e-ABSTRACT VOLUME

International Virtual Workshop on Global Seismology & Tectonics

(IVWGST-2021)

20-30th September 2021

Organized By

Geoscience & Technology Division
CSIR- North East Institute of Science & Technology
Jorhat, Assam, India

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CSIR

AND

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Director of CSIR-NEIST, Jorhat

Dr. G. Narahari Sastry FNA, FASc, FNASc, FRSC	
	
Alma mater	Osmania University, University of Hyderabad
Fields of Research	Chemistry, theoretical chemistry, computational biology, computer aided molecular design, chemoinformatics.
Institutions	CSIR-North East Institute of Science & Technology, Jorhat ; Indian Institute of Chemical Technology; Pondicherry University
Prizes and honours	J C Bose National Fellow (2015), Shanti Swarup Bhatnagar Prize in Chemical Sciences (2011), CRSI Medal (2011), B C Deb Memorial award (2009), National Bioscience award (DBT) (2009), Swarnajayanthi Fellowship 2005 (DST), B.M. Birla award (2001), avH Fellowship.
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Dr G Narahari Sastry has obtained his early education in Khammam, Telangana and obtained his B.Sc. and M.Sc. from Osmania University (campus), Andhra Pradesh and Ph.D from University of Hyderabad. After a couple of post-doctoral stints, he started his independent research career in 1997 at Pondicherry University, and moved to CSIRIICT in 2002, to head centre for molecular modeling. He is a professor of AcSIR in chemistry and lifesciences disciplines. Dr Sastry's research interests are theroetical and computational chemistry, computational biology, computer aided molecular design and chemoinformatics. Dr Sastry has made fundamental contributions in the area of noncovalent interactions and developed several important concepts in this area. His group is interested to apply the data science approaches, and developing indigenous software, Molecular Property Diagnostic Suite. Several of his computational predictions have seen experimental realization. Besides publishing independently, the group also has active collaboration with several experimentalists and strongly believe that 'theory experiment interplay is indispensable' for the progress of science. He has successfully guided 22 Ph.D students and published more than 300 papers. Currently 10 members are doing Ph.D and postdoctoral studies in the group. These publications received over 11,000 citations, with an h-index of 50. Dr Sastry is a J C Bose National Fellow (2015). He was awarded with Shanthi Swarup Bhatnagar Prize in Chemical Sciences (2011), considered as one of the highest prize for science and engineering in India, National Bioscience award (DBT) 2009, one of the highest for Lifesciences in India, Swarnajayanthi Fellowship 2005 (DST), B.M. Birla award for 2001, B C Deb Memorial award (2009), CRSI Medal 2011, and AvH Fellowship. He has delivered more than 350 invited lectures which include talks in national and international conferences. He was a visiting professor at IMS, Japan; LMU, Munich, Germany; Jackson State University, USA, and Kyushu Univesity, Japan. He was elected as a Fellow of the Royal Society of Chemistry (FRSC), Fellow of the INSA (FNA), Fellow of National Academy of Sciences (FNASc), Fellow of the Indian Academy of Sciences (FASc), Fellow of Association of Biotechnology and Pharmacy, Telangana State Academy of Sciences (Founder Fellow) and Andhra Pradesh Academy of Sciences (FAPAS). He is a regular reviewer to some prestigious journals and also in the editorial board of some journals.

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Dr. G Narahari Sastry
DIRECTOR FNA, FASc, FNASc, FRSC

17 September 2021

e-Welcome Message

Warm greetings from CSIR NEIST!

IVWGST-2021 is the second episode of the virtual workshop series which started during the pandemic year of 2020. It is one of the examples of opportunity in adversity that our institution has carved out of the COVID-19 pandemic situation with the aim to boost the morale of the students and researchers, during the distressing pandemic situation, by provisioning opportunities to interact with eminent personalities of their research interest in the domain of Seismology and Tectonics.

I welcome and appreciate the jubilant participation of all the students, researchers, scientists and academicians who have registered for IVWGST-2021. It is a matter of pride that about 1800 participants from more than 40 countries have registered for the event. I would like to thank and commend each and every keynote speaker from recognized global institutions for their philanthropic contribution to promote scientific vigor and knowledge dissemination. I am very confident that the sessions throughout the course of the workshop will immensely augment the inquisitive temper of the students towards pursuing research and higher education. The workshop features highly intuitive sessions discussing diverse aspects of seismology and tectonics- from seismic hazard assessment to public policy, computational techniques to precursory appraisal, tectonic modelling and interpretation to studying kinematics of complex tectonic regimes of the world, etc.

The e-Abstract volume compiles the abstract of all the sessions for aiding the participants to easily refer to the workshop discourse. The e-Abstract volume also documents research abstract submitted by the participants mainly from the broad domains of Geology, Geophysics and Physics. It would serve as a medium of propagation of research erudition across global geoscience forums. I thank all contributors who have submitted an abstract for the volume. This e-abstract volume also includes a monogram of the Geoscience & Technology Division (GSTD) with information on its overall functionalities, former and present human resource, instrumentation facilities etc., which is the first of its kind elaborate publication of the departmental activities.

I congratulate the convener, Dr. Santanu Baruah and his team for successfully organizing the flagship event under the aegis of the **Diamond Jubilee** celebration of CSIR-NEIST. Thanks to Dr. M K Phukan for his active role in organizing IVWGST-2021. I am also thankful to the Chief Patron, International Advisor, Session Advisor, Session Chairman and co-chairman for their kind assistance during the course of the workshop.

