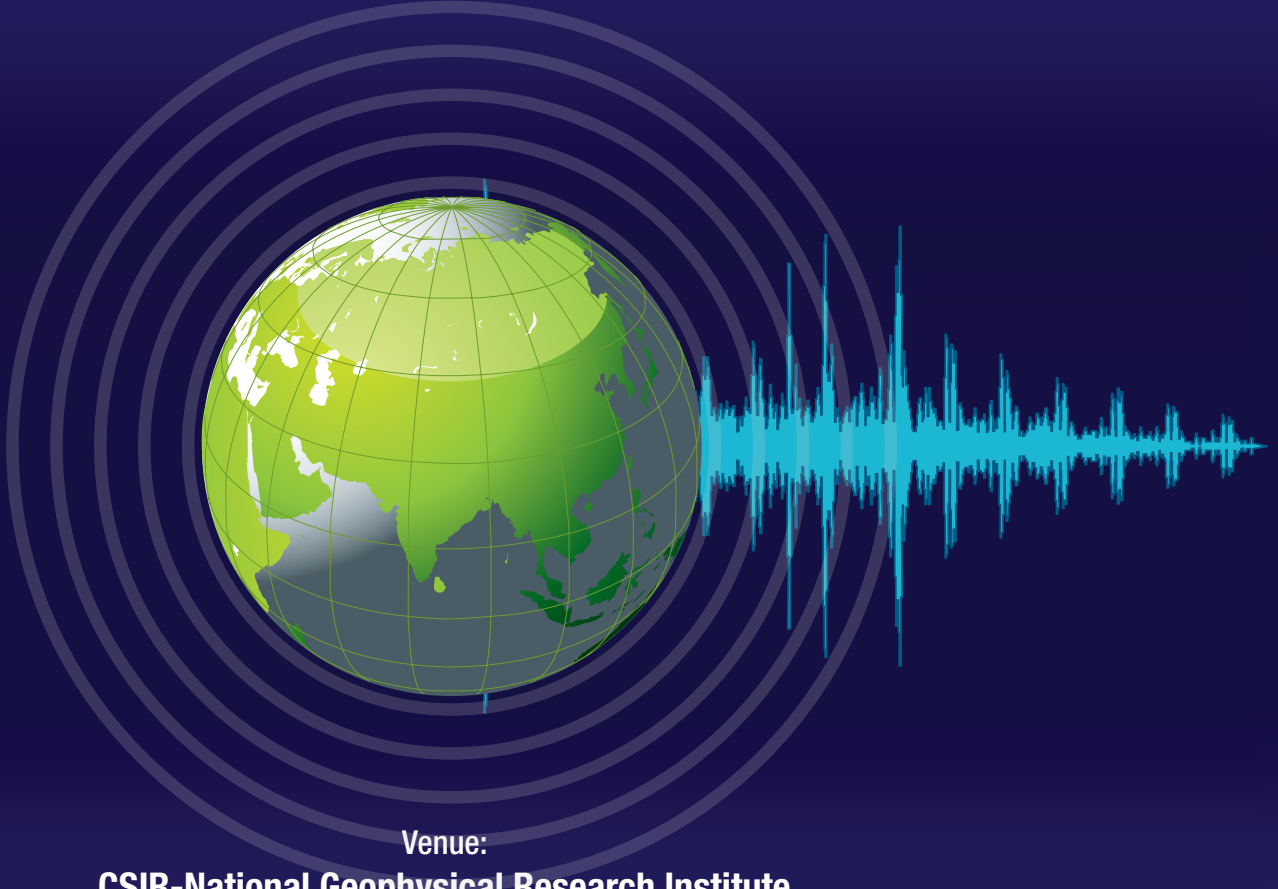
54th Annual Convention of IGU
on

"RECENT ADVANCES IN GEOPHYSICS WITH SPECIAL REFERENCE TO EARTHQUAKE SEISMOLOGY"

December 3-7, 2017



Venue:
CSIR-National Geophysical Research Institute
Hyderabad 500007 TS

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ABSTRACTS

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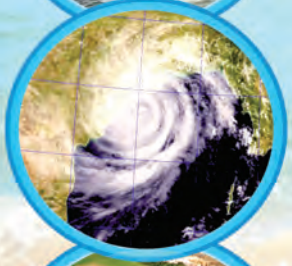

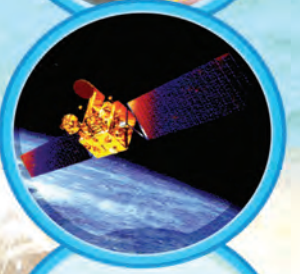

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ABSTRACTS

54th Annual Convention of IGU

on

"Recent Advances in Geophysics with Special Reference to Earthquake Seismology"

Venue:

CSIR-National Geophysical Research Institute, Hyderabad

Sponsored by

NATIONAL CENTRE FOR ANTARCTIC AND OCEAN RESEARCH, GOA

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Message

The Indian Geophysical Union (IGU) has contributed significantly for the growth of Indian Earth Science community. It is heartening to note that the 54th annual convention of IGU is being organized and the central theme of the convention coincides with the golden jubilee celebrations of CSIR-NGRI Seismological Observatory. The observatory has contributed immensely in understanding intra plate seismicity. I acknowledge the contributions of Airborne Geophysical studies which were initiated 50 years ago at CSIR-NGRI in mapping prospective mineralised zones, for Uranium and water.

Though the main theme of five-day convention of IGU has focused on 'Recent Advances in Geophysics with Special Reference to Earthquake Seismology', I am extremely happy to see that IGU is organizing several sessions covering entire gamut of Solid, Marine and Atmospheric & Space Sciences with the Geoscientific implications on Energy, Minerals, Waters, Geo-hazards, Geodynamics and some Fundamental issues related to Earth.

To encourage scientific measures in addressing various policy requirements having societal relevance, I wish that IGU closely associates with both academia and industry as has been practiced in the past. This initiative shall definitely lead to the close interaction of students/young researchers with the senior and experienced scientists to yield excellent results.

I wish to thank each one of you personally and recognize the contribution you've made. My heartiest wishes to IGU for a very successful Annual Convention – 2017.

Girish Sahni

[Girish Sahni]

New Delhi

November 30, 2017

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INDIAN GEOPHYSICAL UNION

The Indian Geophysical Union (IGU) has organized 53 annual conventions on various themes at research organizations, universities and academic institutes. IGU has provided a platform for dissemination of knowledge of earth system science through Plenary lectures, Invited talks, Oral/poster presentations, on Current topics of interest in the earth sciences having societal relevance. The present convention"Recent Advances in Geophysics with Special Reference to Earthquake Seismology" is being jointly organized by CSIR-NGRI in Hyderabad during December 3-7, 2017. I am sure deliberations of the Annual Convention are likely to enrich our understanding on observational seismology as well as to provide insight on exploration of the solid earth and resources with a view to meet societal requirements.

A response from more than 250 delegates and participation of dignitaries is a positive stride towards the success of this annual convention. It is indeed an honour to welcome esteemed dignitaries, delegates, speakers, sponsors, invitees and exhibitors to the 54th convention of IGU and wish an enriching participation. I wish the convention a grand success.

Prof. Shailesh Nayak
President
Indian Geophysical Union

PREFACE

The Indian Geophysical Union (IGU) started in 1963 with the blessings of the-then luminaries like Prof K.R. Ramanathan, Prof. S. Bhagavantham, Prof. M.S. Krishnan and Dr. S. Balakrishna. In the past, the union provided a platform for dissemination of knowledge, sharing thoughts/views, interaction between young scientists/researchers and experienced geoscientists, understanding societal problems and finding feasible solution, and discussion on current topics and recent phenomena, and continues to serve the Earth Scientific Community of India.

Since its inception, IGU has been organizing annual conventions at different organizations/ institutes at different places. This year we are organizing the 54th convention at CSIR-NGRI, which is known for its excellence in Earth Science research activities and education. Though the theme chosen is "Recent Advances in Geophysics with Special Reference to Earthquake Seismology", the sessions during convention cover Solid Earth Geosciences, Marine Geosciences and Atmospheric and Planetary Sciences. There are special sessions on commemorating the 50 years of 'Seismological Observatory' and 'Airborne Geophysics' and Reservoir Triggered Seismicity.

Besides 4 Plenary talks, 16 invited talks, we have 70 orals and 117 poster presentation spread over the convention. Even though there is a two-hour slot for the poster on 4th December, we encourage continued display of posters to enable better projection of results and healthy interaction between the presenters and the delegates. To strengthen the HRD in Geosciences we are separately awarding students and young researchers for their R&D initiatives/achievements. For motivation we have created a four-member Jury that will select two students and two researchers who will be recognized with the IGU Best Poster Awards. Besides, two more Special Awards will be given to them keeping in mind the big number of poster presenters. We have also organized a special session for the Young Researchers with a view to venture their scientific calibre and recognize them through the Best Presenter Award along with a Runner-up. We also encourage participation of students and young researchers by providing them with 4 IGU-ONGC best poster Awards. We inspire the first and second rank holders of M.Sc. Tech. students in Applied Geophysics from different universities by providing

them with travel support, fee-waiver and free accommodation from Prof Jagdeo Singh and Dr. S. Balakrishna Memorial Grant. We have introduced Anni Talwani Memorial Grant to encourage 4 Young Women Researchers to participate in the convention.

Since seniors have contributed significantly by laying a strong foundation to build long lasting structures of quality we have been honoring senior earth scientists with National awards/ medals/ prizes and memorial/endowment lectures. As usual, IGU honours both the young and senior geo-scientists for their excellent contribution to Indian Earth Sciences through 4 National Awards/Prizes and 5 Memorial/Endowment Lectures. Every year, IGU also recognizes Earth Scientists through fellowships. Only 1 Memorial and 1 Special Lecture will be presented at the convention. The remaining memorial/endowment lectures will be arranged at other institutes/ organizations round the year for the benefit of greater audiences and to create more interaction.

The deliberations are brought out mainly as abstract volumes and sometimes as proceedings volume. Besides, IGU has been publishing its own journal during the last 21 years. We salute Dr. P.R. Reddy for his remarkable contribution to make the journal an open access bi-monthly ESCI journal of Clarivate Analytics (formerly Thomson Reuters). He has endeavoured to make it an SCI accredited publication. The journal is already recognized by NISCAIR, UGC and ICI, and provides an opportunity for scientists/researchers to publish their results/discoveries covering topics of local importance in addition to fundamental geosciences. To encourage authors, IGU also bestows the best paper award among the papers published in its journal in a calendar year. It has its own website www.j-igu.in and may be visited for further details. I request all the presenters to submit their full papers at its journal for publication.

We are happy to see that IGU is healthy and growing, which have been possible due to significant contributions made by the past and present Executive Committee (EC) members. The visibility has been increased by associating with other geo-scientific associations like AGU and SPG. Efforts are on to make IGU an internationally reputed scientific society, and to organize special talks on topics of region specific, current interest and relevance to societal welfare. At present we have 900 members and a Drive is on to increase the Number. IGU is working hard to start its Chapters from Different Regions. During the last three years, we have created five

Students' Chapters at NCAOR-Goa, IIT(ISM)-Dhanbad, CSIR-NGRI-Hyderabad, IIT-Roorkee, IIT-Mumbai. They organized Quiz competitions, Memorial/Endowment Lectures, 'Interaction cum Poster Presentation', and we look for similar initiatives by other Institutes/organizations. Since the motive of IGU is to encourage young researchers for improving/increasing research capabilities and widen their knowledge, the senior scientists are hereby requested to instill their vast experiences into young researchers and provide them guidance for sustainable development and growth of society by utilizing the IGU platform.

We are indebted to Prof. Shailesh Nayak - President of IGU for his invaluable suggestions and providing meticulous direction for this convention. For organizing the convention, we have received suggestions from many well-wishers. We shall fail our duty if we do not express our gratitude to Prof. Harsh Gupta and Prof. V.P. Dimri for their guidance. We place on record our sincere thanks to Dr. P.R. Reddy for extending unequivocal support in structuring the convention and sparing valuable time in editing most of the abstracts. We thank Dr. VM Tiwari (LOC-Chairman), Dr. Srinagesh (LOC-Convener), Dr. Ajay Mangalik, Dr. EVSK Babu and many more scientists of Local Organizing Committee for their committed involvement in organizing the 54th Annual Convention. Thanks are due to Dr. Sateesh C. Shenoi, Prof. Talat Ahmad, Dr. A.K. Chaturvedi, Dr. Sunil K Singh, Prof. Madhusudan Rao, Prof. B.V. S. Murthy, Dr. S. Rajan, Prof. Manik Talwani, Prof. Mrinal Sen and many others. We sincerely thank all the Fellows and Members of IGU for their support. We also thank chair persons of various technical sessions for conducting the proceedings as scheduled. Special thanks are due to Mr. Rafique Mohammad Attar, Treasurer of IGU for executing various works related to this Convention.

The convention like this cannot be organized without budget. MoES-Indian National Centre for Ocean Information Services (MoES-INCOIS), MoES-National Centre for Antarctic and Ocean Research (MoES-NCAOR), Indian Institute of Geomagnetism (IIG), CSIR-National Geophysical Research Institute (CSIR-NGRI), CSIR-National Institute of Oceanography (CSIR-NIO), National Remote Sensing Centre (NRSC), Ministry of Earth Sciences (MoES), ESSO-National Centre for Earth Science Studies(ESSO-NCESS), SERB- Department of Science and Technology (SERB-DST) and Council of Scientific & Industrial Research (CSIR) are acknowledged for financial support.

We also thank Himalayan Heli Services Pvt. Limited, New Delhi, and SBI, Hyderabad for financial support and putting stall to demonstrate the state-of-the-art services or products related to acquisition, processing/modeling and interpretation of Geo-scientific data. I request all the delegates to visit the Exhibition Stall and gain the expertise and infrastructural facilities available.

Finally, we solicit your cooperation for uninterrupted conduction of all sessions and better presence of delegates. We request the speakers and session-chairman to restrict to the time allocated for presentation. Delegates are requested to contact Dr. ASSSRS Prasad or Mr. Rafique Mohammad Attar for any help and assistance.

Wishing the IGU-2017 in Hyderabad a resounding success.

Kalachand Sain,

ASSSRS Prasad

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SCIENCE ON THE EDGE

ESSO- National Centre for Antarctic and Ocean Research (NCAOR)

under the Ministry of Earth Sciences is a nodal institution studying the Polar Regions and surrounding oceans.

ESSO-NCAOR, India's one of the premier R & D institution was dedicated to the nation on 5th April, 2000. Being a nodal agency for coordinating and implementing the Indian Polar Science Programs, NCAOR organizes scientific expeditions to Arctic, Antarctic, Himalaya (Three Poles) and Southern Ocean (SO). Currently, India maintains permanent research bases ("Bharati" and "Maitri") in Antarctica, "Himadri" in Arctic, and "Himansh" in Himalaya. Yearly scientific expeditions are undertaken in the Southern Ocean and polar seas during the austral summer. NCAOR conducts research on ice and sediment cores to reveal past climatic history, Climate change studies, teleconnection between polar regions and tropics, polar and marine biology and biogeochemistry including microbiology, using in-situ and remote sensing observations. Apart from polar science, NCAOR is mandated with geo-scientific studies which include Extended Continental Shelf program, mapping Indian Exclusive Economic Zone, Exploration for Hydrothermal Sulphide Mineralisation, International Ocean Discovery Program, understanding Indian Ocean Geoid Low, etc.

Major Thrust Areas


Climate change studies


Ocean-Atmosphere Interaction


Ice core studies


Polar Limnology


Himalayan Glaciology


Paleoclimatology and Paleoceanography


Southern Ocean Processes


Microbial Biodiversity and Biogeochemistry


Exclusive Economic Zone Survey


Extended Continental Shelf Mapping


Environmental Impact Assessment


Exploration for Hydrothermal Sulphide Mineralisation


Polar Remote Sensing

Achievements

- ✓ NCAOR is truly trans-hemispheric organization working on all poles and oceans.
- ✓ Successfully launched 36 scientific expeditions to Antarctica, 9 expeditions to Southern Ocean and more than 10 expeditions to Arctic
- ✓ Established two permanent and over-wintering research bases in Antarctica (Maitri and Bhrarti); 'Himadari' research base in Svalbard, Arctic and 'Himansh' research base in upper Himalaya
- ✓ Established India's first and only Ice Core Laboratory
- ✓ Undertook India's first scientific expedition to the South Pole
- ✓ Deployed India's first multi-sensor mooring in the Arctic called IndARC within Kongsfjorden, Svalbard


Indian Research Base in Antarctica- Bharati

Please join us to explore and understand the Polar Regions and surrounding water for the benefit of mankind

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Science and Engineering Research Board (SERB) is an autonomous body created by an Act of Parliament, viz. the Science and Engineering Research Board Act, 2008 under the Department of Science and Technology (DST), Ministry of Science and Technology, Government of India.It is expected that the autonomous structure of SERB will bring in more professionalism at the implementation level while unlocking the resources of DST to focus on policy matters and larger issues in the overall national context. SERB is committed to promote individual centric excellence in scientific research and development of overall S & T ecosystem in the country.The core objectives of SERB are,-

- To serve as a premier multi-disciplinary research agency for planning, promoting and funding of internationally competitive research in emerging areas,
- To identify major inter-disciplinary research areas, and individual groups or institutions and funding them for undertaking research,
- To enable to achieve synergy between academic institutions, research and development laboratories and industry for promoting basic research in science and engineering, and
- To evolve a management system to speedily provide for funding research, including monitoring and evaluation, by adopting modern management practices.
- There are several programs running under SERB as given below,
- R & D Programs (Core Research Grant, Start-up Grant for Young Scientists, Intensification of Research in High Priority Areas, Empowerment and Equity Opportunities for Excellence in Science, Track Based Research Funding, etc)
- Fellowships (J.C. Bose Fellowship, Ramanujan Fellowship, Prime Minister's Doctoral Fellowship, SERB Distinguished Professorship, Overseas Doctoral Fellowship, Overseas Post-doctoral Fellowship, National Post-Doctoral Fellowship, etc)
- Global Linkages (SN Bose Scholar Program, SERB-NSF Graduate Student Exchange Program, Indo-US Grand Challenge Initiative on Affordable Blood Pressure Management Technologies, Partnership for International Research and Education, etc)
- S&T Support Systems (International Travel Support Scheme, Assistance to Professional Bodies & Seminar/Symposia, etc).

For more details visit SERB portal at http://www.serb.gov.in and www.serbonline.in

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Atmosphere and Planetary Sciences

Anni Talwani Memorial Grant for Women Researchers

SOLID EARTH GEOSCIENCES

PALAEOSEISMICITY: HISTORICAL, ARCHAEOLOGICAL & GEOLOGICAL EVIDENCE OF PAST EARTHQUAKES

A B ROY

Former Professor of Geology, ML Sukhadia University, Udaipur
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Seismicity or seismic susceptibility implies proneness to earthquake incidence in a region. For this we cannot depend entirely on instrumental records, because the facility was unknown till 1897 Great Assam earthquake. The gestation period between two successive major earthquakes may be of several hundred years or more. Pre-instrumental earthquakes come under the domain of Palaeoseismicity, evidence for which comes from historic, archaeologic & geological records. Historical records about the incidence of earthquakes are scanty and contain incomplete details.

Scanning through the records of the prehistoric/ archaeologic periods we find some place names which provide indirect hints about calamities, which cannot be due to anything else other than earthquakes. Hints come from the names of Harappan Sites like Mohen-jo-daro which means 'Mound of Death' or Lothal which means 'Place of death'. Such massive calamities (described as the Archaeological Catastrophes) could only be caused by incidence of earthquakes. At Kalibangan on the Gaggar River some palaeoseismic evidence is recorded in a pre-Harappan site hit by an earthquake of over 8 (in Richter Scale). Some earthquake related destruction of structures is visible at the archaeological site at Mohen-jo-daro. There is a long standing debate on how such a human massacre could have taken place at Mohenjodaro? We don't need to be a forensic expert to understand that the deformed skeletons resulted from a catastrophic disaster. The logical explanation which archaeaologists did not think about is the earthquake. The meaning of Lothal (a combination of *Loth* and *(s) thal*) in Gujarati to be "the mound of the dead" is not unusual, as the name of the city of Mohen-jo-daro means the same We visited the Harappan 'metropolis' Dholavira located in an island in Great Rann of Kachchh in search of evidence of palaeoseismicity. We could see some evidence of earthquake-related destruction at some spots. Beyond historical and archaealogical records, evidence of earth-movements comes from geological evidence of faulting in not so distant geological past.

With these background information, it would be useful to turn on to an enigmatic geomorphic feature showing unusual development of sand dune (Talakad Sand dune) amidst a flat-lying floodplain on the bank of the Kaveri River near Mysore in Karnataka.

On close examination, one would find hosts of temples, mostly in dilapidated condition, which were presumably built during the period dating back between 6th and 17th century AD, entombed under a pile of riverine sand dunes, presumably formed during an 'eco-disaster' that lashed the region in the 17th century. Field studies coupled with archaeological reports on excavation, however, indicated that the mound made over destroyed temples is not entirely made of dune sands. Virtual absence of sand deposits over some severely damaged temples occurring near the top suggests that destruction could not have taken place only because of the load of the overlying sands. On the other hand, the scale of destruction witnessed in some of the affected temples can only be explained by the incidence of earthquakes of high magnitude. Additional proof of earthquake-related destruction comes from the occurrence of sedimentary layers (beds) containing fragmented pieces of building materials like bricks and stones in silt and clay-bearing flood plain deposits at the sites of the destructed temples and other buildings. Historical records of repeated renovation or rebuilding of temples at the same place provide further proof of recurrent incidence of earthquake-related destruction. Geomorphic changes manifested in the form of shifting of river courses consequent with the rise of the sediment mound also indicate uplift-related earth movements which must have ensued repeated earthquakes in the region.

Several possibilities are thought of about the cause of destruction of the Talakad temples. One of that could be the flooding of river banks during monsoons. Vulnerability of the temples to the ravages of floods may be a likely suggestion in view of the fact that these were constructed close to the river bank. However, considering the fact that Talakad is situated amidst a well-spread out flat alluvial plain of the Kaveri Basin, there can hardly be any chance of floodwater becoming a destructive force to cause damage to the temples. The occurrence of small (around 5 mm in diameter) river-worn, well-rounded quartz pebbles embedded in clay–silt matrix reported from several excavated trenches also implies low-energy water current in the flood plains, which in no way can be a factor causing destruction of the Talakad temples. Similarly, we can also rule out any possibility of mudflow along the course of a meandering river flowing through flat alluvial plain. Mudflows develop when a river follows steep mountain-slopes generally triggered by volcanic eruptions and associated seismicity. Reporting the tumbledown condition, especially of the Jain temple and the surrounding 'basadi' (meaning settlement) areas, the archaeologists advocated possibility of 'ransacking' of the temple site inferring possible inter-religious rivalry . However, considering the fact that all the temples in the sand-covered area belonging to different sects are in dilapidated condition, we may also exclude the possibility of anthropogenic vandalism as the cause of destruction of the temples. Finally, considering the constraints in all the above stated causative forces, the only possibility may be that destructions were caused by repeated incidence of earthquakes. Geological proof of earthquake-related destruction of the Talakad region comes from the occurrence of sedimentary layers (beds) containing fragmented pieces of building materials like bricks and stones in silt and clay-bearing floodplain deposits at the sites of the destructed temples and other buildings. Occurrence of floodplain type deposits mixed with earthquake-related debris at a height between 15 and 20 m above the present-day river channel by itself provides unequivocal evidence for uplift of the pre-existing river bank, where the Old Talakad township was located in geologically recent times. We relate the uplift-related geomorphic changes and the southward shifting of the river course consequent to the rise of the sediment mound as an additional proof of the uplift related recent earth movements in the area. The evidence of landform changes coupled with records of seismicity data covering a period of over 600 years, and the archaeological record of repeated renovation or reconstruction of temples at the same place provide proof of recurrent earthquake events in the region. In summary, the destroyed temples of Talakad may be considered as a classic case of archaeology.

ASSESSMENT OF GROUNDWATER QUALITY IN THE PATANCHERUVU INDUSTRIAL DEVELOPMENT AREA IN GREATER HYDERABAD, TELANGANA STATE

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Assessment of groundwater contamination in industrial development areas (IDAs) in Greater Hyderabad area has been carried out to prognosticate its environmental impact on water resources. The untreated industrial waste and toxic chemicals from underground storage tanks contaminate groundwater. These activities can generate pollutants and slowly begin to move through the subsurface environment. The effects of pollution may remain in the aquifers for years because of the residence time of ground water is very slow, and may even result in aquifers or parts of aquifer being damaged beyond repair. The main objective of the present study is assessment of environmental impact on groundwater contamination, if any, due to discharge of waste water from industrial development areas in Greater Hyderabad. The depth to groundwater table from the surface varied from 6.6 m to 25 m

(bgl) with a mean value of 12.2 m. The pH value of water samples has been varying from 6.2 – 7.6, with an average of 6.78, and the Total dissolved solids (TDS) of groundwater samples range from 300 – 4000 mg/l with an average of 1500 mg/l. Heavy metals such as Al, Fe, Mn, Cr, Cd, Co, Ni, Se, Pb, concentrations are found to be above permissible limits. The Electrical Resistivity Tomography (ERT) surveys indicate occurrence of weathered/fractured aquifer, with presence of top layer of alluvium/ weathered aquifer in the Nakkavagu of Patancheru IDA. Occurrence of low resistivity formations up to 5-6 m depth from ground surface was evident from the inverse resistivity model sections of ERT. The low resistivity formations being highly porous allow fast movement of water impounded on the ground or in the streams. Hazardous and industrial wastes with heavy and toxic metals released from industries are entering the surface water and groundwater systems and migrating further towards the Manzira River Reservoir. Such a migration is a great cause of concern as the effluents are polluting the entire hydrological system and aquifer regime of the area.

POTENTIAL OF SHALE GAS IN CAMBAY BASIN: PRELIMINARY STUDY

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Cambay basin can be divided in to three sub basins. These are Cambay basin, Saurashtra basin and Kutch basin. Shale samples were collected from Rajpardi, Tadkeshwar, Mata-No Madh, Surkha and Panandhro lignite mines of Cambay basin. In some of the lignite mines shale core was available for the present study. The data on shale associated with Tadkeshwar lignite mine is very encouraging and need further exploration. Majority of the shale samples from Rajpardi lignite mine are not very encouraging, from shale gas point of view. A few samples, however, have yielded encouraging information, pertaining to potential of shale gas. Those areas that contain encouraging data need detailed investigation for shale gas exploration. The shale samples from Panandhro and Mata-No-Madh lignite mines from Kutch basin were also sampled and analysed for their shale gas potential. The pyrolysis data on these shales show high TOC, S1 and S2. The organic matter contains Type II or Type II kerogen, which has very good potential for hydrocarbon generation. Further petrography and mineralogy work is required to assess the potential of shale gas in these formations. Shale samples were also collected from Surkha lignite mine Bhavnagar in Saurashtra basin. Saurashtra basin is bounded by the Kutch and Cambay rift basins to the north and east and Surat depression to the south. The basin forms a horst block. The shale samples were collected from Gaj formation of Middle Miocene age. The Rock Eval pyrolysis data of the carbonaceous shales from Gaj formation of Surkha mines show high TOC (expand) content. They show the associated gas is Type and also Type IV in thermally immature stage. The results are encouraging and further work is required for the assessment of shale gas potential.

The data in general is quite encouraging and more Petrographical and mineralogical study on these samples is required to better quantify the potential. To know the actual potential of shale gas, detailed analysis of core sample from gas oil well will be very useful to come to a conclusion regarding shale gas potential of the three different basins.

RIVER METAMORPHOSIS AND EVALUATION OF TEMPORAL TERRAIN CHANGES OF CHALAKUDY RIVER BASIN USING GEOSPATIAL TECHNOLOGY

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Rivers readily respond to crustal changes and river pattern metamorphoses through time. Rivers are geomorphological signatures of topographic evolution and the progression of all stages are fundamental to the understanding of the crustal processes of the terrain from time to time. The Chalakudy river, emerging from Anamalai hills of Western Ghats, is one of the 41 west flowing rivers and the fourth longest river system (130 km) of Kerala state. The major portion of CRB is covered by densest evergreen reserve forest of Anamalai, Nelliyampathy, Malayatoor, and Kodasseri. The Athriappilly and Vazhachal waterfalls in the mainstream append the aesthetic signature to the state of Kerala and have been attracting National and International tourists over the years. The river is heavily utilized for hydroelectric power generation and six dams and one diversion weir are constructed in the tributaries. The temporal terrain changes evaluation is relevant in the context of the implementation of proposed Athirapilly hydroelectric power project and alternative thinking of exploring new energy sources to meet the electrical power demand of Kerala and hence protecting the riverine ecosystem.

The general notion of the construction of dams affects the forest cover and environmental setup of a river basin is purely based on a conceptual perception. Geospatial technology coupled with analysis of multi-temporal land survey datasets and remote sensing data products serves as an effective tool for evaluating the extent of temporal forest cover and drainage network changes occurred due to anthropogenic and geologic processes. The land survey data are derived from the Survey of India (SOI) toposheets (surveyed on 1909-10, scale 1:63,360 and published in 1912) and open series map published by SOI (details updated on 2004-05, scale 1:50,000 and published in 2010).The first order drainage networks are updated with Shuttle Radar Topographic Mission (SRTM) remote sensing data (2014) and analyzed using ArcGIS 10.4 software. The terrain and drainage network changes over the past hundred years can be deduced from the multi-temporal data sets and the extent of variations in the land use patterns can be evaluated. The temporal variations in morphometric analytical data including drainage pattern changes in the upstream part of the reservoirs, variation in drainage density and decrease in the number of first order streams are observed. Morphometric analysis of the river basin using GIS software and temporal land survey and remote sensing data is a powerful and reliable approach in eliciting signatures of the extent of structure and processes in shaping fluvial landscape.

SEISMIC TOMOGRAPHY IN DECCAN VOLCANIC PROVINCE OF WESTERN INDIA: CRUST-MANTLE VELOCITY STRUCTURE AND INTRAPLATE SEISMICITY

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The north western Deccan Volcanic Province (NWDVP) in India has undergone major tectonic changes during the Eocene–Paleocene, when voluminous eruptions took place due to interaction of the Indian plate with the Reunion plume. The intense seismic activity makes this region as the most vulnerable intraplate earthquake zones, world over. In this study, we utilize arrival times of 93,140 P and 92,763 S phases from waveforms of 6,564 events registered at 93 seismic stations to obtain high resolution tomographic images of the crust and uppermost mantle beneath the NWDVP, down to 50 km depth. The images shed light on the relation between seismicity and seismic structure in the source

regions of two large earthquakes (Mw ≥ 7.7) at depths > 20 km in the rift basins, shallower moderate (Mw ~5) quakes and swarm, induced activity in the horst region. Higher Vp/Vs ratios are observed for the seismogenic rock matrix with entrapped magma fluid that played an important role in triggering large and moderate tectonic earthquakes. High Vp/Vs ratios are also observed in the uppermost crust, indicating that fluid in sediments/fractures triggered the swarm and induced seismicity. The source zones of the shallow, mining induced seismicity are imaged as low Vp, Vs zones. The vertical and horizontal intrusions of the Deccan volcanic magma in the uppermost mantle and lower crust are also well imaged as high Vp and Vs anomalies. Variations in the depth to the Moho and lower crustal velocities signify alterations due to tectonic processes during different time scales.

SEISMIC CODA DECAY IN THE REGION OF KUMAON HIMALAYA

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Alocal earthquake dataset from the Kumaon Himalaya region is studied to determine the character of coda amplitude decays. 327 records from 67 events are analyzed. Instead of assuming a fixed geometrical spreading of coda amplitudes and a coda $\boldsymbol{Q}$, we estimate the time decay by using an empirical $\boldsymbol{t}^{-\alpha}$ formulation. We make no restrictive assumptions about the model and instead use the observed data to calculate α of coda waves. The values of α are found generally between 1.5 and 2.5, with an average of about 1.9 within the region. The Kumaon Lesser Himalaya has $\alpha \approx 1.75$ and Kumaon Greater Himalaya has $\alpha \approx 2.05$. We also compare our results with previous studies by using the conventional coda $\boldsymbol{Q}$ methodology and find $\boldsymbol{Q}_c = 78\boldsymbol{f}^{1.05}$ in Kumaon Lesser Himalaya, $\boldsymbol{Q}_c = 90\ \boldsymbol{f}^{1.09}$for Kumaon Lesser Himalaya, and $\boldsymbol{Q}_c = 90\ \boldsymbol{f}^{0.92}$ for Kumaon Greater Himalaya. The α is mostly frequency-independent, but we also observe frequency dependent α in a localized area.

We interpret our results in terms of a scattering model considering different types of waves comprising the coda. The first conclusion from this study is that the value of α varies regionally but its average value does not vary much and is correlated with type of rocks in upper crust. Second, the observed geometrical spreading is much higher than the value $\alpha = 1$, generally assumed in coda studies. This observation shows that coda does not consist of body wave scattered within a uniform crust. We find that the backscattered field in the coda is dominated by surface waves. Third, the α is very weakly frequency dependent. This weak frequency dependence α has major implications for estimating other attenuation parameters such as $\boldsymbol{Q}$. Near-constant α causes very steep frequency dependences of $\boldsymbol{Q} \propto \boldsymbol{f}$, which can cause serious biases in seismic hazard estimation. Fourth, the α increases with lapse time from $\alpha \approx 1.7$ to $\alpha = 2.2$,and no azimuthal variations of α were detected.

AN IDENTIFICATION OF BAYYARAM IRON ORE REGION FROM MAGNETIC SURVEY,TELANGANA STATE INDIA

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Geophysical surveys play prominent role in the study and exploration of mineral deposits. Occurrence of mineral deposits is controlled by lithology, structure and stratigraphy, which in turn reveal contrasts in physical properties. When physical property contrast is high and such zones are extensive and nearer to the surface, geophysical signatures will be quite useful in locating mineralized

zones. Else a systematic combination of geophysical methods and techniques of extracting weak signal in the back drop of large noise are to be employed. Basically Gravity, Magnetic and electrical methods are the suitable methods to identify and estimate mineral deposits in complex geological situations. Geophysical logging is an important tool to the geophysical armory in proving and estimating the mineral deposit.

The iron ore, mainly hematite deposits of Bayyaram, Khammam district Telangana state are located in a complex geological setting at the contact zone between the Peninsular gneissic coplex and the Proterozoic Pakhals with the structural geometry reshaped by the tectonic movements of the Godavari graben and sequences of dolerite intrusions at different times. As the iron ore occurrence of Bayyaram is being given attention by the government, as a pilot program , a reconnaissance ground magnetic study was taken up by the authors on a part of the Bayyaram iron ore zone. Five reconnaissance traverses in near East-West direction covering the available tracks and roads were laid using a total field magnetometer. The length of each traverse is nearly 5km with a separation of 1 to 1.5km between successive traverses. Magnetic readings were recorded at every 50m spacing along each traverse. After corrections data from the total magnetic anomaly profiles have been used to prepare a contour map. Analyzing through processes like upward continuation, vertical derivative and analytical signal, anomalous trends and zones were identified to assign appropriate geological answers. Utilizing the physical property values measured on first hand field samples and with the available geological information, possible locations of valuable iron ore concentrations were identified. Quantitative assessment of some of these interesting anomalous pockets was also attempted to study the attitude and extent of these iron ore occurrences. Further studies employing gravity and electrical methods would be helpful to estimate these iron ore occurrences more precisely.

GEOPHYSICAL STRATEGY FOR MANGANESEOREEXPLORATION IN COMPLEX GEOLOGICAL SITUATION – EXPERIENCE IN JODA WEST BLOCK, JAMDA – KOIRA BELT, WEST SINGHBHUM REGION

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The Replacement type manganese deposits of Jamda-Koira (J-K) belt of West Singhbhum region occur in a more complex geological situation than those Syngenetic Gonditic deposits of Central and Western India or the Syngenetic Reef deposits of Khondalitic Eastern Ghats. The Replacement nature of occurrence associated with the basal shales and conglomerates underlying the Banded Iron Formations, the structural complexity with the over turned/ recumbent folding, consequential faulting, the younger dolerite intrusions and the manganese occurrences in the overlying laterite – all contribute to the uncertainty in identifying the deposits by conventional methods. The geophysical methods like Magnetic, Electrical Resistivity and Gravity, which have shown success in the other regions when applied as independent methods or in combination are also not that effective in this J-K belt area. As such a selective sequential integrated geophysical approach is the way for manganese prospecting in this region.

A combination of gravity, magnetic and electrical resistivity surveys was employed in the Joda West Block of size 900m x 800m in Keonjhar District of Odisha. Besides the natural geological complexities, the surface is camouflaged by the old workings, dumps and drainage alterations. A net-

work of 400 gravity observations (40m x 50m grid), over 4000 magnetic observations (10m x 20m grid), 92 Electrical soundings (VES) and Electrical Resistivity Profiling at 5m station interval along 9 W-E traverses spaced at 120 m covering the entire Block were distributed in the area.

Reduction, processing and analysis of these geophysical data revealed significantly:

i. The central gravity high zone of about 100-150m width trending in N-S direction in the northern half then turns toward SE .In addition a few isolated gravity highs are present along the western boundary of the Block.

ii. Magnetic anomaly trends are corroborating with the gravity trends.

iii. Electrical Resistivity marker boundaries aligning in the above said direction are nearly matching with the central gravity high belt and

iv. A diagnostic resistivity- depth variation from VES interpretation controlled by surface topography suggests possible manganese occurrence zones.

Based on the above results and experiences in a few other blocks in the J –K belt, most likely pockets of manganese occurrence in Joda West Block were inferred at four locations. Feed-back from mining agency is awaited

SOIL CLASSIFICATION AND V_{S30} MAPPING FOR SEISMIC SITE EFFECT ESTIMATION IN GUJARAT REGION, WESTERN INDIA

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The Gujarat state is located in the western most part of India and covers an area of 19, 62,04 sq. km with a ~1600km long coastline. In 2001, a large earthquake of Mw 7.7, occurred in the Bhujregion. This is considered as the largest intraplate earthquake world over,which caused losses to both property and lives. It was noticed that during the earthquake site- effects played a major role in certain regions. Thus, the evaluation of site-effects for the Gujarat region is essential for seismic hazard, risk assessment, land use planning and emergency planning. We carried out shallow subsurface investigations at ~ 600 sites using integrated approaches such as MASW, PS-logging and Microtremor covering all types of geological units in the study region. We classified the Gujarat region into four soil classes and developed a site condition map for the region based on the V_{S30}. The results show that the V_{S30} of Granites and Deccan traps are in the range of 760–1500 m/s, suggesting that the units are of B type formation. The V_{S30} of Tertiary, Cretaceous, Jurassic and Palaeo-proterozoic sediments is in the range of 360-760 m/s. These formations are classified as the C type. The Quaternary and Rann sediments show V_{S30} in the range of 180–360 m/s and are classified as D-type. The Holocene tidal flats show $V_{S30}$of about 180 m/s, which are classified as E-type soil. Finally, we prepared a site condition map of Gujarat based on Vs_{30} of corresponding geological-lithological units. We assessed the consistency of Vs_{30} values within generalized-geological classes. We validated our results with the available geological, geotechnical and seismological data. We also compared our results with the damage distributions due to past large earthquakes in the study region.

LOW DEFORMATION RATES IN THE KOYNA-WARNA REGION FROM A DECADE OF GPS MEASUREMENTS

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The Koyna–Warna regionin the stable Indian plate experienced a strong earthquake on 10 December 1967 (M 6.3). This strong earthquake and the continuing earthquake activity in the region are considered to have been triggered by the impoundment of the Koyna reservoir and later on by the Warnareservoir. The earthquakes occur in a very small region of 30x10 km^2in two well defined seismic zones, the NNE–SSW trending Koyna Seismic zone, and the NNW–SSE trending Warna Seismic Zone. These zones are characterised by predominantly left-lateral strike slip motion and normal motion,respectively. In 2003, we initiated campaign-mode GPS measurements. Presently five continuous GPS stations are being operated in this region. Analysis of the GPS data collected for over a decade indicates low to moderate deformation rate ($<1.2\pm0.1$ mm/year) at a few sites to the east of the seismic zones. Such low rates have been seen in many intra-plate seismic regions of the world with varying causative mechanism for the deformation. We propose that the observed surface displacement rates of up to 1.2 mm/year in the northeast direction at sites to the east of the seismic zones load the fault zones and cause earthquakes consistent with the respective focal mechanisms of the Koyna and Warna seismic zones.

MAPPING COMPLEX GEOLOGY AND TECTONICS FOR GROUNDWATER EXPLORATION IN DIFFERENT GEOLOGICAL TERRAINS – A NEW EXPERIENCE

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Groundwater resource is vital for the human. Groundwater prospecting, exploration and exploitation are a challenging task when it comes to its availability in various types of hard rocks. In hard rock terrain locating and pin pointing the water bearing strata, saturated fracture(s) for groundwater resources and their sustenance has become vital due to inadequate surface sources.

Water scarcity is prevalent in hard rocks with no primary porosity namely in granites, volcanic rocks as well as other types of hard rocks present in complex geological terrains of Central, Western, Eastern and Southern parts of India; where we have an introductory information on groundwater exploration from the past geophysical studies. Water availability in these hard rocks is only possible when they develop the secondary porosity during tectonic disturbances in the earth`s interior. The extent of the secondary porosity depends on the intensity of tectonic disturbances. The extent of secondary porosity ultimately decides the availability and amount of water within the geological matrix of the hard rocks. As rains and the large body surface waters are the main sources of water recharge, one has to take in to consideration presence of such recharging surface water sources before taking up exploration and exploitation of ground water, even in zones that probably contain rocks with secondary porosity to ensure sustainability of any ground water sources.

To explore the possibility of groundwater availability in such geological terrains is a major task for the geoscientists. The groundwater exploration and development requires a well planned approach through the integrated geophysical studies to delineate the geological strata, horizons and formations within the hard rock region. Here in this paper, three unique experiences from recent studies are discussed.

A study was carried out at Choutuppal, Telangana, India under the pivotal research project of societal relevance. The true resistivity models generated using inversion in conjunction with the measured apparent resistivity dataset helped in resolving geological/lithological formations, structures, basement topography, depth to bedrock and the potential groundwater resource in the complex granitic terrain. It is concluded that the shallow (<30m) groundwater zones are meager and the best productive groundwater zones lies between 45m to 100m depth. Here resistivity tomography method is well suited to map the hard inner structure of a granitic rock as it gives not only the resistivity values and the contrast based on the physical, chemical and hydrological parameters of the different layers, nevertheless it also provides information on heterogeneity of the lithological variations of the rock.

A new experience is faced when we worked in a drought prone area of Tadipatri mandal, Anantapur district in Andhra Pradesh for prospecting, exploration and exploitation of groundwater in a complex and mixed geological setting underlain by limestone, shale and quartzite rocks. The integrated study revealed a wide variant in water holding capacity in the subsurface geological strata. The collected lithologs of the drilled boreholes based on geophysical anomalies aid in calibrating and refining the interpreted model results of the area in order to upscale the hydrogeological knowledge .This eventually helps in building the realistic conceptual model of the aquifer system in a drought prone area. This was practically experienced.

Another unique study was conducted near Namkum Ranchi, Jharkhand, which is underlain by Chhotanagpur granite gneiss of pre-Cambrian age. The 2D inverted resistivity datasets clearly mapped and delineated the high resistivity geological features and structures. The high resistivity of the subsurface geological formation is well delineated and shows a large resistivity contrast within the complex geological setting. The high resistivity of the subsurface formations ranges from ~2500 Ohm.m to a maximum ~3.5×10^5 Ohm.m. The resistivity of the groundwater prospect zones range from 50 to 650 Ohm.m, which depicts the differential weathering and fracturing of the hard rock and with different amount of water saturation within the weathered-fractured rock matrix. The model results were validated by drilling at four borehole sites up to a depth of 200m with yields ranging from 2.5 to 4.0 inch, which is equivalent to ~4930 litres/hr to 15944 litres/hr of groundwater. These high yields are from a good aquifer zone in this plateau region of Chhotanagpur gneissic complex region.

SCALING RELATIONS OF MOMENT MAGNITUDE, LOCAL MAGNITUDE, AND DURATION MAGNITUDE FOR EARTHQUAKES ORIGINATED IN SHILLONG-MIKIR PLATEAU OF NORTHEAST INDIA

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In this study, we aim to improve the scaling between the moment magnitude (M_W), local magnitude (M_L), and the duration magnitude (M_D) for 162 earthquakes in Shillong-Mikir plateau and its adjoining region of northeast India by extending the M_W estimates to lower magnitude earthquakes using spectral analysis of P-waves from vertical component seismograms. The M_W-M_L and M_W-M_D

relationships are determined by linear regression analysis. It is found that, M_W values can be considered consistent with M_L and M_D, within 0.1 and 0.2 magnitude units respectively, in 90% of the cases. The scaling relationships investigated comply well with similar relationships in other regions in the world and in other seismogenic areas in the northeast India.

