INDIAN GEOPHYSICAL UNION

58th Annual Convention

on

Recent Advances in Earth Sciences with Special Emphasis - Natural Hazards

2-4, February, 2022 (Virtual)

Organized Jointly by

Indian Geophysical Union (IGU)

&

North-Eastren Hill University (NEHU), Shillong

at

CSIR - National Institute of Oceanography

(a constituent laboratory of the Council of Scientific & Industrial Research)

Established in 1966, CSIR - National Institute of Oceanography (NIO) is a premier oceanographic research organisation in the Indian Ocean region. This distinction has been gained over almost five decades of experience on the seas - as far south as the Antarctica, east as Australia and west as the Caribbean.

Mission : *"to continuously improve our understanding of the seas around us and to translate this knowledge to benefit all"*

Research Themes

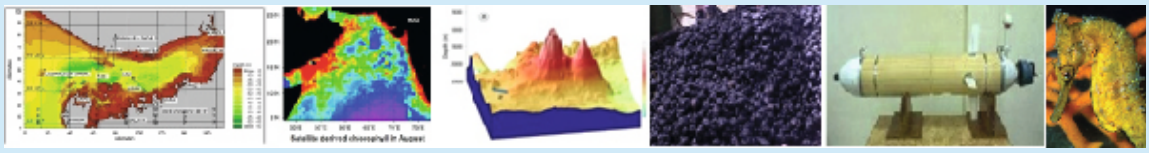
- Ocean processes
- Marine biodiversity
- Marine ecology
- Marine biotechnology
- Human imprint on Aquatic environment
- Marine minerals
- Energy from the ocean
- Seafloor tectonism
- Reconstructing the past
- Marine instrumentation
- Marine archaeology

Services Offered

- Studies related to coastal zone management
- Delineation of Coastal Regulation Zone
- Environmental impact assessment and monitoring
- Numerical modelling of meteorological and oceanographic data
- Oil spill prediction and risk analysis
- Oceanographic design parameters for marine facilities
- Underwater inspection and videography

Infrastructure

- Three Regional Centres
  - Mumbai, Kochi, Visakhapatnam
- 500+ scientific & technical staff
- State of the art analytical facilities
- National Information Centre for Marine Sciences (Library)
- National Oceanographic Data Centre
- AcSIR School of Oceanography
- Research Vessels
  - RV *Sindhu Sankalp*
  - RV *Sindhu Sadhana*



Environment | Processes | Tectonics | Resources | Instrumentation | Biotechnology

CSIR - National Institute of Oceanography

Head Office: Dona Paula, Goa - 403 004, India

Phone : 91(0)832-2450 450 Fax : 91(0)832-2450 602/03
e-mail : director@nio.org
URL : http://www.nio.org

CSIR-NIO

Regional centres

- **Mumbai**
  Phones : 022-26359605 (4 lines)
  Fax : 022-26364627
  e-mail : cmohan@nio.org
- **Kochi**
  Phones : 0484-2390814 (7 lines)
  Fax : 0484-2390618
  e-mail : dineshku@nio.org
- **Visakhapatnam**
  Phones : 0891-2784569, 2539180
  Fax : 0891-2543595
  e-mail : gpsmurty@nio.org

ABSTRACTS

58th Annual Convention of IGU

On

"Recent Advances in Earth Sciences with Special Emphasis –Natural Hazards"

2-4, February, 2022

Venue:

North-Eastren Hill University (NEHU), Shillong

Sponsored by

Ministry of Earth Sciences (MoES)

Indian National Centre for Ocean Information Services (INCOIS-ESSO)

National Centre for Earth Science Studies (NCESS)

CSIR-National Geophysical Research Institute (CSIR-NGRI)

CSIR-National Institute of Oceanography (CSIR-NIO)

February, 2022

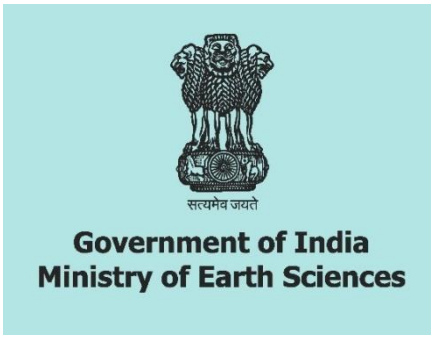
Price: Rs. 1000/-

For Copies

Write to:
Hon. Secretary
Indian Geophysical Union
NGRI Campus, Uppal Road
Hyderabad - 500 007
India

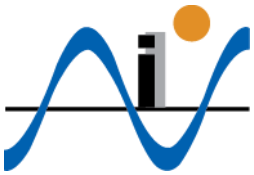
Edited By:
Dr. ASSSRS Prasad, CSIR-NGRI
Mr. Mohammed Rafique, CSIR-NGRI

Printed by:
K V Xerox
Habsiguda, Hyderabad - 500007 India
Tel : (O) 27175019
email: kvdigiprinting@gmail.com



MoES

NCESS

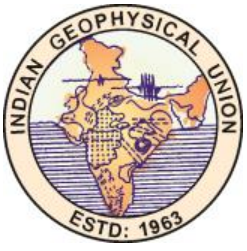


CSIR-NIO

CSIR-NGRI

INCOIS

NEHU



IGU

Dr. Shailesh Nayak
Director, Natl. Inst. Of Adv. Studies
IISC Campus, Bengalore – 560 112

President
Indian Geophysical Union
CSIR-NGRI Campus,
Uppal Road, Hyderabad-500 007

MESSAGE

The 58th Annual Convention on "Recent Advances in Earth Sciences with Special Emphasis on Natural Hazards" jointly organized by the Indian Geophysical Union (IGU) and North-Eastern Hill University (NEHU), Shillong, is being organized virtually during February 2-4, 2022. The focus of the current convention has been on natural hazards such as floods and droughts, cyclones and storms, tsunamis, earthquakes, and landslides, etc. as they affect well-being of people as well as economy of a country. The response to such extreme events depends on the quality of knowledge about hazard, expertise of the organization who is mandated to respond to such an event and hazard consciousness of the communities affected. The development of effective forecasting and early warning system for most hazards during last two decades has certainly helped to provide resilience to communities. However, in absence of responsive social system in many regions, has led to disasters, and resulting in loss of lives and livelihood. The changing climate is likely to further enhance frequency, intensity, spatial extent, duration, and timing of some of the extreme events. The importance of educating people about hazards and their likely impact is equally critical in developing an effective mechanism for addressing hazards. Collaboration with neighbouring countries to build observational systems, data standards and exchange, prediction system, networking of required services and preparing human communities is equally important. Communicating the information about impending danger about hazard to all stakeholders in a timely manner is crucial. In summary, effective resilience to hazards depends on integrating all the three systems, global or earth system with social and human systems. I am sure this Convention will provide a platform to researchers and students to discuss about many aspects of hazards. I wish all success to the Convention.

(Shailesh Nayak)

पूर्वोत्तर पर्वतीय विश्वविद्यालय
पू० प० विवि० परिसर, शिलांग-७९३०२२ (मेघालय)
North-Eastern Hill University
NEHU Campus, Shillong - 793 022 (Meghalaya)

Tele: 0364-2721150 (O): 9436163641 (Cell) email: drdeveshwalia@gmail.com

Dr. Devesh Walia
Professor & Head
Department of Geology, NEHU

Message

The Indian Geophysical Union (IGU) with headquarter at NGRI Hyderabad, a 58-year-old union engaged in the service to better understand societal problems and finding feasible solution, with discussion on current topics and recent phenomena required for development of society.

IGU to promote and encourage young researchers in improving their research capabilities and widen their knowledge under the guidance of eminent scientists to make use of their vast experience in the field of Geophysics, and to continue to serve the Earth Scientific Community of India is jointly organizing with North-Eastern Hill University (NEHU) its 58th Annual Convention on theme *"Recent Advances in Earth Sciences with Special Emphasis –Natural Hazards"* at North-Eastern Hill University (NEHU), Shillong during 2-4, February-2022. The three-day virtual convention will cover award talks and technical sessions on various disciplines of Earth Sciences such as Solid Earth Geosciences, Marine Geosciences, Atmospheric, Planetary & Space Sciences.

NEHU welcomes the participation of all the Scientists, Academicians, Government Representatives, Research Fellows and Students. Such a platform provides an opportunity to interact, understand and create network amongst the participants.

I, on behalf of organizing committee, would invite you to participate and interact freely and learn the research outcomes in a lucid manner by the researcher himself and acquire the knowledge to understand and unravel the mysteries of Earth to find the sustainable solutions and make this Virtual Convention a success.

I would like to owe my gratitude to IGU especially Prof. Shailesh Nayak President, IGU for giving NEHU this opportunity to organize the 58th Annual Convention and would like to acknowledge Prof. Prabha Shankar Shukla, Vice Chancellor, NEHU for all support and cooperation for organizing the same.

Devesh

PROF. DEVESH WALIA
Head, Department of Geology
NEHU, Shillong-793022

PREFACE

In 1963, the Indian Geophysical Union (IGU) started with the initiation and 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 has provided a platform for dissemination of knowledge, sharing thoughts/views, interaction between post graduate students from various universities, young scientists/researchers and eminent geoscientists, understanding societal problems and finding feasible solution, and discussion on current topics and recent phenomena, which are required for development of society, and continues to serve the Earth Scientific Community of India.

Many geoscientists supported enormously for sustaining IGU and its development. We salute them for their contribution and encouragement. The motive of IGU is to encourage young researchers in improving their research capabilities and widen their knowledge in globally. IGU requested senior scientists to provide necessary guidance to the young researchers, making use of their vast experience.

As always, IGU has planned to provide a forum to present the latest work in various disciplines of Earth Sciences including Solid Earth Geosciences, Marine Geosciences, Atmospheric, Planetary & Space Sciences and *"Recent Advances in Earth Sciences with Special Emphasis – Natural Hazards"* as special theme. IGU has taken up the initiative to jointly organize its 58th Annual Convention at North-Eastern Hill University (NEHU), Shillong during 2-4, February-2022. This three-day convention (Virtual) covers award talks and there would be sessions covering different disciplines of Earth Sciences during the convention.

Besides the award lectures, around 125 research papers are expected to be present during the three-day convention. We have included 80 of them under oral presentations and 45 as poster presentations in 10 technical sessions. In general, 300 to 350 delegates participate in every year convention. More than 300, delegates expected to participate in the convention as it is on virtual mode. This would help in better interaction between eminent scientists and young researchers and students. On behalf of IGU, we request the delegates to send full papers of their presentations, for publishing the same in the Journal of IGU, after proper reviewing process.

The IGU congratulates all the medal winners viz., IGU- Hari Narain Lifetime Achievement Award, IGU-Decennial Award, IGU-Krishnan Medal, IGU-Anni Talwani Memorial Prize, IGU-Prof. K.R. Ramanathan Memorial Lecture, IGU- IGU-Electrotek and Geometrics Endowment Lecture, Anni Talwani Memorial Grant for Women Researchers and Prof. Jagdeo Singh and Dr. S. Balakrishna Memorial grant for student's participation in the annual convention. along with IGU-Prof. D. Lal best paper award, papers published in The Journal of Indian Geophysical Union six issues during 2021.

We place on record our thanks to the Local Organizing Committee Prof. Prabha Shankar Shukla, Vice Chancellor, NEHU, Chairperson, Prof. Lucy Zehol, Co-Chairperson, Prof. B. S. Mipun, Co-Chairperson, Prof. Devesh Walia, Head, Department of Geology, NEHU, Convener and Scientific Members: Prof. S. K. De, Prof. D. Paul, Prof. H. J. Syiemlieh, Dr. Shikhar Kumar, Dr. Meghali Baruah and Dr. Lamphrang Laloo for their committed involvement and help in

organizing the 58th Annual Convention. This hopefully, would ensure uninterrupted conduction of various technical sessions and better presence of delegates during the Award talks.

The Executive Committee of IGU is indebted to Prof. Shailesh Nayak, President of IGU, Prof. Harsh Gupta, Prof. V.P. Dimri, Dr. V. M. Tiwari, Dr. Kalachand Sain, Dr. R. K. Srivastava, Dr. Sunil Singh the Vice- Presidents of IGU for their unequivocal support and guidance. IGU is indebted to all the Fellows and Members of IGU and members of the executive committee for their continued support. We also thank the chairpersons for technical sessions for accepting to conduct various sessions, as per suggested schedule. Special thanks are due to Mr. Rafique Mohammad Attar, Treasurer of IGU for continued support in executing various works related to this Congress throughout the year. Finally, we wish to thank IGU office personals for their continued support in executing various works prior to and during the three-day convention.

Abhey Ram Bansal

ASSSRS Prasad

CONTENTS

ORAL PRESENTATIONS

ATMOSPHERE, SPACE AND PLANETARY GEOSCIENCES

MARINE GEOSCIENCES

SOLID EARTH SCIENCES

78. Geoelectrical structure across thermal springs in SW part of Maharashtra

    Vasu Desmukh, P.V. Vijaya Kumar, P.B.V. Subba Rao and A.K. Singh

79. Magnetic anomaly based Subsurface modelling by delaunay triangulations – A case study from Gadarwara region in M.P.

    Vishnu Kant Verma, Anand Singh

80. Impact of temperature on strength of sandstone- A case study from coal-bearing sequence of Sonhat Coalfield, India

    Vivek Singh, Chinmay Sethi, Bodhisatwa Hazra, Shailendra K Singh, Pradeep K Singh, Pramod K. Singh, and Santanu Banerjee

POSTERS PRESENTATIONS

1. Seismic hazard analysis using deterministic approach for Arunachal pradesh, India

   Pr. Daithaoreiyang

2. The coda wave attenuation characteristics for the Kutch Region, Gujarat, India

   Indu Bala, Manisha Sandhu, Santosh Kumar and Dinesh Kumar

3. Signature of Co-Seismic Ionospheric TEC disturbances associated with Mw 7.6 Peru doublet earthquakes

   E. Karthikeyan, Y. Srinivas and S. Sathishkumar

4. Estimation of Site Response using HVSR Technique for North East Region, India

   Mannat Khanna, Saurav Deep, Sakshi, and Manisha Sandhu

5. Application of Hybrid Genetic Algorithm to estimate acoustic impedance from post-stack seismic data: A case study

   S. P. Maurya, Richa, and Alok Kumar Tiwari

6. An updated, harmonized, poissionian and complete earthquake catalogue for the Gujarat region of western India

   Priyanka Chauhan, R.B.S. Yadav and Rajiv Kumar

7. Spatial variation of earthquake hazard parameters in the Himalayan Seismic belt (HSB)

   Rajiv Kumar and R.B.S. Yadav

8. Seismic Hazard Analysis of Kishanganj (India) Using Probabilistic Approach

   Rashid Shams, Mohit Agrawal and Ravindra K. Gupta

9. Joint Modelling of Horizontal-to-Vertical Spectral Ratios and Dispersion Curves for Seismic Site Characterization of Dhanbad City (India)

   Ravindra K. Gupta, Mohit Agrawal, Jay Pulliam

ATMOSPHERE, SPACE AND PLANETARY GEOSCIENCES

MARINE EARTH SCIENCES

SOLID EARTH SCIENCES

RECENT ADVANCES IN EARTH SCIENCES WITH SPECIAL EMPHASIS – NATURAL HAZARDS

SOURCE CHARACTERISTICS OF SMALL TO MODERATE EARTHQUAKES FOR THE DELHI REGION OF INDIA

Abhishek[1], Manisha Sandhu[1], Babita Sharma[2] and Dinesh Kumar[1]
1 Department of Geophysics, Kurukshetra University, Kurukshetra
2 National Center for Seismology, Ministry of Earth Sciences, New Delhi
Presenting Author: abhishekthakur2407@kuk.ac.in

The assessment of the source parameters plays an important role in understanding the mechanism of the rupture process of earthquakes. For this purpose, the locally recorded earthquake waveforms of 30 earthquakes with a magnitude range of 2.5-5.1 have been used for the source characterization of small to moderate earthquakes that have been occurred in Delhi and its adjacent area. We have estimated the various source parameters such as seismic moment, corner frequency, stress drop, radiated seismic energy, etc. We obtained comparatively less static stress drop values after the analysis of source parameters using both P- and S-waves for the region which is elaborated by the well-known 'partial stress drop model' and is in the range of 1 to 46 bars. The low-stress drop values obtained in this study are also inconsistent with the tectonic heterogeneities spread within the subsurface of the study area. The region exhibits the self-similar nature of small to moderate-size earthquakes as there is no variation of stress drop with the seismic moment. The seismic moment lies in the range of 4.05E+12 to 3.44E+15 Nm. The estimated results can be further used to estimate the scaling relation for the region as well as the crustal implications for the region. The usefulness of source characteristics and their scaling relations is very well known to seismologists as these scaling relations may be used as an input for estimating the seismic hazard of this region.

EARTHQUAKE GROUND MOTIONS GOVERNING THE DAMAGE POTENTIAL FOR NATIONAL CAPITAL REGION (NCR) OF INDIA

Babita Sharma, Himanshu Mittal, Sireesha Jaladi and O.P.Mishra
National Centre for Seismology, Ministry of Earth Sciences, New Delhi, India
Presenting Author email: babita_s@rediffmail.com

The proximity of Delhi NCR to the active Himalayan Arc along with its geographical settings is a subject of discussion to comprehend the seismic resilient capital of India. Delhi NCR, which gets affected by the far-field earthquakes from the Himalayas besides the local seismic activity. The present study is an insight to differentiate the damage potential of ground motion associated with near and far-field conditions to further see their consequences to understand the comprehensive seismic hazard of Delhi and surrounding region. We analysed strong motion data from 3 far-field and 3 near field earthquakes by computing acceleration and velocity response, which exhibit a clear distinct behavior in the form of amplification and corresponding predominant period. The comparison of estimated normalised spectral accelerations with that of the seismic design code of Bureau of Indian Standards (BIS), shows that the current Indian building design code is within the structural limits proposed for the seismic forces of long periods, however the exceeded amplitude of the normalised Spectral Acceleration far-field earthquakes may be attributed towards the damage potential for top floors of the high rise

buildings in case of far field earthquakes. On the other hand near-field earthquakes don't meet the criteria with design code of BIS at lower periods from 0.02s to 0.09s. It suggests that the structural heterogeneities within the subsurface of Delhi and surrounding region has the strong bearing in contributing the impact of seismic waves from near field earthquakes and it may be disastrous for non-engineered single storey buildings along with the falling hazards. In this way, the study region affected by the distinct seismicity patterns is important to understand the shaking behavior of the different kinds of infrastructures/buildings in case of near field and far-field earthquakes to appropriately utilize for new buildings and strengthen the existing infrastructures in Delhi and surrounding region of India.

Keywords: Delhi and surrounding region, Long Period; Short Period; Response analysis; Near field seismicity; Far-field seismicity

CHARACTERIZATION OF THE DHAULI GANGA FLOOD, UTTARAKHAND, ON 7TH FEBRUARY 2021 USING SEISMOLOGICAL DATA

Himangshu Paul[1*], N. Purnachandra Rao[1], Rajesh Rekapalli[1], D. Srinagesh[1], Michael Dietze[2] and Kristen Cook[2]

[1]Council of Scientific and Industrial Research-National Geophysical Research Institute, Hyderabad, Telangana, India

[2]GFZ German Research Center of Geosciences, Telegrafenberg, 14473 Postdam, Germany

*corresponding author: Himangshu Paul (himangshu@ngri.res.in; heman2007s@gmail.com)

On 7th February 2021, a rockslide event occurred in the Ronti glacier in the Uttarakhand Himalaya. The impact of the mass on the valley floor triggered a flash flood in the Rishi Ganga and Dhauli Ganga rivers. It has recently been observed that river flow can generate seismic waves by processes like sediment transport, breaking waves and frictional forces. Few models have also been developed recently which associate seismic signals with sediment transport and turbulent flow. Fortunately, the 7th February event occurred within a region where a network of broadband seismological stations, operated by CSIR-NGRI. This provided us an opportunity to study the entire sequence of events. This study focuses on the flood only, its location in time and space and characteristics such as water level and volume of transported sediment. We employed the amplitude source location method to track the flood. It was found that the seismic signal corresponding to the flood attenuates very rapidly. Additionally, the anthropogenic noise and site amplification are high in the same frequency range as the seismic signal due to flood. Both these factors were taken into consideration while locating the flood. The flood was found to be closest to the nearest station AUL from the event at around 5:16 am UTC and it could be tracked until 5:45 am UTC within the network. Near AUL, the flood power was found to be concentrated in the frequency range of 0.5 and 6 Hz, and power level as high as -80 dB. We employed an established empirical relation to model the seismic spectra at various frequency range to infer about the water level. In AUL, we found an average water level height of ~15 m during the event, with the peak water level reaching ~18 m for a duration of 4 minutes. The flood water gauge at Joshimath corroborate with our results.

ROLE OF SITE EFFECTS IN EARTHQUAKE EARLY WARNING ALGORITHMS FOR MAGNITUDE AND SHAKING DETERMINATION

Himanshu Mittal[1], Babita Sharma[1], Naveen Kumar[2], and O.P. Mishra[1]
[1] National Center for Seismology, Ministry of Earth Sciences, New Delhi-110003
[2] Centre for Ocean Atmospheric Science & Technology, Amity University, Jaipur
Presenting auhor: himanshumitt10@gmail.com; Himanshu.mittal@gov.in

An earthquake early warning system is considered reliable if it can predict seismic hazards in terms of various ground motion parameters at a site of interest. Different parameters are used worldwide for determining the earthquake early warning system. Out of these, two parameters namely average time period (τ_c) and the displacement amplitude from the vertical component of the P wave (P_d) are used effectively to estimate earthquake magnitude, intensity, and other parameters of destructing earthquakes. These parameters, in turn, are estimated from the initial portion of the waveform. The ground motion experienced at a particular site is influenced by various factors like source, path, and site effects. In some cases, very different ground motion is observed at two closeby sites (having the same source and path effects), which may be due to site effects. The present study aims to estimate P_d parameter for different site classes i.e. rock sites, medium soil sites, and soil sites. P_d parameter is estimated by considering different time length windows. Traditionally 3s window is used for estimation of parameters, however, sometimes 3s window may not be appropriate to estimate earthquake magnitude and shaking at a particular site.

We estimated the earthquake magnitude using different length time windows (3-10s) from P wave data for different site classes to be used in earthquake early warning systems. The earthquake magnitude is estimated based on P_d. We performed this regression using 125 earthquakes from Japan having magnitude 5<M<7.5. The results reveal that the soft sites used in magnitude estimation overestimate the magnitude as compared to rock sites or stiff soil sites.

Keywords: Earthquake early warning, P_d, τ_c, Site effects, Earthquake

REMOTE SENSING AND GIS-BASED LANDSLIDE SUSCEPTIBILITY MAPPING USING FREQUENCY RATIO METHOD IN SIKKIM HIMALAYAN

Irjesh Sonker, Jayant N. Tripathi[1,2], Swarnim
[1]Department of Earth and Planetary Sciences, University of Allahabad, Prayagraj-211002, India
[2]Centre of Disaster Management, University of Allahabad, Prayagraj-211002, India
irjeshsonker12@gmail.com, jntripathi@gmail.com, swarnimmaurya1@gmail.com

The current study aims to identify landslide susceptibility map for Sikkim Himalaya, India, utilizing an integrated methodology of geographic information system (GIS), remote sensing, and frequency ratio (FR) method. Identification of landslide susceptibility, in the region, has used multiple datasets as Rainfall, Lithology, Distance to faults, Distance to drainage, Geomorphology, Slope, Soil, Stream Transport Index, Topographic wetness index, Stream power index (SPI), Relative relief, NDVI, and LULC. All the above-mentioned factors/thematic layers were generated using remotely sensed as well as

ground data in Arc GIS software. Weights of these thematic layers were calculated using FR for the occurrence of landslides in the area. All thematic maps were integrated with Arc GIS software to generate landslide susceptibility map. The landslide susceptibility map in the study area was classified as 'Very High', 'High', 'Moderate', 'Low', and 'Very Low', respectively. The accuracy assessment of the study area was done in Area Under the Curve (AUC) technique based on the FR model and landslide inventory locations. The findings of this research may be valuable in determining landslide-prone areas

REESTIMATES OF SOURCE LOCATION OF THE 1803 GARHWAL EARTHQUAKE AND ITS TECTONIC IMPLICATIONS

Kapil Mohan*, Babita Sharma and O.P. Mishra
National Center for Seismology, Ministry of Earth Sciences, Lodi Road, New Delhi-110003
Presenting author: kapil.mohan12@gov.in, kapil_geo@yahoo.co.in

The earthquake that occurred on 1st September 1803 was significant for the entire Indo Gangetic Plain as it was felt in the plains from Punjab in the North to Kolkata in eastern India. Based on losses incurred due to this event, two different epicentral areas (Garhwal region and Mathura) were proposed initially. Looking into the damage to high-rise structures like Qutub Minar, Delhi, the Garhwal Himalaya was recognized as the source zone of this earthquake. Based on seismic intensities estimated from past literature, paleoseismological investigations and strain budget, a total of eight different epicenters (e.g. in the vicinity of the epicenter of the 1991 Uttarkashi earthquake, near Nainital, near Srinagar as well as in the higher Himalaya), seven magnitudes (from M7.3 to M8.1) with different rupture propagation directions (NW to SW, towards south, etc.) were proposed for the 1803 Garhwal earthquake by different researchers. We conducted strong ground motion simulation to ascertain the magnitude and location of the epicenter of the 1803 Garhwal earthquake by considering all available epicenters/causative sources with reference to rupture propagations. It is observed that the estimated strong ground motion (peak ground accelerations (PGAs) and the response spectra) have a correlation with the incurred damage for the epicentral location about 7 to 10 km SW of the Uttarkashi earthquake with a magnitude of M7.3 to 7.7 for the 1803 Garhwal earthquake as the plausible location (Latitude 30.65^{O}N and Longitude 78.78^{O}E).

APPLICATION OF CROSSHOLE SEISMIC TECHNIQUE AND MASW FOR DYNAMIC SOIL AND ROCK PROPERTIES FOR EARTHQUAKE DESIGN ANALYSES FOR STRUCTURES, LIQUEFACTION POTENTIAL STUDIES, SITE DEVELOPMENT, AND DYNAMIC MACHINE FOUNDATION DESIGN.

Kolipaka Venu and Ram Raj Mathur
Department of Geophysics, Osmania University, Hyderabad, Telangana
venugeophysics@gmail.com

Crosshole Seismic investigations are performed to provide information on dynamic soil and rock properties for earthquake design analyses for structures, liquefaction potential studies, site development, and dynamic machine foundation design. The investigation determines shear and compressional wave

depth versus velocity profiles. Other parameters, such as Poisson's ratios and moduli, can be easily determined from the measured shear and compressional wave velocities. In addition, the material damping can be determined from Crosshole Seismic tests. The Crosshole Seismic method is a downhole method for the determination of material properties of soil and rock. A source capable of generating shear and compressional waves is lowered in one of the boreholes, and a pair of matching three component geophone receivers are lowered to the same depth in two additional boreholes set at evenly spaced increments (typically 10 and 20 feet from the source borehole) in a line, as shown in in the figure above. The receivers are positioned on the side of the borehole casing to allow detection of the passage of shear and compressional waves.

Shear-wave velocity (Vs) information of subsurface materials is directly related to the stiffness property of the materials, which is the key property dealt in all geotechnical engineering projects. In this sense, the MASW (Multichannel Analysis of Surface Waves) method can be applied to any geotechnical engineering project that requires subsurface mapping of the stiffness in 1-D, 2-D, and 3-D formats. The most common type of application has been the soil-bedrock mapping that delineates topographic boundary between soil and bedrock by an interface of significant velocity (Vs) increase (e.g., from 300 m/sec to 1000 m/sec). It also shows vertical and horizontal variation of soil stiffness by displaying velocity (Vs) variations within the soil range (e.g., 100 m/sec - 300 m/sec). This boundary often shows a gradual change in velocity over a certain depth range rather than a sharply-defined interface, indicating the possible weathered zone on top of the bedrock. More recently, applications to detect subsurface anomalies are merging. These anomalies may include localized low-velocity zones created by various reasons such as existing utility tunnels, void development due to collapse, severely weathered bedrock, loss of cohesiveness in filled materials, etc. In this case, the detection is often facilitated by non-velocity mapping approaches such as back-scattering analysis and common-offset section generation. Another type of application is the performance evaluation that is executed before and after a specific operation is applied. This includes the compaction evaluation for surface and shallow subsurface materials during road and building construction. It also includes the evaluation of grouting performance. The seismic site characterization requires an evaluation of an average shear-wave velocity (Vs) for the top 30-m (or 100-ft) depth. This is the most common 1-D (i.e., depth) application of MASW method.

In general, MASW applications can be grouped into Soil-Bedrock Mapping, Seismic Site Characterization, Anomaly Detection, Compaction Evaluation, and Grouting Evaluation

SEISMIC MONITORING – KEY TO DEVELOPMENT OF EARLY WARNING SYSTEMS FOR GEO-HAZARDS

N. Purnachandra Rao*[1], Rajesh Rekapalli[1], Kristen L. Cook[2], Michael Dietze[2], Himangshu Paul[1], D. Srinagesh[1], V. M. Tiwari[1], Niels Hovius[2]

1. CSIR-National Geophysical Research Institute, Hyderabad, Telangana, India
2. GFZ German Research Centre for Geosciences, Potsdam, Germany

* raonpc@ngri.res.in

Recent research developments indicate a tremendous potential of seismic networks for detection, location and early warning of a wide range of hazards like rockslides, landslides, debris flow, Glacial retreats, floods, etc. The 7 February 2021 catastrophic flood in the Uttarakhand Himalaya was triggered

by a rockslide, resulting in mass flow preceding flooding, resulting in a huge loss to human life and property. This calls for an urgent need for the development of a real time detection and early warning system for mitigation of a suite of hazards in the Himalayan mountain region. The dense seismic network set up by CSIR-NGRI in the Uttarakhand state of India provides a unique opportunity to analyze the detectability levels of landslide, debris flow and flood signals above the threshold noise levels. We demonstrate that a warning time of several minutes is possible with this approach at critical locations, which provides the requisite confidence for the development of a Geo-Hazard Early Warning System for the Himalayan region. This essentially necessitates the deployment of dense seismological networks and integration of the acquired data in real time with those from satellite imagery and water level measurements. An in-depth analysis of past events from the high-hazard zones and use of AI/ML techniques is the key towards developing of such a system so that useful alerts can be issued in future for the population and establishments particularly in the downstream areas.

Keywords: Rockslide, Debris flow, Seismic network, Flood, Early Warning

TRANSIENT LANDSCAPE VARIABILITY ACROSS SHILLONG PLATEAU POP-UP: CONSTRAINS FROM SURFACE PROCESS PROXIES OVER COMPETING DRAINAGE DIVIDE AND DEFORMATION PARTITIONING

Nilesh K. Jaiswara; Prabha Pandey; Anand K. Pandey
CSIR-National Geophysical Research Institute, Hyderabad 500007, India
nileshjs@ngri.res.in, ppandey@ngri.res.in, akpandey@ngri.res.in

The Shillong plateau evolved as a pop-up structure bounded by Dauki and Dapsi in the south and the auxiliary Brahmaputra-, Oldham- and Chedrang- Faults towards the north. The plateau is also laterally segmented by transverse structures, namely Kopili, Barapani, Dhudhnoi and Dhubri/Jamuna faults from east to west, with distinct landscape characteristics. The Shillong plateau substrate is constituted of Precambrian basement rock, which are exposed since ~1.5 Ma when the popup block start attaining positive topography with the erosion of sediment cover (Govin et al., 2018). Since then the Shillong plateau is evolving as a transient bedrock landscape with marked lateral variation. Landscape evolution is a function of active tectonics and erosion therefore its characterization has bearing on understanding tectonic-climate coupling. We estimated the lateral variation in surface uplift with reference to the base-levels in Bengal and Brahmaputra plains. We analyzed the asymmetric surface uplift, with the southern flank experienced twice uplift compared to the northern flank, in terms of variable rock uplift rates or variable initiation timing of the complementary crustal pop-up structure or both during Quaternary. Quantification and modelling of the transient landscape reveal the variation in active deformation across the plateau and the role of controlling structures and climate coupling, which is pronounced towards the southern flank owing to higher precipitation. The landscape modelling demonstrates that the whole plateau does not develop homogeneously as a simple “pop-up” block but evolved in three fault bounded blocks with a variable rate of deformation partitioning.

AN UPDATED PROBABILISTIC SEISMIC HAZARD (PSHA) MAPS FOR THE HIMALAYAN SEISMIC BELT

R. B. S. Yadav*[1], Rajiv Kumar[1] and A. P. Singh[2]
[1]Department of Geophysics, Kurukshetra University, Kurukshetra, India
[2]National Centre for Seismology, Ministry of Earth Sciences, New Delhi, India
*Presenting author's email: rbsykuk@gmail.com

The study deals with the preparation of an updated probabilistic seismic hazard (PSHA) maps for the Himalayan seismic belt which has been recognized as high seismic potential for the occurrences of devastating earthquakes. The region has a rich history of great damaging earthquakes such as 12 June 1897 Shillong Plateau (Mw~8.1), 4 April 1905 Kangra (Mw~7.8), 15 January 1934 Bihar/Nepal (Mw~8.2), 15 August 1950 Assam (Mw~8.6) and several other damaging earthquakes that have occurred in recent past. A homogenous and complete earthquake catalogue covering the period 825-2019 has been prepared and seismic hazard parameters (activity rate, b-value and maximum magnitude) have been estimated using the maximum likelihood method for three-layered seismogenic zones (shallow 0-25km, intermediate 25-70km and deep depth >70km). The suitable ground motion prediction equations (GMPEs) have been considered and seismic hazard has been calculated by dividing the study region into uniform grids of equal size of 0.5°x0.5°. The seismic hazard maps have been exhibited in terms of peak ground acceleration (PGA) and spectral acceleration (SA) at different structural periods of 0.2, 0.6, 1.0, 1.5 and 2.0s for 20%, 10%, 5% and 2% probability of exceedance (POE) in 50 years (i.e. 225, 475, 975 and 2475 years of return periods, respectively) for shallow, Intermediate and deep depths. It has been observed that the maximum PGA for shallow depth (0-25km) exhibits the values of 0.45g, 0.66g, 0.88g and 1.38g for 20%, 10%, 5% and 2% probability of exceedance in the next 50 years, respectively. For intermediate depth (25-70km), the PGA retains the values of 0.30g, 0.55g, 0.75g and 1.22g, respectively, and for deep depth (>70km), it achieved the values of 0.24g, 0.48g, 0.65g and 1.08g, respectively for the same probabilities of exceedance. For shallow depth (0-25km), high spectral acceleration (SA) are observed in five blocks of the Kashmir Himalaya, Garhwal-Kumaun-western Nepal Himalaya, middle Nepal, western Assam-Arunachal Himalaya and eastern Indo-Burmese arc system for all the probabilities of exceedance. Results obtained in the study has highly useful for the assessment of seismic risk associated with this region as well as it has useful implications in updating the building design code of the region for the construction of earthquake-resistant structures.

