A. Rajasree and V.K. Banakar** - p.58

05.20-05.30 : Monsoon-influenced variations in productivity during the Pleistocene from Oman Margin, Arabian Sea based on planktonic foraminifera – **Aswathy M.R. and Mohan K.** - p.58

05.30-05.40 : Connection between climate and tectonics: Implication to Kolhan basin evolution in Proterozoic - **Kasturi Bhattacharyya and Subhasish Das** - p.60

05.40-05.50 : Questions & Discussions

Day 3: Friday, 21st September 2018

08.40-10.30 : **Technical Session–7: Coastal Geomorphology, Ecosystem and Pollution**

Chairpersons : **Dr. Bhawani Singh G. Desai and Dr. Ashutosh K Singh; Rapporteur: Dr. G. Nanthakumar**

08.40-09.00 : **Special Paper-3: "Exploration for Ocean Resources" - Dr. A. N. Singh** - p.72

09.00-09.10 : Coastal Cliffs and Tidal Notches of South Saurashtra, Western India: Significance in Understanding Late Quaternary Land-Sea Interactions - **Bhaskar Acharya, Nilesh Bhatt, Mitali Kadam and Lawrance Parmar** - p.39

09.10-09.20 : Signatures of Late Quaternary Land-Sea Interactions and Landform Dynamics along Southern Kerala Coast, SW India - **Arulbalaji P., Upasana S. Banerji, K.Maya and D. Padmalal** - p.39

09.20-09.30 : Estuarine Dynamics and Shoreface Morphology in a Tropical Coast: Implications for Estuarine Management (A Case Study from the Mulki Estuarine System, Central West Coast of India) - **Shalini, G., Soumya and V.S. Hegde** - p.40

09.30-09.40 : Sediment Movement and Morphodynamic Processes in the Vicinity of a Fishery Port (Bhatkal), Central West Coast of India: Implications for Siltation - **V.S.Hegde, Shalini, G., A.S.Rajawat, Diksha,K. Lavanya, G. Hegde, Girish, K. H., Gosavi, K., Krishnaprasad, P.A, and Tejasvini, B.** - p.41

09.40-09.50 : Assessment of Shoreline Changes of Tropical West Coast of Maharashtra, India using GIS and Remote Sensing Techniques - **Milind A. Herlekar, Prafull B. Kamble and Praveen B Gawali** - p.42

09.50-10.00 : Geochemical status and multivariate analysis of Trace Elements in sediments of the Emerald Lake, Tamil Nadu, India - **Karthikeyan P., Venkatachalapathy, R., Vennila, J. & Aswini, M.** - p.46

10.00-10.10 : Distribution of Diatoms and Water quality assessment of the Thamirabarani River between Papanasam to Kokkirakulam,Tirunelveli District,Tamil Nadu **- Venkatachalapathy, R. and Madhankumar, M.** - p.47

10.10-10.20 : Ecology and Distribution of Diatoms in Thamirabarani River between Naranammalpuram and Punnaikayal, Tamil Nadu - **Venkatachalapathy, R. and Rajeshkanna, A.** - p.47

10.20-10.30 : Diatom-based water quality montoring in India : Perspective - **R. Venkatachalapathy** - p.50

10.30-10.40 : Questions & Discussions

10.40-10.50 : **TEA BREAK**

10.50-12.50 : **Technical Session–8: Overexploitation of Groundwater and Agriculture & Sustainable Development of Mining and Industry**

Chairpersons : **Prof. Arun K. Shandilya and Prof. B. Gurugnanam; Rapporteur: Dr. Milind A. Herlekar**

10.50-11.00 : Quality of groundwater and seawater intrusion in North Chennai Metropolitan City - **Sridhar, S.G.D. and Balasubramanian, M.** - p.63

11.00-11.10 : Integrated approach of saline water vulnerability assessment along the east coast from Vaippar to Tambaraparani river of Thoothukudi District, Tamil Nadu - **Jeyavel Raja Kumar,T., Dushiyanthan, C., Thirunelakandan, B., Suresh, R., Vasanth Raja, S., Saravanan, P. and Karthikeyan, K.** - p.64

11.10-11.20 : Hydrochemical Characterization of Groundwater in Solapur City, Maharashtra, India, Using GIS Techniques - **Kulkarni Dhaval D., Pawar Ranjitsinh S. & Mohaseen Gaibu** - p.65

11.20-11.30 : Evaluation of Decadal (GWDI) Disparities in Raichur District, Karnataka, India - **Sharath Raj B and Mohammed Aslam M. A.** - p.65

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12.30-01.15 : **POSTER PRESENTATIONS**

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THE INDIAN MEGA-SEQUENCES : SALIENT FEATURES AND MAJOR EVENTS

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The primary differentiation of the Indian geological record into four giga and twelve mega-sequences as developed here is based compositely on tectono-thermal events, crustal growth stages and composition, aggregation and segregation, zircon events, large stratigraphic gaps, major quantum biotic changes, plate reorganization, slope change/reversal, climate change and glaciation, anoxic events, GOE, paleosols, stratigraphically controlled mineralization events, changes in ocean water chemistry, significant transgressions/ regressions etc. The oldest giga-sequence nearly without any physical record is based on recent zircon evidence, while the other three are differentiated through the globally spread Huronian and Marinoan glaciations. The differentiated mega-sequences are:

I Singhbhumian ~ 4200- 3500 Ma Giga/Mega-sequence inclusive of the hitherto unknown ~ 4200-4000 Ma and ~ 3700-3600 Ma tectonothermal events through the recently revealed zircon history from the OMTG of the Singhbhum craton ; mostly thin mafic stagnant crust with transient mantle overturn or plume events without any Phanerozoic type of plate-tectonics; possible origin of the single celled prokaryotic organisms around ~ 4.0 Ga and of the organo-sedimentary algal stromatolites in an oxygen lacking hydrosphere and atmosphere around ~ 3.6-3.8 Ga,

II Sargurian ~ 3500 Ma to ~ 2900 Ma Mega-sequence inclusive of the widely spread primary gneissic crust as the basement with near cratonisation of the blocks south of the Narmada – Son Divide up to the culmination of the Pongola glaciation of South Africa; significant iron bearing rocks formed in oxygen lacking reducing environment yet less in iron content than in the overlying Dharwarian mega-sequence,

III Dharwarian ~ 2900 Ma to ~ 2250 Ma of ~ 650 MY duration, inclusive of the richest iron bearing rocks in the Indian cratons with near completion of the cratonisation of blocks north of the Narmada – Son divide along with culmination of the Huronian glaciation; diversification, proliferation, and expansion of stromatolites, as also marking the suggestive origin of the exclusively single celled eukaryotes from the ancestral prokaryotes,

IV Aravallian ~ 2250 Ma to ~ 1750 Ma Mega-sequence of ~ 500 MY duration, featured with the Aravalli (AMB), Satpura (SMB), and East Ghat (EGMB) mobile belts marking the assembly of Columbia, GOE at the start, diversification and proliferation of the single celled eukaryotic organisms and origin of monotypic similar multicellular eukaryotic organisms, also widespread uplift event at the closure,

V the geographically restricted (also radiometrically not that well constrained as the older mega-sequences) Delhiian Mega-sequence ~ 1800-1750 Ma to ~1600-1450 of ~ 300-200 MY duration with lesser extent compared to that of the preceding Aravallian mega-sequence; marking the diversification, proliferation, and expansion of the multicellular eukaryotic organisms with diverse cell types inclusive of acritarchs, continuation of the long duration of uplifted emerged and relatively cool India after the Aravallian mega sequence,

VI ~ 1550-1150 Singhoraian Mega-sequence typified in Chattisgarh basin based on ~ 1500 Ma volcanics near the base of the sedimentary succession as also a widespread ~ 1450 Ma tectonothermal event, differentiation of the mega-sequence tentative, alternatively may even be coeval to the Delhiian mega-sequence, and the interval may represent a widespread gap,

VII Sirohiian Mega-sequence ~ 1150 Ma to ~ 850-820 Ma of ~ 300 MY duration; signaling at its start major geodynamic revival of near pan-Indian character inclusive of the final union of NIB and SIB as part of the the Rodinia assembly; diversification and expansion of the multicellular soft bodied organisms,

VIII Blainiian Mega-sequence from ~ 850-820 Ma to ~ 635 Ma of ~ 185 MY duration within Rodinia of the globally widespread and severest snow ball earth conditions ,

IX Himachalian Mega-sequence of basal Vendian to terminal Ordovician from ~ 635 Ma to ~444 Ma of ~ 181 MY duration, one of the most eventful of all bringing in profound changes, completion of the Gondwana assembly with suggestive suturing of North China to India in the north and of Azania in the south, major uplift and emergence of India up to MCT,

X Kanawarian Mega-sequence near exclusive in High Himalaya, of Early Silurian – Early Permian time span from ~ 444 Ma to ~ 272 Ma of ~ 172 MY span of uplifted emerged and relatively cool India as a constituent of Gondwana up to Middle Devonian; start of dismemberment of Gondwana with intra-Devonian spreading away of North China, Indo-China and South China with consequent origin of Paleotethys ,

XI Neotethyan Mega-sequence from Intra-Permian to Intra-Paleocene from ~ 272 Ma to ~60 Ma of ~ 212 Ma, witnessing the complete dismemberment of Gondwana; origin of the Neotethys at the start, while of the Indian and Atlantic oceans midway of the mega-sequence; also known for the world's hydrocarbon and coal deposits and

XII Himalayan mega-sequence from Late Paleocene to the close of the Pleistocene glaciation, of the last ~ 60 MY span of the docking of India into Asia, the origin and growth of the majestic Himalaya; also of the climatically crucial monsoon framework, additionally featured with substantive hydrocarbons and coal/ lignite deposits.

The older eight of the twelve mega-sequences are only tentatively age-bracketed, while the age-precised younger four guide-fossil bearing mega-sequences in the terminal Neoproterozoic – Quaternary span are here further differentiated into a succession of eleven 1st order sequences with a total of 21 precisely age-constrained sequence surface time-lines towards a comprehensive geodynamic chronicle as endeavored here. It is demonstrated that the mega and and 1st order sequence surfaces (SBs and MFSs) are invariably the resultants of the regional tectono-thermal and related geological events. As a major break-through, the mega and 1st order sequence surfaces in a broadly homogeneous tectono-stratigraphic region, thus, are genetically linked to the geological events that the surfaces are product of with a process/response genetic relationship. It is considered that the regional events invariably affect all the basins of the tectono-stratigraphially homogeneous region or supra-region. Consequently, the said precisely age-constrained sequence surfaces in any basin of the concerned broadly homogeneous tectono-stratigraphic region provide several fold improved ages of the major regional geological events in the Neoproterozoic – Neogene duration than possible or realized any time earlier.

Examples are here provided of the 1st order sequence surface timelines, one each from Neoproterozoic, Paleozoic, Mesozoic and Cenozoic intervals, along with their age-precised geological events.

Late Croyogenian ~663 Ma 1st Order SB of the Blainiian Mega-sequence: The SB is interpreted in South China at ~ 663 Ma at the base of the glacial Datangpo Formation. The said SB is extended in Lesser Himalaya at the close of the globally spread Sturtian glaciation - the top of the older of the two glacial units – the base of the Formation B (inter-glacial unit) or the top of the preceding Formation A (glacial unit) of the Blaini Group in the Lesser Himalaya. The age is extrapolated from South China microblock of the Indo-Australian Proto-tethyan margin. The said SB there marks the base of the lithologically similar homotaxial Datangpo Formation with ~ 663 Ma volcanics in its basal part. It may be noted that the Lesser Himalaya depositional sites, since their relative proximal location compared to the distal South China depositional sites, of the composite submerged part of the Indian Proto-tethyan margin, lack volcanics in the Blaini Group. At this point of time, the Indian plate extended up to South China and was delimited in the north by the Jinsha suture.

The late Middle Cambrian Gujhangian Stage Acantha Zone ~ 500 Ma Mega MFS of the Himachalian Mega-sequence: The MFS determined in Spiti Himalaya provides the precise age of the suggestive suturing of North China to South China micro-block of Greater India in the north, the suturing of the Azania microplate to SIB of Greater India in the south leading to substantive size enlargement of India, plate reorganization, tilting related uplift/emergence of Zanskar and slope reversal, major uplift of the Kurgiakh ridge, ceasure of sedimentation in the Spiti basin and the resultant stratigraphic gap.

The late Middle Oxfordian Early Late Jurassic Orientalis Zone Schilli Subzone ~ 159 Ma 1st Order MFS of the Neotethyan Mega-sequence: The MFS determined in Kachchh is a resultant of diverse isochronous geological events of the initiation of the Indian ocean and associated volcanics with spreading away of the Aargo block and origin of the AAP off NW Australian margin, reversal of paleoslope and bathymetric inversion, drastic reduction of ammonoid density, diversity, and frequency in Kachchh, large submarine gap in the basins on the Indo-Australian neotethyan margin, origin of the Cauvery basin and several other manifestations.

The terminal Cuisian late Early Eocene P8 Zone ~50 Ma mega MFS of the Himalayan Mega-sequence: The mega MFS determined in Kachchh provides the precise age of the principal impingement of the due north drifting India on Asia as the major or at least one of the main events of the collision history.

CRETACEOUS STAGE BOUNDARIES IN SOUTHERN INDIA

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The Cretaceous sediments are built up on the passive margin of the south-eastern Indian subcontinent presenting text book examples of geological features that astound every geological field mapper. The low dipping strata, the rapid changes in the composition in the rock succession in time and space, the swaying lithoboundaries and the varieties of fossiliferous beds are some of the fascinating changes in depositional features. The absence of identifiable microfossils in many rock units is compensated by the ubiquitous presence of mega-invertebrate fossils, especially, the ammonites to date and correlate different strata. This geological succession may be divided into 10 ammonite assemblage zones, namely, *Mortoniceras rostratum* Zone, *Mantelliceras vicinale* Zone, *Calycoceras asiaticum* Zone, *Eucalycoceras pentagonum* Zone, *Pseudaspidoceras footeanum* Zone, *Romaniceras (Yubariceras) ornatissimum* Zone, *Lewesiceras* anapadense Zone, *Kossmaticeras theobaldianum* Zone, *Karapadites karapadense* Zone, *Hauericeras rembda* Zone and *Eubaculites vagina* Zone in the ascending order. This dating on ammonites leads to mark many breaks in faunal sequence. Comparison of the Standard ammonite zones of Europe and Japan with the southern Indian biozones reiterates this point. These breaks, which represent unconformities in its Geological history, are sensitive records of the past forcing factors that triggered environmental changes. High Resolution Sequence Stratigraphy models explore unconformity surfaces for characterization of sequences. Evolution of global climate varies in all time-scales responding to different forcing factors. Unconformities provide evidences for non-linear response across critical thresholds of change. The characteristics of such surfaces are valuable proxies to the reconstruction of Earth's environment record and in prediction of future course of events.

INITIATION OF THE INDIAN OCEAN AT 159 Ma LATE MIDDLE OXFORDIAN ORIENTALIS ZONE SCHILLI SUBZONE MFS EVENT

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The final assembly of Gondwana occurred in late Middle Cambrian through the suturing of the West and East components of Gondwana, while its fragmentation started during the Devonian with spreading away of North China, Indo-China and South China and associated origin of Paleotethys. Among the major events that followed were the intra-Permian origin of Neotethys, Early Jurassic dismemberment of Gondwana into East and West components near the start of Toarcian, the separation between Australo-Antartica and India that culminated during Aptian – mid Albian (~ 127Ma ~ 107 Ma) as evidenced through the Rajmhal igneous outpouring, and a few yet younger events. The oceanisation on the Indo-Australian Neotethyan margin began with spreading away of the Aargo block between NW Australia and Greater India some time during the Toarcian – Barremian interval.

The said oceanisation as an all time important event initiated the ~ 159 Ma – 107 Ma long volcanism east and north of Greater India. The precise start of the oceanisation has remained unresolved over the last many decades in spite of plethora of recent and old (1975 onward) Ar40/Ar39 and U/Pb ages in the Callovian (late Middle Jurassic ~ 163 Ma) – Tithonian (terminal late Late Jurassic ~ 145 Ma) interval, so also realization of voluminous palynological, micropaleontological, magnetic anomaly, and other surface / well / deep-sea data in this geologically complex region. It is in the above backdrop, that an alternative fresh innovative sequence stratigraphic approach is invoked for consideration of the fellow geoscientists of precision dating of the said and other major regional events.

The basic premise is that the major multifaceted regional to global geological events of earth history include apparently unrelated resultant manifestations like the rift/plume volcanism, new oceans, collision, deformation, metamorphism and granitisation on one end, and the visually observable sequence surfaces in guide-fossil rich stratified columns on the other extreme. The premise allows to precisely date the events in tectonically complex belts/areas where evidences are mostly lost and remainder almost impossible to retrieve, through precisely dated sequence surfaces in a distant geologically undisturbed basin as produce of the same event within a spatiotemporally constrained broadly homogeneous tectonostratigraphic region like the Gondwanian Tethyan margin from Arabia to NW Australia.

Thus is dated the initiation of the Indian ocean, perhaps the most significant geological event of the Gondwana dismemberment, at the late Middle Oxfordian Orientalis Zone Schilli Subzone 1st order MFS (maximum flooding surface) of ~ 159 Ma age otherwise précised in the ammonoid rich condensed succession in the Kantkote section of the Kachchh basin in the west sector of India a few thousand km away from the oceanisation event east of India. The said MFS is displayed by a marker bed with maximum ammonoid density, diversity and frequency, and above which is observed sudden drastic reduction in the said parameters on account of bathymetric inversion in the basin. The bathymetric inversion is considered as caused by extension related tilting and slope inversion on the hind margin of the Indian plate as a consequence of rifting and associated spreading away of the Aargo block off NW Australia at the north extreme of the east sector.

ENVIRONMENTAL EFFECTS OF DECCAN VOLCANISM ON BIOTIC CHANGES AND K/PG MASS EXTINCTION IN THE INDIAN SUB-CONTINENT: ORGANO-MOLECULAR EVIDENCES

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Deccan volcanism induced environmental stress causative to biotic transformations and Cretaceous/ Palaeogene (K/Pg) boundary mass extinction in the Indian sub-continent still remains inconclusive. In this follow-up, high resolution organo-molecular studies on marine Um-Sohryngkew River (USR) K/Pg boundary succession have been attempted and further as reference compared to brackish (Jhilmili)/fresh (Anjar) water intertrappeans and terrestrial intra-volcanic bole beds of the Eastern Deccan Volcanic Province (EDVP). Organo-molecular compounds of the former section show strong correlation with the Global Stratotype and Section Point (GSSP). *n*-alkanes and high amount of short chain n-fatty acids were found in this succession, originated from autochthonous marine algal remains. But, dominance of mid and long chain n-alkanes over the short chain n-alkanes in the Jhilmili intertrappean and intra-volcanic bole beds of the EDVP suggest terrestrial origin from higher plants under less humid climatic conditions. Additionally, *n*-alkanes found in the USR section imply mixture of terrestrial input from emergent and submerged/floating aquatic macrophytes. The Low Molecular Weight Polycyclic Aromatic Hydrocarbon (LMW PAH) compounds excursions noticed in CF2 biozone of the USR succession correspond to the Greenhouse effects, linked to second phase of Deccan volcanism at the latest Masstrichtian 29r. Abundant n-fatty acids associated with the EDVP bole beds suggest their origin from bacteria developed in the terrestrial sediments. The negative δ13C bulk values associated with the Jhilmili intertrappean and bole beds of the EDVP, indicate low primary productivity and burning of terrestrial biomass. The TOC spike observed in the lowermost Danian P1a foraminiferal biozone of USR succession is also linked to late Deccan phase-2 eruptions. Presence of three LMW PAH compounds was noticed in the EDVP bole beds; imply incomplete combustion of organic compounds in the terrestrial environment. Dominance of High Molecular Weight Polycyclic Aromatic Hydrocarbon (HLW PAH) compounds noticed in the biozone CF3 of the USR succession is akin to those reported from other well-established K/Pg boundary successions, suggestive of their derivation from the global fire induced by the heat, supplied by the Deccan volcanism, linked to K/Pg boundary transition. Thus, the global wildfire has played significant role in the collapse of the ecosystem which was somewhat accountable for the mass extinction.

Keywords: Deccan volcanism, K/Pg boundary, Um-Sohryngkew river (USR) succession, *n*-alkanes, *n*-fatty acids, PAH compounds.

RELATIONSHIP OF MAASTRICHTIAN–THANETIAN BENTHIC FORAMINIFERAL SPECIES DIVERSITY, PALAEOOXYGENATION AND PALAEOPRODUCTIVITY IN SHALLOW WATERS OF EGYPT

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Benthic foraminiferal analysis (315 samples, 16,271 specimens) of the shallow water (<100 m) Maastrichtian–Thanetian rocks from the Dakhla Oasis (Western Desert, Egypt) were studied to infer the inter–relationships between species diversity, palaeooxygenation, palaeoproductivity, and palaeodepth and changes

at the Cretaceous–Paleogene (K/Pg) boundary. Positive and significant correlations are noted between these proxies, indicative of a well–oxygenated oligotrophic environment. However, a brief interval (mid– lower Maastrichtian) of increased palaeoproductivity with reduced diversity and oxygenation (ventilation) is noted (a characteristic of mesotrophic–eutrophic settings) that coincides with very shallow waters during a Highstand System Tract (HST), and dominated by the dysoxic agglutinated species *Ammobaculites khargaensis*. The diversity index, Fisher's α(<5) and paleodepth proxy (foraminiferal wall structure types) also suggests a shallow neritic (largely littoral) depth for the entire study interval. Species diversity, palaeooxygenation and palaeoproductivity are high at the bottom of the section (Planktic Foraminiferal Zones CF8b–CF7), low and fluctuating values with moderate species dominance until the K/Pg boundary and moderately high values with low to moderate dominance for the post K/Pg interval. Low dominance, high evenness and equitability suggest a largely stable and equitable palaeoenvironment. Present data suggests that 38% of the agglutinated and 40% of the calcareous species became extinct after the K/Pg boundary with an overall 40% extinction rate. The duration just after K/Pg boundary, as in other shallow water settings, is marked by improved basinal ventilation (increased % epifaunal species and BFOI index), higher species diversity (Fisher's α) and lower palaeoproductivity (lowered % infaunal species and % HOFS, high organic–flux species); all attributed to changes in the sea level (transgression and characterized by higher % P vales) with concomitant regional subsidence. However, as stable as the community structure was (i.e. all diversity indices; at or just after K/Pg), the changes in species composition (assemblage) were dramatic marked by a change from a pre–K/Pg agglutinated–dominated fauna (*Haplophragmoides–Ammobaculites*) to a post–K/Pg calcareous assemblage (*Cibicodoides–Cibicides–Anomalinoides*).

Keywords: Egypt, Maastrichtian -Thanetian, Species diversity, Palaeooxygenation, Palaeoproductivity, Palaeodepth, Benthic foraminifera.

EVOLUTION OF LIFE, MASS EXTINCTION AND VOLCANIC HISTORY OF EARTH

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We have found that evolution of internal heat parameters over geological timescales is closely related to history of volcanism in Earth. The origin of life in Earth is around 500 Million years ago with is an outcome of several favorable geophysical conditions such as availability of Oxygen in Troposphere, development of Ozone layer in the Stratosphere, development of oceans in Earths Crust and reduction of internal heat of Earth by a factor of four(since its formation).We will present a model of surface heat flux evolution in Earth is the geological past which will be compared with major mass extinctions and volcanic eruptions during the geological past. The geophysical conditions related to the KT mass extinctions which led to the formation of Deccan Plateau in India will be also discussed. Possible impact on Earth biosphere, with the cessation of volcanic activity in Earth in the near geological future will be also presented.

A REAPPRAISAL ON THE MASS EXTINCTIONS OF DIFFERENT TIME PERIODS OF GEOLOGICAL TIME SCALE

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A mass extinction or biotic crisis is a widespread and rapid decrease in the biodiversity on Earth. Such an event is identified by a sharp change in the diversity and abundance of multicellular organisms. It occurs when the rate of extinction increases with respect to the rate of speciation. Because most diversity and biomass on Earth is microbial, and thus difficult to measure, recorded extinction events affect the easily observed, biologically complex component of the biosphere rather than the total diversity and abundance of life. Ordovician–Silurian extinction events (End Ordovician or O–S): 450–440 Ma (million years ago) at the Ordovician–Silurian transition, Late Devonian extinction: 375–360 Ma near the Devonian–Carboniferous transition, Permian–Triassic extinction event (End Permian): 252 Ma at the Permian–Triassic transition, Triassic–Jurassic extinction event (End Triassic): 201.3 Ma at the Triassic–Jurassic transition, Cretaceous–Paleogene extinction event (End Cretaceous, K–Pg extinction, or formerly K–T extinction): 66 Ma at the Cretaceous – Paleogene transition interval are the 5 biggest examples of mass extinction in the previous period. Except this 5 biggest and notable events of mass extinction there are numerous short termed and relevantly lower effective extinctions are there. In the geological time scale, in the end of every epoch/system/era there is an extinction event. There is still debate about the causes of all mass extinctions. In general, large extinctions may result when a biosphere under long-term stress undergoes a short-term shock. An underlying mechanism appears to be present in the correlation of extinction and origination rates to diversity. High diversity leads to a persistent increase in extinction rate; low diversity to a persistent increase in origination rate. These presumably ecologically controlled relationships likely amplify smaller perturbations (asteroid impacts, etc.) to produce the global effects observed. This review article gives a brief idea about mass extinction events, principles behind mass extinction events, details about all the mass extinctions including the remarkable and unremarkable events, its impact on the society and how it is able to change the world etc.

VOLCANISM, IMPACT AND MASS EXTINCTION

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Volcanism is the phenomenon of eruption of molten rock (magma) onto the surface of the Earth or a solid-surface planet or moon, where lava, pyroclastics and volcanic gases erupt through a break in the surface called a vent. It includes all phenomena resulting from and causing magma within the crust or mantle of the body, to rise through the crust and form volcanic rocks on the surface. Movement of molten rock in the mantle, caused by thermal convection currents, coupled with gravitational effects of changes on the earth's surface (erosion, deposition, even asteroid impact and patterns of postglacial rebound) drive plate tectonic motion and ultimately volcanism. Volcanic eruptions can have a devastating effect on people and the environment. However, unlike earthquakes, volcanoes can also have a positive impact on an area. These positive impacts can help to explain why people choose to live near volcanoes. The dramatic scenery created by volcanic eruptions attracts tourists which bring income to an area and many lives can be lost as result of volcanic eruption. Likewise there are many impacts of volcanism in the society. One possible cause of the end Triassic mass extinction is an enormous rifting event. This was, perhaps, the largest igneous event in Earth history. At the time, many of the

present day continents were still joined as one continent, known as Pangaea, across this continent large rift zones were developing. The 6000 km diameter Central Atlantic Magmatic Province had began to form and could be seen stretching from east to west coasts through what is now known as northwest Africa, eastern America (both north and south) and parts of Europe. The volcanism would have erupted massive floods of basaltic lavas and caused the release of large amounts of gas. Hence it also gives the evidence that volcanism is also responsible for the mass extinction in the past geologic era. This article consists of the cause and processes of volcanism, its impact on the human society (Both positive and negative), how it affects the socio economic activities in the society and mass extinctions for which the volcanism is responsible in the past geologic era.

Keywords: volcanism, mass extinction, volcanic eruption, past geologic era

PETROLOGY OF MAFIC INTRUSIVES ASSOCIATED WITH THE SEMRIS OF THE VINDHYAN SUPERGROUP IN THE EASTERN PART OF THE SON VALLEY, CENTRAL INDIA: IMPLICATIONS FOR BIMODAL VOLCANISM

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Semris in the lower part of the Vindhyan Supergroup represent repository of volcano clasts (~3500 m thick) that occur in the eastern part of the Son valley. Present petrological studies focused on mafic plugs (3-11 m) cutting across Kajrahat Limestone and Porcellanite Formations of the Semri Group in Dala and Mitapur areas, respectively. They are medium to coarse grained contain plagioclase, augite and hypersthene. As a result of late-hydrothermal activities, plagioclase is highly altered. They contain 52-56 % SiO_2 and show sub-alkaline nature, but lie within the basaltic andesite field. Bivariate data plots show increase in the CaO, Na_2O, K_2O and Al_2O_3 with the rise in the MgO content. Chondrite normalized REE patterns of the mafic plug exposed at Dala mine area are comparable to E-MORB. Whereas, REE patterns of the mafic plug exposed at Mitapur village show LREE enrichment (compared to E-MORB). An affinity of these plugs with the E-MORB is also corroborated by Nb/Yb vs Th/Yb data plots. Their spidergrams are characterized by LILE and LREE enrichment on the REE plots. Ce vs. Nd data plotted and the data fall above the chondrite trend line suggesting that there is no significant crustal contamination. Age of the Kajrahat Limestone is 1721 Ma. and Porcellanite shale is 1630-1640 Ma. While age of the plug intruding the Porcellanite Formation is inferred between 1630-1640 Ma. and 1600 Ma. Thus, mafic plugs are contemporaneous with the intra-basinal felsic volcanism, widespread throughout the Porcellanite shale. Genetic relationships between the felsic volcanism and the mafic plugs have been discussed in this paper.

MASS DISAPPEARANCE OF RADIOLARIANS IN THE CENTRAL INDIAN OCEAN BASIN: RESPONSE TO PALEO-EVENTS

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Preliminary observations were made to understand the reported trends in the distribution of radiolarians in the Central Indian Ocean Basin (CIOB). Earlier works exist on disappearance of radiolarian species but this is for the first that we report a discontinuity pattern in the deposition of radiolarians in the basin. Observations

of coarse fraction (63 μm) of the two 5-m long sediment cores recovered from the CIOB revealed the presence of several components such as rock pieces, radiolarians, spherules, manganese micronodules, palagonite and mineral grains. Amongst these we noted remarkable changes in the depositional pattern of the radiolarians. The formation of radiolarians in CIOB is highly controlled by the equatorial productivity and nutrient-rich water-masses. Mass disappearance of these radiolarians in the studied sediments cores, either at species level or in toto from certain depth within the cores below the seafloor, is enigmatic. We reconcile this observation to the paleo-sedimentation rates and environment, corrosive and erosive effect of the Antarctica Bottom Water-mass that traverses through the CIOB and to submarine volcanic and perhaps hydrothermal activities.