DUCTILE BEHAVIOR OF HIGH GRADE GNEISSES ALONGPALGHAT-CAUVERY SHEAR ZONE: GONDWANA CORRELATIONS

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Palghat Cauvery Shear Zone (PCSZ)is a regional Precambrian tectonic dislocation zone in Southern India, marking the northern boundary of Madurai Block. This is E-W trending and depicts a dextral movement. It provides a scope for studying structural characteristics in various scales developed in response to a transpression movement at mid crustal level, forming a part of crustal scale flower structure of Cauvery Suture Zone (CSZ). This shear zone contains granulite facies rocks as the major litho units along with mylonitisations throughout its extension. The present study analyses the ductile behavior of high grade gneissic rocks along south-eastern segment of the CSZ. Major lithologies in the region are migmatites, quartzo-feldspathic gneisses,biotite-amphibole gneisses, pyroxene granulites, calc-gneisses and mylonites. These rocks show a general trend of E-W strike and northerly or northeasterly dippingfoliation planes in a map scale. But these planar fabrics are characterized by complexfold geometry in mesoscopic scale with well developed stretching lineations. Structural styles associated with these rocks include, disharmonic folds, tight isoclinals folds, superposed folds, sheath folds, small scale shear zones, mineral stretching lineations, S-C fabrics, sigmoidal tension gashes, riedel shears etc. Micro-structural behavior of certain rock units in this region presents a unique approach of shearing fractures in terms of sigmoidal tension gashes. Petrography helped in redefining field based terminologies to ***sēnsūstrictō*** nomenclatures of the rock types observed during the field study. The granulites in the northern margin are both garnetiferrous and non-garneti ferrous, where as in western margin they are eclogitic in nature, containing atoll garnets within them. The granulites in the southern margin are showing very high grade metamorphism as the grain sizes are comparatively finer. So, from this it is clear that there is an increase in metamorphic grade when we move from north to south of the study area. Presented reconnaissance structural analysis has revealed pattern of tectonic evolution. Regional as well as mesoscopic kinematic indicators along all the shear zones are consistent with predominance of dextral movements along the CSZ system. Structural investigations and the petrographic approaches from the present study have great significance to the recent models on subduction tectonics of Southern Granulite Terrain and its correlations with Gondwana amalgamation.

EARTHQUAKE EARLY WARNING SYSTEM BY IOT

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Recent earthquakes are becoming major destructions to our mother earth. Opportunities for application of emerging technologies is becoming significant in the disaster management. Internet of Things (IOT) plays an important role by interconnecting intelligent devices and the network devices to connect for the purpose of sharing information and the earthquake data from the different stations. It also provides early warnings through sensor based technologies, thereby creating innovative and effective

systems for disaster management. IOT cannot stop the disasters happening but it will detect the early warning and slows down the major damages and the disasters during the process of the earthquake and help in for the preparedness of the disaster. IOT is mainly having the seamless interconnection with the different types of sensors and the smart phones. Different types of accelerometers are evolving with the help of the emerging technologies to identify and predict the early warning detection of the disasters. Internet of Things(IOT) makes the life better through early warning. Finally, IOT is creating safer and protective environment to face the disasters. The paper creates awareness and appreciation about the potential use and application of IOT for different aspects of disaster management.

ARE TRAPPED FLUIDS TRANSPORTED FROM DEEP CRUSTAL DEPTHS RESPONSIBLE FOR MICROSEIMIC ACTIVITY IN THE KACHCHHINTRAPLATE REGION?

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Fluids play a major role in weakening the strength of rocks by reducing the effective normal stresses across existing faults. The present study is an attempt to understand the role of fluids in the genesis of micro to moderate seismicity in the Kachchhintra plate region. The 2D geoelectric structure of the eastern part of the region derived from the magnetotelluric data acquired along two N-S profiles reveals the presence of a fluid reservoir in the vicinity of the Moho, below the epicenter of the Bhuj earthquake. Interestingly, a shallow (12-15km) fluidized zone is also identified at the Brittle-Ductile (BD) boundary associated with the Gedi fault.We infer that the northeast orientation of the horizontal maximum compressive stresses estimated in the region might probably stimulate the flow of the fluids from the reservoir. Injection of these into the crustal rock matrix might lead to hydro-fracturing. The mid crustal shear zone formed due to this phenomenon might be playing a key role in the flow of these fluids from the reservoir towards the surface that in turn get trapped at the BD transition zone. The release of fluids into the upper crustal levels can result in high pore pressures, thereby triggering earthquakes in the region. The shear zone along with the geometry of the existing faults seems to control the migration and/or occurrence of micro seismicity along the fluid path. Detailed 3D modeling of the region could further constrain the origin of the crustal fluids and image the oblique fluid pathways that possibly control the seismotectonics of the region.

REGIONAL MAGNETIC SURVEYS AROUND ADIKAVI NANNAYA UNIVERSITY CAMPUS, RAJAHMUNDRY

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A regional magnetic survey has been carried out around Adikavi Nannaya University Campus, Rajahmundry for understanding the relationship between the anomalies and the local geology. Most of the study area is occupied on surface by sedimentary formations viz., Rajahmundry sandstone, and Tirupati sandstone. A small linear patch of the area aligning in ENE- WSW direction is occupied by Deccan basalts /Rajahmundry traps of varying width (0.85 km to 3km). The magnetic anomaly values in the area vary between -200 nT to -1400 nT. The area lying between 17.06 ° N and 17.1° N latitudes is strongly magnetic and the area lying north of 17.1°N and south of 17.06N and south of

17.06° N latitudes is magnetically flat. Thus,the nature of the magnetic anomalies observed in this area is strongly correlating with the surface geology. High frequency and high amplitude magnetic anomalies observed in Rajahmundry trap and Tirupati sandstone areas are related to the shallow subsurface basaltic rocks. Extension of magnetic surveys into the surrounding regions and rigorous interpretation of anomalies, rock magnetic studies including paleomagnetic investigations may reveal information about the emplacement history of the basaltic rocks.

IMPROVED PROTOCOL AND TECHNIQUES OF PROCESSING OF MAGNETIC MEASUREMENTS AT CSIR-NGRI MAGNETIC OBSERVATORY

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Upgradation from one minute to one second data recording in keeping with accuracy standards of International Real-time Magnetic Observatory Network (INTERMAGNET) requires new approach in data acquisition and processing at CSIR-NGRI Magnetic Observatory (HYB). Data acquisition methodology and processing technologies were improved and modified. As per standards,control made on variation and absolute observations using improved methodology have modified the way of looking at the initial data. Methods of observational protocol have been improved by adopting new methods of observation, by taking precautions, calibration of instruments and improving the frequency of data checking. New MATLAB processing software scripts and functions with open codes have been employed to handle the enhanced noise level to achieve 1 nT accuracy of definitive data as per international standards. This work presents the techniques of achieving the above and discusses the significance of the results. These processing steps including reported data, elimination of noise due to urbanization, adjusted data calculations. Using these scripts have enabled 1) Visualization of data during every step of processing and 2) processing initial data step by step to produce the final data according to the standards. These processing steps have been applied to data of different magnetometers.

TOMOGRAPHIC IMAGING OF THE MAHANADI DELTA FOR HYDROCARBON EXPLORATION AND CRUSTAL STRUCTURE USING DEEP SEISMIC AND BOUGUER GRAVITY DATA TO UNDERSTAND ITS TECTONIC AND GEODYNAMIC SETTINGS

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Mahanadi delta is an important Gondwana rift-sedimentary basin of India with wide-spread volcanic activity during the Early Cretaceous along the rift zones, which corresponds to the breakup of greater India from East Gondwana super continent. Due to breakup and rifting, the delta has experienced wide-spread volcanic (basalts) activity. This has resulted in volcanic trap acting as a mask over sub trappean formations. Due to this delineating the hydrocarbon bearing Gondwana sediments, deposited within the grabens of the Mahanadi delta, has become very difficult using conventional seismic exploration techniques. However, by using the long-offset first-arrival seismic data and robust tomographic imaging technique, it has become possible to image the thick (3.0 km) column of hydrocarbon bearing Gondwana sediments (3.5 – 4.5 km/s) deposited below the basalts within the Cuttack-Paradip depression (the Gondwana graben). The tomographic image shows smooth velocity variations with alternate horsts

and grabens lying above the basement (5.9 - 6.1 km/s), which is highly undulated and distorted due to the presence of deep basinal faults. Presence of anomalous high-velocity deep seated dyke intrusions (5.5 km/s) has been imaged on either side of the Gondwana graben. High-velocity (6.5 km/s) magmatic material is found to lie below the basement. These dykes are volcanic in nature and emancipated due to the large volcanism (~ 117 Ma) during the Early Cretaceous period followed by the formation of the Early Cretaceous Volcanic Province (ECVP) in the conjugate rift zones of the Mahanadi and Lambert graben of East Antarctica. The modeling and inversion of both wide-angle seismic reflection and Bouguer gravity data in this delta show the presence of five-layer crustal model with velocities of 5.9, 6.5, 6.0, 7.0 and 7.5 km/s and densities of 2.7, 2.8, 2.65, 2.9, and 3.05 g/cm^3. The velocity-density relation along with the heat flux and other geological/geochronological information indicates typical rift-related evolution of the basin with the presence of mid-crustal low-velocity (6.0 km/s) and low-density (2.65 g/cm^3) zone and ~10 km thick high-velocity (7.5 km/s) and high-density (3.05 g/cm^3) layer at the base of the crust. There is significant Moho upwarping or crustal thinning in the rift zone and emplacement of thick high-velocity material at the base of the crust. This strongly suggests basaltic underplating due to the Kerguelen hotspot activity. These activities are synchronous with the ~117 Ma Rajmahal volcanism in the northeast India and formation of the Lambert graben in the East Antarctica. These tectonic activities are closely associated with the breakup of Gondwana in the India-Antarctica sector.

NEW INSIGHTSON THE LITHOSPHERE STRUCTURE AND RIFT TECTONICS BELOW NORTHWEST CONTINENTAL MARGIN OF INDIA THROUGH CONSTRAINED POTENTIAL FIELD MODELING

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Plate tectonic reconstruction models of the Indian Ocean suggest that the Northwestern Continental Margin of India had evolved due to the continental rifting and breakup processes between India, Madagascar and Seychelles since the late Cretaceous. Though several studies were carried out in this region, early spreading history and the exact nature of the crust underlying this region could not be well established due to the wide spread distribution of Deccan volcanism (DVP) both in the onshore and offshore regions. Detailed analysis of potential field data complemented by the existing seismic reflection/refraction and seismological data has provided new insights on crustal architecture of the margin and also explores the possible explanations for nature of crust below the several enigmatic basement features of the eastern basin. The Moho configuration obtained from seismically constrained 3-D gravity inversion reveals that Moho depths vary between 34-42 km below DVP and gradually thins to 16-20 km in the western offshore. Further, the presence of thin lithosphere and low rigidity (Te) values (12-25 km) in this region implies that the lithosphere below the Indian plate has been reworked in the past due to the combined effect of the lithosphere stretching during Gondwana fragmentation in the Mesozoic and subsequent thermal influence of the Reunion plume. Based on the crustal stretching factors (β), Te estimates and the modeled lithosphere geometry at the margin in this study, we propose that the lithosphere below Laxmi-Gop basin region ($\beta > 3.0$) had undergone continuous stretching since India-Madagascar rifting/much prior to this event. However, this continuous stretching did not lead to breakup; instead the developed necking zone got ceased by syn-rift cooling and resulted in the development of new necking zone between Seychelles and Laxmi ridge, which became continental silver. Subsequent stretching between Seychelles and the Laxmi ridge contemporaneous with the Deccan flood basalts eruption led to the seafloor spreading in the western basin (anomaly C28n).

GEOCHEMICAL AND GEOPHYSICAL INVESTIGATIONS ON THE QARATKIBRIT SALT DOME FAULTING SYSTEM SOUTH OF ADAM, OMAN - IN SEARCH OF URANIUM ANOMALIES

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Development of salt domes, often arising from depths of around 10 km or more, causes an intense faulting of the surrounding host rocks (salt tectonics). The fractured rocks then present ideal space for oil that can migrate and get trapped. If such moving of hydrocarbons pass uranium-carrying rock units (e.g., shales), uranium is collected and enriched by organic carbon compounds. Brines from the salt body are also ideal carriers for oxidized uranium species and will further dislocate uranium when in contact with uranium-enriched oils. Uranium then has the potential to mineralize in the vicinity of the dome (blue halite is evidence for radiation having affected salt deposits elsewhere in the world). Based on this knowledge, the Qarat Kibrit salt dome was investigated by two well established geophysical methods: (1) very low frequency electromagnetic (VLF-EM) and (2) magnetic surveys along five traverses approximately 250 m long at a measurement interval of 10 m in order to identify subsurface fault systems. Geochemical in-situ measurements along these traverses as well as chemical analyses of acquired samples in the laboratory were investigated for uranium, if any. In-phase and quadrature components of the VLF-EM signal were recorded at two different transmitter frequencies (24.0 kHz and 24.9 kHz) along with total magnetic field. The images of Fraser filtered response of the in-phase components indicate a conductive zone (fault) in the SE and SW segments of the study area. The Karous-Hjelt current density pseudosection delineates subsurface faults at depths between 10 and 40 m, which is substantiated by the spectral depth from the magnetic field. The stacked profiles of the Fraser filtered responses brought out two plausible trends/directions of faults. However, there seems to be no evidence for uranium enrichment.

ESTIMATION OF SITE RESPONSE BY SPECTRAL ANALYSIS INAN EARTHQUAKE PRONEREGION-A CASE STUDY

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The significance of site characteristics and its likely effects on land use planning or design of critical facilities has long been recognised and is a significant aspect in earthquake hazard reduction program. Among the available host of several methods, spectral studies of earth quake data including the micro tremor/modified micro tremor assumes great importance as it is not only reliable but also inexpensive and easy to implement. Accordingly, the data acquired from as many as 116 sites covering various rock units including alluvial soil in earth quake prone region of Jabalpur (Seismic zone III), Central India were subjected to spectral analysis in order to estimate the response of the ground. Also, the site response and amplification were also computed using an empirical relation based on the harmonic mean of shear wave velocity (V_{S30})up to a depth of 30 m estimated through MASW. It may be seen from the results obtained, that in alluvial soils with thick overburden, the signal amplification is found to be more at low frequency (less than 10 Hz) whereas in areas with thin overburden the amplification is found to be low at low frequencies. The salient feature of spectral study is that it is a rapid way of estimating the site condition instead of using short period seismometers for long

duration (2 to 3 days).Based on the overall study, it was inferred that the western part (predominantly alluvial soil) of the study area comes under moderate to high risk in comparison with eastern part wherein it is risk free or at low risk in the event of an earth quake.

GEOPHYSICAL INVESTIGATIONSFOR BASEMETAL MINERALIZATION IN KAROI–RAJPURA AREA, BHILWARA DISTRICT, RAJASTHAN

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The Karoi–Rajpura forms a part of the Pur–Banera belt in Bhilwara district, Rajasthan. Main rock types exposed in the area belong to rocks of Mangalwar Complex of Bhilwara Supergroup and metasediments of Pur–Banera Group. Regionally the Karoi–Rajpura area forms a part of western limb Pur syncline and all the rocks of the area have in general NE–SW to NNE–SSW trend with gentle to steep dip either due SE or NW. The rocks exposed in the area show surface indication of mineralization in the form of malachite staining and presence of primary copper minerals. The sulphide mineralization has been observed at several locations and the host rock for the mineralization is mostly calc–silicate rock. Integrated geophysical surveys comprising SP, magnetic and IP (TD) cum resistivity techniques have been carried out in Karoi–Rajpura area, Bhilwara district, Rajasthan for delineating the zones of base metal mineralization.

Geophysical surveys employing self potential (SP), magnetic (VF) and IP (Time Domain) cum resistivity (using dipole–dipole array with a=20 m and n=3) were carried out for delineating sulphide mineralization in the area. Results of integrated surveys comprising SP, magnetic, IP chargeability and resistivity methods have been presented in form of contour maps to identify the significant anomaly zones for mineralization. The surveys in the area have delineated four anomaly zones favorable for the occurrence of sulphide mineralization. SP value in the surveyed area varies from + 20 to – 50 mV. The map has indicated SP low anomaly zone of about 100 m width, bounded by – 10 mV contour trending in E–W direction. The highest magnitude of SP anomaly is about – 15 mV. This anomaly extends from 0/W10 in north to traverse S10 in south as indicated from contour map. The dimension of anomaly zone is about 100 m X 100 m. Another SP low anomaly zone of about 200 m width, bounded by – 5 mV contour trending in N-S direction has the peak anomaly of – 10 mV. This anomaly extends from N15/E40 in north to S10 in south. The dimension of this anomaly zone is 200 m X 200 m. The continuous E–W trending SP zone in north–east corner beyond north of traverse N40 is indicative of litho contact in the surveyed area.

The magnetic value varies from – 300 nT to + 700 nT in the area. The magnetic survey has delineated few isolated magnetic high anomaly zones of the order of about 500 nT in the north–west part of the area. In this zone, there are five isolated peaks of order of 650 nT that may be due to the presence of some ferruginous magnetic material. High magnetic responses observed in western part compared to eastern part may be due to the lithological contacts in the area apart from few dipolar anomalies. These high amplitude dipolar anomalies suggest either emplacement of basic bodies along some fault planes or the faults/fractures along which concentration of magnetite is a natural phenomenon.

The results of IP chargeability have revealed four anomaly zones favourable for presence of mineralization. These anomaly zones are trending almost in N-S and NE-SW directions. The peak magnitude in these fair anomaly zones is varying from 20 to 28 mV/V. The chargeability anomaly zones may be due to sulphide mineralization. Zone-I: This zone is reflected by an anomaly having peak magnitude of 28 mV/V over background of 14 mV/V. This anomaly zone is trending almost in NE-SW direction and is occurring between traverses S15 in north and S45 in the south. The extent of this anomaly zone is about 200 m and width is about 50 m (between E5 and E10). This zone has indicated two isolated anomalies of 2 to 6 mV/V near station E5 on traverse S20 and E10 on traverse S40 respectively. Zone-II: This zone is trending almost in NE-SW direction having peak magnitude of 20 mV/V over background of 14 mV/V ,which is localized near station E35 on traverse '0'. The background contour of 14 mV/V extends over wider area and continues further towards north, as reflected from contour map. The extent of this anomaly zone is about 150 m. This zone is also supported by SP anomaly zone. Zone-III: This zone is exhibited by peak magnitude of order of 20 mV/V over background of 14 mV/V. This zone is trending almost in NE-SW direction and occurs between traverses N50 in north and N40 in the south. The extent of this anomaly zone is about 100 m and width is about 40 m (between W35 and W30). Zone-IV: This zone is reflected by an anomaly of magnitude 22 mV/V over background magnitude of 14 mV/V and trends almost in N-S direction. This zone is occurring between traverses N50 in north and N40 in the south. The extent of this anomaly zone is about 100 m and width is about 50 m (between stations W25 and W30). The continuous high chargeability value between stations W10 to E25 of traverses N45 and N50 corroborated with low SP trend recorded in the surveyed area. The magnetic and SP surveys have picked up lithological variations as well as structural features.

Test boreholes are recommended in Zones I, II, III and IV to find out the nature of causative source responsible for geophysical anomalies.

NEW FINDINGS ON INTRACRATONIC RIFTING OF INDIAN SHIELD DURING GONDWANA PERIOD AND POSSIBLE GEODYNAMICAL CONSEQUENCES

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The nature of the continually evolving earth's surface, especially of the ancient Precambrian terrains like the Indian shield, has always been a subject of considerable interest. However, a question which has always puzzled earth scientists is, whether the ancient cratons of this shield terrain have remained unperturbed since the Precambrian era, or the subsequent geodynamic and tectonothermal events have deformed them. Our recent studies have added a new dimension to this debate, as we discovered presence of Gondwana sediments over the Precambrian crystalline basement in different intracratonic settings of the eastern Dharwar craton, based on detailed palynological, seismic and borehole studies that included (i) Killari earthquake region of Maharashtra and (ii) Vinjamuru region of Nellore Schist Belt. These findings together with a newly identified Lower Gondwana sequence in the Tanjore subbasin of the Cauvery basin, suggest that the Gondwana deposits were much more widespread than what is known today. Incidently, in these areas, thicknesses of Gondwana sediments are quite small due to persistent uplift and erosion, which also brought high velocity mafic crust quite close to the surface. Till now, they are known to occure mainly in rifted Gondwana grabens, situated along the periphery of various cratonic blocks, which were perpetual weak zones, formed consequent to the separation/amalgamation of the cratonic blocks time and again. Our studies suggest that the

intracratonic parts of the Archean cratons too were rifting during the Permo-Triassic periods, which totally altered and re-structured the crust/mantle configuration underneath. This would thus challenge the widely held belief of the stability of Indian cratons since Neoarchean Era. It also appears that Gondwana perturbations played an important role in thinning of the Indian Lithosphere and making it unusual. Below Killari, mantle heat flow and Moho temperatures were found to be quite high at 32 mW/m^2 and 540°C, respectively, together with lithosphere thickness of only 100 km. In fact, Moho temperatures are even higher (exceeding 700°C) and lithosphere is anomalously thinner (62 km) in other prominent Gondwana grabens. Further, inland rifting during the Gondwana period that began in Permo-Triassic era may have been a prelude to India-Antarctic break.

FLUID DRIVEN EARTHQUAKES IN THE INTRAPLATE REGION OF KACHCHH, NORTHWESTERN (NW) INDIA: AN INSIGHT FROM LOCAL EARTHQUAKE TOMOGRAPHY

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The Kachchh region in NW India is one of the most active intraplate regions of the world. It has experienced many moderate to large earthquakes,including the 1819 Allahbund (7.8Mw) and the 2001 Bhuj earthquakes (7.7Mw).The intense aftershock activity of the 2001 Bhuj earthquake is still continuing. To understand the processes of earthquake generation in this intraplate setting, we correlated the spatial distribution of earthquakes with the crustal seismic ***P-*** wave velocity (***Vp***) and ***Vp/Vs*** variations, derived from local earthquake data. We inverted 32554***P-*** and 32400***S-*** wave arrival times from 3800 earthquakes that occurred during 2006 to 2015,recorded at 36 seismic stations. The relocated seismicity is mainly associated with the near vertical South Wagad fault (SWF) and the south dipping North Wagad Fault (NWF), which are identified as low velocity anomalies in the seismic tomographic sections. The tomographic images show a mid-crustal (20-25km) low velocity layer. The majority of earthquakes, including the 2001 main shock, fall in the zone of lower ***Vp*** and higher ***Vp/Vs***at 20-30km depth. This is probably a fluid saturated zone that originates from the mantle, sinceit extends down to 40km below the epicenter of the main shock. This fluidized medium represents a pronounced heterogeneity and facilitates stress accumulation in this region. The presence of a fluid reservoir and nature of the faults corroborates with the results from magnetotelluirc studies in this region.

A PROBABLE MODEL FOR THE UNINTERRUPTED OCCURRENCES OF EARTHQUAKES IN THE RUPTURE ZONE OF THE 2001 BHUJ EARTHQUAKE FOR LAST 16 YEARS

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The detailed three-dimensional P and S wave structure of the Kachchh rift zone, Gujarat, India, down to 50 km depth is determined using tomographic inversion of 28,928 P wave and 28,691 S wave arrival times from 4643 well-located aftershocks recorded by a 58-station seismograph network deployed on and around the rift during 2001-13. The main finding of our modeling is the detection of a graben (basin inversion) structure extending down to 24 km below the central Kachchh rift basin, which is

characterized by a dominant high velocity anomaly (mafic intrusive rocks) with several patches of low velocities (fluid-filled) within it. Below the graben structure, we also detect a dominant low velocity anomaly with several zones of reduced seismic velocities and increased bulk velocity extending from lower-crustal to sub-crustal depths, which are inferred to be fractured and permeable zones filled with metamorphic fluids and volatile CO_2 (emanating from the patches of carbonatite melts in the upper mantle). These low velocity zones are inferred to be resulted from the Deccan mantle plume activity of 65 Ma or syn-rift magmatism, which are also facilitating the deeper fluid circulation to cause bursts in seismicity in the region. Source of fluids in the upper crust could be meteoric water while that in the lower crust might be related to metamorphic fluids and volatile CO_2. The mapped graben structure is found to be associated with a Bouguer gravity high and a marked (4 km) crustal thinning, supporting large flexural stress theory. Our P-RF study also delineates a lithospheric thinning below the graben structure. This thinning model receives further support from crust-corrected normalized P-residuals, which suggest dominant negative residuals associated with the central KRZ. Teleseismic tomography using these P-residuals reveals low velocity to a depth of 170 km below the central KRZ, while there are positive residuals associated with the surrounding unrifted zones. Such a complex heterogeneous crust–mantle structure, which could be related to K/T boundary Deccan mantle plume activity and rift-related magmatism, might play a crucial role in seismogenesis of lower crustal earthquakes that have occurred in the KRZ since 2001.

We propose that the flexural stresses induced by crustal density heterogeneties along with the prevailing Indian plate compression can lead to a near critical stress-state associated with the mapped graben structure that can generate small to large intraplate earthquakes through small perturbations in stress regime resulted from crustal fluid flow mechanisms. We also suggest that the continued occurrence of earthquakes in the lower crust is further facilitated by the post-seismic release of deep fluid circulation of entrapped volatile CO2 propagating through fractured zones extending from lower- to sub- crustal depths below the Kachchh rift zone, Gujarat, India.

PASSIVE SOURCE SEISMIC IMAGING OF THE CRUST AND UPPER MANTLE BELOW THE EASTERN INDIAN CRATON: EVIDENCE FOR LITHOSPHERIC DELAMINATION BELOW THE ARCHEAN SINGHBHUM CRATON?

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We herein present shear velocity structure extending down to 300 km depth below the Archean Singhbhum-Odisha Craton (SOC) and Proterozoic Chotangpur granitic-gneissic terrain (CGGT), which has been obtained through the inversion modelling of P-receiver functions. We use three-component broadband recordings of 200 teleseismic earthquakes (30o£D£90o) from a 15 station seismic network that has been operational in the eastern Indian shield since February 2013. We obtain the thinnest crust of 35 km overlying a thin lithosphere of 78 km, below the region near South Singhbhum Shear Zone, which could be attributed to the 1.6 Ga plume activity associated with Dalma volcanic. However, the thickest crust of 47 km overlying a thin lithosphere of 81 km is noticed below the region near the Singhbhum granite of 3.6 Ga. This thinning of lithosphere could be attributed to the delamination of lithospheric root due to the Himalayan orogeny with a shortening rate of 2 cm/year. This delamination model in SOC gets further support from the densification of the lower crust, which could result from repeated episodes of basaltic underplating associated with episodes related to Dalma (~1.6 Ga) and Rajmahal (~117 Ma) volcanisms. This led to relatively more mafic, heterogeneous and deformed crustal

structure in SOC as well as EGMB (with an average crustal Vs of 4.0 km/s) in comparison to that in CGGT (with an average crustal Vs of 3.9 km/s), as seen through our modelling results. The thickest lithosphere of 100 km is observed in the southwestern SOC as well as northeastern CGGT. We als

MICROSPHERULES FROM THE KILLARIINFRATRAPPEANS, DECCAN LIP, MAHARASHTRA (INDIA)

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Occurrences of microspherules from the sedimentary strata are rare, but when present, provide interesting information about the Earth's early history, influenced by extraterrestrial impacts. Such impacts lead to melting and vapourization of both the terrestrial as well as the extraterrestrial materials, which ultimately condense intro impact spherules. Presence of such a microspherule has recently been discovered by us within a layer of eight meter thick infratrappean sediments, pierced below 338m thick 65 Ma Deccan volcanics in the Killari region of Maharashtra. Palynological studies indicate the burial of these infratrappeans, that rests directly over the Neoarchean amphibolite to granulite facies mid crustal basement, in dysoxic to anoxic conditions, having close proximity with lower Gondwana sediments, consisting mainly of undeformed carbonates (sometimes micritic), having calcite as a predominant mineral. Carbon and oxygen isotopic studies indicate the sediments to be of non-marine fresh water origin, similar to early Permian Gondwana sediments of east-central India.

We investigated this microspherule through scanning electron microscope (SEM) and energy dispersive X-ray diffraction (EDX) in order to decipher the images, morphology and its elemental composition. The studied spherule was found to be of mafic/ultramafic in nature, containing Fe (18-19 wt %), O (37-42 wt%) and Si (21-22 wt%), apart from small amount of Ti (1.2-1.5 wt %) and Mg (3.3-3.9 wt %). The study thereby indicates a possibility of an extraterrestrial impact over the Indian terrain during the Gondwana sedimentation period, that may have a link with the Permo-Triassic mass extinction, which wiped out almost 90% of marine species due to disruption of biogeochemical cycles all around the globe.

LABORATORY CHARACTERIZATION OF SHALE ROCK FOR ASSESSING SHALE GAS POTENTIAL OF BARAKAR AND BARREN MEASURES SHALE, EASTERN INDIA

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The last couple of decades have witnessed phenomenal growth in the study of unconventional oil reservoirs. This has become more important for India whose demand for energy has been growing steadily and thus, a lot of emphasis is laid to estimate the shale gas potential of India. The Gondwana shales of India are promising due to their higher thermal maturity, presence of organic matter, type and thickness and wide areal extent. The physical properties of Gondwana shale samples from Barakar and Barren Measures Formations in Eastern India were analyzed for quantitative mineralogy, pore types and dynamic elastic properties using powder X-Ray Diffraction (XRD), Scan Electron Microscopy

(SEM) and ultrasonic velocity measurements, respectively. The measured P-wave and S-wave velocities and the estimated elastic parameters of shale samples from Barakar and Barren-Measures formations show an increase in magnitude with depth indicating the effect of hardness and compaction. The effect of hardness on velocity and elastic parameter is also supported by increase in quartz percentage in shale with depth. An empirical relationship between P and S-wave velocity is proposed for Gondwana shale. The XRD experiments reveal the dominance of clay minerals over the non-clay minerals in the samples lowers the shear strength of South-Karanpura field at shallow depth supported by measured elastic properties. The presence of flaky clay texture/topography and abundant micro (>0.75μm) and nano (< 0.75μm) pores of various shapes in the samples with organic matter in the SEM images suggests that formations are of high shale gas prospecting zones.

IMPACT OF NOISE SOURCE DIRECTIONALITY ON CRUSTAL VELOCITY STRUCTURE FROM AMBIENT NOISE CORRELATIONS

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Researchers have been using the cross correlation of the seismic ambient noise to delineate subsurface velocity structure and its temporal variations. Although the method was popularly employed, the ideal definition of homogeneous distribution of uncorrelated noise sources is not possible in earth system. Therefore, the distribution of noise sources influence the accuracy of the correlation functions and crustal velocities estimated from ambient noise. In this study we have analyzed the impact of noise source direction and distribution on the modeling of crustal velocity structure using synthetic noise generated for velocity depth model. Results suggest that the noise sources or their components collinear to the receiver baseline pair only contribute to the noise correlation functions. The noise correlation function obtained using collinear noise sources are useful for accurate estimation of dispersion and velocity structure. The signals from strong sources away from the line connecting receivers alias with the estimated cross correlation function and influence the results. The study concludes that the inherent signal aliasing from the non-collinear noise sources is a problem that questions the accuracy of results in ambient noise correlation studies.

GEOPHYSICAL SURVEYS FOR GOLD MINERALISATION IN HONNAMARDI NORTH BLOCK, CHITRADURGA SCHIST BELT, KARNATAKA

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Geophysical surveys employing Induced Polarization, resistivity and magnetic (V.F) were conducted in Honnamardi north block, Chitradurga schist belt, Karnataka to identify favourable zones for gold mineralization. The major rock type in the area belongs to Hiriyur formation of Chitradurga Super group of Archaean age. The prominent lithounit is metavolcanic sequence represented by massive schistose metabasalt and argillites intruded by Quartz veins, basic dykes and banded ferruginous quartzites. Acid volcanics are seen mostly in and around Honnamardi hillock and BIF to the west of Honnamardi village. Quartz veins are the carriers of mineralization. The general strike of the formations is N20°W-S20°E.

The geophysical surveys have indicated presence of low resistivity values over soil covered areas and low to moderate resistivity values over argillites. Comparatively high resistivity values were observed over meta-basalts and acid volcanics. At many locations sharp and narrow resistivity highs were noticed and these may correspond to intrusive quartz veins.

The present surveys have helped in identifying six anomaly zones with strike lengths varying from 200m to 1000m. As these zones fall mostly over soil covered areas, these anomalies assume importance. The sharp resistivity signatures in these zones may correspond to intrusive quartz veins. In some of the zones higher order magnetic signatures having correspondence with Banded Ferruginous Formations have been noticed. About 40 anomaly locales have been identified from the six zones. It is interesting to note that a few anomaly zones, when tested by pitting during the survey work, have exposed quartz veins with indications of sulphide mineralization.

Further, detailed IP surveys employing half Schlumberger configuration conducted in the shaft area have delineated the disposition of probable lode zones with characteristic resistivity signatures. Based on the geophysical investigations a few locales are suggested for trenching/ drilling in this area.

GEOPHYSICAL INVESTIGATIONS SUPPORTING GEOLOGICAL AND GEOTECHNICAL INVESTIGATIONS FOR EARTHQUAKE HAZARD ESTIMATION

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ISR has popularized use of various types of geophysical surveys for configuring details of near-surface soil layers and also imagining faults, basement and crustal configuration for assessing earthquake hazard. Near surface information about faults and rock / soil layers is required as seismic hazard is very sensitive to distance from the fault and configuration of subsurface layers. The detailed information of soil layers down to 50 m like seismic-wave velocities and depth is routinely used in SHAKE program for estimating PGA and Response Spectra. Seismic velocity and depth of deeper soil layers in basins is used for estimating low-frequency amplification needed for high-rise buildings. This is done on one hand by (i) geotechnical drilling and soil investigations as well as geomorphological mapping, and secondly by (ii) using passive seismicity, Ground Penetrating Radar, Shallow seismic, P-S logging, Resistivity imaging and Time Domain Electromagnetic geophysical methods. For understanding earthquake generation process the configuration of crustal structure down to deep crust is investigated using the additional methods of gravity – magnetic, 2D seismic reflection and magneto-tellurics.

PROBABILISTIC ASSESSMENT OF EARTHQUAKE HAZARD IN NORTH EAST INDIA AND ADJOINING REGIONS

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North-East (NE) India and adjoining regions are one of the most active continent-continent collision regions of the world,which has experienced two great earthquakes (M≥8.0) and dozens of earthquakes of M≥7.0 in the past. In the present study, maximum likelihood estimation method is applied to study the geographical distribution of earthquake hazard parameters and seismicity in

18 seismogenic source zones of shallow focal depth (≤70 km) earthquakes and 5 seismogenic source zones of Intermediate focal depth (>70 km) earthquakes of the NE India and adjoining regions. For this purpose, we have prepared a reliable, homogeneous and complete earthquake catalogue during the period 1897-2016. In this study, the earthquake hazard parameters, which include maximum regional magnitude (M_{max}), mean seismic activity rate (λ), the parameter b (or $\beta = b/\log e$) of Gutenberg-Richter (G-R) frequency magnitude relation, the return periods of earthquakes with a certain threshold magnitude along with their probabilities of occurrences have been calculated in using earthquake data during the period 1897-2016. The uncertainties in magnitude have been also taken into consideration during the calculation of hazard parameters. The earthquake hazard in the whole NE India region has been calculated in 18 shallow and 5 intermediate-depth seismogenic source zones delineated on this basis of seismicity distribution, tectonics and focal mechanism of large earthquakes. The annual probability of exceedance of earthquake (activity rate) of certain magnitude is also calculated for all seismogenic source zones. The obtained earthquake hazard parameters were geographically distributed in 18 shallow and 5 intermediate-depth seismogenic source zones to analyse the spatial variation of localized seismicity parameters. It is observed that seismic hazard level (low return periods and high probabilities) is high in source zones 4 & 5 (Himalaya Frontal thrusts and eastern syntaxis region), 6, 8, 12 & 13 (Arakan-Yomasubduction belt region) and 16 & 17 (Shillong plateau region) for shallow focal depth (≤ 70 km) earthquakes. For intermediate depth zones, 3 & 4 of Arakan-Yomasubduction belt exhibit high hazard level. The shallow depth source zones that show maximum regional magnitude earthquakes $\boldsymbol{M_{max}}$ ≥7.0 are in Himalaya frontal thrust (zones 1 & 4), Eastern syntaxis (zone 5), Arakan -Yomasubduction belt (zones 6, 8, 9, 12 and 13) and shillong region (zones 15, 16 and 17), while zones 3 & 4 of intermediate-depth zones in Arakan -Yomasubduction belt also show such earthquakes. It is observed that seismic hazard level varies spatially from one zone to another in North-East India and adjoining regions ,which suggests that the examined region has high crustal heterogeneity and seismotectonic complexity.

MAPPING OF BASEMENT DEPTH FROM GRAVITY DATA: A MACHINE LEARNING APPROACH

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Mapping of basement is imperative for any geophysical modelling study. In this work we propose a machine learning (ML) approach in Bayesian framework to model the basement depth from gravity data acquired in parts of Eastern Indian Shield. In contrast to previous work, our 'learner' uses a scaled conjugate gradient-evidence re-estimation (SCG-ER) optimization to develop a statistical model of the relationship between the parameters it controls and the quality of the basement depth results produced. The ML with SCG-ER shows an excellent performance between predicted and computed basement depth in training, validation and test data sets. We demonstrate that SCG-ER learner is able to produce precise variation of basement depth when it uses altitude and Bouguer gravity anomaly (BGA) information. It compares well with 2D radially averaged power spectrum results to identify the prominent faults system in the study area (e.g., Malda-Kishanganj Fault (MKF), Munger-Saharsha Ridge Marginal Fault (MSRMF), Kathihar Fault (KF). The ML-based basement modelling results, coupled with the best variogram model is able to indicate the likely existence of blind faults, buried by rapid sedimentation and provide insight into the transverse tectonics under the Himalayan collision front.

SEPARATION OF THIN RESERVOIR FACIES IN CARBONATE RESERVOIR THROUGH GENETIC INVERSION

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The study has been performed over Jaisalmer limestone formation of Jaisalmer sub-basin under Rajasthan sedimentary basin situated at the western part of India which is considered as Rank-1 sedimentary basin. Jaisalmer limestone is mainly characterized densed limestone with grey color and oolitic nature. The Jaisalmer limestone has potential to produce hydrocarbon but few area it has been assorted by claystone and calcareous sandstone which are considered as non-reservoir facies. In view of current demand of Indian energy market scenario, it is important to find oil and gas from Indian sedimentary basin in enhanced success and reduce the import percentage of crude from other country. Rajasthan basin has potentiality for produce hydrocarbon but few areas are not properly explored. To enhance the crude/hydrocarbon volume the reservoir of small marginal fields with poor petrophysical property are required extensive study for further exploration. Genetic inversion, is such kind of study which is one of the effective tool for delineation of such kind of reservoir those have limited number dataset. The genetic inversion process has been generated the property volume based on well log data which is characterized the reservoir property properly. The post stack seismic data has been used as input seismic volume for distribution of property. The full activity has been carried out based on genetic algorithm along with multilayer neural network process. Seismic amplitude volume along with acoustic impedance volume have been used as input model instead of any prior wavelet based model. The genetic inverted volume has been generated based on convergence inversion method and global minimum error has been achieved high level respect to other neural networking inversion. The genetic inversion has been carried out for creating other property volume also based upon sensitivity of the reservoir. The result of genetic inversion is less uncertain based upon less number of available dataset since in this process unique wavelet for reservoir characterization is not required. The genetic inverted volume has been used as operator for surface attribute analysis for capturing the areal extension thin limestone reservoir. There are various surface attributes have run over genetic inverted volume such as extracted property of the volume, amplitude variation, magnitude variation etc. The extracted amplitude has been produced best possible result for delineation of the thin Jaisalmer limestone reservoir. The delineated property has been used as secondary property for development of geo-celular model to get an integrated subsurface geological model.

PRE-, SYN- AND POST INDIA-ASIA COLLISIONAL GRANITOID MAGMATISM IN THE SE KARAKORAM, INDIA: IMPLICATIONS ON PALAEOGEOGRAPHY, SUBDUCTION AND TRANSPRESSION TECTONICS

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The granitoids from a newly mapped metamorphic sequence of the Karakoram region, India have been subjected to geochemical and U-Pb zircon chronological investigations in order to understand tectono-magmatic and geodynamic evolution of the Karakoram terrane through time. Outcrop-scale

observations reveal presence of syn- and post-kinematic leucogranite bodies, deformed and undeformed, present within the granite gneisses and granite mylonites. Whole-rock geochemical data indicates granitoids are enriched in the Light Rare Earth Elements (LREE) and Large Ion Lithophile Elements (LILE), but are low in High Field Strength Elements (HFSE) and have negative anamolies in Nb, Ti and V. It clearly suggests subduction-related calc-alkaline source for most of the host granite gneisses, which is also supported by mineral chemistry of biotites and amphiboles. The obtained variable geochronological ages (~846-14 Ma) from the granitoids having specific geochemical and structural characteristics reveal: (a) evidences of subduction-related volcanic arc magmatic event during 846-705 Ma from the Karakoram; (b) that the subduction of the Tethyan oceanic lithosphere beneath the southern Asian plate margin initiated at least ~165 Ma ago, and (c) twenty million years of continuous deformation along ~1000 km long lithospheric scale Karakoram Fault (KF) during ~35-14 Ma. Presence of deformed leucogranites dikes in a wide metamorphic sequence suggests that Karakoram Shear Zone (KSZ) is a ~40-50 km broad dextral strike-slip shear zone existing in the trans-Himalaya. The anatexis due to deformation also supported by low Th/U ratio (<0.1) from the zircon rims. Pre India-Asia collisional magmatism indicated by the magmatic pulses from the Neoproterozoic (~846 Ma) and Middle Jurassic (~164 Ma) time, while magmatic pulses from Paleocene (~65 Ma), Late Eocene (~34) to Miocene (~14 Ma) indicate syn to post India-Asia collisional magmatism.

HUMAN INDUCED SEISMICITY – LESSONS TO LEARN IN INDIA

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Human Induced Seismicity refers to typically minor earthquakes and tremors that are caused by human activity that alters the stresses and strains on the Earth's crust. Most induced seismicity is of a low magnitude. The purpose of this paper is to propagate awareness of the hazards related to Human induced Seismicty in several locations around the world due to the creation of artificial lakes, irregular mining activity, Hydrocarbon and ground water extraction without closing the void space, Hydraulic Fracturing etc. Lessons are to be learnt to take necessary precautions to reduce the human and property loss in the nearby areas due to such irrational Human activities. The hidden hazards related to each human activity are explained below. The first case of reservoir-induced seismicity occurred in 1932 in Algeria's Oued Fodda Dam. The largest intraplate reservoir-induced seismicity occurred at Koyna Dam. The 6.3 magnitude 1967 Koynanagar earthquake occurred in Maharashtra, India . Epicenters of main shock, fore and aftershocks are located near the Koyna Dam reservoir. 180 people died and 1,500 were injured. The effects of the earthquake were felt 140 mi (230 km) away in Bombay with tremors and power outages. During the beginnings of the Vajont Dam in Italy, there were seismic shocks recorded during its initial fill. A landslide almost filled the reservoir in 1963, causing a massive flooding and around 2,000 deaths. The reservoir was drained and consequently seismic activity became almost non-existent. A magnitude 6.1 earthquake at Oroville, California, occurred on August 1, 1975 was attributed to seismicity from a large earth-fill dam. The 2008 Sichuan earthquake caused approximately 68,000 deaths. An article in ***Science*** suggested that the construction and filling of the Zipingpu Dam may have triggered the earthquake. Some experts worry that the Three Gorges Dam in China may cause an increase in the frequency and intensity of earthquakes. Results of ongoing multi-year research on induced earthquakes by the United States Geological Survey (USGS) published in 2015 suggested that most of the significant earthquakes in Oklahoma, such as the 1952 magnitude 5.7 El Reno earthquake may have been induced by deep injection of waste water by the oil industry. Induced seismicity can also be caused by the injection of carbon dioxide as the storage step of carbon

capture and storage, which aims to sequester carbon dioxide captured from fossil fuel production or other sources in earth's crust as a means of climate change mitigation. This effect has been observed in Oklahoma and Saskatchewan. Though safe practices and existing technologies can be utilized to reduce the risk of induced seismicity due to injection of carbon dioxide, the risk is still significant if the storage is large in scale.

The Human-Induced Earthquake Database (HiQuake), the world's most complete database of earthquake sequences proposed to have been triggered by human activity, now includes approximately 730 entries, according to a report published in October 4 in the "Data Mine" column of the journal ***Seismological Research Letters***.

Mining projects (37%) and water impounded behind dams (23%) are the most commonly reported causes of induced earthquakes, but unconventional oil and gas extraction projects using hydraulic fracturing, are now a frequent addition to the database, said Miles Wilson, a geophysicist at Durham University working on the HiQuake research effort.

As can be seen from all these examples, seismicity can occur due to different types of human activity. If proper care is not taken, even small seismic activity can severely damage the structure either during or even after stopping the human activity.

It is known that major floods and rains can be forecasted at least before 3 to 4 days and precautions can be taken before the disasters. But natural seismicity that leads to earthquakes, is yet to be predicted. However, seismicity due to major human activity can be expected in advance and necessary precautions can be taken on time to reduce the human and property loss .

The seismic hazard from induced seismicity can probably be assessed adopting similar techniques used for natural seismicity. Subsequently, a risk assessment map can be prepared taking account of the seismic hazard and the vulnerability of the exposed elements at risk using Earthquake Early Warning Systems(EEWS) and RS & GIS.

It is cleared. However, author has to segragate various types of human induced hazards and present a properly structured oral presentation.