DETECTION OF THE 7th FEBRUARY 2021 UTTARAKHAND ROCKSLIDE IN THE HIMALAYAS, INDIA USING SEISMIC DATA

R. Rajesh[1], N. Purnachandra Rao[1], Himanushu Paul[1], V. Venkatesh[1], Niels Hovius[2], K.L.Cook[2] and Michael Dietze[2]

1. CSIR-National Geophysical Research Institute, Hyderabad, Telangana, India
2. GFZ German Research Centre for Geosciences, Potsdam, Germany

* rekapalli@gmail.com

Monitoring and tracking of landslides and floods using seismological networks are emerging as a new dimension of seismology for near real-time hazard mitigation and early warning. Researchers have been using spatial migration and amplitude inversion techniques to locate the landslides and to track mass flow dynamics. Unlike the polarization back-projection technique, other methods involve the crustal material properties like seismic velocity, attenuation, etc., for the estimation of location and tracking. In this study, we present the detection of the devasting Uttarakhand rockslide that occurred along the Rishiganga-Dhauliganga valley in the Chamoli district of Uttarakhand state in the Himalayan region of India on 07 February 2021 using broadband seismic data. We employ spatial migration, amplitude inversion and polarisation back-projection methods to discuss their merits and robustness for real-time monitoring. The locations estimated from the three methods match well with the location of the rock fracture observed in the satellite imagery. However, the estimated results from the polarization method provide the best match the location identified in the satellite image and are comparable with the location estimates provided from the spatial migration and amplitude inversion techniques. As the polarization back azimuth method is non-parametric, we can use this in real-time, where the inconsistencies associated with the determination of accurate velocity and attenuation factors limit the accuracy of location estimates respectively in spatial migration and amplitude inversion methods.

Key Words: Rockslide, Himalayas, Broadband seismic data, Spatial migration, Polarisation, Amplitude Source Location.

UNDERSTANDING STRONG GROUND MOTIONS IN THE INDO-GANGETIC BASIN

R K Chadha, Raja Ramanna Fellow
CSIR-National Geophysical Research Institute, Hyderabad-500 007
Email: rajen0555@gmail.com

During an earthquake ground motions are generated that affect all structures to some degree of shaking and often cause damage if the magnitude is large. The damage can be in the near field due to strong shaking in the epicentral region as well as in the far field where ground motions gets amplified due to local site conditions, especially in the presence of soft sediments. Such a phenomenon was observed during the M_w 7.7 Bhuj earthquake in 2001 in Gujarat, India where several high rise buildings suffered damages in Ahmedabad and Surat cities located more than 350 km from the epicenter of the earthquake in Bhuj. Earlier, similar observations were reported after the 1985 Michoacán earthquake off the Mexican coast which caused heavy damage to buildings in Mexico City situated more than 350 km from

the Pacific Ocean. The reason for such damage was found to be the presence of soft sediments in the Mexico City which amplified the seismic waves at local sites inducing severe shaking. Site effect as the main cause of damage has been documented during many recent earthquakes like the Northridge (1994, M_w 6.7), Kobe (1995, M_w 6.9), Loma Prieta (1999, M_w 7.0), Turkey (1999, M_w 7.4), Nepal (2015; M_w7.9) and Puebla-Morelos (2017, M_w 7.1).

The sediment filled vast Indo-Gangetic Plains (IGP), which runs parallel to the seismically active Himalayan belt presents one such scenario in India where structures, including critical ones like dams and nuclear power plants are located, can be subjected to fairly high degree of seismic hazard. Data from Central Indo-Gangetic Plains (CIGN) operated by CSIR-NGRI provided insights into the understanding of the behavior of strong ground motions generated by an earthquake in Bay of Bengal in 2014 followed by the Gorkha, Nepal earthquake in 2015. Amplifications in Peak Ground Acceleration and Peak Ground Velocity due to Bay of Bengal earthquake were observed to be of the order of 3 and 4 times, respectively. The Standard Spectral Ratios computed at a few sites on the sediments in the IGP with respect to adjacent reference hard sites reveal a broadband amplification reaching a value of about 10 at the dominant frequency. The epicenter of the Gorkha, Nepal earthquake in 2015, which was much nearer to the CIGN network broadly showed similar results. The Ground Motion Prediction Equations (GMPEs) available for subduction zone thrust earthquakes are found to grossly underestimate peak intensities in the IGP. The results of the analysis of CIGN data are discussed with the stress on the need to characterize the ground motions in the IGP in the presence of strong local site effects.

STRONG MOTION SIMULATIONS OF 2021 MIYAGI EARTHQUAKE USING MODIFIED SEMI EMPIRICAL TECHNIQUE

Sandeep[1], Sonia Devi[1*], Parveen Kumar[2], Himanshu Mittal[3], Monika[1, 2], Suraj Pal[1]

[1]Department of Geophysics, Banaras Hindu University, Varanasi

[2]Wadia Institute of Himalayan Geology, Dehradun

[3]National Centre for Seismology, MoES, India

Presenting author: *goyal.sonia012@gmail.com

Site characteristics/local geology can play crucial role in amplification/deamplification of ground motion caused by the earthquakes. Therefore, site estimation and its further inclusion in simulation can provide more realistic results. The present analysis focuses on simulation of high frequency records using modified semi empirical technique (MSET) by incorporating the site effects. This MSET has successfully modelled the 2021 Miyagi earthquake (Mw7.0) which occurred near east cost of Honshu, Japan at focal depth of 54km. The required site effects are estimated using Horizontal to Vertical (H/V) ratio method. The strong motion records are first simulated at borehole conditions and then projected onto the surface by incorporating the site effects. The high frequency records are simulated at near field seismic stations in epicentral range 25-100 km depending on good signal to noise ratio. Further, in order to check the applicability of MSET, the observed and simulated records are compared in time and frequency domain in terms of root mean square error (RMSE). Low RMSE for simulated surface records confirms the validation of MSET. The comparison confirms the effectiveness of MSET for surface conditions.

AN APPROXIMATED MODEL FOR CENTRAL DEPTH AND SOURCE LOCALIZATION OF ANISOTROPY BENEATH THE SHILLONG PLATEAU AND HIMALAYAN FOREDEEP REGION: IMPLICATION TOWARDS DEFORMATION AND MANTLE DYNAMICS

Satyapriya Biswal and Debasis D Mohanty*
Geosciences and Technology Division, Northeast Institute of Science and Technology,
Council of Scientific and Industrial Research,
Jorhat, Assam, India, 785006.
Academy of Scientific and Innovative Research (AcSIR), India.
*Correspondence: debasis@neist.res.in; devlinkan06@yahoo.com
Presenting Author: satyapriyabiswal8763@gmail.com/debasis@neist.res.in

To understand the current geodynamics and deformational mechanism of an active tectonic setting, estimation of possible depth and source localization of anisotropy plays a significant role. Though shear wave splitting measurements are used to depict the mantle dynamics and deformational mechanism behind it, the causative analysis of depth and possible source localization of anisotropy have a great advantage in deciphering the complex tectonics beneath a particular region. Based on the Fresnel zone concept, our present study uses the spatial coherency method to analyze the splitting parameters for the understanding of source of localization and depth of anisotropy beneath the Shillong plateau and Himalayan foredeep region. The method suggests a central depth of anisotropy beneath the Shillong plateau at around 100 km, which coincides with the lithosphere-asthenosphere boundary and boost our understanding that the absolute plate motion due to the asthenospheric drag at the base of Indian lithosphere controls the deformation pattern beneath the plateau. Similarly, the spatial coherency model suggestive of an asthenospheric localized source at around 150 km to be responsible for the mantle deformation patterns beneath the Himalaya foredeep regions.

Keywords: Seismic anisotropy, shear wave splitting, Shillong plateau, Himalayan foredeep, lithosphere, source localization

SURFACE RUPTURE OF THE 1897 EARTHQUAKE (MW~8.1) IN CHEDRANG VALLEY, SHILLONGPLATEAU: EVIDENCE FROM MASW, RESISTIVITY SOUNDING AND FLUVIAL GEOMORPHOLOGY

Saurabh Baruah[1*], Himanta Borgohain[2], Sangeeta Sharma[1], SantanuBaruah[1], Goutam Boruah[1] and Ranjan Kumar Sarmah[2]
[1*]CSIR-NorthEast Institute of Science and Technology, Jorhat-785006, Assam, India.
[2] Department of Applied Geology, Dibrugarh University, Dibrugarh-786004, Assam, India.
Presenting Author: saurabhb_23@yahoo.com

The great Shillong earthquake of 1897 in western part of the Shillong Massif shook the entire stretch of Northeast India, causing huge devastation both on surface and subsurface level. Numbers of land fissures, sand veins, swampy lands, tilting and upliftment of landmass formed during the earthquake in western part of Shillong plateau. In this paper we follow an integrated approach involving seismic, geophysical and fluvial geomorphology to quantify the co-seismic subsurface rupture underneath. MASW and resistivity surveys are carried out in fourteen different locations along three profiles across

Krishnai&Chedrang River in Chedrang valley. We observe massive surface rupture in some specified locations and quantify co-seismic surface through by a measure 5+1 meters on vertical planes at the western end of the rupture of the Oldham fault. The moderately low shear wave velocities along the profiles vary from 184-466 m/s infers a platform for fracture induced intense shallow seismicity triggering. Intense seismicity prevails in the region with bottom of seismogenic zone is inferred as 40 km where it is mostly dominated by thrust with strike-slip components mechanisms. Local stress pattern in Chedrang valley is NE-SW unlike regional stress pattern which is NNW-SSE indicate control of geodynamics.Fluvial-morphometric measurements of Krishnai and Chedrang River for six different stretches in each case during the year 1964, 1991 and 2014 show a westward shifting of Krishnai river which ranges from 190-269m and on the other hand the Chedrang river variably shifted around 132-312m along these stretches shows a south-westward avulsion as manifested in detail fluvial morphological mapping.At a key site, stratigraphy of fault scarp with an up-through 13ft high indicates modern channel, colluviums, gravel and pebbles beds with sand lenses refer a part of mega thrust. Simultaneously, we analyze high-resolution topographic profiles leveled using Total Station (GPS) to observe 1897 earthquake induced co-seismic surface uplifts. We suggest simplest deformation model in which most of the intra-seismic elastic loading east of Krishnai and Chedrang river got uplifted during 1897 earthquake by co-seismic and post seismic rupture mainly on western part of Shillong plateau flat beneath Chedrang valley transferring most of the energy to the N-S of Krishnai valley where Krishnai river and 'Mori'(dead) Krishnai river exists as evidenced from sub-surface deformation and subsequent avulsion of Krishnai river. These parameters will no doubt unravel the geodynamics and seismic hazard assessment of the region.

IMPLICATION OF SITE CONDITIONS ON VIBRANT GROUND SHAKING IN THE FAR-FIELD REGIONS OF 2017 M_W 5.5 RUDRAPRAYAG EARTHQUAKE

Shikha Vashisth, Ajeet P. Pandey, A.P. Singh, O.P. Mishra
National Center for Seismology, Ministry of Earth Sciences, New Delhi – 110003
shikha.vashisth92@gmail.com

The M_w 5.3 Rudraprayag earthquake of February 06, 2017 occurred in the Himalayan arc segment and it was located using broadband data with epicenter (30.467° N, 79.118° E) and focal depth of 19km. The event was located in the close proximity to the 1991 Uttarkashi (M_w 6.8) and 1999 Chamoli (M_w 6.5) earthquakes. Although the event was of moderate category, very strong ground shakings were reported in the Delhi and surrounding regions in the far-field. To understand such unusual phenomenon, various analyses were carried out using well recorded broadband and strong motion data to characterize the site conditions. The h/v spectra analysis was performed at 15 broadband seismic stations, which were located at the distance range ~ 100 – 650 km from the epicenter. The results clearly indicate that a fairly flat response for the rock/hard site in the frequency range 0.30 - 10.0 Hz constitutes a prominent sub-surface seismological signature wherein a prominent amplification observed at predominant low frequency ranges for the soil sites, signifying typical characteristics of the sites.

Estimates of ground shaking parameters (e.g., PGD, PGV, PGA), and analysis of response spectra using the recorded data at the soft and harder rock sites in and around Delhi suggest that the amplification

factor at the soft sites is approximately 2.2 times higher than that on the hard sites, which in turn indicates that the causative factor of the vibrant ground shaking in the far fields of Delhi region was principally due to the 2017 Rudraprayag moderate earthquake. Moreover, the spatial distribution of PGA for the Rudraprayag event was found poorly correlated with the available ground motion prediction equations (GMPEs) for the NW Himalaya. Our results found a good correspondence with the GMPE with that of Fukushima and Tanaka (1990), which was developed for the Japan region derived from analyses of ~1400 ground motion data having distinct spatial variation of PGA in the study region, The present results well corroborate with the results obtained using h/v spectral analysis and site to reference approach and also supported by assimilation of 1-D velocity model at each recording sites using the seismic background noise data.

Key words: Rudraprayag earthquake, h/v spectra, spectral ratio, ground shaking, PGA attenuation, seismic noise data.

ACTIVE SEISMIC ZONES AND EARTHQUAKE VULNERABILITY ASSESSMENT IN THE HIMALAYA BY MACHINE LEARNING AND FUZZY MCDM APPROACH

Sukanta Malakar, Abhishek K. Rai
Centre for Oceans, Rivers, Atmosphere and Land Sciences, Indian Institute of Technology Kharagpur West Bengal-721302
Presenting author: malakarsukanta031@iitkgp.ac.in

Himalayan mountains are one of the most seismo-tectonically active zones on the surface of the earth. Frequent moderate and high magnitude earthquakes are not uncommon in this region, making the area more earthquakes vulnerable. In this work, we use machine learning to identify spatial clusters of earthquakes, besides using multi-criteria decision-making (MCDM) models to estimate earthquake vulnerability in the Himalayan region. Seismicity data available from the ISC-EHB catalogue having more than 1100 earthquakes indicate 12 active source zones of earthquakes in the study area. The source clusters located in the eastern Himalayas are larger in areal extent than those located in the western Himalayas, which are relatively smaller. The vulnerability assessment has been done by two fuzzy MCDM models, i.e. fuzzy analytical hierarchy process (f-AHP) and fuzzy technique for order preference by similarity to ideal solution (f-TOPSIS). Twenty-six parameters were utilized to estimate earthquake vulnerability, categorized in the social, geotechnical, structural, and physical domains. The results show that more than 50% of the populations residing in the Himalayas are under very high to high threat due to earthquakes, 25.81% are moderately threatened, and 23.44% are under low to very low vulnerability. Identifying active source zones and vulnerabilities could be extremely useful for hazard mitigation and infrastructure planning agencies working in the Himalayan region.

INVESTIGATION OF PRECURSORS OF RUDHRA PRAYAG EARTHQUAKE (M = 5.1) OCCURRED ON 06 DECEMBER, 2017 BY USING GPS-TEC AND ULF DATA OBSERVED AT AGRA STATION

***Swati, and Devbrat Pundhir**
Department of Physics, Raja Balwant Singh Engineering Technical Campus, Bichpuri, Agra-283105, India
*Email: swatirbs2709@gmail.com

In this study, ULF and TEC data have been analyzed statistically at Agra (Geograph. 27.2N, 78E) and Lucknow (Geograph. 26.9N, 80.96E) stations corresponding to an earthquake of magnitude M=5.1 Rudra Prayag (Geograph. 30.64N, 79.16E) which occurred on 06 December, 2017. The search coil magnetometer ULF data at Agra station is considered for the duration of 30/11/17 to 06/12/17. The amplitude bursts are observed on different days prior to the occurrence of earthquake in the period under consideration. In order to ascertain the origin of the ULF bursts are due to earthquake only we expanded the ULF bursts and found that these bursts contained short period electromagnetic pulse of duration between the range of 09 sec and 25 sec (f = 0.04-0.11Hz). These bursts are not due to solar terrestrial geomagnetic disturbances as the variation of global magnetic indices and solar flux parameter (ΣKp, Dst, F10.7) has been examined for the same period. GPS TEC data have been analyzed by using well established statistical techniques at Agra and Lucknow stations for the period of 21/11/17 to 06/12/17. We have found the anomalous enhancements and depletions in TEC data at both the observing stations. Finally, the anomalous variations in ULF and GPS TEC data are interpreted in terms of the mechanisms available in the literature.

Keywords: ULF, GPS-TEC; Magnetic storm; Statistical techniques etc.

GPS MEASURED TSUNAMIGENIC IONOSPHERIC PERTURBATIONS AND POSSIBLE EARLY WARNING SCENARIO

Mala S. Bagiya[1*], Srinivas Nayak[1], and Surendra Sunda[2]
[1]Shillong Geophysical Research Center, Indian Institute of Geomagnetism (DST), 3½ Mile, Shillong 793005, India,
[2]Airport Authority of India, Ahmedabad 380003, India
*mala.bagiya@iigm.res.in, bagiyamala@gmail.com

Tsunamis are series of long period waves which are produced in the offshore region by abrupt displacement of a large volume of water column due to sudden disturbance in the ocean floor - mainly linked to submarine earthquakes. Rapid tracing of such natural disaster through reliable early warning and subsequent evacuation can reduce the causalities. Tsunamigenic ionospheric perturbations which travel faster than the tsunami, thus arrive at the coast earlier, were proposed to be of potential importance for tsunami early warning. This warning tool has been offered earlier by using space geodetic measurements at far field coastal regions (>700 km). Here, by studying the tsunami induced ionospheric perturbations observed in the vicinity of the 2004 Indian Ocean tsunami source we aim to assess the performance of this space-based tool to provide early warning for near field regions (<700 km). We have

formulated a geometrical model to compute the tsunami warning time at various geographical locations in view of the propagation of tsunamis and induced ionospheric perturbations. We have further characterised elementary information on effective source distance towards the reliable warnings at any nearby coastal regions. Our analysis suggests that space-based real time monitoring of offshore ionosphere holds enough potential to complement the ground based tools and thus could enhance the effectiveness of existing tsunami early warning systems.

MUONG NONG TEKTITES RESULT OF AN OBLIQUE IMPACT IN TIBET: STUDY BASED ON HALE CRATER

Mahesh Patil
Email Id: mup124@rediffmail.com

Muong –Nong and other Asian tektites are result of highly oblique impact on Indochina border. A study of oblique impact crater on Mars and a laboratory stimulation by Schultz et al. (2012) suggested that impact at an oblique angle to horizontal results not only in oblique craters but also result in high-velocity, low angle ejecta along the initial impact trajectory axis downrange. At early stage of highly oblique impact, fragments of the projectile travel down range at a speed close to initial impact velocity causing sibling impacts. In early stage of oblique impact, projectile momentum coupled to the target is preserved in high-velocity ejecta directed along trajectory axis and is localized within a narrow fan downrange. Thus downrange melt distribution of oblique impact is mix of melt from target rock and projectile fragments, spread in a narrow fan area in the down range of impact trajectory axis. We have extrapolated these findings to understand the distribution of Muong Nong (Layered tektites) and splash-form homogeneous tektites in Asia. We have used Inclusions like lithium, boron and Kyanite in Muong Nong along with other shock metamorphic evidences like high-pressure minerals to locate the possible impact location. Current study suggests a highly oblique impact in Tibet may be responsible for tektites reported from Asia.

A MACHINE LEARNING APPROACH TO ESTIMATE GEOMECHANICAL PARAMETERS FROM CORE SAMPLES

Jwngsar Brahma
Pandit Deendayal Energy University
jwngsar@gmail.com

For hydraulic fracturing design, investigation of wellbore stability and rock failure, the geomechanical and Thomsen parameters play very important roles. The main objective of this paper is to estimate the Thomsen's parameters (ε, γ, δ) and geomechanical properties, namely Young's moduli and Poisson's ratios from the core samples using Machine Learning and conduct a comparative analysis with the conventional mathematical approach; to place emphasis on the use of Machine Learning and Artificial Intelligence in the Oil & Gas industry and to highlight its future potential to help in the digital transformation of the industry. Four different rock samples were considered for this study. Two different

Machine Learning models, Ordinary Least Square method and Random Forest method, were used to predict the afore mentioned geomechanical properties from the wave velocity and confining pressure data. The results demonstrated that the approaches employed in the estimate of geomechanical properties are rapid and reliable (about 93.5 percent accuracy) and may be applied in geomechanical modelling of petroleum reservoirs on a large scale. Through this study, it has been observed that the Young's modulus and Poisson's ratio are heavily influenced by the anisotropy parameters, with this relationship being depicted through the correlation matrix generated for each rock sample. Finally, the results are compared with the results obtained from mathematical approaches. The parameters predicted by machine learning and artificial intelligence approaches are excellently matched with mathematical approaches.

Keywords: Machine Learning, Artificial Intelligence, Core Samples, Thomsen Parameter, Geomechanical.

ATMOSPHERE, SPACE AND PLANETARY GEOSCIENCES

ZTD ANOMALIES ASSOCIATED WITH VOLCANIC ERUPTION AND LARGE EARTHQUAKES: CASE STUDIES

A. Akilan*[1], S. Padhy[1,2], and H.V.S.Satyanarayana[1]
[1]CSIR-National Geophysical Research Institute, Hyderabad- 500 007
[2]Department of Earth Sciences, Indian Institute of Technology Roorkee, Roorkee-247667
*corresponding author, e-mail: akilan@ngri.res.in

Change in atmospheric conditions associated to volcanic eruptions and earthquake events is widely noticed and accepted. Here, we examine the Zenith Total Delay (ZTD) during the time of a volcanic eruption and two large earthquakes to understand anomalies in ZTD during these natural events. In the first case, perturbations in ZTD values are observed over East Antarctica, from 19th, February to 08th, March 2009, during eruption of Mt. Chaiten volcano, and showed good correlation with abnormal atmospheric black carbon (BC) content noticed over Antarctica during this period. We, therefore, suggest that the anomalous high ZTD values might have resulted from high BC influx into the atmosphere. We propose that the 19th, February 2009 massive eruption of Mt. Chaiten is the source of the BC, which moved from the volcanic front to the East Antarctica margin along with the circumpolar current. In the second case, we study ZTD changes associated with the two large Himalayan earthquakes, namely Chamoli (1999) and Nepal (2015). We analyzed the ZTD estimated from GPS data received at HYDE International GNSS Service (IGS) station. The ZTD value, which is sensitive to tropospheric weather conditions, showed a sharp drop in ZTD during and following the earthquakes. Thus, volcanic eruption and large earthquakes are the likely sources causing changes in ZTD observed.

Keywords: GPS, Zenith Total Delay, Black Carbon. IGS, Mt. Chaiten, Himalaya, and IGS.

ANNUAL CYCLE OF BLACK CARBON RADIATIVE FORCING OVER A REPRESENTATIVE CENTRAL IGP LOCATION, VARANASI

Bharat Ji Mehrotra[1], Dirgha Parashar[1,2], Vasu Singh[1], Atul K. Srivastava[3], R. S. Singh[4], Yogesh Kumar Vishwakarma[4], and Manoj K. Srivastava[1]
[1]Department of Geophysics, Banaras Hindu University, Varanasi
[2]Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi
[3]Indian Institute of Tropical Meteorology, Delhi Unit, New Delhi
[4]Department of Chemical Engineering, IIT-BHU, Varanasi
Email: mksriv@gmail.com

Black carbon aerosols (BC) are extensively studied due to their serious impact on climate system. Produced mainly by the incomplete combustion of fossil fuels, biofuels and biomass burning, BC can heat the atmosphere in its vicinity, and thus, it can change the atmospheric dynamics. The main objective of this study is to access optical and radiative impacts of BC during for a year 2009 over Varanasi, a representative site of central Indo-Gangetic Plains (IGP). Aethalometer was used to measure the mass concentrations of BC and the aerosol optical and radiative transfer models were used to compute aerosol radiative forcing caused specifically due to BC (ARF_{BC}) at the top of the atmosphere, surface, and within

the atmosphere. Study suggests hourly BC mass concentrations to vary from 0.03 μg/m^3 to 61.31μg/m^3 with an annual mean concentration of 8.01±9.2 μg/m^3. Modelled BC aerosol optical depth (AOD_{BC}) varied from 0.022 to 0.418 with an annual mean of 0.116±0.04 at 550nm. Monthly AOD_{BC} was significantly correlated with MERRA-2 Model BC AOD (p = 0.01), with a Pearson correlation coefficient value of 0.87. On the monthly basis, the aerosol radiative forcing due to BC aerosols within the atmosphere was found to be 48.44±13.14 W/m^2, which resulted in heating of 1.35±0.4 K/day[1] in atmosphere during the study period. Further processing, however, is being done at present, and results will be presented at a later stage.

MORPHOLOGICAL STUDY OF A LOW LATITUDE STATION GPS -TEC DATA DURING ASCENDING, PEAK AND DESCENDING PHASE OF 24th SOLAR CYCLE

Manish Awasthi[1], Raj Pal Singh[2] , and Devbrat Pundhir[3]
[1]Department of ECE, GLA University, Mathura.U.P.-281406
[2]Department of Physics, GLA University, Mathura.U.P.-281406
[3]R.B.S. Technical Campus, Bichpuri, Agra. U.P.-283105
Email: manishawasthe@gmail.com

GPS-TEC data of Lucknow station, a low latitude station (Lat. 26.9^0NLong 80.96^0E), have been analyzed for the years 2012, 2015, 2018 for its morphological study during ascending, peak, and descending phases of the 24th solar cycle respectively. The third version of software developed by Gopi Krishna Seemala, IIG Mumbai is used for processing the GPS-TEC data. Analysis of the GPS-TEC data yielded (i) major depletion in diurnalGPS-TEC data during January, February and December months and significant enhancements in the month of March, April, May, and September in all the three phases of the 24thsolar cycle. (ii) it maximizes in equinox and minimizesduring winter in the ascending phase of the solar cycle. However,during peak and descending phases of the solar cycle it maximizes in summer season and equinox and minimizes in winter season (iii) enhancements in May and June and depressions duringDecember, January and February in nighttime GPS-TECdata (18:00-24:00hrs) during all the three phases of the 24th solar cycle.

SEASONAL PREDICTION OF ISMR USING WRF: A DYNAMICAL DOWNSCALING PERSPECTIVE

M R Mohanty and U C Mohanty
Indian Institute of Technology, Bhubaneswar
Presenting author: manasmohanty90@gmail.com

The seasonal prediction of the Indian summer monsoon by dynamically downscaling the CFSv2 output using a high resolution WRF model over the hindcast period of 1982-2008 has been performed in this study. The April IC ensembles of the CFSv2 have been averaged to provide the initial and lateral boundary conditions for driving the WRF. The WRF model is integrated from 1st of May to 1st of October for each monsoon season over the period of study. The WRF models improves the rainfall skill and minimizes the errors as compared to the parent CFSv2 model. The rainfall pattern is simulated quite

closer to the observation in the WRF model over CFSv2. Comprehensive statistical rainfall verification scores also support the improvement of rainfall forecasts using WRF. The improvement in the skill of the rainfall can be attributed to the improved in the simulation of low level winds, tropical easterly jet stream, mean sea level pressure and the surface temperatures. The relative humidity and the diabatic heating profiles along the vertical column of the atmosphere are simulated better in the WRF model. Along with the upper air parameters, the surface heat fluxes are realistically simulated in the WRF model. The dynamical downscaling method helps in improving the forecast of the significant meteorological parameters. The dynamically downscaled forecasts are further improved by the methods of linear and quantile mapping bias correction techniques and the results show that the dynamically downscaled forecasts can be further improved and the skill can be increased by the hybrid dynamical-statistical downscaling methods.

OBSERVATION OF MESOSPHERIC FRONT-LIKE STRUCTURES OVER LOW-LATITUDE STATION SILCHAR (24.68 N, 92.76 E)

Nilesh Chauhan[1], S. Gurubaran[1], Krishna Sarkar[2], Mala Bagiya[3]
[1] Indian Institute of Geomagnetism, New Panvel (W), Navi Mumbai 410 218, India.
[2] Magnetic Observatory, Silchar 788 011, India.
[3] Shillong Geophysical Research Centre, Shillong 793 004, India.
Presenting Author: Nilesh Chauhan (nilesh.chauhan1809@gmail.com)

All-sky airglow imaging observations of mesospheric front-like structures over Silchar (24.68°N, 92.76°E), India are presented. An All Sky Airglow Imager is operated round the year at the Silchar Magnetic Observatory of Indian Institute of Geomagnetism. The present work focuses on observations carried out on clear sky nights during 2020 at Silchar. On one of the nights of observations from Silchar, a mesospheric front-like structure was observed in OI (557.7nm) and OH airglow emissions. The front appeared bright in OH emission, while it appeared dark in the OI (557.7nm) emission thus displaying a complementarity effect. The front was followed by small scale ripple like structures which appeared stationary in subsequent airglow images in both emission unlike mesospheric bore event where trailing waves are phase locked with propagating front makes the present observation unique. This case study on the front-like event was further investigated using SABER temperature measurements onboard TIMED satellite and the wind observations from the HWM model winds. Results from this study on such atmospheric disturbances will be presented and discussed.

AI AND ML BASED LONG RANGE WEATHER FORECASTING

G. Ch. Satyanarayana
Center for Atmospheric Science, K L University, Vaddeswaram, Guntur, Andhra Pradesh, India
Email: gcsatya@kluniversity.in

Agriculture is plausibly the fundament of India's economy and agronomic efficiency is greatly dependent on monsoon rainfall. Here we describe our effort to present relationship analysis of the interdependence of the teleconnection indices (independent predictors) – South West Monsoon (June,

July, August and September) and exclusively June (principal rainy month) rainfall using the historic monthly rainfall data (accessible from IITM, Pune) and six different large scale climate teleconnection indices(Southern Oscillation Index(SOI), North Atlantic Oscillation Index(NAOI), Multivariate ENSO Index(MEI), Nino 3.4, Pacific Decadal Oscillation(PDO) and Oceanic Nino Index(ONI)) for the period 1950-2016 (67-years). The correlation analysis of different teleconnection indices(January-May) with the All India Summer Monsoon Rainfall(JJAS) gives the nature of the each potential predictor on the SWM rainfall is elucidated using simple correlation technique and the best months of each index showing the good correlation is selected for the teleconnection combinational trials. Number of trials is done and the 6 best combinations are selected for the analysis and statistical study. Artificial Neural Network (ANN) model employs an approach for the long range prediction of the JJAS and June rainfall. The best combination of the predictors is selected on correlating the predicted rainfall values of each trial with the observed values of the JJAS season. The same is implemented with June. The statistical metrics calculated show that T2, T4 are the best trials for June and JJAS. The results obtained using statistical metric analysis shows how reliable the prediction is and are considered final. The purpose of this paper is to provide the long range prediction of rainfall which is certainly a boon for farmers to reap the benefits of the rainfall and plays a key role in decision making.

Keywords: All India Summer Monsoon Rainfall, long range prediction, teleconnection indices, ANN model.

IONOSPHERIC RESONANCE OSCILLATIONS DURING GREAT EARTHQUAKES

Srinivas Nayak[1*] and Mala S. Bagiya[1]

[1] Shillong Geophysical Research Centre, Indian Institute of Geomagnetism, 3 ½ Mile, Shillong, 793005, India

Presenting Author: nayaksrinivas94@gmail.com

The background free oscillations of the earth and the atmospheric acoustic modes resonantly couple at ~3.7mHz and ~4.4mHz, which lead to increased energy exchange between the earth and its atmosphere at these frequencies. Since earthquake is one of the potential sources which could trigger the earth-atmosphere resonant coupling, the present study discusses the resonant ionospheric oscillations recorded during the three great earthquake (EQ) events which are (i) 11th April 2012 Sumatra EQ (ii) 11th March 2011 Tohoku-Oki EQ and (iii) 26th December 2004 Sumatra EQ. The Sumatra 11th April 2012 earthquake event was a doublet earthquake event consisting of two strike-slip earthquakes of magnitude M_w8.6 (1st EQ) and M_w8.2 (2nd EQ) respectively. The resonance oscillations were observed at stations umlh in prn-32 after 1st EQ and it was also observed at pbri in prn -32 after the 2nd EQ. These resonance oscillations were centred at ~4 mHz. The resonance observed after the 2nd earthquake could be linked to the R2 wave train generated by the 1st EQ. In case of the 11th March 2011 Tohoku EQ of magnitude M_w 9.1, triggered the resonance coupling at the frequencies ~3.7mHz and ~4.4mHz. This event was studied to demarcate the spatial extent of resonance. It was observed that the distribution of resonant ionospheric signals showed significant anisotropy in the north and south of the epicentre. This anisotropy is explained by the role of seismic and non-seismic forcing mechanism. The 26th December 2004 Sumatra EQ was a M_w 9.0 thrust earthquake. This earthquake also triggered the earth-atmosphere-ionosphere resonance coupling at ~4mHz. The ionospheric resonance during this EQ event was recorded at many

stations. The most distinct observations were at phkt in prn-13 and prn-23. The region of ionospheric resonance was restricted to the NE of the epicentre which could be well explained by the direction of seismic forcing and by the manifestation of the non-tectonic forcing mechanisms around the epicentre. Interestingly the frequency of resonant oscillations at Tohoku are different than that of Sumatra.