Keywords: Sediment cores, radiolarians, obliteration, AABW

EVOLUTION AND EXTINCTION OF PLANKTIC FORAMINIFERA IN DEFINING THE CENOMANIAN AND TURONIAN STAGES IN INDIA

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Among the twelve Cretaceous Stages, the Cenomanian Stage is one of the very well developed sections available in India for the study of Earth history during this six million-year interval (100.5 - 93.9 Ma). The base and top of the Cenomanian Stage are easily identifiable. The sections exposed east of Karai, Uttattur Villages in Perambalur District are classical sections comparable with the internationally agreed Global boundary Stratotype Sections and Points (GSSP) for the base of the Cenomanian and Turonian Stages in Mont Risou near the town Rosans, Haute-Alpes, France and Pueblo, Colorado, US respectively.

The Cenomanian-Turonian (C-T) boundary event is considered the second-largest Cretaceous extinction event and one among the five major planktonic and benthic foraminiferal extinction events occurred during the past 100 m.y. at the Cenomanian/Turonian (C-T) boundary, at the Cretaceous/Tertiary (K-T) boundary, in the latest Paleocene, in the late Eocene, and in the early middle Miocene (Kaiho, 1994). Planktic foraminifers are known for their wide geographic distribution, rapid evolution and short stratigraphic ranges are used as excellent markers species. The First occurrence (FO) and Last occurrence (LO) of species are especially important “Bioevents", marking unique moments in geological time.

As planktic foraminifera are able to spread quickly over large areas of the oceans, their bio-events are especially valuable for determination of age and correlation of sediments strata over intercontinental distances. The fine-scale evolutionary patters of planktic foraminifers, their huge populations in the oceans, characteristic features allows tracing of ancestor-descendant lineages, a powerful means for reconstructing the phylogenetic history of this group. In Cretaceous period alone eighteen genera of highly diversified Globotruncanidae family have Hedbergella occurred, whose less evolved species lived throughout the Cretaceous period, as a common ancestor. Many genera are being defined as a consequence of more reliable morphological criteria and phylogeny.

The base of the Cenomanian Stage is marked at the first occurrence of the planktonic foraminifera *Rotalipora appenninica* after the last occurrence of *Planomalina buxtorfi*. The Cenomanian-Turonian (C-T) Stage boundary is placed within the *Whiteinella archaeocretacea* Partial Range Zone, which is defined as the stratigraphic interval between the extinction of *Rotalipora cushmani* (Morrow, 1934) and the appearance of *Helvetoglobotruncana helvetica* (Caron, 1985; Robaszynski & Caron, 1995). The flooding of Whiteinella

population was observed after the extinction of *Rotalipora* (Venkatachalapathy & Ragothaman 1994, 1996) and the keeled species reappear again in Turonian.

The C-T boundary foraminiferal event was thought to have occurred near the peak of a major eustatic sea-level rise characterized by warm equable climates, unique foraminifers, lithology with anoxic or anaerobic/ dysaerobic conditions relative to Oceanic Anoxic Event-2 (OAE-2) led to foraminiferal extinctions. The C-T boundary interval is represented by short ranging biostratigraphic zones Rotalipora chusmani Total Range Zone, *Whiteinella archaeocretacea* Partial Range Zone and *Helvetoglobotruncana helvetica* Partial Range Zone. Keeled species reappear again in Turonian. The First Occurrence (FO) of *Helvetoglobotruncana helvetica* is an important planktic foraminiferal taxon that has been characterized by a short stratigraphic range within the lower–middle Turonian (e.g., Gradstein et al., 2004). The foraminiferal events and zones are compared and correlated with other regions and GSSPs for Cenomanian and Turonian Stages.

PRECAMBRIANS OF SOUTHERN INDIA: NEED FOR RESOLVING DIVERGENT AND CONFLICTING VIEWS

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Dharwar Craton and the Southern Granulite Terrain have always been a topic of interest. The opinion prevailing earlier was that the southern peninsula has undergone progressive metamorphism from north to south as exemplified by the zeolite facies, green schist facies, amphibolites facies (intracratonic Proterozoic sediments and Dharwars) and finally the granulite facies south of the Fermor Line. Currently, the nature of contact between the granulite terrain and the Dharwars is being debated. While most of the researchers state that it is a tectonic junction, opinions vary as to which of the shear zones: Moyar-Bhavani-Salem-Attur (MBSASZ), Cauvery-Noyil (CNSZ), Palghat-Cauvery (PCSZ), Dharapuram (DSZ), Devattur-Kalliyamandayam (DKSZ), Karur-Kambam-Painavu-Trichur (KKPTSZ), mark the suture zone or collision boundary. Majority is in favour of MBSASZ, followed by PCSZ and KKPTSZ. Here again, the generally accepted view is that the Dharwar Craton has subducted and the granulite terrain has thrust over the Craton. Some researchers have indicated that the Dharwar craton extends at least as far south as the KKPTSZ and perhaps even beyond (Ghosh, 2015, Srinivasan, 2018). The Apparent Polar Wander Path which is same to both the regions from Early to Mid-Proterozoic indicates that the Dharwar Craton and Granulite Terrain had no major relative movements or rotation, (Radhakrishna and Mathew Joseph, 1993). Recent work by Subrahmanya and Prakash Narasimha (2017) has shown that most of the structures and lineaments are due to an extra terrestrial impact which has resulted in the formation of Kaveri Crater.

Some of the following views and observations need critical assessment aimed at better understanding:

1. Separate stratigraphic status for Sargurs: Is Sargur group an older member of Dharwar supergroup? (Srinivasan, 2018).
2. Dharwars are divided:

   (a) Into Two - Eastern and Western with the shear zone east of Chitradurga Schist Belt/east of Closepet Granite as the boundary;

   (b) Into Three: Eastern, Central and Western.

   Field evidences and U-Pb geochronological studies do not justify considering Dharwars as mosaic of Eastern, Central and Western Terranes (Srinivasan, 2018). Many E-W profiles have been obtained through seismic imaging to demarcate the boundary/transition zone between Eastern and Western Dharwars. (Ashish and Parvez, 2017; Kajaljyoti Borah, et al, 2014). The very same data can be interpreted to show that there is no boundary or transition zone. The Moho depths very well correlate with topography, thus providing a good example of isostatic compensation.
3. Opinions vary on the nature of movement of Nilgiris: Drury and Holt (1980) opine that there is a dextral movement of 70 km; Naha and Srinivasan (1996) are of the view that there is only vertical movement; Chardon et al (2008) however consider the quantum of dextral slip along Moyar shear is of the order of 120 km. In the light of the work on Kaveri Crater, these appear to be only partially correct. The two mountain ranges, Nilgiris and Anaimalai to its south, have an erosion surfaces approximately at the same elevation. A fault is unlikely to have lifted up these ranges to the same altitude. For this reason, it is appropriate to ascribe elevated nature of Nilgiris and Anaimalai as partly because of subsidence of the adjacent landmass due to impact (Kaveri Crater) and partly due to easterly tilt during the formation of Western Ghats. This conclusion is substantiated by the occurrence of a limestone band in Madukkarai

area which extends without break both to the north and south of Palghat Gap (Subramanian and Muraleedharan, 2001). The pattern of outcrops on either side of Moyar shear does indicate dextral movement, which perhaps is of the order of a few hundred meters. Exact value can be confirmed only if a marker horizon is traced on either side of the shear zone.

4. Subduction of Dharwars southward: if indeed Dharwars have collided with another landmass, there has to be an E-W trending fold belt with its convex side facing north, (a mirror image of Himalayas). This is not seen anywhere.

5. It appears that the landmass which now constitutes Indian Peninsula has a tendency for northerly tilt right from Archaean up till now. Some observations which support such an assumption are: i) Northerly plunging folds in the Dharwar supergroup, ii) Increase in grade of metamorphism to the south thus indicating southern part got elevated more, exposed more, eroded more, iii) Konkan coast is cliffed and submergent, whereas Malabar coast is a strand plain coast and emergent. iv) Decrease in the height of Western Ghats from South to North.

What caused the northerly tilt during Archaean and Proterozoic is difficult to speculate. During the Phanerozoic, possible causes are:

i) Breakup of Gondwana around 125 Ma, Ridge-push, slab-pull during collision with Asia, which could have tilted the Indian plate northward;

ii) Deccan volcanics loading which could have depressed the northern part.

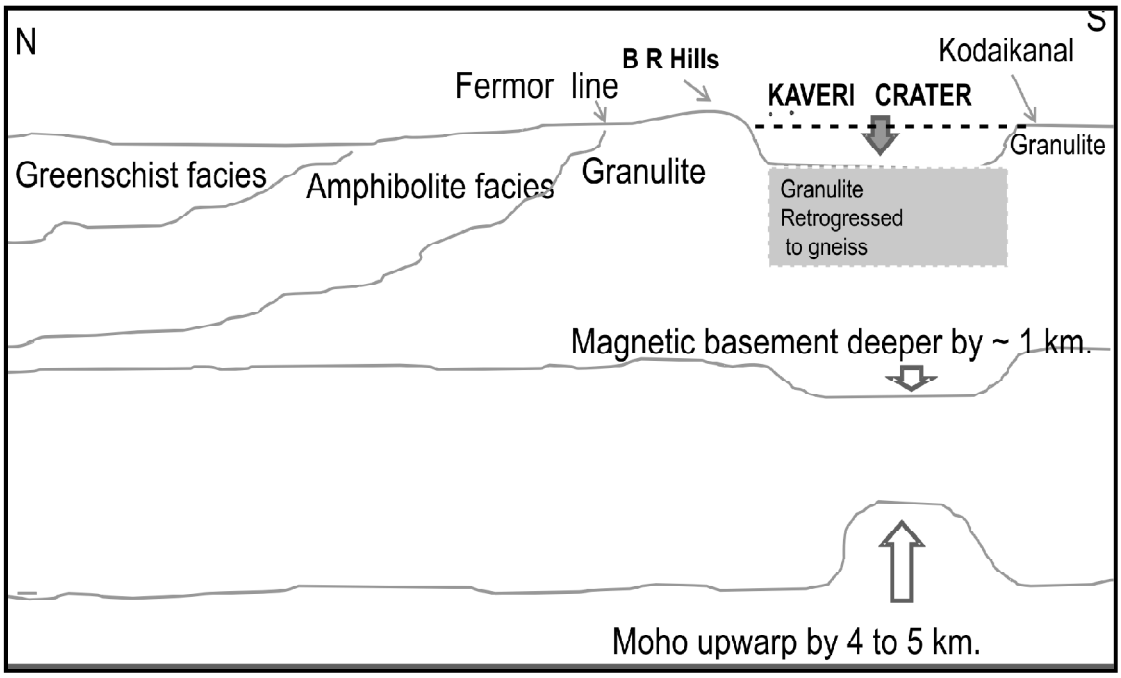

Fig. 1. Interpretation of the Dharwar Craton in the light of some recent observations: 1. No tectonic junction between Dharwars and the granulite terrain; It is a normal Depth Zone metamorphic feature. 2. Area below the Kaveri Crater has undergone retrogression due to intense fracturing; 3. This is confirmed by the magnetic basement which has gone down by about one km. because of the lower temperature regime (Curie isotherm is reached at greater depth, Reddi *et al.*, 1993, Mita Rajaram, 2009). 4. Directly below the Crater, Moho has been uplifted by 4 to 5 km. (Reddy *et al.*, 2003).

A TECTONO-SEDIMENTARY MODEL OF EVOLUTION OF PALEOPROTEROZOIC KOLHAN BASIN

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The pear shaped Kolhan Group in the studied sub-basins of Chaibasa–Noamundi and Chamakpur-Keonjhar is usually represented by a sequence of clastic (+carbonate) association alongwith development of thin and discontinuous patches of basal conglomerates draped by sandstone beds. Six lithofacies have been observed in the area. The result of Markov chain analysis indicates that the deposition of the lithofacies is in Non-Markovian process and represents asymmetric fining- upward non-cyclicity. The chi-square test has been done to test of randomness in hypotheses for lithofacies transition at confidence level of 95%. Petrological study further denotes that the Kolhan sandstones show progressive change towards greater textural maturity in its up building. This fining upward sequence alongwith the vertical and lateral facies variation in the Kolhan implies superimposition of retrograding shorelines on an earlier prograding alluvial fan sand complex. The variations in the size parameters are indicative of changes in the water depth and the velocity at the time of sediment deposition. The increase in average grain size towards the central part of the basin may indicate sediment reworking and a subsequent development of mid channel bars (longitudinal, transverse, and cross) and sand flats that opened up into the deeper basin farther towards north. The moderate-poor sorting (0.40- 1.43 ?) values of the sediments may indicate a strong recycling in the sediments .

The IOG-fault marks the western 'distal' margin of the Kolhan basin showing evidence of passive subsidence subsequent to the initial rifting stage. The basin is thought to evolve as a half-graben under the influence of an extensional stress regime. This assumption of a tectonic setting for the NE-SW trending Kolhan basin can be related to the basin opening as a consequence of E-W extensional stress system that prevailed during the development of the Newer Dolerite dyke. The Paleoproterozoic age of the Kolhan basin is based on the consideration of the conformable stress pattern responsible both for the basin opening, and on the development of the conjugate fracture system along which the Newer Dolerite dykes intruded the Singhbhum Archaean craton.

The half-graben development and fault growth evolve differently through time and produce different basin-filling patterns. In the initial stage the basin evolution can be explained by detachment type half-graben filling model that incorporates a basin-bounding fault soling into a sub-horizontal detachment fault. Two types of genetic sequences reflecting variations in the generated accommodation space have been recognized within the sub-basins of Chamakpur-Keonjhar and Chaibasa-Noamundi. The lower sequence in Chamakpur-Keonjhar is characterised by shallow braided river deposits that lack repetitive facies patterns and were deposited during a period of the slower rate of fault growth and generated accommodation space. An upward increase in the generated accommodation space is recorded by sheet sandstones encased in sand-streaked siltstones representing ephemeral flood deposits. During the fault growth stage the Kolhan basin grew both wider and longer through time as the basin-bounding faults lengthen and displacement accumulated as evident in the sub-basin of Chaibasa –Noamundi. Younger strata consistently pinch out against older syn-rift strata rather than pre-rift rocks in the later fault-growth stage. The basin fill thus commonly forms a fanning wedge during fluvial sedimentation, whereas lacustrine strata tend to pinch out against older syn-rift strata. The fluvial strata progressively onlap the hanging wall block, whereas the lacustrine strata pinch out against older fluvial strata at the centre of the basin but onlap along the lateral edges. The transition from fluvial to lacustrine deposition and hanging wall onlap relationships are thoroughly observed in the sub-basins of Kolhans. The pronounced variations in thickness

of the fan delta succession and the stacking pattern in different measured profiles reflect the overriding tectonic controls on fan-delta evolution. A strong asymmetry in vertical basin architecture and the linearity in the outcrop pattern of the preserved sedimentary sequence are presumed to have developed in an elongated trough during the initial basinal rifting stage, while the later stage is marked by the progressive overlaps and coalesce of the facies built-up. The basin axis controlled the progradation direction which was likely driven by climatically induced sediment influx, a eustatic fall, or both.

Keywords: half-graben, fan-delta lacustrine,braided-ephemeral

THE MORPHOMETRIC CLASSIFICATION AND GEOLOGIC IMPLICATIONS OF KOLHAN BASIN, JHARKHAND, INDIA: A GEOSPATIAL APPROACH

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The Proterozoic Kolhan basin is composed of siliciclastic rocks around Chaibasa-Noamundi region (2.0 - 2.2 Ga) exhibit extensive development of thickly bedded sandstone, impersistent conglomerate and huge deposits of shale with lenticular patches of limestone which lies unconformably over Archaean granitoid basement in the eastern side, whereas western contact is faulted with Iron Ore Group of rocks. The landscape is a result of the coalescence of a number of pediments, and controlled by joints, fractures and lineaments. The present article emphasizes on Digital Elevation Model (DEM) which confirms that the western and south western zones of the basin have maximum, while the eastern zone have low topographic gradient by which the drainage patterns in Kolhan are related which is widely dominated by trellis and dendritic fluvial drainage patterns. The development of the drainage patterns in Kolhan are related to the gross lithology and structural features. The western and southern regions are structural hills comparatively densely forested with many tropical trees. The pediplain surface with some small rugged hillocks, ridges, and ravines is breaking the monotony of the land. The area has an average altitude of 350 m and is bounded by hills towards east where the peaks attain heights ranging between 400- 475m. The episode of the dome and dome structure, faults and joints is indicative of a structural adjustment along the Kolhan basin boundaries. The formation of basinal boundary was a result of collective effect of intracratonic extension and thrust tectonics. Morphometric analysis shows overall broad pediplain and valley filled structure which is widely dominated by trellis and dendritic fluvial drainage patterns.

MELT-CLAST RELATIONSHIP OF DEFORMED PSEUDOTACHYLYTES: AN INSIGHT FROM CLAST SIZE ANALYSIS AND ROUNDNESS STUDY

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Ultramylonite or mylonites are the results of ductile deformation of protolith whereas cataclasite or pseudotachylytes are the results of solidification of syn-seismic melts generated along the slip plane of brittle fault. The pseudotachylyte (also called fresh pseudotachylyte) get subside deep beneath the crust, resulting in ductile deformation and gives rise to deformed pseudotachylyte. These are formed by two stages of deformation which is rarely found and also very difficult to identify ultramylonite in the field as it developed in the order of

proto-mylonite, mylonite to ultramylonite. So, to identify and confirm ultramylonite or deformed pseudotachylyte, we have studied clast size analysis using Power law distribution, and roundness of clast of Jogdadi shear zone, Ambaji, Gujarat. The study area covers a part of South Delhi Fold Belt (SDFB) and mainly included two places where both brittle and ductile deformation was most prominent (Jogdadi: Jogdadi Shear zone and Jhanjhar Vav: Kui-Chitraseni Shear zone). The clast size analysis was done using L-thin section micropictographs, processed by ImageJ software and roundness of clasts using AutoCAD 22.0. The results show, there is left hand fall out in the power law curve, which does not obey power law distribution, as we found it in the brittle shear zone. The left hand fall out may be due to the dissolving of small size clast in the melt or recrystallization of microlites or smaller grains to larger grains. And from the roundness study, we found the maximum cumulative frequency for the roundness value Rd=0.7-0.8, which is due to marginal decrepitation.

Keywords: Deformed pseudotachylytes, shear zone, Jogdadi, roundness, clast size

OCCURRENCE OF AN AMBIGUOUS ROCK NEAR PUTTETI ALKALINE IGNEOUS SUITE, KANYAKUMARI DISTRICT, TAMILNADU, SOUTH INDIA – IS IT PEPERITE?

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Putteti syenite is a unique alkaline suite south of Achankovil Shear Zone in the Nagercoil Block of Southern Granulite Terrain of South India. This syenite is well-known to the geologic community with its unusual zircon megacrysts and anomalous mineral wealth. Detailed field investigation in the area has revealed the presence of an ambiguous rock type that is texturally and compositionally different from the members of the entire suite. It occurs as large masses or pods within loose, weathered top soil and is characterized by both igneous and sedimentary signatures. The rock has a general brecciated appearance with large sub- rounded to angular clasts embedded in very fine grained matrix.

The sediment- magma interactions around an igneous intrusion may lead to the formation of a variety of textures and rock types. Peperite is one such rock believed to form where the processes of magmatism and sedimentation are contemporaneous. Field studies in Putteti area suggest the presence of peperite.Based on clast morphology,two common types are recognized- blocky and fluidal peperite. Petrographic studies indicate that the clasts might be of igneous origin, similar to the phenocrysts in syenite, and the matrix might have recrystallized due to the sediment-magma interaction, resulting in brecciated structure. This could be due to the rapid disintegration of intruding magma and mingling of the same with unconsolidated wet sediments in the vicinity.The proximity of the alluvial plains of the river Thamraparni in lower regimes supports this argument.

Key words: Alkaline suite, Putteti syenite, Southern Granulite Terrain, Peperite

PALEOSTRESS ANALYSIS FROM GANGAVALLI (SOUTHERN INDIA): INFERRED FROM PSEUDOTACHYLYTE EMPLACEMENT AND FRACTURE DATA

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The upper crustal rocks of Gangavalli area in southern granulite terrane are associated with many weak planes/zones such as wide range oriented fracture and gneissic planes. The Gangavalli area, an eastern part of southern granulite terrane is emplaced with a large number of pseudotachylyte veins, a dark vitreous aphanitic rock which genesis involves high strain rate deformation event leading to seismic failure. Therefore, pseudotachylytes are recognized as one of the most reliable direct indicators of paleoseismicity in the rock record. Fast slip (> 10-4 m/s) rate are very susceptible to generate earthquake and form high temperature that is more than the melting temperature of the surrounding rock. Field study suggests that these veins are straight and anastomose in nature. The attitudes of straight veins are considered for the purpose of paleostress analysis where they act as a plane of interest. The dimension of straight veins varies as thin as 1mm to 40 cm in width. Observation of melt filling fracture has been characterized into three categories on the basis of dynamic origin i.e. i) pre-existing fracture filling, ii) emplacement induced fracture filling and iii) syn-deformational fracture filling. All these fracture fillings are tectonically controlled emplacement that depends on the regional and local stress condition of the area as well as the orientation of fractures.

Previous literature study indicates that many paleostress analyses are made with different kinds of fluid and/or melt in form of veins and/or dyke intrusion but for the first time we use pseudotachylyte vein to decipher the paleostress condition of Gangavalli area. Pseudotachylyte veins can also be considered for this analysis as its generation involves high deformation events and in some cases, these are associated with the dynamic deformation along plate boundaries. Therefore, pseudotachylyte can be counted as one of a good indicator for paleostress analysis. Emplacement will occur in all direction in an undeformed stable area or an area of very less difference between the horizontal stresses. In that case, emplaced veins may not be suitable for paleostress analysis, which is not the case for pseudotachylyte. The result shows that Gangavalli area consists of fractures in all directions out of which dominant fractures are oriented along NS, N to NE and W to NW in strike. In the lower hemisphere stereonet, all poles of pseudotachylyte veins are clustered along NW and SE quadrant suggesting a strike direction of NE. Only NE orienting fractures are susceptible for the melt to be emplaced by overcoming the least compressive regional stress from NW-SE direction. Stress orientation during pseudotachylyte formation was obtained as maximum compressive stress (σ^1) along vertical, least horizontal compressive stress (σ^3) along SE, and horizontal intermediate stress (σ^2) along NE. However, we conclude by interpreting from pseudotachylyte vein emplacement that this above stress set up of the area indicates extensional settings which is an unfavourable condition to produce pseudotachylyte melt. Thus, in order to produce pseudotachylyte melt in the above condition, σ^1 and σ^2 must have to be an equivalent amount where both can be interchangeable.

Keywords: Paleostress, pseudotachylyte, emplacement, Gangavalli (Southern India)

PROLOGUE OF ELECTRICAL ENGINEERING IN THE INDIAN EARTH SYSTEM SCIENCES

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The educational schemers of earth system sciences must chew over integrating some basic aspects of electrical engineering in the Indian earth system science curriculum. The earth science students must be taught theoretical and practical aspects of identifying roots or paths of electrical current flow in the earth crust as well as in rock body. In an electric universe a comet is not a dirty snowball from the alleged Oort cloud or the Kuiper Belt of our solar system. It is a normal part of the planetary system, as other meteorites, asteroids or even planets. The Aurora Borealis and the Aurora Australis are today's visible effects of a stable electrical system on Earth. In the normally harmless light phenomena over the poles where the current weak interaction with the sun reaches the deeper layers of the atmosphere, its filamentary structure suggests what to expect from a greater interaction. It will also deal with understanding the importance of electrical energy in the formation of the modern world, applications of electrical energy in the field of earth sciences. These changes must be introduced at the graduate level, with increase academic inflexibility of the syllabus of post graduate level in both applied science and engineering level. This new interdisciplinary field will be known as "Geo-electric", which will be one of the frontier areas of research, which involves diverse fields in natural sciences and engineering including physics, geology and electrical engineering. Earth's physical, biological and chemical processes continuously interact and influenced one another, but we have classified every field of sciences as separate disciplines in the academic world. Both the disciplines geology and electrical engineering have grown and matured independently.

There are several examples of how this educational policy decision can be a game changer in understanding various surface and subsurface processes and providing new insights. And the most important thing is that this approach has not been implemented by a single western country till now. So it's time for our country to adopt this new course and India will be the mother of this new interdisciplinary branch. To be the pathfinder of this new course a lot of research requires and it's the responsibility of our Government to take necessary steps to introduce it in our country and researchers also have to show their interest for the development of this branch. Such a change in educational curriculum will lead to several fundamental advances in basic sciences and engineering as well as have applied outcomes in geophysics, electrical and telecommunication engineering, mineral exploration and other Industries.

Keywords: Geo-electric, Indian earth system science, Natural sciences, Electrical Engineering.

THE AGE OF GENUS MACROCEPHALITES ZITTEL AND THE BATHONIAN BIOSTRATIGRAPHY OF KACHCHH, WESTERN INDIA (SOUTH TETHYS)

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The find of Indonesian *Macrocephalites* in Kachchh (and correspondingly the introduction of the genus into Kachchh) is re–evaluated in context of new ammonite data and correlated with European occurrences. An updated ammonite content and biostratigraphy is provided for the Bathonian strata of Kachchh (Western India). The Indonesian macrocephalitids (*Macrocephalites bifurcatus* transient *intermedius* [M], *M. bifurcatus* transient *cf. intermedius* [M], *M. bifurcatus* transient aff. *bifurcatus* [m] and *M. cf. etheridgei* Spath [m]), have largely been recorded from a single dome, Jumara (from the basal Yellow bed, bed A4), with singular occurrences of *M. cf. etheridgei* Spath [m] from adjoining Nara and Jhura domes (Kachchh). In Jumara, the Indonesian *macrocephalitids* are associated with *Micromphalites* (*Clydomphalites*) *clydocromphalus Arkell* [M], large Procerites (*P. (Gracilisphinctes*) *arkelli Collignon* [M], *P. (G.) intermedius* Jain [m] and *P. hians* Waagen [M]), *Wagenericeras* sp. [m], *Parapatoceras distans* (Baugier and Sauzé) [M], *Sivajiceras congener* (Waagen) [M and m], *Macrocephalites triangularis* Spath [M and m], *Epimorphoceras decorum* [M], and *Reineckeia* sp. A and B [M]. This fauna is correlated with the European Middle Bathonian Bremeri Zone. However, recent magnetostratigraphic analysis from the same sediments of the Yellow bed, have yielded an Early Bathonian age (magnetostratigraphic Zone M41). New nannofossil assemblage from the sediment attached to a typical Middle Bathonian *Micromphalites* (C.) *clydocromphalus Arkell* [M] from the Yellow bed has also given a much earlier but broader age spanning Early Bathonian to early Middle Bathonian (= lower part of the nannofossil Zone NJ11). The nannofossil–based upper age limit of genus Macrocephalites, extracted from the sediment of the last occurring *macrocephalitid – Macrocephalites subcompressus* Waagen [m] from the early Middle Callovian Zeilleria Bed (Jumara) is also provided. Although, for better refining the age of a fauna or an assemblage, such an integrated approach (of combining ammonite, nannofossils and magnetostratigraphic data) should be the norm, but for now, at least for Kachchh, ammonites seem to provide a tighter age control, as there are fewer common Bathonian–Callovian nannofossil index datums.

Keywords: *Macrocephalites*, Nannofossils, Middle Bathonian, Middle Jurassic, Kachchh

ON THE AGE AND OCCURRENCES OF GENUS PARAPATOCERAS SPATH: AN UPDATE

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The age of the heteromorph ammonite genus *Parapatoceras* SPATH in Kachchh (Western India) is now lowered to the late Middle Bathonian Arkelli Zone (= Bremeri Zone). Globally, also, the age of the genus is similarly now lowered to Early Bathonian (Zigzag Zone). The upper limit of the genus, has also recently been revised to Late Callovian (Collotiformis Subzone, Athleta Zone). In Kachchh, *Parapatoceras distans* (BAUGIER & SAUZÉ) ranges from late Middle Bathonian to early Middle Callovian and *P. tuberculatum* (BAUGIER & SAUZÉ) ranges from mid–Late Bathonian to the early Middle Callovian Anceps Zone. The late Middle Bathonian *P. distans* (BAUGIER & SAUZÉ) from Jumara (Kachchh), as recorded here, is the best ancestral candidate for the mid–Late Bathonian *Epistrenoceras* BENTZ; both have now been recorded from

the same section. Varied shell morphologies (coiling) of genus *Parapatoceras* SPATH from Kachchh and of *Parapatoceras distans* from recent finds (globally), are also documented, for the first time.