ELECTRICAL RESISTIVITY TOMOGRAPHY FOR DELINEATION OF GROUND WATER BEARING ZONES TO PREVENT LAND SLIDE IN AN OPEN CAST MINE

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Land slide in open cast mines is taking place very often, which not only obstructs the mining operation but also incurs heavy economic losses resulting due to the removal of debris. The only solution to this problem lies in the delineation of potential groundwater zones and their dewatering by pumping out groundwater from these zones away from the mine. Electrical Resistivity Tomography is an advanced technique of electrical resistivity method, which provides 2D surface images. These images are used to identify groundwater potential zones even in complex hydrogeological setup for different purposes such as groundwater exploration, selection of suitable sites for wastedisposal, identification of geothermal reservoirs, monitoring of leakages from industrial units etc. Tadkeshwar lignite mine

is an opencast mine operated by Gujarat Mineral Development Corporation (GMDC) Ltd. Land slide in this mine is a recurring phenomenon, which is attributed to the groundwater movement. Purpose of the present work is to demonstrate the efficacy of Electrical Resistivity Tomography in delineation of groundwater bearing zones for the purpose of dewatering, to secure safe mining with the help of field example of Tadkeshwar lignite mine. For this purpose electrical resistivity tomography has been carried out at several locations,which have revealed the presence of several potential zones of ground water in the mine lease area in which open cast mining will be extended in the near future. This work can serve as a role model to solve the problem of land slide in similar problematic mines.

SCIENTIFIC DRILLING IN THE KOYNA REGION, DECCAN TRAPS, WESTERN INDIA: COMPLETION OF 3KM-DEEP PILOT BOREHOLE

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The Ministry of Earth Sciences, India has launched a major programme on scientific deep drilling to study recurrent triggered earthquakes over the past five decades in the Koyna region, western India. Setting of a deep borehole observatory to acquire critical data sets and carry out long-term monitoring in the near-field of earthquakes is planned. As a forerunner to this plan,a pilot borehole has been completed successfully to a depth of 3 km, passing through a complete vertical succession of Deccan Trap lava flows as well as the underlying granitic basement rocks. Located in a seismically active domain, the borehole not only tested the indigenous deep drilling capability in Deccan basalt and the crystalline basement rock but also opened up new possibilities for addressing fundamental problems in understanding earthquake mechanisms using near-field data sets. Downhole geophysical measurements up to 3 km depth provide valuable new information on rock types, physical and mechanical properties and the in-situ stress regime in the Koyna region. Besides earthquake studies, the potential benefits extend to addressing significant problems on Deccan volcanism, evolution of the continental crust and deep biosphere.

TOPOGRAPHY CORRECTION APPLIED TO MAGNETOTELLURIC DATA FROM SIKKIM HIMALAYAS

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Magnetotelluric method is one of the powerful tools to investigate the deep crustal structure of mountainous regions. Topographic variations due to irregular surface terrain distort the resistivity curves and hence may not give accurate interpretation of magnetotelluric data. In 3D, the topography effect is both galvanic and inductive in either Transverse Electric (TE) or Transverse Magnetic (TM) mode and hence the interpretation is difficult. The topographic effect is significant along the ramp and is high at top and low at bottom of the ramp. In this study, we analyze the effects of 3D topography for field data from Sikkim Himalaya. This paper presents the impedance tensor correction algorithm to reduce the topographic effects in MT data. The new correction method is applied to the real data from Sikkim Himalayas, which brought out the true nature of the basement in this region.

MARINE GEOSCIENCES

ABIOTIC METHANE: A POSSIBLE SOURCE FOR THE FORMATION OF GAS HYDRATES, IN NORTH-EASTERN INDIAN OCEAN (BAY OF BENGAL).

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Gas hydrates are considered as a store-house of energy for the future, due to its high holding potential of hydrocarbon gases, especially methane. To overcome indigenous energy deficiency, India started to look for alternative sources of energy. Gas hydrates is one such energy source. During initial searches, two potential areas were explored, one in Kerala-Konkan Basin (KKB) in Arabian Sea and another in Krishna-Godavari Basin (KGB) in Bay of Bengal. The results of these preliminary surveys were subsequently confirmed by deep drilling using D/V JOIDES Resolution. The findings were largely unanticipated. The highly prospective KKB showed complete absence of gas hydrates, whereas relatively less known KGB revealed the presence of world's thickest and largest gas hydrate deposit. Our scrutiny of a large data showed that the organic matter content of sediments and Gas Hydrate Stability Zone (GHSZ) do not actually control the formation or absence of gas hydrates in Northern Indian Ocean. We believe that the reason for these abnormal results lie in the origin and structural architecture of the respective Continental margins. We opine that the presence of gas hydrate only in the KGB is mainly due to abiotic source of methane from serpentinized peridotite mantle present as proto-oceanic corridor all along magma-poor Eastern continental margin of India (ECMI) in Bay of Bengal. On the contrary, thick oceanic crust prevents percolation of sea water towards deep seated peridotite mantle, thus preventing the serpentinization and limiting the formation of methane required for the development of gas hydrates in the Arabian Sea.

DEVELOPING MAGNETIC MINERALS AS MARKERS OF EVOLUTION OF NATURAL GAS HYDRATE SYSTEM IN BAY OF BENGAL

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We examined environmental magnetic and sedimentological records of sediment cores (NGHP-01-10D, NGHP-01-3B, NGHP-01-5C and NGHP-01-7B) retrieved from proven cold seep environment of Krishna-Godavari (K-G) basin to develop a "magneto-mineralogical" tool for exploration of gas hydrates. Based on sediment magnetic signatures, three rock-magnetic zones (I,II,III) have been identified. In zone-I, high concentration of detrital ferrimagnetic iron minerals give way to progressive diagnetic dissolution of detrital Fe-Ti minerals and precipitation of secondary diagnetic/authigenic minerals with depth. A uniform band of continuous and highly-enriched magnetite particles in zone -II extending throughout K-G basin appears to be a regional feature and mainly represents a period of higher sedimentation event. Rock-magnetic and electron microscopic observations confirmed the presence of coarse-grained titanomagnetites in this zone. A marked decrease in magnetic susceptibility, abundance of pyrite grains and increase in chromium reducible sulfur (CRS) concentrations provide clues on the deep pyritization in zone-III. We hypothesize that zone-III was formerly a gas hydrate

bearing horizon. The opening of the regional fault system altered the P-T conditions and hydrate started dissociating,resulting in upward migration of methane thereby creating a fossil gas hydrate interval in zone-III. A conceptual magneto-mineralogical model is developed, which needs to be tested and established in other gas-hydrate bearing marine sedimentary systems. The proposed magnetic tool appears to have the potential and can be further used for gas hydrate studies.

IDENTIFICATION, DISTRIBUTION AND GEOPHYSICAL CHARACTERISTICS OF BATHYMETRIC HIGHS OFF SOUTHWEST COAST OF INDIA

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The western continental margin of India and the adjacent ocean basins were formed by break-up and separation of India, Seychelles and Madagascar in the Late Cretaceous and Paleocene time. The initial India-Madagascar separation and the subsequent India-Seychelles separation are believed to have been caused by the Marion hotspot at ~90 Ma and the Réunion hotspot at ~68.5 Ma, respectively. These geodynamic events resulted inthe formation of several bathymetric highs in these regions that probably represent imprints of related volcanic events. Using a fresh set of multibeam bathymetry data, we prepared high resolution bathymetric map of the southwestern continental margin of India and the adjoining deep offshore regions. Analysis of bathymetry data was undertaken to infer detailed morphological setup of the region and to understand the distribution of prominent undersea bathymetric features. We also carried out detailed morphometric analysis of the features to deduce the morphological parameters. A total of 33 individual bathymetric high features were identified and we classified these features as seamounts, hills, knolls, guyots and plateaus based on the IOC IHO 2013 standardization of undersea feature categorization. Multichannel seismic reflection, sea-surface gravity and magnetic data were used to reveal the sub seafloor configuration and qualitative interpretation of the geophysical signatures of the bathymetric highs. Interpretation of the multichannel seismic reflection sections suggest that some of these identified features are extrusive in nature, while others are intrusive. These features are associated with characteristic gravity highs superimposed over regional negative anomalies and complex negative and positive magnetic anomalies. Our study suggests that the genesis of the bathymetric highs mapped in the study area could be attributed to the hotspot volcanism, caused by the Marion or Réunion hotspots. We infer that the features in the southwestern continental slope of India closer to the Alleppey-Trivandrum Terrace Complex might have formed by the Marion hotspot volcanism, while those in the Laccadive Basin and eastern sector of the Laccadive Plateau might have formed by Réunion hotspot volcanism.

CRUSTAL STRUCTURE OF THE GULF OF KUTCH, NORTH-WEST INDIA

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Seismic reflection (single & multi-channel), refraction (OBS), magneto-telluric, magnetic and bathymetric studies results (analyses of data collected during four research cruises during 1976 and 2009) and the satellite derived (free-air & computed horizontal gradient) gravity data of the Gulf of Kutch were synthesized. The single channel high resolution seismic records show mostly acoustic transparency and stratification of the top 20 m thick upper-Pleistocene sediments. While, the analysis of multi-channel records deciphered the seismic reflection pattern, interval-velocities and wave field characteristics are enabling to denote the geologic structure of the area. The near north-south trending +4 mGal anomaly closure noted across the gulf and to the east of the gulf mouth has enabled identifying the NNW-SSE extension of the known Kutch Main Land "Median High" into the gulf middle. Small amplitude limited extent anomaly closures present at several locations perhaps mark shallow promotories of the coastal rocks extensions. At the gulf mouth several anomaly closures of large magnitude are present. The horizontal gradients map helped in easy recognition of the structural trends, namely, off-set in gradient closures associated with "North Kathiawar Fault" . Gradient closures are marked by changes in anomalous trends across the fault location. 2-D crust model studies of the gravity anomalies have been carried out constrained by refraction velocities, to have integrated structural models. Geologic structure has been interpreted based on velocities and densities and correlations with adjoining onshore deep seismic and drill well results. It consists of three layered crust of Tertiary sediments, volcanic rocks (Deccan Traps) and Mesozoic sediments overlying the Granitic basement rocks. The magneto-telluric investigations in the area of proposed crust model and the magnetic anomalies across the gulf mouth have also helped in proposing the crust model. The crustal velocity and structure of the model are compared to onshore crustal model and enablled in recognizing offshore extent of onshore geologic structure, especially in comparison with the Mandovi-Mundra deep-seismic refraction studies results as well with the Suthri drill geologic structure. The magneto-telluric investigations in the area of proposed crustal model and the magnetic anomalies across the gulf mouth have also indicated their causative sources at shallow depth. It has further helped to propose the crustal model. The seismic and magneto-telluric results together with the modeled geologic structure had revealed ca 1 to 1.1 km thick Tertiary formations overlie 1 to 2 km thick volcanic rocks occurring at 0.8 to 1.0 km depth. Further, they overlie a thick low density (ca 2.2 gm/cc) and velocity (3.5-4.0 km/s) Mesozoic sediments of 2.2 to 3.6 km thickness. The model parameters indicate that granitic basement present at shallow depth ca 4.0 km in the west is deepening to ca 6.0 km depth in the east. The noted increase of thicknesses of the formations towards coast, i.e eastwards, suggests probable presence of paleo-depocenters in the east of the gulf, ever since Mesozoic period.

IMPORTANCE OF METAL-SPECIATION STUDY IN MARINE SYSTEM

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The delicate balance between trace metals as micronutrients and toxicants plays a crucial role in the maintenance of life in marine systems. Trace/heavy metals exist in a variety of chemical forms: free metal ions, metal ions incorporated into colloids or adsorbed onto suspended particles, small inorganic complexes and complexes with Natural Organic Matter (NOM)-each with its own unique properties. Knowledge of the metal distribution among their different physical and chemical forms (i.e. Chemical speciation) is essential for predicting their fate and environmental impacts. Fundamental chemical principles can help us to identify the most important variables in controlling chemical speciation in the environment. Metal speciation in coastal marine environment, an emerging research area in India, will be discussed during my presentation. The major thrust of this talk is to increase awareness on the importance of metal speciation study in India.

OCEAN STATE FORECASTING AND SERVICES DURING EXTREME WEATHER CONDITIONS: FOR SAVING LIFE AND PROPERTY

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ESSO-Indian National Centre for Ocean Information Services (INCOIS) is the Indian nodal agency to provide operational ocean information, forecast and advisory services. Ocean State Forecast Services is one of the three major services of ESSO-INCOIS. The users include coastal population, fishing folks, navy, coastguard, offshore industries, port and harbors, maritime boards etc. At present, we provide daily updated user-customised forecasts of Wave height, direction and period (of wind waves and swells), Sea surface currents, Sea Surface Temperature (SST), MLD, D_{20}, (Pl give expansions to these abbreviations to help non specialists) Astronomical tides, Wind speed and direction and Oil-spill trajectory. There are 48 user-customised/demanded products, either in the form of daily operational forecasts or in the form of specifically designed products generated and disseminated to various categories of users, even in local languages according to their interest. Consultancy services in the form of projects or in the form of forecast subscription or as a data delivery are rendered to various agencies like ONGC, JNPT, Maritime Boards, Port and Harbours etc. OSF services are even extended to the neighboring Indian Ocean countries in a phased manner (in total six countries are benefitted now with our services). Modern trends of Information and Communication Technology are used right from the forecast generation through evaluation & fine-tuning of numerical models until the timely forecast dissemination to the end users, local government authorities, non-governmental organisations, and disaster management authorities. The dissemination modes include Public Addressing Systems, Fax, Telephone, Radio, TV, E-mail, Web site, Social media and Mobile phones (both SMSs and audio messages) individually or in combination. Joint INCOIS-IMD bulletins, as a one-stop shop, consisting the meteorological and oceanic information and forecasts, along with separate high sea state warnings, are issued during extreme weather conditions like Cyclones. Statistical bias correction to the forecasts is applied to the direct ocean model output-based forecasts using real-time observations from different parts of the Indian Ocean. The Ocean State Forecasting operations and services Quality Management

System is conferred with ISO 9001:2008 certification in 2014. User feedbacks and delayed mode evaluation/auditing suggest not only that the forecasts are > 80% accurate, but also that the forecasts/ information reach on time to maximum end users, local government authorities, non-governmental organisations, and disaster management authorities, as this factor is equally crucial for saving life and property.

HARAPPAN PORT TOWN OF DHOLAVIRA (GUJARAT) IMPACTED BY TSUNAMI: EVIDENCES FROM GROUND PENETRATING RADAR (GPR), FAUNAL (FORAMINIFERA) AND ARCHAEOLOGICAL (POTTERY) STUDIES

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A majority of the early human settlements in India, thrived either near rivers or in coastal regions. Human settlements in coastal regions, however, face a heavy risk of sporadic extreme oceanic disturbance like tsunami. Therefore, study of the early human settlements in coastal regions not only provide insight into the occurrence and impacts of such extreme events in the past, but also the nature of protective measures used by early humans to survive such events. Here, we report the oldest known evidence of a possible impact and protective measures employed to thwart tsunami, from the Harappan port town of Dholavira, in Gujarat state of India. A homogenous thick sediment layer, which has been deposited around 5.4±0.5ka (as calculated from OSL dating) by an extreme event, was mapped in a detailed ground-penetrating-radar survey. A trench was dug in Middletown area and sediment samples were collected for faunal and pottery contents. The occurrence of exclusive marine organism foraminifera in sediments suggests the transport of sediments from the marginal marine region, against the gravity, under the influence of tsunami. The highly fragmented nature of pottery (no piece is larger than 5 % of the original size of pot) also suggests the transportation in very high energy conditions. In view of the foregoing, we propose that the unusually thick walls (~18 m) surrounding the citadel and medium width (~7 m) for outside area of citadel at Dholavira settlement were a protective measure against extreme events, most likely tsunami.

NATURE OF THE AMBIENT NOISE, SITE RESPONSE AND ORIENTATION OF OCEAN BOTTOM SEISMOMETERS (OBSS): SCIENTIFIC RESULTS OF A PASSIVE SEISMIC EXPERIMENT IN THE ANDAMAN SEA

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We analyze the nature of the ambient noise and site response for Ocean Bottom Seismometers (OBSs) deployed in the Andaman region. The probabilistic power spectral densities (PPSDs) of the OBSs show that the noise level in the Andaman region is within the range of Peterson's new low noise model (NLNM) and new high noise model (NHNM) for short periods (< 20 s). For long periods (> 20 s), the noise level is higher than NHNM. The peak associated with secondary microseisms occurs between 3 and 6 s. The stations that are close to the Andaman and Nicobar Islands show a prominent secondary microseismic peak at 4 s while the stations farther away show a small hump at

1 s. The noise level varies seasonally and shows astrong correlation with the significant wave height (SWH) computed from WAVEWATCH III. The ambient noise is down to -140 dB for the band from 0.1 s to 1 s, which provides the best signal-to-noise level for local earthquakes. For very short periods (< 0.1 s), the ambient noise level increases to -120 dB probably due to the efficient propagation of seismic energy through the low attenuation oceanic crust. The horizontal-to-vertical spectral ratio (HVSR) of the ambient noise curves shows an amplification factor greater than four. Furthermore, the HVSR curves show a broad/flat peak beneath the seamounts and the accretionary prism and a sharp/clear peak in the basinal area. We also estimate the orientation of the OBSs using Rayleigh wave polarization analysis.

HIGH RESOLUTION SEAFLOOR MAPPING USING SIDE SCAN SONAR NEARKALINGAPATNAM COAST, ANDHRA PRADESH, BAY OF BENGAL

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The shallow water seabed mapping is a beneficial component for the coastal developers to understand the underwater landscapes for site selection. This study presents mapping seafloor features off Kalingapatnam coast,which falls at the geographical coordinates of 18.3339°N 84.1402°E,north-eastern part of Andhra Pradesh in Bay of Bengal through High Resolution Edge-tech side scan sonar system operated at 600 kHz. The horizontal positioning was given by Trimble DGPS System and the vessel motions were compensated by SBG Motion Reference Unit. The Side Scan Sonar survey was carried out into the sea up to water depth 20 m. The seabed was scanned at an overlapping of 25% starboard and portside coverage. The Side Scan Sonar records acquired at the site were processed using geophysical signal processing techniques and interpreted based on tone texture, pattern and other geophysical image interpretation methods. The surface seabed sediment samples were collected at 6 locations using Van-veen sediment sampler and analyzed for sediment grain size distribution at fractions 0.600 mm, 0.425 mm, 0.300 mm, 0.212 mm, 0.125 mm, 0.063 mm. The results interpreted from side scan sonar records were confirmed with results derived from sieve analysis. The Side Scan Sonar data shows that the seabed is spread by clayey-sand and sandy-clay, clay and sand. Generally, the near-shore seafloor beyond 3 m water depth is carpeted by sandy-clay. The seabed present further seaward is composed of medium sand and clayey sand. The seabed in the northern side of survey area is distributed by sand with few seashells. A few man-made objects such as fallen anchor, ropes and sunken boats were also identified within the study limit. The Side Scan Sonar images do not show any uneven topographic features and rock outcrops within the studied limit.

HIGH RESOLUTION RECONSTRUCTION MODEL FOR THE INDIAN OCEAN PLATE KINEMATICS

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The Indian Ocean was created by the rifting and drifting among Africa, Madagascar, Antarctica, Australia and India since the Late Jurassic. The geomagnetic investigations carried out till late 1980s could provide a large-scale plate tectonic evolution model to describe the stage-by-stage evolution of the Indian Ocean. Subsequently, for the last three decades, researchers from several countries carried

out investigations independently and jointly over different parts of the Indian Ocean and provided improved models of plate kinematics at different sectoral plate boundaries, revealing the existence of several tectonic complexities. However, combination of all these sectoral plate tectonic evolution does not appear to provide a consistent model for the detailed evolution of the Indian Ocean as a whole. Probably this arises from the lack of adequate knowledge of tectonic complexities in the Indian Ocean caused by several geodynamic events such as hotspot volcanism, extinction of spreading centres, ridge jumps, India-Eurasia collision and the oceanic crustal deformation. The major limitation in the detailed understanding of the evolution of the Indian Ocean are the lack of high resolution magnetic isochrons and the associated tectonic fabric to arrive at consistent rotation parameters for constraining the relative motions of each plate pairs and the lack of knowledge about nature of crust underlying some parts of deep offshore regions and the aseismic ridges. We attempted to arrive at a consistent model for the plate kinematics of the Indian Ocean in high resolution, using an updated compilation of magnetic anomaly identifications, fracture zones, rotation parameters and the recently identified tectonic elements information from the conjugate regions. Towards this, we created a digital database of magnetic anomaly picks in high resolution using the picks derived from our earlier geomagnetic investigations in the Arabian, Eastern Somali, Laxmi, Gop, Central Indian, Crozet, Madagascar, Mascarene and Wharton basins, complemented by those available from published literature. These magnetic anomaly picks were further used to evaluate and refine the rotation parameters that constrain relative motions of various pairs of plates associated with the evolution of the Indian Ocean. Using this information, we constructed the reconstruction models for 13 ages to describe the stage-by-stage evolution of the Indian Ocean considering a plate circuit that results minimum spatio-temporal errors. Unlike the majority of the existing reconstruction models for the Indian Ocean that consider only the major continental blocks, in our revised reconstruction model, we included the various postulated microcontinents in the Indian Ocean as intervening continental slivers. Our model also accommodates the existence of several identified extinct spreading centres, caused by ridge jumps occurred during different episodes of seafloor spreading in the Indian Ocean.

ATMOSPHERE AND PLANETARY SCIENCES

THERMOSPHERIC NIGHTGLOW RESPONSE TO PENETRATING ELECTRIC FIELDOVER THE DIP EQUATOR: A CASE STUDY

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The present investigation on a case study approach, discusses about the response of the nighttime Thermosphere-Ionosphere-System (TIS) over a dip equatorial station, Trivandrum (8.5° N, 77° E, 0.5° dip lat.) to Prompt occurrence of Penetration Electric Field (PPEF) event on 05 January 2016. The investigation carried out using the nightglow emissions measurements at wavelengths OI 777.4 nm and OI 630.0 nm using a multi wavelength Portable Nighttime Photometer (PNP), revealed that the thermospheric airglow emissions, especially OI 777.4 nm and 630.0 nm, respond promptly to the PPEF event during nighttime. It has been observed that these nightglow emissions show a drastic enhancement after a time delay of ~15 minutes. It has been observed that the ionosphere exhibits prompt changes associated with the westward directed PPEF by enhancing the F region dynamo generated electric field. The base height of the ionosphere showed a sudden downward movement and the topside ionosphere (>300 km) exhibited a sudden compression during this PPEF event. Such a sudden downward layer movement brings more ionization to the centroid of these airglow emissions, which in turn enhances the emission rates. The study unequivocally demonstrates the coupling between interplanetary medium and neutral TIS during the nighttime PPEF events.

CHARACTERISTICS OFEQUATORIAL ELECTROJET AND COUNTER ELECTROJET PHENOMENA AT DIFFERENT SPATIAL SCALE LENGTH FROM THE INDIAN SECTOR

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Longitudinal characteristics of Equatorial Electrojet(EEJ) and Counter Electrojet(CEJ) phenomena at three closely spaced sites in Indian sector, separated at 5°E ,15°E and 20°E longitude are studied using 10 months of concurrent data obtained from three equatorial sites: Minicoy, Lakshadweep (MNC, 72°E), Vencode, Kanyakumari (VEN, 77°E), Campbell Bay, Great Nicobar (CBY, 93°E) and three low-latitude sites: Alibag (ABG), Hyderabad (HYB) and Nabagram (NBG, Andaman). The present study illustrates the longitudinal scale lengths of EEJ and CEJ variability in the Indian sector. A linear trend of (a) decrease in EEJ amplitude and increase in CEJ amplitude from east (93°E) to west (72°E), and(b) decline in correlation coefficient of EEJ with increase in spatial separations. The longitudinal trend of increasing CEJ amplitudes and decreasing EEJ strength westward (i.e. from 93°to 72°E) is observed. This effect could be attributed to the greater effect of zonal winds and gravity waves at MNC and VEN that are further from the vortex (100°E), of the global four wave structure of EEJ, in contrast to CBY (93°E).

STORM TIME DISTURBANCE ELECTRIC FIELDS OVER INDIAN LONGITUDES

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Geomagnetic storms are indicators of disturbance period causing significant changes in Earth's magnetic field at ground as well as the electric field in the ionosphere. Prompt penetration and ionospheric disturbance dynamo (IDD) are two examples of the disturbed electric field caused because of the geomagnetic storm. Investigations of the spatial extent of these electric fields are sparse. In the present study, we investigate the latitude and longitude extent of these electric fields using magnetic field data from three longitude sectors viz. Minicoy(MNC), Vencode(VEN) and Cambell Bay (CBY) operated by Magnetic Observatory, NGRI. The longitude separation between these stations is less than 20 degrees which makes the study unique. Along with these equatorial sites, magnetic records from low latitude stations are also investigated to understand the latitude dependence of these disturbed electric fields. The three major storms in 2015 are analysed in this study. It is seen that the effect of prompt penetration is similar at the three equatorial sites. However, the signatures of IDD is significant in MNC and VEN sectors as compared to CBY and their magnitude decreases as we go towards low latitude stations. Corresponding current vectors are computed which support the observed IDD effect. It is interesting to note that the equatorial electrojet (EEJ) and counter electrojet (CEJ) show the similar signatures. This proves that IDDs control the equatorial electrodynamics during geomagnetically disturbed periods.

ASSESSMENT OF URBAN POLLUTION FROM HEAVY METALS CONCENTRATION IN ROAD DUST IN GREATER HYDERABAD MUNICIPAL CORPORATION (GHMC), TELANGANA STATE, INDIA.

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Greater Hyderabad Municipal Corporation (GHMC) is witnessing fast urbanization characterized by rapid urban sprawl, population growth, infrastructural construction, industrialization and motorization, which is leading to environmental degradation, placing human health at risk. Presently, heavy metals in road dusts are used as proxies to illustrate environmental changes of GHMC area. In this study 311 dust samples were collected along the roads of GHMC in one season of the year 2013. Further, measurements like Magnetic susceptibility, ARM and IRM, on these samples have revealed high concentration of magnetic minerals like magnetite and hematite in the urban road dust. The results indicate increasing trends, though not steady, in traffic and industry contributed pollution. Regular measurement and monitoring of these pollution markers in different seasons and for longer periods can help understand area-wise ill-effects of the present trend of urbanization and therefore guide the city planners and rulers.

SOCIO ECONOMIC IMPACTS OF FLOODS AND EXTREME WEATHER EVENTS OVER INDIA IN RELATION TO CLIMATE CHANGE

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In recent years rapid anthropogenic climate change is observed in various climatic and weather trends all over the world. The large growth of population and urbanization together with use of energy and changes in land use pattern are leading to increase in the emission of pollution and occurrence of extreme weather events. Increase in the intensity and frequency of extreme weather events such as tropical cyclones, cloud burst and heavy rainfall, floods, droughts, heat waves and cold waves at global, regional and local levels are being reported more frequently in the last one to two decades..

In 2017, several parts of India such as Assam, Gujarat, Rajasthan, West Bengal, Bihar and Uttar Pradesh were affected by floods. Preliminary reports show that the death toll has exceeded 1100 as of now. Lakhs of people were displaced and property including crops, infrastructure and railway tracks, roads and embankments, worth several hundred crores were either lost or damaged

We cannot avoid natural hazards (like floods), but can minimize their impact on the environment by timely preparedness& planning and prevent them from becoming a disaster. Study of extreme rainfall is essential for designing the water related structure, in agriculture planning, in water management, also in monitoring climate changes. A sound knowledge of spatial and temporal variability of extreme rainfall event is very much useful for the design of dam and apt hydrological planning.

Consequently, it is desirable to study the observed spatial and temporal variability of weather and climate extremes such as floods, in particular. Socio economic impacts of the flood over India had been studied by several researchers using past data. In the present study, for this purpose the incidences of floods have been collected from Annual Climate Summary and Disaster Weather events prepared by IMD from 1981 to 2015 which refer to the most recent period.

The aim of the paper is to see how the recent trends in flood frequency are presently behaving.

The data show that apart from extensive areal floods urban floods are also reported such as the Mumbai's floods of 2005 & 2017 and floods in Chennai during 2016. Various reasons such as occupation of flood plains in the development work, silting of rivers, poor drainage system in cities and location of important infrastructures in fragile ecosystems such as mountain, hill slopes and flood plains are some of them.

Causalities and areas affected, economic losses have also been presented. Global data of the recent flood in different countries have been also compared to identify common features.

CHANGES IN INDIAN OCEAN DIPOLE'S INFLUENCE ON ANTARCTICA IN THE RECENT DECADE.

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Changes in tropical Sea Surface Temperature (SST) result in changes in atmospheric circulation. Some of these changes can be felt far off. These impacts are known as teleconnections. Well known is the influence of EL Nino/LaNIna of the Pacific. The Indian Ocean also has its own intrinsic variability. The dominant mode of Variability in the Indian Ocean, on inter annual time scales is the Indian Ocean Dipole (IOD). The IOD has distinct impact on climate on regional as well as on global scales. It is also noted in recent studies that Indian Ocean is warming at a faster rate, a phenomenon that has far reaching consequences. Interestingly the IOD also shows a positive polarity, since the past two decades. The influence of IOD can be felt in the Antarctica, in sea-ice as well as in the Precipitation. This is articulated by Rossbywave trains emanating from the tropics. During an IOD an anomalous low pressure system forms near the Ross Sea. This drives warm air to the west of the Antarctic Peninsula by southward (warm) atmospheric transport. The northward (cold) heat transport associated with IOD was located west of the Ross Sea. However, this influence did not extend in to the eastern hemisphere. In this study we present evidences for an increased influence of IOD in the Antarctica in the recent decade and examine whether it is related to recent Indian Ocean Warming.

LAST GLACIAL-INTERGLACIAL DYNAMICS OF THE INDIAN SUMMER MONSOON

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Seasonal reversals in monsoon winds strongly influence rainfall patterns on the Indian sub-continent regulating the socio-economic factors of south Asian region. High-resolution proxy records of climate change from the core zone of the monsoon impacted region are nonetheless very few. With a significant U-Th derived age control, the multi-proxy speleothem records across India were generated to characterize the last glacial-interglacial dynamics of Indian summer monsoon. Events marking major global change during the last deglaciation to Holocene are observed in great details. Multi-proxy approach reveals major changes in temperature, precipitation (ISM) and vegetation since the last glacial maximum (LGM) and the coupled role of solar and ocean-atmospheric forcing on Indian summer monsoon. It is observed that the mean annual temperature during LGM was 4°C lower than the present. ISM is found to be coupled with de-glaciation increase in temperature, however, the decoupling is observed during the Younger Dryas (YD) event. Marked with >5‰ change in $\delta^{18}O$, the

advent of Holocene is manifested by the end of YD showing remarkable strengthening of ISM activity with positive changes in vegetation. Early Holocene is characterized with increased monsoon activity with few punctures of drought events like 8.2 ka. Marked with centennial scale dry phases of serious implications for human societies, the Mid to Late Holocene shows alternating modes of ISM activity mainly driven by changes in solar insolation and North Atlantic teleconnection.

IMPACT SPALLATION PROCESSES ON MARS: A CASE STUDY FROM WINSLOW CRATER

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Impact spallation is an important process responsible for the ejection of boulders (large size clasts) from impact sites on the surface of planets. While it is fairly well understood for Earth and the Moon, there have been no detailed observations from Mars. Therefore, we have initiated a new study on Mars by undertaking a detailed geological analysis, mapping of spatial distribution of ejecta boulders in and around impact craters, characterization of sizes and shapes of the boulders and application of theoretical spallation models to our boulder measurements. To begin with, we have selected 1.1-km-diameter Winslow crater. It is located about 75 km south east of Schroeter crater (300-km-diameter peak-ring crater) in Terra Sabaea region on Mars. It is a fresh impact crater exhibiting well-developed ejecta deposits and rays. Absence of visible primary impact craters on its ejecta blanket suggests that it is a recently formed impact crater. The ejecta pattern exhibits a broad asymmetric pattern indicating the oblique impact. Using High Resolution Imaging Science Experiment (HIRISE) images, we mapped the ejectaboulders in and around the crater using ArcGIS mapping tool. About 4200 boulders were mapped on the ejecta blanket so far. The preliminary results are as follows: size of these boulders ranges from 0.75 m to 19 m. The boulders are largely concentrated around crater rim, where they have high population density, while the density decreases away from the crater. Also, there is a decreasing trend of boulder size from the crater to the exterior. The boulders are strewn up to 1.5 crater radius from the rim, beyond which they are fewer and poorly recognizable due to the resolution limit of the images. Axial ratio (shape parameter) of the boulders is found to vary from 0.33 to 0.9 with an average of 0.7. The cumulative size frequency distribution of these boulders defines a power index -3.63 in the diameter range of 3-16 m. It indicates the boulders suffered more complex fragmentation as observed in many cases of impact craters on Earth and Moon. Also, the power index is higher than those on Earth (e.g., Lonar crater) and the Moon (e.g., Censorinus crater). A detailed mapping and analysis of ejecta boulders is in progress. Some of the major results of our mapping work would be presented.

ACCELERATING WATER CYCLE AND CLOUDBURSTS IN THE *CENTRAL-WESTERN* HIMALAYA

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Warming-induced acceleration of the water cycle manifests in increasing frequency of heavy precipitation events in moist, energy-limited environments. Such variability in the precipitation has a cascading effect on human well-being and climate-carbon feedbacks. The Central-Western Himalaya (CWH) has witnessed frequent cloudbursts in the past few decades, which appear to be linked to an accelerating water cycle, primarily driven by regional vegetation change. Observational records indicate warming-induced deciduous vegetation expansion and a decline in water-conservative evergreen conifer forests in the CWH valleys. Tree-ring $\Delta^{13}C$ cellulose fractionation trends in deciduous species relative to coniferous species indicate 12 to 14% higher assimilation rate and enhanced transpiration since the 1950s. Concurrent water enrichment ($\delta^{18}O$) trends in species also confirm enhanced water release to the atmosphere. Periods of high $\Delta^{13}C$ fractionation and low $\delta^{13}C$ and $\delta^{18}O$ correlations (indicating relaxed stomatal control) in deciduous species coincide with increased cloudbursts events in the CWH. Increasing pre-monsoon rainfall, temperature and enhanced glacier-snowmelt have favored deciduous vegetation with shorter (April-October) but with intense periods of CO_2 uptake and water release over the conifers due to higher stomatal conductance and leaf-area. Many times higher transpirational and water storage capacity of deciduous species help to load enormous amounts of water vapour to the atmosphere, for convection during the pre-monsoon and monsoon (April-September). Our results emphasize that increased evapotranspiration coupled with pre-monsoon heating enhance atmospheric vapour loading and ignite mesoscale (valley-scale) convective systems leading to increased incidences of cloudbursts in recent decades. Thus, a solution to cloudburst 'magnitude control' exists in promoting conifers in the CWH instead of broad-leaved vegetation.

RECENT SEISMO-TECTONIC ACTIVITIES ON MARS: A GEOLOGICAL ASSESSMENT

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Unlike Earth and the Moon, seismo-tectonic activity of Mars is poorly understood. The seismicity of a planet reflects the tectonic processes operating in the planetary lithosphere. While the origin of earthquakes is related to plate-tectonics, the seismicity of other terrestrial planets and the Moon (single-plate bodies) are generally assumed to be related to global contraction due to planetary cooling as well as to local to regional lithospheric displacements related to magmatic activity and other instabilities. An outstanding scientific question regarding Mars is whether it remains seismically active or not. If active, what parts of Mars are seismically active, and what are the geological structures involved in the seismic processes? Instrumental records of marsquakes do not exist. Since Mars lacks instrumental seismic records currently, the on-going seismicity of Mars is speculated only through

geodynamic models. These models suggest that Mars could be seismically active today. Among the many seismio-tectonically active sites considered, the Tharsis region is suggested to be a major centre of seismicity on Mars. The region also includes the ~2000 km long, ~500 km wide and up to 9 km deep VallesMarineris (VM) canyon system (chasmata), which are the largest chasmata in the Solar System. However, their recent seismo-tectonic activities are unknown. Therefore, we have mapped thousands of fault systems in an area of 3500 km × 2000 km, determined stratigraphic relations between the faults and chasmata interior materials, identified different generations of faults, measured the lengths of all faults, measured dips and displacements along a few key segments of the two trough floor-bounding faults, determined absolute model crater-density ages of a few key landslides (N 18), mapped many thousands of boulder-fall occurrences on the chasmata walls and documented their morphometric properties, and recognized thousands of possible mud volcanoes on the chasmata floor. In addition, the fault-displacement measurements also provided first-order estimates of total seismic moment released from some of the prominent trough floor-bounding faults. Using the fault-length to seismic moment relation, we estimated the moment magnitudes of marsquakes that could be generated from the faults in the chasmata interior. We have also assessed the relative roles of recent meteorite impacts in and around VM in forming the mass-wasting features on the chasmata interior, by mapping fresh impact craters and calculating seismic moment magnitudes for those impact events. Combining all our results, we conclude that VM is not only recently seismically active, but also in the recent past (Middle and Late Amazonian Epochs).

OBSERVATION OF LITHOSPHERE-ATMOSPHERE-IONOSPHERE VARIABILITYDURING JAPAN EARTHQUAKES

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Present study verified the lithosphere-Atmosphere-Ionosphere variability by using the satellite and ground based data sets of Japan earthquakes. During tectonic activity green house gases methane (CH_4), nitrous oxide (N_2O),water vapor (H_2O) and carbon dioxide (CO_2) are released, which can absorb the certain wavelength of Outgoing Long-wave Radiation (OLR) adding more heat into the atmosphere. NOAA gridded satellite data have observed these local anomalies along the large linear fault system. Ionization of greenhouse gases will also take place and generate modulated anomalous waves, which propagate into the ionosphere F region. Present study shows that multi-parametric analysis is necessary to predict the earthquakes to save human lives in the earthquake prone regions.

YOUNG RESEARCHER PROGRAM

CRUSTAL UNDERPLATING AND ISOSTASY OF TWO MAJOR ASEISMIC LAXMI AND LACCADIVE RIDGES OF THE EASTERN ARABIAN SEA

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Laxmi and Laccadive ridges are the two prominent aseismic features in the eastern Arabian Sea. Free Air Anomaly (FAA) over the Laxmi Ridge is relatively negative, while over Laccadive Ridge it is relatively positive compared to surrounding region. Crustal nature of both the ridges is still not unequivocally established. Shipborne and satellite altimetry derived bathymetry, gravity, geoid and magnetic data are analysed and modelled to establish isostatic compensation mechanism and crustal nature of the ridges. Effective elastic plate thickness (T_e) and compensation mechanism of the ridges are examined based on 3D coherence and admittance computation between Mantle Bouguer Anomaly (MBA) and sediment corrected bathymetry. The best fit model reveals that the T_e and subsurface to surface load ratio (F) for both the ridges vary from 3 to 4 km and 0.7 to 0.8 ,respectively. The low value of T_e implies elastically weak lithosphere, whereas, F value indicates that the amplitude of subsurface load at the Moho is approximately equal to the surface load. Weakening of lithospheric plate can be either due to re-heating and underplating caused by the then nearby Réunion hotspot or volcanic emplacement on young oceanic crust. Further all along the length of both ridges, MBA is negative and its magnitude reaches upto 240 mGal, which is indicative of either presence of thickened crust or less dense mantle beneath the ridges. 2D crustal models derived from FAA data show that both ridges are underplated all along its length. High amplitude magnetic anomaly (>400 nT) over the southern part of the Laxmi and northern part of the Laccadive ridges reveals several lineations in WNW-ESE to NW-SE directions suggesting magma outpouring along week zones. Geoid to topographic ratio over the Laxmi Ridge is negative (-1.98 m/km) and over the Laccadive Ridge is positive (0.47 m/km) possibly indicating shallow subsurface load (<20 km) with small wavelength (<200 km). Based on results of the present study and published geophysical results, we infer that the Laxmi and Laccadive ridges are continental slivers, which are underplated as well as intruded by volcanics, and isostatically compensated by Airy model of compensation.

ACOUSTIC REVERSE TIME MIGRATION OVER STRUCTURAL GEOLOGY

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Seismic signatures are complex in character. They are difficult to interpret. To understand the seismic signatures in a better way; in this present analysis, two commonly occurring velocity-depth models are simulated by the help of MATLAB coding environment, which are to be acoustic in nature. These models are used to generate synthetic shot gathers by second order Finite Difference (FD) forward modelling. The accuracy of the modelling method is outlined. Along with this, to improve the imaging feature, the application of Reverse Time Migration (RTM) technique is used. This technique uses both the forward and reverse travel time for computational purpose. The accuracy of both advantages and disadvantages of the technique is also discussed briefly for the acoustic media.

SIGNATURES OF THE FAIZABAD RIDGE IN THE CENTRAL GANGA BASIN FROM MT DATA ALONG THE CHITRAKOOT - FAIZABAD–TULSIPURPROFILE

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Faizabad Ridge is considered as the NNE extension of the Bundelkhand massif beneath the alluvial cover of the Central Ganga Basin. Its exact extension up to the Himalayan front is not known. In order to delineate its structure and extent beneath the sediments, we have carried out MT study along the 330 km long Chitrakoot - Faizabad- Tulsipur profile across the Central Ganga Basin. Broadband MT data were acquired at 31 sites with inter-station spacing of 8-10 km. The subsurface electrical resistivity image has been obtained by Occam inversion of the data, which reveals very thin sedimentary cover between Chitrakoot and Allahabad. At Allahabad, the basin thickness suddenly increases to more than 2 km and a graben-type structure is seen. Further north, around Amethi the basement comes up to about 1 km and then increases to more than 2 km around Faizabad. Further north, the deepening of the basement is gradual and at the foothill the basement depth remains less than 4 km. A relatively shallow basement along this profile compared to the results of Manglik et al. (2015) indicates that the Faizabad Ridge is present in this section of the Ganga Basin and extends at least up to the Himalayan foothills.

CONJUGATE ANALYSIS OF LANDSAT OLI AND SATELLITE GRAVITY DATA FOR MAPPING STRUCTURAL CONTROLS AND SURFACE SIGNATURES OF GOLD MINERALIZATION IN BHUKIA, RAJASTHAN

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An attempt has been made to process Landsat 8 Operational Land Imager (OLI) and Satellite gravity model EIGEN6C4 data to delineate regional structures responsible for gold mineralization. Geologically, present study area is occupied by Aravali Group of rocks. Major rock units are dolomite, chlorite schist and low grade metasediment of Palaeoproterozoic age. Volcanis are also exposed at the south eastern part of the study area. Basement is older gneiss and migmatite.

Satellite gravity data have been processed to separate regional and residual bouguer gravity anomaly using low and high pass filtering respectively to identify near surface geological structures, which might have played a role as conduit for the movement of ore bearing fluids. Also, basement depth is derived using Euler Deconvolution solution using Satellite gravity data to relate the role of structure and basement depth in gold mineralization. Landsat VNIR-SWIR bands have been processed to derive at sensor radiance using sensor calibration coefficient for each band. At sensor radiance data is further processed to derive different image enhancement products suitable to delineate geological structures and associated rock types. High pass filtered OLI data have been subjected to high pass filtering(7x7 kernel size) to derive convolution image; which has been integrated with selected principal component bands (derived from Landsat 8 OLI bands) to delineate geological structures. Geological structures are also enhanced in decorrelation stretched PC composite of band 3, band 2 and band 1 and index image using band 3 and band 1 of OLI sensor. Geological structures derived from image enhanced products have been reconciled with the gravity derived regional structures. NE-

SW trending structures perpendicular to F2 fold (i.e. gossan) are identified as prominent structures for mineralization. . All the old workings and cap rocks are found to occur in vicinity of geological structures and also have spatial proximity to basement and metasediment contact. Basement – metasediment contact is delineated using selected independent component band composite of OLI bands and also from the Euler solutions of Satellite gravity data. PC and IC composites derived using OLI data also proved suitable in enhancing dolomites, migmatites, basalt and gossan exposures. These products are validated in the field and also available as geological database on ore mineralization.

CHARACTERIZATION OF ATMOSPHERIC DUST IN RELATION WITH LAND USE AND LAND COVER CHANGE IN DELHI

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During past two decades, Delhi has witnessed a significant increase in the Land Use and Land Cover Change(LULCC). From 1985 to 2011, the length of roads in the city has increased by 76% and the number of motor vehicles rose to 80, 52,508 in 2014. The number of industries and factories has also risen by 39.54% in 2011 as compared to that in 1994. Also, between 1989 and 2011, the increase in built-up area has become very high (17%) in comparison with the increase in forest cover (0.5%).The Land Use and Land Cover Change for the expansion of urbanization and industrialization is a significant source of particulate matter contributing very high fluxes of atmospheric dust and its chemical constituents. This study found that the average value of dustfall flux was 35 g/m^2/year, which approximately equals to 52 Gg of dust deposition every year over 1490 km^2 area of Delhi city. Moreover, the dry weather conditions of Delhi add to the enhanced soil erosion and soil suspension in the atmosphere.

In this region, atmospheric dust contains a significant fraction of suspended soil, which interacts with different atmospheric contents including carbon. The mineralogical composition of atmospheric dust revealed that this dust was rich in black carbon. The carbonaceous aerosols are emitted during coal and petroleum combustion. These carbonaceous aerosols are mainly responsible for transforming silica dominated soil dust into the carbon-rich dust and other particulate matter. Such dust has an important role to play in the atmosphere, and it may have a significant influence on radiative forcing, climate change, visibility and human health, etc. Hence, this study suggested that in order to meet the need of transportation, housing, industries, etc. for the rising population of the city, the present pace of urbanization needs to be staggered to arrest the reduced green cover of the Delhi city.

SEISMIC HAZARD EVALUATION IN CENTRAL INDO-GANGETIC PLAINS

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The Mw 7.8 2015 Nepal earthquake was recorded at 18 stations by a strong-motion seismic network in Central Indo Gangetic plains (CIGP). Ground motion simulation and validation study was performed from these recordings using SCEC BBP platform, which produced accurate results. The same study has investigated on the best suited Ground Motion Prediction Equations (GMPE) then available and found that the GMPE model developed by Sharma et al (2009) for the Himalayan

region was close to the recorded PGAs. The recently developed GMPE by Singh et al (2017) was found to predict the PGAs more accurately than Sharma et al (2009) and hence, considered in this study.