After the study of these great earthquakes, it could be realized that the great earthquakes could trigger earth-atmosphere-ionosphere coupling, provided the non-tectonic forcing mechanisms are favourable for the evolution of resonance.

SPATIAL ANALYSIS OF CIRQUES IN NW HIMALAYA: APPLICATION IN PALEO-ENVIRONMENT RECONSTRUCTION

Subhendu Pradhan[1] and Shubhra Sharma[2]
Department of Geography, Institute of Science, Banaras Hindu University
Presenting author: subhendu@bhu.ac.in

Glacial cirques are bowl-shaped depressions with steep headwall and nearly flat base carved by glaciers. Since cirques indicate initiation of glaciation in the mountains, their morphology, distribution, altitude, aspect can serve as valuable paleo-climate indicators particularly in the remote and inaccessible locations where often other proxies may be absent. In the present study an attempt is made to categorize and understand the evolution of both the relict and modern cirques in NW Himalaya (Karakorum, Ladakh, and Zanskar) along the precipitation gradients of Indian Summer Monsoon (ISM) and the mid-latitude westerlies. The relict and modern cirques were mapped in the Karakorum, Ladakh, and Zanskar ranges using Google Earth Imagery, Landsat 8 (30m), Sentinel-2A (10m) and ALOS Palsar Digital Elevation Model (12.5m). Various parameters such as peak elevation, minimum elevation, relief, area, circularity, mean slope, mean aspect and hypsometric maxima (indicate cirque floor elevation) were derived to understand the influence of precipitation gradient, wind pattern, lithology, structure, and aspect in evolution of cirques and thus, glaciation. The preliminary results show that cirques are dominantly deepened and clustered in the western sector of the ranges suggesting that the evolution of cirques is strongly influenced by moisture supplied by the mid-latitude Westerlies. On the contrary, the cirque floor elevation (indicative of the Equilibrium Line of Altitude-ELA) decreases to the north along the precipitation gradient of the ISM following the global ELA vs latitude pattern. The modal aspect of the paleo-cirques in the Zanskar and Ladakh ranges is aligned along with prevailing paleo-wind direction during the LGM (NE direction) as observed in northern hemisphere cirques, where are in Karakorum, its towards NW. The study indicates dominance of glacial erosion in the NW Himalaya (glacial buzzsaw).

DUSTFALL DEPOSITION OF NH_4^+ AND NO_3^- ALONG WITH OTHER INORGANIC SPECIES OVER AN RURAL AGRICULTURAL SITE IN DELHI-NCR.

Sudesh, U.C.Kulshrestha*

School of Environmental Sciences, Atmospheric Chemistry and Climate Change Group,
Jawaharlal Nehru University, New Delhi 110067

Email: U.C. Kulshrestha: umeshkulshrestha@gmail.com; Sudesh: sudeshyadav1902@gmail.com

The rising demand of food and energy have resulted in increasing emissions of reactive nitrogen (Nr) species across the globe. This study majorly highlights NH_4^+ and NO_3^- fluxes along with other inorganic species through dustfall from July 2017 to June 2018 over an agricultural site in Delhi- NCR. Major ionic fluxes followed the order $SO_4^{2-} > Ca^{2+} > K^+ > Cl^- > Na^+ > NO_3^- > Mg^{2+} > NH_4^+$ during Kharif season whereas ionic fluxes decreases in order $K^+ > SO_4^{2-} > Ca^{2+} > Na^+ > Cl^- > NO_3^- > Mg^{2+} > NH_4^+$ during Rabi season. During Rabi season, the concentrations of all the ions were higher as compared to Kharif season indicating the role of intense field activities during Rabi season. The most abundant anion observed was SO_4^{2-} with concentration ranging from 0.72 to 1.27 $mgm^{-2}day^{-1}$ and 0.42 to 2.30 $mgm^{-2}day^{-1}$ with mean concentrations 0.98 and 1.37 during Kharif and Rabi season respectively. Ca^{2+} and K^+ were the dominant cations with mean concentrations 0.96 and 0.79 $mgm^{-2}day^{-1}$ during Kharif season and 1.12 and 1.38 $mgm^{-2}day^{-1}$ during Rabi season respectively. The lowest fluxes of NO_3^- (0.19 $mgm^{-2}day^{-1}$) and NH_4^+ (0.02 $mgm^{-2}day^{-1}$) were observed during June and July respectively owing to its minimum exposure to agricultural activities during these months. On the contrary, the highest fluxes of NO_3^- (0.81 $mgm^{-2}day^{-1}$) and NH_4^+ (0.13 $mgm^{-2}day^{-1}$) were noticed during the month of September and December respectively which will be discussed during the conference. Morphological analysis of dust reflected the anthropogenic influence from biomass burning and fossil fuel combustion.

Keywords : Reactive nitrogen, Dustfall, Agriculture, Kharif season, Rabi season, Morphological.

MARINE GEOSCIENCES

MULTI-ATTRIBUTE ANALYSIS USING PCA AND FCC: A CASE STUDY FROM ANDAMAN OFFSHORE

A. Ramesh[1] and N. Satyavani[*]
CSIR-National Geophysical Research Institute, Hyderabad, India.
1. Academy of Scientific and Innovative Research-NGRI, Hyderabad, India
* Corresponding Author: satyavani.nittala@gmail.com

Seismic attribute analysis is the most effective method to predict geological features from seismic images. However, using a single attribute for the purpose may reduce the prediction quality. Therefore, integrating multiple attributes becomes significant and has the potential to interpret the finer details. Principal Component Analysis (PCA) has the ability to highlight the similarities within the dataset (in our case, different attributes). The process reduces the data dimension so that multiple attributes can be efficiently handled. The present study uses the PCA to carry out a multi-attribute study for post-stack seismic data from the Andaman Offshore. In this study, we extract principal components from multiple attributes and then visualizes using the False Color Composite (FCC) technique. FCC image is an efficient presentation of the principal components (PCs) using bands other than visible red, green and blue as the red, green and blue components. In general, an image can be composed using three different bands of components by assigning a different primary color for each band. Combining these three images can produce a color image with each pixel's color determined by a combination of RGB of different brightness. The resultant FCC images show improved seismic reflectors, migration pathways, and enhanced reflections compared to any single seismic attribute.

Keywords: Multi-Attribute Analysis, Principal Component Analysis, False Color Composition, Andaman Offshore.

SYSTEMATIC DIAGENETIC ANALYSIS OF A NEWLY DISCOVERED ACTIVE COLD SEEP SITE IN THE GULF OF MANNAR

F.Badesab[1]* and V.Gaikwad[1,2]
[1]CSIR- National Institute of Oceanography, Dona Paula, Goa, 403004, India
[2]School of Earth Ocean and Atmospheric Sciences, Goa University, 403206, Goa, India
*Presenting Author: Dr. Firoz Badesab (firoz@nio.org)

Magnetic minerals (detrital, diagenetic, authigenic, biogenic) at active methane seep site are potential recorder of methane seepage (present and paleo) dynamics. In this study, we systematically carried out diagenetic analyses on a seep impacted sediment core from the newly discovered active seep site in the Gulf of Mannar using combined rockmagnetic and robust electron microscope analyses to understand how magnetic minerals respond to diagenetic effects created by methane-induced geochemical processes over geologic time. Detrital, diagenetic and authigenic magnetic minerals governed the bulk sediment magnetic record. Mineralogy diagnostic rockmagnetic proxies revealed the dominance of magnetite and greigite authigenesis in methanic zone. Several layers of methane-derived authigenic carbonates throughout the core indicates episodic intensification of anaerobic oxidation of methane due to variations in the rising methane-flux. SEM-EDS analyses conducted on magnetic particles extracted from different

sediment depth intervals of sediment core clearly recorded the signature of progressive diagenetic dissolution, maghemitization, and pyritization reactions in sulfidic and methanic zones. Magnetic mineralogical based approach presented in this study bears the potential for understanding the unique and complex diagenetic system created at marine cold (methane) seep sites.

MULTIPROXY STUDY OF SEDIMENTS ON THE CONTINENTAL SHELVES OF INDIA: IMPLICATIONS TO THE SEDIMENT SOURCE-TO-SINK PROCESSES

N. Kadam1,2, F. Badesab1, V. Gaikwad1,2, M. Kotha2, L. Fernandes1
1-CSIR-National Institute of Oceanography, Goa, 403004, India
2-School of Earth Ocean and Atmospheric Sciences, Goa University, Goa, 403206
Presenting author: nbkadam@nio.org, nitinkadam7798@gmail.com

Continental shelves of India stores a record of diverse sedimentation brought by the peninsular and extra- peninsular rivers which carries crucial information pertaining to the sediment provenance, transport pathways and climatic conditions. With an aim to delineate the sediment source-to-sink processes, we applied rock magnetic, granulometric, clay mineralogical techniques combined with X-ray diffraction and scanning electron microscopic observations on the shelf sediments off Narmada, off Penner and off Ganga- Brahmaputra Rivers. The magnetic mineralogy is comprised of magnetite, titanomagnetite, hematite along with their maghemitized and diagenetically altered forms. Temperature based magnetic measurements revealed characteristic magnetic mineral phases and their distinct transformations. The differential sediment input generated due to the monsoonal climatic conditions in the hinterland area explains the downcore variations in the magnetic mineral concentration, grain size and mineralogy. XRD, SEM-EDS, Day plot and downcore rock magnetic data suggests events of coarse magnetic particles are correlated with the enhanced magnetic susceptibility representing the episodes of high energy deposition. Ternary plot of clay minerals were successfully able to resolve the provenance of shelf sediments. Magnetogranulometry data unravel the reversal of relationship between magnetic and clastic grain size. This reversal occurred at medium silt (20-40 μm) for shelf sediments off Narmada and off Ganga whereas it is noticed at fine silt (420 μm) for off Penner shelf sediments. The mechanism of such reversal is attributed to the widespread occurrence of magnetic mineral inclusions within different host grains. Overall, contrasting sources, differential weathering and erosive conditions operated by the monsoonal climate controls the observed variations in the magnetic minerals on the continental shelf. The magnetic mineral approach presented in this study provides valuable insights on the sediment source-to-sink processes and bears high potential to delineate the provenance in the complex marine depositional systems.

PALEO METHANE SEEPAGE EVENTS AT A SUBMARINE MUD VOLCANO IN THE ANDAMAN SEA

A. Peketi, P. Dewangan, G. Sriram, A. Mazumdar, V. Mahale, A. Zatale, V. Rajurkar, Gautham S.
Gas Hydrate Research Group
CSIR-National Institute of Oceanography
Dona Paula, Goa-403004, India
*Corresponding author email: aditya@nio.org

CSIR-National Institute of Oceanography recently conducted a scientific expedition (SSD085: 7th November, 2021 to 9th December, 2021) onboard RV Sindhu Sadhana to understand the tectonically induced fluid/gas migration in the Andaman accretionary prism, forearc and backarc basins. The acquired geophysical data and the preliminary analysis shows the presence of a mud volcano in the Andaman forearc basin at water depth of ~1628 m. Mud volcanoes are known for the release of intense gases (CH_4, C_2H_6 and CO_2) and eruption of the mud breccia. The coring activities on the apex of mud volcano showed multiple layers of authigenic carbonates and mud breccia (below ~ 30 cmbsf) in a ~1.5 m long sediment core, confirming the occurrence of multiple paleo gas seepage events. Authigenic carbonates may precipitate by the intense anaerobic methane oxidation (AOM) activity carried out by consortium of sulfate reducing bacteria and methane oxidizing archaea. Presence of shells of chemosynthetic organisms belonging to Vesicomydae and Thyasiridae families at deeper depths (~60 cmbsf), which further confirm paleo H_2S seepage activity in the region possibly driven by AOM. Further studies are to be carried to understand the nature and source of the authigenic carbonates and mud breccia.

Keywords: mud volcano, methane, carbonates, chemosynthetic organisms.

SEISMIC IMAGE ENHANCEMENT USING AI/ML

N.Satyavani
Seismic group, CSIR-National Geophysical Research Institute
satyavani@ngri.res.in

Recent advancements in seismic processing and modelling have provided immense pathways to look at seismic data from various perspectives, while the availability of high-end computing facilities have paved way for the development of new technologies that can effectively address the complexities involved in seismic exploration. Routine seismic processing methods result in providing an overall seismic image, while many subtle features might be hidden. In order to extract such features, new improved techniques were applied to the seismic datasets from different areas of the Indian continent. Techniques like Principal component analysis (PCA), common receiver stacking (CRS), convolutional neural networks (CNN) etc., were used to increase the signal content in the seismic images and the results have shown great promise. The increment in the resolution of the features is also quite significant.

Keywords: Seismic image, PCA, CRS, CNN, resolution

SOLID EARTH GEOSCIENCES

ZIRCON MEMORY OF EPISODIC RECYCLING OF ANCIENT METASOMATIZED CONTINENTAL LITHOSPHERE: EVIDENCE FROM LOWER OCEANIC CRUST GABBROS OF CENTRAL INDIAN RIDGE, INDIAN OCEAN

Abhishek Saha[1], Arghya Hazra[1,2], M. Santosh[3,4], Sohini Ganguly[2], S. Shanshan Li[3], C. Manikyamba[5]

[1]CSIR-National Institute of Oceanography, Dona Paula, Goa 403 004, India

[2]School of Earth, Ocean and Atmospheric Sciences, Goa University, Taleigão Plateau, Goa 403 206, India

[3]School of Earth Science and Resources, China University of Geosciences, Beijing,China

[4]Department of Earth Sciences, University of Adelaide, Adelaide SA 5005, Australia

[5]CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad 500 007, India

*E-mail: asaha@nio.org

Oceanic crust and mantle sections exposed at intermediate, slow and ultraslow spreading centres provide maximum proximal observations of ambient conditions at crust-mantle interfaces and melt generation-migration-differentiation processes that can be translated towards understanding of the mantle heterogeneity. Thus, the thermo-tectonic evolution of global mid oceanic ridge rift systems squares with the geochemical changes in the mantle over the geological history in terms of periodic melt extraction, refertilization, fluid-melt infiltration and crustal recycling. The two viable processes that are attributed to chemical and isotopic heterogeneity of the mantle are: (i) multiple episodes of melt replenishment and melt-rock interaction in open magma systems; and (ii) recycling of oceanic and continental crustal materials and components of sub-continental lithospheric mantle. This study presents continental (2525 Ma-173 Ma) zircons from the lower oceanic crust gabbros of the Central Indian Ridge and invokes Indian Ocean MOR mantle heterogeneity through episodic entrainment of ancient continental lithosphere of Madagascan and Gondwana origin prior to Indian Ocean opening. The geochemical features show a marked deviation from typical depleted N-MORB compositions and conform to an E-MORB affinity, which might suggest enriched lithospheric input into the depleted asthenospheric mantle. The transitional depleted to enriched mantle signature substantiates the role of lithosphere-asthenosphere interaction contributing towards accretion of lower oceanic crust gabbros beneath the CIR. The HFSE and REE compositions can be translated in terms of melt extraction by shallow level melting of a chemically heterogeneous upper mantle carrying depleted asthenospheric and recycled lithospheric components. The continental inheritance of the dated zircon grains and compositional diversity of the Indian Ocean mantle can be interpreted to represent trapped relics of older continental lithosphere into the Indian Ocean MOR mantle. The preservation of 2525 Ma to 173 Ma zircon grains of continental origin within oceanic gabbros of CIR can be correlated with (i) subduction-driven delamination, convective downwelling and recycling of older continental margin lithosphere into the mantle during the Mozambique ocean closure and Gondwana amalgamation at around 750 Ma, and (ii) delamination, convective removal and incorporation of older continental fragments into the upwelling mantle asthenosphere in response to the dispersal of Gondwanaland at ~167 Ma ensued by opening of the Indian Ocean.

Key words**:** Indian Ocean, Central Indian Ridge, Lower Oceanic Crust Gabbro, Upper mantle heterogeneity, Zircon U-Pb age, Continental Recycling

IMPROVING DEPTH OF INVESTIGATION OF AEM DATA USING AVERAGE FILTER: A CASE STUDY

P. Akhil*[1], Amal Joy[1], and Subash Chandra[1]
[1] CSIR-National Geophysical Research Institute, Hyderabad-500007, India
*Presenting author: akhilpenukula123@gmail.com

Airborne transient electromagnetic method is gaining increasing applications as a rapid geophysical tool to cover large area and provide high-resolution information for wide range of geotechnical applications such as natural resource estimation, pollution studies, engineering applications, etc. The TEM measurement that works on induction principle, suffers electrical and metallic installations such as power lines, metallic roads, cultural noise, etc.

In order to reduce this noise from data and improve signal to noise ratio we apply various filters. Though, we culled the noisy data before stacking manually from the raw data, there will be some random noise still left in the data especially later gates of the sounding curve. Paper presents role of average filter to improve the signal to noise ratio at later gates, increasing the depth of investigation and its impact on spatial resolution. This has been applied in various geological and hydrogeological settings.

Keywords: AEM, noise, filter, depth of investigations, and resolution.

BASEMENT CONFIGURATION AND LINEAMENT MAPPING OF KUTCH RIFT BASIN FROM AEROMAGNETIC DATA

Anand.S.P.
Indian Institute of Geomagnetism, Navi Mumbai, Maharashtra
aerospl@yahoo.co.uk

The Kutch sedimentary basin formed during the Late Triassic breakup of Gondwanaland is characterized by horst and graben structures consisting of several east–west trending uplifts surrounded by low-lying plains. The basin is important both in terms of hazard (continued seismic activity) as well as resources. The seismic activities have dramatically increased in the recent past especially in the eastern part of the Kutch rift basin where a large network of faults is present (with or without surface exposure) and probably active. Lineaments/faults, their displacement and intersection are widely identified as one of the important reasons of continued earthquake activity in a region. Hence it is of paramount importance to understand the fault network in a seismically active region while the sediment thickness, distribution of intrusives etc play a crucial role in resource evaluation. Analysis of the aeromagnetic data acquired over the basin was undertaken with a view to determine the basement lithology, sedimentary thickness and mapping of the subsurface lineaments. We could map fourteen lineaments some of which does not have any surface expression. An attempt has also been made to time the formation of some these lineaments by integrating with available stratigraphic data. Several established techniques were employed to compute the sediment thickness both from aeromagnetic and ground gravity data. The computed basement depths suggested that the Banni basin is divided into two sub-basins with average

sediment thickness on 3-4km. Based on the results of the aeromagnetic data analysis and other published data, a generalized evolutionary model is proposed for the Kutch Rift basin in general and eastern basin in particular. The results of these will be presented.

INTEGRATED GRAVITY-MAGNETIC STUDY IN THE SOUTHERN REGION OF THE BUNDELKHAND CRATON AND ADJOINING AREAS ALONG THE CRATON BOUNDARY

Ananya P. Mukherjee*, Harshajit Borah, Animesh Mandal
Department of Earth Sciences, Indian Institute of Technology, Kanpur
*Presenting author: ananyam@iitk.ac.in

The present work involves an integrated gravity-magnetic study done across an area of ~1232 km^2, for delineating subsurface features and understanding the crustal evolution of the southern region of the Bundelkhand craton. It covers the Madawara Ultramafic Complex (MUC) and the Sonrai basin, including areas outlined by the Vindhyan Supergroup along the craton's boundary. The regional Bouguer gravity anomaly, upward continued up to 10 km, shows a high to low trend from SW to NE and the existence of crustal level high in the southwestern region. Coincidence of high residual gravity anomaly with high residual magnetic anomaly (derived from the reduced-to-equator (RTE) magnetic anomaly) deciphered the extent of MUC and the NW-SE trending mafic dykes at the central part of the study area. It is interpreted that the Sonrai basin sediments in the southern part of the survey area overlies the Bijawar Supergroup, a higher density basement, as inferred from the gravity highs observed in the residual anomaly. The low-high magnetic anomaly pair seen to the south of the residual RTE map signifies the existence of the Sonrai-Girar shear zone along with smaller faults across the Sonrai Basin and the Bijawar basement. The residual Bouguer gravity anomaly also shows evidence of high-density material in the southwestern part of the study area, which correspond to the outcrops of the Vindhyan Supergroup implying that their basement comprises of a high-density layer, probably the Bijawar Supergroup, overlying the Bundelkhand granitic basement. The gravity high observed in this region also signifies the probable effects of the Deccan trap outcrops, due to their proximity to the craton boundary. To further ascertain the presence of the gravity high due to deeper crustal sources around the craton boundary, a large scale Bouguer gravity anomaly map has also been derived using the global 1-minute gravity grid (TOPEX). A high gravity anomaly zone along the southern boundary of Bundelkhand craton is also revealed from the TOPEX data. Existence of the same high anomaly zone in the 30km upward continued regional Bouguer anomaly indicates the continuity of high-density source from deeper part. Based on the geological affiliation of the region, present study proposes mafic underplating below the basement of adjoining Vindhyans as the source of such high-density material. Thus, the study provides initial geophysical evidences in understanding the subsurface configuration, thereby the evolution of the region along the southern margin of the Bundelkhand craton.

Keywords: Gravity-magnetic; Bundelkhand craton; Crustal evolution; Underplating

APPLICATION AND UNCERTAINTY ANALYSIS OF GADAM OPTIMIZER IN SEMI-SUPERVISED SEQUENTIAL CONVOLUTION NETWORK FOR SEISMIC IMPEDANCE INVERSION

Anjali Dixit[1]*, Animesh Mandal[1] and Shib S. Ganguli[2]
1 Department of Earth Sciences, IIT Kanpur, Uttar Pradesh, India
2 Marine & Deep Seismics, CSIR-NGRI, Hyderabad, Andhra Pradesh, India
*Presenting author: anjalid@iitk.ac.in

Seismic impedance inversion is a crucial step for estimating sub-surface lithological configuration and reservoir characterization. However, unknown wavelet, band-limitation, and presence of noises in seismic datasets make seismic inversion a nonlinear and ill-posed problem with a non-convex objective function. As a matter of fact, the solution gets trapped at local minima during optimization. Recently, the growing application of deep learning approaches made its footprint into the field of seismic inversion due to its multi-level features extraction capability using multiple hidden layers and enhanced non-linear mapping between the input (seismic data) and output (impedance data). To optimize the objective function, various optimization schemes are used in deep learning algorithms such as Gradient descent, RMS prop, momentum, ADAM, etc. Amongst all, ADAM has been widely used in seismic inversion studies. However, in the case of a non-convex objective function, ADAM often gets stuck at local minima, therefore obtained solution may not be optimal. To tackle these challenges, a novel approach has been proposed in this study with a global optimizer namely, GADAM (Genetic- Evolutionary ADAM) which integrates ADAM and Genetic algorithm (GA) into a unified framework using a designed deep sequential convolution neural network (DSCNN). In GADAM, GA provides an edge over ADAM by offering multiple initial search points. Therefore, it eradicates the possibility of getting stuck at local minima. The efficacy of GADAM has been tested on both synthetics as well as on a 3D seismic field dataset from Poseidon, Browse basin. The performance of both the optimizers, i.e., ADAM and GADAM were evaluated by employing uncertainty estimation on blind well data. Results show that the level of uncertainties for GADAM optimizer is comparatively less than that for ADAM. This study demonstrates the applicability of a hybrid optimizer, i.e., GADAM for seismic inversion with less uncertainty in a DSCNN framework. Which will facilitate well-informed decisions and reasoning in seismic reservoir characterization and sub-surface lithological configration.

Keywords: Seismic inversion, Optimization, ADAM, GADAM, Deep learning, Uncertainty estimation.

CORRELATION BETWEEN CRUSTAL ANISOTROPY AND SEISMOGENIC STRESS FIELD BENEATH SHILLONG–MIKIR PLATEAU AND ITS VICINITY IN NORTH EAST INDIA

Antara Sharma[1], Santanu Baruah[1]
1Geosciences and Technology Division, CSIR-North East Institute of Science and Technology (CSIR- NEIST), Jorhat, 785006, Assam, India
Presenting author: antaras8@gmail.com

A systematic study towards understanding the correlation between polarization direction of crustal anisotropy with seismogenic stress field at different locations of the Shillong-Mikir Plateau and its vicinity in North East India is attempted. We used data from a 17-station broadband seismic network. In our earlier work (Sharma et al., 2017), crustal anisotropic parameters were determined using ANISOMAT+ for the17 seismic stations. In this study, we have estimated stress field in and around the stations using focal mechanism solutions. Some 215 focal mechanism solutions are obtained by waveform inversion. These solutions are used for stress tensor inversion to estimate stress field in and around each location. It is observed that polarization direction of crustal anisotropy is consistent with that of the maximum horizontal stress(σ_{max})as well as the minimum horizontal stress(σ_{min}). In addition to this, two orthogonal fast polarizations in some locations are also noted (Sharma et al., 2017).The bivariate nature of correlations help us to understand that the major mechanisms of seismic crustal anisotropy are not only due to the regional stress, but active faults and other geological conditions play a significant role in contemporary orientation of seismic crustal anisotropy and seismogenic stress field.

Key words: Shear wave splitting, fast polarization, focal mechanism, active faults, stress tensor inversion.

CHANGE IN KINEMATICS ACROSS A BASAL DÉCOLLEMENT: INSIGHTS FROM THE EARTHQUAKES OF GARHWAL HIMALAYA AND AN APPRAISAL TO OTHER HIMALAYAN REGIONS.

R. Arun Prasath[1,2]*, Ajay Paul[1], Sandeep Singh[2], Koushik Sen[1], Naresh Kumar[1]
[1]Wadia Institute of Himalayan Geology, 33, GMS road, Dehradun, India
[2]Department of Earth Sciences, Indian Institute of Technology, Roorkee, India
*Presently at Seismology/Geosciences, Ministry of Earth Sciences, Prithvi Bhavan, New Delhi, India
Presenting author: devanthran@hotmail.com

The Garhwal Himalaya displays the major litho-tectonic zones of the Himalayas formed by the continent-continent collision of Indian and Eurasian plates at ~57 Ma ago. This region is one of the ideal places in the Himalayas to study its Kinematics and Seismotectonics. In this study, we present Spatio-temporal analysis of seismicity (N=585) of 8 years (2007-2015) with magnitudes $1.8 \geq M \leq 5.0$ that occurred in the Garhwal Himalaya, moment tensor solutions (N=47, for $M \geq 3.0$) and stress field from these solutions which reveal the change in kinematics across the Main Himalayan Thrust (MHT, basal décollement). The results show a variety of focal mechanisms in which the thrust fault is dominant,

owing to the under-thrusting of the Indian plate beneath the Eurasian plate. However, thrusting is largely-confined to a zone above and around the MHT, preciously around the mid-crustal ramp. The focal mechanism solutions show shallow plunging NNW-SSE directed P-axis similar to the principle horizontal stress orientations parallel to the relative motion of the Indian plate. The results further indicate a lateral variation of fault type with normal faults in the sub-Himalaya and outer lesser Himalaya regions in contrast to the thrusting along the Himalayan Seismic belt (i.e., along the Inner Lesser Himalaya and Higher Himalaya regions). Based on these results, we suggest a change in kinematics across the MHT beneath the Garhwal Himalaya. We further infer that the zones around the crust-mantle boundary are also seismogenic. We have compared these scenarios with other parts of the Himalayas (e.g., Nepal, Sikkim) and found similar results.

INTERPRETATION OF ELECTROMAGNETIC (EM) DATA USING THE CONCEPT OF ANALYTICAL SIGNAL

Arvind Yadav*, Shalivahan and Akash Chandra
Department of Applied Geophysics, IIT (ISM) Dhanbad, India
*Corresponding author: arvindism2012@gmail.com

The electromagnetic (EM) prospecting technique is most commonly used in mineral exploration. EM data can be acquired by different combinations of transmitter (T_x) and receiver (R_x). Unfortunately, for the same type of geological structure different combinations of T_x and R_x results in different response. EM data obeys Laplace's equation. In the present work one intends to interpret the EM data using the concept of analytical signal. Amplitude of analytical signal (AAS) is approximated by a bell shaped function which is dependent on the constant, the horizontal and vertical locations of the source and the nature of the causative source. The constant depends on the physical property. The peaks of AAS coincides with the edges or the peaks of the source. The methodology is a unified approach which does not require any a priori assumptions about the nature of the source geometry. Rather the nature of the source geometry will be deciphered/visualized by computing the structural index. It is a parameter related to source geometry. We have analysed field examples with different coil configurations over the same geological structure from the published literature. The field examples are over the vertical and inclined sheets. The optimizations of bell shaped function has been made through Grey Wolves Optimization (GWO). The optimization of profiles over the same target but with different coil configurations resulted in same horizontal location, depth of source body and structural index. The analysis over both vertical and inclined sheets resulted in structural index of 1.0.

ASSESSMENT OF WATER QUALITY, HEAVY METALS AND HYDROGEOCHEMICAL STUDIES IN COAL MINING REGION, RAMGARH DISTRICT, JHARKHAND

Atulya Kumar Mohanty*
Hydrogeochemistry Division
CSIR- National Geophysical Research Institute, Uppal Road, Hyderabad, 500 007, India,
Corresponding author: atulyakmohanty@gmail.com,

Groundwater resources in coal mining areas are known to be vulnerable to pollution and that may have a serious impact on the environment. Groundwater quality studies of coal mining areas are very important due to coal explorations, dumping of huge quantities of overburdens, and subsequently mixing with the coal mine drainage areas. Coal mining operations generate huge quantities of solids due to overburden dumping and liquid wastes from the coal washing plants. The untreated water is released from coal washing plants which contain higher levels of TSS, TDS, trace elements and which were acidic in nature, and mixed with surface and groundwater of the surrounding area. The objective of this study is to evaluate the major ions, trace elements, and the hydrogeochemical processes involved in the aquifer and also the possible influence of acid mine drainage (AMD), in the Rajrappa coal mining area. The results show that groundwater is generally neutral to alkaline in nature. The major ions and trace elements concentrations in the groundwater samples were found to be below the permissible limits based on WHO guidelines and suitable for drinking water purposes. Few wells show a higher order in certain parameters due to impact local geologic strata. The piper diagram shows two major hydrochemical water types represented, such as Ca-Mg-Cl, and Ca-Mg-HCO_3 types. Based on major ion concentrations and their minor variations are indicative of the stable geochemical and hydrologic environments, which control the groundwater chemistry in the coal mining area. The geochemical evolution of groundwater chemistry is mainly controlled by the natural geochemical processes such as mineral dissolution, rock-water interactions, and mineral precipitation processes. Saturation index studies show that groundwater samples were near saturation to equilibrium conditions with the carbonate phase minerals of calcite and dolomite and undersaturated with gypsum and anhydrite. Secondary minerals of Fe and Mn – sulphate and carbonate phase species are in undersaturated conditions. The shorter residence times of groundwater in the wells, lack of acid mine drainage generating conditions, and the impact of dilution during high base flows are diluting the coal mining drainage streams and making a negligible impact on acid mine drainage.

ANISOTROPIC PN VELOCITY TOMOGRAPHY BENEATH THE INDIAN SHIELD AND THE ADJACENT REGIONS

Bhaskar Illa and Prakash Kumar
CSIR- National Geophysical Research Institute
Uppal Road, Hyderabad, India
illabhaskar@gmail.com

We have investigated first time the P-wave velocity and anisotropy structure of the uppermost mantle beneath the Indian shield and surrounding regions (Bay of Bengal, Burmese arc, Himalayan arc, Tibetan region, Tarim and Karakoram region) are presented to unravel the tectonic imprints in the lithosphere.

We inverted 19,500 regional Pn arrivals from 172 seismological stations from 4780 events at a regional distance range of 2º to 15º. The mean apparent Pn velocity observed is 8.22 km/s. Our results indicate that the Pn velocity anomalies with fast anisotropic directions are consistent with the collision environments in the Himalaya, Tibetan Plateau, Tarim Basin, and Burmese arc regions. Higher Pn anomalies are also observed along the Himalayan arc explicate the subducting cold Indian lithosphere. The cratonic upper mantle of the Indian shield is characterized by Pn velocity of 8.12–8.42 km/s, while the large part of the central Indian shield has higher mantle-lid velocity of ~8.42 km/s with dominant anisotropic value of 0.2–0.3 km/s (~7.5%) suggesting the presence of mafic 'lava pillow' related to the Deccan volcanism. The impressions of the rifts and the mobile belts are conspicuous in the velocity anomaly image indicating their deep seated origin. Most important observation from the Indian shiled is that the complex Pn anisotropy pattern and deviates from the absolute plate motion directions derived from the SKS study, demonstrating the presence of frozen anisotropy in the Indian lithospheric uppermost mantle, due to the large scale tectonic deformation after its breakup from the Gondwanaland. The Pn and SKS anisotropic observations are well consistent in Tarim basin, Tibetan regions, eastern Himalayan syntaxis and the Burmese arc. The modeled anisotropic Pn clearly manifests a lower velocity anomaly bounded by 85º E and 90º E ridges in the southern Bay of Bengal. Further, 85º E ridge spatially separates the BoB lithosphere into faster and slower regions consistent with the body wave tomography and free-air gravity observation.

MAPPING OF COASTAL AQUIFER SALINITY NEAR SURAT CITY, GUJARAT EMPLOYING GROUND GEOPHYSICAL AND HYDRO CHEMICAL METHODS

K. Bhima Raju[1,2*], K. Lohithkumar[1], Subash Chandra[1,2]
[1]CSIR National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India
[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, India
*Corresponding author (email: bheemusonys@gmail.com)

Surat, fourth fast developing city in the world, is a coastal city of western India located at mouth of Tapti River that joins Arabian sea. Surat is principally dependent on surface and groundwater for industrial, irrigational and domestic purposes. Reduction of inflow in the river and rapid growth in the urbanisation and industrialization are increasing stress on groundwater pumping, which in turn induces sea water intrusion. To analyse coastal in-land salinity, Transient Electromagnetic (TEM) measurements have been carried out in and around the city by using Walk-TEM instrument with a loop of 40mX40m at different sites which facilitates measurement of response of dual moment's transients for shallow as well as deep investigations and followed by 49 water samples for in situ Electrical Conductivity (EC) and analysed for major anions and cations. The minimum and maximum values of EC and Chloride are varying from 533 to 5220 (µS/cm) and 22.728 to 2240.303 mg/l respectively.