G Narahari Sastry

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e-Message from International Advisor

September 10, 2021

Our science is inherently global and so, if we are to fulfill our joint goals of understanding the Earth and reducing the suffering due to earthquakes, we must learn from each other. The pandemic has pushed us to find new ways to connect and the development of the International Virtual Workshop on Global Seismology & Tectonics in 2020 by CSIR-NEIST was a most impressive response. By bringing together over 1,000 people from at least 30 countries, the organizers supported students and researchers, all over the world, in our shared endeavor.

Thus, it is my great honor to be the International Advisor to the International Virtual Workshop on Global Seismology & Tectonics-2021. Due to the amazing work by the organizers, this year's workshop is even larger and includes over 1700 students and researchers from 41 countries. There is no doubt that this flagship event of CSIR-NEIST will boost the morale of the students and researchers, during this distressing pandemic, and will support their critical work on seismology and tectonics.

I appreciate everyone is who participating in IVWGST-2021. I am thankful to all the keynote speakers, representing different countries, institutions, and a wide array of scientific topics, for volunteering to disseminate critical knowledge and skills within the broad domain of Seismology and Tectonics. Their passion and interest towards promulgating advanced techniques and scientific information are greatly appreciated.

The e-Abstract volume will document the talks presented during IVWGT-2021's live webinar series. It also provides an overview of research being done by many of the participants. The e-abstract volume will be distributed and read by a wide scientific community, connecting us together across the globe. I thank all authors who have submitted an abstract to be included in the e-abstract volume.

At the USGS, we always appreciate the opportunity to share our work with students and colleagues around the world. Thus, I express my sincere thanks and gratitude to Prof G N Sastry, Director, CSIR-NEIST, Jorhat, Assam for extending his generous support, encouragement and guidance for this venture on national and international collaboration, the IVWGST-2021. I am thankful to members of our advisory board, Organizing committee, Convener, Co-conveners, Technical Committee, Moderators and associate Members for their hard work and acumen towards IVGWT-2021. A global event of this scope requires the coordination of many skills, each of which is appreciated. Particular thanks in this regard go to the Geoscience and Technology Division, CSIR-NEIST for creating IVGWST-2021.

And now onto the lectures and vigorous discussions after each one. I look forward to hearing new ideas, and fully expect that IVGWST-2021 will immensely augment each of our skills and expertise. And thus, I thank every participant for being part of this great event.

Sincerely

Andrew J. Michael

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17 September, 2021

e-Message from Session Co-Chairman

The idea for the international virtual workshop on global seismology and tectonics (IVWGST-2021) is very well conceived at a time when the whole world is brought to a standstill due to CoVID-19 pandemic. The virtual events, indeed, have been rare source of motivation and inspiration with respect to attributing indulgence with scientific and academic activities. In a blessing in disguise, the virtual events have facilitated a conduit for direct access with experts and pioneers from across the globe. I feel privileged to be a part of the organizing committee of IVWGST-2021 which is organized under the aegis of the diamond jubilee year of CSIR NEIST. I extend my congratulations to the Convener, Dr. Santanu Baruah, for formulating the splendid idea to organize the event under the dynamic leadership of the Director of CSIR NEIST, Dr. G Narahari Sastry.

I wish the workshop a grand success!

Saurabh Baruah

CSIR-NEIST

東北大学大学院理学研究科
地震・噴火予知研究観測センター

e-Message from Session Advisor

The 2nd International Virtual Workshop on Global Seismology & Tectonics (IVGWT-2021), September 20-30, 2021 is a great effort, first of its kind, by the Geoscience and Technology Division, CSIR-NEIST to disseminate knowledge and experience to the under Graduate/post-graduate/Ph.D. students, young researchers, scientists and earthquake engineers. The IVWGST-2021 addresses basic problems towards global as well as local earthquake seismology and tectonics.

I express my sincere thanks and gratitude to Prof. G.N. Sastry, Director, CSIR-NEIST, Jorhat, Assam for extending his generous support, encouragement and guidance for this venture. I thank the participants for their keen interest and active participation at the IVWGST-2021. Sincere thanks to Dr. Santanu Baruah, Convener, IVWGST-2021, for his innovative thoughts, strategies and enormous efforts and patience in developing strong working relationships among scientific communities in different parts of the world. I highly appreciate the working group behind the IVWGST-2021 and the members of the Geoscience and Technology Division, CSIR-NEIST.

This e-Abstract Volume covers abstracts of all the lectures presented at the IVWGST-2021, live webinar series. It is well documented with the informative materials provided by the speakers. I convey my sincere thanks to all the authors and speakers who have contributed to the e-Abstract Volume. My sincere thanks and gratitude to the Advisory Board, Organizing Committee, Convener, Co-conveners, Technical Committee, Moderators and the associate Members for their persistent untiring efforts to make the IVWGST-2021 not only a great success but also in achieving a milestone to knowledge dissemination to the younger generation in India and abroad.

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& CSIR Emeritus Professor, Jadavpur University, Kolkata, India
Ex Adjunct Professor: IIT-Kgp, IIT-ISM, ISR, Tezpur Univ, Manipur Univ.
Ex Guest Faculty: UNESCO & ICTP Training Courses, South Asia
Presently Guest Faculty: NIT, Agartala, India
Member of Advisory Committee: WIHG, NHPC, AERB & NPCIL, India

e-Message from Session Chairman

The International Virtual Workshop on Global Seismology and Tectonics - 2021 (IVWGST-2021) being organized via online mode by the Geoscience and Technology Division of the CSIR-Northeast Institute of Science and Technology (CSIR-NEIST) Jorhat is a magnanimous endeavor of its kind. The workshop would, indeed, serve as an immense boon for the students, young researchers and professionals during this difficult pandemic situation. The Northeast Region (NER) of India as well as its adjoining areas is tectonically one of the most active zones in the world due to its juxtaposition with the Himalayan collision zone to the north and atypical Indo-Burma subduction zone to the east. The seismogenic hazards cause huge loss to human lives and properties in any part of the World. This loss can be significantly minimized with state-of-art scientific knowledge and intervention.