Seismic Hazard Analysis is carried out for CIGP region in this study. The usefulness of hazard analysis has led to the development of several computer codes such as EQRISK, FRISK, SeisRisk, National Seismic-Hazard Mapping Project (NSHMP), CRISIS, EQHAZ, EQRM, OpenSHA and OpenQuake Engine. All these codes provide a useful contribution to the advancement of seismic hazard assessment around the world. However, Open Quake Engine, an open source software that has reproducibility, testing, and community-based development capabilities is selected for seismic hazard evaluation in CIGP. Seismic hazard is computed for the study region using classical PSHA (Probabilistic Seismic Hazard Analysis), Event-based PSHA procedures. Several source typologies, fault ruptures, stochastic event sets, the aleatory variability of ground motions are considered during modeling and results are compared at the selected stations. The results of hazard assessment can be utilized further for engineering seismological research, seismic design of structures, earthquake risk evaluation of assets and effective mitigation in CIGP region.

META-ATTRIBUTES FOR ADVANCED INTERPRETATION OF 3D SEISMIC DATA FROM TARANAKI BASIN OFF NEW ZEALAND

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Attributes are a set of characteristic properties derived or computed from data, and are called seismic attributes when extracted from seismic data. The past decade has witnessed tremendous advancement in seismic attributes that have improved the subsurface images for deciphering geo-tectonics and characterizing hydrocarbon reservoirs. Here we design a meta-attribute by suitably combining multiple attributes based on artificial intelligence of neural networks coupled with interpreter's knowledge, and compute several meta-attributes defined as the chimney cube (CC), fault cube (FC), igneous intrusion cube (IIC) and slump cube (SC) from 3D seismic data in the Taranaki basin off New Zealand. The outcome shows improved visualization of targeted bodies such as the geological discontinuities, gas chimneys, igneous intrusives like volcanic intrusion, sills & dykes, mass-transport complexes like slump deposits etc. from seismic data. The usage of this advanced tool results into an efficient and robust interpretation of seismic data that minimizes the uncertainties and maximizes the confidence level in delineating the subsurface features.

POSTERS

SEISMOLOGICAL EVIDENCE OF HALES DISCONTINUITY IN THE NORTHEASTERN INDIA

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The crust and upper mantle shear velocity structure beneath northeastern India is estimated by joint inversion of Rayleigh wave group velocity and receiver functions, calculated from teleseismic earthquakes data recorded at nine broadband seismic stations. The Assam Valley and the Shillong Plateau are two important geological blocks in the northeastern India, which are surrounded by the Himalayan frontal arc to the north, the Bengal basin to the south, and the Indo-Burmese arc to the north-east. The inversion and modeling of receiver function data reveal 30-34 km thick crust in the Shillong Plateau, 38-40 km in the Assam valley and 36 km in the Mikir hills. The average crustal shear velocity beneath the study region varies between 3.4 to 3.5 km/s. Low upper mantle shear velocity (~4.20-4.3 km/s) is observed beneath the study region, which may be due to either of the composition, grain size, increased temperature and small amount of partial melt (<1%) in the upper mantle or combined effect of allthese factors. The results also show the existence of Hales discontinuity at variable depths (56-74 km) and shear velocities of~4.4-4.6 km/s, in the study region. Variability of the depth of Hales discontinuity can be explained by the geotherm and/or addition of Cr^{3+} and Fe^{2+} in the spinel-garnet system.

DETAILED SHEAR WAVE VELOCITY MODELLING BENEATH CUDDAPAH BASIN, INDIA

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Knowledge of the composition and thickness are two critical parameters to understand the origin and evolution of the continental crust. Geophysical studies over south India are focused mostly on Dharwar Craton and the Cuddapah Basin. In the present study an attempt has been made to evaluate those parameters beneath Cuddapah Basin, a crescent shaped structure, which isone of the largest intra-cratonic Proterozoic sedimentary basins of India. It is in the eastern part of the Dharwar Craton.

Receiver function, a well known seismological technique has been used to find the structure of crust and upper mantle .Receiver functions have been calculated from teleseismic earthquake data of 11 seismic stations located in the Cuddaph Basin. Models have been developed usinga global optimization technique known as Neighbourhood Algorithm (NA) followed by joint inversion.

Results have been compared with H-Vp/Vs method. The results show, crustal thickness varies from 32-40 km (with average of 36 km) and average Vsis~3.55 km/s beneath the study area. It is found that Moho is deeper below Gudur-Cuddapah and the Veldurti-Kalva-Gani fault system. The fault system separates Cudaapah basin into three different blocks. It is seen that crust is thicker towards the east along the west to east trending profile. The overall crustal composition varies from intermediate tomafic (Vp/Vs~1.75-1.83). Average Vs of upper, middle and lower crust is found to be ~3.45, ~3.65, 3.7-3.9km/s, respectively, while high Vp/Vs (~1.8) values are observed all over the mafic crust,beneath most part of study area. Our results also suggest the presence of Moho offset ~6km in the eastern part of the basin.

PETROGENESIS AND DIAMOND PROSPECTIVITY OF THE AHOBILKIMBERLITE, WAJRAKARUR FIELD, EASTERN DHARWARCRATON, SOUTHERN INDIA: INSIGHTS FROM MINERALOGY, BULK CHEMISTRY, AND ISOTOPE SYSTEMATICS.

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Petrography, mineralogy, and geochemistry study of the Ahobilkimberlite from the Lattavaram cluster of Wajrakarurkimberlite field in eastern Dharwarcraton, southern India, is presented. This kimberlite, discovered by the Geological Survey of India, intrudes the Peninsular Gneissic complex and is exposed within the Pennar river bed near Penna Ahobilam. Petrographic study reveals presence of olivine macrocrysts and phenocrysts, with phlogopite, perovskite, and spinel within the groundmass with garnet constituting the xenocrystic phase. Presence of fresh olivine macrocryst, high modal abundance of perovskite and garnet cores of variable composition rimed by spinel are the hall mark of the Ahobilkimberlite. Mineral chemistry analysis of the minerals supports its Group-I (archetypal) kimberlitic affinity. Presence of relatively high Mg# (up to 80), Ni (650-970 ppm) and Cr (560-1180 ppm) contents along with the enrichment in light rare earth elements indicates its primitive nature and enriched mantle origin. Major and trace element geochemical studies suggest that crustal contamination to be minimal. Large ion lithophile elements and high field strength elements display a very good excellent correlation amongst themselves. However, a poor correlation of LILE and HFSE implies effects of weathering, deuteric alteration and hydrothermal activities. Further, presence of spinel rims around garnet is indicative of the metasomatic activity experienced by its magma. Discrimination diagrams based on ratios of highly mobile and immobile trace elements (e.g., La/NbvsTh/Nb, Ba/NbvsCe/Pb) highlight its Group-I kimberlite nature. Trace element petrogenetic modelling depicts its generation by 2-3% of partial melting of a carbonated peridotite source. And their $^{87}Sr/^{86}Sr_i$ and $\varepsilon_{Nd}(t)$ study clearly depicts that they have been derived from LREE deplete source similar to world-wide Group-1 Kimberlites. The Low fO_2 and convex pattern in their first row transitional element geochemistry, in the Ahobilkimberlite suggest more promising diamond forming magmatic processes in this study area.

GEO-DYNAMIC CHARACTERISTICS OF THE KASHMIR HIMALAYA: INFERENCES FROM GEODETIC AND TECTONOGEOMORPHIC TECHNIQUES

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The rate of vertical movement in the Kashmir Valley is poorly known, therefore we acquired and analyzed GPS data from Permanent (Uri, Keran, Drass, Kulgam and Aru) and campaign (Naranag, Sonamarg and Sinthan) GPS stations from year 2009-2014 in Kashmir Himalaya to study the rate of vertical movement in Kashmir valley Northwest Himalaya. A fit to vertical component gives average negative rate of -2.3mm/yr for the north, northeast flank of the Kashmir Valley, Great Himalayan Range (GHR). The average positive rate of 15.8mm/yr has been observed for the stations associated with the south, southwest Pir Panjal Range (PPR) of the Kashmir Valley. The negative rate corresponding to the GPS stations of the Great Himalayan Range may be the result of the downthrown movement of the NE part of the Kashmir valley. The positive uplift rate of the Pir Panjal side of the Kashmir Valley may be the result of actively upliftment and up thrown movement of the southwestern (SW) portion or Pir Panjal range along the Jhelum basin fault with intensive tectonic activity, the locking effect of the Kashmir valley and the thrusts present in this dissection of the Kashmir Valley. The

movement caused along the Panjal thrust, Jhelum basin fault and Balapora fault might have uplifted the southern and southeastern portion of the Kashmir valley. The enhanced upliftment rate of the Pir Panjal Range has decreased the sediment accumulation rate from 32-16 cm/KYr which in turn has enhanced the incision rate of 0.3-0.5mm/Yr. Inferences from the tectonogeomorphic: geomorphic indices and tectonic landforms I,e uplifted river terraces of Rambaria, Romushi, Veshaw and incised valleys, highly braided pattern of the rivers also suggests the same.

IDENTIFICATION OF FAVOURABLE STRUCTURES FOR HYDROCARBON CONCENTRATION FROM MAGNETOTELLURIC (MT) STUDIES IN NARMADA-SON LINEAMENT (NSL) REGION

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We have reanalysed and modelled broadband MT data from NSL region for delineating the structure of basaltic horizon and underlying sediments. Swift's and Bahr's skew and Phase tensor studies suggest that the area is highly heterogeneous. We observe one-dimensionality in the MT data upto 10 Hz, and it changes to high dimensionality in lower frequencies. It is the indication of the layered structure in the shallow region and complexity at greater depths. 1D modelling of the data was carried out to obtain the layer information in the area and to quantify the basalt and Mesozoic sediment thickness. 2D modelling of the data was also carried out to delineate the deeper electrical structure of the study region. Modeling studies show that some locations have thick Mesozoic sediment deposits beneath Deccan basalts. Also, Deccan trap thickness is high in the northern part of the study area, while it is thin in the south. The recent geochemical study points out anomalous light hydrocarbon gas concentration in the study area. However, the high values of anomalous concentration of hydrocarbon gas are not exactly above the locations of high Mesozoic sediment thickness obtained in our study, suggesting migration of gas.

We opine that, as the Deccan basalt is thick to the north, the basalt prevents the escapement of gas to the surface, resulting in migration of gas towards more favourable locales. One can conclude from this anomalous finding that the thick basalt in the north may be more compact compared to thin basaltic layer in the southern part comprising fractured or weathered basaltic formations. Such a structural configuration probably is providing a pathway for the migration of light hydrocarbon gases in the Mesozoic strata to the surface.

MULTIPLE MODIFICATION OF THE EASTERN DHARWAR SUB-CONTINENTAL LITHOSPHERIC MANTLE (SCLM), SOUTHERN INDIA: INSIGHTS FROM THE SHOSHONITIC LAMPROPHYRE MAGMATISM IN WAJRAKARUR KIMBERLITE FIELD

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We present the mineralogy, trace element and Sr-Nd isotope geochemistry of a rare occurrence of a shoshonitic lamprophyre associated spatially and temporally with the kimberlites from the Wajrakarur Kimberlite Filed (WKF) from the eastern Dharwar Craton, southern India. The lamprophyre body is

exposed as NW-SE trending feature and intrudes the Dharwar Batholith near Udiripikonda village, close to the western margin of the Cuddapah basin. The Udiripikonda lamprophyre is rich in crustal xenoliths and clinopyroxene megacrysts and so far known to be non-diamondiferous, whereas the nearby exposed Wajrakarur kimberlites are diamondiferous and with an emplacement age ranging from Mesoproterozoic to Cretaceous are exposed. This poses important constraints on the differences in the depth of melt generation for the lamprophyre and kimberlites.

Minerlogically, the Udiripikonda lamprophyre is phlogopite rich, classifying it as a kersantite. It shows geochemical characters similar to shoshonitic rocks (K_2O/Na_2O >0.5) and abundance in TiO_2 content (> 2 wt%) implies asthenospheric input in the mantle source. On primitive mantle normalized multi-element diagram, a moderate negative anomaly is observed at Nb-Ta, Zr-Hf and Ti, which is a common geochemical character of subduction related magmatism. However, some of the elements have similar concentrations as of average OIB. Various trace element ratios indicate lithosphere-asthenosphere interaction in the mantle source responsible for the generation of metasomatic phlogopite. Radiogenic initial εNd values of -22.5 to -20.1 for the Udiripikonda and -13.8 to -12.9 for nearby exposed calc-alkaline Mudigubba lamprophyres along with their low initial $^{87}Sr/^{86}Sr$ ratios rules out crustal contamination and favour a subduction related modification of the Dharwarian SCLM during Neoarchean.

Various geodynamic models are responsible for the interaction of asthenospheric fluids with a subduction modified SCLM, thus by, imparting mixed orogenic and anorogenic geochemical character of Udiripikonda lamprophyre: (i) slab window model, (ii) percolation of metasomatic fluids from thermal boundary layer to mechanical boundary layer, and (iii) plume induced delamination of the lower reaches of SCLM. Since, (a) subduction predates the magmatism by more than 1 Ga and (b) eclogite xenoliths in the Wajrakarur kimberlites ha

CHARACTERISTICS OF THE OFF NICOBAR ISLAND EARTHQUAKE SWARM AFTER THE 21ST MARCH 2014, 6.5 MW EVENT INFERRED FROM OCEAN BOTTOM SEISMOMETER DATA

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We have analyzed the 21st March 2014 6.5 Mw event and its aftershocks that occurred off Nicobar Island using passive Ocean Bottom Seismometer data. We have also used the island network and seismological land station data to examine the influence of northern trend of the Great Sumatra Fault in modulating the occurrence of the cluster of earthquakes. We have located 178 earthquakes between 21st and 22nd March 2014 and estimated the local magnitudes (ML) of these events ranging from 2.8 to 5.2. The identified cluster of events is the second largest observed swarm activity in the Andaman Sea. This region was influenced by the maximum stress changes due to 24th December 2004 and 28th March 2005 mega thrust earthquakes. The estimated local magnitude (ML) of 21st March 2014 event is 5.2 and the fault plane solution gives strike-slip fault. The earthquake cluster was distributed in a NW-SE trend for a distance of about 90km. These events are distributed between the sliver faults of Seulimeum strand of the Sumatran Fault System, and the Andaman Nicobar fault. The focal mechanism solution of some of these earthquakes gives strike-slip fault, which suggests reactivation of pre-existing strike slip fault systems such as Seulimeum strand of the Sumatran Fault and Andaman Nicobar fault. The estimated hypocenters are shallow with depths below 30 km. The

b-value of less than one (0.97) suggests tectonic origin for the identified earthquake swam. We have also observed southward migration of the cluster of earthquakes along northward extension of the Sumatra fault.

AMPLITUDE DECAYS FOR BODY WAVES, CODA AND PEAK GROUND ACCELERATION IN THE REGION OF KUMA ON HIMALAYA

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283 coda-normalized earthquake records from 67 earthquakes are used to study the attenuation of seismic waves in the Kuma on region of Himalaya consisting of parts of Lesser and Greater Himalaya. The events studied are local earthquakes recorded by a near-linear station array crossing several important geological boundaries, such as the Main Central Thrust and Vaikrita Thrust. The frequency-dependent amplitude-decay exponents of P-wave, S-wave, and coda waves are studied for body P and S waves, coda, and also the peak ground acceleration (PGA). Amplitude dependences with time are modeled as $t^{-\nu}$, where the decay exponent ν varies with frequency and generally lies in the range 1.4 – 2.4 for P waves and 1.6 – 2.6 for S waves. A similar decay exponent α for coda waves is close to 1.8 and shows little variation with frequency. Thus, contrary to the conventional assumptions, for all waves, the amplitude-decay exponents with time are significantly larger than 1.0. The lowest values of ν for P and S waves are observed near 3 Hz and generally increase above this frequency. For PGA, the ν values range from 0.9 to 2.3 and increasing with frequency. From the values of ν and α, we also derive the frequency- and distance-dependent Q in order to compare with the results of other attenuation studies. The values of ν and α show that in contrast to the commonly made assumptions, the coda consists predominantly of surface waves back-scattered within the upper crust. The relative values of ν and α also suggest that multiple scattering occurs within the coda wave field.

PREDICTION OF LITHOLOGY USING NEURAL NETWORK MODELING FROM WELL LOGS OF CAUVERY BASIN, INDIA

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Quick look interpretation technique has been used for identification of hydrocarbon bearing zones, Water bearing zone and Shale from wells with water saturation varying from 12 to 60%. This work has been carried out to evaluate hydrocarbon bearing sediments of Andimadam, Bhuvanagiri, Nannilam and Niravi formations of Cauvery basin, India. Six wells distributed over 5,100sq. km of this basin have been utilized for analysis of conventional well logs and reservoir characterization. We have developed the Multi layered Feed forward Neural Network (MLFN) model to automatically classify the lithology from well log data in Cauvery basin. Three sets of well data, namely; gamma ray, density and neutron porosity are used for classifying the hydrocarbon and water bearing zones. The input parameters are gamma ray, density and neutron Porosity and output parameters are hydrocarbon bearing zone, water bearing zone and shale. This network demonstrates the efficacy of the MLFN model for prediction of lithology using well log data. Network error observed is minimum and stable at 250 epoch, with 10 hidden nodes. It is validated with test data. This model is able to predict the hydrocarbon bearing zone, water bearing zone and shale from well log data from any well located in

the same or adjacent area of the study area. This network prediction has very good correlation with other lithology prediction methods.

STRAIN RATES AND TECTONICS OF THE BURMESE AND ANDAMAN ARCS - A COMPARATIVE STUDY

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The study of the deformation of an area depends on how much strain is accumulated and the tectonics of that region. To know the strain accumulation and tectonic information of a region strain rate values can be computed with focal mechanism data. In this study, we present strain rate values and focal mechanism of both Andaman and Burmese arc regions from the Harvard CMT catalog .For accuracy, we have used relocated earthquake data (Pesicek et al). The strain value calculation depends on the sum of moment tensor elements of every earthquake event, which gives current deformation based on strike, dip, and rake parameters of the fault geometry of each earthquake. The strain rate computation in Burmese region indicates that it has predominant compression in NS direction rather than EW direction; the direction of subducted slab. In comparison, the Andaman arc indicates compression dominantly in EW direction; the direction of Indian plate subduction. This is an interesting result considering that the fault geometry in both the regions indicates that reverse faulting is more dominant in both the regions, with the 57% in Andaman and 53% in Burmese arc, followed by strike-slip and normal faulting. It is demonstrated that the thrust faulting in each region has a completely different causative mechanism. The study also indicates that the possibility of a Great earthquake in Burmese arc as postulated by several authors is very unlikely.

RECENT MICROSEISMICITY IN NELLORE DISTRICT OF ANDHRA PRADESH

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This microseismicity activity started in the month of October 2015, and 248 micro earthquakes have been recorded by the seismological stations of CSIR-NGRI from October 2015 to December 2016. Fluctuations in the elevation of water table accompanied by changes in river flows transmit pore-fluid pressure transients to hypocentral depths where they trigger earthquakes in a crust already stressed close to failure. This was the original concept of the "hydroseismicity". A good rainfall (in excess of 43%) is reported to occur in Nellore district during 2015-16 compared to earlier year 2014-15. Rainfall data during 2015-16 at Udayagiri, Varikuntapadu, and Vinjamurmandals in Nellore have been analysed. A good Correlation is observed after alag of 9 days between rainfall and triggering of seismic events. The Micro tremors are confined to a narrowepicentral zone. We opine that a possible Fault/lineament is responsible for the recent ongoing seismic swarm activity in Chakalikonda-Kothapeta areas situated in Nellore Schist Belt, Andhra Pradesh. All these tremors occurred in upper crust at shallow depths ranging from 3-9 km. The largest magnitude in the earthquake sequence was 3.4. This type of micro earthquake activity can plausibly be associated with dynamics of the hydrologic cycle and is known as hydro seismicity.

INVESTIGATING SUBSURFACE QUATERNARY DEFORMATION WITH GROUND PENETRATING RADAR: IMPLICATIONS TO LATE CENOZOIC STRAIN PARTIONING IN KASHMIR BASIN NORTHWEST HIMALAYA.

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The purpose of this article is to delineate and describe the sub surface Quaternary deformation structures using Ground Penetrating Radar (GPR) in late Pliocene –Pleistocene deposits of Kashmir Basin Northwest Himalaya. The study was carried out using 100 MHz rough terrain antenna (RTA). Information on the visualisation of processed data reveals normal and reverse faults, as well as liquefaction structures, covered by thick recent soil deposits. Steeply-dipping reflections that sharply cut the nearby reflections causing bed offsets are identified as faults. These faults are mostly developed within lower Karewa deposits of early Pleistocene age, though some of the faults might continue into younger deposits (recent soil deposits) as well. The record of deformation is not widespread in these deposits. The GPR data in agreement with the exposed geological units and structural models, have proposed a complex evolution including thrust motion for this area from the late Pliocene to present.

INVESTIGATIONS FROM SWARM AND GROUND AS A SIGNATURE OF MAGNETOSPHERE-IONOSPHERE COUPLING

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An investigation of geomagnetic pulsations is carried out between low latitude Indian magnetic observatory and ESA's swarm mission. The study has two main aspects: (1) Computation of azimuthal wave number from Swarm A and C and (2) Investigation of pulsation from Swarm and ground. The first aspect deals with the azimuthal extent of geomagnetic pulsations,which is important to understand the scale size of these pulsations. The second part deals with the influence of ionosphere on geomagnetic pulsations. For this purpose, both quiet and disturbed period geomagnetic data from 2015 were analysed and more than 50 events of various types of pulsations were identified. From this study, observed modifications in the spatio-temporal structures of pulsation events from Swarm and ground are reported.

DETERMINATION AND CHARACTERIZATION OF SUBSURFACE STRUCTURAL FEATURES AT KOYNA-WARNA REGION IN INDIA

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The geometry of subsurface fractures in four boreholes around the Koyna-Warna region is studied, From Borehole acoustic Tele Viewer (ATV) and core data, to locate subsurface fractures, faults and study their geometry. Major fracture zones identified from ATV images have been correlated with structural data and lithology of corresponding cores. An attempt has been made to also correlate the subsurface and surface fractures information. Fractures, joints, faults are signatures of brittle deformation in rocks. Fluid flow also takes through fractures present in rocks. Understanding of the fracture geometry is important to investigate the surface and subsurface fracture connectivity and implication for geo-hydrological regime. Structural logging in cores provides data on location, orientation and types of

structures as well as their relation to each other. Fault planes slicken sides have been studied as evidences of seismic activity.

SEDIMENTARY STRUCTURE OF INDO-GANGETIC PLAINS FROM INVERSION OF RECEIVER FUNCTION

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We analyzed teleseismic P waveforms recorded by 10 broadband seismic stations deployed along North-South profiles and 26 strong motion seismic stations distributed in the network over the Indo-Gangetic Plains (IGP) and obtained high-quality receiver functions. The seismic shear wave velocity structure of sedimentary layer and thickness beneath every station were estimated using inversion of receiver function by Neighbourhood algorithm (NA).Results show the significant variability of sedimentary layer thickness from ~0.3- 5.0 km beneath the Indo-Gangetic plains. We observed that most of the Northern stations are double sedimentary layers and southern stations are single layered. As we progress from South to North of IGP, we observe an increase in sedimentary thickness from 0.3-5.0 km and a decrease in shear wave velocity from 2.62km/s to 1.0 km/s. The Values obtained in this study are very important for Indo-Gangetic Plain region, the seismically most vulnerable region, due to the high density of human population and presence of thick sediments that amplify the seismic waves due to an earthquake in the region.

PHYSICAL AND MECHANICAL PROPERTIES OF BASEMENT GRANITOIDS FROM KOYNA REGION: CONSTRAINTS FROM LABORATORY AND IN-SITU MEASUREMENTS

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Triaxial and uniaxial compressive strength measurements on cores of granitic rocks recovered from scientific drilling in Koyna seismogenic zone provide unique opportunity to characterize the effect of ongoing seismic activities on rock strength and elastic properties. The cored boreholes penetrated the total thickness of Deccan flood basalt and passed through a few hundred meters in the underlying granitoids. Laboratory data include measurements on granite gneiss, granite, migmatitic gneiss and mylonitised granite gneiss obtained from four boreholes. Salient results are as follows. (i) Spatial variability in rock strength is attributable to ongoing seismic activity during the past five decades. (ii) Inconsistency between failure planes and pre-existing planar fabrics suggests existence of other weak planes induced by frequent earthquakes (iii) Stress-strain curves confirm that axial deformation is controlled by the varying intensity of pre-existing shear in the granitoids (iv) Young's modulus and Poisson's ratio of the granitoids, computed from the linear elastic portion of the stress-strain curves, vary in the range 8-23 GPa and 0.1-0.3 respectively (v) The low and variable rock strength of the basement granitoids from Koyna region when compared to granitic rocks from aseismic areas indicate their generally weak nature, probably induced by the recurrent seismicity. Physical properties of the basement rocks are constrained from the downhole geophysical logs acquired in the 3km deep pilot borehole, recently drilled in the Koyna seismogenic zone.

CHROMIANCLINOPYROXENEMEGACRYST IN LAMPROPHYRE DYKE FROM THE MUNDWARA ALKALINE COMPLEX, NW INDIA

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We report the occurrence of an interesting clinopyroxenemegacryst from a lamprophyre of the Mundwara alkaline complex, NW India. The megacryst is sub-rounded to oval and having a size of 10mm in length and 7mm in width and displays sharp contact boundary with the host lamprophyre. Clinopyroxene and olivine are the major minerals with later occurring as inclusion within the clinopyroxene. The olivine inclusion has an erratic contact boundary with the megacryst. Clinopyroxene is chrome rich diopside with a compositional range of $Wo_{46.29}$ $En_{47.52}$ $Fs_{5.06}$ and $Ac_{1.13}$ and having a variable Cr_2O_3 content (0.52-1.22 wt %). Composition of the megacryst is similar to that reported from the ultramafic xenoliths in kimberlites and is clearly distinct from that found in (i) the Kutch xenoliths,which are derived from spinel bearing peridotite source and (ii) Al-rich megacrysts from alkali basalts. Olivine is forsteritic ($Fo_{84.78}$) and overlaps with those reported from world-wide mantle peridotite xenoliths. REE pattern of the host lamprophyre shows its derivation from an enriched lithospheric mantle within the garnet stability field. Geothermobarometry of the clinopyroxene reveals equilibrium temperatures of 910°C and pressures of approximately 33kb corresponding to depth of ~~100 km at the time of emplacement of lamprophyre.

ORIGIN AND EVOLUTION OF LIFE ON EARTH: EVIDENCES FROM GEOLOGICAL BOUNDARY EVENTS OF INDIA

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We present a review of the geological and geochemical signatures preserved in Permian-Triassic and Cretaceous-Tertiary boundary sections as evidenced from Indian stratigraphic sections along with a comparative account of the global record. We discuss the implications of entwined nature of climatic and biological evolution.

The surficial processes on earth haveundergone several catastrophic events in the geological past that played vital role in structuring the origin, progression and sustenance of life on earth. The Permian-Triassic (P-T) mass extinction or the great dying witnessed the most devastating disappearance of 90% of marine life and nearly 70% of vertebrates on land. Likewise, the Cretaceous-Tertiary (K-T) boundary is characterized by the last major mass extinction on earth with withdrawal of 50-60% of the earth's fauna and flora, including the mighty dinosaurs. Sedimentary records imprint the intense climatic, oceanographic and geological events during earth's history and can act as accurate archives in reconstruction of the past environmental transitions across such extremities.

The Guryul Ravine of Kashmir forms an important Permian-Triassic boundary section in India along with the adjacent area of Barus Spur and Kathsu region of Pahalgam. Bulk organic and stable carbon isotope compositions of black shales and carbonate rocks from the three P-T sections of Kashmir document the transition from the Upper Permian Zewan to Lower Triassic Khunamuh Formation. The Spiti valley section, Himalaya representing another classical P-T boundary section having negative C isotope excursions and presence of fullerenes (unusual carbon polymorph) suggest widespread global

anoxia during the time window. The Deccan volcanism (Cretaceous-Tertiary Boundary, known as K-T boundary) was perhaps the largest geological event in recent history of earth resulting in widespread flood basalt volcanism and attendant atmospheric and biological changes at the surface. The cataclysmic environment that prevailed on earth during the KTB is documented in the volcano-sedimentary rocks at Anjar, Gujarat. Abundance of Iridium along with the presence of high pressure-temperature generated fullerenes suggest a bolide impact which triggered the mass extinction.

COMPARISON OF SURFACE AND BORE WELL RECORDINGS OF THE 2005 KYUSHU EARTHQUAKE USING H/V METHOD

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An intra-plate earthquake (M_W 6.6) occurred 10 km from the city of Fukuoka, Japanon 20th March 2005. This was the largest seismic event to occur in the northern Kyushu region since the Iki-Tsushima earthquake (*M* 7) of 1700 CE. The earthquake caused heavy damage to many structures and inhabitants in the surrounding due to the liquefaction of the ground surface during the earthquake. In the present work site amplification for surface as well borehole recorded data was evaluated using H/V method for six different sites. The acceleration data from K-NET and Kik-Net networks installed across Japan was used in this work. We estimated the amplification and resonant frequency at six stations SAGH03, FKOH03, SAGH04, FKOH04, FKOH08, and FKOH05. The comparison of resonance frequencies for surface and borehole records suggested the low resonance frequencies for surface records and high resonance frequency for borehole records, respectively. This in turn suggested the significance of resonance frequency for estimation of sediment thickness at the sites. Hence H/V study provides us important information related to the site characteristics.

CONSTRAINTS ON THE CONFIGURATION OF ANDAMAN-NICOBAR SUBDUCTION ZONE FROM EM MODELLING

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The Andaman-Nicobar subduction zone is the result of convergence of Indian and Burmese plates and is characterised by oblique subduction, arc volcanism, and Andaman spreading ridge. To investigate the electrical conductivity structure of crust and upper mantle in this region, LMT(Long period Magneto Telluric) data over a period of one month was acquired at 3 sites:NBG (Nabagram) & HAV (Havelock) in Andaman and CBY (Campbell Bay) in Nicobar region. 2D forward models of electrical structure are estimated along profiles across North Andaman, South Andaman and Nicobar Islands. The structure along the profiles across the subduction zone is based on results obtained from seismic reflection data, which is modified iteratively to fit the LMT data obtained at the respective sites.

The EM forward models provide constraints on the offshore subsurface structures in this region. From the variations of conductivity values, we infer significant changes in structure of the continental crust (Burmese plate) east of the Andaman & Nicobar ridge and the accretionary sediment thickness from north to south across North Andaman, South Andaman and Nicobar Islands.

GPS – MEASURED CO-SEISMIC KINEMATIC OFFSETS AND RAYLEIGH WAVE INDUCED SITE RESPONSE STUDIES FROM THE 25TH APRIL 2015 GORKHA (NEPAL) EARTHQUAKE

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The 25th April 2015 Gorkha (Nepal) earthquake of Mw 7.8 was a signicant Himalayan earthquake on the Main Himalayan Thrust (MHT), since the occurrence of 1934 Bihar Nepal earthquake. It was well discussed as it caused, the unzipping of the locked portion of the MHT. The seismic wave propagates in all frequencies of which the long period (low frequency) Rayleigh waves are the most destructive. The sensitivity and signal to noise ratio (S/N) of a short period seismograph is quite low at the lower cut-off frequencies owing to the tapering of its response function. GPS measures absolute ground displacement with a sampling frequency of 1Hz or less and preserves the ground roll information in the sub – Hertz range. Here we investigate the GPS measured co-seismic kinematic offsets at near field (< 150 km) stations close to the epicenter of 25th April Gorkha earthquake and obtained the ground acceleration and station site responses due to Rayleigh wave propagation by applying the well-known Nakamura Method.

Data from permanent GPS stations in the NEGAR network is processed using the TRACK module of the GAMIT /GLOBK with the stable IISC (IGS network) as the fixed station during the earthquake hour (06:00-07:00 UTC). Stations that located (CHLM, KKN4, KIRT, NAST, SNDL) within the rupture length in the direction of rupture towards southeast had shown sharp co-seismic offsets. The estimated velocity of the Rayleigh wave at stations within the rupture zone averages to 2.98 km/s. Other stations in the direction of rupture, show that the Rayleigh wave induced ground displacements are dependent on the local geology of the area. The velocity components of the ground vibration are subjected to frequency (Fast Fourier Transform) analysis. The horizontal and vertical Fourier amplitude spectra and their ratio at each station are estimated. Respective site amplification factors have also been computed.. Results suggest ground resonates in lower frequencies at most stations situated in the alluvial plain of the Katmandu valley. Their amplification factors varied from 5 to 10. Higher resonant frequency sites are situated close to the Tibetan plateau, indicating the hard rock terrain of the region. The amplification varies at these regions due to the varying thickness of the sedimentary deposits. Thus, the higher magnitude of site amplification factor is an indication of vulnerability of the area in the sub-hertz range.

MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW) SURVEY OF KURUKSHETRA REGION , HARYANA

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Multi channel analysis of surface waves is a non invasive method, developed to estimate shear wave profile from surface wave energy. We have used the dispersive nature of the surface waves mainly of Rayleigh waves for subsurface interpretation. Measurement of phase velocity of Rayleigh waves of different frequencies can be used to determine a velocity depth profile. We are doing multi-channel analysis of surface wave test at various sites in the kurukshetra region. The test is carried out with

24 channel digital seismograph with 4.5 hz frequency .The data is interpreted with the SW (surfseis) software. Then we prepared the 1-d and 2-d shear wave velocity map using theoretical relationship between shear wave and Rayleigh wave i.e. rayleigh wave velocity (Vr) is equal to 0.9 shear wave velocity (Vs). The depth range of shear wave map is from 5m to 15m.

DOES VELOCITY ANOMALY EXIST IN THE UPPER-TO-MID MANTLE THAT BEARS SIGNATURE OF THE CAUSE OF INDIAN OCEAN GEOID LOW (IOGL)?

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Indian ocean geoid low (IOGL) is the largest depression (approx. -105 m) in the global geoid but the cause or origin of the existence of such an isolated geoid low in the south of India is not understood unequivocally. Geoid anomalies are associated with density anomalies to the first order. We investigate if such a density anomaly exists in the upper-to-mid mantle using cluster analysis. Cluster analysis of Lekic and Romanowicz (2011) divides a dataset of absolute shear wave velocities (Vs) at discrete depths into families such that the variance is minimum within families. These Vs families help to identify geographic regions that share common Vs. We first test the efficacy of this method on a high resolution Vs model of the Indian subcontinent (Maurya et.al. 2016) to see if the geogrphic regions identified by Vs families correspond to known geological provinces. We found that the method very effectively differentiates between the known geological units of the Peninsular India. We then applied this method to various global tomographic models to identify any obvious anomalous structure. We study a region extending from 50°E to 120°E and 45°S to 45°N. We find no significant anomaly in the first 300 km of the lithosphere. In the region beneath 350 km to 1600 km, we observe high velocity anomaly. A high density anomaly (scaled from velocity) structure corresponding to a low geoid anomaly indicates that the assumption of rigid earth model to predict the geoid is not sufficient. It highlights the importance of dynamic modelling in this region.

PARABOLIC APPROACH TO IDENTIFY THE CRITICAL LIQUEFACTION SITE OR SITES FROM GEOTECHNICAL AND GEOPHYSICAL INVESTIGATION

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Liquefaction is a phenomenon where there is a loss of strength in saturated and cohesion less soil because of the increased pore water pressure and reduces effective stresses due to dynamic loading. The liquefaction causes extensive structural and lifeline damage in the cities from high magnitude earthquakes, such as 1964 Niigata earthquake (M7.5), 1976 Tangshan earthquake (M7.6), 1979 Imperial Valley earthquake(M6.6), 1981 Westmoreland earthquake(M5.9), 1989 Loma Prieta earthquake(M7.0), 1994 Northridge earthquake(M6.7) and 1995 Kobe earthquake(M6.9). Assessment of liquefaction is an important aspect to mitigate the liquefaction hazards in site/sites. In situ test based on blow counts from the Standard Penetration Test (SPT) correlated with a parameter cyclic stress ratio or seismic loading come under simplified procedures, originally proposed by Seed and Idriss(1971). The simplified procedure is the most frequently used in North America and many parts of the world to predict liquefaction resistance. Since 1971, the simplified procedure has been revised several times and updated by Seed 1979, Seed and Idriss 1982, Seed et al 1983, Seed et al 1985. In

addition, other procedures to predict liquefaction resistance are small strain shear wave velocity (V_s) measurements; Becker Penetration Test (BPT) and Cone Penetration Test (CPT) have been developed. The reviews of simplified procedure are now available in National Research Council (1985), National Centre for Earthquake Engineering Research (NCEER-1996) and 1998 NCEER/ National Sciences Foundation (NSF) workshops on evaluation of liquefaction resistance of soils by Youd et al. (2001).

A Parabolic approach for SPT, CPT and V_s, is used first time in this study to define the threshold parameters between liquefaction (LQ) and non-liquefaction (NLQ) potential of soil. The world wide most recent past soil liquefaction case history data from Japan, Canada, United State of America, Taiwan, China, are presented to identify the LQ and NLQ by the different researchers with different approaches. However, the parabolic approach has never been used earlier. Data of 236(SPT), 193 (CPT) and 187 (V_s) are used in this study. The corrected SPT as $(N_1)60$, CPT as qc_1 and V_s as Vs_1 data are plotted with variable earthquake loading ,known as Cyclic Stress Ratio (CSR). The vortex of the parabolic curves for SPT, CPT and Vs are depending upon the threshold values for LQ data of different categories. The parabolic curves show the boundary originated from vortex between the LQ/ NLQ data. The vortex for $(N_1)60$, qc_1 and Vs_1 correspond to the values of CSR are 0.084, 0.089 and 0.229, respectively. A Set of parabolic curves are drawn for each different corrected SPT, CPT and V_S. Result shows that value of smaller than 6 blow counts for (N1)60, 3.5 Mpa for qc_1 and 125m/s for Vs_1 are the more critical values for favourable liquefaction in a site or sites. The observed liquefaction sites and the results obtained through this study are matching with each other. These results are useful for future prediction of earthquake hazard assessments in a site or sites due to soil liquefaction.

MAGNETOTELLURIC RESPONSES IN LAYERED MEDIUM

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Magnetotellurics (MT) is a passive electromagnetic method that uses natural electromagnetic field variations as a source. The MT measures the electrical property of the subsurface. Many people use MT as a pioneer in overthrust, surface and subsurface exploration. The MT source signals are normally generated from the two sources. One of the sources has the frequency less than or equal to 1 Hz. These signals are generated from the interaction of solar wind with the earth's magnetic field. The second one is the high frequency signal, which is having a frequency greater than 1 Hz generated from the thunderstorm activities. MT provides a cost effective way to map the subsurface and as a preliminary exploration technique to determine weather proposed anomolous subsurface is situated and if so to determine its extent. The depth of penetration for this method is a function of frequency; low frequency waves penetrate deeper in to the crust. A forward modelling is done for two cases to predict the responses generated by different kinds of regions assuming a ten layer medium with constant thickness and a four layer medium with varying thickness. The apparent resistivity and impedance phase response are obtained, assuming earth layers are horizontal inside the earth and the layered medium has varying thickness. Modelling has been developed to illustrate the relationship between the apparent resistivity and impedance phase in frequency range from 10^{-3} to 10^{3} Hz.

HOLOCENE CLIMATE CHANGES INFERRED FROM MICROMORPHOLOGY, GEOCHEMISTRY AND STABLE CARBON ISOTOPE OF SOIL ORGANIC MATTER FROM NAINITAL,NW HIMALAYA

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A Holocene paleosol section from Nainital, Lesser Himalaya was investigated to understand pedogenesis, and vegetational and climatic changes using detailed micromorphology, bulk and clay mineralogy, soil geochemistry, and stable carbon isotope compositions of soil organic matter ($\delta^{13}C_{SOM}$). The physical and chemical properties of soil profile indicate the formation of argillic horizon paleosol. Further, the micromorphological features observed in soil thin sections reveal partially decayed root traces, Fe/Mn mottling and clay coatings (>1%) with well-developed subangular blocky structure suggesting the formation of an argillic horizon (Bt). The X-ray diffraction patterns of clay fractions reveal the presence of illite and kaolinite indicating moderate chemical weathering. A constant TiO_2/Al_2O_3 ratio (~0.04±0.001) throughout the soil profile suggests same parent rock. The low calcification values show the absence of carbonate phases in the studied soil profile, which is a characteristic feature of Alfisol formed in a well-drained and semi-humid to humid conditions. The chemical index of alteration values of 79±1 also suggest a moderate degree of chemical weathering and agrees with an illite dominant mineralogy. The calculated average mean annual precipitation (MAP) in the Bt-horizons of the Nainital soil is 1344±19 mm/yr, higher than present-day MAP in the study area of ~1100 mm/yr (100-year average; IMD, 2011). This suggests that Bt-horizons in our profile was formed under more humid condition compared to the present. The vegetation response to climate change during the Holocene inferred from the $\delta^{13}C_{SOM}$ reflects changes in the proportions of C_3 and C_4 plants in the ecosystem. The $\delta^{13}C_{SOM}$ during early to middle Holocene (9.0–4.6 kyr BP) shows a mixed C_3-C_4 vegetation with the dominance of C_3 plants. On the other hand, $\delta^{13}C_{SOM}$ during late Holocene (~4 to 1 kyr BP) suggests vegetation shift to more abundance of C_4 plants. Comparison of the $\delta^{13}C_{SOM}$ with Indian summer monsoon (ISM) records suggests that proportions of C_3 and C_4 plants vary with the intensity of the ISM precipitation; hot and humid climate favors more C_3 plants and cold and arid supports more C_4 plants. A gradual expansion of C_4 plants from ~4 kyr BP until 2.7 kyr BP suggests a gradual weakening of the ISM and consequently increasing aridification.

GPS MEASURED PRE-SEISMIC IONOSPHERIC TEC VARIATION ASSOCIATED WITH 25TH APRIL 2015 NEPAL EARTHQUAKE

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Study of ionospheric disturbances using GPS is one of the interesting topics in the geophysical research since a few decades. Ionospheric electron content variation associated with an earthquake will give an insight about the Lithosphere Atmosphere Ionosphere (LAI) coupling mechanism. It has been observed that Seismo – ionospheric disturbances arising from the seismogenic zone, cause variation in the Total electron content (TEC) in the ionosphere prior to an earthquake. We have investigated the pre-seismic ionospheric TEC variation within the earthquake preparation zone associated with the 25th April 2015 Nepal (Gorkha) earthquake of Mw 7.8 that caused severe loss of human lives and destruction in the Nepal Himalaya and the adjoining Indian region.

In this study, we used GPS data from 15 continuously operating stations from Nepal, WIHG and IGS networks that are located around and far from the earthquake epicenter for a period of 70 days (35 days each before and after the earthquake). We estimated the Mean TEC (MTEC) from the GPS, L1 and L2 carrier phase measurements for the case of near (<100 Km) and far field stations over the observation time. In order to identify the noise in the TEC variation caused by solar and geomagnetic storms over the observation period, we analyzed 'Kp' and 'Dst' indices. The diurnal effects in the estimated daily mean TEC of each station have been removed by subtracting the statistically estimated mean TEC of that station over a period of 70 days. The resultant Differential TEC or DTEC, shows an anomalous building up of total electron content (~30 TECU) in the stations within the earthquake preparation zone (1022 km) before 2-3 days of the main event. Results also show that with respect to the western stations from the epicenter, the values of pre-seismic DTEC at the southeastern stations are relatively higher. The peak value of the co-seismic ionospheric disturbances (CID) from the near field stations associated with this event also show higher values (~8-10 TECU) towards east and the southeast directions. Thus, both Pre-seismic and Co-seismic ionospheric disturbances are in concurrent with the direction of earthquake surface rupture that occurred towards southeast. This implies that there was a preferable direction in the pre-seismic variation of TEC, which was in tandem with the preferred direction of seismic energy propagation.

SEISMIC ANISOTROPY OBSERVATIONS FROM LOCAL EARTHQUAKES IN THE GARHWAL LESSER HIMALAYA

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Seismic anisotropy of the crust of the underthrusting Indian plate in the Garhwal Lesser Himalaya has been estimated using local earthquake data from short-period seismic stations operated in the region. S-wave splitting measurements for local earthquakes have been investigated for the anisotropic parameters. The local events ($M < 3$) occurred from January 2008 to December 2009 have been considered in this study. Total 105 pairs of seismic parameters (ϕ and δt) were calculated form 85 local shallow focused earthquakes (depth < 22 km) with 25 null measurements. The spatial variations both in ϕ and δt suggest a complex anisotropic structure beneath the region caused by a combination of both structural- and stress-induced mechanisms. The average ϕ is NW–SE oriented (N141°), showing clear similarity both with the local and regional faultstrike (MCT and MBT) and the SH max. The above-mentioned fault-parallel ϕ distribution suggests that the observed anisotropy is mostly controlled by the local fault-related structure. In the central part of the study area near SNT and to the west of Tehri fast axes are oriented NE–SW. Here, ϕ are predominantly oriented NE–SW; we interpret this orientation as due to the presence of over-pressurized rock volume which should be responsible of the 90° flips in ϕ and the increase in δt. This mechanism of NE–SW orientation of ϕ may be possible due the presence of a buried, deep NE–SW oriented Delhi Haridwar ridge (DHR) in the region. Another important feature recorded in the study is the complex orientation of ϕ in the region lies northwest to the Barkot. The fast directions are oriented almost in N-S directions, which is not the strike direction of major regional fault system. The possible correlation to these anisotropic directions is to the complex local faults system and due to the highly fracture rock volume beneath the region.