Keywords : *Parapatoceras, Epistrenoceras,* Middle Bathonian, Middle Jurassic, Kachchh

JURASSIC FORAMINIFERA FROM THE DHARANG MEMBER, HABO FORMATION, HABO DOME, KUTCH, INDIA: SYSTEMATICS, AGE, PALAEOECOLOGY AND PALAEOBIOGEOGRAPHY

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The Middle Jurassic, Dharang Member of the Habo Formation, Habo Dome, Kutch, India yields rich foraminiferal assemblages comprising 59 species The assemblages are dominated by the families Vaginulinidae and Nodosariidae This paper is a systematic account of the 22 species *Ophthalmidium* aff *tanuissimum, Ichthyolaria* aff *baueri, Falsopalmula* aff *centralis, F. deslongchampsi, F. jurensis, F.* aff. *primordialis, Nodosaria elegantia, N. mitis, Lingulina esseyana, Lenticulina andromede, L. argonauta, L. brueckmanni, L. desnaensis, Astacolus clava, A. crepidula, Vaginulinopsis* aff. *bartensteini, V. incisiformis, V. longestriata, Citharina decemcostata, Vaginulina ancipitana, Epistomina antorolavaensis and Nodosaria* sp. The genera Ichthyolaria and Falsopalmula are reported for the first time from the Indian Subcontinent.The foraminiferal assemblages indicate a Callovian age for the studied sequence Based on the foraminiferal evidence, the sediments of the Dharang Member at Habo Dome were deposited in open marine conditions in the middle to outer shelf, with a fluctuating shoreline and within a tectonically unstable shelf zone The Dharang Member foraminiferal assemblages, as well as other Jurassic foraminiferal assemblages of Kutch and Rajasthan, are assigned to the Indo-East African Province of the Anti-Boreal Realm.

Keywords: Jurassic; Foraminifera; India; Systematics; Age; Palaeoecology; Palaeobiogeography

BENTHIC FORAMINIFERAL PALAEOECOLOGY AND PALAEOENVIRONMENT OF THE JURASSIC SUCCESSION OF FAKIRWARI DOME, KUTCH, GUJARAT

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The Mesozoic rocks ranging in age from Middle Jurassic to Lower Cretaceous are particularly well developed in Kutch Basin which lies on the westernmost extremity of India and famous for excellent exposures of Jurassic rocks. The present study is aimed at using foraminiferal assemblages in interpretation of palaeoecology and palaeoenvironment of a relatively small but well exposed area of these rocks near Fakirwari village, 8 km southwest of Bhuj. The measured section of the Chari Formation exposed at Fakirwari Dome is divided into eight lithounits A total of 51 samples were collected for foraminiferal analysis which yielded fairly rich foraminiferal assemblages comprising fifty-four species, dominated by the family Vaginulinidae having 22 species (40.75%). Calcareous species are dominating with Agglutinated/Calcareous ratio being 1:2. All calcareous species are perforate or hyaline with absence of imperforate or porcelaneous forms. The foraminiferal assemblages suggest a Callovian age for the studied sequence.

Foraminifera have proved to be highly promising for palaeoecological interpretations due to their sensitivity to minor fluctuations in the environment, minute size, high diversity, rapid evolution, and long geological history. A number of criteria are used for palaeoecological interpretations employing foraminifera including a (Fisher) Index, wall composition, tolerance of taxa to various environmental parameters, occurrence of dominant taxa in relation to species diversity, and concept of morphogroups. These methods are used to interpret various ecological parameters including bathymetry, salinity, and dissolved oxygen during the deposition of the studied sequence.

Dominance of superfamily Nodosariacea in the present foraminiferal assemblages indicates shallow water marine environment of shelf region. However, absence of porcelaneous forms rules out possibility of inner shelf environment and the present foraminiferal assemblages represents a mid to outer shelf environment. On the basis of the changing environmental parameters the entire studied sequence is divided into four palaeoecological units I to IV.

The sedimentation of Chari Formation at Fakirwari Dome commenced with a transgressive phase later on reaching the outer shelf region with near normal salinity and normal oxygen level (Palaeoecological Unit I). This was followed by deposition in shallower region of the shelf with a regressive phase in the mid shelf region having reduced salinity and low oxygen level (Palaeoecological II). The depositional basin witnessed another transgressive phase attaining maximum water depth in the deepest part of the outer shelf, where hyposaline condition prevailed along with low oxygen level (Palaeoecological Unit III). The last palaeoecological unit of the present sequence is represented by a regressive phase in the mid shelf region where salinity was normal and oxygen level high (Palaeoecological Unit IV).

On the basis of palaeoenvironmental analysis of the foraminiferal assemblages recovered from Fakirwari Dome, Kutch it is reasonable to envisage that the overall deposition of the Chari sequence exposed in the area took place in a shallow, open marine environment in the mid to outer shelf region, with normal salinity and well oxygenated waters. However, the site of deposition fluctuated between middle to outer shelf zones in a tectonically rather unstable marine shelf as indicated by frequently fluctuating shoreline. The palaeosalinty level fluctuated between normal saline to hyposaline conditions and the palaeooxygen between well- to low-oxygenated waters.

Keywords: Foraminifera, Jurassic, Fakirwari Dome, Kutch, palaeoecology, palaeoenvironment.

SIGNIFICANCE OF OXFORDIAN–EARLY KIMMERIDGIAN EPISTOMINIDAE (FORAMINIFERA) FOR PALAEOBATHYMETRIC RECONSTRUCTIONS: EVIDENCE FROM THE MIKHALENINO SECTION (EAST EUROPEAN PLATFORM; KOSTROMA REGION, RUSSIA)

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A total of 13,593 foraminiferal specimens were studied from 29 beds (one sample/bed) spanning the ammonite–constrained Middle Oxfordian (upper part of the Densiplicatum Zone) to Lower Kimmeridgian (Kitchini Zone) of the Mikhalenino Section (Kostroma Region; European Russia). The epistominiids make up 55% (7,489 specimens) of the total benthic foraminiferal assemblage including (in stratigraphic order) *Epistominastelligeraeformis, E.gracilis, E.nemunensis, E.parastelligera, E.multialveolata, E.uhligi, E.volgensis, E.raslovensis, E.sudavensis, E.cognita, E.unzhensis and E.praetatariensis.* This contribution uses the bathymetric sensitivity of Epistominidae and attempts to build an Epitomina–based inferred relative sea level for the Middle Oxfordian–Lower Kimmeridgian period. Smooth tests (such as *E.uhligi, E.praetatariensis,*

E.parastelligera and E. stelligeraeformis) are indicative of deeper conditions whereas thickly ornamented tests inhabit shallower settings and suggest regressive episodes. Four approaches are used to infer relative sea level: Epistominamorphotypes, occurrence of trace fossil Chondrites and presence of glauconite, stable isotope data and the generic level benthic foraminiferal dataset. Of the four identified benthic foraminiferal zones (*Ophtalmidiumsagittum–Epistominavolgensis, O.strumosum–Lenticulinabrestica, E.uhligi–L.russiensis and E.praetatariensis–L.kuznetsovae*), we propose that for first two (bottom) zones the paleodepth is uppermost bathyal (<250 m) with progressive shallowing (outer shelf; 100–200 m) in the following E.uhligi–L.russiensis Zone to middle shelf depths (50–100 m) in the lower part of the succeeding *E.praetatariensis–L. kuznetsovae* Zone, which otherwise, for most duration, straddled outer shelf depths. The total absence of agglutinated foraminifera excludes depths greater than 250 m for the deepest part of the section. Deeper conditions in the first two zones (up until the middle Upper Oxfordian Glosense Zone) enabled the introduction of the Tethyan affinity (Mediterranean and Submediterranean) ammonites. Increased shallowing aided increased endemicity marked by presence of strong Boreal (Cardioceratids and Kosmoceratids) and Subboreal (Aulacostephanids) ammonites for the rest of the section (post middle of Upper Oxfordian to Lower Kimmeridgian). The faithful reflection of the distribution of ammonites (cosmopolitan vs. endemicity) by the *Epitomina*–based inferred relative sea level suggests that the latter can be a powerful tool not only to construct a regional sea level curve but can also be used to explain basin evolution.

Keywords: Benthic foraminifers, *Epistomina*, Bathymetry, Upper Jurassic, European Russia.

BIOSTRATIGRAPHY OF EARLY CRETACEOUS SEDIMENTS OF KRISHNA GODAVARI BASIN

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The Krishna Godavari basin, currently positioned at the east coast of Indian peninsula, was connected with western margin of Australia and was rifted during early Cretaceous. Despite large number of studies on the tectonic evolution of the east coast of India, well defined age model for the early rifting history of India-Australia is vague. In the present study, a total of 54 m thick well cutting sedimentary succession from Dengaru well -1 (Provided by oil India ltd.) from Krishna Godavari Basin were analyzed for organic walled dinoflagellate cyst and foraminifera. Samples were collected at approximately 3 m of interval from intercalated shales and thin sandstone layers of Raghavpuram formation. On the basis of Last Appearance Datum (LAD) of dinoflagellate cyst and planktic foraminifera, biostratigraphic study was carried out. A total of Nine species of two genera of foraminifera viz. *Hedbergella infracretacea, Hedbergella excelsa, Hedbergella gorbachikae, Hedbergella tardita ,Hedbergella optiana, Hedbergella mitra, Hedbergella praelippa Hedbergella. Ruka, Minihedbergella miniglobuloris* and 14 species of 12 genera of dinoflagellate cysts viz. *Cassiculosphaeridia magna, Cribroperidinium edwarsii, Cribroperidinium perforans, Cleistosphaeridium aciculare, Cyclonephelium distinctum, Dinoptyrigium dimorphum, Hystrichodinium voigtii, Hystrchosphaeridium tubiferum, Kleithriasphaeridium corrugatum, Litosphaeridium conispinum, Odontochithina operculata, Oligosphaeridium complex, Oligosphaeridium pulcherrimum, Polysphaeridium duma* were recorded. Based on foraminiferal and dinoflagellate cyst biostratigraphy, we conclude that studied sequences correspond to early Aptian age. The presence of large number of planktic foraminifera *Hedbergella excelsa* indicate fairly open marine conditions. The study suggest first transgressive event during early Aptian in KG basin.

PALAEOENVIRONMENTAL AND PALAEOECOLOGICAL IMPLICATIONS OF FRESHWATER AND MARINE MIXED BIOTA FROM EARLY CRETACEOUS SUCCESSION OF JAISALMER BASIN, WESTERN INDIA

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The present abstract embodies new report of plant remains as well as calcareous nannofossils from the new locality of Pariwar Formation, Jaisalmer Basin. The Jaisalmer Basin is a pericratonic shelf basin occupies more or less central part of west Rajasthan Shelf. Pariwar Formation is one of the important stratigraphic units in the Jaisalmer basin represents the lower Cretaceous sedimentary succession and composed predominantly of medium to coarse grained sandstone. The fossiliferous outcrop is exposed at Serawa village about 2 km west of Sanu village and 45 km north-west of Jaisalmer. The palaeoflora of the new locality is of monospecific type. A number of bennetitalean foliage morphogenus *Ptilophyllum cutchense* Morris together with abundant wood fossils and trace fossils are preserved in white colour marl, yellow colour medium grained friable sandstone and red colour fine to medium grained hard micaceous sandstone bed except the lower marl bed. Whereas calcareous nannofossils are recovered from all the four beds. A moderately diversified, reasonably well preserved nannofossil assemblage comprising 11 nannotaxa viz. *Ceratolithoides* sp., *Cyclagelosphaera margerelii* (Noel, 1965), *Calculites* sp., *Diazomatolithus galicinus, Discorahbdus ignotus, Faviconous multicolumnatus, Laguncula pitcherensis, Rhabdophidites* sp., *Watznaueria biporta, W. fossacincta, W. barnesae, W. britannica, Thoracosphaera* sp. *and Prediscoshaera columnata* (Stover, 1966) which is a cosmopolitan marker, whose FAD marks the base of lower Albian (base of CC8a). The presence of leaf impression along with bioturbation and marine calcareous nannofossils indicates shallow marine depositional environment with low energy condition. Occurrence of rich plant remains and abundant gymnospermous wood indicates existence of a luxuriant forest adjacent to the sea. Abundance of *Ptiophyllum* leaves in association with nannofossil perhaps indicate relatively warm (though seasonal), humid environments and prefer to grow at coastal margins.

BIO-EVENTS AND PALEOENVIRONMENT OF ALBIAN FORAMINIFERA IN THE UTTATTUR GROUP, SOUTHERN INDIA

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One hundred and nineteen sediment samples were collected in the area exposed between Karai and Kulakkalnattam Villages for the study of bio-events and paleoenvironment of the Albian foraminifera. One hundred and six species of benthic foraminifera and nine species of planktic foraminifera were identified in the present study.

Hedbergella planispira and *Planomalina buxtorfi* were present indicating Albian age. Diversification bio-events has been noticed in the Albian benthic foraminifera. Many species of benthic foraminifera were observed during Albian period indicating innovation and radiation bio-events. The benthic foraminifera are comparatively more in number than the planktic foraminifera.

The abundant presence of epifaunal to shallow infaunal group of benthic foraminifera namely *Lenticulina* (*L.alexanderi, L.carlsbadensis, L.circumcidanea, L.gaultina, L.grata, L.macrodisca, L.navarroensis, L.nodosa, L.nuda, L.oblongus, L.ovalis, L.planiuscula, L.polygona, L.rotulata, L.saxocretacea, L.secans, L.stephensoni, L.sulcifera, L.warregoensis), Marginulina (M.aequivoca, M.bullata, M.compressa, M.directa, M.hamuloides, M.jonesi, M.lineara, M.munieri, M.perobliqua, M.troedssoni), Nodosaria (N.affinis, N.cylindracea, N.distans, N.glabra, N.lamello-costata, N.larva, N.mutabilis, N.orthopleura, N. paucicosta, N.prismatica), Vaginulina (V.debilis, V.kochii, V.recta, V.tenuistriata), Dentalina (D.catenula, D.fallax, D.gracilis, D.marginuloides, D.nana, D.ovoidea, D.strangulata, D.trujilloi, D.xiphioides, D.wimani*) indicates an outer neritic to upper bathyal environments with water depth of 130-600m. The occurrence of planktonic morphotype *Hedbergella planispira* and *Hedbergella delrioensis* consider to reflect a more neritic type (middle to outer neritic) of environment shallower than 100 m water depth. Based on the occurrence of Benthic and Planktic foraminiferal assemblages, it is inferred that the paleoenvironment of Albian is outer neritic environment (100-200m).

Keywords: Benthic foraminifera, Planktic foraminifea, Bio-event, Paleoenvironment, Epifaunal, Shallow infaunal, Neritic.

AGE AND PALEO – ENVIRONMENT OF CRETACEOUS SEDIMENTS EXPOSED IN KARAI TO KULAKKANATHAM TRAVERSE, UTTATUR GROUP, TAMIL NADU

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Sixty six samples are systematically collected in the Karai – Kulakkanatham traverse of Uttattur Group. The samples are processed in the laboratory using standard Micropaleontological techniques. Thirty one (31) species of foraminifera are identified belongs to 18 genus, 12 sub family, 13 family, 9 super family and 6 sub order. The occurrence of ecological marker species *Dorothia, Lenticulina, Gavelinella, Gyroidinoides, Anomalinoides, Quadrimorphina*, indicates the palaeobathymetry is upper bathyal (>200m) during Cenomanian period. As the key marker planktic foraminiferal species *Thalmanninella appenninica, T. evoluta, T. greenhorneniss, T. reicheli* are present in the samples Cenomanian age is assigned. However, further study based on the close sampling is required.

Keywords: Foraminifera, Cenomanian, Paleoenvironment, Uttatur group.

STUDY OF LATE CRETACEOUS FORAMINIFERA FROM THE EXOTIC LIMESTONE OF NAOTHALUNG AREA IN HUNGPUNG VILLAGE, UKHRUL DISTRICT, MANIPUR STATE, NE INDIA

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Fifty two geological samples are collected from the exotic limestone blocks of the ophiolite mélange zone in Naothalung area in Hungpung village lies within 94º20'12" and 94º20'43" longitudes and 25º20' and 25º20'12" latitudes of Ukhrul District, Manipur, Northeast India. A rich variety of planktic and benthic foraminifera are yielded, 19 genera and 32 species planktic and benthic foraminifera are found in this study area.

The planktic foraminifera obtained in the present study are as follows: *Contusotruncana fornicata, Contusotruncana patelliformis, Gansserina ganseri, Globogerinelloides bentonensis, Globigerinelloides prairiehillenis, Globigerinelloides volutes, Globotruncana aegyptiaca, G.arca, G.bulloides, G.lappararenti, G.linneiana, G.ventricosa, Globotruncanita calcarata, G.elevata, G.pettersi, G.subspinosa,G.stuarti, G.stuartiformis, Globotruncanella havanensis, Heterohelix globulosa, Marginotruncana undulata, Pseudoguembelina costulata, Pseudotextularia* sp., *Pseudotextularia elegans*, and the benthic foraminifera obtained in the present study are as follows: *Bolivina witwickae, Bolivinoides* sp., *Fissurina* sp., *Fissurina orbigyana, Dentalina* sp., *Gaudryina pyramidata, Nodosaria obscura, Pseudonodosaria* sp.

Based on the ranges of key marker planktic foraminiferal species *Gansserina gansseri, Globotruncana aegyptiaca, Globotruncanella havanensis,Globotruncanita calcarata, Globotruncana ventricosa, Globotruncanita elevate*, the study area found to be the age from the Early Campanian to Late Maastrichtian.

Keywords: Late Cretaceous foraminifera, Exotic Limestone, Campanian, Maastrichtian, Manipur.

SMALLER BENTHIC FORAMINIFERAL ASSEMBLAGE, PALEOENVIRONMENT AND SOME NUMMULITIDS BIOMETRICS DATA FROM THE EARLY-MIDDLE EOCENE SYLHET LIMESTONE FORMATION, MIKIR HILLS, ASSAM

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Thirty one genera of smaller benthic foraminifera are reported from an early-middle Eocene limestone-shale-sandstone succession exposed in a quarry in the south-eastern part of Mikir Hills, Dillai Parbat, Assam. The smaller benthic foraminiferal assemblage presents a moderate-rich population in the limestone and shale units and poor to absent in the sandstone intervals. Preservation state is moderate, enabling identification of fourteen taxa up to specific level. These are found co-occurring with larger benthic foraminifera, planktonic foraminifera and other micro and mega fossil groups. Smaller benthic foraminifera are utilised here to define paleoenvironmental conditions of the Eocene succession. Their occurrence is calibrated with larger benthic and planktonic foraminiferal zones established for the area. The latest part of early Eocene experienced alternating shallow marine to deeper open marine conditions, while the early part of Middle Eocene was largely a shallow shelf setting. This was followed by a period of regression in the area resulting in deposition of non-marine sand and shale/clay, which are devoid of microfossils. The later part of middle Eocene saw another period of marine incursion resulting in the deposition of a sandy, glauconite-bearing limestone unit. The middle Eocene sea completely retreated from this area above this unit, resulting in the deposition of thick sandstone and shale. Biometrics data of seven *Nummulites*, one *Assilina* and one *Discocyclina* taxa are also presented and their distribution calibrated with standard Shallow Benthic Zones (SBZs).

Keywords: Smaller benthic foraminifera, Paleoenvironment, Nummulitids, Biometrics, SBZs, Eocene, Mikir Hills

CHARACTERIZATION OF THE PRIABONIAN STAGE IN THE SHALLOW MARINE CARBONATES OF INDIA

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Late Eocene marine strata in India occur as outcrops in Meghalaya, Andaman-Nicobar, Nagaland and Gujarat, and in the sub surface of Bengal, Cauvery, Cambay and Jaisalmer Basins; these are largely undifferentiated in terms of larger and planktonic foraminiferal biostratigraphy and need standardization so as to evaluate eustasy and climate changes. All are assigned late Eocene due to the presence of *Pellatispira* which was considered as late Eocene marker in Indian subcontinent. With Pellatispira occurring in the middle Eocene, the role of the genus as late Eocene index becomes open for discussion; however, some of its species have restricted occurrence in the late Eocene. The standard shallow benthic Priabonian zones SBZ19 and SBZ20 do not have *Pellatispira* and its species; however, with complex morphology, wide geographic distribution in the Tethys realm and short stratigraphic range within the Priabonian, *Pellatispira glabra* may be used as index species. The Kopili Formation in Garo-Khasi Hills of Meghalaya and the Amravati Formation in Surat-Bharuch Districts of Gujarat preserve almost complete Priabonian successions that are easily accessible, structurally undisturbed, foraminifera bearing and amenable to litho- and biostratigraphic subdivisions. The successions in both the areas are divisible into lower and upper units; in Meghalaya, the lower unit comprises alternations of earthy limestone bands, *Discocyclina marlite* and shale while the upper unit contains alternating oolitic marlite band and calcareous shale containing fragile *Discocyclina* and small *Nummulites*; in Surat-Bharuch, buff colored earthy limestone and marlite with rock-forming Pellatispira and Discocyclina constitute the lower unit whereas yellow oolitic marl and mudstone constitute the upper unit. In Garo-Khasi Hills, the base of Priabonian marked by the last occurrence of Truncorotaloides rohri occurs in between *Nummulites perforatus* (B-form) bearing 'large Nummulites bed' and *Discocyclina* marl containing small sized *Nummulites fabianii* and *Nummulites pengaroensis* while the top at the last occurrence of *Hantkenina alabamensis* occurs in between the last occurrence of in situ Discocyclina and the first appearance of reticulate *Nummulites fichtelii*. The lower boundary in Surat-Bharuch is tentative at the base of fabianii pengaroensis bearing Discocyclina marl overlying the ferruginous lateritic claystone while the upper boundary occurs within yellow mud containing profuse tiny gastropods and the first occurrence of *Nummulites fichteli*. In both the areas, the lower unit contains *Nummulites fabianii*, the zonal index of SBZ 19; its range defines *Nummulites fabianii* Zone in which Pellatispira glabra and Pellatispira crassicolumnata remain restricted while the upper unit contains *Nummulites retiatus*, the zonal index of SBZ 20, and its range defines *Nummulites retiatus* Zone which contains Pellatispira madaraszi and *Pellatispira fulgeria*. Though *P. madaraszi* is known in the Bartonian, the late Priabonian forms possess more regular spiral gutter, equatorial chambers and marginal plexus. The two Priabonian zones in India are distinct from their counterparts of the Mediterranean region primarily in the development of *Pellatispira* assemblages. Associated age diagnostic and biostratigraphically significant planktonic foraminifera help to synchronize the two larger foraminiferal zones with *Turborotalia cunialensis* Zone and *Turborotalia cerroazulensis* Zone. Since the Priabonian Stage with lower and upper boundaries is developed along the Therria River section in Khasi Hills and Maheshkhola River section in Garo Hills, the sections are proposed as hypostratotypes whereas the Surat-Bharuch section is regarded as typical.

RUPELIAN (EARLY OLIGOCENE) CALCAREOUS NANNOFOSSILS AND DINOFLAGELLATE CYSTS FROM LUMPY CLAY MEMBER OF MANIYARA FORT FORMATION, KUTCH

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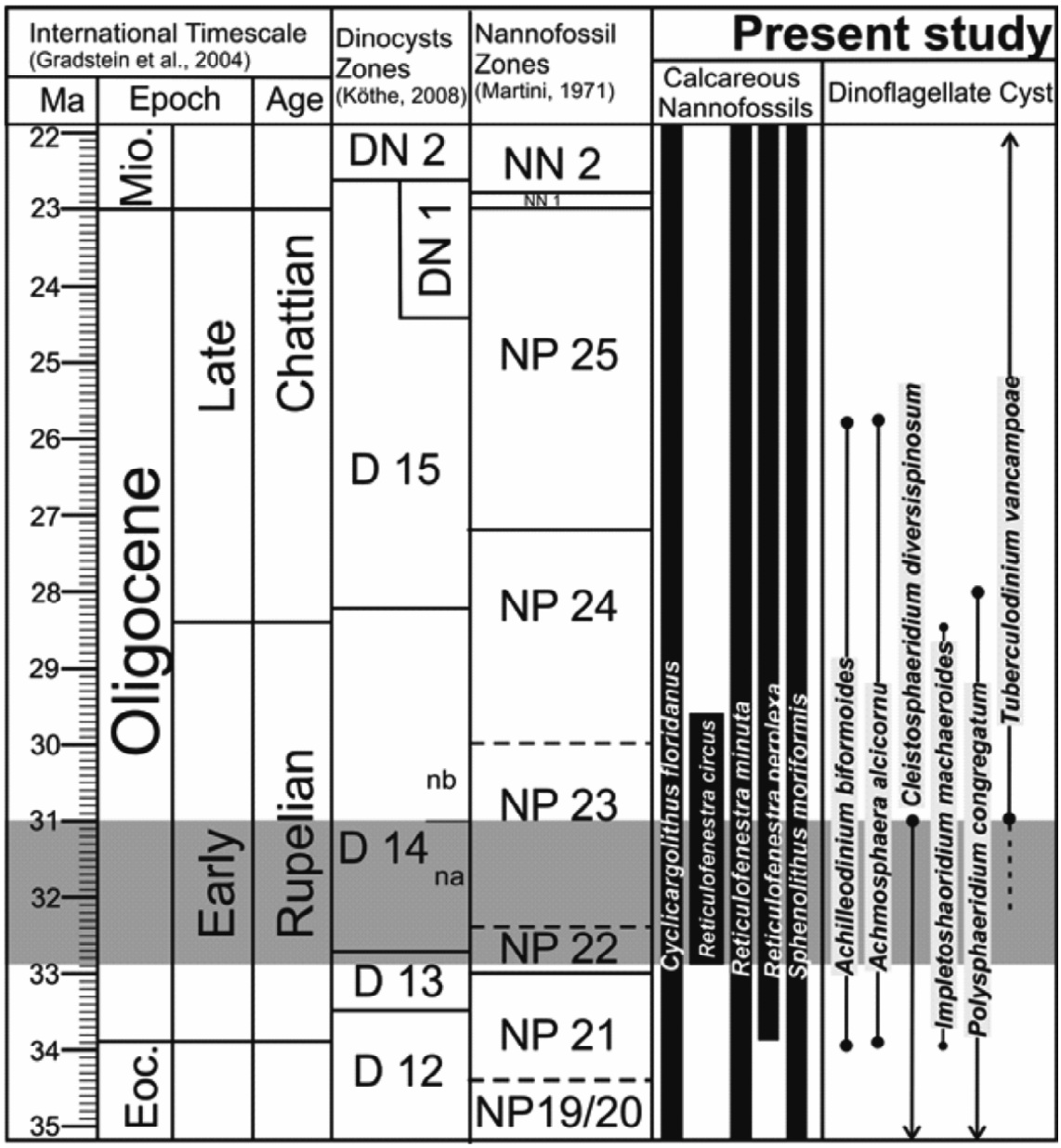
The Paleogene successions of Kutch, Gujarat exhibits huge shallow marine carbonate deposits during Middle Eocene and Oligocene period. These deposits are mainly dated on the basis of larger benthic foraminifers. The paucity of fossils recovery from the intermittent succession created discrepancy in the precise dating of these successions. Lumpy Clay Member of Maniyara Fort Formation is such an example. This member is considered as unfossiliferous in terms of forams and dated together with foraminiferal assemblages of underlain Basal and overlain Coral Limestone members (Kumar and Saraswati 1997). In the present study palynological biostratigraphy have been attempted in succession of Lumpy Clay Member exposed at Bermoti River, Kutch. A well preserved age-diagnostic assemblage of dinoflagellate cysts and nannofossils has been recovered. The nannofossil assemblage is composed of *Coronocyclus* sp., *Cyclicargolithus floridanus, Eiffellithus* sp., *Micula murus, Nannoconus* sp., *Neochiastozygus* sp., *Reticulofenestra circus, R. minuta, R. perplexa and Sphenolithus moriformis*. The investigated interval can be dated as early-middle Rupelian (NP22-NP23 nannofossil Zones) based on the total assemblage and presence of *Reticulofenestra circus* (Martini 1971). The First Occurrence (32.92 Ma) of *Reticulofenestra circus* marks the boundary between NP21-NP22 and the Last Occurrence (29.62 Ma) of it marks the boundary between NP23-NP24. Therefore, the total presence of *Reticulofenestra circus* envisaged the early-middle Rupelian (NP22-NP23) age of the studied sequence.

In general, the palynomorphs assemblage in all samples is dominated by marine phytoplanktons over terrestrially derived organic matter and *sporomorphs.* The *sporomorphs* assemblage is mainly consisting of Bisaccate (*Abiespollenites* sp.), Poaceae (*Graminidites* sp.), Dipterocarpaceae (*Dipterocarpuspollenites retipilatus*) pollen. The diverse dinoflagellate cyst assemblage consists of 40 taxa excluding a few unidentified taxa. The dinoflagellate cyst assemblage is characterised by high numbers of the *Operculodinium* spp., *Polysphaeridium* spp., *Homotryblium* spp., *Spiniferites-Achomosphaera* complex and *Cleistosphaeridium* spp. The typical oceanic taxa such as *Pentadinium* and *Impagidinium* are also recorded in all samples. Although, most of the recovered taxa are long-ranging, this limits their use in age assignment. The stratigraphically most significant dinocysts are *Achilleodinium biformoides, Achomosphaera alcicornu, Cleistosphaeridium diversispinosum, Impletophaeridium machaeroides, Polysphaeridium congregatum* and *Tuberculodinium vancampoae*. The dinoflagellate studies from low latitudes of Northern Hemisphere, suggest FO of Achilleodinium biformoides and Achmosphaera alcicornu in equatorial region is just above the Eocene-Oligocene boundary at ~33.5 and ~33.9 Ma respectively (Brinkhuis and Biffi 1993; Williams et al. 2004). Interestingly, the presence of associated nannofossil, Reticulofenestra circus at base confine the age of present section not older than 33 Ma., as the FO of Reticulofenestra circus nannofossil is at 32.9 Ma (NP22).