The IVWGST-2021 look forward to enhancing knowledge through the brainstorming sessions during the course of the Workshop that includes heightened sense of earthquake preparedness, understanding the Earth Sciences behind large, great and mega earthquakes, translation of scientific knowledge to tools for societal implementation, dissemination of knowledge on earthquake hazard mitigation etc. It can evolve or update the earthquake hazard codes and provisions that can induce policy makers to revise seismic hazard mitigation and management guidelines.

The e-abstract volume documents the IVWGST-2021 Workshop proceedings authored by the eminent resource persons from distinguished global institutions. I extend my sincere thanks and regards to all the resource persons for enlightening us with their contemporary knowledge, experiences and insights. The e-abstract volume also compiles interesting abstracts of young researchers around the World encompassing diverse geoscience topics.

I would like to extend my heartiest congratulations to the Convener, Dr. Santanu Baruah and his formidable team for organizing such a glorious Workshop that benefit some 2000 registered participants from some 41 countries. I also appreciate the leadership of Dr. G. Narahari Sastry, Director, CSIR-NEIST for conceptualization of such splendid ideas with full logistic and moral support.

J R Kayal

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19 September, 2021

e-Message from the Convenor

I am highly delighted to release the e-Abstract volume of the second International Virtual Workshop on Global Seismology and Tectonics (IVWGST-2021) organized by CSIR-NEIST under the aegis of the diamond jubilee celebration year of the institution. The annually recurrent virtual workshop is organized to ease the stress and impact of the pandemic manifestations on the students, and the scientific and academic community associated with Geosciences domain by creating a conduit for direct interaction with several eminent personalities from distinguished global geosciences forums and institutions of the world. More than 1750 participants, mostly students, registered for IVWGST-2021 from Algeria, Australia, Bangladesh, Brazil, Cameroon, Canada, Chile, Colombia, Croatia, Democratic Republic of Congo, Ecuador, Egypt, Ethiopia, Germany, Ghana, Iceland, India, Indonesia, Iran, Iraq, Italy, Japan, Malaysia, Malta, Nepal, Nigeria, Norway, Peru, Philippines, Portugal, Singapore, South Sudan, Sri Lanka, Taiwan, Tanzania, Trinidad & Tobago, Turkey, United Arab Emirates, Uruguay, United States of America and Venezuela.

The workshop featured keynote speakers from diverse geosciences forums and institutes of the world. We were honored to have Dr. Andrew Michael, USGS, Dr. T. G. Sitharam, Director, IIT-G, Dr. B. L. N. Kennett, ANU, Dr. David J. Wald, USGS, Dr. Alan Kafka, Boston College, Dr. Daniela Kühn, NORSAR, Dr. Dapeng Zhao, Tohoku University, Dr. Kendra Johnson, Global Earthquake Model Foundation, Dr. O. P. Mishra, Director, NCS (MoES), Dr. Shreyasvi Chandrasekhar, Global Earthquake Model Foundation, Dr. Sebastiano D'Amico, University of Malta, Dr. Saurabh Baruah, CSIR-NEIST, Dr. J. R. Kayal, GSI, Dr. Jure Žalohar, University of Ljubljana, Dr. V. M. Tiwari, Director, CSIR-NGRI, Dr. Md. F. Abdelwahed, King Abdulaziz University, Dr. Sima Ghosh, NIT-Agartala, Dr. Marco Pagani, Global Earthquake Model Foundation, Dr. Kalachand Sain, Director, Wadia Institute of Himalayan Geology, Dr. Jo Gottsmann, University of Bristol, Dr. Sarah E. Minson, USGS and Dr. Justin Rubinstein, USGS as the keynote speakers for IVWGST-2021.

The e-abstract volume presents the session abstracts of all the keynote speakers and followed by a compilation of classical and contemporary research endeavors primarily in the field of Geology, Geophysics and Physics submitted by the participants. As the convener of the conference, I extend my gratitude to Dr. G Narahari Sastry, Director CSIR-NEIST Jorhat for his kind ubiquitous help and guidance in organizing this event. Working under his profound management is indeed a matter of great opportunity and privilege for me. I would also like to thank Dr. Andrew Michael, USGS, Dr. Dapeng Zhao, Tohoku University, Dr. J R Kayal, Former Dy DG, GSI; Dr. Saurabh Baruah, CSIR-NEIST, Dr. Jatin Kalita, Head, RPBD, CSIR NEIST, Dr. Manoj K Phukan, GSTD, Mr. J L Khongsai, AO, CSIR-NEIST & Mr. Rama S. Sharma, CoFA, CSIR-NEIST for their valuable support and guidance.

The abstract volume also includes a monogram of the GSTD with information on its overall functionalities, former and present human resource, instrumentation facilities, etc. It is the first of its kind elaborate publication of the departmental activities. I thank all the members of the organizing committee for extending their valuable time in organizing the program and all the authors, reviewers, and other contributors for their sparkling efforts and their belief in the excellence of IVWGST-2021.