DELINEATION OF THE CRUSTAL STRUCTURE OF THE EGBM AND CHHATTISGARH BASIN FROM GRAVITY AND MAGNETIC DATA

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A long 622 km gravity and magnetic anomaly profile across the EGMB and Chhattisgarh basin has been modelled, using combined 2-D forward Gravity and Magnetic modeling technique and Power Spectrum analysis. Werner Deconvolution also has been carried out for additional information and depth constrain of causative source. Power spectrum analysis and Werner Deconvolution techniques provide the thickness of the basement of about 2-3 km, 5-7 km below EGMB and Chhattisgarh basin, respectively.

The contracted model suggests that the depth to the intrusive under the Archaean is observed to be at a depth of 4km and relatively shallow intrusive is mapped at depth of 1km in the Eastern Ghats suite of rocks. Deep fault structure is modelled along Deccan traps and Proterozoic formations in the Chhattisgarh basin, where its depth is found to be about 6 km.

The depth to the Moho under EGMB is about 36 km. The Moho depth increases to 40-45 km over Chhattisgarh basin.

UNDERSTANDING BIOGEOPHYSICAL MECHANISM OF CH_4 EMISSION FROM BIOLOGICAL TREATMENT OF WASTEWATER

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Methane (CH_4) is emitted from both natural and anthropogenic sources and is ranked one of the worst global warming potential (GWP) gases as it is more than twenty times warmer than carbon dioxide (CO_2). Major anthropogenic sources of methane emissions are wastewater treatment plants and landfills. Considering the GWP of methane, an effort has been made to find the mechanism for reducing biological methane emission from wastewater treatment plant. This task has been achieved by conducting a laboratory experiment under anaerobic conditions consisting of two similar Plexiglas columns. The first column is filledwith landfill leachate and waste concrete whereas the second column is filled with soil and waste water. Biogenic gases evolved in the columns were monitored at regular interval by connecting headspaces of the columns to the biogas analyzer. Additionally, the anionic and cationic analysis in combination with mineralogical and geomicrobilogical solid phase analysis, are performed on water samples. It is found that the presence of divalent metals enriched materials such as waste concrete reduces the formation of methane by fixing biogenic CO_2 into insoluble metal carbonate through various microbial carbonate precipitation pathways. Inadaquate availability of CO_2 as an electron acceptor and organic substrate reduces the possibility of hydrotropic methanogenesis. Biological CH_4 formation takes place in the strictly anaerobic environment after the accomplishment of microbial sulfate reduction. Self potential(SP) signals associated with CH_4 formation are observed very close to zero whereas the magnitude of the SP associated with sulfate reduction is observed of the order of -450 mV.This study demonstrates that usage of waste material enriched with divalent metals may reduce the production of GWP gases CO_2 and CH_4 from wastewater treatment plants. Furthermore, the proposed mechanism will help in solid waste management, development of green and sutainable water technologies.

DEFLUORIDATION OF WATER BY MONEY PLANT

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Groundwater is the primary source of drinking water, and high concentrations of fluoride in it may cause skin diseases, crippling of bones and brain damage. Considering the adverse effects of fluoride contamination on human health, we have attempted to find the cost-effective ex-situ method for defluoridation of water. In this laboratory study, we have used fluorided groundwater sample from Nalgonda district of Telangana. A laboratory experiment has been conducted to investigate the possibility of phytoremediation of fluoride from water. In the present study, we have considered money plant, water hyacinth, and duckweed for removal of fluoride from water without supplying any nutrients to these plants. It is found that water hyacinth and duckweed died influorided and highly alkaline groundwater (pH≈9) within ten days. However, a consistent growth is observed in money plant (*Epipremnum aureum*). Preliminary results of this study demonstrate that money plant can remediate both fluoride and the total dissolved solids (TDS) from contaminated water and can survive for more than two months without nutrients. Furthermore, anionic and cationic analysis of water samples shows that money plant can accumulate dissolved heavy metals and anionic contaminations such as chloride and sulfate. Unlike other plants, money plant can adapt to any climatic condition, and therefore, it may be a potential candidate for the cost-effective, green and sustainable treatment of fluoride contamination both in soil and water.

LITHOSPHERIC ELECTRICAL CONDUCTIVITY STRUCTURE ON EITHER SIDE OF THE CHITRADURG SHEAR ZONE

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The Archean Dharwar Craton exposes some of the oldest basement rocks on Earth - with ages over 3.0 Ga - making it one of the most significant cratonic regions of the world. The Chitradurg Shear zone and adjoining areas marks the boundary between the Eastern Dharwar Craton (EDC) and Western Dharwar Craton (WDC). Magnetotelluric data were collected along three parallel approximate 280 km long profiles with inter-site spacing of about 15 km. The raw data consists of time series records at 74 MT stations within the period range of 0.01 to about 10,000 s. MT impedance tensors were estimated using robust processing code. The data were modelled using non-linear conjugate gradient scheme taking both apparent resistivity and phase into account to obtain 2D models and rapid approximate modelling schemes (quasi-linear or quasi-analytic approximation) for 3D model to image lithospheric electrical resistivity structure. The strike direction for crustal depths is -50°, -5°, 3° for south, middle and north profiles. The lithospheric mantle (50–400 km) strike directions obtained are -50°, 13°, 16°. The results show there is decreases in the resistivity from south to north indicating proximity of the Dharwar nucleus is towards south. The other prominent results are: 1) Low resistive crust beneath the WDC and Chitradurg Shear zone and High resistive crust beneath the EDC. 2) Highly Resistive upper mantle lithosphere beneath the EDC and less resistivity upper mantle lithosphere beneath the WDC. 3) A thick lithosphere beneath the study region in the Dharwar Craton.

3D LITHOSPHERIC RESISTIVITY STRUCTURE OF RAJASTHAN AND ITS ADJOINING AREAS: EVIDENCE OF PRE-OUTBURST TRACE OF THE REUNION MANTLE PLUME

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Crustal and upper mantle resistivity structure along different transects over the Indian subcontinent was derived from Magnetotelluric (MT) data sets. However, a large part of the northwestern Indian shield, more specifically, the Rajasthan region was unexplored. Keeping this in view, an MT campaign has been initiated under INDEX project to image lithospheric resistivity structure of this region. Under this program, Long period (30 - 30,000 sec) MT data has been acquired at 144 locations in a grid fashion with an average site spacing of 55 km. This region witnesses the geological formations starting from 3.5 Ga to as young as Quaternary sediments. It is disrupted by a number of episodes of crustal accretion, rifting, sedimentary basin development, magmatic emplacement, and mantle plume influence; all led to the development of Rajasthan. The Delhi-Aravalli fold belt is one of the prominent geotectonic features in this area.

A regional three-dimensional electrical resistivity model has been obtained through inversions, using WSINV3DMT, a data-space variant of the Occam inversion approach developed by Siripunvaraporn et al. (2005). The retrieved three-dimensional electrical conductivity model shows a high conductive (< 10 Ohm-m) zone confined to an ~100 km corridor in NW-SE direction at the base of the lithosphere, starting from Jaisalmer in the NW to Ujjain in the SE. This can be attributed to the pre-outburst trace of the Reunion mantle plume. It is also interesting to note that the volume of the high conductive zone increases towards SE and raises to a shallow level, which might have acted as a feeder to conductive magma chambers in the crust and resulted in the outpouring of the Deccan traps at ~65 Ma. The zone of high conducting shallow anomaly in the SE corner also coincides with uplifted Malwa plateau, which is anticipated in the area of volcanic eruption.

LITHOSPHERIC RESISTIVITY STRUCTURE ALONG BIKANER-NAGAUR-JHALAWAR TRANSECT ACROSS THE ARAVALLI-DELHI FOLD BELT

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The NW shield region of the Indian subcontinent encompasses important geologic domains ranging in age from Archean to Phanerozoic, namely the Neoproterozoic Marwarbasin, Palaeo Proterozoic Aravalli and Mesoproterozoic Delhi fold belts, middle/late Archaean Bhilwaragneissic complex,and Meso/Neoproterozoic to early Palaeozoic Vindhyanbasin. Several geophysical studies were earlier carried out to portray the crustal velocity& reflectivity, density and electrical resistivity structure across the Aravalli-Delhi fold beltto study the tectonics and evolution of the region. However, characteristics of the deep lithosphere across the different geological domains in the NW Indian shield region are not yet studied. In this paper, we present the lithospheric electrical resistivity model along Bikaner-Nagaur-Jhalawar transect, which covers the major geological domains in the NW Indian shield. The 2D resistivity section retrieved from 3D inversion of a large MT data set covering the NW part of India shows highly resistive ($>10^4$Ohm.m)lithosphere under the Marwar and Mewar blocks. The high resistive lithosphere, which is typical of cratonicregions, indicates cratonicnature of the Marwarand Mewar blocks. Conductive lower crust and shallow mantle is noticed beneath the

Sandmata complex that consists of high-grade granulite facies rocks. Near vertical conductive feature in the mid crust and extending through upper mantle is imaged below the Great Boundary Fault that marks the eastern margin of Aravalli-Delhi fold belt. The tectonics and evolution of the region is discussed in light of the obtained lithospheric resistivity model and earlier crustal geophysical models across the Aravalli-Delhi fold belt.

QUANTIFICATION OF EFFECTS OF SHAPE OF BASEMENT TOPOGRAPHY BELOW THE CIRCULAR BASIN ON THE GROUND MOTION CHARACTERISTICS AND ENGINEERING IMPLICATIONS

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This paper presents the effects of shape of basement topography on the characteristics of the basin-generated surface (BGS) waves and associated average spectral amplification (ASA) in the 3D basins having circular surface area. Seismic responses were computed using a recently developed 3D fourth-order spatial accurate time-domain finite-difference (FD) algorithm based on parsimonious staggered-grid approximation of 3D viscoelastic wave equations. An increase of amplitude amplification and ASA towards the centre of different considered basins was obtained. Further, it may be concluded that ASA in basin very much depends on the impedance contrast, exposure area of basement to the incident wave front, edge-slope, focusing of the BGS-waves and sediment-damping. There is an urgent need of incorporation of a map of DGM caused by the BGS-waves as one of the output maps of the seismic microzonation.

IDENTIFICATION OFPOTENTIAL GROUND WATER AQUIFERS FROM VERTICAL ELECTRICAL SOUNDING-- A CASE STUDY INNAYA RAIPUR,CHHATTISGARH, INDIA

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Vertical electrical sounding (VES)is one of the most important techniques used during Resistivity survey for ground water investigation. 50 sites in the study area have been covered by VES of maximum spread length of 300m. The study has been carried out in the hard rock terrain of Naya Raipur, Chhattisgarh, India to demarcate the potential ground water bearing fracture zones lying below the subsurface. Factor analysis parameters and the fence diagram over the study area show that high yielding and good quality of ground water with relatively low resistivity can be obtained between 15-150m depth. We have correlated the VES data and curves with an existing dug well, designated as National Hydrograph Monitoring station of Central Ground Water Board (CGWB), and one deep Peizometric borehole existing very near to one of the VES sites in the study area. The phreatic aquifer of low yielding ground water is observed up to the depth of 15m from the surface,which is generally filled with water during rainy season and become dry during summer. The hard rock fractures saturated with fresh ground water are identified from 15 to150m below ground level, with low resistivity of 13.5Ω-m to 415Ω-m. By detailed Scanning of sub surface layers extending up to a depth of ~ 150 m, through VES helped in producing subsurface resistivity images map of the study area. By using

standard software we can better correlate the resistivity results with the depth and thickness details of productive hard rock aquifers, present in different segments of the study area except the two localized sites Bhatagoan and Kotarabhata.

GEO-ELECTRICAL STUDIES TO UNDERSTAND THE GROUNDWATER REGIME IN PARTS OF COASTAL AREA OF SINDHUDURG DISTRICT, MAHARASHTRA

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The present study demonstrates the electrical resistivity studies to understand the groundwater regime in the coastal aquifers of part of Sindhudurg district, Maharashtra. This helps to delineate the zones of seawater intrusion and its extent into fresh water aquifers and to locate fresh groundwater pockets to meet the water demand of society. The study area encompasses the western coastal area of Vengurla-Kudal-Malvan, Sindhudurg district, Maharashtra, bounded by coordinates Latitudes 15.7° to 16.15° and Longitudes 73.50° to 73.8°. The area comprises laterites, basalts and coastal alluvium with varied physiographic conditions and several NE-SW, NW-SE to EW lineaments. Vengurla and Malvan areas are from coastal stretch with varied annual rainfall and physiographic conditions, whereas, Kudal is away from the coast. A total of 67 vertical electrical sounding (VES) points using Schlumberger configuration with a maximum electrode separation AB of 200 m is considered in this study. The apparent resistivity curves were generated and interpreted using IPI2WIN software, after marginally modifying the manually interpreted results, keeping in view the local geology and hydrogeology. The contour maps for the geophysical parameters viz. the transverse resistance (T), longitudinal conductance (S), transverse resistivity (ρ_t), longitudinal resistivity (ρ_l) and electrical anisotropy (λ) were computed to generate the resistivity regime of saline and fresh water bearing formations. The results demonstrate that these parameters provide a constructive solution in delineating the saline and fresh water aquifers, particularly when the resistivity data interpretation encounters constraints due to intermixing of saline water aquifers, fresh water aquifers, clay etc. The pseudo cross-sections of resistivity data in the study region show the flow of saline water from the coastal side and the effect of lineaments.

MAGNETIC SUSCEPTIBILITY OF ENTIRE DECCAN BASALT SEQUENCE EXPOSED ON THE WESTERN GHATS ESCARPMENT

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Present study is aimed at characterizing magnetic susceptibility of the entire Deccan basalt sequence exposed on the Western Ghats escarpment. The samples cover the Deccan Group of lava flows consisting of three Subgroups (Kalsubai, Lonavala and Wai) and twelve Formations (Jawhar, Igatpuri, Neral, Thakurvadi, Bhimashankar, Khandala and Bushe, Poladpur, Ambenali, Mahabaleshwar, Panhala and Desur). A total of 300 block samples were collected from these Formations; they provided about 400 test cylindrical specimens that are used in the laboratory magnetic susceptibility measurements. The data reveal the variation of magnetic susceptibility within and between the Formations. The data provide three groups characterized by distinct magnetic susceptibility values. Jawhar Formation has the highest mean magnetic susceptibility (40 SI units). Igatpuri, Bhimshankar, Poladpur, Ambenali and Panhala Formations are characterized by medium level mean magnetic susceptibility (30 SI units).

On the other hand, Neral, Thakurvadi, Kandala, Bushe, Mahabaleshwar and Desur Formations have low level magnetic susceptibility (20 SI units). Of all these Formations, Desur has the lowest mean magnetic susceptibility value (15 SI units). The magnetic susceptibility variations indicate variation in the concentration of magnetic minerals (e.g., magnetite, titanomagnetite) and post emplacement groundwater related weathering. Since our measurements are from fresh quarry samples, we interpret them to be the original magnetic susceptibility characteristics of the Deccan lava flows possibly related to petrogenetic processes. The measured data are useful for analysis and modelling of field magnetic data for better understanding of the interior structure of the Deccan flow sequence.

CO-SEISMIC GRAVITY CHANGES IN THE KOYNA-WARNA REGION: IMPLICATIONS OF MASS REDISTRIBUTION

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Koyna-Warna Region (KWR) is one of the known sites for reservoir triggered seismicity. The continued triggered seismicity over the five decades is restricted to a region of about of 600-700 sq km, which provides a unique opportunity to monitor geophysical anomalies likely to be associated with seismicity of the region. Present study confers temporal gravity changes recorded by gPhone and GRACE satellite and interprets observed changes in conjunction with seismological, geodetic (cGPS) observations and groundwater level measurements. GRACE data suggest that seasonal vertical deformation due to hydrological loading is ~ 2 cm, which corroborates with continuous GPS observations. Seasonal hydrological loading of the region, which is in a phase of reservoir loading, might be influencing the critically stressed KWR leading to the seasonal seismicity of the region. The gPhone gravity data distinctly show co-seismic gravity signals for eight earthquakes of M > 2 and gravity anomalies show positive correlation on a logarithmic scale with earthquake released energy. To investigate the cause of gravity changes, an estimate is made for 14th April 2012 earthquake for Mw 4.8 using fault dislocation model. The recorded gravity changes of 189 μGal by gPhone located at a distance of 28 km from the hypocentre is much more than the estimate of ~0.1 μGal calculated for Mw 4.8 Koyna earthquake. Therefore, it is inferred that co-seismic gravity signals for eight earthquakes are primarily caused due to redistribution of mass at shallow depth.

RADIOELEMENTAL DISTRIBUTION AND HEAT PRODUCTION OF THE GRANITIC ROCKS FROM THE CENTRAL INDIAN TECTONIC ZONE AND ITS GEODYNAMIC IMPLICATION

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The Central Indian Tectonic Zone (CITZ) is an ENE-WSW trending Mesoproterozoicorogenic belt that formed during the accretion of Southern Indian shield (Baster-Singhbhum-Dharwarcratons) to the Northern Indian shield (Aravalli-Bundelkh and craton). The CITZ is bounded by the Son-Narmada Northern Fault (SNNF) in the north and by the Central Indian Suture (CIS) in the south. The tectonic zone comprises three sub-parallel E-W trending and geochronological difference supracrustal belts, namely Mahakoshal(2.2–1.8 Ga), Betul (1.6–0.8 Ga) and Sausar (~1.1–1.0 Ga) belts, separated by Son-Narmada Southern Fault (SNSF) and Tan shear zone (TS), respectively.

Radioelemental (i.e., Th, U and K) and geochemical studies have been carried out on 80 granitic rocks from the CITZ using laboratory multichannel gamma-ray spectrometer. Radiogenic heat production is determined using radio elemental concentrations and density. Geochemical study shows that rocks are granodiorite to alkali granite. Radioelemental study indicates that rocks are highly variable in Th, U, K and heat production. A systematic trend is observed, both, from east to west and north to south in the CITZ.In the northern part of the Mahakoshal belt, Siddhi granite shows a wide range from low to high heat production (0.8, 1.4, 5.8 μWm^{-3}) and Harda granite shows lower value (2 μWm^{-3}). In the southern part of the Mahakoshalbelt, Badagaongranites show highest heat production (6.5 μWm^{-3}) and the granites in the other parts (e.g., Jabalpur, Majuli and Umaria)show intermediate values (3.0 to 3.5 μWm^{-3}). The Betul belt also shows intermediate value as observed in the southern part of the Mahakoshal belt. The observed distinct radioelemental abundances and heat production patterns suggest that the granites present to the SNNF (Sidhi and Harda granites) and SNSF (Betul, Umaria, Jabalpur and Badagaon granites) are entirely different in time and space and need detailed investigation.

CRUSTAL AND LITHOSPHERIC STRUCTURE BENEATH HIMALAYA AND TIBETAN PLATEAU BASED ON ELEVATION, GEOID, GRAVIMETRY AND SHEAR WAVE SPLITTING DATA

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Investigation of deep crustal and lithosphereric structures is essential to understand the nature of geodynamical processes beneath the Himalaya and Tibetan plateau of the India-Eurasia collision zone. We present a hybrid approach comprising isostasy and spectral analysis to decompose the observed gravity field into its deep crustal and lithospheric components and derived density cross sections beneath the western, central and eastern part of Indo-Eurasia Collision zone using integrated 2D modelling of gravity, topography and geoid data incorporating constraints from seismic information. Our crustal model shows thickening of the crust from ~40km beneath the Indo Gangetic plain to ~70km beneath the Himalayan Mountains and Tibetan Plateau and further north crust thins down to ~40km beneath the Tarim basin in the western and central sector and shows thicker crust of ~50km in the eastern sector. Our new lithospheric thickness map derived from 3D inversion of lithospheric field component brings out many significant features like thickening of the lithosphere beneath Himalaya, thinning of the lithosphere beneath the northern Tibetan Plateau; Pamir and Karakorum Himalaya and Hindu Kush Seismic Zone; crustal bulge in foreland basins related to lithospheric flexure and northern extent of the Indian Lithosphere. This study clearly suggests that entire lithosphere is involved in isostatic compensation of the Himalaya and Tibetan Plateau although the major contribution comes from Moho undulations.

MINERAL CHEMISTRY OF DERGAON AND KAMARGAON METEORITES FROM ASSAM, NORTH EASTERN INDIA

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Mineral chemistry of meteorites, namely, studies of composition, major oxides and trace elements of the bulk meteorite provide the most important constraint for testing theories of Solar System formation . Meteorites retain a record of the elements, isotopes, and compounds that existed in the system's earliest days. One type, called carbonaceous chondrites, includes some of the most-primitive known samples. In the present study, we discuss the geochemical aspects of two meteorites. Ordinary chondrites (also known as stony meteorites) represent more than 85% of all the occurrences and are considered to be falls from crossing orbits of Near Earth Asteroids (NEOs) and the Earth. They primarily consist of olivine, orthopyroxene and variable amount of Fe-Ni, troilite (FeS), and have been grouped as H, L, LL accordingly. The H-type meteorites are high iron bearing olivine bronzite chondrite and are less in occurrence, while the L-type meteorites represent second largest group coinciding with near surface Earth asteroid 433, and show signatures of shock metamorphism. An attempt is made here to study and compare the distribution of rare earth elements (REE) of two ordinary chondrites: Dergaon (H-type) and Kamargaon (L-type) both of which have fallen in Assam during 2002 and 2015, respectively. The H-type Dergaon meteorite shows mild Eu-anomaly (Eu^* : 0.90) and relatively flat REE pattern (La/Yb: 1.70) representing melt fraction with unfractionated REE. The L-type Kamargaon meteorite show LREE enrichment (La/Sm: 3.6) with flat HREE (Tb/Yb: 1.2) and a prominent Eu negative anomaly (Eu^*: -0.76) indicating plagioclase removal from melt phase.

NEW PALEOMAGNETIC RESULTS ON SYLHET TRAPS, SHILLONG PLATEAU, NORTHEAST INDIA

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We present preliminary Paleomagnetic results on Sylhet traps. About 40 oriented samples were collected from eight sites located at and near Kyndrem falls on Cherrepunjee- Shella bazaar road, Shillong plateau, NE India. All the prepared standard specimens were measured for their Natural Ramanent Magnetization (NRM) and Susceptibility values. The average intensity is 1.528A/m. Alternating Field and Thermal demagnetization techniques were used to decipher the Primary Characteristic Remanent Directions. The obtained mean Declination and Mean Inclination were 250° and -18.25° (α_{95}=19.4; k=10.51). The obtained Virtual Geomagnetic Pole (VGP) is at 18.25°S; 346.12°. This pole indicates that Sylhet traps may be a later event of Rajmahal traps. Even the Paleolatitude position for the Indian subcontinent during 117 Ma appears to be closer to the Equator as seen from the shallower Inclinations in this study.

SUCCESSFUL EXPERIMENT OF A UNIQUE BOREHOLE SEISMIC NETWORK TOWARDS A SCIENTIFIC DEEP DRILLING PROGRAM AT KOYNA, INDIA

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Koyna, located near the west coast of India, is a classical site of artificial water reservoir triggered earthquakes. Tremors have started soon after the impoundment of Shivajisagar lake in 1962. The seismic activity has continued till date. The region experienced continued earthquake activity for more than five decades, including the largest triggered earthquake of M 6.3 in 1967; 22 earthquakes of M≥ 5.0 and several thousand smaller earthquakes. During 2005, CSIR-NGRI established a network of six broadband seismometers at Koyna to obtain the earthquake locations in near real time. Later by 2014-15 the network was strengthened to 23 surface seismic stations with a good azimuthal coverage. Inspite of having a dense network,locations of earthquakes have errors of ~1 km due to the presence of thick basalt flows. In 2011 Ministry of Earth Sciences, Govt.of India has initiated a scientific deep drilling experiment, to directly measure the physical and mechanical properties of rocks, pore fluid pressure, temperature and other parameters, to better understand the seismogenic nature of the area specific intra-plate active fault zone in the "near-field" of earthquakes at Koyna. In order to precisely delineate the sub-surface structure and fault zonegeometry, a borehole seismic network of 8 stations is planned covering the most active seismic zone. By 2016,a network of six borehole seismometers wasinstalled at depths of 981 to 1522m successfully. The network is providing noise free waveform data. The seismicity of the Koyna- Warna region is now closely monitored by surface and borehole seismometers. Precise locations are being obtained with an accuracy of ±300m. On this basis, a pilot borehole location (PBH) has been identified and drilled to a depth of 3 km successfully. The drill site is located in the vicinity of the Donachiwada fault zone, which is considered to be a major causative fault for the 10 December 1967, M 6.3 earthquake and subsequently extend the study to understand unique nature of area specific seismicity. Further studies on microseismicity, waveform similarity will provide subsurface fault geometry which will form key inputs for the proposed deep borehole experiment at the Koyna region.

ESTIMATION OF SITE AMPLIFICATION FUNCTIONS FOR THE NATIONAL CAPITAL (DELHI) REGION, INDIA

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The strong ground motion at a site is the product of three factors i.e source, path and site effect. In this study we have analyzed the site effect in NCR region. We have identified Sohna fault as a source, based on the past seismicity and simulated strong ground motions at bed rock due to scenario earthquake (M 6.0) in NCR at certain sites using semi empirical technique. The site amplification functions at 48 sites of NCR have been estimated using the waveforms of 23 events to generate the accelerograms at the surface. Due to the absence of reference site in the region, the widely used horizontal to vertical spectral ratio (HVSR) technique has been used. The maps showing the spatial distribution of predominant frequencies and the site amplifications at different frequencies corresponding to the natural frequencies of the different storey buildings have been presented. The predominant frequencies in general are found to be in the range 2.5 to 7.5 Hz, with an average of 4.4

Hz for the region having older alluvium sediments. Frequencies in the range 1.1 to 6.4Hz, with an average of 3.3 Hz, are found in the region having the younger alluvium deposits.

The average value of the site amplifications for the frequency band 3.0 to10.0 Hz is in the range of 2.0 to 5.3 for the sites with significant soil cover, while the spectral amplification corresponding to the predominant frequency varies from 2.5 to 7.5 at most of the sites and 2.0 to 3.0 for the sites with less or no sediment cover. It has been observed that the site effects have changed the character of the accelerograms as an increase of about 10% to 50% in PGA values from bed rock to surface. The spectral amplification levels presented for the different multi storied buildings may be used for the mitigation of seismic hazard in the region.

ENVIRONMENTAL MAGNETIC STUDIES OF BEACH AND FLUVIAL DEPOSITS OF PARTS OF MAHARASHTRA AND ASSAM TO UNDERSTAND THE SEDIMENT DEPOSITION DYNAMICS

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The present study underlines the utility of magnetic parameters in studying sediment accumulation and erosion (movement) along the beaches and also the characteristics of fluvial sediments deposited. Environmental magnetic methodology is simple and rapid and provides reliable preliminary information about sediments and its movement. In this study the sediment samples taken from two different diversified environments - one from coastal environment in western India (Maharashtra coast) and other from fluvial environment from northeastern India (Assam-Arakan tectono-sedimentary basin) have been analyzed to decipher different features associated with their formation. The coastline of Maharashtra is about 720 km in its length. It is popularly known as Konkan coast. The study has been carried out along this coastline at three different stretches of beaches- 1) Vengurla beach (Vengurla-Kepadevi), 2) Aravali beach (Mochemad-Kerwada), and 3) Redi beach (between Latitudes 16^0 44' - 16^0 52' N and Longitudes 73^0 35' - 73^0 40' E) present along a part of Sindhudurg district, Maharashtra. The other study area lies along Tipkai River from Sanghat, in Assam. The area forms a part of the Assam-Arakan tectono-sedimentary basin (latitude 26°14'43"N and longitude 90° 7'35.79"E). Sediment samples from the beaches were collected during three different seasons, pre monsoon & monsoon and post monsoon seasons. They have been measured for magnetic and geochemical parameters in the environmental magnetism laboratory, IIG, Navi Mumbai. The instruments used in this study include Molspin magnetometer, molspin demagnetizer, .a.f. demagnetizer and electromagnet pulse magnetizer. The results were plotted separately on a contour map using surfer program.

The samples from three different coastal regions are characterized by varied magnetic signatures in terms of their concentration and magnetic grain sizes. The concentration of magnetic minerals at Vengurla beach is higher during monsoon and low in pre- and post-monsoon periods. In terms of magnetic grain size, presence of fine SD grains is high in pre-monsoon; moderate to low during monsoon and post-monsoon seasons. Aravali beach has very low concentration of magnetic minerals for all seasons. At Redi beach, the concentration of magnetic minerals appears low in between seaside and inland areas. The sediments of these three beaches have variable proportions of magnetite, hematite and titanomagnetite. The magnetite and titanomegnetite in these beach sediments may be coming from the Deccan basalt through long shore currents. The other constituents come from the meta-sedimentary formations of the hinterland.

The fluvial deposits at Sanghat, along Tipkai River, Assam-Meghalaya plateau, preserve many signatures of environmental and climatic variations experienced in this area due to frequent calamities like floods, landslides and earthquakes. The magnetic susceptibility (MS) at Sanghat core is high at the bottom of the core with a decreasing trend towards the top. The trends and variations of the SIRM are also similar to that of MS. ARM studies indicate that the magnetic grains are fine and mostly hematite. S-ratio and hard and soft IRM indicate presence of magnetite and hematite concentrations in the sediments. The variations in the magnetic signatures of these fluvial sediments are attributed to the geogenic activities like flooding, seismicity and landslides in this region. The environmental magnetic studies are simple, rapid as well as reliable and indeed are one of the best suitable methodologies to assess the sediment characterization in any geological environment.

TRACING PROVENANCE OF THE GHAGGAR-HAKRA RIVER IN THE NORTHWEST INDO-GANGETIC PLAIN

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The presently ephemeral Ghaggar-Hakra River in the northwest Indo-Gangetic Plain has always been suggested to be the relic of an ancient perennial glacier-fed river, namely paleo-Sutlej. However, studies have also suggested that there was no glacier-fed river but an ephemeral Ghaggar river originating in the Sub-Himalaya at least since the last glacial maximum (LGM). To resolve this issue, we raised two sediment cores on the paleo-Sutlej channel in Sirhind, Punjab and analyzed bulk sediments for Sr and Nd isotope compositions. Weused the Sr and Nd isotope compositions of the sediment cores, deposited during the LGM-early Holocene to reconstruct their sources. We also compared our data with published records from the downstream of the Ghaggar-Hakra. Our isotopic results ($^{87}Sr/^{86}Sr$ and ε_{Nd} values) show significant temporal variation suggesting variable contributions from sources i.e., the Higher and Lesser Himalaya and hence confirm the presence ofa glacier-fed river (paleo-Sutlej). Higher ε_{Nd} (and lower $^{87}Sr/^{86}Sr$) during early MIS1 interglacial period compared to MIS2 glacial period reflects increased contribution from the Higher Himalaya. This can be attributed to the reduced extent of glacial cover over the Higher Himalaya and enhanced intensity of summer monsoon precipitation and its migration into the deeper part of the Higher Himalaya during interglacial period resulting in more erosion of the Higher Himalaya. Our synthesis of the Sr-Nd isotope fingerprinting for sediment sources shows varying compositions of the sediments from upstream to downstream with relatively more radiogenic Nd and less radiogenic Sr in the downstream sediments. This is due to contributions from other sources to the downstream sediments including Thar Desert and Sub-Himalayan sediments carried by Ghaggar River.

DETERMINATION OF CRUSTAL THICKNESSES AND VP/VS RATIOS ALONG TEXAS'S GULF OF MEXICOUSING H-κSTACKING

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The Gulf of Mexico was formed as a result of rifting between the continental blocks of North America and the Yucatan in the middle to late Jurassic. Littleis known about the underlying crustal structure of the Gulf's passive margin. Until recently, a dearth of high quality seismic data has made

it impossible to evaluate hypotheses concerning the structure, composition, and evolution of the region's lithosphere. The coastal plain's deep sediment package provides an additional challenge to seismic studies. From 2010-13, a linear array of 330km with 22 broadband seismic stations, spaced 16-20 km apart, was deployed from Matagorda Island, a barrier island in the Gulf of Mexico, to the Llano uplift of Central Texas.

We performed H-κ stacking of Ps-receiver functions to find crustal thicknesses and bulk Vp/Vs ratios beneath X4 stations. The average crustal Vp/Vs ratio is sensitive to the bulk mineralogical composition of the crust. For example, felsic quartz-rich rocks, such as granite, typically have Vp/Vs ratios of ~1.71 at crustal depths; for intermediate rocks, such as diorite, Vp/Vs ratio is typically ~1.78; and for mafic rocks, such as gabbro, the Vp/Vs ratio is ~1.87. This information, along with the crustal thickness, helps constrain the origin and tectonic history of a region.

We selected teleseismic events with magnitude greater than 5.5 in the epicentral distance range 30^0-90^0.An iterative time domain deconvolution technique was applied to isolate P-to-S converted phases (Ps) and associated reverberations (PpPs and PsPs+PpSs) of an incoming P-waveform beneath a seismic station. Our results along the Texas's Gulf of Mexico estimate a wide range of Vp/Vs ratios on this region, which implies there are significant lateral variations in mineral composition. The northernmost part of the array, on and near the Llano uplift, exhibits deeper Moho depths (>30 km) than the southern part (<20Km).

THERMAL CONDUCTIVITY OF GRANITES AND GNEISSES FROM THE CORE OF THE SINGHBHUMCRATON, EASTERN INDIA

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Singhbhumcraton (SC) is one of the oldest cratonsof the Indian shield exposed in an area of ~20,000 km^2.The craton is surrounded by the Chhotanagpur Gneissic Complex to the north, the Eastern Ghats Mobile belt to the south-east, the Bastarcraton to the south-west, and recent alluvium to the east. The core of the cratonic nuclei (3.53 to 3.1 Ga) consists of Older Metamorphic Group (OMG), Older Metamorphic Tonalite Gneiss (OMTG) and three phases of Singhbhum Granite (SBG I, II, III). The core is bounded in the eastern and western flankby Palaeo- to Meso-Archaean Iron Ore Group (IOG), whereas northern and southern flanksof the shear zonesare known as Singhbhum and the Sukinda Thrust belts.

For the first time we have studied thermal conductivity of major granitoids from the core of the Singbhumcraton, i.e., OMTG, SBG-I, SBG-II and SBG-III, in laboratory using steady-state divided-bar apparatus, on 164 rock samples at dry and saturated conditions. Density and geochemical analysis are also carried out to characterise the samples. The study area is divided into four zones, i.e. Zone 1 (Hata- Rairangapur), Zone 2 (Champua- Hat-Gamaria), Zone 3 (Keonjargarh) and Zone 4 (Pal Lahera). The data show that thermal conductivity of the OMTG variesover a wide range (2.1 to 3.5 $Wm^{-1}K^{-1}$) with amean of 2.7 $Wm^{-1}K^{-1}$in Zone 1 and 2.8 $Wm^{-1}K^{-1}$in Zone 2. The three phases of Singhbhum Granite show slightly narrower ranges reflecting homogeneity in composition. The SBG I is only observed in Zone1 and depicts similar mean value as the OMTG of Zone 1. The SBG II shows an increasing trend in thermal conductivity with a mean of 2.5$Wm^{-1}K^{-1}$ in Zone 1, 2.9 $Wm^{-1}K^{-1}$in Zone 2

and 3.2$Wm^{-1}K^{-1}$ in Zone 3. Similarly, the SBG III shows increasing thermal conductivity with a mean of 2.8 $Wm^{-1}K^{-1}$ in Zone 1 and 3.2 $Wm^{-1}K^{-1}$ in Zone 3. The result indicates that thermal conductivity varies for each rock suites and depicts an increasing trend from north to south (i.e., Zone 1 to Zone 3). The density is correlated well with thermal conductivity for all rocks from north to south with the lowest density in Zone 3. The density of OMTG is higher than the granites. The outcome of the study would be useful for estimating heat flow and thermal structure of the Singhbhumcraton.

ASSESSMENT OF LIQUEFACTION POTENTIAL OF ROORKEE REGION USING STANDARD PENETRATION TEST

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The liquefaction potential has been evaluated for the Roorkee region. For this purpose the liquefaction resistance of the soil, within the radius of 30 km of Roorkee city, was evaluated using In-Situ tests i.e. Standard Penetration Test (SPT). Roorkee city is a densely populated city in Northern India developing at a very fast rate. Geotechnical investigation of the Roorkee region indicates the majority of soil profile to be fine sand. Therefore, liquefaction analysis of Roorkee is very essential to safeguard the city against any major catastrophic earthquake. Investigation was carried out at different locations in Roorkee region by conducting SPTs and collecting soil samples at regular interval. The cyclic shear stress due to earthquake loading (t_{av}) was examined using simplified method (Seed and Idriss, 1971) as well as using ground response analysis (GRA) (Kramer, 1996) for PGA = 0.24g according to IS: 1893- 2002 (Part 1) for seismic zone IV. Shear stresses causing liquefaction i.e. liquefaction resistance (t_{liq}) of soil using simplified procedure based on field tests (Seed et al. 1985) for earthquake of magnitude 7.0 is considered in the study. Using information collected in above steps, factor of safety (FOS) against liquefaction with depth is computed. The FOS against liquefaction for all the sites using simplified method is significantly higher than that using Ground Response Analysis (GRA) method. Thus indicating that the analysis performed using simplified method may not be adequate. The maximum difference in factor of safety using two methods at shallow depths is more than 30% at all the sites. Outcome of present work will be helpful in Microzonation of city and liquefaction hazard mapping. Therefore, this research has significant practical implications.

ANOMALOUS MAGNETOTELLURIC PHASES IN SOUTHWESTERN PART OF CAMBAY BASIN: EVIDENCE OF COMPLEX CONDUCTIVE STRUCTURE

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The problem of current channelling in the analyses of magnetotelluric (MT) data suggests the presence of a strong and complex conductive feature or the ratio of length of a 3-D body to skin depth is high. In the present study, we attempted to interpret the anomalous phases encountered in the MT data collected in the western part of the Cambay basin, India. MT study is carried out at the southwest part of the Cambay basin near Dholera region (100 km southwest of Ahmedabad, on the left bank of Cambay basin) Gujarat. A total of 13 MT stations data along an E-W profile with interstation spacing of 2-3km is analysed. Two dimensional modelling of the MT data suggested the presence of a heat pathway that reflected as a fractured basement, which is probably connected to a deep seated

conductor, a geothermal reservoir. The surface location of the fractured basement coincides with the location of the hot water spring in the study region. Interestingly, at higher period (>100 s) the MT phases are out of quadrant i.e. above 90°. Due to the lack of geophysical evidence of strong anisotropic layer in the mid to upper crustal levels, we infer that the presence of highly conductive and complex geothermal reservoir /L-shaped conductor might lead to the abnormal behaviour of the phases.

IMAGING CRUST AND UPPER MANTLE STRCTURE IN THE DHARWAR CRATON

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We have calculated fundamental mode Rayleigh wave group velocity using ~2000 ray paths from 1000 good quality events recorded at 35 broad-band stations operated in the Dharwar craton during 2009 and 2010. Our results show group velocity of 30 s in the Eastern Dharwar craton (EDC) is higher as compared to the Western Dharwar craton (WDC). It suggests that the crust in the EDC is thinner compared to the WDC. Group velocity at 30 s is found to be similar for the Eastern Ghat (EG), the Western Ghat (WG) and the EDC. It suggests similar crustal thickness over these areas. Results also show high group velocity at 60 s for the entire region, which may correspond to the Hales discontinuity, observed in other cartons all over the globe, due to the spinel to garnet phase transition at ~70 km depth. Results also show lower group velocities at ~100 s that suggests thick lithosphere beneath the Dharwar craton.

GEOELECTRICAL INVESTIGATION USING SUBSURFACE RESISTIVITY IMAGING METHOD IN KURUKSHETRA UNIVERSITY CAMPUS, KURUKSHETRA, HARYANA

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The resistivity method is a useful technique to identify the sources of ground water as well as ground water contamination. The Geoelectrical resistivity survey was conducted in pre monsoon and post monsoon seasons in the Kurukshetra University campus(latitude 29°52′N to 76°25′E),to investigate the subsurface resistivity. The focus is to understand the subsurface lithology from geotechnical perspective. The survey was conducted using Syscal Kid -24 instrument and the data were interpreted using RES2DINV software.A total of 10 sites were selected inside and in the neighborhood of the university campus. Vertical electrical sounding (VES) survey was carried out using Wenner configuration with electrode spacing of 3 m, with expected depth of investigation of approximately 12 m. The average resistivity values of the region is about 100ohm-m. The VES has yielded significant information about the resistivity of different subsurface formations and provided a clear view of thickness and depth distribution of various lithological units.

3D FORWARD MODELLING OF GRAVITY DATA AND INVERSION USING VERTICAL FOURIER TRANSFORM OF A PART OF AFRICA AND NORTH ATLANTIC REGION

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A novel approach that uses Fast Fourier transform is used in this study. Fast Fourier transform (FFT) has been a powerful tool that is extensively used in potential-field data. Using this, a rapid forward modelling has been built by FFT of gravity data from spatial domain to spectral domain. In spatial domain complex relation exists between gravity with density that can be converted to simple convolution product in spectral domain. Under this assumption, a biunivoc relationship exists between data space 'g' and density distribution. To achieve very fine spatial discretization, a large number of points (where both the source distribution and field data are defined) in 3D grid are used. The main essence of this formulation is that it reduces the execution time to a significant extent and helps in modelling anomalies at different altitudes.

Next to forward modelling, inversion is done to understand the density structure within the region 0-10 degree latitude and longitude, which covers an area of approximately 1.23 * 10^6 sq. Km including north Atlantic ocean and part of Africa.

Vertical Fourier transform technique is used for potential field inversion to get rid of the data collected on undulating surfaces. Thus, models containing topographic surfaces can be dealt.

SITE RESPONSE EVALUATION USING AMBIENT NOISE

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It has now been well established that the characteristics like amplitude, frequency and duration of earthquake ground motions are influenced significantly by the local site conditions. Site amplification function plays an important role for determining the site-specific seismic hazard. It is one of the important factors for the microzonation studies of a region. The site amplification functions are useful for the simulation of earthquake strong ground motions at the surface. In the present study we have determined site response frequencies from H/V spectral ratios using ambient noise records. HVSR technique is also used to determine the fundamental frequencies of the structure,which may be of importance to earthquake engineers and civil engineers. The parameters obtained here are useful for the preparation of seismic hazard evaluation of the study region and thus help in mitigating the hazard.

ESTIMATION OF MESOZOIC SEDIMENT THICKNESS IN THE WESTERN CENTRAL PART OF KACHCHH BASIN, GUJARAT (INDIA) USING MAGNETOTELLURICS

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The Magnetotelluric survey is conducted along a profile of length 55km with station spacing of 2-3km in the western central Kachchh from Dujapar village in the south to Shervo village in the north to estimate the Mesozoic sediment thickness. Total 17 stations are used for the study. 1D

data modelling technique of Occam linearized inversion (Constable et al., 1987, Bostick et al., 1977) and Smoothed inversion are applied to the data. Three different types of subsurface layer sequences are observed. In the northern part of the profile the Mesozoic sediments are underlying the recent sediments whereas in the southern part of the profile Mesozoic sediments are inferred to be laid under Deccan basalt. The Mesozoic sediments are imaged as a shallow conductive layer overlying the resistive crystalline basement rocks at the middle of the profile. The Mesozoic sediment thickness of average 1.7 km is computed.

GEOMAGNETIC DEPTH SOUNDING IN SAURASHTRA REGION

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Four different geomagnetic depth sounding (GDS) profiles have been carried out in Saurashtra region in different phases during 2007-2012. Transfer functions, showing the relationship between anomalous (Z, vertical field transfer functions) and normal components of transient geomagnetic variations (X and Y variations) have been computed for various periodicities. Induction arrows thus obtained are sensitivity to subsurface electrical conductivity distribution facilitate to constrain that the sediments filling the offshore basins are more conducting than the basins in Saurashtra region. The contact zone between Jasdan plateau and surrounding basins is marked by the reduction in the amplitude of induction arrows.

2D modeling of the four profiles in conjunction with tectonics/and other geophysical methods permit to infer that the conductivity anomaly in the eastern part of the profiles is associated with the crustal/lithosphere thinning. The possible cause for these anomalies may be explained in terms of highly conducting sediments filling the western part of Cambay basin and partial melts associated with mafic intrusions, related to Deccan and pre-Deccan volcanism.

RECOGNITION OF BED BOUNDRY USING WAVELET AND FOURIER TRANSFORM ON LWD LOGS- A CASE STUDY OVER GULF OF MEXICO

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Identification of stratigraphic bed boundary in a reservoir using well log data is an uncontroversial challenge in modern geophysics. The presence of low and high-frequency noise in well log data creates difficulty in identification of the separate stratigraphic discontinuities. Statistical analysis also has an essential role in identification of different type of lithology in study of well log interpretation. In order to solve this complexity number of mathematical techniques has been applied. Often used Fourier transform may misleads to identify the interfaces in some cases due to presence of noise in the well log signals. In present study we have used a combined application of wavelet and Fourier transform on well log data of integrated ocean drilling program with three well sites of Gulf of Mexico to identify the discontinuity between different lithology. The combined approach of wavelet transform, Fourier transform, frequency filtering and its logarithm distribution provides clear identification of lithological discontinuity in the signal. The proposed algorithm has also tested and validated on ideal box car signal with two discontinuities to check its reliability. In present study this technique applied on gamma

ray and resistivity log for identification of stratigraphic boundaries and the electrofacies analysis to identify different type of lithology in reservoir. In an analysis of core of wells, it is found that wavelet transform and conventional method showed the similar result. The result of the combination of wavelet transform and Fourier transform is better than wavelet transform.