The Lumpy clay member section is also characterised by presence of *Cleistosphaeridium diversispinosum* range of which has been reported from Ypresian to Rupelian from the Grand Banks, offshore eastern Canada (Eaton et al. 2001). More precisely, it is reported up to D 14(na) Dinocyst Zone (~31 Ma) of Germany (Köthe 1990; Köthe and Piesker 2007). In present study, the LO of *Cleistosphaeridium diversispinosum* envisages the age section is not younger than mid Rupelian (~31 Ma). Recently, the FO of *T. vancampoae* establish to Rupelian in dinoflagellate cysts record of eastern Equatorial Atlantic, West Africa (Awad and Oboh-Ikuenobe 2018) and recalibrated its occurrence in D14(nb) dinocysts Zone (Köthe and Piesker 2007). The *Polysphaeridium congregatum* have it's LO ~28 Ma (Williams et al. 1993) is also commonly

recorded in all samples. Other recovered dinocysts, *Impletosphaeridium machaeroides* was recorded from Rupelian of Boom Clay Formation of Belgium (Stover and Hardenbol, 1993).

The present palynological results helped us to precisely date the Lumpy Clay Member succession to early Rupelian (~33-31 Ma) on the basis of integrated record of dinoflagellate cysts and calcareous nannofossils (Figure 1). The inferred date corresponds to NP 22 to lower part of NP 23 Nannofossils Zone (Martini, 1971) and Upper most part of D13 to D14(na) Dinocysts Zones (Köthe and Piesker 2007). The palynological assemblage implies that the deposition took place in a shallow marine neritic lagoonal environment. The study also suggests initiation of Oligocene marine transgression in western India during the Early Rupelian.



PLEISTOCENE DEEP-SEA BENTHIC FORAMINIFERAL DIVERSIFICATION FROM CASCADIA MARGIN (IODP HOLE 1325B), NE PACIFIC OCEAN

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The study reveals the taxonomic benthic foraminiferal fossil records of 52 individual species belonging to 31 genera with their distribution and diversification from ~1200 ka (Pleistocene to Holocene) at Cascadia Continental Margin, NE Pacific Ocean. It is noted that, *Bulimina exilis, Cibicides kullenbergi, Elphidium batialis, Epistominella exigua* and *Uvigerina proboscidea* generally shows higher abundances during Pleistocene. The benthic foraminifera diversity parameters show close linkages to changes in the food web, productivity and bottom water oxygenation condition. The study hole 1325B is analyzed in terms of the information function (H), equitability (E), number of species (S) and Sanders' rarefied values combined with the increasing percentages of *Uvigerina* taxon are indicative of high productivity in the region. The Gas Hydrate Stability Zone (GHSZ) in the Cascadia Margin at is marked through ~240 to 70 meters below seafloor and therefore we found that the low temperature and high-pressure conditions in this particular zone, favor less abundance of every taxon in study area. The Alaska Current, North Pacific Current and California Current also known as Eastern Boundary Currents (EBC) plays a major role in the transportation of suspended sediments and coastal upwelling throughout the Washington coast (~650-450 ka and ~35-2 ka). The population of the benthic foraminiferal community decreases with increasing core depth of this region indicates the influence of less ventilated and nutrient-enriched North Pacific Intermediate Water (NPIW). The evolution of mid-Pleistocene Transition (MPT) had occurred in two phases and this might also reflect in the disappearance of benthic faunas throughout the time period (~1200-700 ka) due to increased cyclic seasonality and decreased food supply, with exception of very few species.

Keywords: Benthic foraminifera, Species diversity, Gas hydrates, Pleistocene, Cascadia Margin.

EVOLUTION AND EXTINCTION OF PLANKTIC FORAMINIFERA IN DEFINING THE CENOMANIAN AND TURONIAN STAGES IN INDIA

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Among the twelve Cretaceous Stages, the Cenomanian Stage is one of the very well developed sections available in India for the study of Earth history during this six million-year interval (100.5 - 93.9 Ma). The base and top of the Cenomanian Stage are easily identifiable. The sections exposed east of Karai, Uttattur Villages in Perambalur District are classical sections comparable with the internationally agreed Global Boundary Stratotype Sections and Points (GSSP) for the base of the Cenomanian and Turonian Stages in Mont Risou near the town Rosans, Haute-Alpes, France and Pueblo, Colorado, US respectively.

The Cenomanian-Turonian (C-T) boundary event is considered the second-largest Cretaceous extinction event and one among the five major planktonic and benthic foraminiferal extinction events occurred during the past 100 m.y.: at the Cenomanian/Turonian (C-T) boundary, at the Cretaceous/Tertiary (K-T) boundary, in the latest Paleocene, in the late Eocene, and in the early middle Miocene (Kaiho, 1994). Planktic foraminifers are

known for their wide geographic distribution, rapid evolution and short stratigraphic ranges are used as excellent markers species. The First occurrence (FO) and Last occurrence (LO) of species are especially important “Bioevents", marking unique moments in geological time.

As planktic foraminifera are able to spread quickly over large areas of the oceans, their bio-events are especially valuable for determination of age and correlation of sediments strata over intercontinental distances. The fine-scale evolutionary patters of planktic foraminifers, their huge populations in the oceans, characteristic features allows tracing of ancestor-descendant lineages, a powerful means for reconstructing the phylogenetic history of this group. In Cretaceous period alone eighteen genera of highly diversified Globotruncanidae family have *Hedbergella* occurred, whose less evolved species lived throughout the Cretaceous period, as a common ancestor. Many genera are being defined as a consequence of more reliable morphological criteria and phylogeny.

The base of the Cenomanian Stage is marked at the first occurrence of the planktonic foraminifera *Rotalipora appenninica* after the last occurrence of *Planomalina buxtorfi*. The Cenomanian-Turonian (C-T) Stage boundary is placed within the *Whiteinella archaeocretacea* Partial Range Zone, which is defined as the stratigraphic interval between the extinction of *Rotalipora cushmani* (Morrow, 1934) and the appearance of *Helvetoglobotruncana helvetica* (Caron, 1985; Robaszynski & Caron, 1995). The flooding of *Whiteinella* population was observed after the extinction of *Rotalipora* (Venkatachalapathy & Ragothaman 1994, 1996) and the keeled species reappear again in Turonian.

The C-T boundary foraminiferal event was thought to have occurred near the peak of a major eustatic sea-level rise characterized by warm equable climates, unique foraminifers, lithology with anoxic or anaerobic/ dysaerobic conditions relative to Oceanic Anoxic Event-2 (OAE-2) led to foraminiferal extinctions. The C-T boundary interval is represented by short ranging biostratigraphic zones *Rotalipora chusmani* Total Range Zone, *Whiteinella archaeocretacea* Partial Range Zone and *Helvetoglobotruncana helvetica* Partial Range Zone. Keeled species reappear again in Turonian. The First Occurrence (FO) of *Helvetoglobotruncana* helvetica is an important planktic foraminiferal taxon that has been characterized by a short stratigraphic range within the lower–middle Turonian (e.g., Gradstein et al., 2004). The foraminiferal events and zones are compared and correlated with other regions and GSSPs for Cenomanian and Turonian Stages.

ICHNOASSEMBLAGES AND TIERING IN CRETACEOUS GIUMAL FORMATION, SPITI HIMALAYAS: IMPLICATIONS FOR UNDERSTANDING COLONIZATION OF TURBIDITE SEQUENCE IN DEEP SEA ENVIRONMENT

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Ichnoassemblages and Tiering analysis provide valuable evidence on marine benthic organism colonizing deep sea environment. It is often seen that any disturbances like turbidite, debris flow or sediment collapse within the deep sea environment defaunate the substrate and a new set of benthic organism colonizes. Moreover, the diversity records of deep sea ichnogenera suggest a global decrease in a number of ichnogenera recorded during Early-Middle Cretaceous times. The paper explores short term and long term colonization strategies employed during early Cretaceous Sediments of Giumal Formation in Tethyan Himalayas. The Giumal Formation has intercalated contact with underlying Spiti Formation and consists of dark shales alternating with quartz-rich glauconitic sandstones. Detailed ichnological studies of Giumal Peak section shows completegradation from Upper part of Spiti Formation to Basal part of the Giumal Formation. The upper part of the Spiti Formation is similar to the Giumal Formation however abundant occurrences of concretions, ammonites, belemnites,and bivalves Buchia characterizes it. These fossils indicate low energy shelf environment. The basal part of the Giumal Formation (at least in the studied section) shows rare occurrences of ammonite and belemnites.However, the base of the sandstone and overlying shales shows abundant occurrences of trace fossils. Based on the ichnological studies following trace fossils were identified and includes *Bergaueria* isp; *Helminthopsisabili; Laevicyclus* isp; *Protopaleodictyonincompositum; P. submontanum; Palaeophycusalternatus; Planolites* isp, *Phycosiphonincertum ; and Thalassinoides* isp. The trace fossils are classified as pre-turbidite / pre-depositional ichnoassemblages comprising of (a) Shallow tier Helminthopsis-Laevicyclusichnoassemblage (b) Middle to deep tier *Protopaleodictyon-Thalassinoides* ichnoassemblage and post-turbidite/post-depositional ichnoassemblage of shallow to middle tier Phycosiphon ichnoassemblage. The distinction between pre and post turbidite ichnoassemblage suggest that pre-turbidite environment was of the low energy quiet environment with moderately diverse trace fossils comprising. The turbidite event was responsible for defaunating the pre-depositional traces. Deposition of turbidite sand layer with organic-rich matter was favorable for opportunistic *Phycosiphon* trace maker for exploiting top sediment layer. Published trace fossil data from MallahJohar area also suggest similar trace fossil assemblages in Giumal Formation. Thus, the transition from fossils rich shales of Spiti Formation to trace fossils rich alternating sandstone-shale sequence of the Giumal Formation indicates deepening of the environment with abundant turbidite sandy flows.

TRACE FOSSILS AND ICHNOFABRIC ANALYSIS IN EARLY –MIDDLE MIOCENE INGLIS FORMATION: INSIGHT FROM ICHNOLOGY OF FOREARC BASIN, ANDAMAN SUBDUCTION ZONE, ANDAMAN AND NICOBAR ISLANDS, NORTHEAST INDIAN OCEAN

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The Andaman and Nicobar group of Island, situated in the Bay of Bengal, represents a central part of the Burma–Sunda–Java subduction complex. The rocks exposed in Andaman and Nicobar Island consist of Ophiolites suites, flysch sediments along with deep marine nanoplankton foraminiferal chalk sediments. This sediment was scraped off the subducting Indian plate and accreted as an accretionary prism on the outer arc

ridge of the subduction zone. Stratigraphically, the deposit ranges from Jurassic to Recent with the sequence starting from metasedimentaries and ophiolite suites followed by turbidite sequences along with foraminiferal and nanoplankton chalk. Previously published literature on these deposits estimated water depth of between 2000 to 3000 meters for the deposition of the chalk, based on microfossils. The present study deals with trace fossils and ichnofabric from thick-bedded, alternating dark and light coloured chalk deposits of Inglis Formation (Early to Middle Miocene) studied systematically in two sections (a) Kalapathhar Section and (b) Lacam Point of Havelock Island. These chalks are moderateto highly bioturbated with several weak discontinuity surfaces. The studied section shows the recurring occurrence of ichnospecies belonging to *Astereosoma, Chondrites, Cladichnus Ophiomorpha, Palaeophycus, Planolites, Saerichnites, Taenidium, Thalassinoides* and *Zoophycos*. The trace fossil data shows four prominent ichnoassociaiton (a) *Astereosoma* Association(b) *Thalassinoides-Chondrites* Association (c) *Zoophycos-Chondrites* Association (d) *Zoophycos* Association. Ichnofabric data on tiering profile reveals that the middle tier *Astereosoma* and Zoophycosichnotaxa were first to colonize the sediment and were quite abundant in the units with discontinuity surfaces. These were cross-cut by deep tier *Chondrites, Thalassinoides* and *Palaeophycus* which were among the last to colonize the sediment. The in-depth ichnofabric analysis shows also suggest that trace makers exploiting light coloured sediments (DOL) exhibits more expanded tiering with diverse trace fossils, however trace fossils exploiting dark coloured (LOD) exhibits contracted tiering and reduced trace fossil diversity. This clearly indicates control of bottom water oxygenation in ichnofabric development. Additionally, it also indicates control of various factors like organic matter, pore water,andsedimentation rate as the controlling factor. Thus the ichnofabric analysis of the Early Miocene deep marine sediments of forearc setting from Andaman and Nicobar Island gives first-hand information regarding poorly known deposits belonging to deep marine sediments of pre-Bengal fan stage during subduction of the Indian plate.

PALAEOECOLOGICAL ANALYSIS OF GASTROPODS FROM THE EOCENE OF KUTCH, GUJARAT REVEALS STORM INDUCED CONCENTRATION IN SHELL BED WITHIN A QUIET MARGINAL MARINE SETTING

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The Eocene succession of Kutch basin accommodates mainly argillaceous sediments in its lower part, which are divided into two litho-units - Naredi Formation and Harudi Formation. Mega-invertebrates are relatively scanty in this part of the succession except for a molluscan shell bed that occurs at the basal part of the Harudi Formation. This about 30 cm thick bed yielded about 70 species of benthic molluscs – bivalves and gastropods - in contrast to about 10 from the rest of the succession, which is about 60 m thick. The succession largely represents marginal marine ecosystem where faunal paucity is the norm. In contrast to this the high diversity recorded in the shell bed is interesting. A palaeoecological analysis of the gastropods found from this succession is done here to decipher possible causes behind this contrasting pattern.

A quantitative analysis of the abundance pattern of the species was carried out and palaeoecological inferences were made from gastropods of the Eocene succession of Kutch basin. Using the PAST software, we attempted to fit rank-abundance data of gastropods to a mathematical model. Species-abundance models are of four types – 1) Geometric model, 2) Log series, 3) Log-normal and 4) Broken stick. The models reflect different stages of maturation and stability of an ecosystem including differences in depositional condition of the basin, resource availability, and niche pre-emption occurring in a community. Rarefaction analysis of the gastropods

from the shell bed of Harudi Formation shows that the sample size is good enough for rank abundance analysis. Using chi-squared goodness of fit tests, our data were assessed for all the four models ($p>0.05$). The gastropod data of rank-abundance most closely fit the log-normal model. A log normal model indicates a matured and stable ecosystem with a large, variable community, heterogeneous habitat, and availability of abundant resources in a low-stress environment.

The Eocene succession of Kutch, represented by the Naredi Formation and the Harudi Formation, broadly reflects a quiet water marginal marine setting. Such an environment often experiences stress from fluctuations in factors like salinity, oxygen availability, pH condition, terrigenous influx etc. Biodiversity of such a stressful environment is generally low. The gastropod fauna from the shell bed, on the other hand, reflects a stable, low-stress environment which encourages biodiversity. Ecological information about the genera found in the shell bed indicates a preference of this gastropod community for shallow to very shallow open shelf. The associated diverse bivalve community, which is dominated by shallow burrowing species, also exhibits similar preference for the shallow open shelf.

This matrix-rich shell bed with high share of fragmented shells, sharp contact with underlying shale, and micritic matrix, which is foreign in this setting, is a storm deposit. This high-energy event brought the sedimentary material along with mollusc shells from open shallow shelf to this restricted environment. However, presence of large fragments and especially many well-preserved entire shells near the top of this shell bed indicate a short distance of transport.

SANDSTONE PETROGRAPHY, HEAVY MINERAL ANALYSIS AND GRAIN SIZE ANALYSIS IN A LITHOSTRATIGRAPHIC SEQUENCE: A CASE STUDY FROM THE PROTEROZOIC KOLHAN GROUP, ODISHA AND JHARKHAND.

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The Kolhan group unconformably overlies Singhbum granite and show a faulted contact with Iron ore group of rocks. The Kolhans are shale dominated succession, and consists of gently westerly dipping, unmetamorphosed and undeformed strata of sandstones at the base overlain by extensive occurrences of shale. The shale succession in its basal part often laterally grades to calcareous shale and encloses lenticular bodies of limestone, interbedded limestone-shale sequence and thin interval of manganese oxide interbedded with shale. The widespread occurrence of thin sandstone overlain by thick shale represents an asymmetry in vertical basin-fill architecture. The upper part of the lithostratigraphy exhibits widespread and monotonous occurrence of shale. The PaleoproterozoicKolhan Group (2100-2200 Ma) in the Chaibasa-Noamundi and Keonjhar-Chamakpur basin consists of interbedded conglomerate, sandstone and shale with lenticular patches of limestone. This assemblage is divided into six lithofacies {granular lag (GLA), granular sandstone (GSD), sheet sandstone (SSD), plane laminated sandstone (PLSD), rippled sandstone (RSD) and thinly laminated siltstone-sandstone (TLSD) facies}. The work done under the thesis includes sandstone petrography, modal analysis & grain size analysis. The Kolhan display increasing textural and mineralogical maturity from base to top of its lithological succession. Continued regression promoted deposition of super mature sandstone in the uppermost horizons of the Kolhan. The sedimentological and petrofacies salient were plotted in Q-F-Lt diagrams. The plots show the sandstones are mineralogically sub matured sub-arkose to quartz arenite and derivatives of a craton interior. Qm/Qp ratio shows that the grains are mostly matured monocrystalline quartz grains and derived from either adjoining granitoid terrain or the Iron Ore Group. The shallowness of the basin is indicated

by the development of thin sequences of rocks. Heavy minerals are the sensitive indicators of kolhan basin. However because they are so sensitive to the process of weathering, transportation, diagenesis and deposition, the suite of an area does not necessarily reflect the source area mineralogy in most cases but the hydraulic controls and at the time of deposition and subsequent diagenesis may cause major modifications. The kolhan basin is set in a diversified lithological provenance, so that it exhibits the development of a rudaceous, arenaceous, calcareous and an argillaceous facies within only a few hundred feet of thickness. Six lithofacies arranged, in two genetic sequences, have been recognized within the succession. The lower sequence records little available accommodation space with a high degree of reworking, which resulted in, high-energy, bed load-dominated, sheet-like, braided fluvial deposits that lacked recurrent facies patterns. The kolhan basin has more than single phase of deposition and the internal surface erosin indicate channel avulsion. Identity of each lithofacies was based on the presence of a set of primary textures and structures. The provenance studies indicate the evidence of dual provenance. Petrofacies studies of the sandstones of Chaibasa-Noamundi basin suggest their derivation from varying source rock lithology including plutonic acid igneous rock to Iron Ore Group source. The observed vertical variation in framework grains and heavy mineral composition may be considered as the basic sedimentary response to source area denudation and tectonism. The sandstone is compositionally mature and plots in terrestrial recycled zone. The wavy planar sandstone beds with laterally persistence wavy internal lamination were deposited under wave-current combined flow regime.

Keywords: kolhan basin, sandstone, petrography, heavy mineral, grain size

EARLY CRETACEOUS MARINE SIGNATURES IN PALAR BASIN AND ITS EQUIVALENTS IN EAST COAST OF INDIA

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Onset of fragmentation of eastern Gondwana land followed by rifting of the Indo-Antartic-Australian continents during late Jurassic (?) and early Cretaceous period envisaged the formation of peri-cratonic basins with half graben geometry in the eastern margin of India. As a result, two major basins viz. Palar basin in the north and Cauvery basin in the southern part of Tamil Nadu have formed.

Occurrence of the Talchir Formation of lower Gondwana group followed by Sriperumbudur and Satyavedu Formations of upper Gondwanas and Cuddalore Formation of Mio-Pliocene age were only reported in the earlier surface geological maps. However, subsequent mapping of the Avadi, Ambattur, Sriperumbudur, Odappai areas have indicated the occurrence of undoubted marine sediments containing agglutinated forams, pelecypod shells etc of early Cretaceous age. These marine sediments were mistaken earlier as the Cuddalore sediments, because of its weathered, lateritic appearance.

A few boreholes drilled up to the Archaean basement in the southern part of the Palar basin by Geological Survey of India, near Kanchipuram and Avadi areas indicated the deposition of a thick pile (> 500m) of marine sediments containing early Cretaceous marine fossils like belemnite, ammonite, mollusc etc. Boreholes data validates the surface expression of marine outcrops within the basin. Marine rocks of Neocomian to Aptian age only are recorded in Palar basin and the marine sedimentation appears to have ceased beyond Aptian.

These marine sediments were named as the AVADI Formation (Kumaraguru, 1994) and given a separate stratigraphic status in view of its large aerial spread and considerable thickness of the strata. Early Cretaceous Marine sediments are also recorded in Cauvery and Krishna-Godavari basins in the east coast of India.

MINERALOGICAL STUDIES OF CRETACEOUS PHOSPHATIC NODULES OF NAMBAKURUCHI BLOCK OF TRICHINOPOLY DISTRICT, TAMIL NADU, INDIA

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The Onshore Cretaceous phosphatic nodules of the Trichinopoly contribute to the study of global geological events and economic minerals deposit in India. The nodules occur in different sizes and shapes as elliptical, cylindrical, globular, conical and irregular, with veins of the calcite, gypsum and celestite. The thin section, X-ray diffraction and Scanning Electron Microscope (SEM) studies show that the CFA is the main constituent of the phosphatic mineral in the nodules and calcite, quartz, feldspar, kaolinite, chlorite, montimorlinite are the minor constituents. The composition of the vein/crack is gypsum; calcite, celestite and minor amount of the montetrisaite. The crystal of the phosphate is brown to grey colour with bryozoan fragments. Thin sections of the nodules indicate that the fine phosphate grains with silt size particles are embedded in fine matrix. Fragments of the foraminifera and others small carbonate particles are in the form of light to dark lamination. Coated grains peloids, and fine detrital grains are in cavities. The shape of the peloids is rounded and structurless which may may be due to fluctuating/ or high energy environments. Micro crack with microbial mat is also common with algal structure. The thin section studies and SEM images of lamination of microbial mat with algal structure, Peloids and coated grains revealed that the phosphatic nodules may have been deposited due to biogenic activities of microorganisms in intertidal environmental conditions.

Keywords: Phosphatic nodules, Cretaceous, Nambakuruchi, Carbonate fluorapatite, Celestite.

SOURCE ROCK CHARACTERIZATION OF DISANG SEDIMENTS IN PARTS OF NAGA HILLS NORTH EAST INDIA

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The Disang Group of rocks lying between Chakhabama and Kekruma area forms parts of Inner Fold Belt of Naga Hills. The Disang Group of rock is divided into Upper Disang Formation and Lower Disang Formation. In both the Lower and Upper Disang Formation, shale is the dominant litho-unit which has thickness of 3000 meters, within which intercalation of thin beds of sandstone siltstone, phyllites and occasional thin beds of oil shale and marlstone are present. The thickness of sandstone beds ranges from few inches to few feet's in the Lower Disang to few meters in Upper Disang. The Upper Disang Sandstone contains chromite fragments within the corrugated parts of feldspar (plagioclase). The chromite grains are detected through SEM-EDX study and EPMA studies of the chromite grain reveals that the grains of chromite are actually chrome spinel. Good amount of volcanic glass were observed in both the Lower Disang sandstone and Upper Disang sandtone. The upper Disang sandstone contain appreciable amount of chrome spinel and illemenite whereas in the lower Disang sandstone chrome spinel were not observed which indicate that during the deposition of Lower Disang sandstone only the upper part of Ophiolite blocks were expose aerially and the ultramafic peridotite of the Ophiolite were expose later during deposition of Upper Disang sandstone, as chrome spinel is a mantle derivative the possibility of its occurrence in other nearby protolith is rule out. The presence of good amount of chert rock fragment, volcanic glass, sedimentary rock fragment and sutured polycrystalline quartz indicate a mixed protolith for both the LDS and UDS. The presence of authegenic pyrite inclusion within tourmaline indicates anoxic condition. The exudation of mica between grain boundary and crude alignments of mica in the Lower Disang sandstone indicate mild metamorphic affect.

TIDAL FACIES CHARACTERISATION OF PALAEOGENE SEDIMENTS OF TIRU VALLEY, MON DISTRICT, NAGALAND.

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Abutting against Brahmputra alluvium and caught between the Naga thrust and the Disang thrust (Belt of Schuppen), there occurs a thrust slice made up of Oligocene Tikak Parbat Formation of Barail Group in Tiru valley which is coal bearing and provides an excellent opportunity to study the rock units in terms of processes. Based on lithology including grain size, sedimentary structures, bed thickness, fossils contents, vertical and lateral relationships,10 lithofacies were identified along exposed vertical profile sections. The various lithofacies consists of fine to very fine sands, medium to fine sands, heterolithic beddings, coaly shale, shales, mudstone and thick coal seams along with associated sedimentary structures such as wavy to ripple laminations, planer and trough cross stratification etc. The presence of bipolar palaeocurrent pattern indicated by the cross-lamination in the thicker sand beds, abundances of mud drapes in the forsets, reactivating surfaces, Heterolithic facies and their association indicate a sub-marine environments deposited under various tidal ranges possibly in a partially enclosed basin (eustrarine).

Keywords: Heterolithic beds, Schuppen belts, mud drapes, Barail group, Nagaland.

THE STUDY OF IRON PRECIPITATION CONDITIONS ON EARTH AND MARS ENVIRONMENT AND ITS IMPLICATIONS IN UNDERSTANDING FORMATION OF HEMATITE SPHERULES ON MERIDIANI PLANUM, MARS

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Iron oxides concretions are present in various terrestrial environments on earth. They carry unique similarities with the Martian hematite spherules present on Meridiani Planum, Mars suggesting similar mode of formation. The Mars Exploration Rover Opportunity has detected Martian hematite spherules widely known as blueberries at Meridiani Planum, Mars. Experiments reported previously are performed to understand the Iron precipitation mechanism forming hematite rich spherules on Earth and Martian environment. Various sulphate and carbonate minerals along with basalt were taken representing Meridiani Planum, Mars host rock for experimental studies. The minerals and the basalt were mixed with Ferrous Ammonium Sulphate (10 gm each) and charcoal (5gm) with 200 ml water in separate vessel. Each of the vessel has carbonate/sulphate/basalt, Ferrous ammonium sulphate, charcoal and water. Eh–pH values, colour and temperature are observed and checked regularly for 6 months. The gypsum and siderite vessels are showing iron precipitation in increasing acidic and oxidizing conditions, whereas calcite and magnesite vessels are showing iron precipitation in increasing alkaline and reducing conditions. Terrestrial Iron oxides concretions are formed from mixing of Iron bearing reducing fluids and oxidizing fluids. It is evident from the field, petrographic and chemical studies of the Iron oxides concretions present in sandstone of biharia, shankargarh, Allahabad, India. Experimental studies confirm that the iron precipitation involves changing oxidation and reducing conditions and variations in alkaline and acidic environment. On combining the results from the experimental studies and terrestrial analog studies of Iron oxides concretions, it is confirmed that the Martian hematite spherules are formed through diagenetic fluid processes with solublity of ferruginous Sulfate compound.

MEGAFOSSILS FROM THE RAJMAHAL BASIN, JHARKHAND, INDIA

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The present investigation deals with the first comprehensive record of the plant megafossils mainly Glossopteris flora from the Barakar Formation of the Rajmahal Open Cast Mine, Rajmahal Area, Rajmahal Basin. The assemblage is well preserved and represented by pteridophytes and gymnosperms. Pteridophytes comprise Equisetalean axes (order Equisetales), whereas, gymnosperms include nine species of Glossopteris namely *Glossopteris communis, G. damudica, G. gigas, G. indica, G. lanceolatus, G. longicaulis, G. oldhamii, G. taenioides, G. tenuifolia and Vertebraria indica* belonging to the order *Glossopteridales* and *Noeggerathiopsis hislopi* of order Cordaitales. The present study adds to the knowledge of the Glossopteris flora of India, especially that of the Rajmahal Basin from where the plant fossil records are sporadic and which is one of the major coal producing area (about 10.5 million ton coal per- annum). The area is a treasure for palaeobotanical studies as evinced by different fossil localities. However, there are fears of fossils disappearing from this area as the state government of Jharkhand has given out a mining lease in the area to private companies. Therefore, it is very necessary to study such coal forming vegetation and their systematic study from the area to generate a new palaeobotanical database, palaeoenvironmental interpretation, basinal correlation and for the understanding of evolutionary perspectives. The floral assemblage compares with those recorded from the Barakar Formation of other Lower Gondwana basins of peninsular India.

Keywords : Glossopteris flora, Barakar Formation, Rajmahal Basin, database, Gondwana.

DIVERSITY AND PALAEOBIOGEOGRAPHIC SIGNIFICANCES OF GONDWANATHERIAN MAMMALS FROM THE LATE CRETACEOUS OF INDIA

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Gondwanatheria is a clade of extinct, highly derived, less diversified non-tribosphenic mammals restricted to the Gondwanan landmasses, whose distinctiveness is marked by the earliest development of hypsodont dentitions among mammals. These mammals have been documented from the rocks ranging in age from Late Cretaceous to Middle Eocene from all Gondwanan continents except Australia and New Zealand. The known fossil record of gondwanatherian mammals from India is poor and restricted to the Maastrichtian epoch only. Till date only three forms: *Bharattherium bonapartei,* Sudamercidae indet. and Gondwanatheria indet. have been described from the four sites associated with the Upper Cretaceous Deccan-volcano sediments exposed at Naskal and Bacharam in Telangana, Kisalpuri in Madhya Pradesh and Gokak in Karnataka. The phylogenetic analysis of the Indian Late Cretaceous gondwanatherian mammal, *Bharattherium*, shows close relationship with the Late Cretaceous Madagascan gondwanatherian Lavanify and to some extent with the South Americam form, Sudamerica. The broad geographic distribution of *sudamericid* mammals in the Maastrichtian of India, together with the inferred sister-group relationship with Madagascan forms, supports the cosmopolitan distribution of the group and further suggests some Late Cretaceous physical connections among the Gondwana landmasses. Alternatively, it can't be ruled out that the ancestral stock of gondwanatherian mammals had a pan-Gondwanan distribution prior to the fragmentation of Gondwana landmass and its presence in India is a result of vicariant event.