(Santanu Baruah)

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		Ashish Pal and Dilip Kr. Yadav	
	35.	**Spatial Variation of b-Value and Analysis of Seismicity of Seismic Hazard Assessment for Northern India**	

e-Abstract Volume for International Virtual Workshop on Global Seismology & Tectonics-2021

Published By: ***THE ORGANIZING COMMITTEE***
2ND INTERNATIONAL VIRTUAL WORKSHOP ON GLOBAL SEISMOLOGY & TECTONICS -2021 (IVWGST-2021)
20-30 SEPTEMBER, 2021

WORKSHOP BROCHURE

Geoscience & Technology Division
North East Institute of Science & Technology
(Council of Scientific & Industrial Research)
Jorhat, Assam, India

Webinar Series

LIVE

2nd International Virtual Workshop on Global Seismology & Tectonics

20-30th September 2021

Institute at a Glance:

North East Institute of Science and Technology (NEIST), Jorhat, Assam, a constituent establishment of Council of Scientific and Industrial Research (CSIR), New Delhi, has been engaged in multidisciplinary R&D work relevant to the country in general and North East of India (NE India) in particular. The Geoscience & Technology Division (GSTD) of CSIR-NEIST has been involved in monitoring the seismicity of NE India since 1982. Seismic hazard and vulnerability assessment of the populated cities and urban areas in NE India and propagating seismic hazard awareness have been some of the major programs of the division, apart from conducting geotechnical/geophysical consultancy services.

Workshop Info.

- Registration Starts: 22nd July 2021
- Registration Closes: 20th August 2021
- Acceptance: 15th Sept. 2021
- Inauguration: 20th Sept. 2021
- Time: 09:30 am IST, +5:30 hrs GMT
- Registration Fee: Nil (Free)

Aim of the Virtual Workshop:

Due to several physical communication constraints brought about by the COVID-19 pandemic situation, the practice of disseminating knowledge and ideas through webinar, a live interactive event where attendees join via their desktop or mobile device over the internet, have significantly proliferated. While research activities, including research exchange and collaborations, during this unprecedented situation have decelerated, it is imperative to boost the morale of the students and researchers by providing opportunities to interact with eminent personalities of their research interest. In accordance with this, the Geoscience & Technology Division (GSTD) of CSIR-NEIST Jorhat would like to conduct the 2nd INTERNATIONAL VIRTUAL WORKSHOP on "Global Seismology & Tectonics" series targeting the geosciences students and community, during 20-30 September, 2021.

The lecture sessions aim to impart important information on emergent and impending topics of Seismology and Tectonics, involving case studies from seismically active zones of the world. The eminent keynote speakers of the workshop represent diverse geosciences forums and institutes or institutional departments across the world, including the United States Geological Survey, Global Earthquake Model, Norwegian Seismic Array (NORSAR), National Center for Seismology, Geological Survey of India, Wadia Institute of Himalayan Geology, CSIR-National Geophysical Research Institute, CSIR – North East Institute of Science and Technology, University of Bristol, University of Malta, Australian National University, Tohoku University, King Abdullah University, University of Ljubljana, Boston College, Indian Institute of Technology – Guwahati and National Institute of Technology, Agartala, India.

Targeted Discipline

- Physics
- Geophysics
- Geology
- Seismology
- Geography
- Civil Engineering
- Earthquake Engineering
- Environmental Science

Targeted Group

- Graduate/ Post Grad. Students
- Ph.D. Scholars
- Scientists Academician Researchers

Registration/Workshop Link

- Event Details — Scan QR Code — Click Here
- Registration Link — Scan QR Code — Click Here
- Joining Link — Scan QR Code — Click Here

Workshop joining link will be sent to the registered email of all the participants

NEIST — CONNECTING SCIENCE & TECHNOLOGY — FOR A BRIGHTER TOMORROW

Contact

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2nd International Virtual Workshop on Global Seismology & Tectonics

20-30th September 2021

Webinar Schedule

Inauguration 20th September, 2021 @ 9:30 am IST (+5:30 GMT)

SPEAKERS

Day # 1

Andrew J. Michael, USGS, USA

Collapsing Calderas and Aftershocks: When We Need to Include Clustering in Seismic Hazards Assessments?

20th September @ 10:00 am IST
19th September @ 09:30 pm PDT
20th September @ 06:30 am CEST

T. G. Sitharam, Director, IIT-G, India

Attenuation Characteristics and Seismicity Analysis for Himalayan Region

20th September @ 07:00 pm IST
20th September @ 06:30 am PDT
20th September @ 03:30 pm CEST

Day # 2

B. L. N. Kennett, ANU, Australia

Characterising Earth Structure from Seismic Data

21st September @ 10:00 am IST
21st September @ 02:00 pm ACST
20th September @ 09:30 pm PDT
21st September @ 06:30 am CEST

David J. Wald, USGS, USA

An Overview of UGSC near-real time Earthquake information products

21st September @ 07:00 pm IST
21st September @ 07:30 am MDT
21st September @ 06:30 am PDT
21st September @ 03:30 pm CEST

Day # 3

Alan Kafka, Boston College, USA

Reflections on My Past Two Decades of Teaching "Geoscience and Public Policy", an Undergraduate Science Course for Non-Science Major

22nd September @ 09:30 am IST
22nd September @ 12:00 am EDT
21st September @ 09:00 pm PDT
22nd September @ 06:00 am CEST