EFFECT OF WINDOW SIZE IN THE ESTIMATION OF DEPTH TO BOTTOM OF MAGNETIC SOURCES/CURIE DEPTH FROM MAGNETIC DATA USING SPECTRAL METHODS

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The estimation of depth to the bottom of magnetic sources (DBMS)/Curie depth and top depth from magnetic data depends on the window size; shorter the window size shallower is the estimation. To ascertain the magnetic responses from deepest layer, the optimum window size is required. In this study, we systematically carried out effect of window sizes in estimation of DBMS, from synthetic magnetic data generated for different combinations of top and bottom depths by assuming three dimensional random and uncorrelated distribution of magnetization, using Centroid and Spectral Peak modelling methods. In centroid method, the top depth of anomalous magnetic bodies is generally carried out from lower and middle wavenumber part of the magnetic field power spectrum. Large error of the order of 50-85 % is found in deeper top depth estimation when these are computed from the middle wavenumber part of the power spectrum, irrespective of window sizes. Top depth can be estimated within 30 % error ,while computed from lower wavenumber part of the power spectrum for window sizes $\geq$ 100 km $\times$ 100 km. Spectral peak modelling provides error of the order of $\sim$60 % and $\sim$30 % in shallow and deep top depth estimation, respectively for window sizes $\geq$ 100 km $\times$ 100 km. The DBMS values can be obtained within 10 % error for window size of $\sim$ 5$\times$DBMS ,using both the methods.

STRUCTURAL FABRIC OF THE KAILANA-TAKHAT SAGAR RESERVOIR REGION, JODHPUR, RAJASTHAN AND ITS CONTROL ON GROUND WATER FLOW

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The city of Jodhpur, in recent times has been experiencing the widely occurring phenomenon of a steadily rising groundwater level. The water requirement to the city is catered to by the supply from the Kailana–Takhat Sagar reservoirs. As the city receives adequate water from the reservoirs, pumping of water from the boreholes was summarily discontinued. Consequently, these factors have caused an increase of groundwater level, which has begun to seep through the basement structures in many of the buildings. Various Organizations have carried out investigations, but, the cause of the groundwater rise in the city has not yet been understood. The previous studies point to a linkage of the Kailana–TakhatSagar reservoirs that are thought to have recharged water through E-W lineaments. However, others point to a linkage between the increase of water supply and the sewerage networks that could have caused the shallowing of groundwater levels in the city. In order to assess the role of lineaments as conduits of groundwater transport, we have carried out a detailed structural analysis in and around Kailana–Takhat Sagar reservoirs region. The geological configuration of Jodhpur district

comprises an assemblage of sandstone, limestone, granite, rhyolite, schist, phyllite and slate. Rhyolite dominates the reservoir area. Field geological analysis involves locating the lineaments on the ground, examination of fractures and faults, geometry and spacing of these structures. Analyses of satellite imageries show that the lineaments have N-S, NE-SW and very few E-W orientations. Similarly, our field studies also reveal fracture systems with predominance of NNE-SSW to NE-SW orientations similar to the lineaments. Further, we have conducted thousands of fracture spacing measurements along the lineaments for calculating the modal porosity of the lineament area. They are generally low in the range of 0.5 to 3%; higher porosity is only observed in a few localized pockets. Therefore, groundwater storage potential of the lineaments is low to medium level. Our geological studies suggest that the structural lineaments abounding the Kailana-Takhatsagar reservoirs do not have connectivity to Jodhpur city region and hence cannot act as groundwater conduits for transporting groundwater to the inundated areas.

INTER STATION VELOCITY STRUCTURE FROM EARTHQUAKE WAVEFORM CROSS-CORRELATION FOR THE REGIONS UNFAVORABLE FOR SEISMIC AMBIENT NOISE CORRELATION STUDIES

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The success of seismic ambient noise cross correlation studies for inter station velocity estimation depends on the noise source distribution. Besides the fundamental assumption of randomly distributed noise sources in time and space, only signals from sources or their components along the line connecting the receivers contribute to the successful estimation of cross correlation functions. However, in regions with tectonically active segments, the local sources are strong and nonrandom in time and space. This creates problem for pairs aligned in some specific directions. Therefore, in such regions with complex noise source distribution the noise correlation method fails to provide the required accuracy. Based on the principles of interferometry, we propose here the cross correlation of earthquake signals along the line connecting the two receivers to obtain the dispersion characteristics between the two receiver stations. The dispersive signal obtained from the above cross correlations was processed to estimate the surface wave groupvelocity. These group velocities are inverted to obtain shear wave velocity structure. The active faults surrounding Arunachal Pradesh in northeastern part of India produce the noise continuously as the stress buildup and thereby act as strong local noise sources. Therefore, we have applied the earthquake signal cross correlation method to estimate the 1D velocity structure between two stations from Arunachal Pradesh, India, where the ambient noise correlation fails to give satisfactory results from 1 year continuous data. The shear velocity structure was estimated between two stations from two different earthquake signals. Both the velocity models agreed well with each other as well as with available regional velocity model. Our results indicate that the proposed method is the most suitable for estimating inter-station velocity structure, where noise correlation studies have limitations due to complex local noise source distribution.

TOWARDS PREPARATION OF A HOMOGENEOUS AND POISSIONIAN EARTHQUAKE CATALOGUE FOR THE HIMALAYAN SEISMIC BELT

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The rudimentary requirement for seismic hazard and risk assessment of any seismically active region is a homogeneous and poissionian earthquake catalogue. This earthquake catalogue also serves as a basic source for seistotectonic modelling and earthquake source characterization in active tectonic regions. The aim of present study is to prepare a homogenized earthquake catalogue for the Himalayan seismic belt and adjoining regions. It should be free from dependent events (foreshocks and aftershocks). The examined region is one of the most active seismic regions of the world, which has witnessed four great earthquakes of M≥8.0 and more than dozen earthquakes of M ≥7.0 in recent past. The available earthquake catalogues from international and national seismological agencies for this region are not homogenized in one magnitude scale. Therefore, we have developed depth-dependent magnitude conversion empirical relations during the period 1964-2016 to convert classical earthquake magnitude scales into $M_{W,HRVD}$ proxy estimates. For this purpose, different published earthquake catalogues and literatures have been consulted from different seismological agencies e.g. International Seismological Centre (ISC) of UK, National Earthquake Information Centre (NEIC) of USGS, Harvard Centroid-Moment Tensor Catalogue (HRVD), International Data Centre (IDC) of CTBTO, China Earthquake Information Centre, Beijing (BJI) and National Centre for Seismology, New Delhi, India (NDI). Different empirical regression relations have been established for moment-magnitude ($M_{W,HRVD}$) with the body-wave magnitude (m_b), surface-wave magnitude (Ms), local magnitude (M_L) and duration magnitude (M_D) scales provided by different agencies for three depth ranges 0-25 Km, 25-70 Km and >70 Km. Orthogonal Distance Regression (ODR) and General Orthogonal Regression (GOR) techniques have been used to derive the regression relations.

To prepare Mw-homogenized earthquake catalogue for the Himalayan seismic belt, we defined code numbers or number combinations, which describe in a unique way how proxy estimates for $M_{W,HRVD}$ have been derived. The same code numbers have been used to convert pre-1964 earthquake magnitudes. Priority has been given to direct Mw of HRVD and proxies Mw have been estimated for ISC (Ms, mb), NEIC (Ms, mb), IDC (Ms, mb, M_L), NDI (M_L, M_D) and BJI (M_L). We have also illustrated the difference between proxy $M_{W,\ HRVD}$ derived from different seismological agencies for different magnitude scales with the original $M_{W,HRVD\ ,}$ which suggest the reliability of converted proxy $M_{W,HRVD}$ values. The prepared $M_{W,HRVD}$ based homogenized earthquake catalogue during 25 – 2016 AD have been declustered (removal of dependent events) using suitable windowing method. Our future aim is to analyse the completeness of the catalogue in space and time.

LITHOLOGY PREDICTION OF CARBONATE RESERVOIR THROUGH ATTRIBUTE STUDIES

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Lithology prediction implies the recognition of the rock layers in general and grains in particular of the formation. As, most of the reservoirs of Oil and Gas in the world are of Carbonate, we chose to do

the lithology prediction on the Carbonate reservoir only. Lithology prediction includes the estimation of the petro-physical measurements of Porosity, Permeability, Water saturation. Identification of lithology is very important as the measuring tools are going to respond to the physical and chemical properties of reservoir rocks. Reservoir lithology is the basis for all kinds of petro-physical parameters. Rock type includes the pore system whereas lithology includes the grain system. There are mainly two ways for determining the Lithology i.e. Direct and Indirect and can also be done with the help of acoustic logs.

Carbonate sediments in immense volume are deposited in situ, which are formed by the calcareous deposits of the dead remains of plants and animals. Carbonate reservoir formations contain the alternate layers of Carbonate, Dolomite, Anhydrite, Salt and Shale. The complicated depositional geometry and diagenesis leads to the heterogeneity of the Carbonate reservoir, which may pose a great challenge as the injecting well and production is a very cumbersome process in that type of geology. Carbonate reservoir porosity is affected by weathering, dissolution, compaction and fracturing. Fractured reservoir has a width and thickness of hundreds of meters and they are having a huge areal extension spread over few hundreds of kilometers. Fractured reservoir paves the way for the hydrocarbon migration and improves the permeability leading to the good production of the hydrocarbons. Carbonate reservoirs are controlled by mainly three factors: Structure, Depositional, Diagenesis.

The present study for lithology prediction has been done with the help of Seismic attributes at Rajasthan Basin, Western India. As there are lots of Seismic attributes based on Amplitude, Frequency and Phase, which can be populated as core attribute analysis. There are a lot of combined/ complex attributes generated from core attribute analysis, which can be used to enhance the more subtle information of the traditional seismic image leading to the improvement of sub-surface data interpretation towards lithology prediction.

Seismic data provides the valuable information of the heterogeneities present in the subsurface. This information needs to be processed well in an optimized manner so that Geological model generated on this basis can be well correlated with the real Geology. Attribute analysis helps in extracting the concealed information present in the Seismic data to come out with the more precise interpretation of the Geological features. In the current study, mostly frequency and phase based attribute analysis have been performed based on seismic volume (zero offset to far offset) and interpreted surface. The information of the heterogeneity of the subsurface is collected with the help of structural, lithological and depositional conditions maps and output of the seismic attribute has been correlated with proper scaling with well information at reservoir level.

ESTIMATION OF SEISMIC AMPLIFICATION AND PEAK FREQUENCY IN UTTARAKHAND BY TOPOGRAPHIC SLOPE GRADIENT METHOD AND ITS VALIDATION USING STRONG MOTION DATA

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Soil types behave differently when subjected to a ground motion from the earthquake. Observations of ground motion during previous earthquakes have indicated that source, path and site effects contribute predominantly to the vigour of shaking. Estimation of site response and local site effects are important in Probabilistic Seismic Hazard Assessment (PSHA) and microzonation studies. Shear wave velocity (Vs30) has been estimated using slope-angle method.An estimation of general

amplification factor (F) and predominant period (T_0) up to bedrock level can be estimated using shear wave velocity (Vs30) data. In the present study, we have used Cartosat DEM (30 m) to obtain the slope map of Uttarakhand in ArcGIS software. Subsequently,'F' and T_0 were estimated using empirical relations. The results indicated that amplification factor is varying 0.93-5.8 and predominant period is varying 0.1-0.66. The validation of the result was done using earthquake strong motion data. Site response estimation generally uses microtremor or strong motion data by Horizontal to Vertical Spectral Ratio (HVSR)method also called as "Nakamura technique". The method is more efficient in estimating the natural frequency of soft soil site when there is a large impedance contrast with the underlying bedrock. In the current study we have used strong motion data of PESMOS-IIT Roorkee with earthquake magnitude >3 within 2005 to 2017 period and found 54 events. Seismo signal software was used for processing the data. We observed that F and T_0 are well matching with results obtained from strong ground motion data if ground is bedrock. In the case of soil and alluvial plains there was a mismatching in the results since the above used empirical relations were proposed for bedrock level hazard estimation. The results show that shear wave velocity from topographic slope can be used for preparation of site amplification maps and peak frequency estimation in the regional scale.

SIMULATION OF STRONG MOTION GENERATION AREAS FOR A GREAT EARTHQUAKE IN CENTRAL SEISMIC GAP (CSG) REGION OF HIMALAYA USING MODIFIED SEMI-EMPIRICAL TECHNIQUE

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Sandeep et al. (2014b) successfully tested modified semi empirical technique (MSET) for the simulation of strong motion time histories of the 1991 Uttarkashi earthquake in central seismic gap (CSG) region of Himalaya. They have estimated a source model incorporating two strong motion generation areas (SMGAs) for this earthquake. In the present study, this modified semi-empirical technique incorporating the effect of SMGAs has been used for modelling of great earthquake in this region. Strong motion records have been simulated using this estimated source model and modified semi- empirical approach. It has been observed that the entire CSG can expect peak ground acceleration and the distribution of PGA values within the CSG region is mainly affected by the location of nucleation point in the rupture. The estimated PGA values in the present study are comparable with the other works in this region. This confirms the ability of MSET and fitness of estimated rupture parameters of the scenario earthquake to simulate strong motion results.

MODELING OF GRAVITY ANOMALY OVER SEDIMENTARY BASIN USING HYBRID PSOGSA TECHNIQUE

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Gravity method plays an important role in the studies of sedimentary basin modeling because the observed residual gravity anomalies is significant on the surface of the earth due to presence of notable density contrast between sediment in fill and the underlying basement. These observed gravity anomalies can be used in modeling of sedimentary basin to decipher the geometry of basement structure

below the sedimentary basin. Geometry of basement structure regarded as irregularly shaped body and can be estimated either by breaking it into number of juxtaposed prismsor assuming polygonal shaped with number of sides. In order to interpret the depth of basement of sedimentary basin various inversion techniques have been used but still interpretation requires more accurate model. Here, we applied a new hybrid PSOGSA technique in MATLAB environment to determine the depth of the sedimentary basin. In order to test and validate, the algorithm has been applied over synthetic gravity anomaly over sedimentary basin and then applied over various geological terrains. The proposed method produces global optimal solution and provides robust and plausible results even in the presence of noise that is consistent with the results obtained from other classical methods. This novel technique is a powerful tool that improves the results of standard PSO and other techniques significantly with less time and high success rate.

MODELLING OF EMPIRICAL ACCELEROGRAMS OF 2011 SIKKIM, HIMALAYA EARTHQUAKE (M_W 6.9) USING A HYBRID TECHNIQUE

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The site specific earthquake ground motions are required for the proper evaluation of seismic hazard of a region. These empirical accelerograms are not available adequately in the different regions of the world including Himalaya. An alternative is to model/simulate the earthquake strong ground motions of future earthquakes using appropriate techniques. The simulated strong ground motions provide time histories for specific source and medium in addition to enhance the data base. The simulated earthquake ground motions play a vital role in the evaluation of seismic hazard of a region.

This study presents the modeling of empirical accelerograms of 2011 Sikkim earthquake (Mw 6.9). A hybrid technique, which is a combination of techniques of envelope functions and composite source model, has been used for this purpose. This technique has been applied successfully to model the Himalayan earthquakes (1991 Uttarkashi and 1999 Chamoli earthquakes). In this technique, the smaller earthquakes (sib-events) of varying sizes are distributed randomly on the fault plane instead of uniform distribution of same size sub-events. This allows the rupture variability in the simulation. The locations of sub-events on the fault plane have been obtained using a genetic algorithm process.

A comparison between the simulated and empirical accelerograms in terms of important parameters like peak ground acceleration (pga), duration, Fourier and response spectra. The successful modeling of empirical accelerograms of 2011 Sikkim earthquake indicates that the hybrid technique can be used for the prediction of accelerograms of the future earthquakes with similar magnitudes. This will help to produce a scenario hazard map of the region and can be used to mitigate the seismic hazard.

LG ATTENUATION FOR THE INDIAN SHIELD

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Lg waves are characterized by the sharp arrival and larger amplitude, representing the superposition of multiple S-wave reflections between Moho and the free surface recorded in a seismogram at regional distance more than 200 km. These phases usually fall within the group velocity of 3.7 and 2.8 km/s

at a frequency range of 0.2 to 10 Hz. The insensitivity of Lg for source characteristics makes it an ideal tool to study the large-scale crustal variations along the path such as magnitude determination, artificial and natural source discrimination, crustal velocity gradient and crustal attenuation estimation.

The Lg studies from the Indian shield are meager. Mitchell et al (1997), first reported Q >800 for the Indian Shield from regional study of Lg coda Q across Eurasia. In the recent times, Singh et al (2004) and Mitra et al (2006) have carried out attenuation studies using Lg waves with limited event-station pairs across the Indian shield. Here, we used large number of events (94) and stations (67) to study the attenuation characteristics of the Indian crust. An attempt has been made to prepare a comprehensive attenuation map for the Indian shield. Most of the stations are deployed and operated by CSIR- National Geophysical Research Institute, National Center for Seismology and station HYB (Hyderabad is from GEOSCOPE). While computing the Lg spectra, we took care of all the pre-processing steps, including the noise level by selecting pre-Pn data. In order to compute Q, we utilized two-station method proposed by Xie et al. (2004), and then inverted to generate a Q-image for the Indian shield.

The inversion results clearly show that the Indian crust has variable attenuation characteristics with Q ranging from ~80 to ~800. The estimated Q values can be categorized into three broad classification viz. Low, < 300, moderate, 300 ≤ Qo ≤ 650 and high, Qo > 650. Mahanadi and Godavari basins and Southern Granulitic Terrain exhibit lower Q values. The thick sedimentary covered crusts of Indo-Gangetic province and Himalayan region are characterized by fast attenuation of seismic waves. The cratonic regions of Indian plate are characterized by the higher Qo (> 500) suggesting low attenuation similar to many global cratonic regions. The Qo values for Deccan Volcanic Province, where intensive volcanic activity occurred during the end of Mesozoic era is categorized as low Q (less than ~200-400). Our attenuation image clearly demarcates the geological provinces of the region in general.

DEVELOPMENT OF SURFACE TOPOGRAPHY IN BI-VERGENT SUBDUCTION SYSTEMS: IMPLICATIONS OF IN-DIP SLAB INTERACTION

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Topographic evolution of a subduction zone is governed by various contributors (both lithospheric and sub-lithospheric). A large amount of contribution comes from the isostatic force (*H*) accompanied by significant contributions from flexural bending (*F*) and dynamic topography (*DT*). Flexural bending is a lithospheric phenomenon, which mostly influences the topographic development near the trench region. On the other hand dynamic topography is the result of vertical to sub-vertical upwelling motion of mantle. There are other contributing factors for topographic development such as erosion and depositional processes. However, in large time scale and preliminary or first order topographic evolution their contribution becomes negligible. It is a well known fact that subduction zones yield complex patterns of topography depending upon different controlling parameters. Things get more confusing when a single overriding plate is juxtaposed between two in-dip subducting slabs. Using a two-layer mechanical model we ran real time computational fluid dynamic (CFD) simulations to explore the underlying dynamics of the overriding plate (OP) topography in a bi-vergent subduction system. We formulate the problem considering viscous rheology, hence using the Navier-Stokes equation. For tracking the deformed geometry of the system we coupled an Arbitrary Lagrangian Eulerian (ALE) scheme in the model. The ALE scheme has been used in computational physics and

geo-scientific problems for explicitly tracking deformed internal boundaries and domain geometries in case of large deformations. It is efficiently used in case of time dependent topographic modeling by many previous workers. Our model topography develops typically a continental scale plateau, flanked by two distinct fore-arc highs and topographic depressions. We show that large scale flow vortices produced by the two subducting plates (SP) can sustain such first-order elevated plateau topography, whereas compressive stress localization in the OP lithosphere decides the higher order fore-arc highs. Both symmetric and asymmetric subduction models were used to perform a quantitative analysis of the surface topography of OP as a function of the inter-trench distance (λ_d), and convergence plate velocity (V_c) on a time scale (t) 1 to 10 Ma. For t = 10 Ma, the relative plateau elevation (ΔH_{OP}) is 1250 m, which multiplies to nearly 1800 m on an increase of V_c from 1 to 5 cm/yr. In contrast, ΔH_{OP} varies inversely with λ_d. Bi-vergent subduction with the two trenches differing in V_c, slab dip (θ_s) and mechanical coupling (slip versus non-slip condition) of SP gives rise to asymmetric OP topography. Among these parameters, the mechanical coupling is found to have the strongest control in switching the symmetric to asymmetric transition. We finally take two natural examples, the Philippines and the Caribbean subduction systems, to discuss the applicability of our bi-vergent model to natural settings. Although the natural systems are more complex than simple model considerations and while taking into account the limitations of our model, the calculated topographic nature holds a good first order correlation with the observed one.

OCCURRENCE OF COBALTOAN PYRITE IN A LAMPROPHYRE DYKE FROM THE SIDHI GNESSIC COMPLEX OF MADHYA PRADESH, CENTRAL INDIA

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Lamprophyres are small-volume, deep mantle-derived, volatile-rich alkaline igneous rocks and are widely considered as products of a metasomatised (enriched) mantle and owing to their occurrence in varied tectonic regimes are regarded to of geodynamic significance Lamprophyres contain high abundances of both compatible as well as incompatible trace elements and some of their occurrences are also known to be economically important hosts of diamond and gold.

Pyrite enriched in cobalt with some amount of nickel in a lamprophyre dyke from the Sidhi Gnessic complex, Mahakoshal belt, Central India is being investigated. The electron microprobe analysis (EPMA) of pyrite shows high concentration of cobalt (0.02 to 5.61 wt%) and some variable concentration of nickel (0.02 to 0.70 wt%), while there is complete absence of cobalt and nickel in chalcopyrite of same dyke, i.e. out of pyrite–chalcopyrite association, cobalt is prefeberally sequestered in pyrite. However, cobalt and nickel are conspicuously absent in the pyrite of the Bari syenite, reflecti

SUBSURFACE STRUCTURAL PATTERN AND DENSITY DISTRIBUTION USING GRAVITY AND GRAVITY GRADIENT

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Understanding the complex responses of full gravity gradient tensor, their invariants, curvatures and other combinations are still vogue when it comes to complex geological subsurface structural

variations. We have tried to elaborate the effects and importance of computed response of gravity gradient and their relative response for several regular geometries with different cases of density distribution. We have found that the different combinations of full gravity gradient tensor (FTG) can accurately map the subsurface density contrasts caused by geological sources and structures in various geological settings. In addition, a MATLAB algorithm is developed for the enhanced imaging of subsurface to isolate target signature patterns using linear regularization method, where Tikhonov formulation is used for appropriate choices of SVD and GSVD components. First, the program has been used for 2D and 3D synthetic models, to test its efficacy, and then applied to real field data of Vredeforte Dome, South Africa. The reliability of the developed programme is verified using Picard Plot & Depth resolution plot (DRP) for a regularized solution.

CRUSTAL AND UPPERMOST MANTLE SEISMIC STRUCTURE OF EASTERN DHARWARCRATON BY JOINTLY MODELLING TELESEISMIC RECEIVER FUNCTIONS AND RAYLEIGH WAVE GROUP VELOCITY DISPERSION CURVES

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We investigate crust and uppermost mantle seismic velocity structure and identify Moho beneath southern Indian shield by jointly modelling teleseismic receiver functions and Rayleigh wave group velocity dispersion curves. For this purpose, three component seismograms were downloaded from the IRIS Data Management Centre for the years 1990-2006 for GEOSCOPE seismic station HYB situated on Eastern Dharwar Craton. Events were selected to have epicentral distance range of 30°-95° for Ps receiver functions and 60°-85° for Sp receiver functions and magnitude greater than 5.5. For this study,we selected 398 good Ps receiver functions and 22 good Sp receiver functions. Since, receiver functions are more sensitive to the abrupt changes in velocity at seismic discontinuities and dispersion curves are sensitive to absolute shear wave velocities, therefore,joint modelling of these disparate but complementary datasets should improve the constraints imposed on models and result in increased uniqueness of the final best-fitting model. This joint modelling technique performs a search for models that satisfy goodness-of-fit criteria guided by a variant of simulated annealing and uses statistical tools to assess these products of searches. These tools, a parameter correlation matrix and marginal posterior probability density (PPD) function, allow us to evaluate quantitatively the constraints that each data type imposes on model parameters and to identify portions of each model that are well-constrained relative to other portions.

Results from this joint modelling technique reveals Moho at ~ 34.5 km depth beneath HYB seismic station. Crustal P- and S- wave velocities range from 5.5 to 7.6 km/s and 3.2 to 4.25 km/s, respectively. We observed that a high-velocity zone of ~ 7.0 km thickness in lower crust, which begins at the depth of ~ 21 km, both for Vp and Vs, for which P-wave and S- wave velocities are found to be ~ 7.6 km/s and ~ 4.26 km/s, respectively. We also observed that both Vp and Vs velocities suddenly decrease at a depth of ~ 68 km up to ~ 104 km. At these depths, P- and S- wave velocities are nearly around 8.2 km/s and ~ 4.55 km/s, respectively. Below these depths, our results estimate that Vp and Vs velocities increase up to 146 km and P-and S-wave velocities are 8.6 km/s and 4.9 km/s, respectively.

SEISMIC ANISOTROPY BENEATH THE MALANI IGNEOUS PROVINCE OF NORTHWESTERN INDIA THROUGH SKS AND SKKS SPLITTING MEASUREMENTS

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The 750Ma Neoproterozoic Malani Igneous Province (MIP) occupies a large area of 0.5 Million sq. kms in northwestern India. The MIP comprises felsic (rhyolitic) lava flows and granitic plutons with subordinate mafic lavas and felsic and mafic dykes. The genesis of the MIP is debatable with theories supporting extensional, plume or subduction processes. We investigate the seismic anisotropy beneath the MIP through SKS and SKKS splitting measurements made at broadband stations established at 26 locations in MIP during the period 2012-2017. A total of 263 measurements were utilized, which include 117 SKS and 146 SKKS measurements corresponding to 180 teleseismic events (M≥5.5) in the epicentral distance range 85-150^{o}. Both SKS and SKKS splitting measurements are used to enhance the back azimuth coverage of the data. The seismic anisotropy is quantified in terms of fast polarization direction and delay times between the fast and slow axis of anisotropy using the rotation correlation and minimum energy methods. The delay times range between 0.4-1.8s with the average delay time being 1.08s. The fast polarization direction of anisotropy at a majority of the stations is NE-SW direction, which is consistent with the absolute plate motion direction. However, at several stations two directions of anisotropy are observed viz., NE-SW and N-S directions. An analysis of the patterns of anisotropy indicates that the direction of anisotropy is varying with backazimuths. The NE-SW directions are observed in the backazimuthal range 0-150^{o} ,while the N-S directions are observed in the southern and western backazimuths. The azimuthal variation may be linked to the difference between the frozen anisotropy and the APM directions. The large time delays are a result of contributions from asthenospheric flow due to the strain induced lattice; preferred orientations of anisotropic minerals and the frozen anisotropy in the lithosphere.

SLIP MODEL OF THE 1967 M 6.3 KOYNA EARTHQUAKE FROM INVERSION OF NEAR-FIELD WAVEFORM

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Koyna, located in the deccan volcanic province in western Indian state Maharastra, is the most significant site of reservoir-triggered seismicity globally. The largest event of M 6.3 occurred here on December 10, 1967, which caused severe damage in the region. The reservoir-induced/ triggered seismicity at Koyna and nearby Warna region has continued. This includes many M≥5.0 and thousands of smaller events over the past 60 years. The yearly loading and unloading cycles of waters in the Koyna reservoir and the nearby Warna reservoir trigger seismicity in this area. Finite-fault source model detailed with the spatial and temporal evolution of earthquake rupture for M 6.3 1967 Koyna earthquake is presented. 1D velocity model, developed from surface recordings of a local earthquakes is employed for this inversion. We will show results of possible slip distribution and rupture propagation on the plausible fault plane.

CRUSTAL STRUCTURE FROM MODELLING OF REGIONAL GRAVITY AND MAGNETIC DATA IN THE WEST BENGAL BASIN

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We have used the regional global satellite gravity and magnetic data to derive the crustal density/susceptibility models along four profiles in the West Bengal sedimentary basin covered by the Rajmahal (Cretaceous) basalts and younger sediments. The basin at the margin of eastern Indian shield is a consequence of Gondwana rifting. The aim of this study is to delineate different crustal units in terms of density and susceptibility variation with a view to provide geo-tectonic implications of the basin. We have modelled gravity/magnetic data along three E-W and one N-S profiles, i.e., the Beliator-Burdwan-Bangaon profile (A-A^{I}) of about 180 km, Arambagh-Taki (B-B^{I}) of about 120 km, Gopali-Tamluk-Port Canning (C-C^{I}) of about 150 km and Kandi-Palashi-Bishnupur profile (D-D^{I}) of about 200 km using constraints from recently-derived seismic velocity models.

The study shows four formations of Tertiary Group with densities varying between 1.6-2.48 g/cc, Rajmahal Trap with density of 2.81 g/cc and Gondwana sediments with density of 2.35-2.43 g/cc overlying the crystalline basement having density of 2.73 g/cc. The presence of sub-Trappean Gondwana sediments is also observed at a nearby deep well. In general, the depth to the basement increases from west to east with a maximum depth of around 12 km at the eastern part of the profiles. A basement upwarp with a sharp flexure in the middle of the profiles possibly brings into focus the regionally extending NNE-SSW 'Hinge zone'. A low density layer with density of 2.66 g/cc and thickness of 2 to 3 km has been inferred in the upper crust. The Moho lies at varying depths from 40 to 26 km along the E-W profiles with a prominent Moho upwarp or thin crust in the eastern part of the basin.

SEISMOLOGICAL INVESTIGATIONS IN A CLASSIC EXAMPLE OF THE CONTINUED RESERVOIR TRIGGERED SEISMIC ENVIRONMENT AT KOYNA, INDIA.

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Artificial water reservoir triggered earthquakes have been continued to occur at the Koyna region of western India since the impoundment of the Shivaji Sagar Lake in 1962. The seismicity is confined to a small region of ~ 30 x 20 km^2 and limits to shallow focal depths (within ~10 km). CSIR-NGRI is operating a unique combination of borehole seismic network and surface seismic network at Koyna as a part of the scientific deep drilling investigations, a major program initiated by MoES, Govt. of India during 2011. With the advantage of borehole seismic network, the absolute locations of earthquakes have been improved significantly, achieving a major leap in one of the prime objectives of the investigations. During January 2016 to May 2017, a total of 2478 earthquakes of M_L -0.8 to 3.7 including 1623 microearthquakes (M_L -0.8 to 0.4) that located only using the borehole seismic network have occurred. These seismicity patterns indicated few new zones of intense seismicity clusters in the vicinity of the borehole locations. During the study period, a strong association of reservoir water levels with seismicity is noticed, where the seismicity is found to be concentrated during January – May and disseminated during June – December. The recent largest earthquake of M_w

4.0 occurred on 3rd June 2017 at 18:14:52.30 h (UTC). The epicentre of this earthquake is located at a distance south of the Koyna and Warna Dams. There was no occurrence of M ~ 4 earthquakes at this location previously, since the impoundment of the Koyna Dam in 1962. Interestingly, it is found that the epicentre is in the vicinity of two small check-dams of the region. Several aftershocks continued thereafter forming an intense cluster. A double couple normal focal mechanism has been obtained using the P-onset data of the seismic network, which delineated a NNW trending fault plane. Two aftershocks of M_W 3.5 & 3.0 are also indicating the similar focal mechanism. For the first time, accurate fault plane solutions of earthquakes of M_L ~ 2.0 are estimated using the sharp onsets of the high quality borehole seismic records, which complimented by a dense surface seismic network data. Our analysis presents a significant improvement in the estimation of absolute locations and fault plane solutions of earthquakes at Koyna. Also, a 3D velocity inversion is carried out in the source zone of 1967 main Koyna earthquake to investigate subsurface structure and location of seismogenic layers. Initial results on tomograms of Vp, Vs and Vp/Vs across the major causative fault 'Donachiwada' in the study region are discussed.

SENSITIVITY STUDY OF FLUID SUBSTITUTION ON SEISMIC ANISOTROPY

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Fluid substitution is an important tool during reservoir characterization to understand the effect of fluids on seismic parameters. The most commonly used fluid substitution analysis assumes that the Earth as an isotropic medium may not represent the practical field scenario. Nevertheless, anisotropic fluid substitution aids to avoid exploration risk, and perhaps be most useful to understand the variation in reservoir properties.

In the present study, we investigate the fluid substitution effects in a porous fractured medium to improve the quantitative interpretation of seismic data. This analysis uses anisotropic Gassmann's equation and linear slip theory for fluid substitution in transversely isotropic media with a horizontal symmetry axis (HTI). We show examples for a two layered, half space model with top layer as shale and bottom layer as HTI sandstone reservoir to analyze the effect of changing background porosity and fracture weakness on, (1) elastic moduli, (2) P-wave velocity, (3) anisotropic (Thomsen's) parameters, and (4) azimuthal reflection coefficients variations for an HTI medium.

We observed that brine and oil sands have highest elastic moduli, while CO_2 sands are the opposite, which imply that anisotropic CO_2 behavior will be visible in surface seismic parameters. Gassmann assumes (and as has been observed) that shear modulus does not depend on fluids, and hence, we observe no changes in shear-wave moduli for different fluids. Further, P-wave moduli and P-wave velocity are found to increase for gas-to-brine and gas-to-oil substitution, especially in the direction normal to fractures. This study has major implications to understand the seismic response in an anisotropic media, especially when a reservoir is fractured and undergoing fluid injection.

STUDY OF ON LAND AND OFFSHORE GRAVITY ANOMALIES: EXTENSION OF STRUCTURES IN KUTCH REGION, INDIA

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Many authors suggest that the west coast of India contains several structural features, which have evolved as a consequence of rifting and seafloor spreading between India, Madagascar and Seychelles. They also believe that the structural trends in the offshore region were affected by shearing movements along the shelf edge.

The Kutch, Cambay and Narmada rifts are three major rift-basins in the western continental margin of Indian sub-continent that is covered by Deccan Volcanism. The Kutch basin was originated as a pericratonic rift during the break up of Gondwana land in Late Triassic and evolved through three different phases corresponding to breakup, drifting and collision of Indian plate.

It is believed that the Kutch basin extends into offshore region with a wide shelf platform. In order to bring out regional tectonic features and their continuation into offshore region, composite gravity anomaly map of Kutch onshore and offshore have been prepared by using Bouguer and satellite free air anomaly maps. This map brings out a broad gravity high over Kutch main land uplift (KMU) and its extension up to shelf edge. This high may be related to the emplacement of high density mafic material as observed in seismic studies. Many highs are observed over uplifted areas and lows over sediments filled structures in between the fault bounded uplifts. Major low corresponding to depo-centres of thick Mesozoic and Tertiary sediments is observed to extend up to SW part of Kutch offshore basin. Prominent high near Dwarkwa can be interpreted in terms of volcanic plug of high-density rock.

Gravity modeling across north-south profile brings out a high density underplated material up to 36 km. The possible cause for this anomaly may be explained in terms of mafic intrusions related to Deccan and pre-Deccan volcanism.

SOURCE PARAMETERS ESTIMATION OF THE 2009 BHUTAN EARTHQUAKE

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Earthquakes occur due to rupturing of rocks in subsurface when stress accumulation exceeds the strength of elasticity. This sudden rupturing releases a huge amount of energy that makes earth tremor. Earthquakes are one of the worst natural disasters responsible for huge amount of loss of life and wealth. An earthquake of magnitude (M_w 6.1) occurred in the East Bhutan on 21th September 2009. This earthquake caused serious damage to the residential area and was widely felt in the Bhutan Himalaya and its adjoining area. This earthquake was recorded on many strong motion stations located about 81-333 km away from its epicentre. We estimated the source parameters of this earthquake using Brune's source model. The long-term flat level and corner frequency from source displacement spectra are used to calculate stress drop, source radius and seismic moment of this earthquake. The present study suggests that the source radius, stress drop and seismic moment of this earthquake estimated from source displacement spectra are 8.2 km, 54.66 bars and 2.81×10^{25}dyne cm, respectively.

STUDY OF VARIATION INGPS-TEC DURING NEPAL EARTHQUAKE 2015 USING INTERNATIONAL GNSS SERVICE (IGS) STATIONS

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The data analysis of GPS (Global Positioning System) based Total electron content (TEC) in ionosphere isan advanced technique in Earthquake precursor study.This research work has been taken up to study the variation in Global Positioning System (GPS) based total electron content (TEC) in Ionosphere in the light of two earthquakes: One isM_w 7.8, 36km E of Khudi, Nepal and the other is M_w 7.3, 19km SE of Kodari in 2015. In this study, we have taken International GNSS Service (IGS) stations, which are lying within earthquake preparation zone for the period from Mar-2015 to June-2015. We have processed the GPS data using GPS-TEC software version 2.9 and also computed the Upper and lower bound for the Vertical TEC. Plotted the Vertical Total Electron Content, Upper Bound, and Lower Bound with respect to time. The better understanding of variation in Vertical Total Electron Content before, during and after the earthquake can be used in identifying the ionospheric anomaly/ abnormality. The ionospheric anomalies can be identified by systematic observation of the plot area where the Vertical Total Electron Content crosses the Upper or Lower bound. The identification of ionospheric anomalies prior to the earthquake can be used for prediction of earthquake/ earthquake precursor study. All the results have been tabulated.

CRUSTAL THICKNESS VARIATION ACROSS DECCAN VOLCANIC PROVINCES AND EASTERN DHARWARCRATON THROUGH RECEIVER FUNCTION MODELLING

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The Indian subcontinental crust has undergone many geodynamic processes during its geological history. Western central part of India is covered by flood basalts known as Deccan Volcanic Province (DVP). It is believed that rifting of the Seychelles from India and passing of Indian plate over the Reunion plume at about 65 Ma gave rise the eruption of Deccan volcanism. The south-east part of India is occupied by late Archean Eastern Dharwar Craton (EDC) and Eastern Ghat Mobile Belts (EGMB). This region is affected by separation of Australia from India at ~ 100 Ma. Our study is aimed at delineating the crustal thickness beneath the plume affected DVP and late Archean EDC.

We analysed receiver function (RF)data recorded at 20 broadband seismic stations along a profile of about 900 km across DVP-EDC and deployed during from 05/2015 to 10/2016. to estimate crustal thickness andinfer crustal composition. The estimation of crustal thickness was made using P to s conversion (Ps) and crustal reverberation phases from RF. We used nearly 1500 three- component seismograms from the earthquakes of magnitude ≥ 5.5 and epicentral distance of 30^0 -95^0 to generate the RFs.

The stacked RFs from the stations over DVP indicate an average delay of 0.35 sec in Ps arrival time compared to EDC domain. It is an indication of thicker crust in DVP as compared to EDC.

For precise determination of crustal thickness, we used two approaches i.e H – Vp/Vs stacking and inversion of receiver functions. The major findings of study are: (1) Crustal thickness is varying from 32 ± 1 km to 40 ± 2 km across DVP and EDC(2) Localized thicker crust near Nashik is obversed, which may indicate the compressional tectonics.(3) We found average crustal Vp/Vsratio of1.74 ± 0.01for both DVP and EDC; it infers DVP crustis similar to the EDC crust.

AN APPRAISAL TO CRUSTAL STRUCTURE OF THE INDO-MYANMAR SUBDUCTION ARC

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The Indo-Myanmar subduction arc is a prominent active subduction tectonic zone in the entire Indian plate in which Indian platesubducted beneath the Burmese arc. This~700 km long arc is a highly seismic active region and can producelarge earthquake with focal depth extending down to 250 km. The underlying structure is mainly responsible for depth wise seismicity along a sharp inclined plane.We delineated the crustal structure of this subduction zone in the Indian sub continent by receiver function analysis. Analysis of the data from the seven broadband seismic stations located in and around the subduction zone (LEKHA, KOHI, MOKO, IMPH, MDY, AIZW and SAIHA) has revealed an average 45 km Moho depth in the Indian segment. It sharply increases to 54 km in the Burmese part. We observed sedimentation of Imphal valley (IMPH station) extends upto a depth of 2.5 km. It is absent towards Naga Hills and Tripura fold belt. This thick layer of alluvial layer or loose soil can amplify the ground motion violently during earthquake's rupture time. A mid crustal low velocity layer(Vs dropped by 1.0km/sec and reach 2.2 km/sec) is observed at IMPH, KOHI and MOKO stations, with depth range of LVL varying between 25-35 km . This low velocity layer may represent the upper surface of indenting Indian plate, where seismic activity is clustered in Indian territorial part. An intermediate to high values of Poisson`s ratio (0.270-0.300) in this region implies occurrence of mafic to ultra mafic crust of oceanic lower crust.

FRACTURE ZONES DEDUCED FROM SHORT DURATION EARTHQUAKE DATA WITH THE WAVEFORM CROSS CORRELATED, RELOCATED HYPOCENTERS: KOYNA-WARNA PROVINCE, MAHARASHTRA

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The Koyna- Warna province is covered with Deccan volcanic traps. This region is well known for artificial triggered seismicity. The identification of precise hypocenter locations in this region is fraught with some limitations. This limitation has affected proper delineation of faults/ fractures locations and geometry. To overcome this problem we have generated and utilized the seismic data from 6th January 2010 to 28th May 2010 acquired by National Geophysical Research Institute (NGRI) with a network of mobile seismographs paired with the three component geophones. The network of seismographs has relatively high frequency (4.5 Hz) sensors with perpetual recording of 100 samples/ second,strengthened by GPS with a horizontal precision of 5-10 meters. A total of 499 earthquakes were identified from the data utilizing SEISAN software. Additionally, the data from 499 earthquakes

has been cross collated, utilizing CORR in SEISAN with minimum stations as 3 and minimum correlation 0.5 and maximum event distance of 5 km. Out of 499 events 379 events include the P-wave cross-correlation dtimesof 6227 and S- wave cross-correlation dtimesof 6327 and total dtimesof 12549, Which were utilized in HypoDD for relocation. From the mapping of relocation results, it was observed that the hypocenters were gently dipping from south to north and several vertical alignments of hypocenters are present from west to east. The error in depth and RMS error was reduced to 0.1 km and 0.05, respectively. After relocation, we have further made a comparison between the events. The relocated events pattern shows presence of the three faults (F1-F3) aligning in NNW-SSE direction. These faults were also revealed in the early study. The earthquakes are falling in the depth range from 3 km to 8 km. A close look in to the geometry of F2 and F3 has revealed diminutive seismic patterns connecting F2 and F3. These connecting seismic patterns might have developed due to the resulting energy relinquishing activity in F2 and F3 faults and development of incipient fracture zones between F2 and F3 faults in NE-SW direction.

NON NEGATIVE MATRIX FACTORIZATION : SEISMIC IMAGING

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Geophysical seismic signal is nonstationary and multiscale in character. Acquisition, processing and Interpretation(API) are tasks before geoscientist in exploration seismology in upstream hydrocarbon industry. For precise seismic imaging, Extracting information from subsurface formation from datasets, measurements, observations and understanding complex data has become an important challenge and objective. Datasets collected from dynamical complex phenomena represent the integrated result of several inter-related variables as they are combinations of underlying latent components or factors. Such datasets can be first decomposed or separated into different components to discover structures and extract hidden information. Separation in to different components includes application of Nonnegative Matrix Factorization (NMF), Nonnegative Tensor Factorization (NTF) and Nonnegative Tucker Decomposition (NTD). The minimization problems in NMF are nonlinear due to the nonnegativity constraints. Geoscientists are interested for data analysis, multidimensional data visualization, and signal/image processing. In NTF and NTD approaches, high-dimensional data seismic images is factored or decomposed directly and approximated by a sum of rank-one nonnegative tensors. NMF/ NTF processing permits the detection of alternative or context-dependent patterns of seismic data. Impact of NMF and its extensions on scientific advancements might be as great as the Independent Component Analysis (ICA), or the Singular Value Decomposition (SVD) and Principal Component Analysis (PCA). In contrast to ICA or SVD/PCA approaches, NMF/NTF and NTD techniques, improve interpretability and visualization of large-scale data. Techniques are assigned to extract or separate useful information from superimposed seismic data corrupted by a large level of noise and interference. The techniques include Independent Component Analysis (ICA), Nonnegative Matrix Factorization (NMF), Sparse Component Analysis (SCA), Morphological Component Analysis (MoCA), and Minor Component Analysis(MCA).Higher-Order Singular Value Decomposition (HOSVD) is a generalization of SVD to higher-order tensors, and plays an important role in various domains, such as harmonic retrieval, image processing, and statistical methods involving Independent Component Analysis (ICA).The problem of separating or extracting source signals from a sensor array, without knowing the transmission channel characteristics and the sources, Blind source separation (BSS) and related methods, e.g., independent component analysis (ICA), employ a wide class of unsupervised learning algorithms .The recent trends in blind source separation and generalized component analysis (GCA) are to consider problems in the framework of matrix factorization or more general multi-dimensional

data or signal decomposition with probabilistic generative models and exploit a priori knowledge about true nature, morphology or structure of latent (hidden) variables or sources such as nonnegativity, sparseness, spatio-temporal decorrelation, statistical independence, smoothness or lowest possible complexity. Techniques also include MATLAB in the toolboxes for Signal and Image Processing: NTFLAB, NMFLAB & MULTI-WAY-LAB for data analysis, and blind source separation.