COASTAL CLIFFS AND TIDAL NOTCHES OF SOUTH SAURASHTRA, WESTERN INDIA: SIGNIFICANCE IN UNDERSTANDING LATE QUATERNARY LAND-SEA INTERACTIONS

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The south Saruashtra region of Gujarat possesses a unique sedimentary formation – the Miliolite Formation that range in age from about 200ka to 45ka. This limestone constitute an erosional coast facing the Arabian Sea forming coastal cliffs of as high as 25m that in places exhibit tidal notches, shore platforms, surf benches and coastal caves. The tidal notches bear signatures of relative sea level changes along the Saurashtra coast under the influence of both, eustatic and tectonic activities in post-miliolite time i.e. <100ka. We investigated the coast of Diu and Babarkot areas for sedimentary facies, cliff profiles and biological erosion/construction on notches and platforms. Accordingly, in both the areas the Miliolite sequences are constituted by mainly thinly bedded cross-stratified facies, thickly bedded cross-stratified facies and thickly bedded horizontal facies. Numerous joints could be seen in these sequences which are mainly oriented in NE-SW direction having its aperture 0.5 to 20 cm. These facilitate cliff collapse especially, where the cliff orientation becomes parallel to the prominent joint sets. Such cliffs have not preserved any notch on it. Whereas, the notches observed on the coast of Diu are asymmetrical tidal notches that has extended notch floor having extent of 0.4 to 0.8 m and the retreat point at an elevation of 0.4 to 1m as well as vertex of the notches are measured to be 0.8 to 1.36m from the low water line. The notches along the coast of Babarkot are highly exposed and are asymmetrical with overhanging roofs. These notches have depth ranging from 1 to 5 m and vertex 1.5 to 10 m. At places raised platforms are present that has an elevation of 3m from the reference datum and raised notch with depth approximately 1m. Prominent extensive shore platforms are developed along the coast that are also of Miliolite covered with biological encrustation such as growth of marine algae, colonies of barnacles and chitons. Active tidal notches also show a systematic distribution of biota; littorina being at higher level and spray zones, chitons on the floor of the notch and barnacles and vermitides near to the low water line. The studies of cliff profiles and relative elevations from mean sea level manifest two distinct phases of relative sea level change. Looking towards the freshness of the profile and available ages it seems that the land-sea interface has witnessed a tectonic episode younger than 6ka.

SIGNATURES OF LATE QUATERNARY LAND-SEA INTERACTIONS AND LANDFORM DYNAMICS ALONG SOUTHERN KERALA COAST, SW INDIA

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The Kerala coast displays a spectrum of varied geomorphic features that are evolved as a function of Late Quaternary land-sea interaction. The southern Kerala coast, south of Achankovil Shear Zone (ASZ) has been characterised by cliffed coast with entrenched estuarine basins, pocket beaches, promontories, older and younger strand plains, etc., that are evolved as a result of the transgressive-regressive phases to which the coast has been subjected during late Quaternary Period. In spite of having varied geomorphic features, lacuna in comprehending the evolutionary phases of the coastal landform features is the primary impediment that bolstered us to unravel the Late Quaternary land-sea interactions and landform changes of the coast between Valiyazheekal and Vizhinjam. Moreover, the last two centuries are known to have been witnessing many natural as well as human induced environmental perturbations in the area.

The Late Quaternary landform dynamics were reconstructed based on the satellite data while the last century changes were extracted from Digital Shoreline Analysis System (DSAS). The evidences based on geomorphic variations suggest that the present study area hosts two distinct paleo-coastlines – 1) coincides with the eastern boundary of the older strand plains (accreted during Late Pleistocene) and, 2) marks the boundary between older and younger strand plains (accreted during Early – Middle Holocene). A sector-wise analysis reveals that the northern half of the study area is characterised by many coast perpendicular estuarine basins with well-developed Bay Head Deltas in its fluvial end and flood tide islands near the estuarine mouth. On the contrary, the southern half is characterised by pocket beaches and coast parallel backwater bodies developed during the regressive phases of the sea. A high-resolution analysis of the shoreline changes during the period, 1920–2018 reveals that the younger strandlines are vulnerable to severe coastal erosion and shoreline retreat at many places compared to coastal accretion in the area. All these stress the eminent need for continuous monitoring and implementation of mitigation strategies so that a sustainable development and conservation of coastal ecosystem can be achieved.

Keywords: Late Quaternary, Cliff, Land-sea interactions.

ESTUARINE DYNAMICS AND SHOREFACE MORPHOLOGY IN A TROPICAL COAST: IMPLICATIONS FOR ESTUARINE MANAGEMENT (A CASE STUDY FROM THE MULKI ESTUARINE SYSTEM, CENTRAL WEST COAST OF INDIA)

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Abstract Tropical estuarine systems are highly dynamic in response to seasonal variations in wind and wave pattern as well as sediment influx, and create a management problem. In this paper we discuss spatiotemporal variations in the morphodynamic process around a tropical estuary located in the Central west coast of India using the Mluki river system as a case example. The study is based on the multidate satellite images, seasonal variations in river mouth configuration complimented with seasonal shore face variations on either side of the river mouth and sediment characteristics. Multi date image analysis for the period 1965 to 2013 (toposheets and satellite images) shown that the northern spit has grown by 590m towards south and southern spit has shortened by 600m a suggesting sediment displacement towards north and alongshore sediment drift towards south around the river mouth. These changes are accompanied shifting of the river mouth towards south. The combined effect is siltation in the estuary and dredging is going on the maintain the depth. A sediment trap across the river `8km from the mouth is constructed, yet sedimentation in the estuary is going on and dredging is undertaken to maintain the required depth in the estuary. Sediments on the beach, in general are fine to medium grained, moderately to well sorted implying effective winnowing action under moderate energy condition. C-M plot suggest suspension to saltation mode of sediment transport while bi-variant plot suggest dominance of wave derived, and insignificant river input. Our study indicate that sediments deposited a in the estuary and sediment movement around the estuary are derived from the adjacent beach , hence onshore movement of sediments through estuary. The present study indicates that dredging is not a permanent solution hence other means of sediment management is suggested.

Keywords: tropical coast, paired Spits, estuarine dynamics, shore-face morphology, dredging, siltation.

SEDIMENT MOVEMENT AND MORPHODYNAMIC PROCESSES IN THE VICINITY OF A FISHERY PORT (BHATKAL), CENTRAL WEST COAST OF INDIA : IMPLICATIONS FOR SILTATION.

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Bhatkal is a small fishery harbor in central west coast of India bounded by a head land on the north and 1.2 km long beach on the south. Siltation is a major problem in the navigational channel of the port. It was believed that siltation was due to sediment coming from the catchment, hence, to trap the sediments a barrier was constructed. Siltation continued and the barrier also filled up. Later it was realized that northerly alongshore sediment drift is responsible for siltation in the channel, and a groin was constructed at the northern end of the southern side beach, but the groin also filled up and sediment was by passing the groin causing the siltation in the navigational channel. In order to understand the problem of siltation, the present study focused on the sediment transport pattern on either side of the navigational channel based on the seasonal beach profile variations, sedimentological analyses of both beach and channel sands followed by OCM data analyses for different season. Beach profile changes on the north of the head land showed nearly stable to marginally gaining, and beach slope is steep and reflective in nature; southern side beach is growing towards its northern end. Beach sands on the north of the headland are coarse grained, moderately well sorted and show beach characteristics in all the season. Southern side of the beach show net sediment movement northward. Channel sediments show characteristic features of both riverine and beach derived. OCM data suggest shoreward movement of materials during pre-monsoon. Integration of the beach profile data, sediment characteristics, OCM pattern followed by wind and wave set up in the area, it is inferred that siltation in the Channels is due to multiple sources alongshore, off shore and land /reverine source.

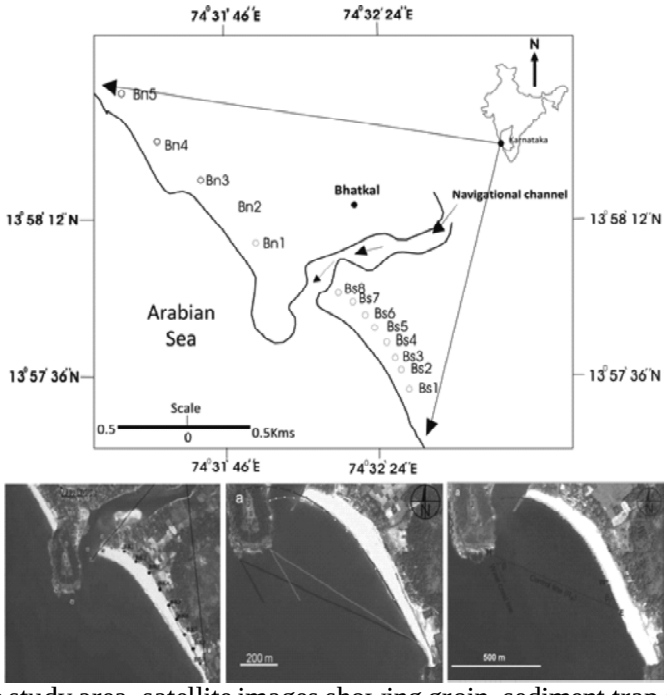

Fig.1 Location of the study area, satellite images showing groin, sediment trap and stable/unstable part of the beach (after Hsu et al., 1989).

ASSESSMENT OF SHORELINE CHANGES OF TROPICAL WEST COAST OF MAHARASHTRA, INDIA, USING GIS AND REMOTE SENSING TECHNIQUES

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Shoreline changes have been monitored for the tropical west coast of Maharashtra through GIS and Remote Sensing for a time period from 1981 to 2013. The overall coastal erosion calculated was 174.92 km (36%); deposition 224.21 km (46%); and there was no change in around 85.97 km (18%) area. The erosion was seen to be more in the northern, and deposition in the southern part of the coastal tract. The middle portion was seen to be stable, due to presence of headlands and promontories. At some places sand spits are growing or receding in response to storm events. The present pattern of coastal landform changes are related to shoreline geometry, wave energy conditions, precipitation, drainage, wind pattern and anthropogenic activity. The study indicate a variable response of the coast to the above governing factors at decadal scale for the current trend of sea level rise in response to kilometer scale changes in coastal bathymetry and geomorphology.

STUDY OF COASTAL GEOMORPHOLOGICAL LANDFORMS USING REMOTE SENSING BETWEEN NAGAVALI AND VAMSADHARA COASTAL STRETCH, SRIKAKULAM, ANDHRA PRADESH.

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Remote sensing visual interpretation techniques help in identifying various coastal and near shore geomorphological features and grouping them into different units. The present study area is a coastal stretch of 33km from Nagavali to Vamsadhara river mouths of Srikakulam district, Andhra Pradesh, East Coast of India. The geographical coordinates of the study area lie between 18^0 12.410' N to 18^0 21.995' N latitude and 830 55.432' E to 84^0 08.730' E longitude. Using LANDSAT images various geomorphological features in the study area such as sand dunes, rock protrusions, estuaries, creeks, bay morphology etc., are identified and grouped in to different units. By using the basic recognition elements of remote sensing the geomorphology of the area is studied. Making use of both the topomaps and satellite images the lithological and structural influence on geomorphology is identified and is cross-checked with the field survey. By studying the influence of geomorphology in the study area the heavy mineral assemblages and their groupings is observed.

GEOCHEMICAL CHARACTERISTICS OFF SURFACE SEDIMENTS FROM THE CONTINENTAL SHELF REGION, LITTORAL ENVIRONMENT ALONG THE SOUTHEAST COAST OF INDIA.

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Geochemistry is a major tool for assessment of the health of the seas, it is a combination of the fields of geology and chemistry. As the oceans use as a sink for anthropogenic pollutants, the marine environmental geochemistry has gained importance in the recent days. In the present study the origin and fate of pollutants in the marine environment along the Northern Tamil Nadu Coast, have been investigated. The geochemical characters of the sediments have been discussed and the spatial and temporal variation is analysed. Heavy metal concentration in sediments which is an indicator of pollution increases with mud and organic matter which acts as a sink. As a result the metal content of the sediments of pre monsoon are lower in Puducherry offshore areas when compared to Cuddalore offshore. In Karaikal – Velankanni offshore sediments all the elements with the exception of Cu register a rise though clay content and organic matter (OM) content are higher in the sediments. The post monsoon sediments shows higher trace metal content due to increase in clay content. Considering the Enrichment factor the sediments are uncontaminated to moderate contaminated excepting in the case of Pb which shows moderate to significant contamination in Puducherry – Cuddalore sector and in Karaikal sector, the enrichment factor indicates that all the sediments are uncontaminated excepting for Pb content based on which the sediments are moderately contaminated. Considering the Contamination factor, the level of pollution is moderate to considerable in Puducherry – Cuddalore offshore sediments and in Karaikal – Velankanni the contamination is moderate and low in Pre monsoon and post Monsoon excepting Cr occurs in considerable contamination range in post monsoon. The I_{geo} values indicate most elements are in moderate to extremely contaminated levels in the sediments collected off Puducherry – Cuddalore coast. In Karaikal – Velankanni coast offshore I_{geo} values indicate that the sediments are moderately to strongly contaminate in pre monsoon and moderately contaminated to extremely contaminate in post monsoon. Thus the trace metal content of the sediments indicates moderate pollution excepting in the case of lead. The characterisation of the sediments and examination of the spatial and temporal variation has shown that the sediments have been modified significantly in different seasons but the spatial distribution pattern remains similar. The conclusions drawn on the environmental health of the marine ecosystem and the modifications due to the hydrodynamic processes of post tsunami are presented. To assess the level of pollution and health of the seas in two regions in the southeast coast of India and to document the impact of both monsoon on the sediment characteristics. The regions selected for study are the Puducherry – Cuddalore coastal area with receives anthropogenic input from urban and industrial centres located on its coast and Karaikal – Velankanni coast which receives the domestic, industrial and agricultural inputs through the Cauvery River.

TAXONOMY OF RECENT BENTHIC OSTRACODA FROM OFF KURUSADAI ISLAND, GULF OF MANNAR, SOUTH EAST COAST OF INDIA

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Eighty one Ostracoda species belonging to fifty four genera have been identified from sixty six bottom sediment samples from the shallow inner shelf region off Kurusadai island, Gulf of Mannar. The samples were collected for the year 2013 during three seasons such as Fair Weather (May 2013), Southwest monsoon (August 2013) and Northeast monsoon (December 2013) seasons. Detailed systematic studies of these Ostracoda are discussed. Among these, eleven species belong to the suborder Platycopa and rest of them belongs to the suborder Podocopa. Seven species are reported for the first time from the east coast of India. Among the seasons, northeast monsoon season recorded the highest population of Ostracoda. The assemblage indicates the mangrove ecosystem.

Keywords: Recent Benthic Ostracoda, Systematics, Shallow inner-shelf, Mangrove ecosystem, off Kurusadai island, and Gulf of Mannar.

STUDY OF FRESHWATER DIATOM ABUNDANCE AND SEDIMENTOLOGY FROM THE RANI-GARBHANGA RESERVE FOREST, ASSAM, INDIA

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This study was conducted for an investigation of fresh water diatom abundance and sand-silt-clay percentage in Rani-Garbhanga Reserve Forest, Assam. Twelve surface samples were collected from Forest, Margin area and Open land areas from two widely separated regions, namely Nalapur and Sukurbaria. The dominant genera of diatom were found to be *Pinnularia, Nitzschia, Eunotia, Stauronies, Nevicula* etc. The results from this study of total diatom count and sand-silt-clay percentage show that the number of diatom is low and sand percentage is maximum with in forest area, whereas in margin area, diatom number is increased and sand percentage is decreased compared to forest area, and in open land area diatom number is maximum and sand percentage is low. The study infers that the diatom abundance and sand-silt-clay percentage varies with the different settings within a forest. This study can be useful to decipher past forest setup from the core collected around the study area.

Keywords: Freshwater diatom, Rani-Garbhanga Forest, Sand percentage, Open land area

DIATOM INDICES AND WATER QUALITY INDEX FOR ASSESSMENT OF ENVIRONMENTAL CONDITIONS IN YERCAUD LAKE, TAMIL NADU, INDIA

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Diatoms play a significant ecological role and are being extensively used as indicators of water pollution as they are natural inhabitants of water. The distribution of diatom species in surface water bodies are mainly governed by the physico-chemical parameters of the water. It is important to understand the role of environmental variable which can affect the growth of diatom, assemblage and distribution. In India, Diatom studies especially on the monitoring of environment are yet to gain momentum. The study area Yercaud Lake is located between longitude 78°12' 28" to 78°12' 40" E and latitude from 11°46' 56" to 11°47' 08" N with an area of 2.11 km^2 . The present work is an attempt, first of its kind in the study area, to record the diatom species, study of diatom indices and water quality index for assessment of environmental conditions in Yercaud lake, Salem district, Tamil Nadu, India. As diatoms provide interpretable indications of specific changes in water quality, diatom indices were tested in this study for its applications.

Macrophytes, Epilithic and Water samples were collected from Yercaud lake in pre- and post-monsoon season for three years during 2011-2013. Fifty two (52) diatom taxa belonging to 23 genera, 18 families, 13 orders, 6 subclasses and 3 classes were recorded for the first time in the study area. The results of the present study show that the pollutants were drained into the lake and create problems to the ecosystem. The pollutants were generated by the settlement and hotels in and around the lake. It leads to high bacterial load, high BOD and deoxygenation of water which affect the affect the biotic life in the lake. The conclusions of the present study provide scope for utilization of diatom species and indices for water quality assessment and management of lake water.

Keywords : Diatom Taxa, Macrophytes, Epilithic, Physico-chemical Parameters, Yercaud lake

GEOCHEMICAL STATUS AND MULTIVARIATE ANALYSIS OF TRACE ELEMENTS IN SEDIMENTS OF THE EMERALD LAKE, TAMILNADU, INDIA

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The scope of the present study is to evaluate the pollution of the trace elements such as Co, Ni, Pb, Cr, Cu, Zn, Mn and Fe from 25 surface sediment samples at different sites of the Emerald Lake with the help of statistical analysis like correlation and principal component analysis. From the result, the ranges of Fe, Cu, Cr, Mn, Zn, Ni, Co and Pb are noticed to be 78,128 to 132,876, 314 to 462, 336 to 523, 520 to 701, 20.1 to 53.21, 128 to 215, 91 to 129.9 and 151 to 158 µg g-1, respectively. The order of the average trace element concentration is Fe>Mn>Cr>Cu>Pb>Zn>Co>Ni. From the correlation result, Cu, Ni, Cr and Pb are found to be considerably correlated as they are usually related to anthropogenic activities, wastewater and sewage. From the Principal Corresponding Analysis (PCA) results retrieved from PC3 suggest that Fe, Mn, Cr, Cu, Pb and Ni have common origin and are mainly due to anthropogenic input, inorganic fertilizers in agriculture, human activities, sewage effluents, traffic and boat activities. The study relatively provides a significant approach for trace element pollution origin in the surface sediment in the Emerald lake.

Keywords: Surface sediments : Trace elements : PCA : Sewage : Emerald Lake

DISTRIBUTION OF DIATOMS AND WATER QUALITY ASSESSMENT OF THE THAMIRABARANI RIVER BETWEEN PAPANASAM TO KOKKIRAKULAM, TIRUNELVELI DISTRICT, TAMILNADU

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Twenty macrophytes sample and were collected from the fresh water locations Thamirabarani river between Papanasam to Kokkirakulam. Thamirabarani River (Porunai) is situated at Tirunelveli, Tamil Nadu, India. A total number of 30 species were recorded . They are following: *Amphora australiens, A. ovalis, Aulacoseria distance, ctenophore pulchella, Cyclotella meneghinian, C. atoms, Cymbella tumida, Gomphonema Truncatum, G. undulatum, G. parvulum, G. affine, Melosira moniliforms, M. varians, Sunedra ulna* etc… The dominance of Pollution tolerant taxa in Sivanthipuram areas of Thamirabarani River diatoms species like *Gomphonema auger, G truncatum and G affine*. The presence of *Synedra ulna* in kallidaikurichi and Thirupudaimarudur areas indicate Pollution may be due to the Anthropogenic events. The dominant presence of *Melosira granulate, Cyclotella atomus, Cymbella tumida* at Mukkudal and Kokkirakulam areas in indicate that less polluted.

Keywords : Diatoms, water quality, Thamirabarani River, Ecology

ECOLOGY AND DISTRIBUTION OF DIATOMS IN THAMIRABARANI RIVER BETWEEN NARANAMMALPURAM AND PUNNAIKAYAL, TAMIL NADU

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Diatom-based indices are increasingly becoming important tools for assessment of environmental conditions in aquatic systems. In the present study an attempt has been made to evaluate the applicability of diatom for water quality assessment in Thamirabarani River, Tamil Nadu. A total of 40 diatom taxa belonging to 16 genera were recorded in the study area. They are as follows:*Amphora holsatica, A.ovalis, Achnanthes brevipes, Aulacoseira distans, A. granulate, Bacillaria paxillifer, Cocconeis pediculus, Ctenophora pulchella, Cyclotella atomus, C. catenata, C. meneghiniana, C stelligera, Cymbella aspera, C. tumida, Diadesmic confervacea, Eunotia curvata, E. fallax, E. pectinalis, Fragilaria intermedia, F. rumpens, Fragilaria rhomboids, Gomphonema affine, G. clavatum, G. augur, G. gracile, G. lanceolatum, G. parvulum, Melosira granulate, M. moniliformis, M. varians, Navicula cryptocephala, N. mutica, Nitzschia obtuse, N. pseudofonticola, Pleurosigma angulatum, Synedra rumpens, S. ulna, Tabellaria ventricosa, Tryblionella levidensis, T. levidensis, and T. hungarica*

The dominant presence of *Melosira varians, Nitzscia obtuse, Tryblionella levidensis* and *Cymbella tumida*. at Karugulam, Srivaikuntdam, and Punnaikayal areas in November 2017 indicate that the Thamirabarani river water is less polluted, this may be due to the monsoon and good flow of water in Thamirabarani River. However, the Adichanallur, Eral and Author like *Ctenophora pulchella* and *Gomphonema parvulum* areas are dominated by the pollution tolerant diatom taxa *Synedra ulna, Gomphonema affine, Cyclotella atomus and Ctenophora pulchella* in March 2018 indicating highly pollution. This may be due to the merge of domestic sewage in the river and less flow water in the river which has contributed for the abundant and dominant diversity of Synedra ulna, Cyclotella atomus and Ctenophora pulchella the pollution tolerant taxa in March 2018.

Keywords : Diatom, Thamirabarani River, Ecology, River health, Water quality

EFFECT OF HEAVY METALS LIKE CADMIUM DEPOSITION ON FRESHWATER ECOSYSTEM

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Heavy metals are generally defined as metals with relatively high densities, atomic weights, or atomic numbers. The criteria used, and whether metalloids are included, vary depending on the author and context. Density criteria range from above 3.5 g/cm3 to above 7 g/cm3. Cadmium is a naturally occurring toxic heavy metal with common exposure in industrial workplaces, plant soils, and from smoking. Due to its low permissible exposure to humans, overexposure may occur even in situations where trace quantities of cadmium are found. Cadmium is used extensively in electroplating, although the nature of the operation does not generally lead to overexposure. Cadmium is also found in some industrial paints and may represent a hazard when sprayed. High concentrations of heavy metals in soil have an adverse effect on micro-organisms and microbial processes. Human uptake of cadmium takes place mainly through food. Foodstuffs that are rich in cadmium can greatly increase the cadmium concentration in human bodies. Examples are liver, mushrooms, shellfish, mussels, cocoa powder and dried seaweed. Cadmium can be transported over great distances when it is absorbed by sludge. This cadmium-rich sludge can pollute surface waters as well as soils. The susceptibility to cadmium can vary greatly between aquatic organisms. Salt-water organisms are known to be more resistant to cadmium poisoning than freshwater organisms. Animals eating or drinking cadmium sometimes get high blood-pressures, liver disease and nerve or brain damage. In India many city has been affected by the cadmium deposition. Day by day heavy metals are creating lot of problems for both the human society and freshwater ecosystem. Cadmium is first transported to the liver through the blood. There, it is bond to proteins to form complexes that are transported to the kidneys. Cadmium accumulates in kidneys, where it damages filtering mechanisms. Cadmium is responsible for the diseases like diarrhea, stomach pains and severe vomiting, bone fracture, reproductive failure and possibly even infertility, damage to the central nervous system, damage to the immune system etc. so here we have discussed about the cadmium depositions of our country as well as the world, its applications, its effect on the human resources and freshwater ecosystem, how fought with the problems regarding cadmium deposition etc.

Keywords: heavy metal, freshwater ecosystem, cadmium, micro organisms, microbial processes.

ENVIRONMENTAL ISSUES IN THE SEMI-ARID RIVERS: SIMULATION OF FLOOD DUE TO PROSOPIS JULIFLORA INVASION

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River is defined as a natural stream of water of fairly large size flowing in a definite course or series of diverging and converging channels. The functions of the river are to carry water from the basin to the ocean. Through this process it recharges the ground water, washes away the unwanted nutrients, sediment transportation, mineral deposition, accumulation of water in storage structures, etc. Climate change alters the functions of rivers by shifting the rainfall patterns due to the warming climate. Mainly the environmental flow of the semi-arid region rivers is affected by climate change followed by the issues such as erratic rainfall which leads to consecutive floods and droughts, improper maintenance of the river system, absence of river banks, etc. Ecosystem is also getting affected by means of climate change. The native species are facing extinction whereas the

invasive species starts to intrude the surroundings. Thus, every river has issues, but not likely. So, the issues need to be identified clearly for proposing mitigation techniques. The main objective of this study is to do Rapid Rural Appraisal (RRA) to find the linkages between the issues in the functions of the river. During the filed study many issues like occupancy of *Prosopis Juliflora* (*P. Juliflora*), sand mining, detachment of streams, improper maintenance, etc was identified through which the river has lost many functions. Among all the issues *P. Juliflora* has been founded as one of the basic issue which occupies the bed of the river. *Prosopis Juliflora* is one of the most economically and ecologically crucial tree species in arid and semi-arid zones of the world. (Pasiecznik, N.M, et al., 2001). It creates many hydrological impacts like modified flow regime, altered species composition, modified channel form, increased bank erosion, loss of species habitat, modified nutrient content, decrease in the velocity of flow, changes in river geometry which totally leads to the collapse of river system. So, an attempt is made to do flood modelling using HEC RAS for finding the flow of water with and without the presence of *P. Juliflora*. Flood year was found for modelling flood by doing rainfall analysis for the period 1980-2017. The flood year 2005 was taken for flood modelling. The result validated that occupation of *P. Juliflora* in the river bed affects the flow which creates flood inundation and the impacts were assessed. Therefore, methods for removal of *P. Juliflora* are suggested. Also, policy options for removal and maintenance of *P. Juliflora* along the river stretch is recommended.

Keywords: Rapid Rural Appraisal, *P. Juliflora*, Policy options, Restoration.

MARINE POLLUTION AND CORAL REEFS

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Marine pollution occurs when harmful, or potentially harmful, effects result from the entry into the ocean of chemicals, particles, industrial, agricultural, and residential waste, noise, or the spread of invasive organisms. Eighty percent of marine pollution comes from land. Air pollution is also a contributing factor by carrying off pesticides or dirt into the ocean. Land and air pollution have proven to be harmful to marine life and its habitats. There are many ways which are responsible for the pollution of marine environment such as direct discharge, land runoff, ship pollution, atmospheric pollution; deep sea mining etc. This marine pollution has a huge impact on the coral reefs. Coral reefs are diverse underwater ecosystems held together by calcium carbonate structures secreted by corals. Coral reefs are built by colonies of tiny animals found in marine water that contain few nutrients. Coral reefs are dying around the world. In particular, coral mining, agricultural and urban runoff, pollution (organic and inorganic), overfishing, blast fishing, disease, and the digging of canals and access into islands and bays are localized threats to coral ecosystems. Broader threats are sea temperature rise, sea level rise and pH changes from ocean acidification, all associated with greenhouse gas emissions. A study in 2014 lists factors such as population explosion along the coast lines, overfishing, the pollution of coastal areas, global warming and invasive species among the main reasons that have put reefs in danger of extinction. Coral reefs are exposed to many anthropogenic stresses increasing in impact and range both on local and regional scales. On a global scale there is a marked and alarmingly accelerated deterioration in the status of coral reefs. This has led to concentrated efforts at national and international scales to evaluate the extent of the phenomenon, and to find the means and measures to mitigate the results and possibly to reverse the trend. This paper will give a brief description about the marine pollution across the world, its impact, reasons behind the red alert on the coral reefs and how the relation between marine pollution and coral reefs.

Keywords: Marine pollution, coral reefs, anthropogenic stresses, underwater ecosystem.

SOME GEOPHYSICAL AND HEALTH PHYSICS ASPECTS OF MINERAL SPRINGS IN SOUTHERN KERALA

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Study of mineral springs finds applications in the areas of Geophysics, Hydrology and Health Physics. High dissolved Radon (Rn-222) content in ground water in general and mineral springs in particular may be a matter of concern in areas like southern Kerala with rich radioactive heavy mineral deposits. In this paper we will report measured values of Rn-222 in selected mineral springs in Trivandrum district which are located in areas such as Trivandrum city, Varkala and Neyyattinkara. Indiscriminate use of mineral spring waters due to its assumed medicinal properties is observed in international tourist destination such as Varkala. The association of mineral springs with tectonic (seismic) and volcanic activity is of scientific interest to geologists. Ground water surveys has reported more than 200 mineral springs in Trivandrum and Kollam districts which includes areas with high background natural radioactivity. The geological origin of mineral springs in Southern Kerala will be also discussed.

DIATOM-BASED WATER QUALITY MONITORING IN INDIA: PERSPECTIVE

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Surface water quality has been indiscriminately polluted by anthropogenic activities. The impact on environment includes changes in environment conditions of surface water bodies, biodiversity loss and health hazards. The survey of water quality data shows that the water quality of rivers and lakes changed over time and most systems remain polluted while many others have been retrieved/ improved by countries viz. Australia, Canada, Europe and U.S.