Daniela Kühn, NORSAR, Norway

Probabilistic Moment Tensor Inversion: Examples from Europe

22nd September @ 07:00 pm IST
22nd September @ 06:30 am PDT
22nd September @ 03:30 pm CEST

Day # 4

Dapeng Zhao, Tohoku University, Japan

Seismic Anisotropy Tomography: New insight into Seismotectonics, Volcanism and Geodynamics

23rd September @ 10:00 am IST
23rd September @ 01:30 pm JST
22nd September @ 09:30 pm PDT
22nd September @ 06:30 am CEST

Kendra Johnson, GEM Foundation, Italy

Introduction to Probabilistic Seismic Hazard Analysis (PSHA)

23rd September @ 07:00 pm IST
23rd September @ 06:30 am PDT
23rd September @ 03:30 pm CEST

Day # 5

O. P. Mishra, Director, NCS (MoES), India

Seismic Microzonation: An efficient tool for earthquake risk resilient Structures

24th September @ 10:00 am IST
23rd September @ 09:30 pm PDT
24th September @ 06:30 am CEST

Kendra Johnson & Shreyasvi Chandrasekhar GEM Foundation, Italy

Building a Probabilistic Seismic Hazard Analysis (PSHA) input model

24th September @ 07:00 pm IST
24th September @ 06:30 am PDT
24th September @ 03:30 pm CEST

ACST: Australian Central Standard Time, CEST: Central European Summer Time, EDT: Eastern Daylight Time, IST: Indian Standard Time, JST: Japan Standard Time, MDT: Mountain Daylight Time, PDT: Pacific Daylight Time

2nd International Virtual Workshop on Global Seismology & Tectonics

20-30th September 2021

Webinar Schedule

SPEAKERS

Day # 6

Sebastiano D'Amico, Univ. of Malta, Malta

Seismotectonics of the central Mediterranean area

25th September @ 10:00 am IST
24th September @ 09:30 pm PDT
25th September @ 06:30 am CEST

Saurabh Baruah, CSIR-NEIST, India

Kinematics of Shillong Plateau & Eastern Himalaya Region-the sites of Great earthquakes

25th September @ 07:00 pm IST
25th September @ 06:30 am PDT
25th September @ 03:30 pm CEST

Day # 7

J. R. Kayal, GSI, India

Recent Large and felt Earthquakes in Northeast India: Seismotectonics and Precursor Appraisal

26th September @ 10:00 am IST
25th September @ 09:30 pm PDT
26th September @ 06:30 am CEST

Jure Žalohar, Univ. of Ljubljana, Slovenia

The Omega-Theory and the time-dependent earthquake forecasting

26th September @ 07:00 pm IST
26th September @ 06:30 am PDT
26th September @ 03:30 pm CEST

Day # 8

V. M. Tiwari, Director, CSIR-NGRI, India

Lithospheric Structure of Himalayan Collision Zone

27th September @ 10:00 am IST
26th September @ 09:30 pm PDT
27th September @ 06:30 am CEST

Md. F. Abdelwahed, KAU, Saudi Arabia

SGRAPH system for seismic waveform analysis and source parameters estimation: Review and case study

27th September @ 07:00 pm IST
27th September @ 05:30 pm (Dubai)
27th September @ 06:30 am PDT
27th September @ 03:30 pm CEST

Day # 9

Sima Ghosh, NIT-Agartala, India

Recent Seismicity and Probability Assessment of Earthquake Occurrence in North East and Himalayan Region

28th September @ 10:00 am IST
27th September @ 09:30 pm PDT
28th September @ 06:30 am CEST

Marco Pagani, GEM Foundation, Italy

Introduction to the OpenQuake Engine

28th September @ 07:00 pm IST
28th September @ 06:30 am PDT
28th September @ 03:30 pm CEST

Day # 10

Kalachand Sain, Director, WIHG, India

State-of-the-art Seismic Techniques for Advanced Modeling and Interpretation: Solution to some Geoscientific Challenges

29th September @ 10:00 am IST
28th September @ 09:30 pm PDT
29th September @ 06:30 am CEST

Jo Gottsmann, University of Bristol, UK

New insights on the inner workings of volcanoes

29th September @ 07:00 pm IST
29th September @ 06:30 am PDT
29th September @ 03:30 pm CEST

Day # 11

Sarah E. Minson, USGS, USA

Shaking is Almost Always a Surprise: The Earthquakes That Produce Significant Ground Motion

30th September @ 10:00 am IST
29th September @ 09:30 pm PDT
30th September @ 06:30 am CEST

Justin Rubinstein, USGS, USA

Earthquakes in the Heartland: How Energy Production Causes Earthquakes in Unexpected Places

30th September @ 07:30 pm IST
30th September @ 07:00 am PDT
30th September @ 04:00 pm CEST

ACST: Australian Central Standard Time, CEST: Central European Summer Time, EDT: Eastern Daylight Time, IST: Indian Standard Time, JST: Japan Standard Time, MDT: Mountain Daylight Time, PDT: Pacific Daylight Time

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20-30th September 2021

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GUIDELINES

- The virtual workshop, in the form of a series of lectures, will be held only via Microsoft Teams, an internet based visual communication platform.
- The participants are requested to download and install Microsoft (MS) Teams software (https://www.microsoft.com/en-in/microsoft-365/microsoft-teams/download-app) in their desktop or mobile devices.
- The participants are expected to mute their microphones and turn off their cameras during lectures by the speakers. They can be turned on only if direct interaction during Q&A session is desired.
- E-certificate shall be provided to registered participants upon request, if they have attended at least 80% of the virtual workshop.

e- Abstracts from Key Note Speakers

Collapsing Calderas and Aftershocks: When Do We Need to Include Clustering in Seismic Hazards Assessments?