SINGULAR VALUE DECOMPOSITION FOR SEISMIC DATA ANALYSIS

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The singular value decomposition (SVD) is among the most important and widely applicable matrix factorization. Enhancement of signal embedded in background noise is an important issue in seismic data processing. The SVD method is effective in removing the background noise. It is less capable of interpolating discontinuous events than f-x deconvolution. Seismic wave separation by SVD and (F-K) combined filters: Seismic explorations and especially near surface study require information conveyed by reflecting waves. Separation of interfering wave-fields is a crucial step to enhance reflecting wave's quality. Nonetheless, in near surface experimentation, this stage is really difficult and requires high-resolution methods, both in the acquisition and in the processing of data. There are two different wave-separation methods to extract structural information from data recorded in near surface acquisitions. Since reflected waves are partially hidden, one aim is to remove all the energetic wave-field in order to provide a better imaging of the reflecting wave-field. The SVD-ICA (Independent Component Analysis) filtering has been used to separate the down-going and up-going wave-fields of the VSP (Vertical Seismic Profiling) datasets. Merit of combining F-K and SVD-ICA wave-separation methods to remove all the energetic wave-fields (surface, air and refracted waves) provides a better imaging of the reflecting wave-field. SVD is a coherency-based technique that provides both signal enhancement and noise suppression. SVD is better than *f-x* deconvolution and median filtering in removing background noise. However, its performance is not sufficient in enhancing weak events or events with conflicting dips. Adaptive SVD filtering can be used to enhance the spatial coherence of seismic data, making reflections more evident and useful in attenuating non-coherent noise. This SVD filtering technique of seismic data processing problems is employed to separate the up and down wave fields of seismic profiling (VSP).; SVD filtering to attenuate ground-roll in earthquake data; local SVD approach to noise suppression. The SVD decomposition of the seismic volumes and the appropriate choice of the index and the number of eigen-images used in the reconstruction of the data matrix provide better results in terms of filtering efficiency to suppress or minimize the random noise present in the data, improving the continuity of the reflectors (spatial coherence) and their better identification and tracking, valuing the stratigraphic aspects of the seismic sections and volumes. The attribute with the magnitude of the eigen-images is already provided with a promising tool. It allows to better identification of the discontinuities, thus better valuing the structural features (fault planes, dome flanks, etc.) present in the data. Separation of diffracted waves from reflections can be of use to identify stratigraphic traps, such as geological faults, in which hydrocarbons are often accumulated. SVD enhanced seismic interferometry helps in better travel-time estimates between microquakes in geothermal reservoir and hydrocarbon reservoir. The combination of seismic interferometry and the singular value decomposition helps to obtain accurate inter-event travel-times for microquake pairs at a reservoir. SVD analysis helps in better application of the technique for full waveform inversion of multicomponent seismic data.

SEARCH FOR THE SEISMIC DISCONTINUITY IN THE UPPERMOST MANTLE

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Seismic data processing plays an important role to generate accurate images of the sub-surface. One of the key problems in seismic data processing (exploration seismic or deep seismological probe) is to attenuate multiples from the seismic data. There are different approaches to attenuate the multiples. In this direction, Radon transform, which is an industry standard has attracted a lot of attention in the last two decades.

In order to separate the direct conversions and multiples, particularly in the uppermost mantle levels, we apply the Radon transform to the Receiver Functions. Receiver Functions are time series, which can identify the Earth structure by analyzing the amplitudes and arrival times of converted seismic waves at the receiver. The velocity contrast at the different layers of the earth also generates multiples along with the converted waves. These multiples from the shallow layers, may obscure the direct conversions from the deeper interface(s) if exist, and therefore, the important region of upper mantle (say from ~50 to ~700 km) may remain elusive. It should be noted that the move out for the multiples are more than that of the direct conversions and will be more prominent at the deeper parts. Therefore, in order to identify discontinuities in the upper most mantle (i.e., sub-Moho to upper mantle depth range), we need to separate the direct conversions and multiples based on their move out characters. In order to achieve this goal, we transform our converted wave data into the Radon domain, which will enable us to clearly identify the forward and back scattered phases. The Radon transform (τ-p transform) can effectively remove these multiples by inverting the move out time series from space domain (t-x) into Radon domain (τ-p) (e.g. Yilmaz, 0., 1987; Gu, Y .J et al., 2009). This allows line integrals in the t, x domain to be mapped into points in the (τ,p) domain.

The present concept has been applied to the seismological data set of the stations located in Indian shield. These stations are deployed and operated by the CSIR- National Geophysical Research Institute and National Center for Seismology. Data from the station HYB (Hyderabad) are from GEOSCOPE. Firstly, we compute the Receiver functions for all the waveforms and then apply move out correction for the direct conversions with reference to the slowness 6.4s/deg with respect to the IASP91 earth model. The move out corrected traces are then subjected to the Radon transform. The preliminary results show that the stations located in the Deccan Volcanic province, show an additional layer in the depth range of ~300-360 km apart from the earlier known discontinuities. The results and interpretations based on the detailed analysis will be presented.

THERMAL CONDUCTIVITY OF THEGRANITIC ROCKS FROM THE CENTRALINDIAN TECTONIC ZONE (CITZ) AND ITS IMPLICATION IN THERMAL STRUCTURE

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Central Indian Tectonic Zone (CITZ) divide the Indian subcontinent into two blocks, i.e., Bundelkhand Block in the north and the Deccan Block in the south. The CITZ is bounded by Son-Narmada Northern Fault (SNNF) in the north and Central Indian Suture (CIS) in the south. The

zone comprises a wide variety of rock types, e.g., granite, gneiss, gabbro, granulite, quartzite, etc., ranging in age from Neoarchean to recent. In this zone few more faults are active from Neoarchean, e.g., Son-Narmada Southern Fault (SNSF), Tan Shear zone (TSZ), etc. The Central Indian Suture Zone (CISZ) can be divided into three belts, i.e., Mahakoshal, Betul and Sausarby SNSF and TSZ where granitic rocks are exposed.

In present study, thermal conductivity on 20 granitic samples from Mahakoshal belt (Harda) and Betulbelt have been measured in the laboratory by a steady-state thermal conductivity meter. TC of the Hardagranites ranges between 3.0 and 3.5 W m^{-1} K^{-1}, whereas Betul granites ranges between 2.5 and 3.3 W m^{-1} K^{-1}. Gneisses in both regions are showing slightly lower values than the granites. Geochemical analysis on these samples indicates that Harda samples are granite to alkali granite, whereas Betul samples are alkali granite. The observed variations in thermal conductivity values suggest that the granites present in the Mahakoshal belt and Betulbelts possibly have different thermal scenarios. Thermal gradient in these areas are necessary to arrive at final conclusion.

STUDY OF RADON CONCENTRATION VARIATIONS DUE TO METEOROLOGICAL EFFECTS AND SEISMIC ACTIVITY AT MPGO, GHUTTU, GARHWAL HIMALAYA

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Observations of radon concentration in the form of temporal variations are in progress at Multi-Parametric Geophysical Observatory (MPGO), Ghuttu in Garhwal Himalaya since year 2007. The MPGO is located at Ghuttu (Geographic Lat. 30.53°N, 78.74°E), Garhwal Himalaya was established by the Wadia Institute of Himalayan Geology (WIHG), Dehradun. This observatory is situated in the central part of the seismic gap between the epicentre of the 1905 Kangra earthquake (M 7.8) and 1934 Bihar–Nepal earthquake (M 8.2) and located immediately to the south of the Main Central Thrust (MCT) within the High Himalayan Seismic Belt (HHSB).The radon measurements at MPGO are being carried out continuously and automatically at 10m and 50m depths in a 68m deep borehole for taking observation of radon concentration in the soil and underground water, respectively. The continuous records of radon data show clear seasonal variations as well as effects of different meteorological parameters. This includes a trend of high concentration during summer, low in winter and a high fluctuation in the rainy season. The atmospheric temperature, atmospheric pressure and rainfall are identified as influencing factors, which cause considerable changes in radon concentration. We developed the empirical relations to remove these effects and evaluate the residual for abnormal behaviors related to local moderate size seismic activity. It is observed that some cases of abnormal behaviour in radon data are found to be associated with seismic activity. In general, a significant decrease is seen in radon concentration, few days before occurrence of an earthquake. The abnormalities recorded in radon data prior to the occurrence of earthquakes are interpreted in terms of dilatancy-diffusion model as the well-known model of earthquake generation process. A long continuous time series has some interesting results. These results will be presented in the convention.

COMPILATION OF SEISMIC CATALOGUE FOR THE NW HIMALAYA: IMPLICATION OF LITHOSPHERE HETEROGENEITIES BASED ON B-VALUE VARIATION

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Himalaya is one of the most seismo-tectonically active regions in the world due to the ongoing thrusting of Indian plate beneath the Eurasian plate. A high rate of convergence of these two plates within Himalayan wedge plays an important role for high seismicity as observed for the NW Himalaya in the present study. Study on b-value is a useful tool to assess the stress building process, which is variable along the fault zones due to the occurrence of heterogeneities. The present study is aimed at understanding the general trend in the heterogeneity of the crust and lithosphere in the Northwest Himalaya using seismic catalogue compilation and b-value measurements.

We used the homogenous seismic catalogue (1977-2005) compiled by Lyubushin et al. (2010) containing 5410 events for estimating the variation in b-value for understanding the crustal heterogeneity of the region. This catalogue includes 27 major and strong earthquake events of magnitude range of 6 to 8 with the addition of data till date. The compilation of recent events through International Seismic Centre and India Meteorological Department data and its refinement through WIHG seismic network assisted to lower the magnitude threshold to 2.4+-0.2 for catalogue completion up to 2015. It is evident that the seismicity is highly concentrated within Outer Himalaya and Higher Himalayan Crystalline region around the surface trace of Main Central Thrust similar to central and eastern Himalayan regions. Low b-value for the Kangra-Chamba (0.6+-0.05) region suggests a low capacity of the sub-surface crustal material to withstand the ongoing tectonic stress resulting in heterogeneities within the Himalayan wedge. Majority of hypocenters are concentrated within upper crust mainly around and above Main Himalayan Thrust indicating the detachment zone is highly stressed due to under-thrusting of Indian plate beneath the overriding wedge. The frequency-magnitude distribution of earthquake events indicates that comparatively, moderate magnitude earthquakes are dominant. However, the regions are capable of generating devastating earthquakes such as 1905 Kangra earthquake and large magnitude (Mw 7.6) 2005 earthquake of Kashmir region. Therefore, it is necessary to delineate the hazardous zones that are vulnerable to occurrence of future high magnitude earthquakes in order to reduce the loss of lives and property. Although most of the study region exhibits shallow focused earthquakes, a localized zone of Hindukush to the north of western Himalayan syntax has intermediate focused earthquake up to 300 km, which has been related with the breaking and submerged part of the under-thrusting Indian plate. The present study highlights the existence of variable heterogeneity zones variation by estimating the temporal and depth wise variation of the b-value and finding the empirical relations between different magnitude types in the Northwest Himalayan region.

TRACKING BETWEEN AIR AND GROUND TEMPERATURES: A TEST CASE IN SOUTH INDIA

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The relationship between changes in air and ground temperatures is of critical importance in understanding the energy balance near the ground-air interface. A Geothermal Climate Change Observatory has been operating in south India since August 2009 to quantify the inter-relationships

between surface air temperatures, surface ground temperatures and subsurface temperatures on annual to decadal timescales. The Observatory is located in the Choutuppal campus of CSIR-National Geophysical Research Institute (17.29 ^{o}N, 78.92 ^{o}E), in a relatively rural area ~60 km to the east of Hyderabad. Surface meteorological parameters including air temperature, relative humidity, rainfall, solar radiation, wind speed and wind direction are being recorded continuously at the site. At the same site, ground temperatures are being recorded continuously at depths of 0.015, 0.09, 0.19, 0.49, 0.99 and 1.19 m in the granite regolith to track the diurnal changes in surface temperature. To track the seasonal and decadal changes, repeat temperature measurements were carried out periodically in two boreholes CH-11 and CH-10 drilled to depths of 21 m and 210 m respectively and located within 3 m of the weather station.

Salient results obtained so far are as follows. (i) Surface air temperature (SAT) and incident solar radiation show a general correlation over the length of the record; (ii) Comparisons of SAT and ground temperatures measured at depths of a few cm to 1.2 m below the surface reveal both attenuation of high frequency temperature variations and time lag in the signals with increasing depth, which support conductive heat transfer in the subsurface; (iii) Diurnal variations of SAT decay to insignificant levels at a depth of ~1 m, whereas the seasonal variations persist up to 15 m depth at the site; (iv) Comparisons of ground temperatures calculated using 1D - heat diffusion to different depths up to 1 m with the observed temperatures at corresponding depths yield a mean in-situ thermal diffusivity of 0.9 m^2s^{-1} for granite regolith at the site. (v) Ground temperatures appear to track SAT variations but with important time varying offsets; (vi) The difference between surface ground temperatures (SGT) and SAT is primarily a function of incoming solar radiation. Ongoing measurements over the next few years would bring out a wealth of information on the nature and extent of tracking between the surface and subsurface temperature variations at longer timescales.

SURFACE FRACTURE GEOMETRY IN KOYNA-WARNA SEISMIC ZONE, WESTERN INDIA

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The high-resolution Bare Earth Model(BEM) has been derived from LiDAR imagery. This has been utilised to identify, map and visualize fault related geomorphology in densely vegetated terrain surrounding Koyna-Warna seismic zone. BEM derived from LiDAR gives a tree removal algorithm. This algorithm was applied to the data; the resulting images reveal surface scarps and tectonic landform features in detail. We used different geospatial technique tools for identification of lineaments. The lineaments trend in the N-S, NW-SE and NE-SW directions. They intersect with each other particularly to the west of the study area, just adjacent to the WGE (give expansion). The density of these lineaments and their intersections are very high in the regions that have rapid changes of slopes and rugged topography. At several locations ground verification has been done with outcrop measurements. The earthquake clusters also fall on the rapidly changing slopes and lineaments intersection places. The earthquakes of M $\geq$4.0 occurred during 1967 to 2015 have been utilized for this study. The earthquakes are spatially correlated with N-S lineaments zone,which may represent surface expressions of seismically active basement faults.

GAS HYDRATESFROM ISOTROPIC AND ANISOTROPIC VELOCITY MODELING IN KRISHNA GODAVARI BASIN, EASTERN INDIAN MARGIN

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We carried out thorough analysis of well log data at NGHP-02-19C site in the Krishna-Godavari basin of Eastern Indian margin for the estimation of gas hydratesusing both isotropic and anisotropic velocity modeling. The isotropic velocity modeling is based on three phase Biot equation that uses density derived porosity log and calculated bulk density of sediments as input. The anisotropic velocity modeling is based on a transverse isotropic media formed by two isotropic components in which the first component is fractures filled with 100% gas hydrates and the second component is 100 % water saturated sediments. The isotropic modeling assumes a homogeneous condition of borehole, while the anisotropic modeling assumes fractures with variable dips into the borehole. The saturation of gas hydrates has been estimated from isotropic as well as by including fractures from 0^0 to 90^0. The results in terms of percentage volume will be presented and compared with the pressure core datato characterize the borehole condition.

AN INNOVATIVE METHOD OF PARTICLE SIZE CHARACTERIZATION USING SMEAR-SLIDE IMAGE ANALYSIS: A COMPARATIVE STUDY

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A comparative study has been made on the textural analysis of a sediment core from Krishna-Godavari (K-G) Basin, Bay of Bengal. The measurements were carried out using a sieve–laser diffraction technique, sieve-pipette method and a smear-slide image processing method using Giovis Particles Plus software. The clay and silt percentages determined by the three methods provide similar results. In this smear-slide method, high quality images are captured in high magnification using a high resolution camera attached to the microscope. The images are then processed using the Giovis Particles Plus software, which determine the percentage of silt and clay. The results obtained from smear-slide method when compared to the other two, well established methods show a positive correlation. The correlation coefficient values for all the three methods show R^2 values ranging from 0.84 to 0.9, with an average of 0.86, thereby proving the compatibility of the values generated by all the three methods. In addition the Giovis Particles Plus software offers a wide range of parameters such as sphericity, roundness, area including the grain morphology unlike the previous two methods. In view of the above merits, this new innovative smear-slide image processing method could be used as an alternative method for routine sediment texture analysis with high precision. In this paper we have discussed the protocols for smear-slide preparation, image processing techniques and the data analysis.

MAGNETIC SIGNATURES OF PALEO-METHANE SEEPAGES AND GAS HYDRATE DYNAMICS IN KRISHNA-GODAVARI BASIN, OFFSHORE INDIA.

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Greigite is anauthigenicferrimagnetic mineral that forms in association with microbially-mediated processes including sulphate reduction, anaerobic oxidation of methane (AOM) and formation of gas hydrates. Understanding the greigite magnetism can provide vital information on the variability

of paleo-methane fluxes and occurrences of gas hydrates at continental margins. In this study, we examined environmental magnetic, sedimentological and geochemical records of sediment core (MD/161/Stn/8) overlying methane hydrate deposits to establish linkages between gas hydrate dynamics (formation/dissociation), methane seepages and magnetic mineral diagenesis. An anomalous zone of enhanced magnetic susceptibility (17 - 23 mbsf) below the present day SMTZ was identified and theincrease in magnetic susceptibility is mainly due to precipitation of ferrimagnetic iron sulfides. The magnetic analyses, first order reversal curves (FORC) and TEM observations confirm the presence of both diagenetic and biogenic greigite in this zone. The diagnetic greigiteis controlled by variations in terrigenous inputs and dissolved pore water sulfate concentrations, while biogenic greigite is probably biosynthesized by magnetotactic bacteria.

For the first time, we report the occurrence of silicate-hosted magnetic (Fe-S, Fe-O) inclusions within the greigite bearing zone. The increase in pH, alkalinity and dissolved silica concentration in this zone suggests that anaerobic oxidation of methane fuelled by intensification of methane seepagesmight have enhanced the dissolution of biogenic silica thereby increasing the dissolved silica concentration in pore waters, which resulted in re-precipitation of silica along with the diagenetically/ bacterially produced iron sulfides forming magnetic (Fe-S, Fe-O) inclusions in the vicinity of AOM hot spot. Our results demonstrate that silicate minerals can protect the magnetic mineral inclusions arresting the pyritization process thereby increasing the preservation potentials. The occurrence of diagenetic greigite below present day SMTZ also suggests the greigite might have been formed as a result of microbial activity enhanced by methane hydrates in the past and remains preserved as inclusion within silicate matrix even after hydrate dissociation. This suggests that silicate-hosted greigite inclusion enables rapid screening of potential gas hydrate zones and can be used for tracking the fossil gas hydrate systems in marine sediments.

STRUCTURAL INTERPRETATION OF SEISMIC REFLECTION DATA FROM THE SOUTH WESTERN INDIAN MARGIN

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South Western Indian Margin (SWIM) is a passive continental margin deformed by lithospheric stretching, rifting, magmatic emplacement, sedimentation, erosion etc. We studied the subsurface structural features of this margin using 2D multichannel seismic reflection (MCS) data of approximately 19000km length. MCS data is acquired with acquisition parameters of 6000m streamer length, record length of 8s and shot interval of 25m. MCS data integrated with gravity, magnetic and well data to classify the structural features, demarcate the extension of structural features and determine the timing of deformation.

The morphology of Prathap ridge (PR) and Laccadive ridge is re-examined from the available seismic, gravity and magnetic data. Extension of NNW-SSE trending Prathap ridge is marked between 9°N to 16°N in the Laccadive basin area. The discontinuous basement highs of Prathap ridge seen as single limbed basement high features from 9°N to 11°30′N and as a multilimbed basement high features from 11°30′N to 16°N. The width of the ridge is varying between 25 km to 40 km along this path.

Structural interpretation also imaged the fault system, and horst graben structures. It is a significant signature of passive rifted continental margin. Extensional tectonics resulted in normal faulted basements, in which many faults are extended up to seafloor. Fault structures are dominant in

the northern part of SWIM compared to southern part of SWIM. The faults resulted inhorst and graben structures in the entire continental margin and thus it carries the pre, syn and post rift sediments. The detailed results of the structural features such as fault system, horst and graben structures and tectonic activity across the margin will be discussed in poster presentation.

GIS BASED QUANTITATIVE MORPHOMETRIC ANALYSIS OF THE MEENACHIL RIVER BASIN, KOTTAYAM, KERALA

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The Meenachil River Basin (MRB) encompasses an area of 1272 km^2 flows through tropical midland basins of Kottayam district, Kerala. Systematic quantitative morphometric analysis of the sixth order Meenachil River is carried out by determining the linear, areal and relief aspects of digitized drainage network derived from the Watershed Atlas of Kerala State Land use board of 1:50,000 scale. For quantitative analysis, the basin is divided into 47 major sub-watersheds and 115 micro basins. Parameters such as stream ordering, stream numbering, and stream length are calculated manually. Other parameters such as basin area, basin perimeter, slope, the height of the basin mouth, basin length etc., are also calculated. A total of 67 parameters have been calculated and different maps have been created. From the slope analyses, the slope of the basin varies from 0^0 to 40^0, which implies that the basin has a steep slope. The south-western part of the basin is more susceptible to landslides. Various statistical analyses have also been carried out using the values for the systematic quantitative analysis of the study area. The results revealed by the analysis have been interpreted to arrive at a final conclusion regarding the dynamics of Meenachil River. The analysis revealed that the Meenachil River has established dendritic, sub-parallel to parallel, trellis and rectangular drainage pattern with drainage development up to VI order stream. The stream number follows Horton's law of stream number and it represents 76.96% first order streams, 17.55% second order streams, 4.05% third order

GEOCHEMICAL FRACTIONATION OF SEDIMENTARY CD AND ITS BIOACCUMULATION IN OYSTER (CRASSOSTREA SP.): IS THERE ANY LINK?

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Cadmium (Cd) concentration in the edible oysters (Crassostrea sp.), collected from the tropical mangrove estuarine region of Goa, have shown high bioaccumulation of Cd (2 to 9.5 mg.kg-1). The concentration of bioaccumulated Cd in edible oysters was found to exceed the maximum permissible limit for human consumption. This study examined the importance of Cd speciation and its ability (in sediments) on its bioaccumulation in oysters. Geochemical fractionation study of Cd from both bulk and finer sediments revealed that Cd in exchangeable, carbonate and bicarbonate forms were bioavailable. The results also indicate that Cd associated with Fe/Mn oxyhydroxide of finer sediment controlled Cd bioavailability in the mangrove sediment systems. Cd associated with suspended particulate matter (SPM) did not show significant correlation with the concentration of bioaccumulated Cd. The speciation study of Cd suggests that sedimentary Cd, especially Cd in finer fraction of the sediment is one of the important routes for Cd uptake in oyster soft tissues.

1-D CRUSTAL VELOCITY STRUCTURE IN THE INDIAN OCEAN GEOID LOW REGION

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Long wavelength geoid anomalies are more responsive to density inhomogenities deep within the Earth, which can be well explained by the internal processes of Earth that could lead to such large scale fluctuations. The Indian Ocean Geoid Low (IOGL) is the world's largest geoid low, centred near to south of Sri-Lanka and covers a large part of the northern and central Indian Ocean. The geoid fluctuation in the Indian Ocean region is of the order of -100m, which is much significant as compared to other parts of the world. Our objectives are to explore possible reasons attributing to such extreme deficiencies in the geoid height and to understand the crustal influence on the origin of the IOGL. Earlier studies support that the source depths of IOGL range from crust to the core mantle boundary and the influence of crust on the geoid height was significant (Spasojevic et al. 2010). An initial segregate study of contribution of these sources of different depths is important. Influence of crust on the geoid signature has been found to be mainly due to the long wavelength variation of the shape of crustal layers and variation of density inside the layers plays a secondary role (J. Kakkuri, 2003). In a view to investigate how crustal structure across the region could have any implications of the geoid signatures in the IOGL region, velocity modelling of ocean bottom seismometer (OBS) data has been done. We present a 1-D crustal velocity structure, which will be of great significance to investigate the origin of the IOGL. It is observed that crustal thickness varies significantly along the profile, which lies radially across the centre of the largest geoid low region.

P-WAVE VELOCITY FROM SEISMIC ATTRIBUTES USING MULTI-LINEAR REGRESSION: A STUDY FROM KRISHNA-GODAVARI OFFSHORE, INDIA

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P-wave velocity plays an important role in the reservoir characterization including porosity & permeability calculation, lithology identification, prediction of reservoir fluids, fracture evolution etc. The velocity variation across a bottom simulating reflector (BSR) can be translated in terms of saturation of gas hydrates and free gas across the BSR. It also helps in risk assessment about the reservoir. In the present study we have employed the seismic attributes to predict the P-velocity along a seismic line in the Krishna-Godavari offshore basin using a multi-linear regression (MLR) technique. The present approach reveals the zone of gas hydrates bearing sediments in the study area.

GEOMETRY OF THE SUBDUCTING INDIAN PLATE AND THE SPATIAL VARIATION OF B-VALUE IN THE ANDAMAN REGION FROM A PASSIVE SEISMIC EXPERIMENT

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The seismological data from a temporary Ocean Bottom Seismometer (OBS) network is analyzed to understand the seismicity pattern in the Andaman region. 559 local earthquakes are identified from the OBS network, which are integrated with the data from the ISLAND network and the seismological

stations from neighboring countries. The joint hypocenter determination (JHD) is carried out after estimating the minimum 1-D velocity model from VELEST. The velocity model suggests the presence of Moho at a depth of 30 km. The model is acceptable beneath the Andaman and Nicobar Islands, and the shallowing of Moho is observed away from the Islands particularly beneath the Andaman backarc spreading center (ABSC). The seismicity pattern can be broadly classified into two categories i) the intermediate depth earthquakes from the subducting Indian plate or from the upwelling of Magma in the vicinity of volcanic arc and ABSC, and ii) the shallow depth earthquakes from the active faults (WAF, EMF, and DF) and the system of short spreading centers and transform faults extending from Sagaing fault in the north to Sumatra fault in the south.

The configuration of Wadati-Benioff zone is clearly observed from the combination of local and well-constrained global earthquakes. The dips at different segments of the subducting plate seem to vary.It is noticed that, for example,the dip of the subducting plate decreases from 52° to the north of 11° N to 42° at 10.5° N. It further decreases to 38° at 9.5° N and to 26° to the south of 9° N. The decrease in the dip may be attributed to the decrease in the age of the subducting plate and the obliquity of the plate motion. A couple of slab-tear faults are observed on the local seismicity, which are associated with the abrupt change in dip of the subducting plate. The change in dip, slab-tear and the presence of backarc spreading center suggest poor mechanical coupling between the subducting Indian plate and overriding Burmese plate in the Andaman segment. The slab tear may also explain the abrupt reduction in rupture velocity of 26th December 2004 earthquake to the north of the Nicobar Islands at 8° N. High b-values (2-2.5) for the regions in between the slab tear faults, ABSC and volcanic arc suggest weak crust, which is not capable of accumulating high stress conditions. In contrast, low b-value (0.74) off Nicobar Islands suggests that the region is accumulating high stress and is susceptible for high magnitude earthquakes.

ESTIMATION OF PORE PRESSURE AND VERTICAL STRESS IN GAS HYDRATE BERING SEDIMENTS USING WELL LOG DATA OF MAHANADI BASIN, INDIA

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Mahanadi basin located at eastern continental margin of India (ECMI) is a petroliferous basin, which contains valuable amount of gas hydrate. It is considered to hold gas hydrate bearing sediments at the shelf of deep sea water. Mahanadi is a major river system in India, which is flowing eastwards and draining into the Bay of Bengal. The occurrence of gas hydrate is sand-rich depositional facies in the Mahanadi basin. Gas hydrate holds immense amount of potential energy. Structure of gas hydrates is stabilized by the guest gas molecule. Almost twice of energy is contained in fossil fuels. The most common molecules of gas are methane molecules trapped by water molecules called methane hydrates. The gas hydrate bearing zone sediments occur in low temperature and high pressure condition. Its applications have enhanced significantly deepwater exploration, pore pressure prediction in safe well planning and hydrocarbon exploration during the past couple of decades. Predrill estimation of pore pressure and vertical stress are essential for understanding the geomechanical behaviour of the gas hydrate stability zone. Three wells namely well-A, well-B and well-C have been considered for estimation of pore pressure and stress gradient, using Eaton sonic equation and Bowers relation in the selected depth intervals for the gas hydrate sediments. The prediction pore pressure value varies from 17.33 to 21.3 MPa in depth ranges 1701.08 to 2046.49m for well-A, 19.83 to 23.72 MPa in depth interval

1935.02 to 2258.87m for well-B and 14.86 to 16.81 MPa in depth interval 1493.11 – 1690.32 m for well-C. The vertical stress gradient varies from 10.26 to 10.71 MPa/km within these wells. Normal pressure is observed but slightly high pressures are also noticed at lower depth of the wells for gas hydrate bearing sediments.

GEOCHEMICAL FRACTIONATION AND SEASONAL VARIATION OF PB IN THE ESTUARINE SEDIMENTS OF MANDOVI AND ZUARI RIVERS

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Seasonal distribution and chemical speciation of lead (Pb) in estuarine sediments of Mandovi and Zuari Rivers were studied. The estuarine sediment samples were collected during the month of March (pre-monsoon) and October (post-monsoon). The Community Bureau of Reference(BCR) sequential extraction protocol was used to understand the Pb speciation and distribution in different binding phases of the sediment. The total concentration of Pb varied from 6-32 μg/g during pre-monsoon season and 8- 30 μg/g during a post-monsoon condition in estuarine sediment. Lead didn't exhibit significant seasonal variations during post-monsoon and pre-monsoon seasons. However, the geochemical fractionation study showed that Pb concentration in Fr 1 consisting of water-soluble, exchangeable, carbonate and bicarbonate complexes vary in the range of ~0-2 % of total Lead in both the seasons. The concentration of Pb associated with Fe/Mn oxyhydroxide (Fr2) significantly varied seasonally. Pre-monsoon Pb association with Fe/Mn oxides were high, in the range ~10-32% (with an average concentration of 3.51 μg/g) and in post monsoon~ 8-20% (with an average concentration of 1.41 μg/g). Concentrations of Pb associated with sedimentary organic matter (Fr3) present in the studied sediment were high in the both the season. The association of Pb with sedimentary organic matter was high during pre-monsoon condition (ranging ~6-38% of the total Pb, concentration ranged from 0.4 to 5.41 μg/g) and post-monsoon ranging from ~1-26% of the total Pb, the concentration ranged from 0.18 to 4.28 μg/g). This decrease in concentration of associated Pb with sedimentary organic matter was probably due to the decrease in suspended organic matter (SOM) concentration during the post-monsoon season. The very similar residual concentration Pb in residual fraction (Fr4) with an average concentration of 9.57 μg/g in pre-monsoon season and 9.76 μg/g in post-monsoon season suggest that the source rocks of the sediments were the same. This study showed the importance of sedimentary organic matter and Fe/Mn-oxyhydroxide in controlling Pb speciation in Mandovi and Zuari estuarine sediment systems.

SEISMIC VOLCANO-STRATIGRAPHY OF THE SOUTH-WESTERN CONTINENTAL MARGIN OF INDIA (SWCMI)

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Passive continental margins are evolved by extensional tectonics and volcanism. The nature of the passive margins can be recognised on the basis of degree of volcanism. However, passive margin can be divided into two types on the degree of breakup related volcanism; 1) Magma Rich characterised by massive emplacements of mafic extrusives and intrusives and 2) Magma-Poor characterized by extension, stretching and thinning of crust, rotated fault blocks.

The South-western continental margin of India (SWCMI) is the southern part of the western margin of India. It developed after breakup between south-west margin of India and eastern Madagascar during Mid-Cretaceous (85 Ma). This event was associated with Marion hotspot activity and produced voluminous basaltic flows and igneous intrusive on the south-west India (Radhakrishna et al 1994; Kumar et al 2001; Pande et al 2001), and led to the emplacement of a large volume of subaerial volcanic flows. Subsequently SWCMI was modified by tectono-magmatism during northward movement of Indian plate over Reunion hotspot trail (Krishna et al 1992). SWCMI Margin is characterised by rotated fault blocks, emplaced volcanism, intrusive, flows, grabens (Chaubey et. al. 2002) and extrusive volcanism (SDRs) on the western

IDENTIFICATION OF FAULTS USING NEURAL NETWORKS AND MULTI-ATTRIBUTES: A STUDY FROM KRISHNA-GODAVARI OFFSHORE, INDIA

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Seismic attributes are extensively used in reservoir characterization for prospect evaluation. If a single attribute is not sufficient for delineating a subsurface feature such as a fault, an amalgamation of multiple attributes can be used for precise detection of the target. We demonstrate that this approach based on artificial neural networks (ANN) can improve the signal-to-noise ratio or enhance the subsurface image with fault detection from seismic data in the Krishna-Godavari offshore basin. The results of neural network based fault detection show more reliability and greater certainty by comparing with individual attribute responses, and help in better structural interpretation and understanding migration pathways for hydrocarbon exploration.

NEURAL NETWORK APPLICATION OF SIMILARITY ATTRIBUTE FOR FAULT ANALYSIS: A STUDY FROM 3D SEISMIC DATA IN OPUNAKE FIELD, OFFSHORE NEW ZEALAND

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Faults play an important role to understand the geo-tectonics and hence hydrocarbon prospects in any sedimentary basin. Opunake field off New Zealand is a complex petroliferous basin, and we want to extract subsurface information in the best possible way. Since the Neural network can recombine multiple input attributes and extract the subsurface features efficiently, we have applied this tool to gain more geological information from seismic data. We compute similarity attribute from available 3D post-stack migrated seismic data and combine them using neural network essentially low similarity with different step-outs. The results demonstrate the application of neural network for the high quality extraction of subsurface features such as faults from seismic data in the Opunake field.

MARINE GEOPHYSICAL STUDIES OVER THE CENTRAL INDIAN RIDGE BETWEEN 3°S AND 11°S, INDIAN OCEAN

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The Central Indian Ridge (CIR) is a part of the major active mid-ocean ridge system trending north-south between Rodriguez Triple Junction (25°83′S, 70°E) and the equator. The present work consists of a detailed study over a 750 km long segment of the Central Indian Ridge (CIR) between 3°S and 11°S, to understand the processes leading to the generation of the oceanic crust and its evolution through the analysis of marine geophysical data. The 750 km long section of the CIR is characterized by rugged topography, steep valley walls, and well defined rift valley floor, all characteristics of slow spreading ridge. Based on the multibeam bathymetry we have identified twelve ridge segments and seven distinct ridge-transform intersection (RTI) highs occurring at the inside corner tectonic setup. Three of these prominent RTI highs are identified as oceanic core complexes /megamullion structures. The ridge segments have been classified into magmatic and less magmatic ridge segments based on the rift valley configuration and off axis morphology. Magnetic model studies qualify the ridge as a slow spreading ridge with average full spreading rates varying from 27 to 38 mm/yr. We identified up to anomaly 3 across the ridge axis. The disposition of the magnetic anomalies suggests that the plate opening direction has not changed during the last 0-4 Ma period. Gravity data has been analysed to understand the crustal structure. The computed mantle Bouguer anomalies (MBA) and the residual mantle Bouguer anomalies (RMBA) of the study area show significant variations along the ridge segments that are separated by transform and non-transform discontinuities. The identified megamullion structures are associated with less magmatic ridge segments. Based on our detailed high resolution studies we propose that the oceanic core complexes are formed preferentially at the segment ends undergoing tectonic extension under sparsely magmatic regime. Both the transform faults and the non-transform discontinuities are characterized by thin crust. The along-axis crustal thickness computed from RMBA on an average is 5.23 km. The longer linear segments L and N have shown up to 7.8 km thickening of the crust towards the middle of the segment. The derived spreading rates are comparable to the slow spreading Mid-Atlantic and Carlsberg Ridges and also compare well with spreading rates derived from the MORVEL model.

DEVELOPMENT AND EVALUATION OF BENTHIC FORAMINIFERAL PROXIES FOR MODERNAND PALEO COLD-SEEP SITES FROM KRISHNA-GODAVARI BASIN (BAY OF BENGAL)

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In comparison with well-established geophysical and geochemical proxies benthic foraminifera are other important input data components that can be used as a potential tool to study methane fluxes and seep zones. Numerous species of benthic foraminifera have been found in different methane rich

marine settings and have proved to be good indicators of methane seepage events. The continental slope region of the K-G Basin is one of the promising petroliferous basins of India. The drilling and coring was carried out in this basin during the National Gas Hydrate Program Expedition 01 (NGHP-01) in 2006. Site 10D is characterized by abundant gas hydrates and shallowest sulfate-methane transition zone (SMTZ) drilled during the entire NGHP-01 expedition. This site 10D offers unique opportunity to test and establish the relationship between benthic foraminiferal assemblages and gas hydrate dynamics over different time scales.

About 100 sediment samples have been studied for benthic foraminiferal abundance, vertical distribution, diversity and species composition. The total faunal abundance (count %) ranges from 60 to 7160 with an average of 237. We have noticed the highest faunal abundance coinciding with present SMTZ at this location. Relatively higher abundance of some particular taxa of benthic foraminiferas species including the genera *Bolivina, Bulimina, Cassidulina, Fursenkoina, Epistominella, Melonis, Nonionella, Uvigenrina* etc. within the gas-hydrate stability zone are indicative of high TOC content reflecting prevalence of the anoxic environments. This study is focused to examine benthic foraminiferal population from methane rich environments to understand if certain species of benthic foraminifera can be classified as methane seep-site specific and therefore could be developed as a potential tool/ proxy to characterize modern and paleo cold-seep sites in the Krishna-Godavari basin.

GEOPHYSICAL STUDY OF THE RAMAN SEAMOUNT, EASTERN ARABIAN SEA

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The Raman Seamount is an anomalous bathymetry feature located in the Laxmi Basin, which forms a part of the Eastern Arabian Sea. This seamount is the northernmost among the seamount chain situated over the Panikkar Ridge that represents the extinct spreading centre of the Laxmi Basin. Geomorphology of the Raman Seamount was studied in detail by earlier researchers, however its detailed characteristic geophysical signatures are not yet been clearly established. In this context, we attempted to understand the geophysical signatures of the Raman Seamount using a fresh set of densely covered profiles of multibeam bathymetry, sea-surface magnetic and gravity data acquired onboard *RV Sindhu Sadhana* in December 2016, complemented by a single channel seismic reflection profile, acquired onboard *AA Sidorenko* in 1995. The Multibeam bathymetry data could provide an improved understanding of geomorphology and the morphometric parameters. The multibeam bathymetry data depicts the presence of numerous dendritic gullies and a secondary peak over the seamount. The acoustic basement topography reveals that the Raman Seamount is characterized by the presence of relatively steeply dipping flanks, with onlap of sediments on its eastern and western flanks. The free-air gravity anomaly map shows that the seamount is associated with a very short wavelength gravity high, superimposed on the short wavelength gravity low representing the Panikkar Ridge. The free-air gravity anomalies are well correlatable with topography of the area, with their maximum located over the summit of the seamount. The major part of the Raman Seamount is characterized by a magnetic low, with its minimum located in the southwestern part. We further used these magnetic anomaly profiles to delineate additional magnetic anomaly picks, which represent the estimated age of the oceanic crust, and to construct an updated high-resolution magnetic isochron map around Raman Seamount region. Our isochron map shows that the Raman Seamount is located over oceanic crust with an age younger to chron C28ny (62.5 Ma). This implies that the volcanism that caused the formation of the

Raman Seamount cannot be older than chron C28ny (62.5 Ma). Though the exact age of initiation of volcanism cannot be obtained from the nearby magnetic isochrons, we believe that the volcanism that caused the formation of the Raman Seamount was probably initiated at around chron C28ny (62.5 Ma), since the bathymetric extent of the Raman Seamount in both the western and eastern sides are nearly bounded by the magnetic isochrons corresponding to this age. This phase of volcanism might have continued till the extinction of the spreading centre in the Laxmi Basin.

COMPARATIVE BIOGEOCHEMICAL SIGNATURES OF SEDIMENTS DEPOSITED WITHIN OXYGEN MINIMUM ZONE OF THE EASTERN ARABIAN SEA DURING THE HOLOCENE AND BOLLING-ALLOROD

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Two Accelerator Mass Spectrometry (AMS) radiocarbon dated marine sediment cores collected from the oxygen minimum zone (OMZ) of southeastern Arabian Sea, separated by distance of 67 km were studied for changes in the depositional environment, the paleoredox condition and paleoproductivity. The two cores collected at 381 m (MGC-2) and 835 m (MGC3) depth were studied for minor, trace elements, $CaCO_3$ and total organic carbon (C_{org}) content. Cores MGC-2 with length of 1.84 m was deposited at higher sedimentation rate (37 cm/kyr) covers 9 kyr and MGC-3 with length of 1.73 m was deposited relatively at lower sedimentation rate (23.25 cm/kyr) and spans past 15 ka. The $CaCO_3$ and C_{org} are high indicating high productivity and exhibit fluctuations suggesting changes in the productivity in the two cores. Elemental concentrations were normalized with titanium to remove the source effect.The Ti normalized values of Cu and Ni in core MGC 3 show gradual increase from early to late Holocene. This increase is also seen in organic carbon concentration, which indicates increased productivity. However, the behavior of these elements in core MGC-2 is different. They show abrupt fluctuations without any steady increase,which suggest different depositional conditions at these two core sites probably related to difference in sedimentation rate.The Ti normalized terrigenous elements (Sc, Rb,Sr andTh) exhibit higher concentrations in MGC 3 compared to MGC 2. The MGC 3 core exhibitsoscillations from 15 to 10 ka and with limited variation since 10 ka, whereas core MGC 2 exhibits fluctuations throughout the core. The fluctuations observed between 15 to 10 kain MGC 3 may be related to changes in the terrigenous transport of the sediments in response to the Indian summer monsoon (ISM) intensity. Lower concentrations during the late Holocene at the core MGC2 indicate reduction in terrigenous sediment supply at this site and probable transport of these sediments at deeper depths at MGC 3 under the influence of the under currents with rise in sea level. The Ti normalized ratios of redox sensitive elements U and Mo are much higher and Mnis lower as compared to Post Archean Australian Shale (PAAS) ratios in the maximum part of the cores. The redox elements (Mo/Ti, U/Ti) in MGC 3 suggest that 12 and 3 ka core experiences more deducing conditions and more oxygenated waters before 12 ka and after 3 ka. We conclude that the study area has experienced changes in productivity and redox conditions, input of sediment fluxes during the past 15 ka under the influence of changing intensity of ISM, OMZ and the sea level rise.

RESPONSE OF EQUATORIAL AND LOW LATITUDE MLT DYNAMICS TO SUDDEN STRATOSPHERIC WARMING EVENTS

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The Sudden Stratospheric Warming(SSW) event that takes place in the polar middle atmosphere is capable of inducing changes in the low latitude counterparts by virtue of modifying the zonal mean circulation and pole-ward temperature gradient. Numerous studies have investigated the effects of SSW events in the low latitude Mesosphere- Lower Thermosphere (MLT) region. Using meteor wind radar observations, the present study examines the response of semidiurnal tides and quasi 2-day waves in the MLT region, simultaneously over low latitude and equatorial stations Thumba (8.5^{o}N, 76.5^{o}E) and Kototabang (0.2^{o}S, 100^{o}E). The present study investigates the behaviour of low and equatorial latitude MLT region during Quiet winter, Major SSW winter and Minor SSW winter. The present results reveal that (i) Semidiurnal tidal and quasi 2-day wave amplitudes in the equatorial and low latitude MLT region enhance in association with major SSW events, (ii) the semidiurnal tides show significant enhancement selectively in the zonal and meridional components over the Northern Hemispheric low latitude and the equatorial stations, respectively (iii) The minor SSW event of January 2012 resulted in anomalously large quasi 2- day wave amplitudes without any noteworthy increase in semidiurnal tide amplitudes. The significance of the present study lies in comprehensively bringing out the signatures of SSW events in the semidiurnal tides and quasi 2-day waves in low latitude and equatorial MLT region, simultaneously for the first time over these latitudes.

MASS WASTING PROCESSES ON THE MOON: A GLOBAL STUDY

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Geological manifestations of mass wasting processes on the Moon are landslides, gullies, boulder falls, slumps, flows and creeps, as in the case of Earth, Mars and other solid planetary bodies. These landforms generally form in response to tectonic moonquakes and meteoroid impacts. Unlike on Mars and Earth, mass wasting landforms on the Moon are formed in absence of atmosphere and crustal volatiles. However, these landforms exhibit many similarities and differences to those on other planets. Availability of high-resolution images at sub-meter scales and topographic maps with decameter resolution from recent and on-going lunar missions enabled easy identification of these landforms and their morphological characterization. Although the recent studies have brought out a global catalogue of these landforms, hundreds of landforms are yet to be discovered and characterized. Therefore, using high resolution images (0.5m/pixel) obtained from LROC (NAC images) and LOLA topography data (100 m/pixel), we have identified hundreds of potential sites where the mass wasting landforms can be identified and classified for further detailed studies. Our preliminary geological mapping and analysis reveals that hundreds of landslides, gullies and boulder falls are identified on the interior walls of impact craters. Geomorphological characteristics of some of these landforms occurring in the impact craters would be presented. Our study would also bring out the sources of surface shaking such as moonquakes along lobate scarps and ground vibration from recent impacts.