The improvement of water quality in parts of the world has become a reality through River health programs, passionate researchers contributing to the ever-increasing knowledge and verification of ecological and taxonomic data on Diatoms besides the efforts of the governments in constructions of sewage treatment plants and to educate the public about water quality.

Diatoms can be found in almost all aquatic habitats and are used for comparison ecosystems. According to Stevenson et al., (2004), two fundamental questions need to be answered in almost all ecological assessments: 1. “Is there a problem?” and “What is causing the problem?” The answers for these questions are important while attempting to use Diatoms as tool in solving the problems.

In recent years, Diatoms are widely used as a tool because of their importance in ecosystems, sensitively to many physical, chemical, and biological changes, their fundamental role in food webs, their utility as indicators of environmental conditions and their ease of use. Thus, the study of diatoms has become an important element of monitoring and assessment programs in countries around the world.

This paper discuss about role of Diatom studies in assessment and monitoring ecosystems in India.

SURFACE OCEAN CIRCULATION AND CLIMATE CHANGE: EFFECTS OF PALEO AND ANTHROPOGENIC EVENTS

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Oceans have played a major role in driving climate changes through geological past and continue to affect the Earth's climate in modern times. The present day debate on "Climate Change" is incomplete if we do not understand properly the role of oceans. Ocean water has large specific heat and thus has a vast storage of heat energy. Through their massive transport system in the form of ocean currents, the oceans transfer vast amounts of heat from tropics to pole and from surface to deep Ocean. A number of climatic phenomena are directly linked to the ocean circulation and ocean- climate interaction. For example

1. El Nino and La Nina linked to Humboldt Current (Ocean) in Eastern Pacific- weakening of trade winds (Atmosphere)
2. Moderate climate of Europe and North America- Linked to Transport of heat through Gulf Stream and Thermohaline circulation
3. Asian Monsoon- linked to Land- Sea temperature contrast and transport of moisture from ocean- leads to high productivity in Arabian Sea
4. Walker circulation in the Pacific Ocean- linked to obstruction of South Equatorial Current at Indonesian Seaway
5. Permanent ice cap on Antarctica- linked to development of Antarctic Circum Polar Current
6. Thick ice caps on Green Land and ice land- linked to intensification of the Gulf stream

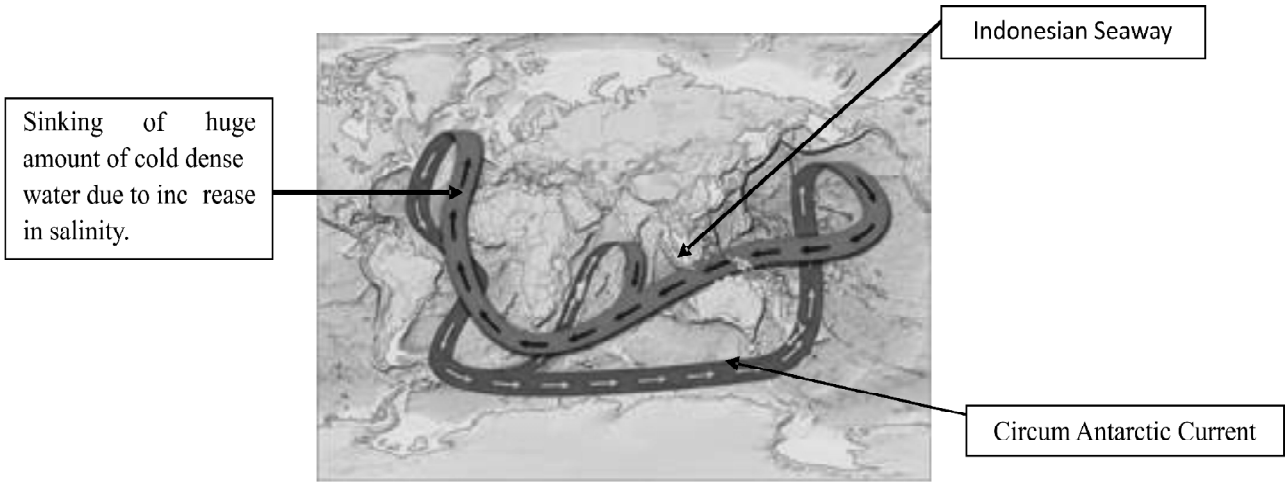

Figure: 1. Great Oceanic conveyor belt showing connectivity of all the major oceans of the world. The cold water sinks in the North Atlantic and travels southward joining with sinking Antarctic bottom waters. All these upwell in the Pacific and return through Indonesian seaway and Agulhas leakage back to Atlantic via Gulf Stream. (taken from: www.nature.com/.../full/news.2010.461.html)

The study of modern and past ocean circulation gives us answers to **many intriguing questions** like

1. When and why did the Antarctic ice cap developed?
2. When and why did the Northern Hemisphere Ice sheet developed?
3. Why did the Northern Ice Sheet form later than Antarctic Ice sheet?

4. How did the large scale movement of continents and changing ocean- continent geometry affect climate?
5. Why has the Earth undergone a series of Glacial- Interglacial stages?
6. How can the past climate be inferred from Ocean Archives?
7. How did the formation of mountains like Himalaya cause climate changes in the world?
8. How is it possible that deepest part of the sea has oxygen and life?
9. How the present climate change will affect the biota?

The present "fear" of so called "Global Warming" due to Anthropogenic activities is also linked to a possible abrupt change in oceans thermohaline circulation. Geological archives have shown that such a change occurred 12000 years back known as "Younger Dryas" when there was a shut down in the Thermohaline circulation leading to an Ice age in North America and Europe. Such a scenario is predicted if seas surface temperatures continue to rise in case of a "possible Global Warming". Much of the debate about an abrupt climate change and the parts of the world most affected can be understood through ocean circulation. The microorganisms living in the sea when preserved a fossil provide us clues to climate change in the past and predictability in future. The role of developed vs developing nation can also be addressed through a proper understanding of the ocean circulation. Large numbers of researchers from all over the world are joining this field and for many countries the funding on ocean studies is only next to space programme.

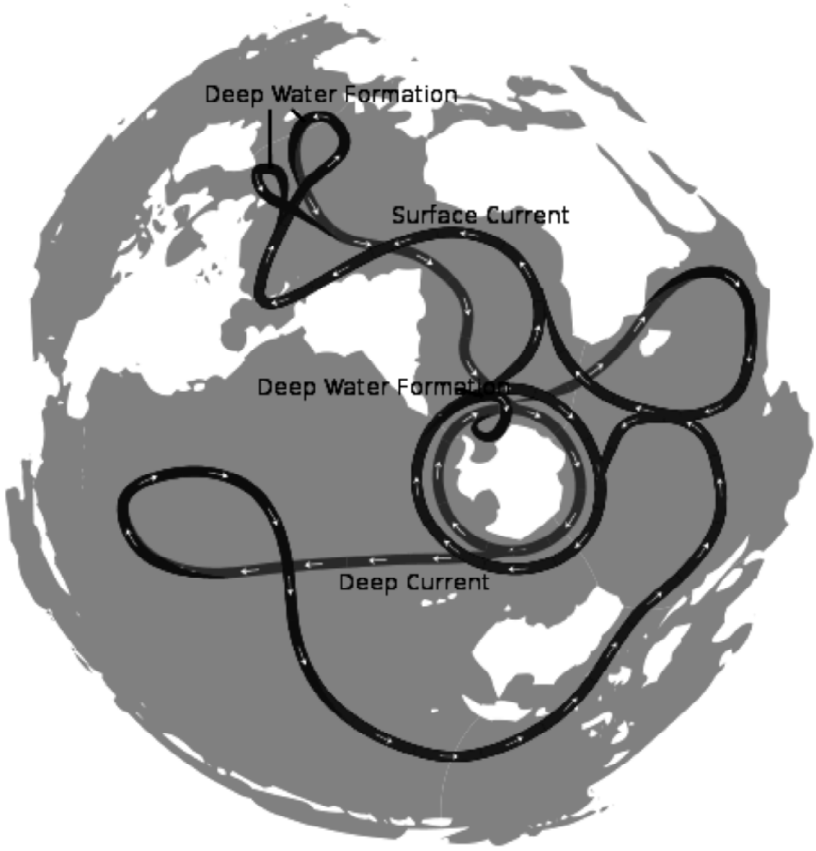

Figure : 2. Thermal isolation of Antarctica due to establishment of circum polar current (Circum Antarctic Current) (taken fromhttp://joannenova.com.au/2010/06/the-deep-oceans-drive-the-atmosphere/)

RECORD OF PERMIAN TETHYAN TRANSGRESSION IN SIKKIM-DARJEELING HIMALAYA WITH SPECIAL REFERENCE TO THE PALEOCLIMATIC EVENT.

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Signature of Permian Tethyan transgression in the peninsular Gondwana basin of India is well recorded and documented in the form of sedimentary facies. An upper Paleozoic rock of Gondwana Sikkim-Darjeeling Himalaya also records the marine transgressive event, which is one of the remarkable phenomena in the Gondwana history. The Lower Gondwana sediments were deposited during the early Permian marine transgression in different parts of the NW and NE Lesser Himalaya. The signature of the Permo-Carboniferous Permian global cryospheric event is well preserved in the Tatapani area and lower Namchi of the Rangit window in south Sikkim Lesser Himalaya. The present study deciphers the documentation of transgressive event which is well preserved in the stratigraphic unit of Rangit Gondwana Basin of Sikkim-Darjeeling Himalaya. Alternating beds of gravel-pebble, Sandstone, shale and mudstone facies indicate the transgressive phenomenon. In some sections, the clasts of chert and stromatolitic dolomite belonging to the Buxa Dolomite are also observed. We have recorded many large size stromatolitic boulders embedded in the consolidated diamictite beds which infer the glaciomarine influence. Clay mineralogy of mudstone facies has been investigated to understand the paleoclimatic condition. The collected samples of mudstone were investigated by X-ray diffraction analysis. The presence of Illite and Kaolinite suggest their source of derivation from crystalline rocks containing feldspar and mica. We also developed the paleo-depositional environmental model of marine transgressive and lithofacies of lower Gondwana sedimentation in the Rangit basin and correlated this event with global sea level change in order to demonstrate the Paleoclimatic conditions which have global significance.

Keyword: Tethyan Transgression, Paleoclimate, Rangit Gondwana Basin

EFFECTS OF CLIMATE CHANGE AND OTHER GEOLOGICAL EVENTS ON THE EVOLUTION OF PALAEOBIOGEOGRAPHIC DISTRIBUTION PATTERN OF PALEOGENE BIVALVES

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Palaeobiogeographic provinces based on global distribution of bivalves for the three Paleogene epochs have been erected using cluster analysis and palaeo-position of the geographic areas. Generic similarity between each of the provinces has been calculated. Parsimony analysis based on presence-absence of genera in the provinces has also been done. Latitudinal distribution and modification in it with the passage of time have been analyzed for each of the genera. Extinction and new appearance of genera in the two intervening epoch boundaries have also been calculated. These have been utilized in deciphering evolution of these provinces and surmising possible routes of dispersal of the Paleogene bivalves. The major observations made from these exercises are as follows.

The northern hemisphere, especially different basins of Europe and Gulf Coastal Plain, USA, record most diverse generic composition. These areas offered most extensive shallow benthic habitat. A large degree of similarity has been observed between provinces in the east and the west coast of the Atlantic Ocean through the Paleogene implying presence of trans-Atlantic current system. The relict Tethys Sea lying between Europe

and Africa played pivotal role in communication between these western provinces and the Western Indian Province to the east. All these tropical to sub-tropical provinces including those to the west of the Atlantic Ocean largely share their genera indicating persistence of the Tethyan legacy of the Mesozoic.

Provinces lying in relatively higher latitudes of the northern hemisphere share large number of common genera. The most plausible dispersal route for these northern higher latitude provinces was through the Bering Sea. Their affinity with Tethyan provinces was also significant implying more equitable distribution of temperature due to global warming. The connection with Tethyan provinces was through the shallow sea route between the North and the South Americas, which was severed much later with the establishment of Isthmus of Panama. The Austro-New Zealand Province and the Antarctic Province appear to host unique faunas in the Eocene whereas they share affinity among them and with Argentina in the Paleocene. The Antarctic circumpolar current has already appeared in the Eocene that acted as a barrier to north-south dispersal.

Modifications in the latitudinal distribution of bivalve genera through the Paleocene-Eocene and the Eocene-Oligocene boundaries reflect a tendency of migration to higher latitudes in the former whereas to the lower latitudes in the latter. These are responses of the fauna to the increase and decrease of temperature across these boundaries respectively. The Paleocene Eocene Thermal Maximum and early Eocene hyperthermal events essentially extended the tropical zone by lowering latitudinal thermal gradient. This necessitated and allowed migration of tropical biota to higher latitudes. This tendency was reversed with the global cooling and formation of cryosphere in the poles during the Oligocene. The Eocene also exhibited much higher biodiversity than the Paleocene. This is in response to global transgression in the early Eocene that inundated many low-lying continental areas, thereby encouraging diversification.

CARBON CAPTURE AND LONG-TERM STORAGE IN BASALT OF THE DECCAN VOLCANIC PROVINCE: A POSSIBLE DEVICE TO CONTROL CLIMATE CHANGE

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CO_2 is one of the most important greenhouse gases accountable for global warming of the atmosphere and the Earth's surface temperature variation. Atmospheric CO_2 concentration increased with time and attained anomalous values. To reduce atmospheric CO_2 concentration, CO_2 immobilization in Deccan basalt was attempted for a longer geological period. Present study is focussed on the Deccan basalt-water-CO_2 interaction thermodynamic modelling and experimental validation under hydrothermal-like conditions. Obtained results show negative entropy (ΔS) and enthalpy (ΔfH) suggest feasibility of plagioclase, pyroxene and magnetite dissolution. Obtained negative Gibb's free energy (ΔfG), ΔfH and ΔS values for calcite, dolomite and magnesite indicate spontaneous reaction. Positive ΔfG, and negative ΔfH and ΔS values for siderite suggest non-spontaneous and opposing reactions. Calcite is the first carbonate mineral to form, but, at a faster rate. XRD reflections revealed formation of calcite, aragonite, ankerite, huntite and siderite. SEM images show stepped growth of calcite crystal. Cubic chabazite formed along with the chlorite, smectite, chlorite and smectite/chlorite mixed-layer clays. Formation of carbonates predominated over the secondary silicates when experiments run for a shorter period (up to 80 h), but, with the increase in the reaction time (up to 1000 h), the carbonates no longer persisted in the system as they were replaced by silicates and chabazite. Chemical composition of experimentally derived smectite data plots clustered close to naturally formed bole horizon smectite of the Deccan, suggest compositional commonality between experimentally and naturally derived smectites. Rietveld refinement (RR) results also indicate weakening of Ca-O and C-O bond, led to calcite degeneration after 80 hours of experiments;

therefore, no calcite persisted in the system. In long term experiments (~ 1000 h), carbonate formation rate gradually decreases due to the formation of smectite adjacent to basalt grains, causal to surface coating, thus, clogg the pore spaces and slows down carbonation reaction rate. Thus, basalt treated for shorter time period at low temperature and pCO_2 conditions is more conducive for carbonate formation.

PALEOCLIMATIC AND PALEOCEANOGRAPHIC VARIATION IN THE SULU SEA SINCE LGM: PLANKTIC FORAMINIFERAL ABUNDANCE AND STABLE ISOTOPIC RECORDS

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The Sulu Sea (SS), located in the Indo-Pacific Warm Pool (IPWP) region, is a shallow marginal and poorly ventilated sea surrounded by landmasses and a number of small islands. SS is connected to the South China Sea (SCS) by the Mindoro and Balabac Strait from the West; to the Western Pacific Warm Pool (WPWP) by Surigao Strait from the East, and to the Celebes Sea by Sibutu passage from the South. Changes in the WPWP cause variations in the hydrography of the SCS which also affects the SS and thus past record of various proxies from core obtained from SS reflects changes in WPWP, SCS and SS. The studied core ODP Hole 769B is located in the SS and we have studied past variation in relative abundance of planktic foraminiferal species as indicator of variations in paleoclimatic and paleoceanographic conditions. Planktic foraminifera are pelagic passive dwellers, latitudinally provincialized and their global distribution through passive transport by ocean currents makes them a wonderful indicator of past shifting of oceanic fronts and relative dominance of warm/cool ocean currents. The variability in the planktic foraminiferal census data from the core examined gives evidences for changing monsoonal patterns and oceanographic conditions since last glacial maximum (LGM). Planktic foraminiferal species like *Gg. bulloides* (upwelling indicator), Gs. ruber (mixed layer dwelling oligotrophic species), and *N. dutertrei* (thermocline dweller and productivity indicator) show significant down core fluctuations in their relative abundances. On the basis of relative variation in the water mass sensitive planktic foraminiferal species' abundance a number of intervals of enhanced productivity has been observed, that envisages intensified East Asian monsoon. It was also noticed that the changing monsoonal patterns, in conjunction with the sea level changes have remarkable effect on the nutrient conditions in the Sulu Sea.

PALYNOFLORISTIC AND PALAEOCLIMATIC INVESTIGATIONS OF LOWER GONDWANA SEDIMENTS FROM WEST BOKARO COALFIELD, JHARKHAND, INDIA.

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The Present palynofloristic and palaeoclimatic investigationdeals with the study of Lower Gondwana sediments of the Pundi area of West Bokaro Coalfield, Damodar basin, Jharkhand, India. The Coal bearing sediments recovered from the sub surface samples (borehole TEPE-19) has been characterized with two distinct palynoassemblagei.ePalynoassemblage I and Palynoassemblage II. Palynoasseblage I (540.6 to 92.1m) is dominated by the abundance of non - striate bisaccate genera represented by Schueringipollenites and sub dominance of striate bisaccate Striatopodocarpites and Faunipollenites whereas Palynoassemblage II (41.13m)

is characterized by the predominance of Faunipollenites and Striatopodocarpites and sub dominance of non-striate bisaccateSchueringipollenites along with the good percentage of pteridophytic spores. The two palynoassemblages have been compared with the known lithostratigraphic zones of the other basin and suggested that the recovered palynoassemblages shown is equivalent to Lower Barakar and Upper Barakarpalynoflora andArtinskian and Kungurian age has been assigned for Palynoassemblage I and Palynoassemblage II respectively. The pre-eminence of glossopterids along with the contributory presence of cordaites, conifer, and pteridophytic spores represent a peat swamp forming vegetation in a telmatic environment with periods of standing water.

Keywords : Plynofloristic, Palaeoclimatic, Lower Gondwana, Damodar Basin, West Bokaro Coalfield, Barakar Formation, Artinskian, Kungurian , Telmatic.

QUATERNARY FLUCTUATIONS IN AGULHAS LEAKAGE AND SURFACE WATER HYDROGRAPHY OF SOUTHERN OCEAN

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The relative abundance of planktonic foraminifera is analysed from Site 1088B to understand the extent of Agulhas influence during the Quaternary period. The Site is located on the Agulhas ridge, places itself in the vicinity of modern Sub Tropical Front (STF). The region is bathed in transitional waters and the surface to thermocline waters are dominated by *Globigerina bulloides* and *Globorotalia inflata* during the Quaternary period. The glacial intervals are marked by huge increase in Sub-Polar species *Neogloboquadrina pachyderma* (s). We noticed that rare occurrences of tropical – subtropical Agulhas leakage fauna (*Globigerinoides ruber* (%) including *Globigerinoides sacculifer* (%) at periodic intervals during the past 1.6 Ma. This leakage fauna have been used to detect the presence of Indian Ocean warm waters by Agulhas input towards the Southern Ocean. The study indicates high variability in water exchange throughout the Quaternary in the study area with enhanced Agulhas leakage during interglacial (MIS7,9,11,19) and largely reduced during glacial periods. The southward shift of STF during the interglacial is the key for increased leakage to South Atlantic sector. Meanwhile the glacial periods are marked by northward positioning of STF and strong South Atlantic Current (SAC) which restrict the Agulhas leakage causing retroflection eastwards to the Indian Ocean. This study show evidences of Agulhas leakage extending as far as 41°S during MIS 7, 9,11, and 19 thus influencing the surface water hydrography of this region.

Keywords: Agulhas leakage, Southern Ocean, Sub Tropical Front, Agulhas leakage fauna.

A REVIEW ON THE MONSOONAL CHANGES INFERRED FROM THE LATE QUATERNARY SEDIMENT RECORDS FROM THE ANDAMAN SEA

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The Andaman basin is a semi-enclosed basin in the northern Indian Ocean, and its sediment type and distribution are controlled by the tectonics and physico-chemical properties of ocean water, which influence the carbonate deposit. Palaeoclimatic and palaeoceanographic studies are numerous from the Indian Ocean, but

the majority of the studies are confined to the Arabian Sea and only a few notable past records are available from the Andaman Sea. A review of the monsoonal changes inferred from the isotopic, elemental and foraminiferal proxies from the Andaman Sea has been carried out. A short core collected from the northern Andaman Sea also studied for planktonic foraminifera abundances and impact of fresh dilution on assemblages. The huge amount of freshwater outflow during monsoon season has to dilute the salinity structure as well as creating a well-defined stratification. The major rivers in India and Bangladesh are the main contributors of freshwater and sedimentation in the Andaman Sea. River run off and fresh water dilution plays a critical role in process of summer monsoon intensification in the Andaman Sea. Several studies have been conducted and inferred that relative to modern, enhanced monsoon precipitation and runoff during early Holocene caused freshening in the Andaman Sea. The majority of the studies concentrated on oxygen isotope analyses on planktonic foraminifera shells. Whereas only few attempts based on planktonic foraminifera species that track salinity changes. Large temporal variations in the distribution of planktonic foraminifera assemblages were reported in the northern part of the Andaman Sea driven by the freshwater influx. Overall, the results document last glacial-Holocene millennial scale monsoonal climate changes and associated water column stratification and productivity fluctuations. All the records from the Andaman Sea attribute that monsoon variability in the late Quaternary has been controlled by either variation in solar insolation, Atlantic teleconnection or shifting feedback associated with summer-winter monsoon interaction.

Keywords: Andaman Sea, Foraminifera, Palaoclimate, Oxygen isotope, Stratification

IMPRINTS OF HOLOCENE CLIMATE INSTABILITY ON INDIAN SUMMER MONSOON – AN OVERVIEW

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Global Holocene paleoclimate records show major abrupt climatic events which had remarkable imprints on Indian Summer Monsoon (ISM) intensities leading to spells of severe drought and heavy rainfall periods. The ISM rainfall plays a pivotal role in the socio-economy of the Indian subcontinent which invigorates the imminent need to comprehend the past ISM intensity and variability of the regions in the monsoon domain. ISM rainfall over the Indian subcontinent takes place mainly through the Arabian Sea Branch or Bay of Bengal branch or even both. The recently identified anomalous pattern of ISM rainfall has been associated with various climatic variables like ENSO, NAO, IOD etc., and thus strengthening of ISM linkage with climate variables needs to be achieved for betterment of the existing climate prediction models.

The present study provides a synoptic assessment of globally established major climatic episodes and their attributes on ISM variabilities. The evaluation of the continental and marine records from Indian subcontinent and nearby regions revealed that the globally established dry events of 8.2 ka, 4.2 ka and Little Ice age (LIA: 500–150 yr BP) of the Holocene period has been recognised as ISM weakening periods. Most of the marine records from Northern Indian Ocean has demonstrated the 8.2 ka and 4.2 ka dry events (ISM weakening periods); at the same time, the continental records have showed only limited occurrence of the 8.2 ka dry event. The consistent occurrence of 4.2 ka global cooling event as a weak ISM period over Indian subcontinent in both marine and continental records is possibly attributed to the solar forcing. The inhomogeneity in the climatic condition recognised in case of LIA with wet conditions in Central and Northern India, and dry climate in the Peninsular counterparts has been related to winter precipitation caused by southward migration of Intertropical Convergence Zone (ITCZ). Additionally, the source of moisture plausibly another aspect for the inhomogeneity in LIA rainfall between north-central India and peninsular India as the central and northern India gets ISM

precipitation from both Arabian Sea and Bay of Bengal branches. Thus, asynchronous strength of rainfall could have been resulted in the weakening of Arabian sea branch compared to the Bay of Bengal branch causing inhomogeneity in rainfall during LIA.

To conclude, the present review reinforces the need to address the ISM rainfall pattern by studying each of the ISM rainfall pathways (Arabian Sea Branch and Bay of Bengal branch) separately using various natural archives which we believe could provide a comprehensive understanding of the behaviour, intensity and progress of the ISM rainfall in the Indian subcontinent.

LAST GLACIAL MAXIMUM TO HOLOCENE ABUNDANCE PATTERN OF *UVIGERINA* SPP. IN THE EASTERN ARABIAN SEA –IMPLICATION TO PALEOPRODUCTIVITY.

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The abundance of *Uvigerina* - a benthic infaunal foraminifera species have been quantified in two radio carbon dated sediment cores from Eastern Arabian sea. The last around 35 to 5 kyr abundance record of *Uvigerina* spp. shows higher abundance during Last Glacial Maximum when compare to Holocene. The abundance of the benthic species is significantly higher between 35 and 21 ka. The decreasing trend is seen from 19 to 14 ka. Whereas, the period between 13 and 5 ka records the lowest abundance. These temporal patterns are closely comparable to the climate events viz., LGM, Deglacial Transition and the Holocene respectively. We suggest that the abundance variation observed in the two sediment core is an indicative of paleoproductivity, as the *Uvigerina* Spp. feed on the organic matter in the sediments. The higher abundance of *Uvigerina* spp during LGM suggests that the EAS has witnessed significantly increased productivity as compared to Holocene. The enhanced productivity during LGM probably due to an increase in deep nutrient injection into the mixed layer resulting from intensified and prolonged winter monsoons.

MONSOON-INFLUENCED VARIATIONS IN PRODUCTIVITY DURING THE PLEISTOCENE FROM OMAN MARGIN, ARABIAN SEA BASED ON PLANKTONIC FORAMINIFERA

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The Indian Monsoon system influences large parts of the world's population. The differential heating between the Asian continent and Indian Ocean produces a pressure gradient which leads to the summer and winter monsoons during June-September and November-January respectively. The primary productivity of Arabian Sea is induced by the upwelling and convective overturning during the summer and winter monsoons. A sediment core from NW Arabian Sea (Hole 723B, Oman Margin) is taken for the present study to understand the variation in the Indian Summer Monsoon. This study is reconstructing the Pleistocene variability of summer and winter monsoon with planktonic foraminiferal abundance. The decreased abundance of *Globigerina bulloides, Globigerinita glutinata* and *Globigerinoides sacculifer* during ~ 2.2Ma to 1.9Ma indicates that weak summer monsoon due to the Northern hemisphere glaciation (NGH). During mid-Pleistocene Transition (MPT, ~1.2Ma to 0.7Ma), the species *G. bulloides,, G. glutinata*, *G. sacculifer* and *Neogloboquadrina dutertei* shows less abundance in the first phase of MPT (~1.2 Ma to 0.9Ma) and increasing towards the end of the MPT (~0.9Ma

to 0.7Ma), the high primary productivity was probably related to the onset of an intensive meridional overturning circulation in the Atlantic Ocean at the end of the Mid-Pleistocene transition. During the interglacial period (MIS9 and MIS13) the abundance of *G. bulloides*, *G.* and *glutinata* are relatively high, indicates intense upwelling due to the strong summer monsoon causes the surface productivity and, hence, by the occurrence of an exceptionally strong summer monsoon event during MIS 13. The glacial periods (MIS10 and MIS8) are characterized by the higher abundance of *N. dutertrei* and lesser abundance of *G.bulloides* is responsible increased winter monsoon. The upwelling indices G. bulloides is high in early Holocene it indicates the intensification of summer monsoon and its relation to the North Atlantic warm period.

Keywords: *G. bulloides*, Pleistocene, MPT, Oman Margin and Arabian Sea

A REVIEW ON PALEOCEANOGRAPHY OF THE EASTERN INDIAN OCEAN BY GEOCHEMICAL PROXIES

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The Bay of Bengal and the Andaman Sea are the core convective areas of the Indian Ocean monsoon in the eastern Indian Ocean and the sediments of these seas host a potential record of past climate and oceanography. The sediments accumulated in these seas are derived from Himalayan and Burman ranges through major rivers and ideal for studying late Quaternary climate. The distributions of major, trace and REE elements in these sediments should potentially provide forensic tools for determining provenance, paleoclimate, hydrothermal input etc. It is very essential to know the various processes and conditions in ocean for knowing and predicting the climatic condition. A review of the sediment geochemistry of eastern Indian Ocean has been studied. There are large number of studies on the geochemistry of surface sediments whereas limited studies on core samples. The results of the geochemistry of surface sediments are giving inferences on recent conditions as well as basis for interpreting the temporal records. The majority of the studies attempted are major, trace and REE element geochemistry and important findings has been reported. There are very few studies on geochemistry of authigenic fraction of the marine sediments. Overall, comparing with the Arabian Sea, the quantum of work carried out in the Bay of Bengal are less and very limited studies in the Andaman Sea. All these studies are very helpful to find the provenance of the sediments, erosional and climate history of the adjoining land masses, pollution status, hydrothermal and hydrogenous processes. Most of the geochemical studies were carried out for In this regard Sr/Nd isotope study is relevant to know the provenance of the sediments. In this paper we have discussed various studies on major, trace and rare earth element studies of the Bay of Bengal and the Andaman Sea including hydrothermal input along the Andaman back-arc spreading center as well as lacunas and future prospects.

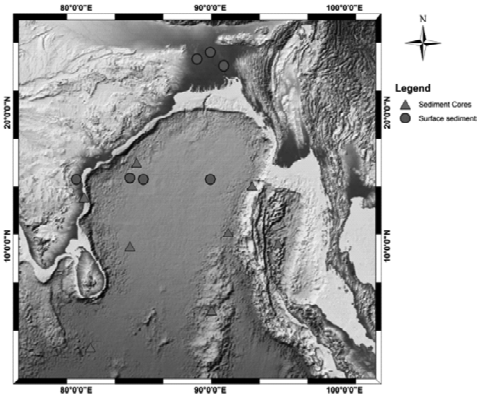

Fig : Showing the locations of surface samples (single circle denotes the area in which number of samples taken) and sediment cores of some important studies.