Andrew J Michael

Alma mater	MIT; Stanford University, USA
Field of research	Geophysics, Earthquake Processes and Probability Research
Present Institution	U.S. Geological Survey Earthquake Science Center, Menlo Park (Research Geophysicist)
Webpage	https://www.usgs.gov/staff-profiles/andrew-michael
E-mail	ajmichael@usgs.gov

Probabilistic Seismic Hazard Assessment (PSHA) combines information about earthquake occurrence with information about the ground motions that result from earthquakes into estimates of exceedance probabilities: the probability that ground motion will exceed some level, one or more times, in a given time period. Standard approaches to Probabilistic Seismic Hazard Assessment (PSHA) assume that earthquakes are random, independent events that follow a Poisson distribution of occurrences. But we know that isn't true. The occurrence of aftershocks implies that earthquakes cluster together in time. The elastic rebound model means that a large earthquake on a fault makes a future large earthquake less likely, at least until plate motions reload the stress on the fault. But the Poisson assumption makes PSHA simple and so we ask whether it is good enough. In this talk, I will review Poisson PSHA methods, discuss how numerical simulations can be used for non-Poisson PSHA, and introduce a new analytic method, using order statistics, for non-Poisson PSHA. I will then explore the implications of non-Poisson earthquake behavior for PSHA by applying this new method to the highly clustered seismicity associated with caldera collapses at Kilauea and explore the general implications of non-Poissonian behavior for PSHA. As others have found,Poisson PSHA is a good approximation for many standard engineering applications that focus on low probabilities of a single exceedance over long periods of time. In contrast, non-Poissonian behavior has the greatest impact for high probabilities of exceedance, low mean rates of occurrence, and multiple exceedances. Those conditions can be important for applications such as operating standards for buildings and infrastructure engineering, standards for temporary structures and during construction, the insurance industry, the design of earthquake early warning, and to clustered processes such as aftershock sequences and earthquake swarms.

A Scrutiny of the Attenuation Attributes and a Seismic Evaluation of the Himalayan Region

T G Sitharam

Alma Mater	Indian Institute of Science, Bangalore; University of Waterloo, Canada
Field of Research	Rock Mechanics and Engineering, Earthquake Engineering, Microzonation and Site Response Studies, Micromechanics of Granular Materials, Numerical Methods in Geomechanics
Present Institution	Indian Institute of Technology, Guwahati (Director)
Webpage	https://www.iitg.ac.in/director/
Email	proftgs@gmail.com

About 59% of the land area of the Indian subcontinent has high chances of moderate to severe earthquakes, of which the Himalayas are the most seismically active. Regardless of the high seismic activity, the seismic network in the region is largely insufficient and designs incapable of safely resisting the ground motions. For seismic zonation, estimation of Peak Ground Acceleration (PGA) at bedrock level and ground level is important to understand the seismic hazard in the region. For this, region-specific Ground Motion Prediction Equations (GMPEs) should be generated, considering the tectonic setting, wave propagation characteristics, fault and rupture characteristics and site effects, based on recorded or synthetic strong motion data. Larger and more comprehensive datasets should be used to make the GMPEs applicable to larger magnitude and distance ranges, thus overcoming a major limitation of the currently available region-specific GMPEs. After validation, the new or selected GMPEs can be used for Seismic Hazard Analysis (SHA), considering various source models. Based on the regional seismic source zoning using the Gutenberg-Richter (GR) parameters, the study area should be delineated into various seismic source zones. The whole study area can be divided into grids of size 0.05° × 0.05° and the PGA at the center of each grid point can be estimated using deterministic and probabilistic approaches, using the selected GMPEs. The deterministic approach provides a rather conservative hazard, as it considers the worst-case scenario event at the closest possible distance between the focus and the site. Also, it doesn't consider the major uncertainties associated with location or distance, which are covered in the probabilistic approach. Seismic Hazard maps can be then generated using a GIS platform which can show the ground acceleration estimated in the study region.

Characterising Earth Structure from Seismic Data

Our understanding of the 3-D structure of the Earth has been built around reference earth models such as *PREM* (1981) and *ak135* (1995). These models have specific characteristics associated with the way they were constructed that influence inferences made about the Earth. Even the presentation of 3-D results from seismic tomographic models can be strongly influenced by the reference models used, particular when relative perturbations are plotted.

Observational advances have indicated a few places where radial models need to be updated, notably at the top of the outer core and in the inner core. An updated model *ek137*has recently been developed that improves the rendering of core structure whilst retains the good fit to the properties of the full range of seismological phases.

Spin transitions in iron bearing lower mantle minerals have long been regarded as seismologically invisible, but the relative behaviour of the shear and bulk modulus in the body-wave models suggests that a weak signature survives 3-D averaging.