Formation resistivity derived from ground TEM measurements shows resistivity varying from 0.1 to 1,000 Ωm, where north-western part of the area is found often with dominantly low resistivity i.e. ~3 Ωm or low. The measured resistivity is function of lithology, groundwater saturation and its salinity. The area with resistivity ~3 Ωm or low is classified as groundwater affected by sea water salinity. The data was in good agreement with the results from the analysed hydro chemical data. The resistivity falling

down to 3 Ωm or low are analysed as an effect of increased salinity in groundwater by sea water intrusion. Thus, resistivity distribution from TEM data has demarcated zone affected by sea water intrusion, which is found extending ~10 km away from the sea coast towards city. Study further suggests to optimize the groundwater pumping to curb sea water ingress.

Key words: Coastal aquifer, Transient electromagnetic, Electrical Conductivity, groundwater, sea water intrusion.

THE DEEP SEISMIC IMAGING OF THE SOUTHERN INDIAN SHIELD USING THE COMMON REFLECTION SURFACE (CRS) STACK: A REVIEW

Biswajit Mandal[1,2*], V. Vijaya Rao[1], P. Karuppannan[1], K. Laxminarayana[1,2], Prakash Kumar[1,2]

[1]CSIR National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India

[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, India

*Presenting author (email: bisuman@gmail.com)

The present paper reviews the deep seismic reflection imaging of the South Indian Shield using the Common Reflections surface (CRS) approach. The CRS method identified many complex structural details from the southern Indian shield, hitherto elusive using the Common conventional Mid-Point (CMP) processing chain. The paper discusses the structure and tectonic evolution of all the three crustal blocks, the western and eastern Dharwar cratons and Southern Granulite Terrain.

The CRS image from the Perur-Chikmagalur profile of the Dharwar craton identifies two distinct crustal blocks of different reflectivity patterns in the Mesoarchean Western and Neoarchean Eastern Dharwar Cratons (WDC and EDC). The EDC exhibits a complex reflectivity pattern with oppositely dipping reflection fabric and a thrust fault. A west-dipping reflection fabric extending from 34 to 43 km represents the upper mantle subduction zone of the EDC. We interpret the EDC was thrusted against the protocontinent WDC and accreted to it during the Neoarchean. On the other hand, the WDC shows a simple structure with a significant part of the crust from 6 to 30 km depth displaying a gently dipping reflection fabric and a subhorizontal reflection fabric from 30 to 40 km. The subhorizontal reflection fabric represents the lower crust and its base, the Moho. The Pseudo-three-dimensional CRS image derived from the orthogonal profiles suggests that the lower crust is modified with a 10 km thick magmatic underplating in the region and identifies the Moho as a regional feature. The underplating could be due to Marion and Reunion mantle plume activities during 88 Ma and 65 Ma on the western part of Dharwar craton and is responsible for the epeirogenic uplift of the Dharwar craton.

The architecture of the Achankovil Shear zone (AKSZ) of the Southern Granulite Terrain is controversial and debatable. The Kalugumalai-Kanniakumari seismic profile resolves it. The CRS stack image of this study identifies a distinct south-dipping reflection fabric from the surface to the upper mantle up to 70 km depth. This fabric is formed due to the subduction-accretion of Madurai block with Trivandrum block during the East-African orogen. Two distinct deep-seated shear zones, the Achankovil and Tenmalai, were also developed at both ends of the collision zone.

Key words: Common Reflection Surface Stack, Dharwar Craton, Southern Granulite Terrain, Tectonics.

APPLICATION OF SPECTRAL DENSITY RATIO TECHNIQUE FOR ISOLATION OF SEISMO-ELECTROMAGNETIC EMISSION FROM COMPOSITE LOW FREQUENCY MAGNETIC FIELD CLUSTER

Chandan Dey[1,2], Saurabh Baruah[2], Santanu Baruah[2]
1 Academy of Scientific and Innovative Research (AcSIR), Ghaziabad – 201002, India
2 CSIR-Northeast Institute of Science and Technology, Jorhat, Assam – 785006, India
Presenting author: s.chandandey@gmail.com

Seismo-electromagnetic (SEM) emission in the ultra-low frequency (ULF) band, i.e. between 0.001 and 10 Hz, is supposedly caused by mechanical deformations inside earthquake preparation zones and investigated as a likely candidate for short-range earthquake prediction. Several methods are proposed to isolate these faint SEM signals, which occur in the same frequency range as the magnetospheric emissions; the most widely used method is spectral density ratio analysis or polarisation ratio analysis (PRA), which calculates the ratio of the horizontal and vertical field components. Induction coil magnetometers (ICM) installed at the Multi-parametric Geophysical Observatory, Tezpur, which is located at proximity to the Kopili Fault and the Bomdila Fault, the Main Boundary Thrust of the Eastern Himalaya, the Naga and Disang Thrust, the Assam Syntaxis Zone, and the two tectonically active Precambrian shields – Shillong and Mikir, were employed to study probable SEM emissions using PRA technique for 51 (M_W 3.5 – 6.1) earthquake events recorded during the campaign period of April 20 – September 3, 2019. These 51 events were screened using strain radius, index of seismicity, and earthquake radius-magnitude relationship parameters to identify nine credible events that were then studied retrospectively for correlation between PRA results calculated for a frequency range of 0.03-0.1 Hz from local midnight ICM data that corresponds to the 18-21 hours K_P (Global geomagnetic activity) time window. All seven credible occurrences were related to PRA enhancements, establishing a case for candidate SEM emissions. On the other hand, several enhancements could not be linked to credible events, even though unscreened seismicity may account for such contingencies.

MODELLING OF PORE PRESSURE USING SEISMIC VELOCITY: A CASE STUDY IN THE UPPER ASSAM BASIN

Dip Kumar Singha [1,2*] Neha Rai[1], Rima Chatterjee [3]
[1]Department of Geophysics, Banaras Hindu University, Varanasi, India-221005
[2]Department of Geology and Geophysics, IIT Kharagpur
[3]Department of Applied Geophysics, IIT(ISM), Dhanbad, India
Presenting author: dipgeo89@gmail.com

The Assam-Arakan Basin in northeastern India is tectonically active basin, and the sedimentation of nearly 7000m of sedimentary rocks is found of tertiary period with the Precambrian granitic basement. In the study area, the various oil fields are explored along the border of Naga thrust. Pre-drill estimation of pore pressure within the formations of the complex lithology of the Assam-Arakan Basin is essential for the selection of drilling mud, and to avoid catastrophic incidents. First, the high pressure zones have been identified from the departure of shale velocity from normal compaction trend and, shale sonic and

density plot. Our main objective is to build a velocity model using seismic inversion to estimate the pore pressure. Derivation of velocity from the seismic data is the fundamental task of seismic inversion to predict pore pressure (PP) using Bowers method. It involves iterative forward modelling while reducing the cost function between the observed and synthetic data, and assuming that the wavelet derived from the seismic trace is known. Model based seismic inversion is currently advantageous to build a higher correlation model of the subsurface image beyond the seismic band limit. We estimate a spatial variation of pore pressure model in the study area from 3D seismic data. The PP model is build using Bowers method. The predicted PP model matches with the PP observed at well location, namely KM with the goodness of fit 0.87. The 3D PP mapping concludes the transition of Pore pressure within the Kopili and Sylhet formation, while Kopili is highly effective of high pore pressure. In addition, the results show the occurrence of high-pressure zones in Kopili formations of age Eocene. The 3D pore-pressure model Assam-Arakan Basin shows the high pore pressure magnitude ranges between 32-42 MPa in the Kopili formation.

ESTIMATION OF MAGNETIZATION DIRECTION USING DEEP LEARNING

T. Hemasundar Rao*, Abhey Ram Bansal
CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad, India
Presenting Author email: sundar.tandule@gmail.com

Magnetic studies offer a cost-effective method for investigating sedimentary basins' thickness, mineral deposits, and crustal structure. The precise knowledge of magnetization directions (inclination and declination) is required to interpret magnetic data. The existing methods of its estimation are complex and require extensive computational processes. Machine learning is found suitable for the assessment of magnetization directions. The convolution Neural Networks (CNNs), a deep learning model, is ideal for estimating magnetization directions. The CNN is applied to the synthetic magnetic data, which is generated by assuming different directions and depths. The assumed magnetic inclination varies from -90° to 90°, whereas declination varies from -180° to 180°. The anomalous magnetic body is assumed at depths ranging from 100 m to 1000m in a homogeneous nonmagnetic field. The synthetic magnetic data is randomly sorted and trained with 80% data. The synthetic magnetic data is corrupted with Gaussian white noise. The addition of noise does not affect the accuracy of prediction, whereas the depth of anomalous bodies reduces the prediction accuracy. The lateral extent of the body also affects the estimation of depth values. Reliable estimates within 95 % actual values can be obtained when the depth and lateral extension of anomalous bodies are provided close to reality. The synthetic trained CNN model is applied to the Central India aeromagnetic data.

Keywords: Magnetic, Magnetization direction, Inclination, Declination, Deep Learning

RESPONSE OF CHROMITE IN LATERITE ENVIRONMENT-THEORETICAL GRAVITY APPROACH

B. laxman, K.Satish Kumar and P.V.Sunder Raju
CSIR-National Geophysical Research Institute, Hyderabad
satish_marine777@yahoo.co.in

Chromite is an oxide of chromium and iron ($FeCr_2O_4$) with a density of 4.5 gm/cc. It's used in the production for strengthening and preparation of paints and other industrial applications. It is mainly associated with mafic/ultramafic rock units in the form of lenses, pods like dunite, serpentinite, norite, anorthosites and gabbro suites. The chromite deposits in India are overlain by laterite capping's for e.g. in Sukinda Valley, Orissa. A recent study under GEOMET project by CSIR, the integrated G^3 results shows that the exploration of chromite deposits can be well delineated by ERT, Gravity, Magnetic and Geochemical studies. An experimental study was conceptualised by using theoretical gravity models to understand the signature of rocks, with varying thickness, uniform density and uniform depth. In the present study, 50 standard gravity models are generated and discussed. The conclusion drawn using ideal conditions for laterite shows negative gravity anomaly, positive gravity anomaly for chromite and negative gravity anomaly for chromite with laterite. The laterite cap over the chromite play a crucial role to understand the gravity response of chromite occurrence. it is required to filter the laterite response from the actual field gravity anomaly to understand the clear response of chromite.

DELINEATION OF BASEMENT CONFIGURATION ALONG THE KHANDALA-BRAHMANWADA AND POPATKHEDA-PATUR PROFILES IN CENTRAL INDIA, USING TRAVEL TIME INVERSION

K. Laxminarayana[1,2*], P. Karuppannan[1], ASSSRS. Prasad[1], Biswajit Mandal[1,2], V. Vijaya Rao[1], Prakash Kumar[1,2]
[1]CSIR National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India
[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, India
*Presenting author (email: laxmingeo109@gmail.com)

The seismic refraction studies in the southeastern part of the Deccan syneclise along (I)Khandala-Brahmanwada (E-W), 120 km long, (II)Popatkheda – Patur (N-S), 80 km long between Satpura basin and Gondwana graben in central India was carried out to delineate basement configuration. Deccan Syneclise is an intracratonic sedimentary basin in western and central India covered mainly by the Deccan traps with hydrocarbon and coal potential. Imagine Gondwana and Mesozoic sediments below the Deccan traps is a challenging task. Conventional imaging within the near-vertical range fails to image the sediments below the traps due to a poor signal-to-noise ratio. The analysis reveals three layers above the basement along the two profiles. The study from profile (I) reports recent alluvium of maximum thickness of 0.4 km and seismic velocity of 1.8 km s^{-1} in the west and is terminated in between SP 30 and SP 31. The Traps are exposed from SP 31 onwards in the east. The Deccan traps with a velocity of 5.1 km s^{-1} are thinner in the west and become gradually thicker as it reaches the east with a depth of 1.5 km. The thickness of the Gondwana sediments varies from 0.2 km to 0.1 km with a velocity

of 3.8 km $s^{-1,}$ and it is sandwiched between the trap (5.1 km s^{-1}) and basement (6.1 km s^{-1}) in both profiles. Decay of amplitude is noticed in some observed seismograms with a small-time skip in refraction phases. This might be due to the presence of a low-velocity layer overlaying the basement.

Keywords: Deccan syneclise, Low velocity layer, Seismogram, Gondwana Sediments

SEISMIC NATURE OF UPPERMOST MANTLE AND INDIAN MOHO GEOMETRY BENEATH THE EASTERN KUMAON-HIMALAYA

S.Madhusudhan [1], Sandeep Kumar Gupta*, Nagaraju Kanna, Sudesh Kumar, K.Sivaram
CSIR-National Geophysical Research Institute, Hyderabad 500007, India
[1]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad 201002, India
Presenting author email Id: sriramamadhu1994@gmail.com

We provide geometry of Indian Moho and seismic nature of uppermost mantle beneath the eastern Kumaon Himalaya by investigating the uppermost mantle velocities (Pn and Sn) using 10 regional earthquakes recorded by 30 digital broadband seismological stations from ganga basin to Tethys Himalaya along a ~160 km profile. We use the two-way travel time and interstation velocity methods to calculate the Pn and Sn velocities. The results show that the apparent Pn and Sn velocities are different for the earthquakes from north (Updip direction) and south (up dip direction) of the profile. The significant difference between the updip and downdip velocities are clearly indicating the Moho is dipping at shallow angle (3.43°-4.2°) beneath the study area. We calculate the true Pn and Sn velocities are 8.06±0.01 and 4.43±0.01 km/sec throughout profile by considering the dip angle. The calculated Pn interstation velocities South Chiplakot Thrust (SCT) clearly indicates almost flat Moho to south of SCT in the Lesser Himalaya. Significant Pn interstation velocity variation in both updip and downdip directions for stations pair to the north of SCT and reveal a sudden steepens (8.65±0.95°) of the Moho further north of SCT whereas sudden rise in topography.

Keywords: Eastern Kumaon Himalaya; Chiplakot Thrust; regional wave form analysis; Upper most mantle velocities; Indian Moho geometry

MUONG NONG TEKTITES RESULT OF AN OBLIQUE IMPACT IN TIBET : STUDY BASED ON HALE CRATER

Mahesh Patil
Mail id : mup124@rediffmail.com

Muong –Nong and other Asian tektites are result of highly oblique impact on Indochina border. A study of oblique impact crater on Mars and a laboratory stimulation by Schultz et al. (2012) suggested that impact at an oblique angle to horizontal results not only in oblique craters but also result in high-velocity, low angle ejecta along the initial impact trajectory axis downrange. At early stage of highly oblique impact, fragments of the projectile travel down range at a speed close to initial impact velocity

causing sibling impacts. In early stage of oblique impact, projectile momentum coupled to the target is preserved in high-velocity ejecta directed along trajectory axis and is localized within a narrow fan downrange. Thus downrange melt distribution of oblique impact is mix of melt from target rock and projectile fragments, spread in a narrow fan area in the down range of impact trajectory axis. We have extrapolated these findings to understand the distribution of Muong Nong (Layered tektites) and splash-form homogeneous tektites in Asia. We have used Inclusions like lithium, boron and Kyanite in Muong Nong along with other shock metamorphic evidences like high-pressure minerals to locate the possible impact location. Current study suggests a highly oblique impact in Tibet may be responsible for tektites reported from Asia.

SITE RESPONSE ANALYSIS FOR THE LAND OF MAHABHARATA-KURUKSHETRA, HARYANA, INDIA

Manisha Sandhu[1*], Abhishek[1], R.B.S. Yadav[1] and Dinesh Kumar[1]
Department of Geophysics, Kurukshetra University, Kurukshetra-136 119
Presenting author: sandhu.manisha553@gmail.com

The surface geology is one of the dominant factors that affect the amplitude, duration, and frequency content of strong ground motion. In the present study, the validity of seismic site response characteristics inferred from the 'single site' ambient noise H/V spectral ratio has been investigated. Site amplification functions have been estimated at 60 different sites in and around Kurukshetra. The fundamental frequency is found to be low for most of the region and falls in the range 0.60-0.90 Hz i.e. less than 1 Hz whereas the amplification level ranges in between 2 and 3. The value of the site amplification is high which is maybe due to the loose sediment cover over the region. The spatial distribution of site amplification and the predominant frequencies also has been prepared. The results obtained in this study demonstrate the usefulness of the H/V spectral ratio method using ambient noise to provide reliable information on the dynamic behavior of surficial layers such as estimating sediment thickness and shear wave velocities, and for the preparation of seismic hazard maps in the region. Based on these results we can suggest that the ambient noise H/V spectral ratio technique can satisfactorily indicate areas of higher or lower damage potential in the city of Kurukshetra. Hence, it can be employed to microzonation studies in urban environments because of the fast data acquisition, low cost, limited requirements in personnel and equipment and reliable results.

IMPROVEMENT OF STRUCTURAL IMAGING IN FOLD BELT AREA BY SWATH-LINE SEISMIC DATA

Manoj Kumar Bhartee*[1], NM Dutta[1], Yadunath Jha[1], Uma Shankar[2]
[*1] Oil and Natural Gas Corporation Limited;[2] Banaras Hindu University, Varanasi
manoj.bhartee@gmail.com

In spite of advancement in seismic data acquisition and processing, imaging in structurally complex area such as fold belts has improved marginal. In such geologically complex areas conventional approach to imaging may not yield satisfactory results. Though in such areas 3-D survey is more preferable but due

to several constraints, acquiring 3-D data may not be possible. Rough topography & difficult accessibility can make 3-D land seismic data acquisition prohibitively expensive. Conventional 2-D land seismic data has its own limitations especially in fold belt areas, difficult to image anticlinal portion properly. An alternative to conventional 2-D in such areas is swath-line recording geometry. Swath-line recording provides much higher fold (720 fold in the present case) than typical 2-D land surveys, thus provides data with a much higher signal-to-noise ratio.

Keywords **:** Swath-line, CMP line, S/N, Semblance, CVS

3D SEISMIC INTERPRETATION FOR DELINEATION OF COAL SEAMS: A CASE STUDY FROM SOUTH KARANPURA COALFIELD

V. Muthulakshmi[1, *], Uma Vadapalli[1] and Nimisha Vedanti[1]
[1] CSIR-National Geophysical Research Institute, Hyderabad-500007, India
*Presenting author: lakshmiraj@ngri.res.in

Given the growing energy demand and faster depletion of conventional energy resources, Coal Bed Methane (CBM) is considered the most viable future energy resource. In India, the CBM reserves in the Gondwana basin hold significant prospects to ensure a sustainable energy supply in the future. However, Gondwana coalfields are highly challenging for various reasons. Under such heterogeneous conditions, a reliable estimation of CBM resources needs continuous subsurface information of the coal seams. Thus, for delineation of coal seams in one of the Gondwana fields called 'South Karanpura,' situated in the Damodar basin, we have carried out a High-Resolution Seismic (HRS) interpretation. The interpretation of the 3D HRS data from the study area delineated the major coal seams and the associated discontinuities. The coal seams and discontinuities are identified based on Acoustic Impedance and Coherency attributes, respectively. The delineated coal seams are broadly in agreement with the well markers provided by the CMPDI. Thus, based on this study, we suggest that HRS data can be beneficial for delineating coal seams and CBM resource evaluation.

Keywords: Coal seam, Seismic Interpretation, Acoustic Impedance, CBM, Coherency attribute.

AN INTEGRATED TECTONIC MODEL OF THE SIKKIM HIMALAYA FROM MAGNETOTELLURIC INVESTIGATIONS

G. Pavankumar and A. Manglik
CSIR-National Geophysical Research Institute, Uppal road, Hyderabad – 500 007
gayatripavan@ngri.res.in

The occurrence of deep crustal strike-slip earthquakes in the Sikkim Himalaya is indicative of ongoing transverse tectonic deformation of the Indian plate, in addition to the N-S convergence related deformation within the wedge. The two dominant tectonic forces that are operating in this region could lead to a complex variable spatial deformation within the Indian lithosphere. Two-dimensional modelling of the broadband (0.01-1000 s) and long period (up to 10,000 s) magnetotelluric (MT) data

incorporating the NW-SE transverse tectonic trend within the Main Central Thrust zone (MCTZ) yields a lithospheric electrical resistivity structure of the region down to 100 km. By integration of the MT results with other geophysical information, seismological data and in conjunction with a kinematic wedge model, we propose a comprehensive tectonic model for the Sikkim Himalaya that highlights the complex nature of the lithospheric structure and a ramp-flat-ramp type geometry of the Main Himalayan Thrust in the region. A major contact beneath the MCTZ separating two geologically and compositionally distinct blocks of the underthrusting Indian plate is suggested to be a NW-SE trending lithospheric-scale fault in this segment of the Himalaya. Partitioning of the stresses generated due to the northward convergence along the transverse tectonic feature can explain strike-slip nature of the earthquakes as well as occurrence of upper mantle earthquakes in the region. The tectonic model also demonstrates another crustal-scale tectonic feature beneath the Main Frontal Thrust that demarcates a transition zone of moderately conductive crust of the Ganga Foreland Basin and a resistive crustal block beneath the Sub-Himalaya. We attribute the zone to a necking process that possibly resulted in the omega shape of the Main Central Thrust in this region.

TIME LAPSE HYDROGEOPHYSICAL METHODS TO ASSESS THE VARIABILITY IN GROUNDWATER CONDITION

Piya Mohasin, Tanvi Arora, Sujata Ray
IISER Kolkata, CSIR-NGRI Hyderabad, IISER Kolkata
Piya Mohasin: piyamohasin@gmail.com

Water security is vital for sustainable aquifer in day to day lives. Groundwater is the main source of irrigation in rural Indian villages The hydrogeophysical (electrical resistivity) method is used to analyze the seasonal variations in groundwater level at seven locations near the region Khujutipara, Birbhum district, West Bengal during pre-monsoon, monsoon, and post-monsoon seasons. Very Fast Simulated Annealing (VFSA) global optimization technique has been used to interpret the subsurface resistivity. The analysis of the field data indicates that the layers show low resistivity signatures in pre-monsoon season and high resistivity signatures in post-monsoon season in majority of the locations. This suggests a long recharge/infiltration duration and rapid discharge characters for the top layers. The discharge from the top layers is received by the subsequent layers justifying vertical hydraulic conductance. While the subsequent layers are characterized by rapid recharge and discharge character. Due to this character, the layers get depleted with huge abstraction of the groundwater mainly used for irrigation purposes in the Kharif cropping season. Since, the top layers are not conducive for rapid rate of infiltration, thereby hindering the natural recharge and increases runoff. The subsequent layers, have rapid discharge property and therefore gets depleted easily due to pumping of groundwater for irrigation purposes. Hence, managed aquifer recharge is strongly needed to maintain the groundwater level in this area and provide a water security for futures usages.

PORE STRUCTURE ANALYSIS AND PERMEABILITY PREDICTION BY USING FRACTAL THEORY BASED ON SEM IMAGES OF CARBONATE SAMPLES

Pydiraju Yalamanchi[1], Saurabh Datta Gupta[1]
[1] Department of Applied Geophysics IIT(ISM) Dhanbad.
Email: pydiraju.geo@gmail.com

Pore structure analysis of carbonate reservoirs is complex and heterogeneous. Permeability is one of the primary critical parameters for quantitatively estimating subsurface reservoir resources and accurately predicting the rates of fluids (water and hydrocarbons) inflow into complex reservoirs. This study presents an efficient algorithm for pore structure analysis on a quantitative and quantitative approach. In the qualitative analysis, we estimate discrete pore size distribution (DPSD) and grain size distribution using different binary image segmentation algorithms. The Euclidean distance transformation approach performs after image segmentation, where the segmented images extract the connected voxel skeletons, which were used to mask the calculated distance maps. In quantitative analysis, we estimate the porosity and permeability of the carbonate samples based on the box-counting method using the Kozeny – Carman equation and fractal parameters. The pore structure's geometrical parameters (area and perimeter) were calculated using Green and Euler distance methods. The logarithmic relationship between geometrical parameters of the pores and power function illustrates the higher correlation value of 0.98. This whole work has been carried out by using an Open-source ImageJ application and Matlab coding. Comparing different binary segmentation algorithms, the estimated porosity of carbonate samples based on the MaxEntropy algorithm gives accurate values (15% to 19%). These results validate those of the existing studies of the same carbonate samples. We found the effect of the magnification scale on the image resolution and its influence on the minimum pore size and maximum grain size distribution. This study shows minimum pore size characterization of sample S1:(x1500) 0.89 µm and at (x2000) 1.19 µm, like maximum grain size characterization of sample S3:(x1500) 780 microns and at (x2000) 480 microns. We can conclude that at high resolution, more micropores and less grain matrix are observed in the formation. These results help to understand the pore network variation and fluid flow in carbonate samples.

RECENT SEISMICITY AND MINIMUM 1-D VELOCITY MODELS OF NORTH-EAST INDIA REGION

Rabin Das[1*], S. Mukhopadhyay[2], Mala S. Bagiya[1] and Nava Kumar Hazarika[1]
[1]Shillong Geophysical Research Centre, Indian Institute of Geomagnetism, Shillong- 793005, India
[2]Department of Earth Sciences, IIT Roorkee, Roorkee- 247667, India
* Corresponding Author Email: rabingeophy@gmail.com

A high rate of seismic activity was observed in North-East India region due to northward and eastward movement of the Indian plate with respect to the Eurasian and Burmese plates, respectively. Understanding of seismicity of North-East India is essential as these areas lie in the seismic zone V. A total of 726 local earthquakes recorded by the Seismic Network of National Centre for Seismology,

India, and Indian Institute of Geomagnetism in North-East India region between latitude 22^0N to 28^0N and longitude 89^0 E to 97^0E that occurred between April 2011 and June 2020 are analyzed for 1D velocity models. Finally, a total of 326 well-located local earthquakes having 1865 P and 1822 S arrivals are used for 1D traveltime inversion. Taking five initial velocity models, a minimum one dimensional (1D) velocity model is estimated. For incorporation of data for inversion, only those earthquakes are chosen for each of which a minimum of five P- and five S-phase readings are available with azimuthal gap $\leq 180^0$. The Vp and Vs models show systematic increase in velocity with depth with a large jump in velocity at 40 km depth. We interpret this as the average location of Moho in this region. Just below Moho the P and S velocity are around 8.1 km/s and 4.8 km/s respectively. The Vp/Vs value between 30 and 40 km depth is 1.8. This shows that just above Moho there is a fluid filled fractured zone present in this region.

THE P AND B VALUES SUCCEEDING THE 25 APRIL AND 12 MAY, 2015 CENTRAL HIMALAYAN EARTHQUAKES.

Ram Krishna Tiwari [1, 2] Harihar Paudyal [2]

[1]Central Department of Physics, Tribhuvan University, Kirtipur, Kathmandu, Nepal

[2]Birendra Multiple Campus, Tribhuvan University, Bharatpur, Chitwan, Nepal,

Corresponding email: ram.tiwari@bimc.tu.edu.np

The 2015 Gorkha earthquake in the central Himalayan region commenced with a magnitude Mw 7.8 on April 25 and followed by intense seismicity including an Mw7.3 Dolakha earthquake on 12 th of May. In this study, we used the data from National Seismological Centre (NSC), Nepal and analysed 374 events (Mc=4.2 ML) from 2015.04.25 to 2015.05.11 for Gorkha earthquake and 175 events (Mc=4.2 ML) from 2015.05.12 to 2015.06.12 for Dolakha earthquake. The Aftershocks sequences for both events were well modelled by the Omori-Utsu law with p = 1.2 ± 0.11 for Gorkha earthquake and p = 0.76 ± for Dolakha earthquake. These values indicate that the temporal decay of seismicity agreed with typical decay with p=1 for Gorkha earthquake and decay rate is slow for Dolakha earthquake. The frequency magnitude distribution b–values 0.89 ± 0.05 and 0.90 ± 0.07 are observed for the respective events. The relatively high p value observed for the Gorkha earthquake may correlate well with the large slip experienced by the seismogenic source and relatively small p and b-values observed for Dolakha region may indicate that the region has not gone through complete rupture yet and it is under high stress. The findings indicate the regions are in the verge of getting stable value of the stress level through the small to moderate earthquakes.

Keywords: Aftershocks, Decay rate, Omori law, Stress, Central Himalaya

INTEGRATED GEOPHYSICAL APPROACH FOR LOCATING FRESH WATER LOCATIONS IN A SALINE AFFECTED COASTAL TERRAIN

Ratnakar Dhakate[1] and Ayushi Agarwal[1,2]
[1]CSIR-National Geophysical Research Institute
(Council of Scientific & Industrial Research)
Uppal Road, Hyderabad-500 606, A.P., INDIA Tel: +91-040-27012000; Fax: +91-040-27171564
[2]Academy of Scientific and Innovative Research (AcSIR) Ghaziabad-201002, India
Corresponding Author: dhakate.ratnakar@gmail.com

Vertical Electrical Sounding (VES), Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) were carried out in a coastal terrain of saline affected areas of Vizag Steel Plant (VSP), Visakhapatnam, A.P., India for locating fresh water locations. The area was covered with recent alluvial of varying thickness consists of sand, clay and silt with basement as Kondalite rock with few saline water pockets. Locating favorable fresh groundwater locations in such a terrain is a difficult task. The resistivity signatures for saturated clay, saturated silt and saline water are same and mislead the data interpretation for locating and recommending the suitable fresh groundwater locations. To overcome these uncertainties, a second geophysical approach or combinations of geophysical methods become necessary to resolve these resistivity ranges in a more reliable and better fruitful interpretation of sub-surface layers. In order to pin-point the fresh groundwater locations; VES, ERT and GPR investigations were carried out. Interpreted results of VES, ERT pseudo-section and GPR images (radargram) were correlated with each other to ascertain confidently the geophysical signature of the sub-surface. Combination of geophysical methods gives better resolution or interpretation of sub-surface information before recommendations for drilling of borewell. Based on integrated geophysical investigation few borewell sites were recommended and drilled. The observed drilled lithologs was well correlated with the VES, ERT and GPR data. Besides, this hydrochemical analysis of water samples was carried out from the existing borewells and dugwells. Total Dissolved Solids (TDS) concentration were ranges from 189-3398 mg/l. TDS concentration of drilled borewell was found to range from 400-500 mg/l. The observed yield of drilled borewells ranges from 104-3623 gallons/hr.

Key words: Vertical Electrical Sounding (VES), Electrical Resistivity Tomography (ERT), Ground Penetrating Radar (GPR), and Groundwater Potential.

STRUCTURAL STYLES AND PETROGRAPHY OF HIGH-GRADE GNEISSES PERTAINING TO EVOLUTION OF ASSOCIATED ULTRAMAFIC INTRUSIVES IN ADDITION TO AMS STUDIES, WEST OF SALEM CITY, SOUTHERN INDIA.

V. V. Salve[1*] and D.P. Mohanty[1]
Department of Geology, Savitribai Phule Pune University, Pune-411007, India
*presenting author email id: vinayvsalve@gmail.com

The Southern Granulite Terrain (SGT) has preserved Archaean and Proterozoic crust with extensive high-grade granulite facies rocks and is believed to be of lower crustal origin through a complex evolutionary history with multiple deformations, anatexis, intrusions and polyphase metamorphic events.

A crustal-scale suture zone divides SGT into discrete tectonic, juxtaposed crustal blocks, which are fragmented and dismembered. Among these high-grade crustal blocks, the block north of the Cauvery Suture Zone (CSZ), designated as the Northern Granulite Block (NGB), consists of high-grade gneisses, charnockites, mafic granulites and mafic/ultramafic intrusions. Our data emphasizes the fold styles and other structural patterns of the area, which includes regionally metamorphosed high-grade rocks as basement for the multiple ultramafic intrusions to the north of CSZ which highlights the finite strain geometry, complex deformation pattern and high-grade metamorphism. Structural map of the study area shows two generations of folding, namely F1 whose axial trend is subparallel with general trend of gneissic foliation and are tight isoclinal folds while F2 which are open folds with axial trend NW-SE. Structural cross section across the general trends of foliation planes, represent antiformal and synformal fold patterns of the basement due to varying dip directions which also reflects superposed fold patterns demonstrating type-3 interference. Mesoscopic structures include ductile features such as small scale shear zones of dextral kinematics developed in response to E-W collision during Paleo-Meso Archean time, kinematic indicators (delta type porphyroclasts, S-C fabrics) along all the foliation planes are consistent with the dextral movement of CSZ system, riedel shear, thrust imbricates implying duplex structures, rotation of mafic boudins along shear zones. Brittle structures like different generations of joints and faults indicate younger deformation as well. Petrography classifies the major lithologies into amphibolite gneiss, migmatite gneiss, charnockites, granulites and mylonites as basement rocks to the younger pyroxenite intrusions. Typical textures like, perthite, granulose, reaction rims, sieve textures and microstructures like S-C fabrics, kink bands, rotated porphyroclasts, etc are observed within the basement rocks. Granulites show coarse grained textures with fractured porphyroblasts of garnets indicating the water interactions and retrogradations within the granulite facies rocks. Reaction rim texture are indicative of retrogression is observed in charnockites and granulites. The coarse grained cummulate nature of pyroxenites neither represent deformation nor metamorphism. From the Anisotropy of Magnetic Susceptibility (AMS) analysis of various pyroxenite samples denote different deformational paths, susceptibility, degree of anisotropy and shape of the fabrics. From the structural cross-section and AMS it is conjectured that the origin of the dykes may be from a single magma chamber, however there is a significant gap between the intrusions.