Keywords: Bay of Bengal, Andaman Sea, Geochemistry, Paleoceanography, Provenance, Hydrothermal input.

CONNECTION BETWEEN CLIMATE AND TECTONICS: IMPLICATION TO KOLHAN BASIN EVOLUTION IN PROTEROZOIC

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A simple logical model for the development and evolution of the Kolhan Basin is proposed. The first event consists of a rapid stretching of the continental lithosphere, which produced thinning and passive upwelling of hot asthenosphere. This stage is connected with block faulting and subsidence. This is synchronous to the existence of the Columbia supercontinent. There was no glaciation during the existence of Columbia. This indicates moderate weathering rate during which the Kolhan Basin formed. This simplistic logical conclusion is supported by the predominance of quartz arenite in the sandstone of the basin . The paucity of feldspars in the thin sections supports the above findings. The main shallow elongated basin of the Kolhan Formation extends from Chaibasa (85^0 48', 22^0 33') to Noamundi (85^0 28', 22^0 09') covering about 34 miles in length and maximum 10 miles in width along the western extremity of the Singhbhum Granite. The occurrence of detached outliers of the Kolhan rocks east of the unconformity on Singhbhum Granite and north of Chiabasa suggests the wide extent of the Kolhan basin in the past. The petrography and geochemistry of the basin concludes an intracratonic rift tectonic setting in Proterozoic time. This indicate a granitoid source with moderate chemical weathering. High Al_2O_3/SiO_2 and K_2O/Na_2O ratios reflect a derivation of all the sediments from stable cratons during tectonic quiescences. These alumina ratio indicates that the clastics were deposited in a passive margin or cratonic margin. Both petrography and geochemistry indicates the same tectonic framework of the basin. The existence of Columbia supercontinent during the life of Kolhan Basin indicates no glaciation during that time. This scenario is well supported by findings of petrography and geochemistry of the basin.

Keywords: quartz arenite, intracratonic , passive margin, Kolhan.

A REVIEW ON THE PTEROPOD STUDIES CARRIED OUT IN THE INDIAN OCEAN

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An overview of the research contributions related to the pteropod preservation and abundancesstudies (surface, core and trap samples) in past years in the Indian Ocean is presented. These integrated studies provided better insights into our understanding of past changes in oceanographic settings and climate on different time scales. Recently, paleoceanographersand paleoclimatologistspay more attention to investigate pteropods in water and sediment samples, owing to their aragoniticcomposition, and used as a reliable indicator for ocean acidification, bathymetry, productivity, upwelling, current circulations, the intensity of Aragonitic Compensation Depth, Oxygen Minimum Zone, monsoon and paleo climatic reconstructions. Since the Pteropod studies have been reported in the Gulf of Aqaba, Red Sea, NorthernArabian Sea, Andaman Sea and along the west coast of India, most of these records are limited to late Quaternary period. Andaman and the Bay of Bengal were least studied. In the Bay of Bengal most of the studies were done on the abundance and distribution of Pteropods in shallow waters and coastal region. From the recent studies, it is noted that anthropogenic CO_2 shoals the Aragonite saturation depth and ACD in all oceans hence, it is a global phenomenon. The occurrence of Pteropods will also affected by the influx of fresh water from the land. It is noted that the deepest saturation depth of aragonite is 200–1400m in the southwestern Indian Ocean and the shallowest in the Bay of Bengal. In the northern Arabian Sea and the Bay of Bengal, the aragonite saturation depths are found to be 100 and 200 m

shallower, respectively, than in preindustrial times. The ACD depth deepest in Southwest Indian Ocean (919m), Arabian Sea (~515m) shoals from north to south and again deepen in southernmost transect and in the Andaman Sea, it is less than 2900m.

From the compiled pteropods studies it is inferred that the abundances/preservation and distribution of pteropods in sediments were higher during glacial periods and Cold Stadials (Younger Dryas, LGM, DO and Heinrich Events) due to the fall in Aragonite Compensation Depth and biogenic productivity, well-ventilated water column and highly oxygenated bottom waters. During Holocene, the preservation were poor in the Indian Ocean and were completely absent up to a certain depth (7-9ka) except the Red Sea where the preservation is higher during Holocene. The total absence of pteropods may be attributed to the depth range of the core collected, upwelling and resulting high productivity and enhanced local CO_2 production and increased atmospheric CO_2 during Holocene resulted in acidic water and reduced saturation state of $CaCO_3$. Seasonal variation of monsoon is also having an impact on the abundance and preservation of pteropods as intense summer monsoon resultin high productivity which in turn strengthen OMZ and poor preservation. During weak monsoon, the pteropods preservation was good because of weaker OMZ. Thecharacteristics preservation spike/ events are reported in all parts of the Indian Ocean and in aglobalnature.

Keywords: Pteropod, Holocene, ACD, OMZ, Productivity, Indian Ocean

CLIMATE CHANGE AND ITS IMPACT WITH REFERENCE TO CHENNAI CITY

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Urban centres located along the coastline of developing countries are facing the fury of climate change induced disasters, especially cyclones and urban floods. Being located on a flat coastline, the Chennai city has severely impacted by several cyclones and urban flooding since 2005, which necessitated quantifying the resilience of vulnerable communities. Through research collaborations with the Kyoto University in Japan and the ETH, Zurich, studies on measuring Climate Disaster Resilience Index (CRDI) and Climate Disaster Recovery Process (CDRP) have been carried out and the research results were share with the end users for their effective utilizations. The salient observations of these studies are: (i) the community resilience is not uniform and the same shows variations from one zone to another, (ii) the recovery process are influenced by various factors such as elevation, socio-economic conditions etc., (iii) local authorities play a vital role in the physical recovery after every disaster, and (iv) the vulnerable communities are developing adoptive skills. The case study experience of Chennai including the methodology and salient outcomes of CDRI and CDRP will be discussed in this presentation.

SATELLITE IMAGE BASED ANALYSIS OF LAND USE/LAND COVER CHANGE AND ITS IMPACT ON MICRO-CLIMATE IN CHENNAI METROPOLITAN AREA (CMA)

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The physical growth of urban areas is horizontal or vertical due to rapid increase in population, industrialization. As more number of human population lives in cities, urbanization has become an important contributor to global warming. The effect of anthropogenic activities on micro-climatic variations is outlined in this paper. Chennai Metropolitan Area (CMA) in Tamilnadu, Southern India, is one of the major cities experiencing rapid urbanization that has resulted in significant Urban Heat Island (UHI) effect, which impacts the regional climate and environment. The Landsat 5 (TM) and Landsat 8 (OLI/TIRS) images are used to enumerate land-use classification (LUC) and Land Surface Temperature (LST) to understand the process of microclimate. Based on Various Normalised Difference Spectral Indices, the LULC changes were identified for years 1989, 1996, 2007 and 2017. Land Surface Temperature calculation was done with respect to the Satellite Brightness Temperature. The results LULC types found to be decreased in vegetation from 51.01% to 23.54%, water bodies from 7.00% to 2.73% and forest from 8.29% to 3.29%. The Built up area in CMA has been increased from 12.05% to 40.19% which results in increase of average temperature from 28.88 to 33.55 degree Celsius. Finally areas of Urban Heat Island have been identified based on the relation between the LULC changes and LST.

Keywords : Landuse / Landcover, Urban Heat Island (UHI), Spectral Indices, CMA, Landsat.

LITHOGENIC SEDIMENTATION IN THE INDUS SUBMARINE FAN DURING LATE QUATERNARY: IMPLICATIONS TO CLIMATE, TECTONICS AND SEA LEVEL

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The Indus submarine fan is the second largest deep sea fan in the world which extends over ~1.2 million km2 in the Arabian Sea with up to 9 km thick pile of sediments. Lithogenic sediment supply to the Indus submarine fan is mainly derived from the Himalayan Mountain through Indus river system. The lithogenic sediment supply have the potential to record the changes occurring in the catchment area. In connection to this a sediment core has been retrieved from Indus submarine fan to understand the history of lithogenic sedimentation. Retrieved sediment core has been dated using radiocarbon method which gave maximum age of 34.6 ka BP. Lithogenic sediment flux has been reconstructed by removing the authigenic fraction from total flux. Reconstructed lithogenic sediment flux has highest sedimentation (21.6 g/m-2/yr) during LGM and lowest (4.8 to 5.8 g/m-2/yr) during Holocene. The reconstructed lithogenic sediment flux has been compared with sea level changes and Himalayan climate as well as tectonics. The results indicate variation in the influence of the each of the above factors on lithogenic sediment flux. However sealevel variation seems to be the major controller of lithogenic sedimentation in the study area.

QUALITY OF GROUNDWATER AND SEAWATER INTRUSION IN NORTH CHENNAI METROPOLITAN CITY

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Fifty five groundwater samples were collected during each season representing premonsoon and postmonsoon seasons for two consecutive years of 2014 and 2016 to assess the quality of groundwater in North Chennai metropolitan city. They were analyzed to know the physical and chemical characteristics of groundwater. Some of the trace elements were determined. The results of major and trace elements have been compared with BIS to know the pollution/contamination level of groundwater in the study area.

Stable isotopes δ18O and δ2H were determined for 24 groundwater samples (12 in each season) based on EC, TDS, Na and Cl concentration for premonsoon (July 2014) and postmonsoon (January 2015) seasons. Seawater intrusion into the coastal aquifer is being observed using Isotopes, Piper plot, Chada's plot and Molar ratio diagrams and the extent to which the Chennai metropolitan city being affected due to overexploitation of groundwater is identified.

OVEREXPLOITATION OF GROUNDWATER AND ITS IMPACT ON THE ENVIRONMENT OF INDIAN SUBCONTINENT

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India is overusing its groundwater resources stocks. The present impacts on the groundwater itself are manifested in the drop in groundwater levels, reduction in or ceasing of spring discharges, saltwater intrusions and deteriorating water quality. The socio-economic impacts are results of reduced water quality and quantity. The negative impacts, both on the groundwater resources as such, and on socio-economic are expected to intensify with the passage of time. The increasing shortage and unreliable canal supplies have induced farmers to use more and more groundwater to irrigate their crops. The accessibility to groundwater has helped farmers to improve crops yield. At present, 51 billion cubic meters of groundwater is extracted annually with the help of 800,000 tube-wells across the country. More than 50 per cent of irrigated lands are now served by groundwater wells. Investment on private tube-wells is around Rs25 billion. The annual benefits in agricultural production are worth Rs150 billion. Over 2.5 million farmers directly or indirectly benefit from groundwater. On an average, every fourth farming family has a tube-well and a large proportion of non-owners purchase water from their neighbors. Over 80 per cent of groundwater exploitation is in the private sector and there is no restriction or control on its extraction. The over extraction of groundwater i.e. excessive withdrawal beyond the normal recharge in any given area creates many harmful effects which could be identified as continuous lowering of water levels. (Both pre-monsoon and post- monsoon)Lowering of pump sets, causing low efficiency, higher cost of operation etc. it has also a great impact on the aquifer systems and it also creates disturbances in the quality of groundwater. So in this article we have focused on the how the overexploitation happens, how it affects the groundwater level, how it creates the uproar in the quality of groundwater as well as the procedure of controlling it in the Indian subcontinent and many more.

Keywords: over exploitation, groundwater, socio-economic impacts, Indian subcontinent

INTEGRATED APPROACH OF SALINE WATER VULNERABILITY ASSESSMENT ALONG THE EAST COAST FROM VAIPPAR TO TAMBARAPARANI RIVER OF THOOTHUKUDI DISTRICT, TAMILNADU

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East coast of Tamil Nadu is one of the important coastal ecosystem where saline water vulnerability is witnessed as a major problem. The vulnerability is not only affect ecosystem, socio-economy but also damage fresh water aquifers which is prime water source for survival. Keeping this, an attempt was made to assess saline water vulnerability and saline fresh water interface along the east coast from Vaippar to Tambaraparani of Thoothukudi District. The coastal stretch is located between the North latitude of 8º 30' to 9 º 05' and the East Longitude of 77 º 55' to 78 º 15'. Geologically, the region comprises recent age of coastal sand, calcareous sandstone, clay, kankar and clayey sand along the coastal belt whereas hornblende biotite gneiss is in interior. Major geomorphologic units are pediplain, coastal and alluvial plan. Hydrogeologically, the area consisting of porous sedimentary formation along the coastal track and fractured gneiss and quartzite veins in hard rocks. Normal annual rainfall over the district varied from 570 mm to 740 mm. Field well inventory study was conducted in 31 open wells and it is found that total depth of the open wells varied from 6.5m to 18.5m bgl and water level varied from 1.5m to 11.5m bgl. Shallow depth wells are observed in the southern part and moderate to deep wells are noticed in central and northern part.

Multi electrode electrical resistivity scanning was carried out at 40 locations using SSR-MP-AT-ME model resistivity meter. The scanning was carried out for a length of 100m using 50 electrodes at an interspacing distance of 2m. The obtained field data were analyzed using IPI 2WIN software. Interpreted data shown a resistivity variation of less than 1 Ohm m to 34000 Ohm m. Very low resistivity of <10 Ohm m was observed in 24 locations and most of them are located along the coast. Variation of resistivity was found less near to the coast and high variations were noted away from the coast. Weightage score based overlay analysis was done in GIS by overlaying aquifer thickness, slope, land use/cover, geology and geomorphology. The integrated analysis shown possible saline water intruded zone in the central and northern part and it advocates with TDS and Na/Cl ratio values.

GROUNDWATER POTENTIAL ZONE DELINEATION-A CASE STUDY IN CHITTAR BASIN, TAMILNADU

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Groundwater resources are dominant in subsurface layers of earth's surface. Earth surface is prominent a various characteristics and organize the Groundwater potential Index (GWPI) within the semi-arid basin. GWPI gives the natural and artificial recharge sites but in artificial recharge sites is implements the suitable idea for locating of rainwater harvesting and groundwater recharge sites with the help of Remote Sensing (RS) and Geographical Information System (GIS) technology. For the present study, GWPI of Chittar basin of Tamilnadu,

India is carried out. In this basin nearly 70 % of land is agriculture area. The Chittar basin is to generate different themes with the help of RS and GIS. Thematic Layers are prepares from various sources of data such as Drainage density, Lineament Density, Lithology, Geomorphology, SCS-CN and groundwater Level. RS and GIS help to combine as all the thematic layers to integrate with the Analytical Hierarchical Process (AHP) to develop a GWPI. AHP is adopts by giving the rank and weightage values for local priority of thematic layers judgment with the natural recharge occurrence. AHP values is add into intersect thematic layers using GIS and following steps are provide in non-spatial whereas pairwise comparison of thematic layers, normalized weight of thematic layers and normalized weight features of subclasses thematic layers. Finally, subclasses thematic layers are add the AHP values which derive the ranges from high to low GWPI. Groundwater recharge sites are pointed with the low GWPI region within their surroundings. Simultaneously, irrigated practices of Chittar basin are done through the suitable constructive groundwater recharge sites to improve agricultural activities. The rainfall of Chittar Basin is major input for groundwater resources while adding the GWPI derive with the AHP values. By combining the GWPI values with the rainfall it provides high to low possibility groundwater recharge for the Chittar basin.

Keywords: Groundwater recharge, Groundwater Potential Index and Analytical Hierarchy Process

HYDROCHEMICAL CHARACTERIZATION OF GROUNDWATER IN SOLAPUR CITY, MAHARASHTRA, INDIA, USING GIS TECHNIQUES

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Groundwater is a chief natural resource and a key element for the development and human demands. Groundwater quality is extremely influenced by natural as well as anthropogenic contamination. In general, this contamination is due to various factors such as speedy urbanization, industrialization and severe fertilizer application. Solapur City selected to the study area is one of the most important textile hubs of Maharashtra where intensive sewage waste and industrial applications cause the groundwater contamination. It can be seen that the pH has remained alkaline in nature. Majority of the groundwater samples the parameters like Total dissolved solids, total hardness, Calcium, Magnesium and chloride content is above the maximum permissible limit. The WQI, Irrigation quality, Gibbs ratios, Piper diagram, Wilcox diagram and statistical data results, most of the groundwater samples collected in the study area were good for drinking and irrigation purposes. The aim of the study was to assess the spatial distribution of hydrochemical parameters on the major ion chemistry of 46 groundwater samples collected in the study area.

Keywords: hydrochemical parameters, groundwater, domestic, irrigation, industrial purposes, etc.

EVALUATION OF DECADAL GWDI DISPARITIES IN RAICHUR DISTRICT, KARNATAKA, INDIA

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The need for freshwater has increased significantly since last few decades in response to the population explosion and associated events. To meet the needs of the people, exploitation of the groundwater attained its

highest peak of the history at different parts of the world. Low rainfall regions are much affected by these unbalanced human activities which resulted in extreme droughts at different parts. Raichur district of Karnataka state in India is one among the severe drought prone areas. Being hard rock terrain, Raichur district is having numerous lineaments which act as key locations of yielding water wells. Groundwater level data of 1996 to 2017 made available in Central Ground Water Department website has been used along with Landsat8 images downloaded from USGS website to accomplish the target. Here, work is aimed to evaluate the variations in the depth to groundwater which results from the changes in precipitation pattern and pace in exploitation of groundwater. In addition to this, hydrologic as well as structural lineaments are incorporated along with Normalized Difference Vegetation Index (NDVI) of the May month to understand the relation between water level variations, Ground Water Drought Index (GWDI), Lineament density and NDVI. Water level data shows marked increase in the depth to water level through decades. NDVI and lineament density is showing good relation reflecting the water availability of the area. Ground water drought index calculated and its spatial representation for different decades from oldest to recent is giving clear indication of drought expansion. Overlay analysis of lineaments and yield data is giving the high resolution picture of the area for better understanding of the groundwater potential. It is concluded from the work that, drought in the study has intensified drastically in recent years and GWDI is an effective tool to understand and evaluate the same for planning better groundwater management strategies. It is also concluded that, NDVI and detailed lineament analysis are good information sources which supports the conclusions from water level and associated data inferences.

Keywords: Groundwater drought index, Raichur, NDVI, Lineament.

WATER RESOURCES OF INDIA: TIME FOR EVALUATION AND NEW STRATEGY FORMULATION

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Two consecutive droughts (2015 and 2016) in country have put unbearable demand pressure on the available water resources of the country despite not significant shortage of overall rainfall scenario. A sub-continental size country receives rain water of top bracket commensurate to its size. But the country already has jumped into water stress category means per capita net supply is less than 1000 cubic m per year while gross supply is much more as a larger part cannot be used.

Groundwater exploitation report indicates only 52 percent utilization of available groundwater resources in India. In places of highly strained ground water resources, the report suggests 70 percent development of ground water while in some regions of same category it is above 250 percent development. The crisis comes to the fore despite availability of water. The water shortage in acute area is met with train transported tankers. This mismatch between crisis groundwater records and limited public needs clarification. Agriculture consumes nearly ninety percent available water is the largest consumer of water in India.

There is no substantial change in long term rainfall pattern and impact of climate change on volume of rainfall, however rise in population and change in agricultural, industrial, aesthetic practices increased the demand of water which is mostly met through exploitation of groundwater. The interlinking of rivers may provide short term and partial respite with considerable uncertainties provokes to find out alternate and highly promising option sea water exploitation after treatment. Conjunctive blending linked river water, surface water, ground water and desalinated water along with mandatory provision of preventing wastage of water can only adequately address the rising demand of water. The paper deals with these recurring issues such as effects of draughts,

requirements of water, available supply and ways and means to find long term solutions from regulated use to supply of desalinated water.

PHYSICO-CHEMICAL PARAMETERS OF SURFACE WATER IN PARTS OF PANCHMAHALS DISTRICT, GUJARAT – A GENERAL INFERENCE TOWARDS SUITABILITY FOR IRRIGATION

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Water quality for irrigation refers to its suitability for agricultural use. The estimation of concentration and composition of dissolved constituents in water plays an important role in ascertaining its quality for irrigation.Geochemical mapping carried out by Geological Survey of India in toposheet nos. 46F/9 and 46F/13in parts of Panchmahals district, Gujarat, covering an area of 1456 sq. km,also includes one of the parameter for water quality assessment for irrigation purpose. The farmers of the area are mainly dependent on rain water for cultivation as the irrigation potential developed so far is very limited. Geologically the area is represented by metasedimentaries belonging to Lunavada Group of Aravalli Supergroup intruded by Godhra Granites and some basic dyke/sill. Besides,basaltic flows pertaining to Deccan trap are also found in the area.Altogether 18 surface water samples were collected from the largest stream in 5'X5' grids close to the point where the stream leaves the catchment/grid. The sample collection was done as per the Standard Operating Procedure of National Geochemical Mapping of Geological Survey of India and chemical analysis was done at GSI, Chemical Lab, WR. The pH of water ranges from 6.6 – 8.47 indicating slightly acidic to alkaline in nature. TDS ranges from 98 – 890 mg/l. Total Hardness (TH) ranges from 50 – 210 mg/l. In terms of pH, TDS and TH it is inferred that the water samples are suitable for domestic purposes. The suitability of water for irrigation is evaluated by various indices like Salinity Index (EC), Sodium Absorption Ratio (SAR), Kelly's Ratio (KR), Magnesium adsorption ratio (MAR), Soluble Sodium Percentage (SSP), Permeability Index (PI). Salinity index is an assessment of all soluble salts in water samples, which is a measure of electrical conductivity (EC). The higher the EC, the less suitable is the water available to plants, because plants can only transpire pure water and usable plant water in the soil solution decreases dramatically as EC increases. In the study area 15 samples out of 18 samples fall in the low to medium EC range for irrigation. SAR accounts for high sodium concentration in water that leads to development of alkaline soil, which is not suitable for agricultural production. The SAR values of water in the study area is found to be within excellent class (<10) and hence can be used for irrigation purpose. The concentration of Na^+ measured against Ca^{2+} and Mg^{2+} is known as Kelly's ratio. The concentration of Na^+ is considered to be one of the prime concern in making the water unsuitable if Kelly's ratio > 2. In the study area only two sample have KR values >2. Magnesium is essential for plant growth, but excess magnesium can have severe toxicity effect on plants. MAR is broadly classified into two groups. Less than 50 MAR values of groundwater are considered to be suitable for irrigation whereas greater than 50 MAR values are unsuitable. Out of 18 samples 6 samples found to be unsuitable for irrigation purpose.SSP values<50 indicates good quality of water whereas higher values (i.e., >50) is unsafe for irrigation. The study shows that 10 samples fall in good quality of water for irrigation in the area. When concentration of sodium ion is high in irrigated water, it tends to be absorbed by clay particles, dispersing magnesium and calcium ions. This exchange process of sodium in water for Ca^{2+} and Mg^{2+} in soil reduces the permeability and eventually results in soil with poor internal draining. The permeability of soil is affected by sodium, calcium, magnesium and bicarbonate contents of irrigation water. The PI values of samples (all values < 80) indicate surface water to be suitable for irrigation purpose in

the area. Besides this, Wilcox diagram and Gibb's plot were studied for geochemical controls, and hydrogeochemistry of surface water. In Wilcox diagram, EC is taken as salinity hazard and SAR as alkalinity hazard. The diagram shows that most of samples fall in field S1-C2 (low sodium-medium salinity), indicating suitability of surface water for irrigation purpose.Gibbs plots are indicated by the variation diagrams of TDS against the ratios $(Na^{+} + K^{+}) / (Na^{+} + K^{+} + Ca^{+2})$ and TDS against $Cl^{-} / (Cl^{-} + HCO^{3-})$ for both cations and anions groups. Gibbs plots indicate that water chemistry of area is mainly controlled by the interaction between the surface water and the litho units. On the basis of all the above studies, it is found that, the water quality of the study area is mostly suitable for irrigation and can be used for domestic purposes as well, with a local exception in the northwestern part of the study area which is occupied by the Godhragranitoids and metasedimentaries of Lunavada Group and their contact zone.

VINDHYAN ROCKS POURING THE HELIUM IN SAUGOR DIVISION, SOUTHERN GANGA BASIN, BUNDELKHAND REGION, M.P. INDIA.

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The discovery of the helium in the petroliferous tube wells in Saugor Division, southern Ganga Basin region has been carried out in great detail in 50 Tube wells, along with the stable isotopic analysis were carried out for the gas sample were collected from the 50 tube wells in Sagar and Damoh District of M.P. The discovery of the rare gas helium in hydrocarbon rich zone in the tube wells in agricultural field at Garhakota, Rahatgarh, Bina, Banda & Sagar Tahsils, of District and Batiyagarh, Patharia, Jabera, tahsils in Damoh District of M.P. is a unique finding in rocks of the Vindhyan Super Group, in the history of Earth Science in India. The depth of tube wells are varying in 300 feet to 750 feet.

On the basis of geochemical analysis, it is remarkable to note that average values of helium contents varies from 0.34 % to 0.732 % along with the 72% to 99 % of methane and ethane, and minor amount of oxygen, nitrogen and CO_2 gases in the hydrocarbon rich zone are recorded during the geochemical and stable isotope analysis. It has been found in the stable isotope $\delta C13$ value the values for the methane is - 43.6 per mil w. r. t. to - 54.9 per mil w.r.t. PDB and for the Ethane gas is -24.9 to -26.4 per mil w. r. t. PDB in the gas samples. The occurrence of rare helium gas in the Hydrocarbon rich zone is reported first time in the tube wells of Sagar Distt, which were geochemically and stable isotopically analyzed in the labs of KDMIPE,ONGC, Dehradun & NGRI Hyderabad. The gaseous hydrocarbon analysis show the presence of moderate to low concentration of methane (C1) 1 to 104 ppb, Ethane(C2)-1 to 14 ppb, Propane(C3) 1 to 10 ppb, i- Butane (i C4) 1 to 9 ppb and n Butane (n C4) 1 to 8 ppb in the soil samples collected from different locations.

The Result of the stable isotopic analysis of Ethane gas in these samples $\delta C13$ value are ranging from -24.9 per mill w.r.t. PDB and -26.9 per mill w.r.t. PDB are indicative that this gas is of thermogenic origin, which must have been formed at very high temperature & pressure condition in the deeper horizon of the Great Vindhyan sedimentary basin of an early Proterozoic (> 600 m.y.) period.

Keywords: Petroliferous, tube wells, hydrocarbon gas, helium gas, proterozoic, isotopic, thermogenic.

STUDIES ON THE DATING OF NATURAL GAS IN VINDHYAN ROCKS SAGAR- DAMOH DISTRICT, SOUTH GANGA BASIN, MADHYA PRADESH, INDIA

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The dating of natural gases were carried out for the gas sample were collected from the 50 tube wells in Sagar and Damoh District of M.P. The discovery of the rare gas helium in hydrocarbon rich zone in the tube wells in agricultural field in the various Tahsils of Sagar District and Damoh District of M.P., in the south ganga basin in rocks of the Vindhyan Super Group.

On the basis of geochemical analysis, it is remarkable to note that average values of helium contents varies from 0.34 % to 0.732 % along with the 72% to 99 % of methane and ethane, and minor amount of oxygen, nitrogen and CO_2 gases in the hydrocarbon rich zone are recorded.

The stable isotope analysis. It has been found in the stable isotope σ C13 value the values for the methane is - 43.6 per mil w. r. t. to - 54.9 per mil w.r.t. PDB and for the Ethane gas is -24.9 to -26.4 per mil w. r. t. PDB in the gas samples. The gaseous hydrocarbon analysis show the presence of moderate to low concentration of methane (C1) 1 to 104 ppb, Ethane(C2)-1 to 14 ppb, Propane(C3) 1 to 10 ppb, i- Butane (i C4) 1 to 9 ppb and n Butane (n C4) 1 to 8 ppb in the soil samples collected from different locations.

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ENERGY SCENARIO IN INDIA: FUTURE PERSPECTIVE

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The energy scenario in India is changing very fast. The new schemes like Make in India, giving boost to industry, propose high level of manufacturing activity, requiring more power supply. The present installed capacity of power plants is 3,29,000 MW while the operational units are 2,71,498 MW. Out of the operational capacity, 2,19,755 MW is thermal power generation and 62,846 MW are Renewable Energy sources. The heavy dependence on thermal power generation adds to emission of green house gases, contributing to global warming. Considering the plan of Government of India to replace thermal power generation by renewable power generation around the year 2050, to control the green house gas emission, it is essential to encourage non-conventional energy sources. The main renewable energy sources are hydropower, nuclear power, biogas, biomass energy, wind energy, solar energy and geothermal energy. The installed power generation capacity of renewable energy sources is 62,846 MW. Considering the need to augment the power generation by renewable energy sources, an energy mix of different sources is suggested to reduce pollution and enhance sustainable power production.

The renewable sources of energy viz. Wind energy, solar energy and bio mass energy provide ample scope to substitute the thermal energy. Besides these, geothermal energy, tidal energy are good site specific sources of energy. The electric cars, fuel cells, hybrid automobiles and solar powered vehicles are possible substitutes in transport sector. The Government of India has encouraged use of new and alternate energy sources by offering incentives for indigenous production, to reduce the production cost. Thus, the future energy scenario suggests a mixed basket of energy sources comprising wind, solar, biomass and geothermal energy, depending on the industrial activity and geographical conditions to substitute the thermal power, thus controlling the environmental pollution.