INTEGRATED WATERSHED CONSERVATION AND MANAGEMENT OF K-J WATERSHED, NORTH, INDIA

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Remote Sensing and GIS collectively play a vital role in natural resources mapping and management like: land and water resources planning, conservation and management. Koshalya-Jhajhara (K-J), two tributaries of Ghaggar River have been taken for study of watershed conservation and management. Linear, Areal and Relief aspects for morphometric analysis were calculated using Geographic Information System (GIS). The changes in Land Use/ Land Cover (LU/LC) in K-J watershed have been detected by using Remote Sensing (RS) and Geographical Information system (GIS). Landsat (7 ETM^+ & 8) data have been used for LU/LC mapping and monitoring. Global Positioning System (GPS) and topographical maps have been used for ground truth verification. The classification approach used is a hybrid of unsupervised, supervised and on screen digitization and comparison. The watershed exhibits mainly nine categories of LU/L. Major Change is detected in the area under category built-up, which has increased from 7.12 to 24.84 km^2 over the study period from 1999-2000 to 2015-2016. The area under forest has decreased from 109.35 to 96.78 km^2 and agricultural land decreased from 12.61 to 7.35 km^2, respectively over the study period. Various thematic layers like geology, geomorphology, drainage density, slope, Landuse/Landcover have been generated and integrated in GIS software so as to generate the groundwater potential zone (GPZ) map of watershed. Each layer has been assigned weightage and rank to prepare final GPZ map of watershed. The area falls into five categories of groundwater potential zones i.e. very good, good, moderate, poor and very Poor depending on the availability of ground water. It is found that only 5.83 km^2 and 4.91 km^2 area is under very good and good category of availability of groundwater, respectively. An area of 24.48 km^2 is found under moderate category of availability of groundwater. Dominant portion of K-J watershed i.e. 61.83 km^2 and 37.87 km^2 area falls under poor and very poor category of availability of groundwater, respectively. The Revised Universal Soil Loss Equation (RUSLE) integrated with GIS has been used to estimate soil loss in K-J watershed. Raster maps of Rainfall erosivity, Soil erodibility, Slope length-steepness, Cover management and Conservation practice have been integrated so as to prepare soil erosion risk map, which reflects five soil erosion risk categories. The results show an area of 85.54% under very low to low category of soil erosion, whereas 7.92% area under moderate soil erosion category. Only 6.54 % of the area of the watershed falls under moderate high to high category of soil erosion. Erosion pattern in various sub-watersheds indicates that maximum area of sub-watersheds (1, 2, 4, 5, 6, 7, 8, 9, 12 and 13) falling in the hilly region are in low to very low category of soil erosion risk, whereas maximum area of sub-watersheds (0, 14, 15, 16, 17 and 18) is prone to high to very high soil erosion risk because of low vegetative cover, agricultural and human interventions. The study indicates that substantial amount of agricultural land and forest land has come under urbanization. This is an unhealthy situation for land management in such a sensitive ecosystem. The area is facing increasing problems of erosion, deforestation and other land use conversions issues, which are unsustainable in nature. The river is facing continuous threat due to land degradation in the catchment area and also increasing soil erosion. The water resources in the upper catchment also need immediate attention for their conservation and management. A surface water resource action plan map depicting 14 sites for check dams and fifteen sites for percolation tanks have been suggested as per guidelines of Integrated Mission for sustainable Development (IMSD, 1996). These sites need thorough geotechnical investigations before constructing.

SHALLOW SUBSURFACE IMAGING OF KACHCHH MAINLAND FAULT OF KACHCHH INTRAPLATE REGION USING TIME DOMAIN ELECTROMAGNETIC METHOD – A QUALITATIVE EVIDENCE OF NEOTECTONIC ACTIVITY

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The recognition and characterization of faults and its splays in terms of geometry, type of movement and rates of activity are essential to understand morphotectonics as well as assessing seismic hazard potential of a region. The 200km long Kachchh Mainland Fault (KMF) in the Kachchh region striking NW-SE to E-W forming the northern limit of the highly rugged Kachchh Mainland against the Quaternary Banni and Rann sediments. We present the analyses of time domain electromagnetic data at 52 sites, distributed along seven traverses across the KMF zone coupled with seismological results. The study not only demarcated the KMF but also reveals the presence of splays and transverse features in the area. The subsurface structure of the fault zone infers segmented nature of the KMF with activity increases from western to eastern part. Some of the splays are of negative flower structure suggesting localized transtensional geometry of the study region. We speculate that some of the transverse structures are associated with historic tectonic event. The presence of buried colluvial wedges seen as high conductive zones in the hanging wall side of the fault could indicate record of palaeo-earthquakes suggesting neotectonic activity in the study region.

Key words: TDEM, Kachchh mainland fault, splays, Colluvial deposits

Introduction

Kachchh situated in the western India, is one of the most seismically active regions of the world, falls under Zone V of seismic zoning map of India (BIS, 2000). The basin witnessed four large earthquakes in the past two centuries that include M7.8 on the Allah Bund fault (1819); the M6.3 earthquake on the Kachchh Mainland fault (KMF) (1845), the M6.1 Anjar earthquake (1956) on the Katrol Hill fault (KHF) and the widely destructive M7.7 Bhuj earthquake (2001) on the step over near South Wagad fault (SWF) along with many moderate to low earthquakes, continuously occurring till present showing its high seismic activeness. For a realistic estimate of seismic hazard scenario one of the primary input parameters is to map the causing fault along with the geometry of the fault zone and its attributes. The attributes include, dip, slip, length etc. Many geophysical and geological investigations carried out after the 2001 earthquake along with current aftershock activities inferred re-activation and branching of couple of existing faults in the region.

In the present study, we carried out TDEM investigations across the KMF zone to image the primary, secondary faults and delineate possible deep buried colluvial packets over the KMF zone for an idea on historic seismic activity that leads to formation of the deposits. The study also aimed to delineate the subsurface image for better understanding of the fault zone and its segments, information about the KMF geometry, nature of splays/ branches (if any), the transverse structures and their role on seismic activity of the region.

About the study region:

The landscape of Kachchh is a unique example of active intraplate region in the world. Seismically active paleo- rift basin of Kachchh traversed by major E–W-trending faults, viz. Nagar Parkar Fault (NPF), KMF, Katrol Hill Fault (KHF), South Wagad Fault (SWF) and Island Belt Fault (IBF). The KMF marks the boundary between the rocky Kachchh mainland extended up to Gulf of Kachchh in the

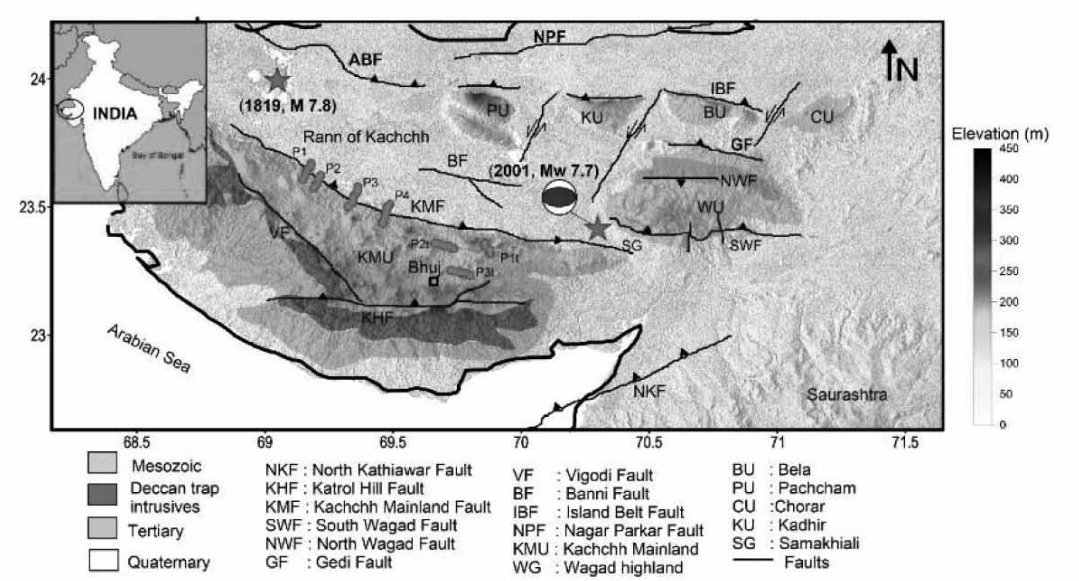

Figure 1. General geological scenario of the Kachchh superimposed on elevation map (modified after Pavan Kumar et al., 2017). TDEM sites are shown with magenta colour symbols. The stars are the locations of 2001 Bhuj earthquake & 1819 Allah Bund earthquake.

south and, on the northern side, the Quaternary sediments of the Great Rann and Banni Plains , which reach up to the southern margin of NPF. The area consists of limestones, sandstones and shales of Middle Jurassic to Cretaceous in age exposed in domes and anticlinal structures. The geological sequences of the studyarea are greatly influenced by the KMF.

Methodology

We carried out the TDEM investigations at 52 sites along four approximately 10km long N-S profiles and three E-W profiles in the Kachchh Mainland (Fig. 1) for mapping shallow-subsurface structure of the KMF zone and its branch/splays in terms of electrical resistivity. The four N-S profiles are across the main KMF and three ~E-W cut the transverse features that have been inferred by the geomorphological studies. We use Zonge (USA) made data acquisition system comprises the GDP-32 receiver, transmitter (ZT-30), transmitter controller (XMT) and a receiver antenna. During the TDEM survey, a primary electromagnetic field is generated by a 100m sided transmitter loop laid on the ground, through which alternating current of 9.2 amp is passed with equal periods of time-on and time-off, at various frequencies ranging from 1 to 32 Hz. A receiver located near centre of the transmitter loop recorded the secondary vertical magnetic fields (Hz) in terms of the induced voltage (in nanovolts/m^2) during the time-off period at 31 discrete time intervals ranging from a few μs to a few ms. To reduce the influence of EM noise, the recorded transients are stacked over a number of cycles (512, 256 and 128 cycles). We recorded data at 32, 16 and 8 Hz (high frequencies) currents for shallow depths and low frequencies (4, 2 and 1 Hz) for deep probing. Apparent resistivity at late times can be calculated using the formula:

$$\rho_a = \left(\frac{I\,A_T A_R}{V}\right)^{2/3} \left(\frac{1}{t}\right)^{\frac{5}{3}} * 6.3219E-3\ ohm.m$$

A_T& A_R are the transmitter and receiver moments in square meters, I is the transmitter current, V is the voltage in Microvolts, **t** is time in milliseconds and ρ is the resistivity in Ω.m.

The measured transient decay and estimated apparent resistivities are used to model the subsurface resistivity of the underlying structure. We, choose the processed data at 4 Hz transmitter frequencies for good late time data and hence deeper information. One dimensional Inversion modelling is performed by considering the horizontally layered earth model with homogeneous and isotropic layers. Elevation data at each site is incorporated during the inversion routine. For the present study, we use STEMINV (Zonge, USA) program to estimate layered-earth resistivity models.The algorithm uses an iterating best-fit technique to minimize the RMS residuals between the observed and calculated rate of magnetic field reflected as the induced voltage for each station.

Results and Discussions

1-D models of all the sites along the four N-S and three E-W profiles are used to generate resistivity sections shown in figure 2 along with the elevation data across each TDEM profile.The N-S resistivity sections show significant variation of shallow resistivity values across the fault zone down to 250m. We have marked the surface location of the KMF in the resistivity section. The geoelectric section along the profiles clearly shows the resistivity contrast in the south and north sides of the study region.

The geological contact between the two formations, the Mesozoic sediments (resistivity of ~100 Ω.m) and quaternary sediments (resistivity below ~1 Ω.m), marks the location of KMF and is observed

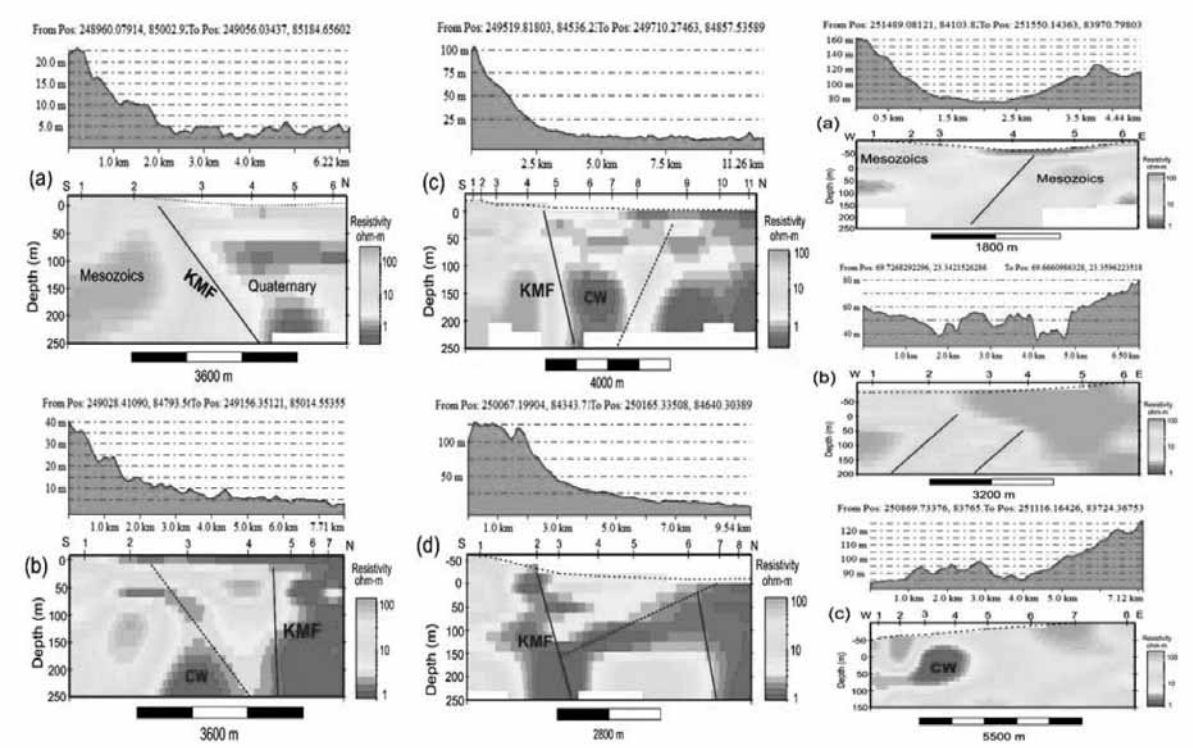

Figure 2: Geoelectric resistivity section across the four N-S profiles (left) and three E-W profiles (right) cutting the Kachchh Mainland Fault zone (Pavan Kumar et al., 2017, Tectonics (Under revision)

to be dipping towards north. The sections are illustrative of upward movement of hanging wall of KMF, as in the case of reverse faults. The segmented nature is well strengthened by seismological and geomorphological observations. In some segments of the region, the branch faults/splays of primary

KMF are observed tobereaching up to the surface suggesting possible Holocene deformation. The resistivity structure across the fault zone images the primary fault and its splays across the fault zone and most of these secondary faults associated with the colluvium wedges (CW) that are buried in the subsurface at a depth of 90-100m. The presence of the deep buried colluvium wedges along with geomorphological features suggest the late tertiary tectonic activity in some segments of the region. The negative flower structure of the secondary faults of the KMF suggests the localized transtensional deformation in the study region.

Acknowledgments

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References

McNeill, J.D. Principles and application of time domain electromagnetic techniques for resistivity sounding: Geonics technical note TN-27, Mississauga, Ontario, p. 1-15, 1994.

Mills, Theodore, Hoekstra, P., Blohm, M. and Evans, L. Time domain electromagnetic soundings for mapping seawater intrusion in Monterey County, California, Ground Water., v. 26, pp: 771-782, 1988.

Nabighian, M.N. and Macnae, J.C. Time domain electromagnetic prospecting methods. In: Nabighian, M.N. (Ed.), Electromagnetic methods in applied geophysics, 02. Society of Exploration Geophysicists, pp: 427– 520, 1991.

Prizomwala, S.P., Solanki, T, Chauhan, G., Das, A., Bhatt, N., Thakkar, M.G. and Rastogi, B.K. Spatial variations in tectonic activity along the Kachchh Mainland Fault, Kachchh, Western India: Implications in seismic hazard assessment. *Nat. Hazards*, DOI:10.1007/s11069-016-2228-x, 2016.

ASSESSMENT OF POROSITYFROM DIRECT INVERSION OF POST-STACK SEISMIC DATA, MAHANADI OFFSHORE BASIN - A CASE STUDY

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We have used a fast and reliable technique of direct inversion of post-stack seismic data along a 2D seismic line at site NGHP-01-19B in the Mahanadi offshore basin with a purpose of predicting reservoir properties such as porosity that can be useful in appraisal of gas hydrates. This methodology involves the detailed study of geology of target zone that helps further in implementing a lithology dependent empirical relation between acoustic impedance and porosity. The density-derived porosity ranging from 50% to 75%, within a depth interval of 1475 to 1680m has been used as an input for porosity estimation by direct inversion of post-stack seismic data, where reflectors like BSR (marker for gas-hydrates) are found. The crossplot of acoustic impedance and porosity with maximum correlation (0.82) exhibits a linear relationship. The lateral extent of porosity varies from 64% to 80% along the 2D seismic line, which illustrates a very good match between seismic inversion porosity results and porosity log.

DISTRIBUTION AND SPECIATION OF COPPER IN TROPICAL MANGROVE SEDIMENTS

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BCR sequential extraction protocol, proposed by Community Bureau of Reference of the European Commission,(further modified by Rauret et al., 1999) was used to study the geochemical fractionation of copper (Cu) in mangrove sediments from the Zuari estuary in the central west coast of India. The study showed that sedimentary Cu was present in five different binding phases of the sediments. These fractions are water soluble Cu complexes (Fr-1), Cu associated with carbonate/bicarbonate (Fr-2) and Fe/Mn oxyhydroxide (Fr-3) phase, Cu bound with sedimentary organic matter (Fr-4), and the non-residual fraction (Fr-5). Furthermore, the study shows that non-residual fraction formed a major part of the Cu in the sediments. Sedimentary organic matter was the major hosting phase for Cu. The concentration of Cu in the residual phase was found to show the signature of the source of the sediments. The initial study showed that variation in physico-chemical parameter (such as, pH, salinity, dissolved oxygen concentration etc.) of the overlying water column determines the distribution, speciation and mobility of Cu in mangrove sediments.

Keywords: Copper, fractionation, pH, BCR, Zuari estuary

INTRODUCTION

Estuarine sediments act both as sink and source for metals (Chakraborty et al., 2012). Contamination of sediments with metal pollutants is a widespread environmental problem that poses serious risk to aquatic ecosystems and eventually to mankind. The degree of toxicity and mobility of these metals depends on their chemical forms (speciation) and oxidation states (Chakraborty et al., 2015a, 2015b; 2016a, 2016b). As a result, their biogeochemical pathways and toxicity can only be understood if their chemical speciation is known. In essence, understanding of chemical speciation of toxic metals and their geochemical cycling is an important field of research.

The coastline of India is dotted with more than a hundred estuaries. The estuarine channels are widely used for discharging industrial and household wastes, including metallic pollutants (for example, Mercury (Hg), Arsenic (As), Chromium (Cr), Cadmium (Cd), Lead (Pb) and Copper (Cu)). Among metallic pollutants, Cu is one of the most important trace metals required for both plants and animals (as micronutrient), but this can become toxic at an elevated level.

Speciation of Cu refers to identification of the exact form of Cu and its complexes. Often in natural sediment samples, this is a difficult task. Consequently, sediment analysis is often based in leaching or extraction procedures (single or sequential extraction) so that broader forms of Cu (such as bioavailable or water soluble) are identified (Quevauviller et al., 1993). Owing to reproducibility of the results and applicability to different sediment matrices modified BCR method has been widely preferred (Quevauviller et al., 1993). The aim of this work was to understand the distribution of sedimentary Cu in estuarine mangrove sediments. An effort was also made to identify the factors that control Cu speciation and its mobility.

This paper is organized as follows. In Section 2, we describe the methods used for fractionation of Cu. Section 3 briefly summarizes Copper distribution using BCR technique using samples collected from the Zuari estuary in Goa, central west coast of India. Section 4 concludes this paper.

METHODOLOGY

The community Bureau of Reference of the European Commission (BCR) recommended sequential extraction protocol, further modified by Rauret et al (1999). It was used to determine the geochemical fractions of metals in the sediments. The modified protocol has been extensively described by Chakraborty et al (2015). An additional step with water (Fr-1) was added to extract the water soluble Cu complexes, which represents the bioavailable Cu fraction.

The sediment samples were collected from four stations in the mangrove forests in Sancole in the Zuari estuary, a monsoonal estuary located in the state of Goa, central west coast of India. The sediments were collected using grabs from a boat stationed at Sancole, about 5 km upstream of the mouth of the Zuari estuary. The samples were collected at low tide during August 2015.

The hosting phases of sedimentary Cu can be categorized into two groups. First, Cu in residual phase (Fr-5; where Cu is present within the structure of the sediment and is considered as an inert, immobile phase of Cu). The second phase is Cu in non-residual phase (which includes water soluble Cu-complexes (Fr-1), carbonate/bicarbonate binding phase (Fr-2), reducing phase (Fr-3) and oxidizing phase (Fr-4)).

Cu from residual fraction and sedimentary Cu concentrations determined by the complete digestion of 0.05 g of sediments samples with 15 mL of acid mixtures (Supra-pure HF: HNO3: HClO4= 7:3:1). The residue was re-dissolved in 2% supra-pure HNO3 and analyzed by a Perkin Elmer ETAAS, PinAacle 900T, Waltham, Massachusetts, USA. MAG-1, a certified reference material, (United States Geological Survey, Virginia, USA) was used. The sedimentary total carbon (TC) and total nitrogen (TN) content were determined by using Flash 2000 CHN elemental analyzer. Soil NC (CRM, UK) was used as certified reference material. Total inorganic carbon (TIC) was determined by UIC coulometer.

RESULTS

Figure 1 shows the distribution of Cu in different binding phases in mangrove sediments. Concentration of total Cu was found to be high in all the four stations ranging from 63.7±0.5 to 77.9±0.9 mg. kg^{-1}. It was found that about 85-90% of total Cu was present in the residual fraction. The concentration of residual Cu was found to be close to the concentration of the adjacent source rocks Quartz-sericite schist, phyllite with banded iron formations, Granite gneiss, metabasalts, metasediments and Quartz-chlorite-biotite schists (Dessai et al. 2009)

Highest concentrations of the non-residual Cu were found to be associated with sedimentary organic matter (Fr-4) followed by reducible phase (Fe-Mn oxyhydroxide binding phase) (Fr-3) and exchangeable and $CO3^{2-}$/$HCO3^{-}$ forms of Cu (Fr-2). Figure 1 also shows that there isn't any noticeable variation in this distribution between samples collected from the four stations.

Cu has been reported to form thermodynamically as very stable complexes with sedimentary organic matter in sediment (Chakraborty et al., 2016a). There was a significant relation between the total Cu and sedimentary organic matter (SOM) concentration with an R^2 value 0.64 (see Figure 2b). The accumulation of Cu in the sediment was found to increase with increasing SOM in the sediments (Figure 2b). The lowest fraction of the sedimentary Cu was present in the form of water soluble Cu-

complexes (Fr-1). This fraction of Cu is expected to be a direct representative of bioavailable fraction of Cu. It is important to understand the impact of other factors that may change the speciation and distribution of Cu in the estuarine sediments. Thus, further study should be carried out to recognize the impact of varying physicochemical parameters of overlying water on mobility and transformation of Cu-sediment complexes in a mangrove system. This preliminary study showed that sedimentary organic matter plays key role in controlling speciation and bioavailability of sedimentary Cu.

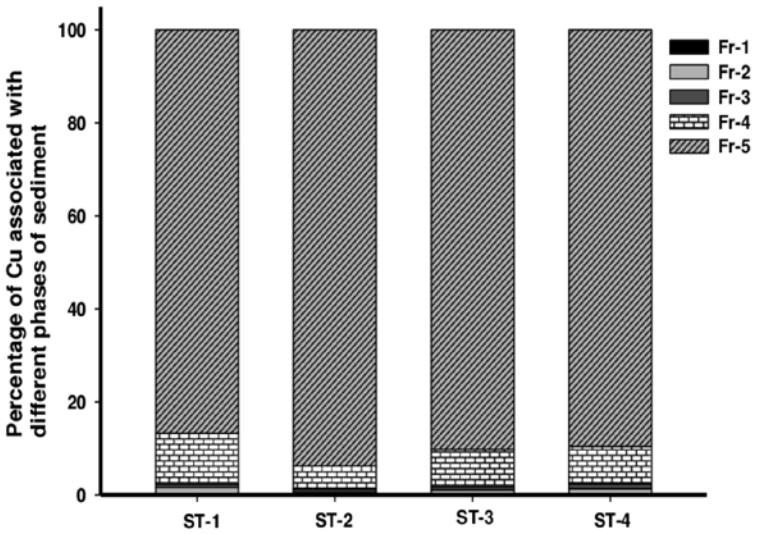

Figure 1. Distribution of Cu associated with different phases.

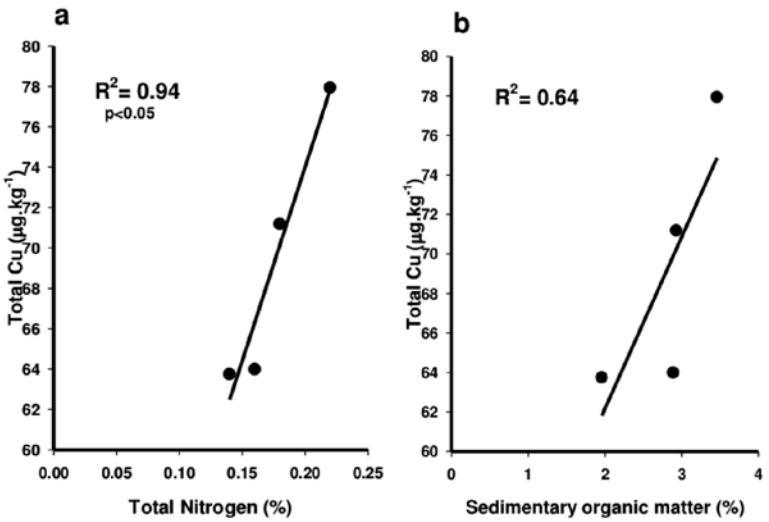

Figure 2. Variation of total Cu with (a) total nitrogen and (b) Sedimentary organic matter.

CONCLUSIONS

This study revealed that major fraction of the total Cu was present within the structure of the sediments. Sedimentary Cu showed very strong affinity for sedimentary organic matter. The sedimentary organic matter was found to control the bioavailability and mobility of Cu in estuarine sediment. Further investigation has been planned to understand the influences of different biogeochemical parameters (pH, salinity, DOC) on Cu speciation and its bioavailability in the system.

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REFERENCES

Chakraborty, P., Chakraborty, S., Jayachandran, S., Madan, R., Sarkar, A., Linsy, P. and Nath, B.N. 2016a. Effects of bottom water dissolved oxygen variability on copper and lead fractionation in the sediments across the oxygen minimum zone, western continental margin of India. Science of the total environment, v.566, pp:1052-1061.

Chakraborty, P., Jayachandran, S., Babu, P.V. R., Karri, S., Tyadi, P, Yao, K. M., Sharma, B. M. 2012. Intra-annual variations of arsenic totals and species in tropical estuary surface sediments. Chemical Geology, 322-323, 172-180.

Chakraborty, P.; Mason, R.P.; Jayachandran, S.; Vudamala, K.; Armoury, K.; Sarkar, Arindam; Chakraborty, S.; Bardhan, P.; Naik, R. 2016b. Effects of bottom water oxygen concentrations on mercury distribution and speciation in sediments below the oxygen minimum zone of the Arabian Sea. Marine Chemistry, 186; 2016; 24-32.

Chakraborty, P., Ramteke, D., Chakraborty, S, (2015b). Geochemical partitioning of Cu and Ni in mangrove sediments: Relationships with their bioavailability. Marine Pollution Bulletin, 93(1-2); 2015; 194-201.

Chakraborty , P., Sarkar, A., Vudamala, K., Naik, R., Nath, B. N, (2015a). Organic matter — A key factor in controlling mercury distribution in estuarine sediment. Marine Chemistry 173, 302–309.

Dessai, D.V.G., Nayak, G. N, (2009) Distribution and speciation of selected metals in surface sediments, from the tropical Zuari estuary, central west coast of India. Environmental Monitoring and Assessment. 158:117–137.

Quevauviller, P., Rauret, G., Griepink, B, (1993). Single and sequential extraction in sediments and soils. International Journal of Environmental Analytical Chemistry 51, 231–235.

Rauret, G., Lopez-Sanchez, J.F., Sahuquillo, A., Rubio, R., Davidson, C., Ure, A., Quevauviller, P, (1999). Improvement of the BCR three step sequential extraction procedure prior to the certification of new sediment and soil reference materials. Journal of Environmental Monitoring. 1:57-61.

PROBING CHEMICAL HETEROGENEITY OF THE MANTLE USING OPEN SYSTEM ISOTOPIC MODELS OF THE SILICATE EARTH

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The layering and convection within the Earth's mantle plays a major role in the formation of continental crust as well as tectonic activities and the heat budget of the Earth. The mode of mantle convection (whole versus layered) is still debatable despite concerted geophysical and geochemical studies for the past several decades. This study is an exhaustive numerical approach to develop an open system geochemical model for the Earth comprising bulk continental crust (CC), depleted upper mantle (UM)–source of mid–ocean ridge basalts (MORB),a lower non-chondritic mantle (LM)–source of ocean island basalts (OIB), and an isolated reservoir (IR). The model is solved numerically using fourth-order Runge-Kutta method at 1 Ma time step over the age of the Earth, simulating the evolution of key radioactive isotope systems in terrestrial reservoirs. Coupled Rb–Sr, Sm–Nd, and U–Th–Pb isotope systematics will constrain various aspects related to the Earth's differentiation processes leading to chemical heterogeneity within the mantle. Various crustal growth scenarios (linear vs. non-linear, early vs. delayed, and continuous vs. episodic growth) and their effects on the evolution of isotope systematics in the silicate reservoirs have been evaluated. The most plausiblemodel−derived solution is the one that produces the present–day concentrations as well as isotopic ratios in the terrestrial reservoirs, constrained from published data. Modeling results suggest that a whole mantle (compositionally similar to the present–day MORB) model fails to satisfy observational constraints. However, a layered mantle model, in which the present–day UM is ~ 60% of total mantle mass and the lower mantle is non–primitive produced the required isotopic ratios and abundances in the terrestrial reservoirs. Modeling also suggests that isotopic evolution in reservoirs is strongly affected by the mode of crustal growth. It is observed that Pb paradoxes result from open system evolution, which allows large−scale mass exchange between reservoirs.

Keywords: Mantle convection, open system modeling, crustal growth pattern, Pb paradox.

INTRODUCTION

Several geochemical approaches have been adopted to study layering and convection in the mantle, which includes mass balance models (Jacobsen and Wasserburg, 1981; Turcotte et al., 2001), open system evolution models consisting both forward transport modeling and inverse approach (e.g., Kramers and Tolstikhin, 1997; Allègre et al., 1983; Paul et al., 2002; Kellogg et al., 2002 and 2007) .This study presents a four–reservoir open system evolutionmodel of the Earth comprising a bulk continental crust (CC), a depleted upper mantle (UM) that is source of mid– Ocean ridge basalts (MORB), an enriched lower mantle (LM) that is source of plume– derived ocean island basalts (OIB), and a highly–enriched isolated reservoir (IR) at the base of the mantle where majority of the subducted lithospheric material is stored. The term "depleted and enriched" are used with reference to highly incompatible trace elements. Incorporating Rb–Sr, Sm–Nd, Lu-Hfand U–Th–Pb isotope systematics, isotopic evolution in terrestrial reservoirs is numerically simulated with time (age of the Earth) from aninitial to its final state (t = 4.55 Ga; age of the Earth) that is constrained by the present–day compositions.

Further, the secular growth of the continental crust may have been largely affected the distribution of chemical heterogeneities within the mantle to the extent of producing chemically distinct

layers. In other words, continuous production of crust, episodic production at certain time intervals, higher growth initially followed by negligible growth etc. as well as recycling of this crustal material at different times will affect the timing of depletion of highly incompatible radioactive parents in the

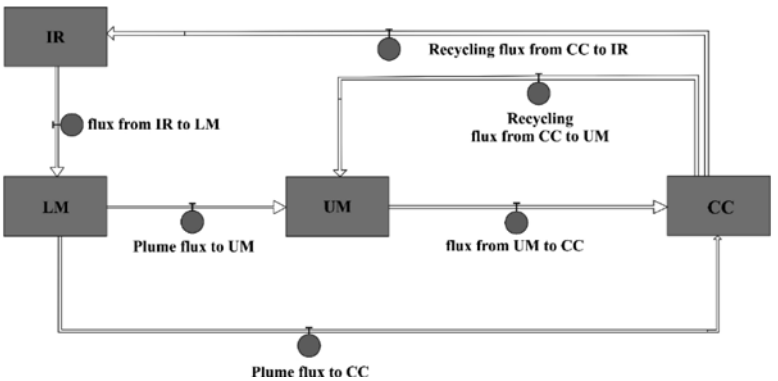

Figure 1. Open system mass transfer model considered in this study. Input and output flux to the reservoir is shown by arrows. UM– Depleted Upper Mantle; LM– Lower Mantle; CC–Bulk Continental Crust; IR−Isolated Reservoir.

mantle and consequential enrichment in the crust. This, in turn would affect the evolution of daughter isotopic compositions in the respective reservoirs. Therefore, growth of continental crust with time should be an important constraint in open system models. One of the key goals of this study is to understand the means and to quantify the mass transfer processes between different portions of the earth through the geologic time in an open system isotope evolution model.

METHODOLOGY

In our model (schematics shown in Figure 1), the continental crust grows at the expense of magmatic fluxes from both the upper and lower mantle. Also the mass of UM is a function of input fluxes such as plume flux from LM, recycling flux from CC and the output flux from UM to the CC. Similarly, LM mass grows due to incoming flux from CC that is stored in the IR reservoir at first and then slowly mixed with the LM after a transit time of about one billion years. LM also contributes to the growth of UM and CC in the form of rising plume.

Mathematically, the rate of change of mass of the continental crust can be expressed as

$$\frac{dM_{CC}}{dt} = F_{LM\rightarrow CC} + F_{UM\rightarrow CC} - F^{R}_{CC\rightarrow D\ layer} - F^{R}_{CC\rightarrow UM}$$
$$= c_1 e^{\lambda(b-t)} f_{LM} + c_1 e^{\lambda(b-t)}(1-f_{LM}) - c_2 M_C e^{\lambda(b-t)} f_C - c_2 M_C e^{\lambda(b-t)}(1-f_C) \quad \text{(Eq. 1)}$$

where b and λ are constants and M_{CC} refers to the mass of the continental crust. Initially, $t = 0$, and for the present–day $t = b$, where b represents the age of the Earth. The parameters c_2 are adjusted in different scenarios such that the model must yield present–day mass of the continental crust (M_{CO}); c_1 is a function of c_2. The parameter λ is scaled according to the radiogenic heat generation in the mantle, which is directly proportional to the concentration of heat producing elements (HPE: U, Th and K) in the mantle. f_{LM} and f_C are fractional contributions of LM to the crust and crust to the LM (through IR), respectively. Hence, $1–f_{LM}$ is the fractional contribution of UM to the crust and $1–f_C$is the fractional contribution of crust to UM. The first two terms on the R.H.S of equation (1) are additive as they are the growth terms (magmatic fluxes from LM and UM to the crust), whereas the other two terms are subtractive as it represents the recycling fluxes from crust to LM and UM.The rate

of change of total amount i.e. moles of isotopic species in each reservoir can be specified in a very similar manner as that of the mass transfer. For a given species i (e.g., ^{87}Sr), the flux from reservoir a to reservoir b (F^i_{ab}), is a function of the mass flux $F_{a\rightarrow b}$, the concentration of i in reservoir a, and the mean enrichment factor for that species/element during the transfer between the reservoirs. Note that the mean enrichment factor essentially controls the extent of enrichment of the incompatible trace element in the crust, and is a variable parameter in our model.

The initial state of the model is assumed to be of homogeneous chondritic composition, which further differentiated into crust and mantle reservoirs. A set of differential equations fully constraining

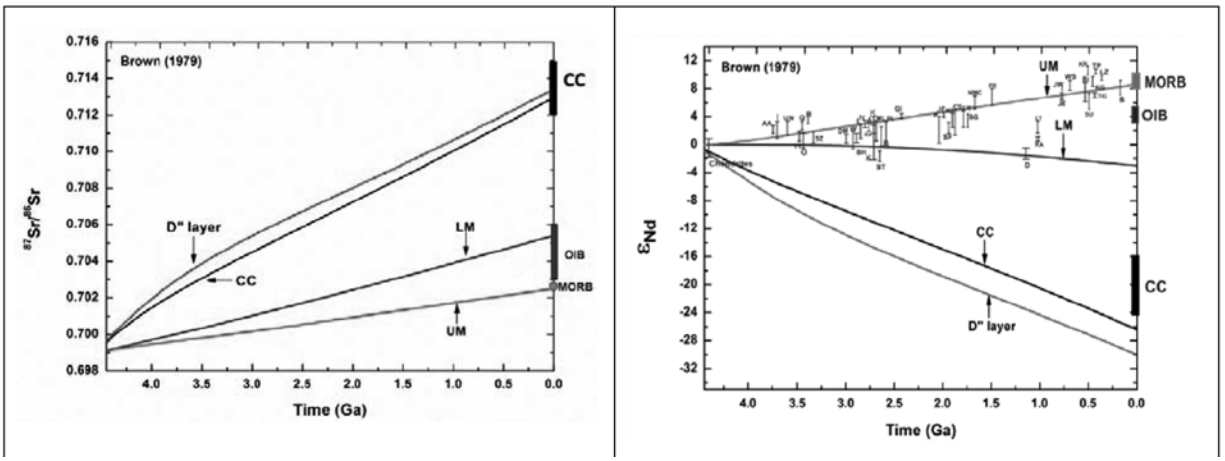

Figure 2. Evolution of Sr and Nd isotopic composition in terrestrial reservoirs in case of the exponential crustal growth model. The model–derived ε_{Nd} evolution pattern in UM is compared with the available initial ε_{Nd} values in mantle–derived products of known age, such as komatiites, other volcanics, granites and ophiolites, compiled by Galer et al. (1989).

the Rb–Sr, Sm–Nd, U–Th–Pb isotope systems are solved repeatedly using Runge–Kutta numerical algorithm over the age of the Earth at 1 Ma time steps.

DISCUSSION AND CONCLUSIONS

The geochemical modeling explores how different continental crust extraction models (continuous versus episodic and early versus late and concave upward versus concave downward growths) modify the geochemical evolution of the silicate reservoirs. The objective was to reproduce the present–day isotopic ratios in the UM and crust (shown in Figure 2 as vertical bars in the right-hand side Y-axis), which are well–constrained values from global data bases. Our modeling results strongly favor exponential crustal growth (Brown, 1979). The temporal evolution of $^{87}Sr/^{86}Sr$ and Nd isotopic ratios (ε_{Nd}), respectively are shown in Figure 2 for the exponential crustal growth case.

The failure of other crustal growth models (not shown here) in reproducing the present–day isotopic compositions in the CC and mantle reservoirs suggests that neither the production of the entire crust within the first 1 Ga nor the rapid growth in a single event where ~80% of crust formed by the end of Archean within 700 Ma period, are viable scenarios. Particularly, concave upward crustal growth models in which ~50% of crust was formed in the past 1 Ga failed to satisfy isotopic constraints. The simulations show it is possible to resolve the Pb paradox in an evolutionary model that also matches mass balance constraints. This study represents an important effort to better constrain the chemical and geodynamic evolution of the silicate Earth.

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REFERENCES

Allègre, C.J., Hart, S.R., Minster J.-F.(1983) Chemical structure and evolution of the mantle and continents determined by inversion of Nd and Sr isotopic data, II.Numerical experiments and discussion, *Earth and Planetary Science Letters,* 66, 191-213.

Brown, G.C. (1979) The changing pattern of batholith emplacement during earth history, *In: Atherton, M.P., Tarney, J. (Eds.), Origin of Granite Batholiths.Shiva, Nantwich, UK*, pp. 106–115.

Galer, S.J.G., Goldstein, S.L., O'Nions, R.K. (1989) Limits on chemical convective isolation in the Earth's interior, *Chemical Geology*, 75, 257–290.

Jacobsen, S.B., Wasserburg, G.J. (1981) Transport models for crust and mantle evolution, *Tectonophysics,* 75, 163–179.

Kellogg, J.B., Jacobsen, S.B., O'Connell, R.J. (2002) Modeling the distribution of isotopic ratios in geochemical reservoirs, *Earth and Planetary Science Letters* 204, 183–202.

Kellogg, J.B., Jacobsen, S.B., O'Connell, R.J. (2007) Modeling lead isotopic heterogeneity in mid–ocean ridge basalts, *Earth and Planetary science Letters*,262, 328–342.

Kramers, J.D., Tolstikhin, I.N. (1997) Two terrestrial lead isotope paradoxes, forward transport modelling, core formation and the history of the continental crust, *Chemical Geology* 139, 75–110.

Paul, D., White, W.M., Turcotte, D.L. (2002) Modelling the isotopic evolution of the Earth, *Phil. Trans. Royal Society London.,* 360, 2433–2474.

Turcotte, D.L., Paul, D. White, W.M., (2001) Thorium–uranium systematics require layered mantle convection, *Journal of Geophysical Research,* 106, No. B3,4265–4276.

ESTIMATION OF SOURCE PARAMETERS FOR SMALL EARTHQUAKES IN THE KACHCHH REGION OF GUJARAT, USING SEISAN.

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The estimation of the source parameters plays a vital role in understanding the characteristics of the ground rupture process at the source.

The recorded ground motions carry important information about the source parameters, which may be used for modeling of the source and thus used for seismic hazard estimation. The estimation of the source parameters helps in understanding the complexities involves in rapture process at the sources.

Kachchh rift basin is one of the three major rift basin in the western margin of the Indian craton and is bounded by the ENE-WSW trending Nagar Parker fault to the north and the North Kathiwar fault to the south. Available first-motion fault –plane solution and MT solution indicates that the kachchh seismic zone predominantly shows reverse faulting, but strike-slip faulting.

Calculation of Earthquake Source Parameters has been worked out using good quality broadband Seismograms from 50 small Earthquake(3.0- 4.9) in the Kachchh region of Gujarat. The 538 spectra of P and S waves have been analyzed for this purpose.Seismic moment, Stress drop, Corner frequency, radius of rapture, moment magnitude are calculated .

The average ratio of P/S wave corner frequency is found to be 1.1298 suggestive of higher corner frequency for P wave as compared to that for S wave.

The Seismic moments estimated from P-wave , Mo(P) ranges from 1.58489E10+13Nm to 5.01187E10+15 Nm and those from S wave, Mo(s) range from 6.30957E10+12 Nm to 6.30957E10+15 Nm. Average ratio, Mo(P)/Mo(S) of 1.011. The source radii are between 0.16km and 0.45 km. From this calculation we found anomalous behavior of small earthquake in the Kachchh region. The parameters thus estimated can be used further for modeling and simulation of the earthquake.

LITHOSPHERICELECTRICAL CONDUCTIVITY STRUCTURE IN THE DHARWAR CRATON AND SOUTHERN GRANULITE TERRAIN

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The crustal and the upper mantle lithospheric electrical conductivity structure of the Dharwar Craton (DC) and Southern Granulite Terrain (SGT) is evaluated by using the magnetotelluric (MT) data. The profile length is about 750 km covered by about 60 stations from Belgaum in the North (Deccan Trap covered region)to Palani in the South (in Madurai Block). The MT transfer functions are obtained byrobust time series processing techniques of the acquired data. Regional strike analysis is carried out using multi station-multi frequency methods. 2D modelling is carried out using Nonlinear Conjugate Gradient scheme. 3D inversionis carried out using the data space Occam's inversion code. The 3D model grid size is 78 X 60 X 40 blocks.The final RMS of the model is 2.70.

Major results from our 2-D and 3-D models are: electrical classification of crustal structure in Dharwar Craton shows essentially a highly resistive (>10,000ohm-m) upper crustal layer overlying a moderately resistive (a few hundred ohm-m) lower crustal layer which in turn is underlain by the upper mantle.The model also brings out six major conductivityfeatures in the Dharwar Craton and SGT. Some of these cut transversely the crustal column reaching the upper mantle depths. The electrical characteristics of the conductors and their close spatial correlation with two of the major structural elements, viz., Chitradurga Shear Zone and Palghat Cauvery Suture Zone suggest that these conductive featuresare closely linked to the subduction-collision tectonic processes in the region. Finally, it is inferred that the minimum estimated thickness of the lithosphere in the Archean Dharwar Cratonis 200 kmindicating "Cratonic Keel" is still preserved in this region.

Keywords: Magnetotellurics, Dharwar Craton, Southern Granulite Terrain,Electrical Conductivity,Lithosphere, Cratonic Keel

NON-TECTONIC DEFORMATION IN THE NW HIMALAYA USING SPACE BASED OBSERVATIONS

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Himalayan belt is rapidly deforming plate boundary zone between India and Eurasia and consist complex tectonics. Past studies on space based measurements confirm the presence of non-tectonic deformation in the Himalaya. Non-tectonic deformation in the Himalaya appears due to the anthropogenic activity, movement of bed rock, redistribution of mass in the continent, ocean and earth's atmosphere, etc. Mass redistribution in the Himalaya generally show annual periodicity and thus known as seasonal variation.

Non-tectonic deformation can modulate the stress conditions on the Main Himalaya Thrust and therefore a quantitative analysis of different processes responsible for non-tectonic deformation is required. We have derived the non-tectonic deformation in the NW Himalaya based on continuous GPS measurements and used the mass redistribution models for the quantitative analysis of the surface deformation caused by continental water loading, atmospheric pressure loading and non-tidal ocean loading. Seasonal variation in the displacement components derived from GPS measurements and mass redistribution models suggest that the seasonal variation in the NW Himalaya is mainly due to the hydrological loading and atmospheric pressure loading. We have identified two future potential landslide zones in Garhwal Himalaya (Phata, Guptkashi and Raithal, Uttarkashi) based on GPS and InSAR observations. We have observed strong seasonal variation at GPS site Kunair, Chamba, situated near to Tehri dam, and estimated the elastic deformation at site due to loading and unloading of Tehri reservoir.

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