SEISMOGENESIS OF TWO M > 4.0 RECENT EARTHQUAKES IN SOUTHWESTERN PARTS OF DELHI NCR AND THEIR SOURCE CHARACTERIZATION

Sanjay K Prajapati[1], Ajeet P Pandey[1], Arun K Gupta[2] and O. P. Mishra[1,2]

[1.] National Centre for Seismology, Ministry of Earth Sciences, New Delhi

[2.] Ministry of Earth Sciences, New Delhi

Email: sanjaynecessary@gmail.com

Two significant earthquakes (M 4.6 and 4.2) occurred close to a NE-SW trending lineament in the southwestern part of Delhi NCR (National Capital Region). The events occurred within a short time span of about five months in 2020 and they were located to the north of the Alwar district of Rajasthan, which generated a significant ground shaking in and around Delhi. In the present study, an effort was made to

understand a causal relationship between the events and a nearby source in the region, which has been geologically demarcated with the presence of lineaments. We analysed broadband waveform data of 17-seismic stations that recorded recent two events, viz., July 03, 2020 (M4.6) and December 17, 2020 (M4.2). Typically, the epicentral area has been devoid of such significant earthquakes since past six decades; however, a few minor events (M < 4.0) have been recorded. Analysis of earthquakes database for two decades (2000-2020) revealed low seismicity (nearly quiescent like situation) in ~100 sq km area around the epicentral zone, unlike large seismicity along faults / lineaments close to the Delhi region. The full-waveform inversion analyses of the events indicate a normal faulting with a minor strike-slip component. The source parameters consisted of source radius, stress drop, and seismic moment were estimated to be 6 km, 166 bars, and 8.28E+15 Nm, respectively for the July 03, 2020 event and 4 km, 138 bars, and 2.29E+15 Nm, respectively for December 17, 2020 event. In addition, the causative source of the events is ascertained based on stress inversion modelling that indicated NW-SE tensile stress corroborating well with a NE-SW trending lineament mapped in the study region. We opine that the lineament was probably activated due to the regional tectonics of the study area. The causative source with strike 47.8°, dip 86.8°, rake − 61.1° is found to be in conformity with the local tectonics, and is well supplemented by a high-stress ratio (0.72 ± 0.05) as well as low friction coefficient (0.5).

Keywords: Waveform inversion, source parameters, stress drop, seismic moment, stress modelling, tectonics, lineament.

IMPROVED PREDICTION OF THE SONIC LOG USING VOTING REGRESSOR ALGORITHM: A CASE STUDY FROM GANDHAR OILFIELD, CAMBAY BASIN, INDIA'S FIRST CO_2 EOR PROJECT

Saqib Zia[1, 2,*], Shubham Dabi[3] and Nimisha Vedanti[1, 2]

[1] CSIR-National Geophysical Research Institute, Hyderabad-500007, India

[2] Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India

[3]Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines), Dhanbad-826004, India

*Presenting author: saquibzia@ngri.res.in

The Gandhar oilfield is a pilot study for India's first large-scale CO_2 enhanced oil recovery (EOR) project, operated by the Oil and Natural Gas Corporation (ONGC), Govt. of India. To reduce ambiguity in geological interpretation and reservoir characterization, integrating geophysical well-logs with seismic data is crucial. The sonic log plays a vital role in static and dynamic reservoir characterization, which is a well-established fact. However, the sonic log was not recorded in all the wells in many matured fields due to economic or logistic issues. In such cases, the static and dynamic reservoir characterization becomes a challenge, especially if the seismic data quality is poor. In many cases, empirical equations are used to estimate the sonic logs, but these equations are highly dependent upon the lithology and do not consider other logs.

We, therefore, propose an efficient data-driven machine learning (ML) ensemble technique called Voting Regressor (VR) to predict the missing sonic logs using the information from the density, gamma-ray, neutron-porosity, and resistivity logs. The main concept behind the Voting regressor is to combine

different machine learning regressor methods and return the average predicted values. Here, we have deployed Gradient Boosting (GB) Regressor and Stochastic Gradient Descent (SGD) regressor in VR to balance their individual weaknesses and make improved predictions than the particular method.

The VR method is validated using a test data set. It was observed that this method predicts less root-mean-squared-error (RME) than the individual regressor methods and fits the recorded curve more efficiently. The proposed method predicts the sonic logs in 3 blind wells from Gandhar oilfield, Cambay Basin, India. We found that the VR produces reliable predictions and demarcates the significant lithological changes efficiently.

PEARSON CORRELATION COEFFICIENT STATISTICS FOR DISPERSIVE CURVE CONSISTENCY

K. Satish Kumar, K.Swapna Sri*, B. Laxman, P.Sivasankar, P.Pavan Kishore and D.Srinagesh
CSIR-National Geophysical Research Institute, Hyderabad
Email:kandepuswapna979@gmail.com

Precision of Multichannel Analysis of Surface Wave (MASW) resultsmainly depends on generation of dispersive curve, extraction of dispersive energy and its inversion. The characteristics of the dispersive curve may vary based on the nature of the surface geology (sedimentary, Igneous and Metamorphic) and selected data acquisition parameters (offset, group interval, source and length of the traverse).Theaccuracy of final 1D shear wave velocity results can be evaluated based on the consistency of dispersive curve endorses. Pearson Correlation Coefficient (PCC) is one of the statistical analysis tool useful to measure the linear relation between two different data sets. The strength of the relation between two data sets provided in terms of coefficient between -1 to +1. The positive coefficient indicates the strong/best relation, whereas negative coefficient indicates the reverse correlation between two data sets.PCC analysis is very much useful for correlation and evaluation of the consistency in dispersive curvesgenerated by MASW study. This methodology was examined on MASW data acquired along the two orthogonal profiles (P1&P2) in a Kaladgi basin with a lithological succession of clay/slit/soil and quartzite and granitic rock sequentially up to depth of 150 m. Pearson Correlation Coefficient analysis carried out for phase velocities of the two profiles and obtained positive correlation.MASW study results with similar acquisition parameters in a constant lithological terrain provides same phase velocities irrespective of the direction of the profile. Further, 1D shear wave velocity images from the two orthogonal profiles well corroborated with the existing borehole information. Hence, it is concluded that PCC analysis is effectively useful for cross verification of the MASW parameters and results.

Keywords: Pearson Correlation Coefficient, MASW, Dispersive curve, Kaladgi basin and sedimentary.

CAPTURING GROUNDWATER DISASTER WITH TIME VARIABILITY OF THE REPRESENTATIVE PARAMETER

Seema Begum[1, 2, *], Salman Ahmed[3], Tanvi Arora[1,2] and Shakeel Ahmed[4]

[1]Electrical Geophysics Group, CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India

[2]Academy of Scientific and Innovative Research (AcSIR)-National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India

[3] Department of Geology,Baba Farid institute of technology(BFIT), Dehradun College, Dehradun

[4]School of sciences, Maulana Azad National Urdu University, Hyderabad

*presenting author's email ID: mominseema94@gmail.com

Water disaster tops all types of natural disasters and the visible climate change adds to this situation. Thus a scientific and systematic assessment of its cause and spatio-temporal variability is imperative. Water resources has to be very judiciously managed because too much of water or too less of water, both cause disaster. Even polluted water is a disaster. Groundwater quality of an Alluvial aquifer in Ganga basin have been analysed. The basic quality parameters and cations as well as anions have been monitored from a dense network for six seasons mainly in pre-monsoon and post-monsoon periods of 3 consecutive years. The spatio-temporal variability of EC that represents most of the quality of groundwater has been presented here. The variograms of the EC values monitored during pre and post monsoon periods for 3 years were computed as experimental Variogram. The experimental variogram was suitably fitted with theoretical Variogram models and the basic parameters defining the variogram viz., sill, range and the nugget effect were compared for various time periods. Although Post-monsoon variability tends towards randomness but we found this trend in pre-monsoon variograms also. This is attributed to anthropogenic causes and hence disastrous. This of course, may be confirmed with a few more parameters. However, Variography analysis that is a simple exercise reveals that the variation in time variability can be attributed to the disaster.

Keywords: Spatio-temporal variability, Electrical Conductivity (EC), variogram, water disaster

MODEL-BASED GROUND ROLL ATTENUATION OF SEISMIC DATA THROUGH GENETIC ALGORITHM

Shaik Nasif Ahmed [* 1,2], Alok Kumar Routa [1], Nimisha Vedanti [1,2]

[1] CSIR-National Geophysical Research Institute, Hyderabad-500007, India

[2] Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India

[*]Presenting author: shaiknasifahmed@gmail.com

Ground roll is a common coherent noise observed in land field seismic data, characterized by low frequency, low velocities, and high amplitudes. It interferes with desired signals, and masks the reflections both in spike source and vibroseis data. In the case of vibroseis, the effect of the ground roll is more prominent. Conventional methods for noise removal do not remove it efficiently and in the worst-case, mute is applied which leads to the loss of data. Hence, we are demonstrating the application of a

model-based surface wave attenuation technique for the efficient removal of ground roll from 2D seismic data. The model-based ground roll attenuation method employs inversion and adaptive subtraction filtering of surface waves. An initial model is characterized to compute synthetic seismogram, by considering thickness, P & Sv velocities, density, and P & Sv wave quality factors for each layer. Then, a Genetic Algorithm (GA) is used to match the dispersion spectra of raw seismic data and model predicted synthetic data. Once the difference between these two dispersion spectra is minimized, the synthetic data is stored and adaptively subtracted from the raw seismic data to attenuate the ground roll. The proposed technique is applied on a 2D shot gather (Oz25.segy) taken from the SEG wiki Open data set collection of Oz Yilmaz-40 shots. From the result, it is observed that the ground roll is efficiently attenuated and reflections appeared more prominently by restoring the actual amplitudes. The study suggests that the method is quite efficient for surface wave attenuation.

Keywords: Coherent noise, Ground roll attenuation, Genetic Algorithm, Adaptive subtraction.

GEOCHEMICAL EVALUATION AND HEALTH RISK ASSESSMENT OF FLUORIDE AND NITRATE IN GROUNDWATER AND SURFACE WATER OF YADADRI-BHUVANAGIRI DISTRICT, TELANGANA

Shekhar More[a,b], Gunnam Venkata Ratnalu[a,b] and Ratnakar Dhakate[a,b]

[a]CSIR-National Geophysical Research Institute, Hyderabad-500007, India

[b]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India

Corresponding Author, E-mail: shekharmore4444@gmail.com

Twenty-eight groundwater and 19 surface water samples were collected for pre and post-monsoon season from Yadadri-Bhuvanagiri District of Telangana and analysed for major ions. The fluoride and nitrate concentration in groundwater ranges from 0.4 ± 2.9 and 8.3 ± 394.5 for pre-monsoon and, 0.6 ± 3.6 and 0.0 ± 506.7 in post-monsoon while in surface water it ranges from 0.4 ± 3.5 and 0.0 ± 92.9 for pre-monsoon and, 0.9 ± 3.2 and 0.0 ± 55.8 for post-monsoon seasons respectively. The geochemical evaluation for drinking and irrigation purpose were observed in the study area. The water quality data and sources of the dissolved constituent were analyzed by Piper Trilinear Diagram, Gibbs Plot, and Chloro-Alkaline Indices. Besides these, Principal Component Analysis (PCA) and health risk assessments were carried out for different age groups. PCA result procures the water chemistry is controlled by geogenic and anthropogenic activities. The health risk assessment for fluoride results divulged the hazard quotient via ingestion (HQ_{ing}) had a higher chronic hazard than the dermal pathway. Pre-monsoon HQ_{ing} percentage values of fluoride in groundwater and surface water for the age group of 6-12 months are 92.85 and 97.73 respectively and for other age groups, higher values of HQ_{ing} were also observed. All the samples of age group 6-12 months of post-monsoon have HQ_{ing} values greater than 1 for fluoride. Similarly, the hazard quotient for nitrate via HQ_{ing} had a higher chronic hazard in groundwater than in surface water. Based on the results strategic mitigations were suggested to improve the groundwater quality.

A GRADUAL DENSITY HETEROGENEITY BENEATH THE INDIAN OCEAN GEOID LOW

Shib S Ganguli, Akash Debnath, and Prakash Kumar
CSIR-National Geophysical Research Institute
Presenting author: shibg@ngri.res.in (SSG)

The Indian Ocean Geoid Low (IOGL) anomaly, situated at the south of the Indian peninsula, is one of the most remarkable features on Earth. To date, several hypotheses have been postulated to elucidate this negative anomaly, but no consensus has been reached so far. Through this study, we took the opportunity to get insights into the genesis and causative source depth of the largest negative geoid anomaly by combining gravity and the global seismic tomography dataset. Generally speaking, crustal or sub-surface heterogeneities exhibit scaling or fractal characteristics, and therefore the power spectrum method following scaling law can offer better perceptions into the sub-surface source distribution. Scaling spectral inversion of the gravity data suggests that the causative source depth lies between 150 to 1000 km. Further, the global tomography models indicate the occurrence of low-velocity zones in the upper mantle that resembles closely to our inferred source depths. Through integrated analysis of seismic and gravity, we conclude that such negative geoid anomaly can be explained by a gradual density heterogeneity model, possibly due to a collective effect of low mid-to-upper mantle hot, less dense rocks and cold dense rocks corresponding to the depth ranging from 150 km to a depth down to 1000 km.

COSEISMIC IONOSPHERIC DISTURBANCES (CID) DUE TO 2004 (ANDAMAN-SUMATRA EARTHQUAKE) AND 2005 (KASHMIR EARTHQUAKE) – ANALYSIS OF TOTAL ELECTRON CONTENT (TEC)

Shikha Vashisth[1], Sasi Kiran Gera[1], Ambikapathy Ammani[1*], O.P Mishra[1]
National Center for Seismology-Ministry of Earth Sciences, New Delhi
Presenting author: ammani.ambikapathy@gmail.com

We have analyzed the Coseismic Ionospheric Disturbances (CID) due to the 26th December 2004 earthquake of Mw 9.2, which occurred in the Sumatra-Andaman subduction zone and 8th October 2005 earthquake of Mw 7.6, using cGPS-aided Total Electron Content (TEC) measurements. For the CID analysis, of 2004 earthquake we used data from nearby seven Sumatran GPS Array (SuGAr) and two International GNSS Stations (IGS) located to the south of the epicenter, at a distance 500-1000 km (near-field) and two IGS stations located to the north-west of the epicenter at a distance 2000km (far-field) are considered. For the analysis of 2005 earthquake we used GPS data from 10 stations, namely, Chumysh (CHUM), Kitab (KIT3), Tashkent (TASH), Bishkek (POL2), Soloman Islands (SOL1), Kazarman (KAZA), Naval station Newport (NPRI), Talas (TALA), Kumtor-2 (KMTR), NADI and PAN2, which were geographically located within 1000 km of the epicentre and about 10 km to the east of Balakot and 19 km to the northeast of Muzaffarabad in Pakistan

In case of 2004, the CIDs with a propagation velocity of 595- 694 m/s arrived within 2–10 min after the earthquake, depending upon the distance of station from the epicentre. Variation in the CIDs can be prominently seen at the nearest cGPS Station SAMP immediately after the earthquake. NTUS, being the farthest station shows some small variations. The delay in the occurrence of variations at GPS sites can also be associated with the rupture propagation. Because all the stations used in our analysis are located south of the epicenter and rupture and there were no GPS sites north of the rupture, the trend of rupture propagation could not be analysed clearly.

In case of 2005, a prominent anomalous co-seismic CID observed at three GPS stations, viz., NADI, PAN2 and SOL1, which are located in the distance range of about 350 – 500 Km from the epicenter. However, other GPS stations located beyond 500 km have not shown such anomalous changes. The co-seismic ionospheric disturbances have been observed approximately 23 - 25 minutes after the occurrence of the earthquake. The similar time delay in co-seismic changes at NADI, PAN2 and SOL1 may be attributed to near identical distances of the stations from the epicenter, which can be studied extensively as one of the potential earthquake precursors.

TWO DIMENSIONAL INDUCED POLARIZATION IMAGING TO DELINEATE KAOLINIZED ZONES IN THE KHONDALITIC TERRAIN OF NORTHERN PARTS OF EASTERN GHATS OF INDIA

Siva Prasad Yellapu[1] and Venkateswara Rao Bekkam[2]

[1] Deltaic Regional Centre, National Institute of Hydrology, Kakinada, India
[2] Centre for Water Resources, IST, JNT University University, Hydeerabad India,
Presenting Author: cwr_jntu@yahoo.com

The Khondalitic (garneti ferrous silliminite gneiss) terrain of northern parts of Eastern Ghats of India is being faced with the problem of identification of high yielding water wells when the aquifers become kaolinised. An attempt is made in this paper to delineate the kaolinised layers with the Two Dimensional (2D) Induced Polarization (IP) technique leading to the Identification of high yielding water wells. A number of 2D IP Imaging profiles were conducted near Chipurupally in Vizianagaram district of India along success and failed wells located within short distances. The 2D IP Chargeability images have provided reasonable clarity about the occurrence of the highly weathered zone (kaolinised zone) at both success and failed wells. The layers having higher thickness (12–21 m) obtained at deeper depths (21–43 m) with moderate chargeability values of 1.07- 3.58 m.sec are identified as aquifer layers in the khondalitic suit of rocks. The layers having the higher thickness (20–43 m) obtained at deeper depths with lower chargeability values of 0.235 - 1.0 m-sec are indicating the kaolinised formations which are responsible for failure of wells.

Keywords: Kaolinisation, Aqifer, Induced Polarisation, Chargeability, Groundwater.

ASSESSMENT OF SITE RESPONSE, SEISMIC VULNERABILITY AND SUB-SURFACE SHEAR VELOCITY USING THE HORIZONTAL-TO- VERTICAL SPECTRAL RATIO (HVSR) OF LOCAL EARTHQUAKES AND THEIR INVERSION ACROSS A TRANSECT IN EASTERN KUMAUN HIMALAYA, INDIA

K. Sivaram[*1], S. Madhusudhan[*], Sandeep Gupta, Sudesh Kumar, B.N.V Prasad, M. Sai Dixith,
[*]CSIR-National Geophysical Research Institute, Hyderabad 500 007, India
[1]corresponding presenter: email: sivaramk@ngri.res.in

We study the site response, seismic vulnerability and sub-surface shear velocity V_S, using the Fourier Amplitude Spectrum (FAS) and the Horizontal-to-Vertical Spectral Ratio (HVSR) from the broadband, 3-component recordings of local earthquakes, recorded along 30 seismological stations, in operation since October 2018, covering a transect-portion (~200 km long, ~6 km station-station) in the seismically active, eastern segment of Kumaun Himalaya. We assess the site response (peak frequency, f_0; peak amplitude, A_0) from the highest peak/first peak frequency (f_0) of the HVSRs in the frequency range 0.02-10 Hz, which is of special interest to engineering seismology and lithology. From the estimates of peak frequency and amplitude, we further estimate the seismic vulnerability index (K_g), an important engineering parameter that depends on the dynamic properties of sub-surface structures beneath the stations. In addition, we attempt to estimate the sub-surface V_S values based on diffuse wave-field theory from isotropic energy equipartition and the corresponding inversion of the HVSR curves of local earthquakes. We characterize all the sites based on their fundamental peak frequencies and V_{S30} (time averaged shear velocity to 30m) values, as per the National Earthquake Hazards Reduction Program (NEHRP) classification. We observe the usefulness of the HVSR parameters to describe the site response and also provide robust estimates sub-surface shear velocity V_S, along with the reliable estimates of time averaged shear velocity,V_{S30}. Our detailed measurements and analyses suggest possible high site responses for the stations located within the MCT. The results have significant implications for constraining the performance-based engineering measures, and also offers a window for the development of strong ground motion models along the eastern segment of Kumaun Himalaya.

Key words: HVSR, Site response, Spectral Ratio, Peak frequency, Peak amplitude, Seismic vulnerability, Sub-surface shear velocity, Kumaun Himalaya

SITE CHARACTERIZATION STUDIES AT VELDURTI- KALVA- GANI (VKG) FAULT, EASTERN DHARWAR CRATON - MULTICHANNEL ANALYSIS OF SURFACE WAVES (MASW) APPROACH

P. Sivasankar, K. Satish Kumar, K. Swapna Sri, B. laxman, V. Maha Laxmi Naidu, Phalke Mahesh Devidas, D. Srinagesh
CSIR-National Geophysical Research Institute, Hyderabad
Email: sivamarine007@gmail.com

A 60 km long ENE-WSW oriented Veldurti Kalva Gani (VKG) fault, Eastern Dharwar Craton (EDC) known to be a strike-slip character. Previous seismological studies reveal that no significant earthquakes were recorded in the vicinity of the fault. During the period from 2012 to 2016, three microseismic

events are noticed with a magnitude of <2.0 Mw near to this fault. The recent earthquakes activity near to this fault may suspect the great potential of a frightful earthquake in future. Hence, early detection of fault characteristics with respect to recent earthquake activity is useful to understanding the seismotectonics. In view of the importance of site characterisation studies, Multichannel Analysis of Surface Waves (MASW) studies were executed to map the subsurface characteristics in terms of shear wave velocity in the vicinity of the fault at shallow depths. MASW data were acquired at five locations using 24 channel seismographs with considerable source offset field configurations, subsurface Rayleigh waves obtained from spike coupled low-frequency multi-channel seismic receivers. Dispersion curves are constructed from dispersion analysis; finally, the shear wave velocity profile was obtained from inverted experimental dispersion curves up the depth of 40 m. It is observed from the shear wave velocity images, the velocity of the study region varies from 100 m/s to <1500 m/s with an average shear wave velocity of 850 m/s and accordingly NEHRP classification site are corresponds to hard rock. It is inferred from the shear wave velocity structure, the characteristics of the alluvium, shale and quartzite are well delineated. The vertical contacts between these layers are also distinguished.

Key wards: Veldurti Kalva Gani (VKG) fault; Eastern Dharwar Craton(EDC); Multichannel Analysis of Surface waves (MASW); fault; lineament; earthquake

NEO-TECTONIC STUDY OF A NORTH BRAHMAPUTRA RIVER BASIN: INSIGHTS FROM REMOTE SENSING STUDY.

***Sujit K. Pradhan[1], Nava K. Hazarika[1], Mala S. Bagiya[1] & Damepaia S.M. Pdah[2]**

[1]Shillong Geophysical Research Centre, Indian Institute of Geomagnetism, Shillong-793005.

[2]Directorate of Mineral Resources, Govt. of Meghalaya, Risa Colony, Shillong- 793003.

*Corresponding e-mail: sujitpradhan05@gmail.com

Remote sensing study of drainage pattern and morphometric analysis of large and inaccessible river basins helps in understanding the lithology & structural control of the area. A Preliminary study of Manas river, a north Brahmaputra tributary has been undertaken to understand the lithology variation & structural elements presents in the study area. Manas river originates from Bhutan Himalayan region and flows south ward cutting through upper Assam alluvial plain in Indian territory to join the main course of mighty Brahmaputra. A Preliminary study of drainage pattern mostly shows trellis to parallel pattern in the northern part of the basin indicating the presence of closely spaced faults or joints which controls the flow of the lower order streams with a gently dipping strata in the northern region. The major tributaries of Manas river mainly flow in N-S and NE-SW directions in the northern part. The river suddenly changes its course to an E-W direction in southern part of the basin indicating the presence of a fault/lineament and finally enters the upper Assam plain & flows in a N-S direction with a narrow basin till the pour point near the Brahmaputra. The southern part of the basin shows the presence of a dendritic pattern inferring a nearly horizontal strata and a uniform lithology in this region. Further, more morphometric parameters should be undertaken to study the neo-tectonic activities of the region.

QUANTIFYING STREAM FLOWS AND GROUNDWATER RESPONSE UNDER THE CLIMATE AND LAND USE CHANGE THROUGH INTEGRATED HYDROLOGICAL MODELING IN A SOUTH INDIAN RIVER BASIN

L. Surinaidu
CSIR-National Geophysical Research Institute, Hyderabad – India
Corresponding author: suryangri@gmail.com

Nagavali is one of the important east flowing river basins, providing water source for more than 5 million people for various applications in two south Indian states namely Orissa and Andhra Pradesh. During the last two decades, expansion and intensification of agriculture have increased through the development of various surface water storage projects to support agriculture development. In this scenario, understanding complete water balance under different land use and climate is required for the sustainable management of water resources and agriculture development. The present study attempted to quantify integrated hydrological processes under changing land use and climate over three decades from 1985 to 2018 with the help of coupled SWAT-MODFLOW. The study quantified the river-aquifer interactions and dynamic groundwater recharge by implementing dynamic land use and climate in the coupled hydrological model for three decades. The integrate model revealed that the combined impact of land use change and climate has increased runoff by 26%, percolation by 16%, groundwater storage has declined by 20% and irrigation water requirement increased by 48% by end of 2018 when compared to 1985. The present study emphasized the need of modelling surface-groundwater in an integrated manner for better understating hydrological processes to support sustainable water resource management.

Keywords: SWAT; MODFLOW; base flow; coupled hydrological model and groundwater recharge

GROUNDWATER QUALITY ASSESSMENT AND MODELING IN AND AROUND RED MUD PONDS, KARNATAKA-INDIA

G. Swapna[1,2] and L. Appalanaidu[1]
[1]Geospatial and Environmental Solutions, Dharmavaram – Andhra Pradesh
[2] Department of Environmental Science-Andhra University, Visakhapatnam-Andhra Pradesh
Email: swapnarongali187@gmail.com

The Belagavi unit of Hindalco, located in Karnataka, houses an alumina plant, a world-class research Centre for alumina, and a carbon paste plant. It is storing red mud on ground called red mud ponds with proper environmental safety measures near to the company at Belagavi. In the present study, we have assessed the impact of the red mud on groundwater by carrying out hydrogeological and geophysical investigations in the area covering 25 square kilometers watershed. The watershed topographic elevations range from 960 to 682 m amsl. Groundwater levels range from 1.2 m bgl to 25.8 m bgl. pH of red mud ponds alkaline nature with high electrical conductivity > 3000 microsemens. However, EC of all other groundwater samples are within the prescribed limits of BIS drinking water standards. The average background TDS in the area is ~350 mg/l. The higher TDS (500 mg/l) is around Red mud ponds are observed that show the impact of red mud and in the downstream (~800 mg/l) at one location

that is due to domestic pollution leaching from sewage drain. All other locations concentrations are within the limits of drinking water limits of BIS. However, there is a need to understand the pollution transport from Red mud ponds using numerical solute transport models to understand the future migration and to control the pollution migration. The contaminant transport model show extent of pollutants migration and it is limited to only red mud ponds area.

Keywords: Red mud pond, environment, groundwater, major cations and anions

SPORADICALLY ERODED SUBCONTINENTAL LITHOSPHERIC MANTLE BENEATH THE DHARWAR CRATON, INDIA

Tarun C. Khanna
CSIR-National Geophysical Research Institute, Hyderabad-07, India
khannangri@ngri.res.in

Prolonged scavenging of the subcontinental lithosphere by mantle plumes can trigger lithospheric erosion, thinning and extension resulting into continental rifting and subsequent break-up. The processes as such can be constrained by petrological and geochemical studies in the mafic dikes that are well-preserved in the cratonic provinces of the Earth. The Nuggihalli dikes of this study record a new unseen pulse of tectonomagmatic event in the geological history of the Dharwar craton. The dikes are unmetamorphosed, petrographically and geochemically unaltered. A bulk-rock Sm-Nd isochron for fifteen samples yielded a robust age of 2506 ± 110 Ma having an initial isotopic composition of $^{143}Nd/^{144}Nd = 0.50954 \pm 15$, which has a mean square weighted deviation of 0.24. The MORB-like trace element signatures and rare earth element attributes of these dikes require at least 20% partial melting of a spinel lherzolite sourced in the shallow asthenospheric upper mantle by an upwelling mantle plume. Geochemical and isotopic compositions of these dikes preclude interaction with the overlying continental crust and/or subcontinental lithospheric mantle during their genesis and/or en route to their emplacement. Consequently, the mode of emplacement reflects upon sporadically eroded subcontinental lithospheric mantle beneath the Dharwar craton, south India.

GEOELECTRICAL STRUCTURE ACROSS THERMAL SPRINGS IN SW PART OF MAHARASHTRA

Vasu Desmukh*, P V Vijaya Kumar, P B V Subba Rao and A K Singh
Indian Institute of Geomagnetism, Panvel, Navi Mumbai 410 218, India.
Email: vasu.deshmukh@iigm.res.in

In India, different geothermal provinces occur in (a) subduction related process in Himalayan region, (b) mid-continental rifting (Son-Narmada-Tapti, Godavari and Mahanadi basins) and (c) along the west coast of India that is related to the Deccan volcanic province (DVP). All the thermal springs in the west coast of India are aligned between the west coast fault (WCF) and Western Ghats. Due to lack of geophysical evidence, audiomagnetotellurics (AMT) and magnetotelluric (MT) soundings were carried

out in Aravali, Tural and Rajawadi geothermal zones of SW Maharashtra to bring out source region as well as to understand the deep seated structure of these geothermal regions.

2D inversion of AMT and MT data jointly brings out different conductivity anomalies (a) shallow conductivity anomaly related to the upward propagation of meteoric water through faults/fracture zones. AMT studies also bring out the presence of the source rock (S) at shallow depth beneath Tural and Rajawadi geothermal springs. This source rock could be an igneous intrusion (the volcanic plug) over which meteoric water circulates apart from the basement. Thus, surface water temperature recorded at Tural and Rajawadi is higher than Aravali. (b) Major fracture/fault zones extending up to mid-crustal depths through which Deccan volcanism may have erupted and (c) the presence mid-crust (12-15 km) and deep seated conductivity anomalies related to trapped carbonate fluids that is linked to basaltic magmatic intrusions at the base of the crust (Moho). Different resistivity blocks may represent igneous (mafic/ultramafic) intrusions and later crystallization of these blocks may have given rise to high resistance values.

MAGNETIC ANOMALY BASED SUBSURFACE MODELLING BY DELAUNAY TRIANGULATIONS – A CASE STUDY FROM GADARWARA REGION IN M.P.

Vishnu Kant Verma, Anand Singh
Department of Earth Sciences, Indian Institute of Technology Bombay, India
vishnu.kant.verma1@gmail.com

Regular grid-based discretization of subsurface has been widely used as conventional discretization approach. However, it provides lower precision for modeling the irregular topography and complex shaped anomalous bodies within the subsurface. In the present work, we have used Delaunay triangulation for discretizing the subsurface; it does overcome the problems encountered by the regular gridding methods. The algorithm for forward formulation of magnetic methods is designed in such a way to support the resulted anomaly due to a three-sided polygon which in our case is a Delaunay triangular cell. Since, Magnetic response of the subsurface is a potential field based method; hence, it does follow the principle of superposition. We have utilized this aspect by assuming physical properties within a particular triangular cell as constant and calculated the net response of the anomalous subsurface body by summing the effect due to all individual triangular cells. For inversion, we have used the optimization scheme of the Conjugate Gradient method (CGM), which guarantees the convergence within n-steps for n-dimensional model space. We have provided preconditioning to our CGM to improve the kernel matrix's condition number and achieve a faster convergence to the solution. Preconditioning is also compensating for depth decay of potential field anomalies. The obtained results of forward and inverse modeling have been compared with real field data sets, and it is found that the developed approach provides trustworthy results.

Keywords: Unstructured Gridding, Delaunay Triangulation, Preconditioned Conjugate Gradient Method

IMPACT OF TEMPERATURE ON STRENGTH OF SANDSTONE- A CASE STUDY FROM COAL-BEARING SEQUENCE OF SONHAT COALFIELD, INDIA

Vivek Singh[1,2], Chinmay Sethi[1,2]*, Bodhisatwa Hazra[1,2], Shailendra K Singh[1,2], Pradeep K Singh[1], Pramod K. Singh[3], Santanu Banerjee[4]

[1]CSIR-Central Institute of Mining and Fuel Research, Dhanbad- 826001, India

[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, India

[3]Department of Geology, Birsa Institute of Technology Sindri, Dhanbad- 828123, India

[4]Department of Earth Sciences, Indian Institute of Technology Bombay, Powai, Mumbai-400076

*Presenting author: chinmaysethigeology@gmail.com

This study examines impact of high-temperature (250–750 °C) treatment on Uniaxial Compressive Strength (UCS), Young's Modulus, and Poisson's Ratio of sandstones collected from a borehole in India, using a hydraulic servo-controlled machine. Two stage variation in the compressive strength of the sandstone was observed. In the first stage, temperature treatment imparts the 'strengthening effect' on the sandstone samples. The compressive strength of the sandstone samples increased in the temperature range of 25 – 250 °C. At room temperature the UCS of the sandstone was found to be 56.69 MPa while at the temperature of 250 °C it was observed to increase by 8.1 % to a value of 61.30 MPa. The second stage marked the beginning of the strength deterioration of sandstone samples as a result of high-temperature treatment. The UCS of the sandstone decreased by approximately 29 % after heating at 450 °C compared to the room temperature counter-part. At 600 °C, the loss in strength was about 22.84 % of the UCS at room temperature. The peak strength was at minimum (24.67 MPa) at the highest experimental temperature (750 °C). An overall decrease in the Young's modulus was observed from 25 to 750 °C. At room temperature Young's modulus was 13.43 GPa. At 250 °C, no significant change was observed. Subsequently, a sharp decrease of about 51.22 % was observed for the rocks tested at 450 °C. This dramatic decrease in Young's modulus continued till the highest test-temperature. At 600 °C it was reduced by 56.21 % and by 77.51 % at 750 °C. Repeated swings between the increasing-decreasing trends of Poisson's ratio were observed till the temperature of 600 °C, followed by a sharp increment at the highest experimental temperature (750 °C). The peak axial strain did not change till 250 °C, but increased significantly from 450 to 750 °C. Rock-deformation under uniaxial loading was 'brittle' till the temperature of 250 °C, and showed an increasingly 'ductile' nature at the higher temperatures. Density and ultrasonic wave velocity (P-wave and S-wave) of the sandstone decreased gradually with increasing temperature. Treatment temperature of 250 °C was identified as the transition temperature (T_t) above which considerable changes in the mechanical and physical properties of the sandstone were observed. Thin sections of the samples reveal the development of thermally induced micro-cracks and alteration of feldspar to pseudo-matrix at higher temperatures. Field emission scanning electron microscope (FE-SEM) analysis reveals development of intergranular and intragranular crack within the internal structure of the rock with rising temperatures. The alteration of minerals and microfracture development corresponded directly with the strength behavior.