Brian L N Kennett

Alma mater	University of Cambridge, UK
Field of research	Geophysics,Theoretical Seismology
Present Institution	Australian National University, Research School of Earth Sciences (Emeritus Professor of Seismology)
Webpage	https://researchers.anu.edu.au/researchers/kennett-bln
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An overview of USGS' near-real time earthquake information products

The U.S. Geological Survey (USGS) continues to further develop several near-real time earthquake information systems that provide rapid and automated alerting of shaking distribution, critical facility inspection priorities, and estimates of economic and human impacts following earthquakes. I'll describe the evolving scientific research and development behind the components required to rapidly assess an earthquake's impact: rapid faulting characterization, estimates of shaking distribution, computing losses, and communicating uncertain loss estimates in an appropriate form for actionable decision-making among a variety of critical users. New products and efforts include 1) rapid estimates of earthquake-induced landsliding and liquefaction around the globe, 2) refactored ShakeMap, ShakeCast, and DYFI codes and functionality, 3) and a focus on incorporating of ground-truth observations for rapidly updating loss models. In addition to the critical response users of these tools, loss-modelers, (re)insurers, governments and aid organizations use rapid earthquake information for loss estimation, situational awareness, and financial adjudication. Such financial tools can be a significant benefit to the at-risk public by facilitating risk transfer, fostering sensible management of portfolios, and assisting disaster response. I will also discuss the challenges of communicating uncertain, real-time loss estimates for earthquakes around the globe to a highly diverse set of users and decision-makers.

David Wald

Alma mater	Caltech; University of Arizona, USA
Field of research	Characterization of Rupture Processes; Analysis of Ground Motions and Site Effects; Modeling of Earthquake-Induced Landslides and Liquefaction
Present Institution	U.S. Geological Survey, National Earthquake Information Center, Golden, CO (Research Geophysicist)
Webpage	https://www.usgs.gov/staff-profiles/david-j-wald
E-mail	wald@usg.gov

Reflections on My Past Two Decades of Teaching "Geoscience and Public Policy", an Undergraduate Science Course for Non-Science Majors

Alan Kafka

Alma mater	New York University; Stony Brook University, USA
Field of research	Geophysics, Earthquake Science, Environmental Systems, and Citizen Science for public good
Present Institution	Boston College, USA Weston Observatory (Director)
Webpage	https://bit.ly/Alan_Kafka_Website
E-mail	alan.kafka@bc.edu

For many years, I have been teaching a course for non-science majors at Boston College called Geoscience and Public Policy (GSPP). The theme of the course is "Life is uncertain." There will always be uncertainty and risks we have to accept as part of our lives. In GSPP, we explore how the search for certainty in an uncertain world affects peoples' understanding of science and of science-based public policy issues, and how that informs their personal beliefs on science-based issues. The course uses examples from a variety of geoscience topics, including seismology, as a springboard for exploring issues in the nexus of science and public policy.

Seismology is an ideal topic for teaching about science and public policy. It is deeply intertwined with human society in ways that directly affect peoples' lives. The course provides background on the science underlying a wide range of geoscience topics ranging from Galileo and the controversy over a sun-centered solar system to current concerns about global warming and climate change. Embedded in that storyline is a variety of examples from seismology, including examples from my own research and my own experiences with seismology and society. In 2020 and 2021, the course was notably affected by my involvement in a study of seismic quieting associated with lower levels of human activity due to COVID-19 lockdowns (Lecocq, et al., 2020). Through my involvement in that study during the COVID-19 interruption of in-person classes, students had very immediate, personal experiences of the nexus of science and policy, providing an ideal teachable moment regarding how humans interact with global Earth processes. The theme of "Life is uncertain." was particularly relevant as we navigated the COVID-19 pandemic, when students experienced the challenge of coping with uncertainty in science in the context of their own response to claims about the science underlying the pandemic. Hopefully, courses like GSPP will help provide students with the level of scientific literacy they will need to make well-informed decisions about science-based problems affecting citizens of planet Earth in the 21st century.

Probabilistic moment tensor inversion: examples from Europe

Daniela Kühn

Alma mater	University of Hamburg, Germany
Field of research	Microseismicity, Induced Seismicity, Moment Tensor Inversion of Local and Regional Events, Seismic Hazard, Ambient Seismic Noise Analysis, Waveform Modelling, Numerical Fracture Mechanics
Present Institution	GFZ German Research Centre for Geosciences, Potsdam, Germany (Scientist); NORSAR, Norway (Senior Research Geophysicist)
Webpage	https://www.gfz-potsdam.de/en/staff/daniela-kuehn/sec21/
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Seismic waves generated by earthquakes may be used to study source processes, analyse the material through which seismic waves propagate or investigate the near surface around recording stations. Focal mechanisms represent a way to describe the geometry of faulting during the event and moment tensors serve as generalised concept including other types of seismic sources.

The lecture shortly summarises the basics of both concepts and continues to present a probabilistic version of the moment tensor inversion in more detail (the *grond* algorithm, part of the *pyrocko* toolbox, https://pyrocko.org/).

Human-induced or -triggered earthquakes are more and more brought into the focus of public attention. Environments prone to induce or trigger seismicity are numerous, e.g. oil and gas fields, large-scale surface quarries and mines, enhanced geothermal systems (EGS), dam sites and injections of e.g. CO_2 or waste water. In some of these projects, seismicity is intentionally induced to enhance reservoir permeability by hydrofracturing, e.g. to increase oil or gas production or to explore geothermal reservoirs. Induced or triggered earthquakes occur close to engineering activity and in addition at very shallow depths, therefore, even weak events may pose a seismic hazard or be felt by the population. Since induced seismicity may exhibit non-double couple rupture processes, which are usually not observed for natural seismicity, a moment tensor inversion may be an important building block in the discrimination of induced, triggered and natural seismicity. Such a discrimination may have economic consequences for the compensation of claims.

The realisation of a moment tensor inversion is more problematic when small magnitude events are concerned, since the signal-to-noise ratio is lower and the dominant frequencies are higher, which requires a better knowledge of the velocity model. This will be demonstrated using examples from earthquakes occurring within the gas fields of Northern Europe.