RAMAN SPECTRA TO STUDY THE STRUCTURE AND CHEMISTRY OF HEAVY MINERALS RECOVERED FROM KAPPIL-VARKALA COAST, SOUTH KERALA, INDIA

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A micro-Raman spectroscopic study of pumice materials from El Gasco (Sierra de Gata, Spain) has been performed for the first time. The obtained spectra allow the precise identification of the minerals, quartz, haematite, magnetite, ilmenite, rutile and anatase, in general agreement with results obtained by complementary

techniques of X-Ray Diffraction (XRD) and Electron Microprobe. Also, fayalite and ferroan ringwoodite have been identified. The presence of high-pressure polymorphs indicates that the pumice rocks were subjected to high-pressure conditions quite similar to those observed in shock-induced molten and recrystallised materials, such as some meteorites and impact-related rocks. A micro-Raman spectroscopic study of pumice materials from El Gasco (Sierra de Gata, Spain) has been performed for the first time. The obtained spectra allow the precise identification of the minerals, quartz, haematite, magnetite, ilmenite, rutile and anatase, in general agreement with results obtained by complementary techniques of X-Ray Diffraction (XRD) and Electron Microprobe. Also, fayalite and ferroan ringwoodite have been identified. The presence of high-pressure polymorphs indicates that the pumice rocks were subjected to high-pressure conditions quite similar to those observed in shock-induced molten and recrystallised materials, such as some meteorites and impact-related rocks.

The beach sands of Kappil-Varkala coast situated in Thiruvananthapuram (Trivandrum), the southernmost district of Kerala, India shows good THM (Total Heavy Mineral) content. The heavy mineral sand deposits contain an assemblage of predominantly ilmenite followed by sillimanite, monazite, zircon, rutile, leucoxene and garnet. The heavy minerals were recovered from the beach sands and Raman spectroscopic study has been performed to analyse the mineral chemistry, structure and composition, in general shows good agreement with results obtained from other complementary techniques of Energy dispersive- X-ray fluorescence (ED-XRF) and X-Ray Diffraction (XRD). The Raman spectroscopy provides an efficient and user-friendly method for analysing heavy minerals under a polarizing microscope. The strongest Raman peak at ~679cm-1 of the ilmenite mineral is due to the Ag symmetry corresponds to the symmetric stretching vibration of Ti_4O_6 octahedra. Rutile TiO_2 shows two prominent Raman shifts at ~443cm-1 and ~603cm-1 which belongs to doubly degenerate species Eg and totally symmetric species A1g. Other than mineral identification, an attempt has been made to investigate the degree of metamictization in zircon, discrimination of isomorphous series of garnet, discrimination of opaque and non-opaque Fe–Ti oxide minerals, and the anisotropic crystal behaviour due to physical or chemical processes. The ED-XRF provides the detailed geochemistry of the mineral which includes major oxides and other possible minor elements. The values of Fe^{3+}/Fe^{2+}, Fe/Ti and Ti/(Ti+Fe) ratio indicates the alteration undergone by ilmenite mineral. Combined Raman spectroscopy, ED-XRF and XRD enabled the advanced chemical characterisation which impacted on the efficiency of determining the grade and potential applications of these strategic minerals.

MINERAL EXPLORATION SCENARIO IN INDIA

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The mineral scenario in India is changing very fast. The new schemes like Make in India, formed to give boost to industry, propose high level of manufacturing activity, requiring more mineral input. This requires additional production of major minerals like iron ore, bauxite and base metal minerals for supporting expansion of railways, defense network and manufacturing industry. Besides this, the limestone is required for civil construction, bridges and irrigation projects; phosphorite is needed for improving the agricultural production and industrial minerals, building material to meet the needs of growing demand of development projects. The power supply needs to be ensured to complete the development projects by monitoring the coal output, keeping a balance between production and environmental guidelines. The modern instruments like computers, supersonic jets, spacecrafts and defense machinery demand specialized trace metals and alloys for which exploration of

trace metals and strategic minerals has to be encouraged. The international production and prices of these minerals fluctuate greatly creating an uncertain supply position. Considering this, the Government of India has taken up exploration of the strategic minerals on priority.

Government of India has formulated a National Mineral Exploration Trust to boost up the exploration activity. The national Mineral Exploration Policy 2016 provides framework for prospecting of mineral occurrences leading to exploitable mineral deposits. The national scenario indicates the urgent need for import substitution and indigenous production. The present scenario suggests stress on exploration of iron ore, basemetals, trace metals and strategic minerals to achieve the self sufficiency in metal production required for industrial development and rare metals required in high precision technology.

Total 60 projects worth 246.5 crores are taken up in 10 states under NMET scheme. The main thrust is to augment resources of limestone, iron ore, bauxite which are building blocks of infrastructure and economy. The base metals, gold and diamond prospects, useful for trade and export are also being explored in Jharkhand, Karnataka and Madhya Pradesh. The agriculture will get boost by additional resource of phosphorite generated under NMET. Manganese ore, REE and PGE minerals will be explored for supporting high technology industrial applications. Lignite investigation will be taken up for power plant project. Thus, NMET will give boost up to mineral sector by addition of more mineral wealth to meet challenge of increasing demand and global competition.

EXPLORATION FOR OCEAN RESOURCES

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Among all the types of mineral resources available to mankind, perhaps none has attracted so much public attention and speculation within the past 10 to 15 years as those minerals in and under the oceans of the world.

Although the oceans cover in excess of 70 percent of the surface of our globe, the explorers/scientists/ engineers who have involved themselves with mineral exploration during the past two to three centuries, have been remarkably slow in learning economic significance about the mineral content of the oceans.

Till recently, information concerning world distribution of potential subsea mineral resources was sparse. Ocean floor Samples of mineral deposits, their related pictures and geophysical surveys were very minimum. Even basic information on the topography of the sea bottom is scant in most parts of the ocean and large areas have not been surveyed at all. Detailed bathymetric charts cover only a few shelf areas. The available drill hole data are largely restricted to near shore areas where the oil companies have undertaken petroleum exploration activities.

Therefore, the distribution of potential ocean floor minerals remained highly conjectural.

But now there is a sudden spurt of activity to complete basic information concerning the ocean. Government undertakings, academic institutions and industrial corporations around the world have now collected hundreds and thousands of ocean bottom samples and thousands of shallow cores and bottom photographs. In the USA, the National Oceanographic Data Center alone has data on approximately 80,000 ocean-bottom samples. Nearly

100 deep borehole lines have now been drilled to depths of several thousand feet in the deep ocean floor. In addition, millions of miles of geophysical traverses and a few tens of thousands of drill holes/wells in the shallower parts of the continental shelves have been completed by petroleum companies.

A wide variety of minerals occurring in the oceans are grouped into:

(1) Dissolved or suspended in seawater,

(2) On the sea floor, and

(3) In the bedrock, below the sea floor.

Only eight elements account for bulk of the materials dissolved in seawater, although at least 77 elements have been detected. The eight elements in order of abundance are chlorine, sodium, magnesium, sulfur, calcium, potassium, bromine and carbon. Chlorine constitutes over 58 percent of all dissolved elements, whereas carbon makes up less than 0.1% of them.

The mineral deposits of econmomic importance occur mainly (i) on the beaches, (ii) on the continental shelves, (iii) on the continental slopes, and (iv) on the deep sea floors.

The minerals in beach deposits are those resistant to weathering and to the mechanical action of waves. The latter deposit them on the shore. Quartz, feldspar and a variety of other silicates make up the bulk of beach material and are a resource for sand and gravel. But, at places, considerable quantities of heavy mineral or "black sand" deposits contain strategically important columbite (with rare earth elements), magnetite (iron oxide) limonite (containing titanium), and zircon (zirconium oxide). Other heavy beach sands less commonly carry gold, diamonds, platinum, chromium, and minerals of tin, tungsten, and thorium.

Detrital deposits on the continental shelves include most of the minerals that are found on beaches. Special efforts in recent years have been made in various parts of the world to recover gold and diamonds, but with little success. It is common knowledge that the economic deposits of gold are universally found only within a few miles of their igneous sources. Since only a few continental shelves contain metalliferous igneous sources, the likely hood of finding a major gold deposits in such environments is very bleak. Likewise, diamonds in known offshore deposits occur in concentrations of only one part diamond in 100 million parts of gangue, or waste, material. In the shallow seas off Malaysia and Indonesia, however, considerable success has been achieved in dredging cassiterite (tin oxide).

Chemical precipitates on the continental shelves include phosphorite, glauconite(?) and barite(?) of which phosphorite has received by far the most attention. Phosphorite nodules and crusts are widely distributed on the continental shelves and upper slopes in areas of upwelling ocean currents and low latitudes. They are abundant in some areas like off the coasts of Baja in Mexico, southern California, and east of New Zealand. However, no offshore phosphate deposits are being mined now because of the actual over supply of much lower cost and higher quality phosphate on land.

Among the deep sea floor deposits, those with mineral resource possibilities are calcareous oozes, siliceous oozes, zeolites, red clay and manganese nodules.

The oozes, zeolites and clays theoretically could be used for industrial purposes, but the depths at which they occur (10,000 to 36 000 feet) make them inaccessible, for all foreseeable practical purposes as sources of low unit value products.

Together with phosphorites on the continental shelves, the manganese nodules on the deep sea floors of several parts of the world have attracted the attention from government surveys and mining companies in recent years. Surficial deposits of manganese oxide nodules, crusts, and pavements, which are currently of more interest for their content of nickel, copper, and cobalt than for manganese are largely confined to the very deep ocean floors at depths of 10,000 -14,000 feet, and to the undersea mountain ranges that occupy the deeps.

AS per USGS estimates the subsea oil and gas produced off shores of 25 countries contribute 17 percent of the of the total world's output and make up nearly 90 percent of total value of current subsea mineral production. In other words, petroleum production at present is the only significant ocean mineral resource industry and petroleum will continue to be the principal mineral produced from the sea bed throughout the remainder of the present century and probably longer.

Saline deposits formed in ancient marine basins are extensive on land and many extend beneath the sea not only under the continental shelves, but also under some of the small ocean basins.

Potash deposits in the salt basins are not as widespread as salt and gypsum but individual deposits are large generally in the range of hundreds of millions or billions of tons. World's supplies from land sources are presently abundant.

Nearly 60 percent of the world's production of sulfur comes from deposits associated with anhydrite, either in bedded deposits or salt domes. Subsea production however, is presently limited to two salt dome deposits offshore Louisiana, which yields about 20 percent of United States production.

One of the most exciting possibilities in ocean minerals related to certain hot, high-density brines located in the Red Sea during 1964-1966. These brines have temperatures as high as 56°C at a depth of about 2,000 meters and they have a high salinity (25.6 percent).

Virtually a whole new technology will have to be devised to discover offshore, sub bottom lode and bedded deposit,

According to the United States Commission on Marine Science, mineral exploration in the ocean requires a sequence of activities. These include exploratory bathymetric, geophysical and geological surveys followed by sample analysis

These operations included 'recovery of minerals from seawater, from placer deposits on beaches and the continental shelves, and from bedrock deposits in the continental shelves. The total value of offshore mineral production was just over $700 million, of which about 30 percent is attributed to United States offshore production. Worldwide less than $200 million worth of mineral products is mined directly from the ocean floor annually.

The Commission on Marine Science that the risks of ocean milling ventures are increased by the lack of operating experience. Dredging operations, even in relatively shallow waters, cost more than twice as much as similar operations on land; the difficulties, of locating, proving, and developing resources in deeper, unprotected waters are formidable.

The technology for future ocean mining in deep water will require equipment such as:

- Submarine crawlers and bottom-hovering vehicles for exploration and recovery of deposits;
- Stationary or neutrally buoyant platforms;
- Drilling rigs on the ocean floor;

- Submarine dredges; High-capacity;
- low-cost vertical transport systems;
- High-capacity equipment for horizontal transfer between sea surface platforms.

For example, C.O. Ensign Stresses that very little is known in terms of the details needed in the technology for deep water mining California and that although there are numerous detailed engineering studies upon which cost data for deep water mining have been estimated.

SITE SELECTION FOR BOREHOLE DRILLING IN FRACTURED ROCK TERRANE : A STRUCTURAL AND MULTI ELECTRODE RESISTIVITY IMAGING (MERI) STUDY

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Majority of borewells drilled in the hard rock areas fails due to lack of adaptation of scientific methods. Borewells are generally located based on the surface and subsurface features. In northern Gujarat, local communities depend on fractured Precambrian basement rocks as the primary source of water supply. The hydrogeology of these aquifers is poorly understood and the boreholes are frequently placed with little appreciation of the local fracture systems. Increasing demand for water puts stress to explore groundwater from less reliable sources of basement rocks and hence, makes it vital to identify high yielding hydrogeological zones. The present study comprising of structural data featuring fractures/joints and geoelectrical survey (Multi-electrode resistivity imaging) has been done by fieldwork. The main objective of this study is to find out the potential site for borehole from which groundwater can be explored economically. The study area falls in Dahanpura-Kanpura-Ghoda regions of Aravalli-Delhi fold belt which has undergone multiple phases of deformation. The field area comprises gabbro - norite - basic granulite series, granite, cataclasite and mylonitic type of rocks and due to late stage brittle fracturing, these rocks have been fractured. These fractures are mainly reactivated fractures which are controlled by preexisting fractures in the shear zone and control the groundwater circulation. The fractures in the study area are oriented mainly in NW-SE, NE-SW, and E-W directions. Based on structural study, electrical resistivity tomography (ERT) has been carried out along and across the lineaments to delineate the subsurface fracture geometry. The advancement of resistivity methods using multi-electrode arrays has led to an important growth of electrical imaging for subsurface studies and to identify borehole/tube well drilling site. A traditional resistivity measurements are made using four electrodes and the measured values are depends on the lithology, weathering zones, porosity, compactness, water content of the geological formations. Here we have used Multi-electrode resistivity Imaging (MERI) against traditional 1D resistivity survey to identify both lateral and vertical resistivity (2D) variations of geological formations. This helps to pinpoint subsurface fracture system and hence potential borehole site. For the present study, electrical resistivity imaging (ERI) was carried out at 27 diverse locations. Among twenty seven (27) profile locations, nine (09) prominent deeper fracture zones has been identified which are correlated with surface fracture data for pinpointing potential borehole site. Furthermore, the deeper conductive zones are due to the presence of deep-seated shear zones.

Keywords: Fracture, Hard rock, Aravalli, Groundwater, electrical resistivity

THE CONCEPT, PRINCIPLES AND GOALS OF SUSTAINABLE DEVELOPMENT WITH REFERENCE TO MINING INDUSTRIES

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This paper is discussing the concept, principles and goals of the sustainable development of the mining sector, the ones that will significantly shape the development of mining in the future.Sustainable development (SD) have an all-inclusive, the "3 pillars" viz. Economic, Environmental and Social concern. That endures over the long-term and its core ethic is intergenerational equity. Sustainability principles have application for all stages of mine life cycle – exploration, mine planning, construction, mineral extraction, mine closure and post-closure reclamation and rehabilitation and sustainable goals covers many other sectors there is no primary point of connection between mining and one single sustainable development goal. Instead, operations have the extraordinary potential to contribute to several different goals at any one time. This is due to the multifaceted impacts (both positive and negative) that companies and operations can have on communities, ecosystems and economies and also this paper highlights the basic concepts and philosophy of sustainable development practices for mining industry. It also discusses in detail the various strategies to be adopted to make mining socially, economically and environmentally sustainable. It also elaborates important aspects of promulgated sustainable development framework for the mineral sector in India besides International practices on SD in Australia.

Keywords: Mining, Economic, Environmental, sustainable development, Socio-economic principles, Goals.

DEPOSIT CHARACTERISATION AND THE RIGHT TECHNIQUES OF QUARRYING TO ENHANCE THE RECOVERY PERCENTAGE IN COMMERCIAL GRANITE QUARRIES- A CASE STUDY FROM THE BLACK GALAXY GRANITE DEPOSIT OF ON GOLE, AP.

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Deposit Characterization in evaluation of Commercial Granite Quarries is the foremost and fundamental aspects that determine the success and failure of quarry operations besides on adopting the right techniques of quarrying to enhance its output to maxmise the operation and conservation of natural resource at large. This is the most emerging scientific technique and sought after to establish the geometry of the prospect and broadly includes an in depth study on regional geology, micro analysis on geomorphology, petrography, structure and its impact on recovery in the quarry. All these factors ultimately decide on the investment plan and production prognostication to work out the marketing strategy and supply schedule to meet the demand. Considering the importance, the paper highlights based on case study of working premium granite quarries in black galaxy belt of Ongole , Andhra Pradesh to explain the overall impact on recovery of saleable blocks besides on methods of quarrying that are more suitable to maxmise the output.

Mining and quarrying are major anthropogenic activities that cause direct impact on the ecology and environment of the earth. Quarrying for granite along with minerals like quartz and feldspar are found in many places in the adjoining districts of Hyderabad city. A considerable number of quarries are distributed in erstwhile Mahbubnagar district. Some of these quarries are now abandoned either due to exhausted resources or completion of lease approval. An attempt is made in this paper to quantify the disturbed ground due to quarrying operations and allied activities. For this purpose, four to five major quarries at Balanagar, Kammadanam, Gouthapur,

Peddarevelly and NakkalabandaTanda in the Balanagar- Jadcherla tract have been selected and have been mapped using satellite imagery of past and recent. In 2003, no quarrying was present. With the advent of sanction of leases, quarrying started between 2006 and 2012 period. A considerable area of 3.43 Sq.Km has experienced the impact of quarrying. The maximum ground disturbance has occurred at Balanagar quarry amounting to 1.63 Sq.Km. In the immediate surroundings, several environmental changes were observed: 1. dust pollution, 2. reduced vegetation and forest cover, 3. Depleted groundwater levels 4. increased salinity in the groundwater making it not potable. Examination of satellite image and field traverses also revealed that there has been a tremendous increase in the development of residential plots.

MICROTREMOR STUDIES - AN INNOVATIVE METHOD FOR EXPLORATION AND EXPLOITATION OF MINERAL RESOURCES.

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Minerals and Mineral base industries drive the country's economy. with advent of technology, the current millennium demands innovations at two fundamental levels viz., exploration and exploitation of mineral recourses so as to sustain delicate balance between economy of mining industry and chaotic market. Mining industry need to decide how best to locate, calculate and allocate their scarce resources.

In present talk we discuss application of microtremor technique to map subsurface stratified boundaries in two mining lease viz., Umarsar Lignite Mine, and Shivrajpur Manganese Mine managed by Gujarat Mineral Development Coorporation.

Umarsar lease area was evaluated taking forty-six stations in a grid format at ~250 m resolution. Microtremor studies lead to estimate thickness of both lignite bearing Tertiary sedimentary sequence and late Cretaceous Deccan basalt flows and comprehends basinal geometry of Umarsar Basin (Babia syncline).

The studies help to carry out rapid economical assessment covering large mining lease areas complementary to local geological studies and forms base to develop economical borehole plan for calculating realistic reserve estimate.

Shivrajpur Manganese mining which falls along the axial trace of the Narukot Dome was surveyed using Microtremor technique taking 32 station at about1 km interval. The studies reveal presence of granite pluton underneath WNW plunging Champaner group of Rocks suggesting mine planner deeper exploration is futile

Microtremor study provides a subsurface insight to the stake holders in terms of variaiton in depth of Tertiary sediment, Deccan Traps, Mesozoic sediment, and plutons. The studies therefore offers a quick and cost effective method to estimate depth of contrasting rheological boundaries.

ENVIRONMENTAL IMPACT DUE TO QUARRYING IN BALANAGAR AREA, MAHBUBNAGAR DISTRICT, TELANGANA USING REMOTE SENSING & GIS

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Quarrying for earth's resources like minerals is one of the major anthropogenic activities that cause direct impact on the ecology and environment of the earth. Quarrying for granite along with minerals like quartz and feldspar are found in many places in the adjoining districts of Hyderabad city. A considerable number of quarries are distributed in erstwhile Mahbubnagar district. Some of these quarries are now abandoned either due to exhausted resources or completion of lease approval. An attempt is made in this paper to quantify the disturbed ground due to quarrying operations and allied activities. For this purpose, four to five major quarries at Balanagar, Chilkamarri, Burgul, Appajipally and Chinnapally in the Balanagar- Kadthal-Jadcherla tract have been selected and have been mapped using satellite imagery of past and recent. In 2003, no significant quarrying was present in the study area. With the advent of sanction of leases, quarrying started between 2006 and 2012 period. A considerable area of 3.43 Sq.Km has experienced the impact of quarrying. The maximum ground disturbance has occurred at Balanagar quarry amounting to 1.63 Sq.Km. In the immediate surroundings several environmental changes were observed: 1) dust pollution, 2) reduced vegetation and forest cover, 3) depleted groundwater levels and 4) increased salinity in the groundwater making it not potable. Examination of satellite image and field traverses also revealed that there has been a tremendous increase in the development of residential plots.

Keywords : Quarrying, Environment, Ground disurbance, Remote Sensing, GIS, Telangana.

ECOLOGICAL BALANCING DURING PROGRESSIVE MINE CLOSURE IN NEYVELI LIGNITE MINE 2

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The major environmental concern of India today includes all physical (air, water, land etc.) and biological factors (plants & animals including man). But today man has emerged as the most powerful and intelligent component of environment, who keeps on modifying the natural ecosystem by the technocratic industrial development.

NLC is harnessing the power of nature - like lignite mining and power generation. Being conscious that environmental regeneration is the foundation on which productivity has to be built, Neyveli Lignite Corporation started investing to 'Eco Care' long back in early eighties and is continuing to Re-Create the original beauty of Mother Nature.

This paper highlights the various environmental problems faced during mining the lignite deposit in the Neyveli Mines and the tangible protection & remedial measures adopted to tackle and maintain the ecological balance where all species can live balancing each other i.e. Land reclamation & Soil dumping; Ecology and Water pollution, Ground water resources management and Air pollution are important classified categories of pollution, which this paper discusses in detail.

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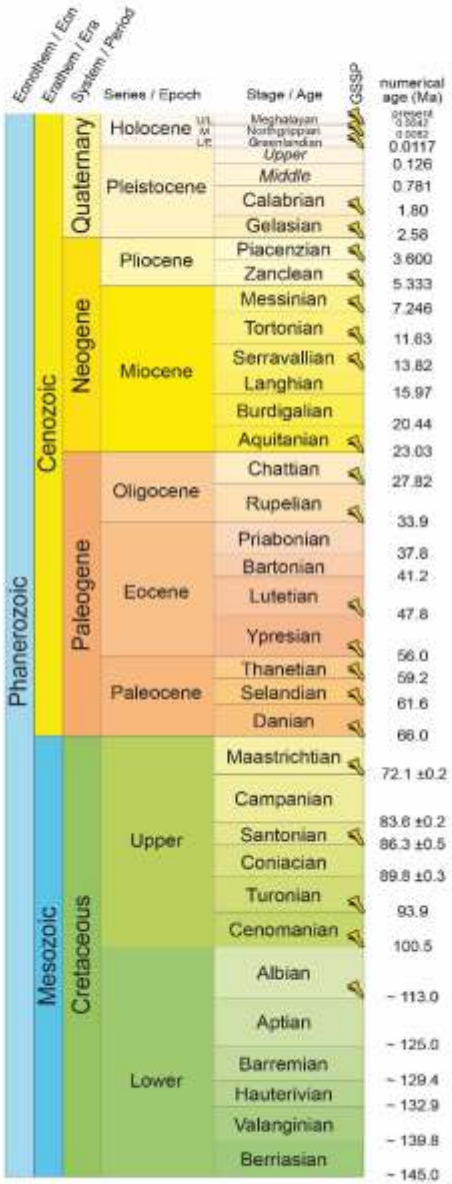

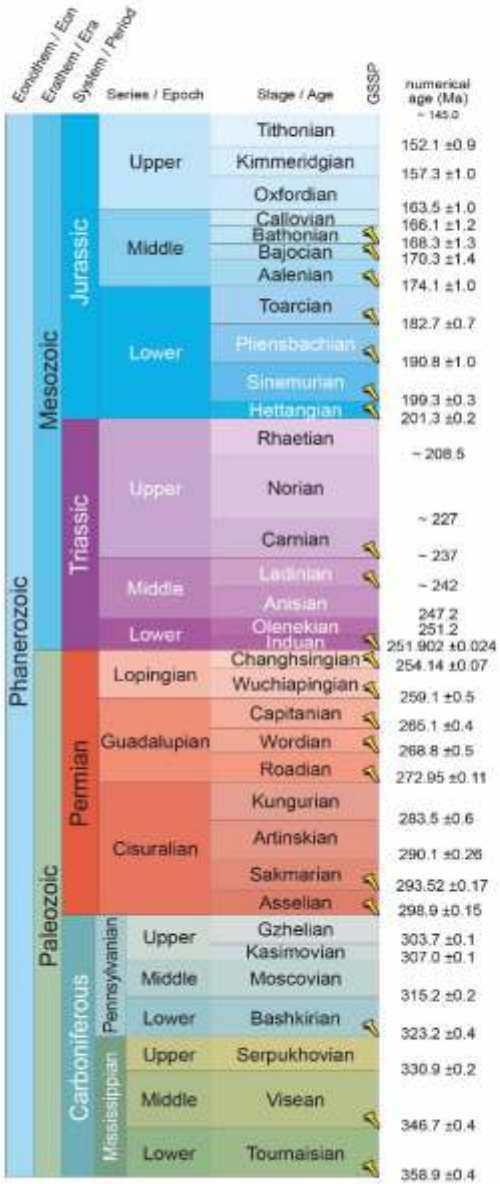

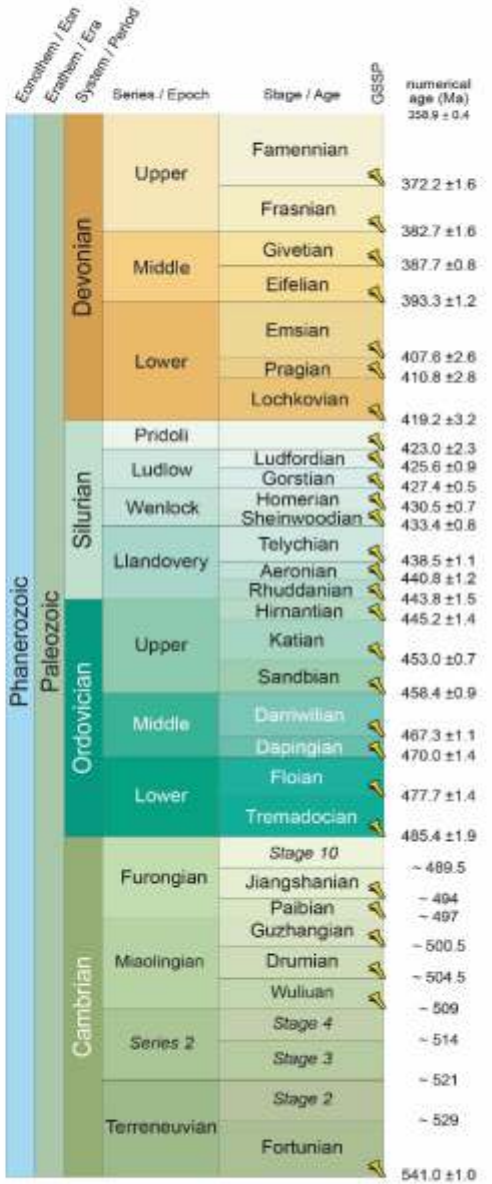

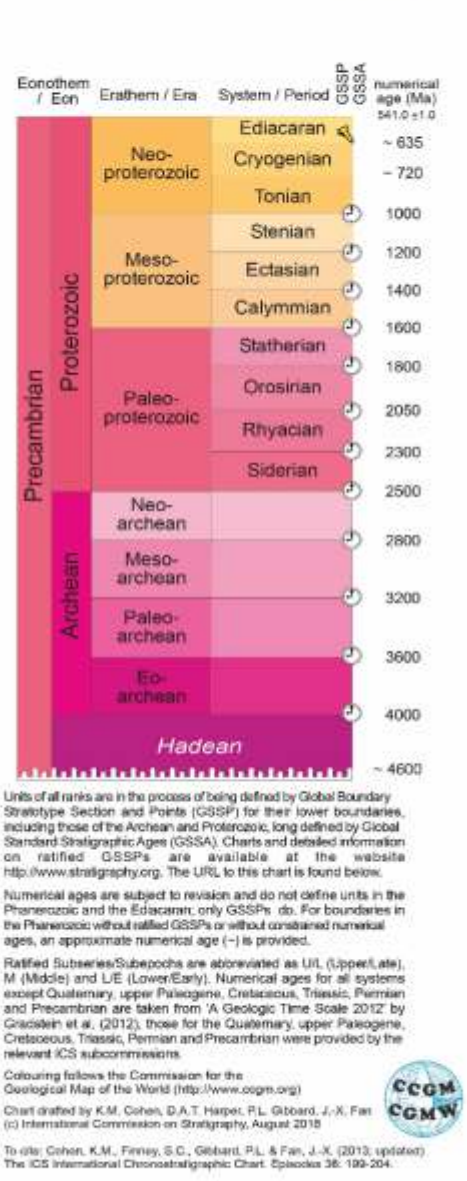

Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Charts and detailed information on ratified GSSPs are available at the website http://www.stratigraphy.org. The URL to this chart is found below.

Numerical ages are subject to revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

Ratified Subseries/Subepochs are abbreviated as U/L (Upper/Late), M (Middle) and L/E (Lower/Early). Numerical ages for all systems except Quaternary, upper Paleogene, Cretaceous, Triassic, Permian and Precambrian are taken from 'A Geologic Time Scale 2012' by Gradstein et al. (2012); those for the Quaternary, upper Paleogene, Cretaceous, Triassic, Permian and Precambrian were provided by the relevant ICS subcommissions.

Colouring follows the Commission for the Geological Map of the World (http://www.cgmw.org)

Chart drafted by K.M. Cohen, D.A.T. Harper, P.L. Gibbard, J.-X. Fan

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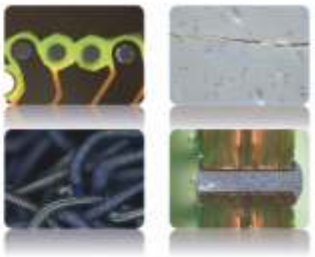

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