SPATIAL B-VALUE VARIATIONS AND HAZARD ANALYSIS IN THE NAGA-PATKAI HILL, INDO-BURMA RANGE

Gourab Dey and Debasis D Mohanty*
Geosciences and Technology Division, Northeast Institute of Science and Technology,
Council of Scientific and Industrial Research, Jorhat, Assam, India, 785006.
Academy of Scientific and Innovative Research (AcSIR), India.
*Correspondence: debasis@neist.res.in; devlinkan06@yahoo.com
Presenting Author: me.gourab.2015@gmail.com/debasis@neist.res.in

To understand the seismicity and tectonic activity of the North-East India, b-value estimation is an important parameter. In North-East India, Indo-Burma Range is tectonically and seismically most active region. The Naga-Patkai Hill is situated at the northern part of the Indo-Burma Range. In the last forty years, more than 1400 earthquakes have struck in the Naga-Patkai Hill region. Using the homogeneous earthquake catalogue from 1995 to 2021, the spatial distribution of the b-value has been examined. In our present study using the maximum curvature method, the estimated b-value in this region is 0.60. There is a drastic change in seismic b-value from 0.4 to 0.6 and 0.45 to 0.75 in end of 2012 and 2016, respectively, which are may be due to the earthquakes of magnitudes 6.1 in November 2012 and magnitude 6.6 earthquake in January 2016, respectively. Spatial distribution data shows a higher b-value in the northern part of this region than in the southern part. The overall trend of b-value increases with increasing depth, where the earthquakes are distributed up to a depth of 150 km.

Keywords: Seismic b-value, Indo-Burma Range, Naga-Patkai Hill, Earthquake

PREVALENCE OF TRANSVERSE TECTONICS IN THE COMPRESSIVE REGIME

Charu Kamra*[1, 2], Sumer Chopra[1] and R.B.S. Yadav[2]
[1]Institute of Seismological Research, Gandhinagar, Gujarat, India 382009
[2]Department of Geophysics, Kurukshetra University Kurukshetra, Haryana, India 136119
*Email: charukamra007@gmail.com

The Kachchh region of Gujarat is seismically one of India's most active intra-plate regions, with three large damaging earthquakes—Kachchh (1819 Mw 7.8), Anjar (1956 Mw 6.0), and the most recent Bhuj (2001 Mw 7.6) occurring in the past 200 years. The tectonics in the Kachchh rift basin are heterogeneous and complex. The focal mechanism and source parameters of 41 local earthquakes (Mw 4.0–5.1) that occurred in the Kachchh rift basin, are determined to characterize various active fault systems in that region. It is found that one-third of the earthquakes exhibit reverse mechanism and three-fourth are either strike slip or have some components of strike slip. Thus, we conclude that transverse tectonics are currently dominant in the Kachchh rift. These transverse faults are preferably oriented in the northeast–southwest and northwest–southeast directions in the eastern and western parts of the rift, respectively. These transverse faults are almost vertical (dip > 70°) and mostly blind with no surface expressions. Most of the significant faults that strike east–west dip toward the south and are listric. Using focal mechanisms results, dominant stress field and direction of maximum horizontal stress is explored. It is

found that KRB exhibits radial compression with maximum principal stress (σ1) oriented NNE. Thus, Kachchh region of Gujarat is moving towards NNE coinciding with the movement of Indian plate motion. The stress drop of these 41 earthquakes ranges between 2.3 and 10.39 MPa. It is found that the stress drop of earthquakes may depend on the focal mechanism and is independent of focal depths. The average stress drop is found to be the highest (7.3 MPa) for the earthquakes that show a dominant normal mechanism accompanied by strike slip (5.4 MPa) and reverse (4.7 MPa). The average stress drop of the Kachchh intraplate region is 5.3 MPa, which is consistent with other intraplate regions of the world.

APPLICATION OF SPECTRAL DENSITY RATIO TECHNIQUE FOR ISOLATION OF SEISMO-ELECTROMAGNETIC EMISSION FROM COMPOSITE LOW FREQUENCY MAGNETIC FIELD CLUSTER

Chandan Dey[1,2], Saurabh Baruah[2], Santanu Baruah[2]
1 Academy of Scientific and Innovative Research (AcSIR), Ghaziabad – 201002, India
2 CSIR-Northeast Institute of Science and Technology, Jorhat, Assam – 785006, India
Presenting author: s.chandandey@gmail.com

Seismo-electromagnetic (SEM) emission in the ultra-low frequency (ULF) band, i.e. between 0.001 and 10 Hz, is supposedly caused by mechanical deformations inside earthquake preparation zones and investigated as a likely candidate for short-range earthquake prediction. Several methods are proposed to isolate these faint SEM signals, which occur in the same frequency range as the magnetospheric emissions; the most widely used method is spectral density ratio analysis or polarisation ratio analysis (PRA), which calculates the ratio of the horizontal and vertical field components. Induction coil magnetometers (ICM) installed at the Multi-parametric Geophysical Observatory, Tezpur, which is located at proximity to the Kopili Fault and the Bomdila Fault, the Main Boundary Thrust of the Eastern Himalaya, the Naga and Disang Thrust, the Assam Syntaxis Zone, and the two tectonically active Precambrian shields – Shillong and Mikir, were employed to study probable SEM emissions using PRA technique for 51 (M_W 3.5 – 6.1) earthquake events recorded during the campaign period of April 20 – September 3, 2019. These 51 events were screened using strain radius, index of seismicity, and earthquake radius-magnitude relationship parameters to identify nine credible events that were then studied retrospectively for correlation between PRA results calculated for a frequency range of 0.03-0.1 Hz from local midnight ICM data that corresponds to the 18-21 hours K_P (Global geomagnetic activity) time window. All seven credible occurrences were related to PRA enhancements, establishing a case for candidate SEM emissions. On the other hand, several enhancements could not be linked to credible events, even though unscreened seismicity may account for such contingencies.

POSTERS

RECENT ADVANCES IN EARTH SCIENCES WITH SPECIAL EMPHASIS – NATURAL HAZARDS:

SEISMIC HAZARD ANALYSIS USING DETERMINISTIC APPROACH FOR ARUNACHAL PRADESH, INDIA

Pr. Daithaoreiyang
Indian Institute of Technology (Indian School of Mines), Dhanbad
Email: pr.daithaoreiyang@gmail.com

Arunachal Pradesh is one of the North-eastern states of India which falls in seismic zone V. Therefore, this state is highly vulnerable to earthquakes due to which proper seismic design for building any structures is required. The state has experienced several large earthquakes in the past, it has experienced one of the largest earthquake in twentieth century with moment magnitude '8.6' (15th August 1950, Indo-China Border region), Great Assam earthquake of moment magnitude '8.1' (12th June 1897) and frequent occurrences of earthquakes. There are some past seismic hazard assessment for whole India like NDMA 2010 using probabilistic approach, and for North-east India using probabilistic approach (Das et al. 2006). However, no seismic hazard analysis has been done for this particular state. So, this study attempted to analyse the seismic hazard of Arunachal Pradesh at bedrock level by using deterministic approach. A 500 km radius around the state is taken as the study area, and the past earthquake data for this study area are collected from several websites and literatures. The details about seismic sources for the study area are collected from SEISAT (Dasgupta et al., 2000) and from some literatures (Raoof et. al.,2017, Basab Mulkhopadhyay,2020 & others) and accordingly a seismotectonic map is prepared using ArcGIS (version 10.8). Ground motion intensity like Peak Ground Acceleration (PGA) and Spectral Acceleration (SA) are computed using appropriate Ground Motion Prediction Equations (GMPEs) or Attenuation Relation. In this study, due to the absence of region specific GMPE, the logic tree approach is adopted to incorporate more than one GMPE. The GMPEs along with the corresponding logic tree and weights are taken from Olympa et al. (2018). After this, seismic hazard map corresponding to PGA values is prepared. The PGA value for this state is in the range 0.27 to 0.79 g. The Southern part of the state such as Kamle, East Siang, Lower Siang and Lower Subansiri are found to be the most vulnerable districts to seismic hazard.

THE CODA WAVE ATTENUATION CHARACTERISTICS FOR THE KUTCH REGION, GUJARAT, INDIA

Indu Bala [1, 2], Manisha Sandhu[1], Santosh Kumar[2] and Dinesh Kumar[1]
1. Department of Geophysics, Kurukshetra University, Kurukshetra
2. Institute of Seismological Research, Gandhinagar Gujarat
Presenting author: indubala1920@kuk.ac.in

The coda wave attenuation characteristics for the Kutch Region of Gujarat, India have been assessed in the present study. Seismic Attenuation is measured by a dimensionless quantity, known as Quality factor (Q). For this purpose, we have used 75 waveforms of 15 local earthquakes recorded at 6 different stations. The data used in this study is the part of the seismic network installed by the Institute of Seismological Research (ISR) Gandhinagar, Gujarat. The earthquakes with magnitude range 3.0 to 4.5 that occurred in the Kutch region and having an epicentral distance up to 70 km have been used for the

analysis. The recorded amplitudes of seismic waves are directly related to the attenuation properties of the medium. We analyzed Coda-Q for these 15 local earthquakes based on the Single backscattered method propose by Aki and Chouet (1975). For Coda Q estimation, 20 sec lapse time window at five frequency bands (1- 2, 2-4, 4-8, 8-16, and 16-24 Hz) has been used. The obtained Q_C values shows that the attenuation is strongly frequency-dependent (as the frequency increases attenuation will be increased) which is related to the heterogeneity of the medium. Q_C is also useful for the estimation of earthquake source parameters. The estimated attenuation values can also be used to understand the tectonic stability and medium heterogeneities of a region.

SIGNATURE OF CO-SEISMIC IONOSPHERIC TEC DISTURBANCES ASSOCIATED WITH MW 7.6 PERU DOUBLET EARTHQUAKES

E. Karthikeyan[1], Y. Srinivas[1] and S. Sathishkumar[2]
1. Center for Geotechnology, Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu -627012
2. Equatorial Geophysical Research Laboratory (IIG), Tirunelveli, Tamil Nadu -627011
Presenting author: ekarthikeyan2791@gmail.com

We investigate the co-seismic ionospheric disturbances (CID) for the doublet Peru earthquakes of magnitude (Mw) 7.6 occurred at 22.45 UT & 22.50 UT on 24th November 2015 using the GPS total electron content (TEC) for the possible signatures in the ionosphere. During earthquakes, the Rayleigh wave induced gravity waves to propagate the ionosphere region and cause fluctuations in the ionospheric TEC after 10 – 15 minutes. The CID propagates to the horizontal distance of 4000 km from the epicenter. It attains the maximum amplitude variations of ±1 TECU for nearby stations located at the southside region of the epicenter such as POVE and SCRZ. Whereas, the amplitude of CID for the nearby stations located over the north of the epicenter appears to be ±0.05 TECU variations. We observed the ionospheric disturbances propagate to the southeast direction of the epicenter. From these results, we suggest that there is a coupling process exists between the seismic activity and ionospheric perturbations.

Keywords: Peru; TEC; CID; doublet earthquakes; ionosphere.

ESTIMATION OF SITE RESPONSE USING HVSR TECHNIQUE FOR NORTH EAST REGION, INDIA

Mannat Khanna*, Saurav Deep, Sakshi, Manisha Sandhu
Department of Geophysics, Kurukshetra University, Kurukshetra-136 119
*Presenting author: mannat1230@gmail.com

The north-east region of India is one of the highly earthquake hazard prone regions of the Indian subcontinent. Additionally, it is also quite geologically complex. Since the damage caused by the occurrence of an earthquake depends not only on its magnitude and epicentral distance, but also on the local geological conditions, site specific studies are important for seismic hazard analysis. The site effect is typically represented by resonance frequency and the associated ground motion amplification. In this

study, we have used the Nakamura technique (H/V site response spectral ratio) for estimating the site amplification and the associated predominant frequencies of seismic ground motion for some of the sites in north east region. The spatial distribution of site amplification and the predominant frequencies has been prepared as well. The output of the study will be beneficial for further microzonation studies such as estimating sediment thickness and shear wave velocities, and for the preparation of seismic hazard maps in the region.

APPLICATION OF HYBRID GENETIC ALGORITHM TO ESTIMATE ACOUSTIC IMPEDANCE FROM POST-STACK SEISMIC DATA: A CASE STUDY

S. P. Maurya[1*], Richa[1], and Alok Kumar Tiwari

[1]Department of Geophysics, Institute of Science, Banaras Hindu University, Varanasi, U.P. -221005, India

Email ID: mauryasatya@bhu.ac.in

Genetic Algorithms (GAs) are adaptive heuristic search algorithms that fall under the evolutionary algorithms category. Natural selection and genetics are the foundations of genetic algorithms. It is randomized approach to find solution to a wide range of complicated nonlinear problems. Genetic algorithms have the advantage of being effective at locating the globally optimal solution in the presence of discontinuities, noise, and local optima. The application of GA to the seismic reflection data is time consuming. By considering development of super computer, the method still time consuming as seismic data have large samples and hence take much time. To overcome with this challenge, in this study we used hybrid genetic algorithm to maximize/minimize the objective function. The final product is an inverted acoustic impedance section that depicts impedance dispersion in the Blackfoot field, Alberta, Canada. The goal of the study is to assess the qualitative and quantitative performance of hybrid genetic algorithm and characterize reservoir from non-reservoir zones. To begin, a synthetic seismogram is created by combining reflectivity series with wavelets taken from the borehole and seismic data. The algorithm's performance is then evaluated using synthetic and real data. The Hybrid Genetic algorithm is a two-step procedure in which the best model derived from each generation of the genetic algorithm is applied to a local algorithm. Based on error analysis, the hybrid Genetic Algorithm outperforms since it saves computation time and money while producing a superior result with fewer iterations. The inverted impedance section is then analyzed and the interpretation reveals a low impedance anomaly zone between (1055 and 1070) ms time interval, with an impedance value of (6500 to 8500) m/s*g/cc. Low impedance zone defined as a clastic glauconitic sand channel as reservoir zone. The study reveals that the hybrid genetic algorithm performs in better way as comparison with traditional algorithm and provides excellent subsurface information.

AN UPDATED, HARMONIZED, POISSIONIAN AND COMPLETE EARTHQUAKE CATALOGUE FOR THE GUJARAT REGION OF WESTERN INDIA

Priyanka Chauhan, R. B. S. Yadav and Rajiv Kumar
Department of Geophysics, Kurukshetra University, Kurukshetra, India
Presenting Author: priyankac2018@kuk.ac.in

An updated, harmonized for moment magnitude (Mw), poissionian (declustered from dependent events) and complete earthquake catalogue is a fundamental ingredient for the seismic hazard assessment of any region. It consists the information about earthquakes viz. their time of occurrences, location (latitude and longitude), size (magnitude and intensity), depth, damage effects etc. In the present, an attempt is made to compile an up-to-date earthquake catalogue for the Gujarat region of western India (latitude 20°-25°N and longitude 68°-75°E) using the historical data from published literature and instrumental data from local, regional and international seismological agencies. The main contributors of instrumental data are the Institute of Seismological Research (ISR), Gujarat, India; National Centre for Seismology, New Delhi, India (NDI); Gujarat Engineering Research Institute (GERI), Gujarat, India; International Seismological Centre (ISC), U.K; National Earthquake Information Centre (NEIC), Global Centroid Moment Tensor Solution (GCMT) and International Data Centre (IDC). The raw catalogue contains 2251 earthquake events during 1668-2021 with magnitude 2.0-7.8 of different magnitude scales viz. moment magnitude (Mw), surface-wave magnitude (Ms), body-wave magnitude (mb), local magnitude (ML) and duration magnitude (MD). These scales have been harmonized into Mw by developing empirical magnitude conversion relations using standard least-square regression (SR), inverted standard least square regression (ISR), orthogonal regression (OR), generalized orthogonal regression (GOR) and orthogonal distance regression (ODR) techniques. The intensity-magnitude conversion relations have been also developed using the above-mentioned regression techniques. The harmonized earthquake catalogue has been declustered for dependent events (i.e. foreshocks and aftershocks) using different windowing techniques viz. Gardner and Knopoff, (1974), Reasenberg, (1985) and Uhrhammer (1986) and their comparative analysis has been performed. Further, the harmonized and poissionian catalogue is performed for completeness analysis for magnitude (Mc) and time using frequency-magnitude recurrence relation and Stepp (1972), respectively. This compiled catalogue has useful implications in studying seismicity patterns and seismic hazards in Gujarat.

SPATIAL VARIATION OF EARTHQUAKE HAZARD PARAMETERS IN THE HIMALAYAN SEISMIC BELT (HSB)

Rajiv Kumar[1]* and R.B.S. Yadav[2]
[1,2]Department of Geophysics, Kurukshetra University, Kurukshetra, India
*Presenting author: tomargp18@gmail.com

In this study, the geographical distribution of earthquake hazard parameters, viz. a- and b-values of the frequency-magnitude distribution (FMD), mean seismic activity rate (λ), maximum expected regional magnitude (M_{max}), return periods and probabilities of different earthquake magnitudes were assessed along the Himalayan seismic belt (HSB) bounded by latitude 25^0-35^0N and longitude 72^0-98^0E. For this

purpose, we compiled an updated earthquake catalogue from 25 B.C to 2019 A.D. that is homogenized for moment magnitude (Mw) and declustered from dependent events (foreshocks and aftershocks). The maximum likelihood technique is applied to estimate the earthquake hazard parameters, which allow the data to contain either historical or instrumental periods or even a combination of the both. The hazard parameters were calculated for thirty-four (34), twenty-seven (27) and five (5) seismic source zones corresponding to depth intervals of 0-25 km, 25-70 km and ≥ 70 km, respectively that are identified based on their seismicity level, focal mechanism, and seismotectonic setting. The determined hazard parameters have been geographically mapped in all different seismic source zones for three different depths to analyze the spatial variation of localized seismicity parameters. The source zones 16, 18, 26, 29 and 33 for depth h= 0-25Km exhibit M_{max} ≥8.0, while zone 19, 22 and 24 of depth range h=25-70 km and zone 5 of depth range h>70 km have the potential to generate M_{max} 7.0-7.7. The estimated return periods of earthquake for Mw 7.0 show low return periods (35-94 years) for the source zones 1, 5, 6, 15, 19, 22, 23, 26, 31 and 33 of depths h=0-25km, 329-789 years for zones 19 and 24 for depths h=25-70km and 72.8-1300 for zones 1 and 5 for depth h>70km. The high probabilities (>0.70) for the occurrences of Mw 7.0 in the next 100 years are observed for zones 1, 5, 6, 15, 26, 31 and 33 for depths h=0-25km; zones 19 and 24 for depths h=25-70 km and zones 1 and 5 for depths h>70 km. The low return periods and high probabilities are observed in zones 1, 5, 6, 15, 26, 31 and 33 for depths h=0-25km; zones 19 and 24 for depth h= 25-70 km and zones 1 and 5 for depth h>70 Km. It is perceived that the seismic hazard level changes spatially and reveals high-level crustal heterogeneities and seismotectonic complexity in the Himalayan regions.

1D NON-LINEAR SEISMIC GROUND RESPONSE ANALYSIS FOR VARIOUS LOCATIONS IN DHANBAD CITY, JHARKHAND, INDIA

Rashid Shams and Mohit Agrawal
Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand, India
Presenting author: rashid98.20MT0321@agp.iitism.ac.in

Dhanbad is one of the major coal producers in India and it is also the second most populous city in Jharkhand. It is situated in the moderately seismic Chotanagpur Plateau, 400 km to the south of Indo-Eurasian Thrust and is also proximal to Purulia and Singhbhum shear zones in the south. Hence, it is imperative to study the effect of local soil on bedrock ground motion. The local soil conditions can significantly amplify the bedrock motion leading to higher acceleration at the ground surface. There is no previous study carried out for this region to study the response of local soil to earthquake motion. The aim of this study is to carry out 1D Non-Linear Seismic Ground Response Analysis using Standard Penetration Test (SPT) data from 11 boreholes distributed sparsely all over the Dhanbad city. The major soil types obtained from the SPT data include sandy and silty soil deposits. Two earthquake records viz. Nepal (Gorkha) earthquake (M_w=7.8, 2015) and Imperial Valley earthquake (M_w=6.5, 1979) are adopted as bedrock input motion for the study. The final ground level responses were estimated for acceleration, strain, shear stress ratio and Fourier amplitude ratio. The results reveals that various sites in Dhanbad exhibit high to moderate amplification of the bedrock ground motion with a ground acceleration

amplification ratio ranging from 1.3 to 3.5. The amplification factors obtained at borehole BH-1 (Medical College), BH-2 (Behind SDM Office), BH-3 (Barwadda), BH-4 (B Type Officers Colony) and BH-5 (C-Type Staff Qtrs.) show low to moderate amplification with amplification ratio less than 2. While BH-6 (Academic Complex), BH-7 (Rosaline Hostel), BH-8 (Senior Academic Hostel) and BH-11 (R.S. More College) exhibited high amplification with amplification ratio greater than 2. Some sites such as BH-9 (FDC, IIT(ISM)) and BH-10 (Press Club) displayed very high amplification with amplification ratio ranging beyond 3. The response spectrum for ground surface using both input motions are found to exceed the recommendations set by IS-1893 for Zone-III (Rock and Soil sites at 5% damping). These results are important for structural designers and government agencies for the construction of earthquake resistant designs in Dhanbad and its adjacent regions.

SEISMIC HAZARD ANALYSIS OF KISHANGANJ (INDIA) USING PROBABILISTIC APPROACH

Rashid Shams, Mohit Agrawal and Ravindra K. Gupta
Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand, India.
Presenting author: rashid98.20MT0321@agp.iitism.ac.in

Probabilistic Seismic Hazard Assessment (PSHA) is carried out for Kishanganj district of Indian state of Bihar, which shares its international border with Nepal to the north. PSHA may help determine the bedrock level ground motions from future scenario earthquakes happening due to tectonic plate motions on nearby seismically active Indo-Eurasian thrust zone. It is important to assess the seismic vulnerability of the Kishanganj region to properly develop seismically resistant infrastructure in the area. During PSHA calculations, an earthquake catalogue of the past 300 years is prepared considering earthquakes of magnitude greater than 2.5 for assessment of substratum level Peak Ground Acceleration (PGA) values at 2% and 10% probability of exceedance in 50 years. The catalogue prepared is homogenized to moment magnitude scale, declustered and checked for completeness, where it is found complete for magnitude greater than equal to 4.0. All the seismic sources in the study region were identified and deaggregated. The b value for the Himalayan region and North-East Indian region is estimated using G-R relation is 0.73 and 0.68 respectively. Due to the absence of region-specific Ground Motion Prediction Equations (GMPEs), a logic-tree based approach consisting of four GMPEs is considered. The uncertainties in magnitude, distance and ground motion parameter were then combined using total probability theorem to obtain frequency of exceedance. The final seismic hazard map shows that the southern parts and some eastern parts of Kishanganj district are most vulnerable to seismic hazard. PGAs vary between 0.36g and 0.39g from the southern to eastern periphery considering Maximum Considered Earthquake (MCE) condition. Within Kishanganj district, Kishanganj city (0.33-0.39 g) and Kochadhamin (0.33-0.39 g) are found most vulnerable to seismic hazard while Terhagachh (0.28-0.31 g), Dighabank (0.30-0.29 g) and Thakurganj (0.25-0.35 g) are found to have least ground motions. The results of this study may prove to be vital for agencies such as National Disaster Management Authority (NDMA) and Geological Survey of India (GSI) in the construction of seismic microzonation maps of Kishanganj district.

JOINT MODELLING OF HORIZONTAL-TO-VERTICAL SPECTRAL RATIOS AND DISPERSION CURVES FOR SEISMIC SITE CHARACTERIZATION OF DHANBAD CITY (INDIA)

Ravindra K. Gupta[1*], Mohit Agrawal[1], Jay Pulliam[2]
[1]Department of Applied Geophysics, Indian Institute of Technology(ISM), Dhanbad, India
[2]Department of Geosciences, Baylor University, Waco, TX, USA
Email*: meravindra13@gmail.com

We present a novel strategy of shear wave velocity estimation for seismic site characterization via joint modeling of Horizontal-to-Vertical Spectral Ratios (HVSR) and dispersion curves obtained from noise microtremor data for the Indian city of Dhanbad. The model search space is explored rigorously via global and nonlinear optimization technique of Very Fast Simulated Annealing (VFSA) and the uncertainties are statistically quantified using Posterior Probability Distributions (PPDs) and Parameter Covariance Matrices (PCMs). These tools help us identify the portions of the acceptable models which are well or less constrained. A confirmatory test is also conducted to demonstrate the effectiveness of the proposed modelling scheme by both synthetic as well as field data from the Dhanbad city.

Dhanbad is situated in the moderately seismic Chhotanagpur Plateau, 400 km to the south of Indo-Eurasian Thrust and is also proximal to Purulia and Singhbhum shear zones in the south. Hence, it is imperative to generate the shear wave velocity profiles for site characterization to aid in the seismic hazard efforts for this region. The acquired datasets are sparsely distributed across the municipal limits of Dhanbad at an average spacing of 2 km. The obtained shear wave velocity profiles show good match with the borehole blow count values found from Standard Penetration Test (SPT); which further explains that the joint modelling technique is reliable and capable of producing realistic results.

B-VALUE STUDY FOR HINDU KUSH-PAMIR REGION

Rudra Karmakar, Prosanta Kumar Khan
Department of Applied Geophysics. IIT(ISM), Dhanbad
Presenting Author: rudrakarmakar34@gmail.com

In Central Asia One of the greatest watersheds names is Hindu Kush. The Hindu Kush-Pamir region forms the part of one the most seismically active region of the world, where Indian plate is subducting beneath the Eurasian plate. A large number of earthquakes originate from deep ongoing subduction in the region. There have been a number of studies to study the deep focus events but the origin of Hindukush and Pamir microplates is still under debate. Many models suggest the presence of two subduction zones i.e., one at Hindukush and other at Pamir. We know that in earth's crust and in the depth the horizontal stresses are compressional. Recently, an M 7.5 deep earthquake event occurred in October, 2015 in the region at a focal depth of 200 km. Hence, it is indispensable to study the seismicity of the region to mitigate any future earthquakes and enhance our current understanding of geodynamics of the region. The Seismic b-value represents the seismicity of the region and can be used to study the

seismic hazard in any region of intertest. In this study we have prepared a comprehensive earthquake catalogue considering events from 1980-2021 with earthquakes of magnitude greater than 2.5. My study of the region lies between 33 to 40 North to a longitude of 66 to 75 East. The distribution of the frequency–magnitude distribution (b-value) for the seismicity of the Hindu Kush - Pamir region from 1980-2021. The prepared raw catalogue has been homogenized and declustered. The event clusters over the Hindukush-Pamir region have been used to estimate b-value. The Gutenberg frequency–magnitude distribution of earthquakes has become very known in seismology. We have carried out a comparative analysis of the b-values obtained using three approaches i.e., Gutenberg-Richter relation, ZMAP and Maximum Likelihood Method. The b-values obtained using the depth cross sections varied from 0.77-1.25 while for spatial clusters b-values showed variation from 0.75-1.26.

EVALUATION OF SEISMIC HAZARD FOR KISHANGANJ, BIHAR AND COMPARISON OF SEISMIC DECLUSTERING METHODS FOR BIHAR- NEPAL HIMALAYAN REGION INDIA

Yehya Rasool and Mohit Agrawal
Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines), Dhanbad, India-826004
Presenting Author: rasool.yehya12@gmail.com

Kishanganj is a bordering district of Bihar, sharing its border with Nepal and west Bengal state of India, and has suffered numerous earthquakes in past including India-Nepal earthquake (1934), Nepal (2015) etc. Majority of them are happening due to striking of tectonics of Eurasian and Indian plates on the north side, and from the east side there is a subduction beneath the Burmese arc. Kishanganj lies in the vicinity of Himalayan thrust faults, East Patna fault, Malda Kishanganj fault etc. Thus, making it more vulnerable to seismic risk. Hence, it is necessary to assess seismic hazard analysis in this region. In our study, a comprehensive homogenized earthquake earthquake catalogue has been prepared from the earthquake data of past 400 years within a radius of 500 km from Kishanganj. Analysis of seismicity has been done through three different declustering methods. These methods have been compared and the suitable method i.e. Reasenberg (1985) has been used for the declustering of catalogue. From the results, the method proposed by reasenberg (1985) and Zhuang et al. (2002) also called stochastic declustering method are suitable methods for the analysis of seismicity for Bihar-Nepal Himalayan region. In this study, we have also prepared the seismic hazard map for Kishanganj. For the construction of peak ground acceleration (PGA) maps logic-tree approach has been adopted in which four Ground Motion Prediction Equations (GMPEs) has been considered. It ranges from 0.25-0.37g and the acceleration response curves are also plotted for our study region by dividing it into four region. So, this study will be beneficial for town planning, land use planning and earthquake resistant design of structures in the vulnerable regions.

ATMOSPHERIC, OCEAN AND SPACE SCIENCES

EXPERIMENTAL FINDINGS OF ORGANIC MATTER IN METEORITES USING FOURIER TRANSFORM AND MICRO-RAMAN SPECTROSCOPIC INVESTIGATIONS

Bhaskar J. Saikia[1], G. Parthasarathy[2], and Rashmi R. Borah[3]

[1] Department of Physics, Anandaram Dhekial Phookan College, Nagaon 782002, India

[2] National Institute of Advanced Studies, School of Natural and Engineering Sciences, Indian Institute of Science Campus, Bengaluru 560012, India

[3] Department of Physics, Nowgong College (Autonomous), Nagaon 782001, India

e-mail: vaskaradp@gmail.com

We report here the possible presence of organic matters in Dergaon, Mahadevpur and Natun Balijan ordinary chondrites using Fourier transform infrared and micro-Raman spectroscopic technique. The Fourier transform infrared spectrum of these ordinary chondrites in the range 2700–3000 cm^{-1} indicates the presence of CH_3 asymmetric stretching, and CH_2 symmetric and asymmetric stretching modes due to aliphatic hydrocarbons. The micro-Raman spectrum exhibits the diamond and graphite peaks correspondingly at 1331 cm^{-1}, 1349 cm^{-1} and 1588 – 1618 cm^{-1}. The full wave at half maximum value correspondingly 120 cm^{-1}, 70 cm^{-1} and 17.5 cm^{-1} for Dergaon, Mahadevpur and Natun Balijan indicating the nature of disordered phase involved shock metamorphism in the meteorites. The diamond and graphite peaks intensity ratios ~1.121, ~1.075 and ~0.532, correspondingly for Dergaon, Mahadevpur and Natun Balijan indicates the disordered nature of graphite. This study has strong implications in understanding of the organic matters in extra-terrestrial materials.

Keywords: Organic compound, Dergaon, Mahadevpur, Natun Balijan, Raman, infrared

SIMULATION OF AN EXTREME RAINFALL EVENT OVER MUMBAI USING A REGIONAL CLIMATE MODEL

Manas Pant[1,2], R. Bhatla[1,2], Shruti Verma[1]

1. Department of Geophysics, Institute of Science, Banaras Hindu University, Varanasi, India.

2. DST-Mahamana Centre of Excellence in Climate Change Research, Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi, India.

Email- pant.manas95@gmail.com

The recent version of ICTP's regional climate model RegCM4.6 has been utilized to simulate one of the most catastrophic rainfall events recorded in the history of Mumbai, India on 26th July, 2005. The dynamical downscaling using RegCM4 has been performed at 25 km horizontal resolution over South-Asia Coordinated Regional Climate Downscaling Experiment (SA-CORDEX) domain with initial and lateral boundary conditions from ERA-Interim reanalysis (EIN15). Analysis suggests that the RegCM4.6 using mixed cumulus parameterization scheme (CPS; where the Emanuel scheme is considered over land and the Grell scheme is forced over ocean (EL_GO) is able to reproduce the heavy rainfall event with higher accuracy compared to the driving fields. This highly confined event over Mumbai might be a manifestation of the low-pressure area formed over Orissa and the adjoining regions associated with mid-tropospheric cyclonic (MTC) circulation over the western coastal region. There is a significant

improvement in the model simulated output closer to the observations of rainfall and large-scale fields. Further, the RegCM4 satisfactorily simulates the features such as the convergence at the lower level accompanied with the divergence at the upper level, higher cyclonic vorticity near lower level, and presence of an enormous amount of moisture content at different pressure levels.

Key Words: RegCM4.6, CORDEX, Mixed CPS, Mid tropospheric cyclone (MTC).

APPLICATION OF ARTIFICIAL NEURAL NETWORKS ON ASSESSMENT OF NATURAL AND ANTHROPOCENTRIC FORCING ON INDIAN SURFACE AIR-TEMPERATURE VARIABILITY

Padmavathi[1], B., R. K Tiwari, and V. M Tiwari[1]
[1]CSIR-NGRI, Hyderabad, India
Email Id: paddu.geophysics@gmail.com

To examine, the relative influence of natural and anthropogenic forcing on surface air temperature variability over the Indian sub-continent (INDSAT/T_{mean}), we analyze the normalized data of maximum (T_{max}) and minimum (T_{min}) temperatures, TSI (Total Solar irradiance), ENSO (El-Nino Southern Oscillations), PDO (Pacific Decadal Oscillations), NAO (North Atlantic Oscillations), Sea Surface Temperature (SST), All India Rainfall (AIR) and CO_2 using Artificial Neural Networks (ANN). Sensitivity analysis reveals that the dependency of each of the natural (e.g. TSI, OAC, SST, AIR) and Anthropogenic (CO_2) parameters on SAT as, i) SAT is considerably sensitive to incessant emission of Anthropogenic CO_2, ii) Intensive influence of natural solar irradiance at 11 and 22 years, iii) Intermittent influence of Ocean Atmospheric Circulations (OAC) and SST at low intensive solar radiance. These dependent parameters used to develop a model and to envisage the future temperatures by developing a multi perceptron non-linear feed-forward and back-propagation with NARX network encoded with Bayesian regularization (BR) training algorithm and the feeding parameters are TSI, CO_2, OAC, SST, and AIR data as input and T_{mean}/INDSAT as Target (supervise learning). To ensure the stable and best possible result, we trained the network successively with the different numbers (1 to 10) of neurons and delay parameters. We found that the MSE and R values (minimum MSE and maximum R-value) of training with 8 neurons are optimum and appropriate for the present analysis. we, therefore, accepted 8 neurons to develop a model for training and testing the data, and the obtained MSE=0.00039976 and R=0.98933. We have validated the model from 2001 to 2007 and predicted temperatures from 2008 to 2018 with an error $\leq$ 20%.

Keywords: INDSAT, SST, OAC, TSI, CO_2, NARX

GLOBAL CLIMATE LINKAGE OF INDIAN OCEAN DIPOLE (IOD) DYNAMICS DURING HOLOCENE

Pavan Miriyala[1, *] and Bejugam Nagender Nath[2]
1. CSIR-National Geophysical Research Institute, Hyderabad, Telangana, India
2. CSIR-National Institute of Oceanography, Dona Paula, Goa, India
* Presenting author mail:pavanmiriyala@ngri.res.in

Though the Indian Ocean Dipole (IOD) phases affect the socio-economic conditions of Indian Ocean rim countries through its inter-annual extremities, main triggers are yet to be resolved to predict future IOD behavior in the present global warming scenario. As our direct instrumental observations of monsoon are limited to the last 160 years, we need proxy records that archive climatic and environmental conditions. The results of precipitation proxies of weathering and erosional records from both sides of the Indian Ocean, along with other monsoonal and productivity records of the terrestrial as well marine environment during the Holocene, presented here, suggests a shifting monsoonal east-west contrast similar to the present-day Indian Ocean dipole (IOD) like phenomenon, but longer than the present day. A tightly coupled positive and negative phases of IOD since early Holocene and well-synchronized variability with strengths of Atlantic meridional overturning circulations suggests strong atmospheric teleconnections associated with the extremities in IOD until El Niño–Southern Oscillation (ENSO) strengthened at around 4.2ka.

Key words: Indian monsoon, IOD during Holocene, atmospheric teleconnections

VARIABILITY OF SNOW WATER EQUIVALENT AND SNOW MELT RATE OVER SIKKIM HIMALAYAS

Shruti Verma[1], R. Bhatla[1,*], Manas Pant[1,*]
1. Department of Geophysics, Institute of Science, Banaras Hindu University, Varanasi, India.
*DST-Mahamana Centre of Excellence in Climate Change Research, Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi, India
Presenting Author's Name: Ms. Shruti Verma
E Mail: shrutiverma072@gmail.com

India is a mega biodiverse agrarian nation whose fate is controlled by Monsoon and Himalayas. The glacial region of Hindukush Karakoram Himalaya (HKH) are called as 'water tower of Asia' which stores large volumes of water in the form of ice and snow after the polar ice (Adnan et al., 2017). The trends of rising global temperature and accelerated receding of glacier. Sikkim is the second most vulnerable Indian state to climate change due to glaciers and stream power dependence. the present study focuses on understanding the impact of climate change to snow water equivalent (SWE) and snowmelt rate in Sikkim Himalayas for the time period of 1979 to 2017. Hence this study is conducted to discuss the temporal variation of melt rate and associated melt amount through degree day modeling. The average decadal rate of Snow water equivalent (SWE) and Degree Day factor (DDF) for the months of March to August for Sikkim Himalayas over 1979-2017 is increasing except for 2009-2017 decade

indicating the impact of Global Warming. The average decadal temperature trend is increasing with 0.91 coefficient of determination for Sikkim Himalayas for months of March to August from 1979-2017 indicating increase in humidity, increase in cloudiness and Climate change due to accelerated Greenhouse Effect in recent decades. Hence, the rate of snowmelt is critical for information about flood forecasting, extreme weather event, agriculture and optimal management of water resources.

Keywords: Sikkim Himalaya, Snow Water Equivalent (SWE), Degree Day Modeling (DDM), climate change impact

MARINE GEOSCIENCES

A STATISTICAL STUDY OF EARTHQUAKES OF MID-INDIAN OCEAN RIDGE

Abhilash K.S[1] and Ajayakumar P[2]
[1] Shillong Geophysical Research Centre, IIG. [2] Department of Marine Geology and Geophysics, CUSAT
Presenting author: abhilashks91@gmail.com

Mid Indian Ocean Ridge plays an essential role in the tectonic movement of India as it controls the significant tectonic activity of the Indian Ocean. To study the effect of the spatial and temporal variation of the seismicity of the region, the earthquake data is collected from ISC reviewed catalogue from January 1964 to December 2018. The data is then statically analysed for obtaining the trends for the temporal variation in the occurrence of the earthquake, and they are also analysed for spatial variation of earthquakes; b-value of the region is calculated to know about the frequency- magnitude relationship of the events in the region and the spatial and temporal variation of the same.

In the present study, 15520 earthquakes were selected from the South East Indian Ridge, South West Indian Ridge and central Indian Ridge. The frequency magnitude distribution of the events is calculated using maximum likelihood method and found to be 1.24±02 with a magnitude of completeness of 4.8. For further analysis, the temporal variation of the b value and magnitude of completeness are done to get information about the distribution of earthquakes in the study area.

CONVOLUTIONAL BIDIRECTIONAL LSTM NETWORK FOR GENERATION OF MISSING WELL LOG DATA

D. Haritha* and N. Satyavani
Deep Seismic Group
CSIR – National Geophysical Research Institute, Hyderabad, Telangana, 500007.
***** Corresponding author email: haritha4274842@gmail.com

Well log data gives the geological information of a borehole. Distorted data are very common in well log, due to instrument damage, poor borehole conditions, imperfect logging, and so on. These causes the data missing and leads to poor interpretation. Without increasing the expenditure, the missing well log data can be retrieved with the deep learning methods from the existing/ available logs in the borehole. In this study, we propose a Convolutional Bidirectional Long short-term memory (CNN-Bi-LSTM) with fully connected layers to estimate the missing well data. This method extracts the important features from the well log data along the borehole, which helps to predict the trend of the missing data. Dropout used as a regularization in between Bidirectional LSTM and fully connected layers to reduce the overfitting. The accuracy of the predicted data is calculated with mean square error and root mean square error. The predicted data from CNN-Bi-LSTM network is compared with Bi-LSTM and ANN network. The results proved that this method is successful in predicting the Neutron log from Density and Gamma logs.

Keywords: LSTM, Missing data, Convolution, Bidirectional, well log, neutron.

GAS HYDRATE DISSOCIATION IN THE KRISHNA GODAVARI BASIN-ROLE OF SALINITY AND BOTTOM WATER TEMPERATURES.

Palle Jyothsna[1,2] and Nittala Satyavani[1,*]

[1]CSIR-National Geophysical Research Institute, Marine Seismic Group, Hyderabad-500007, Telangana, India.

[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India.

[*]Corresponding author: Nittala Satyavani email: satyavani@ngri.res.in

Dissociation of gas hydrates occurs if the any of its thermodynamic properties are altered. Salinity is one such factor that is responsible for the formation and dissociation of methane hydrates. Any changes in the salinity result in the fluctuation of the methane hydrate phase boundary. The increasing salinity shifts the methane hydrate phase boundary toward the higher pressure/lower temperature and towards shallow depths. Bottom water temperature is another factor that will influence the hydrate stability zone. We have examined the probable causes that can result in the dissociation of gas hydrates in the Krishna Godavari basin using seismic data and found that the stability is influenced majorly by the salinity and bottom water temperature. The seafloor temperature in the study area is around 6.5 degree centigrade which is close to the dissociation temperature of gas hydrates. From our study, we infer that the elevated salinity and bottom water temperatures from the year 2004-2019 might have resulted in shoaling of Bottom Simulating Reflector. The dissociation temperatures observed in the laboratory correlate well with the temperatures observed in our study area. We conclude that the hydrate in the Krishna Godavari basin is dissociating and the overpressure is migrating through the pathways, creating large slumps in the continental slope.

Keywords: Salinity, Gas hydrate stability zone, shoaling of Bottom Simulating Reflector

STRUCTURES AND TECTONICS OF KRISHNA-GODAVARI OFFSHORE BASIN AS REVEALED FROM SEISMIC ATTRIBUTES AND OTHER GEOPHYSICAL DATA

Satendra Singh[1, *] and Kalachand Sain[2]

[1]CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad - 500007

[2]Wadia Institute of Himalayan Geology, 33 GMS Road, Dehradun - 248001

[1]satkavisingh@gmail.com; [2]kalachandsain7@gmail.com;

[*]Corresponding author: satkavisingh@gmail.com

Krishna-Godavari (KG) basin is a passive margin and deltaic sedimentary basin of India which was formed as a consequence of continental rifting and seafloor spreading progressions between India, Antarctica and Australian plates during the Late Cretaceous period. Krishna and Godavari rivers are continuously filling this basin with huge amount of sediments to make it a suitable womb for hydrocarbon accumulation. In reflection seismic data, the seismic attributes play an important role to enhance the information and leading to a better geological and geophysical interpretations. The present study aims for delineating of subsurface structures in the KG offshore basin using seismic attributes and other geophysical data. The time migrated 2D multi-channel seismic data, acquired by CSIR-NGRI, Hyderabad have been utilized for explaining the geological and tectonic features of the basin. The

seismic data is initially conditioned using Dip Steered Median Filter (DSMF) to eliminate the noisy events hiding the subsurface information and to make reflectors stronger and continuous such that resultant image can be easily interpreted. Different types of seismic attributes such as amplitude, curvature, frequency, phase, similarity, energy and sweetness have been calculated along two seismic profiles. NE-SW profile shows horst and graben features in seabed topography while it is constantly dipping in NW-SE profile towards deep sea. Many geological, tectonic and structural features such as horsts/grabens, mini fill basins, chaotic reflections, faults, folds, channels, gas upthrusts/chimneys, blanking, and Mass Transport Deposits (MTDs) have been delineated along the seismic lines of study. An anomalous, known as the bottom simulating reflector (BSR) which is a main marker for gas-hydrate occurrence, have also been identified along the profiles. Free air and bouguer gravity responses and their variations have been calculated and modelled to ascertain the subsurface features.

Key words: KG basin, Seismic Attributes, Subsurface Features.

A COMPARATIVE DIAGENETIC ANALYSIS OF SHALLOW AND DEEP-SEATED GAS HYDRATE SYSTEMS FROM THE BAY OF BENGAL

Virsen Gaikwad[1, 2]*, Firoz Badesab[1], Mahender Kotha[2]

[1] CSIR-National Institute of Oceanography, Dona Paula, Goa, India.

[2] School of Earth Ocean and Atmospheric Sciences, Goa University, Taleigao, Goa, India.

Presenting author*: virsengaikwad@yahoo.com

We conducted a detailed rock magnetic, mineralogical and petrological analyses on the sediment cores retrieved from shallow (active methane seep), relict and deep-seated gas hydrate systems from the Bay of Bengal to constrain the methane-related diagenetic and authigenic mechanisms. Detrital, authigenic and diagenetic minerals contribute to the bulk sediment magnetism at these sites. Presence of several layers of methane-derived authigenic carbonates in the sulfidic and methanic zones manifested by distinct minima in magnetic susceptibility confirmed that the formation, sustenance and migration of sulfate-methane transition zone is highly controlled by the fluctuations in methane supply which led to the multiple events of intensification of anaerobic oxidation of methane at the studied sites. Rockmagnetic data sets delineated different stages of diagenetic dissolution of detrital (PSD-MD) grains followed by subsequent precipitation of ferri (SP greigite) and para-magnetic (pyrite) iron sulfides. Magnetic concentration and grain size dependent proxy parameters provided vital information on the factors controlling the formation and preservation of different magnetic mineral phases in sulfidic and methanic zones. We developed conceptual model to explain different stages of diagenetic and authigenic processes influencing the sediment magnetism at active, relict methane seep sites linked with shallow and deep-seated marine gas hydrate systems.

SOLID EARTH GEOSCIENCES

SEISMOTECTONICS OF THE INDENTING NORTHEAST CORNER OF THE INDIAN PLATE IN THE TIDDING-TUTING SUTURE ZONE OF THE EASTERN HIMALAYAN SYNTAXIS

Abhishek Kundu[1,2*], Devajit Hazarika[1]
[1]Wadia Institute of Himalayan Geology, 33 GMS Road, Dehradun, India
[2]Department of Geology, Institute of Science, Banaras Hindu University, Varanasi, India
*Presenting Author: abhishek.kundu@832gmail.com

The seismicity in the northeast fringe of the Indian Plate in the Eastern Himalayan Syntaxis (Tidding-Tutting Suture) and adjoining area has been studied analyzing the earthquake data recorded by the local broadband seismograph network as well as reviewed catalogue data of the International Seismological Center. The study reveals that the region is seismically active up to ~40 km depth. In contrast, the seismicity in the Indo-Burma Ranges (IBR) is observed up to a depth of ~200 km suggesting the subduction process of the Indian plate beneath the IBR. The study suggests that the subduction process terminates to the north of ~27^0 N Latitude and the indentation process of the rigid Indian plate into south-east Asia predominantly controls the seismicity to the north of the IBR. The seismicity and its linkage with the existing tectonic features are critically examined in the Lohit Valley and Mishmi Hills region. Source mechanisms of 10 earthquakes (3.5 >M > 4.2) are evaluated with the help of the waveform inversion technique. The results of the source mechanism study reveal that the closely spaced Mishmi, Tidding, and Lohit faults are steeply dipping thrust sheets that accommodate the large crustal shortening owing to the indentation process and clockwise rotation tectonics. The Walong fault can be characterized by strike-slip motion which helps to facilitate the clock-wise rotation of crustal material around the syntaxis. Significant strain partitioning is anticipated from the variation of pressure (P) axes orientations indicating the effect of complex syntaxial tectonics.

SN WAVE AND VP/VS TOMOGRAPHY OF THE UPPERMOST MANTLE BENEATH THE INDIAN SHIELD AND ITS ADJACENT REGIONS

Bhaskar Illa and Prakash Kumar
CSIR- National Geophysical Research Institute
Uppal Road, Hyderabad, India
illabhaskar@gmail.com

We first time inverted high-resolution Sn travel time data from the Indian shield and its adjoining regions by inverting 11,243 Sn arrivals. The average apparent Sn velocity is 4.60 km/s with a velocity perturbation of ±0.2 km/s. High velocities are found under some parts of the Indian cratons, the Tarim Basin, the north-west part of the Indian plate, and the Bay of Bengal, whereas the Burmese arc, Hindu-Kush, Tibetan Plateau, and eastern parts of the Indian shield are dominated by low Sn velocities. The Sn image clearly reflects the heterogeneous character of the Indian lithosphere. The cratonic blocks of Singhbhum, Bastar, and Aravalli show low Sn. The intracratonic Cuddapah Basin and the north of the Southern Granulitic Province also exhibit higher uppermost mantle shear velocity. We also observe a

localized high beneath the exotic Coorg microcontinent, located in the south of the western Dharwar Craton. The intriguing feature is the central Indian highs, which we interpreted as the basaltic lava pillows concomitant to the Deccan volcanism. Along the Himalayan arc, we observe higher Sn velocity, which supports the idea of subduction of the Indian lithosphere into the mantle. The Indian Shield region has been dominated by low to moderate Vp/Vs ratios, except for Singhbhum and Bundelkhand Cratons. The E-W trending Palghat Cauvery Shear zone in the north of the SGP has a low Vp/Vs anomaly (~1.75) that clearly distinguishes it from the Dharwar Craton. The east part of the Bay of Bengal lithosphere can be characterized by the presence of partial melts and water content in the uppermost mantle, while the wester part support the presence of an orthopyroxene-rich mantle or eclogite. High Vp/Vs values in the Burmese arc and Hindukush region support the subduction and further upwelling of asthenosphere partial molten material.

ROLE OF PRE-ERUPTIVE TECTONIC STRUCTURES IN THE OCCURRENCE OF SEISMIC SWARM ACTIVITY AT PALGHAR, DECCAN VOLCANIC PROVINCE – A MAGNETOTELLURIC STUDY

N.N.Chakravarthi[1,2]*, G. Pavankumar[1] and A. Manglik[1]

1) CSIR-National Geophysical Research Institute, Hyderabad – 500 007, India.

2) Academy of Scientific and Innovative Research (AcSIR)

(*Email: nalluru.ngri21j@acsir.res.in)

The Peninsular Indian shield, including the Deccan Volcanic Province (DVP), is considered to be a stable continental region. However, this region also experiences moderate level of seismicity, e.g., the Koyna (1967) and the Latur (1993) earthquakes, and swarm type earthquake activities mainly in the western part of the DVP. One such swarm activity started in 2018 in the Palghar region of Maharashtra. We have studied this activity by delineating the geoelectric crustal structure of the region using magnetotellurics (MT) and correlating it with the seismic activity. MT data were acquired along an E-W profile traversing through the Palghar Swarm Zone (PSZ) (profile-I) and along another profile 60 km south of the PSZ (profile-II) to explore causative mechanism for the seismic activity. 2-D inversion of distortion corrected MT data along profile-I yielded a 5-6 km thick U-shaped shallow conductor resting on a crustal-scale listric-type fault system. A good correlation of the hypocentral distribution of the seismic events with the conductor broadly indicates possible role of fluids (either meteoric or of crustal origin) in the genesis of the earthquake swarm activity. The results along profile-II suggest an extension of the shallow conductor further south. In addition, the results reveal a near-vertical crustal-scale conductor coinciding with the surface trace of the West Coast Fault. The presence of a U-shaped conductor with variable geometry in both profiles indicates a possible northwest extension of the Kurudwadi rift beneath the DVP. We hypothesize that the coupling and stress transfer between the extended Kurudwadi rift and the N-S faults in the coastal plain may be responsible for the earthquake activity in the Palghar region.

PREVALENCE OF TRANSVERSE TECTONICS IN THE COMPRESSIVE REGIME

Charu Kamra*[1, 2], Sumer Chopra[1] and R.B.S. Yadav[2]
[1]Institute of Seismological Research, Gandhinagar, Gujarat, India 382009
[2]Department of Geophysics, Kurukshetra University Kurukshetra, Haryana, India 136119
*Email: charukamra007@gmail.com

The Kachchh region of Gujarat is seismically one of India's most active intra-plate regions, with three large damaging earthquakes—Kachchh (1819 Mw 7.8), Anjar (1956 Mw 6.0), and the most recent Bhuj (2001 Mw 7.6) occurring in the past 200 years. The tectonics in the Kachchh rift basin are heterogeneous and complex. The focal mechanism and source parameters of 41 local earthquakes (Mw 4.0–5.1) that occurred in the Kachchh rift basin, are determined to characterize various active fault systems in that region. It is found that one-third of the earthquakes exhibit reverse mechanism and three-fourth are either strike slip or have some components of strike slip. Thus, we conclude that transverse tectonics are currently dominant in the Kachchh rift. These transverse faults are preferably oriented in the northeast–southwest and northwest–southeast directions in the eastern and western parts of the rift, respectively. These transverse faults are almost vertical (dip > 70°) and mostly blind with no surface expressions. Most of the significant faults that strike east–west dip toward the south and are listric. Using focal mechanisms results, dominant stress field and direction of maximum horizontal stress is explored. It is found that KRB exhibits radial compression with maximum principal stress (σ1) oriented NNE. Thus, Kachchh region of Gujarat is moving towards NNE coinciding with the movement of Indian plate motion. The stress drop of these 41 earthquakes ranges between 2.3 and 10.39 MPa. It is found that the stress drop of earthquakes may depend on the focal mechanism and is independent of focal depths. The average stress drop is found to be the highest (7.3 MPa) for the earthquakes that show a dominant normal mechanism accompanied by strike slip (5.4 MPa) and reverse (4.7 MPa). The average stress drop of the Kachchh intraplate region is 5.3 MPa, which is consistent with other intraplate regions of the world.

CRUST AND UPPER MANTLE BENEATH THE KISHTWAR REGION, NW HIMALAYA, INDIA

C. Haldar *, S. Kumar and K. Sain
Wadia Institute of Himalayan Geology, 33 GMS road, Dehradun-248001, India
* Email: chinmay@wihg.res.in

We have used the converted wave seismological data across the Doda-Kishtwar region in the Kashmir seismic gap of North-West Himalaya, and present the first image of the crust including the intra-crustal low-velocity layer (LVL), upper mantle discontinuities, and seismic velocity structure based on receiver functions (RFs) analysis. The study provides a correlation between the upper crustal LVL and local seismicity, role of the underlying structure on seismogenesis, and geodynamic evolution of the region. Three-component waveforms of the teleseismic earthquakes, recorded by a network of 6 broad-band seismological stations that are operated by Wadia Institute of Himalayan Geology (WIHG), have been used for this study. The results from the inversion of the stack RFs show increase in crustal thickness

from 47 km to 57 km from south to north. The Main Himalayan Thrust (MHT) is observed beneath four stations out of six from an individual as well as stack receiver functions whose depth varies from 21 to 26 km. However, the LVL is observed below each station, which varies from 11.1 km to 13.3 km with a high value of Vp/Vs. The high value of Vp/Vs in the LVL of upper crust may be due to shear heating within the ductile regime and/or decompression and cooling related to the exhumation indicating the presence of fluid/partial melt at depths between 10 to 15 km. Out of 211 local events in the study region, 143 earthquakes occurred at depths of <= 15 km and remaining 68 events occurred at depths of 16 to 35 km. Interestingly, the LVL coincides with the occurrences of most of the crustal seismic activity, and thus we conclude that the upper crustal LVL, associated with weak zone, is responsible for the generation of most of the local earthquakes. The arrival time difference between the T_{P660s} and T_{P410s} converted phases in the study region are larger than the normal 24 s (w.r.t. the standard time of IASP91 due to the effect of low temperature, indicating the Indian plate would be cooler by a few hundred degree Celsius than the ambient mantle at this depth. This means that the consumed part of the Indian shield has extended up to the transition zone.

Key Words: Crust, Moho, Kishtwar, Receiver functions, Low-Velocity Layer, NW Himalaya.

A FULLY UNSUPERVISED DEEP LEARNING APPROACH FOR DE-NOISING THE CONVERTED WAVE SEISMIC DATA

B. Dalai [1,2], P. Kumar [1,2], U. Srinu [1], M. K. Sen [3]
[1] CSIR- National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India
[2] Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, India
[3] The University of Texas at Austin, Texas 78758-4445, USA
Presenting Author's Email: bijayanandadalai@gmail.com

The enhancement of signal-to-noise is of paramount importance in any geophysical signal processing. Converted wave seismic data commonly contain noise of various origins and hence, may lead to ambiguous interpretations of the subsurface features. Several methods have been devised to suppress the noise from the geophysical time series data. Here we utilize an unsupervised deep learning approach to de-noise the converted seismic wave data. This approach is based on the idea of deep image prior followed by the representation and residual learning concept. The input noisy data are split into several patches and then the algorithm compresses the input patches to a new representation following the encoder and decoder network to extract some meaningful features. Then the output patches corresponding to the approach are unpatched to retrieve the denoisy data. The method is first evaluated on a suite of synthetic data contaminated with various amount and types of Gaussian and realistic noise. The efficiency of the method has been tested on observed receiver function data from three typical stations viz. HYB (Hyderabad, India), LBTB (Lobatse, Botswana, South Africa) and COR (Corvallis, Oregon, USA).

STRESS DROP INVESTIGATIONS BASED ON EARTHQUAKES AND ITS TECTONIC IMPLICATIONS IN SIANG VALLEY OF ARUNACHAL PRADESH, NORTHEAST-INDIA.

Dilip Kr. Yadav*, Ashish Pal, Naresh Kumar and Ajay Paul
Wadia Institute of Himalayan Geology, Dehradun 248001, India
*Corresponding author Email: yadavdk@wihg.res.in

Investigations of micro- and low-magnitude earthquakes in the Siang valley of Arunachal Himalaya, Northeast India were performed to evaluate the earthquake source parameters based on Brune's circular model. The seismic events used for this study were recorded by a recent digital network of eight broadband seismic (BBS) stations installed in December 2018 by Wadia Institute of Himalayan Geology (WIHG). These seismic stations falls in the miezoseismal zone of the great Assam earthquake of 1950 (Mw 8.4). The earthquake source parameters were calculated using spectral analysis. The stress drop obtained for a felt earthquake of Mw 5.9, the Mechuka earthquake has 88.5 bars, the seismic moment (Mo) of 3.26E+15Nm and the source radius of 554 m. This high stress drop in the Siang Valley compared to its low values for lower magnitude earthquakes indicates that the Mechuka earthquake of 23rd April 2019 is associated with high strength material accumulating high strain during the earthquake building and brittle failure processes. The seismic moments obtained from the micro-earthquakes having the magnitudes in the range $1.5 \leq M_L \leq 5.9$, varies between 2.30×10^{11} Nm and 3.26×10^{15} Nm causing circular deformation of source radius from 116 m to 554 m. Seismically intense clustering of micro-earthquakes of 36 events has low-stress drop below 10 bar except 88.5 bars for the recent M5.9 Mechuka earthquake. Evaluated low-stress drop for the small magnitude earthquakes shows brittleness of the upper crustal region. In Siang valley most of the seismic events are located around the major tectonic faults (i.e MCT, MBT, MT, LT and Tidding Thrust). In Siang valley, the linkage between stress drop, seismicity and tectonic elements is well observed.

Key words: Source parameters, Stress drop, Siang Valley, Eastern Himalaya.

SPATIAL B-VALUE VARIATIONS AND HAZARD ANALYSIS IN THE NAGA-PATKAI HILL, INDO-BURMA RANGE

Gourab Dey and Debasis D Mohanty*
Geosciences and Technology Division, Northeast Institute of Science and Technology,
Council of Scientific and Industrial Research, Jorhat, Assam, India, 785006.
Academy of Scientific and Innovative Research (AcSIR), India.
*Correspondence: debasis@neist.res.in; devlinkan06@yahoo.com
Presenting Author: me.gourab.2015@gmail.com/debasis@neist.res.in

To understand the seismicity and tectonic activity of the North-East India, b-value estimation is an important parameter. In North-East India, Indo-Burma Range is tectonically and seismically most active region. The Naga-Patkai Hill is situated at the northern part of the Indo-Burma Range. In the last forty years, more than 1400 earthquakes have struck in the Naga-Patkai Hill region. Using the homogeneous

earthquake catalogue from 1995 to 2021, the spatial distribution of the b-value has been examined. In our present study using the maximum curvature method, the estimated b-value in this region is 0.60. There is a drastic change in seismic b-value from 0.4 to 0.6 and 0.45 to 0.75 in end of 2012 and 2016, respectively, which are may be due to the earthquakes of magnitudes 6.1 in November 2012 and magnitude 6.6 earthquake in January 2016, respectively. Spatial distribution data shows a higher b-value in the northern part of this region than in the southern part. The overall trend of b-value increases with increasing depth, where the earthquakes are distributed up to a depth of 150 km.

Keywords: Seismic b-value, Indo-Burma Range, Naga-Patkai Hill, Earthquake

COPPER MINERALIZATION IN THE NORTH DELHI FOLD BELT-A PROGNOSTIC IRON-OXIDE-COPPER-GOLD TYPE DEPOSIT IN THE INTRACONTINENTAL RIFT SETTING

Jyoti Priyam Sharma*[1], Prabodha Ranjan Sahoo[1],

[1]Department of Applied Geology, Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand - 826004, India, jyotipriyam.sharma@gmail.com

Low grade secondary copper dominated mineralization are ubiquitously found within the metasedimentary rocks along a NE-SW trending sequences of Delhi Supergroup. A few of these copper occurrences with considerable concentration and size are exposed in the SE fringe of the Khetri basin and is well known as Nim ka Thana copper belt. Barite and iron ore mineralization are also observed in the area besides the copper mineralization. Petrographic studies of the host rocks, ore petrography and fluid inclusion studies suggest the copper mineralization to be of a sedimentary as well as low temperature epithermal type which has been modified by a supergene enrichment event distinguishing it from the adjoining Khetri copper deposit. The primary sedimentary copper mineralization within the metapelites and dolomites refers to a shallow to moderate deep basin which can be well correlated with the intracontinental rift type basinal setting for the Delhi Supergroup metasediments. Further, a large scale Na metasomatism resulting albitites and occurrence of hydrothermal barite mineralization in the area support a rift related basinal evolution for this belt. Mineral chemical data from the different copper sulphide phases suggest the copper mineralisation to be having a high cobalt-nickel ratio that refers to a sedimentary origin. Fluid inclusion data suggests a moderate to low salinity condition related to the epithermal system which is an indicator of Iron-Oxide-Copper-Gold (IOCG) deposit type. An established IOCG type copper mineralization in Khetri basin and a predictive IOCG type mineralization in Nim ka Thana point towards a rift related copper mineralizing belt.

A MACHINE LEARNING APPROACH TO ESTIMATE GEOMECHANICAL PARAMETERS FROM CORE SAMPLES

Jwngsar Brahma
Pandit Deendayal Energy University
Email: jwngsar@gmail.com

For hydraulic fracturing design, investigation of wellbore stability and rock failure, the geomechanical and Thomsen parameters play very important roles. The main objective of this paper is to estimate the Thomsen's parameters (ε, γ, δ) and geomechanical properties, namely Young's moduli and Poisson's ratios from the core samples using Machine Learning and conduct a comparative analysis with the conventional mathematical approach; to place emphasis on the use of Machine Learning and Artificial Intelligence in the Oil & Gas industry and to highlight its future potential to help in the digital transformation of the industry. Four different rock samples were considered for this study. Two different Machine Learning models, Ordinary Least Square method and Random Forest method, were used to predict the afore mentioned geomechanical properties from the wave velocity and confining pressure data. The results demonstrated that the approaches employed in the estimate of geomechanical properties are rapid and reliable (about 93.5 percent accuracy) and may be applied in geomechanical modelling of petroleum reservoirs on a large scale. Through this study, it has been observed that the Young's modulus and Poisson's ratio are heavily influenced by the anisotropy parameters, with this relationship being depicted through the correlation matrix generated for each rock sample. Finally, the results are compared with the results obtained from mathematical approaches. The parameters predicted by machine learning and artificial intelligence approaches are excellently matched with mathematical approaches.

Keywords: Machine Learning, Artificial Intelligence, Core Samples, Thomsen Parameter, Geomechanical.

GEOMAGNETIC VARIATIONS FROM GEOMAGNETIC CONJUGATE SITES FROM THE INDIAN SECTOR

L.Majula and Archana R.K
Geomagnetic Observatories, CSIR-National Geophysical Research Institute,
Uppal Road, Hyderabad-500007, India
Corresponding Author: manjulalingala@gmail.com

The geomagnetic diurnal H (ΔH) variations from geomagnetic conjugate sites HYB and GAN, which are located in the low latitude (8º geomagnetic latitude) of northern and southern hemisphere respectively, has been analysed for quiet and disturbed days of solar cycle-24. It is observed that the ΔH from GAN is higher in amplitude and width compared at HYB for majority of the days indicates that the asymmetry in the Sq current system of both hemispheres. The seasonal pattern of the ΔH from the sites also shows different trend could be attributed to the fact that GAN is located on the geographic equator and subjected to direct solar irradiations compared HYB. The response of the geomagnetic field at these to major storms and flares also been studied.

Keywords: sq current, geomagnetic activity, Geomagnetic storms

MODELLING OF STRONG GROUND MOTIONS FROM 4 APRIL 2011 INDIA-NEPAL BORDER EARTHQUAKE USING A SEMI EMPIRICAL ENVELOPE TECHNIQUE

Monika, Dinesh Kumar and R.B.S. Yadav
Department of Geophysics, Kurukshetra University, Kurukshetra, India
dhimanmonika560@gmail.com

A simple and efficient semi empirical technique has been used to model the empirical accelerograms of 2011 India-Nepal border earthquake (M 5.7). The earthquake was recorded by the network of 23 accelerograph stations maintained by IIT Roorkee. The semi empirical technique involves the construction of an envelope function and then combined with the random white noise to obtain the simulated accelerograms. The technique requires parameters like peak ground acceleration (PGA)-distance relationship, hypocentre, duration, attenuation relation, high frequency decay parameter and site effects.

The peak and duration of envelope function have been obtained from the empirical relations available for the region. The site effects have been computed from the empirical accelerograms using Horizontal to Vertical Spectral Ratio (HVSR) technique. The high frequency decay parameter, Kappa, has been estimated from the log-linear slope of Fourier spectra of observed accelerograms.

The simulated accelerograms have been compared with those of observed ones in terms of peak ground acceleration, duration, Fourier and response spectra. The pga, duration of simulated accelerograms and corresponding Fourier as well as response spectra have been found to be satisfactory with those of observed ones at most of the recording sites. The value of kappa varies from 0.02 to 0.09.The estimated site amplification is minimum at station kotdwar (3.08) and maximum at Bageshwar (44.05) for this earthquake.

The semi empirical technique can be used for the simulation of future earthquake in the region for proper evaluation of seismic hazard.

ANALYSIS OF SPATIO-TEMPORAL VARIATIONS OF EVAPOTRANSPIRATION IN MUSI RIVER WATERSHED, SOUTH INDIA

M.Ramya[1], K.Ramamohan Reddy[1] and L.Surinaidu[2]
[1]Jawaharlal Nehru Technological University-Hyderabad-India
[2]CSIR-National Geophysical Research Institute-Hyderabad-India
Corresponding author: suryangri@gmail.com

Land resource management and Earth science play a crucial role in maintaining sustainability. Land use and land cover changes (LULC) are among the most hydrologically significant alterations of the land surface and considered as a central component of the earth's environmental issues. It is a key factor for

global change by providing scenarios for regional and global models of earth-ecological systems. This analysis helps in understanding the land and human interactions. The changes in Land use and Land cover are induced by the rapid anthropogenic activities like massive infrastructure development, land use transformation, diversion of water for irrigation and urbanization are the major causes of change in hydrological and watershed processes. All these factors together especially in megacities, affects the LULC dynamics. Another key component of earth's hydrological cycle and energy balance is Evapotranspiration, which is closely related to LULC. In this regard, it is important to understand the concept of evapotranspiration, to quantify the influence of human activities on water cycle and strengthening watershed management that could improve the water use planning and efficiency. The present study involves, analysis of expansion and shrinkage of the land use land cover in Musi river catchment, using the integrated approach of remote sensing and Geospatial technologies at different temporal scales. The obtained LULC maps of different time periods show that, the musi river catchment has experienced a remarkable land cover change between 1990 and 2020. Subsequently, the results of this study in conjunction with evapotranspiration statistics, assess the impact of the LULC changes on the temporal and magnitude variations of evapotranspiration. This evaluation identifies the extent of exposure of water resources to the changes occurred over a period of time and monitors long term variations in evapotranspiration.

Keywords: LULC, Evapotranspiration, Anthropogenic activities, Water Resources.

THREE-DIMENSIONAL CRUSTAL VELOCITY STRUCTURE BENEATH THE HIMACHAL HIMALAYA USING LOCAL EARTHQUAKE TOMOGRAPHY: IMPLICATIONS FOR TRAPPED FLUIDS AND SEISMOGENESIS

***Shubhasmita Biswal[1,2], Sushil Kumar[2], Keith Priestley[3], W K Mohanty[1], Mahesh Prasad Parija[5]**

[1]Department of Geology and Geophysics, Indian Institute of Technology Kharagpur, Kharagpur 721302, (W.B), India.

[2]Wadia Institute of Himalayan Geology, Dehradun 248001, Uttarakhand, India.

[3]Bullard Labs, Madingley Road, University of Cambridge, CB30EZ, UK

[4]National Geophysical Research Institute, Hyderabad 500007, Telangana, India

Presenting author: susmitabiswal123@gmail.com

3D velocity inversion has been performed to investigate the subsurface structure and seismogenic layers in and around the source zone of the 1975 Kinnaur earthquake (M6.8) in the Himachal Himalaya. The study region exhibits low P-wave velocity (Vp) and low Vp /Vs including a lower velocity zone (LVZ) at middle crust down to 30 km depth. The existence of LVZ indicates presence of fluid or any partial melting strata in the upper crust of the lithosphere. This may be a consequence of under thrusting of the Indian crust, which produces a frictional heat and cause metamorphic dehydration reaction. This reaction causes the released fluid to percolate upwards into the brittle portion of the crust that manifests the leucogranites, which marks the low-velocity layer. A LVZ is prominently observed from shallow levels

(10 km) to 30 km depth, where this normal fault KCF is intersecting with the LPDZ zone and Satluj River in the region. The sedimentary rock composition of Tethys Himalaya as well as sediment deposition along the Satluj River, may be an important cause for this observed phenomenon. The structural discontinuity along the KCF rift, which is orthogonal to NW-SE trending MCT and STD fault structure, can be related to this observed anomaly. The major findings in this analysis provide constraints to the lithospheric structure of the Himachal Himalaya, India region with special emphasis on its observed minimum 3-D tomographic crustal structure.

SHALLOW SEISMIC VELOCITY STRUCTURE AROUND LONAR CRATER USING AMBIENT NOISE TOMOGRAPHY

P. Sion Kumari[1,2], Sandeep Gupta[1,2]
[1]Academy of Scientific and Innovative Research (AcSIR)
[2]CSIR-National Geophysical Research Institute, Hyderabad, India
Corresponding Author: psionkumari10@gmail.com

The Lonar crater is a 1.8 Km-wide impact structure formed in the basaltic target of the Deccan traps in western India. It is a site of great significance and has distinct geomorphic signatures. In this study we use continuous data recorded at a digital seismic network of 23 broadband seismographs, which were installed in March 2014. The ambient noise recordings were collected in continuous mode during the period from March 2014 to October 2015. The Empirical Green's functions (EGFs) have been estimated using vertical component data and it has enabled us to extract the group velocity dispersion curves in the period band 0.3 – 1.0 s. To reveal the 3D variation of shear wave velocity in order to understand the impact deformation around the Lonar crater, the inversion of surface wave dispersion data is carried out by the direct surface-wave tomographic method. The results obtained from the inversion of dispersion data represents the existence of sedimentary layers at shallow depths.

GEOPHYSICAL INVESTIGATIONS FOR SARASWATI RIVER PALAEOCHANNEL IN KURUKSHETRA, HARYANA, INDIA

Sushil Kumar and Kamal
Department of Geophysics, Kurukshetra University Kurukshetra
sushil_gp24@kuk.ac.in, kamalgeophy18@kuk.ac.in

Groundwater is one of the Nation's most important natural resources. It is being used for domestic, irrigation as well as industrial purposes. Due to the overexploitation of groundwater, there is a need to explore more areas for groundwater resources. Palaeochannels are promising features for good quality as well as quantity of groundwater. Several palaeochannels are present in the northern plains of India due to the presence of various courses of ancient Rivers. A network of rivers originated from the foothills of Himalaya in the Siwaliks in Northern Haryana. The groundwater exploration studies have been conducted along and across the possible Saraswati River palaeochannel in a part of Kurukshetra district

of Haryana to understand the subsurface groundwater regime. Electrical Resistivity Tomography (ERT) surveys were conducted at Garhi Roran and Indbari villages and Vertical Electrical Sounding (VES) surveys were conducted at seven villages in the Kurukshetra district. The ERT results indicate broadly three distinct lithological units up to the explored depth of 20 meter (m). The VES results have explored up to a maximum 120 m depth and delineated a palaeo-path from 15 to 50 m depth of high resistivity 170-1225 Ω-m. The width of the palaeochannel in the study area is interpreted as about 10-12 km. The hydrological data analysis shows a high productive zone of good quality groundwater.

Keywords: Palaeochannel, ERT, and VES Survey, Saraswati River, Kurukshetra.

APPLICATION OF DIMENSIONALITY REDUCTION AND IMAGE COMPRESSION ON THE ERT DATASETS FOR DNN MODELS

Utsav Mishra*, Arpit Bansal, Animesh Mandal
Indian Institute of Technology Kanpur
* Presenting author: utsavm@iitk.ac.in

In last few years, neural network approaches, especially, deep neural networks (DNN) have gained significant popularity in inverting the electrical resistivity tomography datasets. However, these complex deep learning models require huge number of labelled data sets of apparent resistivity values (input) and resistivity model (output) pairs for training. These datasets are fed as an array of features to the model, herein the arrays are nothing but the pixel values of each pixel in the image. For example, if we have an image of dimensions 720 * 1080, there will be 2332800 (assuming a RGB image) features in an array. Hence, training the model for these huge number of features is computationally expensive and often requires large storage space to process these huge datasets. Thereby, pre-processing of the datasets is one of the crucial steps to optimally train the model. In this work, an innovative workflow has been proposed based on the concept of dimensionality reduction of the datasets using principal component analysis (PCA). This helps to reduce the number of input attributes while keeping the variation in datasets as much as possible thereby with minimal loss of information.

Further, to resolve the storage constrain, the concept of image compression using k-means clustering has been applied on the training datasets. The application of dimensionality reduction and image compression on the synthetically generated electrical resistivity datasets have shown significant reduction in number of features and overall size of the image without any loss of the information and resolution of the training datasets. Therefore, the proposed workflow will be very useful in efficient and optimal inverse modeling of the ERT datasets.

Keywords: Deep neural network, Principal component analysis, K-means clustering, Electrical resistivity tomography

PREDICTION OF GROUNDWATER LEVEL CHANGES FROM PRECIPITATION DATA USING BAYESIAN NEURAL NETWORKS IN VISAKHAPATNAM DISTRICT, ANDHRAPRADESH, INDIA

G.Vinod Mathews* and S. K. Begum
Andhra University, Visakhapatnam, Andhra Pradesh, India.
*****mathewsvinod36@gmail.com

The groundwater is sensitive to precipitation, runoff and manmade exploitation. Generally, the runoff and man-made exploitation variations on the decadal scales are low unless there was a revolutionary increase in industrialization or farming. Precipitation is the major factor that influences the input/recharge of the groundwater system. However, the precipitation which varies with superimposed periodicities ranging from annual mode to kilo years is sensitive to the changes in the solar activity and ocean-atmospheric circulations. Therefore, we analyze the groundwater levels derived from GRACE and GRACE-FO missions and average precipitation data from multiple rainwater gauges in Visakhapatnam district of Andhra Pradesh, India using Artificial neural networks (ANN). We use Nonlinear autoregression Bayesian neural networks with rainfall data as an exogenic input in our study with 10 hidden neurons. The delay was tested from 2 months to 12 months and found 6 months delay as the best estimate that provides accurate prediction with the best performance. The trained network can predict the data with an input-output correlation of 0.78. Interestingly, the neural net reconstructed the large data gap during the gap in the timeline of GRACE and GRACE-FO missions. These values are corroborating well with the regional groundwater levels obtained from the average of multiple borehole measurements. Interestingly, the study indicates that (i) 78% of the groundwater level changes are sensitive to the rainfall/precipitation and (ii) 22 percentile of the changes are attributed to randomly varying manmade and weather changes.

Keywords: Artificial neural network, Rainfall, Static groundwater level.

AWARD TALKS

TELECONNECTIONS BETWEEN POLES AND TROPICS

Dr.M. Ravichandran

Ministry of Earth Sciences, Govt. of India, New Delhi

Under the global warming scenario, it is becoming increasingly important to understand the dynamics of the polar atmosphere-ocean-sea ice system and its linkages to tropics. The Arctic and the Antarctic are the two coldest climatic regions on the Earth, and they affect the global climate and ocean circulation systems of the entire planet. The presentation will highlight the present status and future projections of sea-ice changes in the Arctic and the Antarctic. Teleconnection between the poles and tropics on various timescales will be presented, which include energy transfer from tropics to Poles and vice versa. The presentation will highlight (a) How the tropical climate modes, such as "ENSO" and "IOD", and intraseasonal mode "MJO" influence the Antarctic sea ice and how the sea-ice modulate Indian Monsoon? (b) How the warming trend in the Southern Ocean affect the Asian Monsoon, and (c) How Arctic sea ice decline modulate Indian extreme rainfall & vice versa?

STRUCTURE AND TECTONIC EVOLUTION OF THE EASTERN CONTINENTAL MARGIN OF INDIA AND THE CONJUGATE EAST ANTARCTICA MARGIN BASED ON THE INTEGRATED GEOPHYSICAL STUDIES: CURRENT UNDERSTANDING AND FUTURE FOCUS

Dr.M Radhakrishna

Department of Earth Sciences, Indian Institute of Technology Bombay, Powai Mumbai 400076
Email: mradhakrishna@iitb.ac.in

The Eastern Continental Margin of India (ECMI) has evolved during rifting and seafloor spreading between India and East Antarctica in the early Cretaceous. Hence, the delineation of crustal structure below ECMI and its conjugate east Antarctica margin will be useful to understand the early breakup evolution of the margin. Though previous geophysical investigations in this region have provided some insights on the nature of rifting, the deep offshore part of the ECMI was little understood due to the presence of thick sediments along the margin. However, due to the availability of IndiaSpan seismic reflection data in the eastern offshore of India, many new results and integrated geophysical interpretations on the structure and tectonics of the ECMI came out from 2010 onwards. While these studies have enhanced our geological understanding of the ECMI as a whole, but at the same time threw many new challenges and knowledge gaps that require our attention in order to bring out robust tectonic evolutionary models and tight-fit reconstructions. In this presentation, I provide a brief overview of all salient results of geophysical investigations and discuss several outstanding issues for a holistic understanding of the ECMI and build better reconstructions.

EARTHQUAKE CYCLE AND SEISMIC HAZARD IN THE HIMALAYA: SPACE GEODETIC PERSPECTIVES

Dr. Sreejith KM

Geosciences Division, Space Applications Centre (ISRO), Ahmedabad, India-380 015

An earthquake deformation cycle typically consists of interseismic, coseismic and postseismic phases of strain accumulation and release. Space geodesy, particularly InSAR and GNSS data provides an opportunity to probe the earthquake deformation cycle at plate boundaries that facilitates estimating earthquake recurrence times.

The Himalayan plate boundary, where the Indian plate underthrusts the Eurasian plate at an average rate of 40 mm/yr is known to have produced great earthquakes causing colossal destruction to human life and properties. About half of the India-Eurasia convergence is accommodated along the Himalayan arc on the Main Himalayan Thrust (MHT) system of faults. The stored elastic strain produces occasional massive devastating earthquakes on segments of the MHT. A key science question is whether the MHT can rupture to a large extent producing an earthquake M 9+ earthquake? or the accumulated strain will be released by a sequence of large to moderate magnitude earthquakes. The interseismic coupling (ISC) at the MHT derived from geodetic observations provides vital clues on the state of strain accumulation and extent of future rupture.

We discuss recent InSAR based results from the Himalayan region that has provided new insights to the mechanism of strain accumulation and release their implications in understanding the regional seismic hazards. We also briefly discuss limitations and recent technological advances of this technique with a future perspective.

AGGRADATION, INCISION AND PALEOHYDROLOGY FROM THE INDUS RIVER, LADAKH HIMALAYA

Dr. Anil Kumar

Wadia Institute of Himalayan Geology, 33, G.M.S. Road, Dehradun

Email: akumar@wihg.res.in

River systems in the Himalaya have been studied extensively to understand mechanism of valley aggradation and incision resulted due to intensified precipitation, relief changes, and deformation. The landscapes along the Indus River are largely affected by suture zone tectonics and monsoon intensity as the river is situated in the hinterland Himalaya. Valley filling and progradation of lateral outwash fans along the Indus River took place in three pulses: at ~ 52 ka, ~ 28 ka and ~16 ka during the strengthened SW monsoon. During ~13 to ~9 ka, the Indus suffered an incision phase marked by exposure of bedrock near the Indus-Zanskar confluence.

The present study constrained the paleodischarge of the Indus River during periods of established river aggradation and incision to discuss climatic conditions causing enhanced sediment load driven by increased discharge during aggradation or incision time. Here, clast geometric data from imbricated

gravels of channel fills were utilized to calculate paleodischarges when the river was aggrading at 47–23 ka, and preserved slack water deposits (SWDs) of age 14–10 ka at Indus-Zanskar confluence were used to constrain the paleodischarges during net river incision. Catchment scale discharge derived the valley fill sequences ranges from 834±47 to 4457±253 cumecs. However, syn-incision discharge estimates yielded discharge values ranges from 19030 to 47954 cumecs are three to tem fold higher than discharges estimated from the aggradation time. An important observation emerges that the aggradation in the Himalayan rivers occurred in glacial-interglacial transient warm climatic conditions (33–21 ka and 17–14 ka), when the sediment budget in the rivers increased just after the glacial events. Thus, aggradation took place in the Indus River, when sediment to water ratio was higher during MIS-3 and net river carrying capacity reduced, subsequently incision initiated when sediment to water ratio reduced when the river sediment carrying capacity increases during post-glacial climatically wet phase (early Holocene).

IGU-ANNI TALWANI MEMORIAL GRANT FOR WOMEN RESEARCHERS

APPLICATION AND UNCERTAINTY ANALYSIS OF GADAM OPTIMIZER IN SEMI-SUPERVISED SEQUENTIAL CONVOLUTION NETWORK FOR SEISMIC IMPEDANCE INVERSION

Anjali Dixit[1]*, Animesh Mandal[1] and Shib S. Ganguli[2]
1 Department of Earth Sciences, IIT Kanpur, Uttar Pradesh, India
2 Marine & Deep Seismics, CSIR-NGRI, Hyderabad, Andhra Pradesh, India
*Presenting author: anjalid@iitk.ac.in

Seismic impedance inversion is a crucial step for estimating sub-surface lithological configuration and reservoir characterization. However, unknown wavelet, band-limitation, and presence of noises in seismic datasets make seismic inversion a nonlinear and ill-posed problem with a non-convex objective function. As a matter of fact, the solution gets trapped at local minima during optimization. Recently, the growing application of deep learning approaches made its footprint into the field of seismic inversion due to its multi-level features extraction capability using multiple hidden layers and enhanced non-linear mapping between the input (seismic data) and output (impedance data). To optimize the objective function, various optimization schemes are used in deep learning algorithms such as Gradient descent, RMS prop, momentum, ADAM, etc. Amongst all, ADAM has been widely used in seismic inversion studies. However, in the case of a non-convex objective function, ADAM often gets stuck at local minima, therefore obtained solution may not be optimal. To tackle these challenges, a novel approach has been proposed in this study with a global optimizer namely, GADAM (Genetic- Evolutionary ADAM) which integrates ADAM and Genetic algorithm (GA) into a unified framework using a designed deep sequential convolution neural network (DSCNN). In GADAM, GA provides an edge over ADAM by offering multiple initial search points. Therefore, it eradicates the possibility of getting stuck at local minima. The efficacy of GADAM has been tested on both synthetics as well as on a 3D seismic field dataset from Poseidon, Browse basin. The performance of both the optimizers, i.e., ADAM and GADAM were evaluated by employing uncertainty estimation on blind well data. Results show that the level of uncertainties for GADAM optimizer is comparatively less than that for ADAM. This study demonstrates the applicability of a hybrid optimizer, i.e., GADAM for seismic inversion with less uncertainty in a DSCNN framework. Which will facilitate well-informed decisions and reasoning in seismic reservoir characterization and sub-surface lithological configration.

IMPACT OF COVID-19 LOCKDOWN ON THE BASE OF MARINE FOOD WEB IN THE NORTH INDIAN OCEAN

Swastika Bhaumik[1], Parthasarathi Chakraborty[1] and Akshay Bawaliwale[1]
[1]Centre For Oceans,Rivers,Atmosphere and Land Science (CORAL)
Indian Institute of Technology, Kharagpur. Kharagpur-721302 West Bengal

The novel coronavirus pandemic (COVID-19) had brought the world to a standstill in the early part of 2020. Several countries (including India) had imposed a lockdown to avoid the spreading of the disease. As a result, all anthropogenic activities were stopped. Fewer anthropogenic nutrients and pollutants were

released into different compartments of the environments during the lockdown period. This study focuses on the changes in magnitude of satellite retrieved concentration of coastal sea surface chlorophyll-a (*chl-a*) data from MODIS-AQUA sensor, off major cities (Kolkata, Vishakhapatnam, Chennai, Kochi, Mumbai, Gujarat) along the Bay of Bengal and the Arabian Sea around India, and also regions in the Central Arabian Sea and the Central Bay of Bengal. During the phases of complete lockdown (24th March-31st May 2020), the magnitude of the average chl-*a* concentration decreased in the coastal surface waters of the Arabian Sea but increased in the Bay of Bengal as compared to the average *Chl-a* concentrations of the last decade (2010-2020) during this time, signifying the impact of decline in supply of anthropogenic nutrients during the lockdown. A significant decrease in *chl-a* concentration observed off Vapi (Gujarat), whereas, an increase was observed off Kolkata (West Bengal). In the central regions of both the Arabian Sea and the Bay of Bengal, no significant change was observed; the alteration in the concentration of coastal sea surface *chl-a* was more in the coastal waters.

SUBSURFACE STRUCTURAL ARRANGEMENTS IN THE KANGRA-MANDI RE-ENTRANT OF THE NW HIMALAYAS: NEW INSIGHTS FROM 2D REFLECTION SEISMIC STUDY

Shibakalyani Sahu[1, 2] and Kalachand Sain[1,2]
[1]Wadia Institute of Himalayan Geology, Dehradun, Uttarakhand, India
[2]Seismic Interpretation Laboratory-WIHG, Dehradun, India

The Cenozoic fold thrust belt of Kangra re-entrant represents the largest among the recesses present within the active orogeny of the young fold Himalayas. Seismic profiling augments the understating of subsurface disposition in the complex tectonic settings of the thrust-fold belt regime of the Sub-Himalayas. The present study includes interpretation of 2D time migrated seismic data in the Kangra-Mandi region of the NW Himalaya. The seismic data is structurally conditioned employing structure-oriented filter (SOF) with a motive to enhance the visibility of the subsurface structures. The seismic data prominently defines the subsurface structural elements along with their geometrical configuration. The NE-SW oriented seismic line crosscuts some of the major thrusts of the Himalayan thrust belt including the Main Boundary Thrust (MBT) along which the older (Proterozoic) rocks have been thrusted over the younger (Tertiary) rocks of Sub-Himalayas. Even the geometry and extension of other major thrusts like the Galma thrust, Joginder Nagar thrust, Palampur thrust and Chail thrust are prominent in the seismic lines. The Palampur thrust emerging from the Pre-Tertiary sediments demarcates the boundary between the Dharamshala formation and the Shiwaliks and several culminations of antiforms created by its ramp-flat trajectory can be observed all along its length both in the hanging wall and the footwall. However, the N-S oriented seismic line demarcates few traces of the MBT. The unconformity surface between the Tertiary and Pre-Tertiary rocks of the Kangra re-entrant is observed from the interpreted profiles and highlights the geometry of the Tertiary strata over the Pre-Tertiary in the study area. The basal decollement surface, as evident on the seismic data, acts as a sole thrust. The study reveals that the Kangra region of the Himalayas is intensely faulted and is prone to high stress accumulation. The trend of the seismic patterns has been traced to decipher the style of

deformation, define the fault geometry and the variation in the amount of deformation in the region below the Kangra-Mandi area. The major thrusts arise from the decollement as splay structures and also the minor faults branch off from the major thrusts signifying that there is huge accumulation of stress which is being distributed by these splaying off structures and which in turn is adding to the complexity of the subsurface picture of this region. No doubt the rock strength has a significant role in it.

CAPTURING GROUNDWATER DISASTER WITH TIME VARIABILITY OF THE REPRESENTATIVE PARAMETER

Seema Begum[1, 2, *], Salman Ahmed[3], Tanvi Arora[1,2] and Shakeel Ahmed[4]

[1]Electrical Geophysics Group, CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India

[2]Academy of Scientific and Innovative Research (AcSIR)-National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India

[3] Department of Geology,Baba Farid institute of technology(BFIT), Dehradun College, Dehradun

[4]School of sciences, Maulana Azad National Urdu University, Hyderabad

*presenting author's email ID: mominseema94@gmail.com

Water disaster tops all types of natural disasters and the visible climate change adds to this situation. Thus a scientific and systematic assessment of its cause and spatio-temporal variability is imperative. Water resources has to be very judiciously managed because too much of water or too less of water, both cause disaster. Even polluted water is a disaster. Groundwater quality of an Alluvial aquifer in Ganga basin have been analysed. The basic quality parameters and cations as well as anions have been monitored from a dense network for six seasons mainly in pre-monsoon and post-monsoon periods of 3 consecutive years. The spatio-temporal variability of EC that represents most of the quality of groundwater has been presented here. The variograms of the EC values monitored during pre and post monsoon periods for 3 years were computed as experimental Variogram. The experimental variogram was suitably fitted with theoretical Variogram models and the basic parameters defining the variogram viz., sill, range and the nugget effect were compared for various time periods. Although Post-monsoon variability tends towards randomness but we found this trend in pre-monsoon variograms also. This is attributed to anthropogenic causes and hence disastrous. This of course, may be confirmed with a few more parameters. However, Variography analysis that is a simple exercise reveals that the variation in time variability can be attributed to the disaster.

CSIR - National Institute of Oceanography

(a constituent laboratory of the Council of Scientific & Industrial Research)

Established in 1966, CSIR - National Institute of Oceanography (NIO) is a premier oceanographic research organisation in the Indian Ocean region. This distinction has been gained over almost five decades of experience on the seas - as far south as the Antarctica, east as Australia and west as the Caribbean.

Mission : *"to continuously improve our understanding of the seas around us and to translate this knowledge to benefit all"*

Research Themes

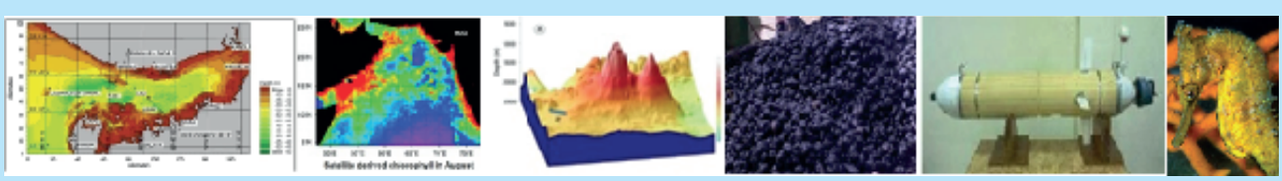
- Ocean processes
- Marine biodiversity
- Marine ecology
- Marine biotechnology
- Human imprint on Aquatic environment
- Marine minerals
- Energy from the ocean
- Seafloor tectonism
- Reconstructing the past
- Marine instrumentation
- Marine archaeology

Services Offered

- Studies related to coastal zone management
- Delineation of Coastal Regulation Zone
- Environmental impact assessment and monitoring
- Numerical modelling of meteorological and oceanographic data
- Oil spill prediction and risk analysis
- Oceanographic design parameters for marine facilities
- Underwater inspection and videography

Infrastructure

- Three Regional Centres
  - Mumbai, Kochi, Visakhapatnam
- 500+ scientific & technical staff
- State of the art analytical facilities
- National Information Centre for Marine Sciences (Library)
- National Oceanographic Data Centre
- AcSIR School of Oceanography
- Research Vessels
  - RV *Sindhu Sankalp*
  - RV *Sindhu Sadhana*



Environment | Processes | Tectonics | Resources | Instrumentation | Biotechnology

CSIR - National Institute of Oceanography

Head Office: Dona Paula, Goa - 403 004, India

Phone : 91(0)832-2450 450 Fax : 91(0)832-2450 602/03
e-mail : director@nio.org
URL : http://www.nio.org

Regional centres

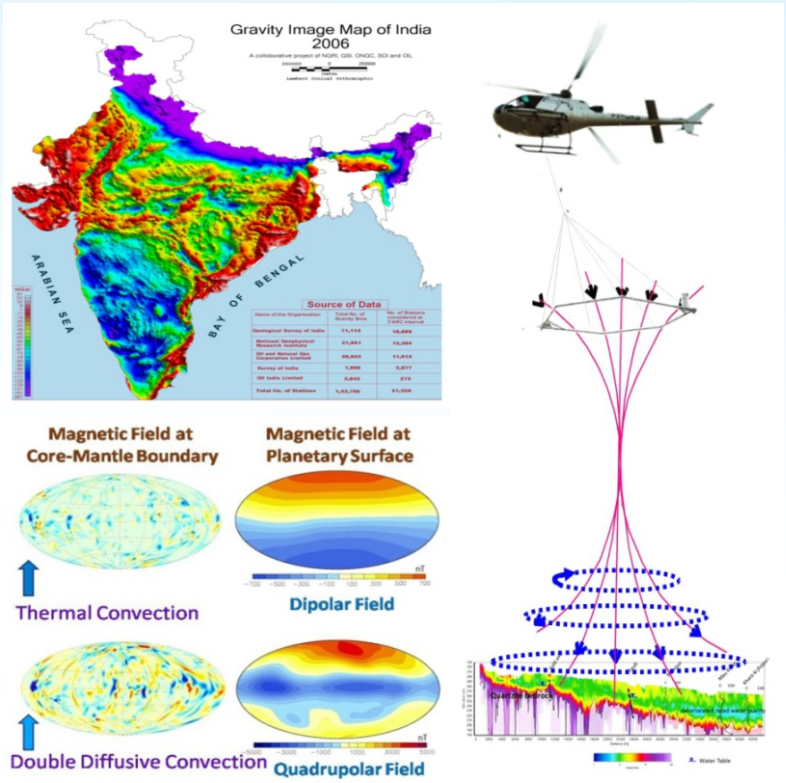
- **Mumbai**
  Phones : 022-26359605 (4 lines)
  Fax : 022-26364627
  e-mail : cmohan@nio.org
- **Kochi**
  Phones : 0484-2390814 (7 lines)
  Fax : 0484-2390618
  e-mail : dineshku@nio.org
- **Visakhapatnam**
  Phones : 0891-2784569, 2539180
  Fax : 0891-2543595
  e-mail : gpsmurty@nio.org

CSIR-National Geophysical Research Institute

A Premier Research Institute in Solid Earth

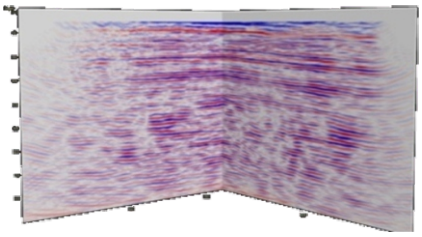
Exploring the Earth for 60 Eventful Years

CSIR-National Geophysical Research Institute (CSIR-NGRI) established in the year 1961, is a premier institute for research on solid earth sciences. It carries out innovative basic and applied research encompassing the fields of Geophysics, Geology, Geochemistry & Geochronology. Since its inception, the scientific output of the institute is reflected in terms of ~ 5000 SCI research papers, ~ 1260 technical reports, >100 books, more than 300 PhDs, several granted patents and many such laurels.



Significant Achievements

- Pioneer in Airborne Geophysical Research in India
- Gravity Map Series of India (GMSI)
- Developed first indigenous ground and airborne geophysical instruments
- State of Art observational and modelling infrastructure and expertize in crustal seismic studies
- Largest Seismological Network across the country
- Borehole (1.5 km) seismological studies in Koyna
- First Geochemical Baseline atlas of India
- Expertize of sub-Basalt imaging for oil and gas exploration
- Initiation of Heli-borne Aquifer Mapping in India
- Simulation of deep Earth processes and magnetic field



Unique Geophysical Research institute of the country for Near Surface to Deep Earth Exploration

The state-of-the-art facilities of the institute are focused on research related to ground and heli-borne geophysical surveys for water & mineral exploration, deep Earth probing, geochemistry & geochronology, environmental monitoring, shallow subsurface exploration, gas hydrates & hydrocarbon exploration, geotechnical investigations and active crustal deformation studies

Contact :
Dr. V.M. Tiwari
Director

CSIR-NATIONAL GEOPHYSICAL RESEARCH INSTITUTE
Uppal Road, Hyderabad-500007, Telangana, India.
Email:director@ngri.res.in; Ph: 040-23434600; Fax: 91 40 27171564

National Centre for Earth Science Studies

Ministry of Earth Sciences, Government of India

The National Centre for Earth Science Studies (NCESS) is an autonomous research institute under the Ministry of Earth Sciences (MoES), Government of India. The vision of NCESS is to excel in the understanding of the Earth's deep internal and surface processes, their interactions with the hydrosphere and atmosphere, and their implications for natural hazards affecting the society at large. The institute hosts multiple sophisticated analytical facilities which enable multidisciplinary research in emerging areas of solid earth research in the country. The Centre has made significant contributions in the fields of solid earth geophysics, geodynamics, geochronology, petrology, hydrology, critical zone studies, submarine ground water discharge, palaeo-climate studies, aquatic biogeochemistry, coastal hydrodynamics, coastal erosion, slope stability and landslides, and cloud microphysics.

Experimental Infrastructure

NCESS is equipped with modern experimental / analytical laboratory facilities which include:

- XRF, EPMA, LA/MC-ICP-MS, Q-ICPMS, Petrology Laboratory and Thin Section Preparation Laboratory.
- Palaeomagnetism laboratory and Resistivity imaging system.
- Seismological Observatories with 7 broadband seismographs.
- Fluid inclusion laboratory with Raman spectrometer coupled to microscope.
- Critical Zone Field Observatories (CZOs) at Munnar, Attapadi and Aduthurai.
- Central Chemical Laboratory with LC-MS/MS, GC-MS/MS, MP-AES, GC, UHPLC, AAS, UV-Vis-NIR Spectrophotometer, CFA, Flame photometer, CHNS-TOC-Mercury-Surface Area Analyzers, Sedigraph. Microbiology, Aquatic Biology and Wet Chemistry Laboratory.
- Sedimentology Laboratory, X-RD, SEM-EDS, Particle Size Analyzer.
- Marine field equipment like Acoustic Doppler Current Profiler (ADCP), Wave Rider Buoy, Current meter, Echo sounder, Tide gauge for near shore hydrodynamic study.
- High Altitude Cloud Physics Observatory at Munnar, Mid Altitude Observatory at Braemore and NCESS Campus Observatory with Disdrometer, Micro rain Radar, Ceilometer, Rain drop charge sensor, Automatic weather stations, etc., Air Quality Monitoring Laboratory & Lightning Detection Network.
- Central Geomatics Laboratory with Remote Sensing and GIS facility for producing thematic maps including cadastral scale maps for demarcating coastal regulation zone.

Scientific Groups

NCESS functions under six scientific groups, viz.,

Solid Earth Research Group (SERG) primarily deals with research in geodynamic evolution of Archean cratons, Proterozoic mobile belts, Western Ghats and active subduction zones.

Crustal Dynamics Group (CDG) addresses dynamic processes taking place at or near-surface conditions on the earth's crust, hydrocarbon movements in sedimentary layers and slope failures leading to landslides.

Hydrology Group (HyG) focuses on research in hydrology and water resources with specific reference to Earth's Critical Zone.

Biogeochemistry Group (BgG) focuses on evolution of springs, aquatic biogeochemistry, solute dynamics, water quality monitoring, pollution assessment and mitigation.

Marine Geoscience Group (MGG) focuses on understanding of waves, currents, sediment transport and their effects on beaches and nearshore environment, and the national network project on Submarine Groundwater Discharge.

Atmospheric Science Group (ASG) is engaged in the research on atmospheric clouds, thunderstorms, lightning, atmospheric electricity, and regional climate over Western Ghats.

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
राष्ट्रीय पृथ्वी विज्ञान अध्ययन केन्द्र
Ministry of Earth Sciences, Government of India
पृथ्वी विज्ञान मंत्रालय, भारत सरकार

PB No. 7250, Akkulam, Thiruvananthapuram-695011, India
पि.बि.नं 7250 आक्कुलम, तिरुवनन्तपुरम - 695011, भारत
दूरभाष/PHONE +91-471-2442213, 2511720, 2511501
फैक्स/FAX +91-471-2442280 ई-मेल/E-MAIL director@ncess.gov.in
वेबसाइट/WEBSITE www.ncess.gov.in

Committed to Our Earth Our Future | हमारे भविष्य हमारी पृथ्वी केलिए प्रतिबद्ध