Seismic anisotropy tomography: New insight into seismotectonics, volcanism and geodynamics

Dapeng Zhao

Alma mater	Tohoku University, Japan; Peking University, China
Field of research	Seismology, Geophysics, Geoscience
Present Institution	Tohoku University, Japan (Professor)
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The subduction of oceanic and continental lithospheric plates into the mantle drives mantle convection and causes large earthquakes and vigorous magmatism along island arcs and continental margins. These processes induce different stress and strain regimes at different depths and generate varying seismic anisotropies. Hence, measurements of seismic anisotropy provide direct constraints on the subduction processes, in particular, mantle convection in subduction zones. In the past decade, seismic anisotropy tomography has been successfully applied to many subduction zones to resolve 3-D isotropic and anisotropic velocity structures simultaneously. The obtained results provide direct evidence for deformations in different domains of subduction zones, including the overriding lithosphere, mantle wedge, subducting slab, and the mantle below the slab. The crustal anisotropy may be attributed to the alignment or preferred orientations of micro-cracks in the upper crust and crustal minerals in the lower crust, which may be strongly affected by local geological structures such as active faults, folds, and volcanoes. The mantle wedge is very important part of subduction zones because it is the source zone of arc magmatism, and fluids in the mantle wedge resulting from slab dehydration can ascend to the shallow part to trigger large crustal earthquakes. To the first order, mantle-wedge convection is driven by the active subduction, generating trench-normal azimuthal anisotropy as well as faster vertical velocities in general. At the same time, strong along-arc variations of the slab geometry and other features may induce significant along-arc mantle flow, resulting in trench-parallel anisotropy. The anisotropy in the subducting slab may arise from either fossil anisotropy or present deformations. In the top portion of the slab, fast-velocity directions (FVDs) show systematic transition from trench-parallel in theout-rise to trench-normal under the forearc, and back to trench-parallel under the volcanic front. In contrast, within the slab, the FVD is generally trench-parallel. These results suggest that the anisotropy reflects present deformations rather than the frozen-in fossil anisotropy. Under the forearc area, the anisotropy indicates complex deformations along the megathrust zone. In and around asperities for large megathrust earthquakes (M 7.0-9.0) or areas where interplate coupling is very strong, the FVD is generally trench-parallel, which may reflect trench-parallel preferred fabrics under trench-normal compression during the inter-seismic period. However, in patches dominated by aseismic slip or weak interplate coupling, the FVDs are trench-normal, which may be produced by strong shear along the plate interface. Anisotropy in the sub-slab mantle estimated from shear-wave splitting measurements is still ambiguous, because neither local nor teleseismic S-wave data set could provide proper constraints on the azimuthal anisotropy beneath the slab. SKS splitting can sample the sub-slab region, but the interpretations are not unique. The P-wave anisotropic results obtained to date revealed both trench-normal and trench-parallel anisotropies, which may reflect subduction-driven entrained flow and 3-D mantle flow, respectively.

Introduction to PSHA

Probabilistic Seismic Hazard Analysis (PSHA) is currently the default methodology used for assessing seismic hazard at various scales from regional to national until the evaluation at a single site.

This lecture introduces the central concepts of PSHA, including the distinction between aleatory and epistemic uncertainty, and describes the main components of a hazard input model, the results produced by a probabilistic analysis, the main limitations of PSHA and ways currently available to overcome them.

Following the conceptual introduction, the lecture will exemplify some of the main themes using components of PSHA models developed within the Global Earthquake Model (GEM) Foundation, in particular highlighting some of the toolkits and approaches that GEM currently uses to address common obstacles in PSHA. The examples will draw from two recently developed PSHA models, which cover China and the island of Hispaniola.

This lecture is complemented by two other contributions: *Building a PSHA input model* and *Introduction to the OpenQuake Engine.*

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Seismic Microzonation: An Efficient Tool for Earthquake Risk Resilient Structures

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Earthquakes are categorised as one of the worst natural calamities that cause a huge loss of lives and properties, injuries, and disruption of economic activities without any premonition and notice prior to their occurrences of varying strengths at different source depths. Several incidences of devastating earthquakes, especially in the Indian subcontinent and south Asian region have been reported for the seismo-tectonically active regions, which suggest that South Asia is one of the hotspots of disastrous earthquakes.

Based on potentially catastrophic consequences of largely unpredictable earthquakes, particularly in growing urban areas in different seismic zones of South Asia, it is imperative for countries of the region to use their resources to develop earthquake risk resilient structures and infrastructures for safe dwelling, which in turn also reduce the recurrence losses due to earthquakes.

In this context, seismic microzonation, a tool for detailed investigation of the existing seismic macro hazard zones into several micro-zones by setting up of a closely spaced grids, as an efficient tool to generate a set of site specific seismo-geophysical-geotechnical parameters to update the existing building design code into the sound earthquake risk resilient code for constructing sustainable structures and infrastructures. State-of-the-art techniques are being deployed to estimate soil attributes along with delineating the disposition of faults and structural heterogeneities to assess how and which earth layer gets aptly amplified during earthquake shaking to damages structures. In order to achieve the safety of structures and infrastructures deployment of seismic microzonation is essentially required, which would be discussed during presentation.

Building A PSHA Input Model

A Probabilistic Seismic Hazard Analysis (PSHA) Input Model is the combination of two components: the Seismic Source Characterization (SSC) and the Ground-Motion Characterization (GMC).

The SSC provides a comprehensive description of the location of earthquake sources, their potential to generate earthquakes of a given magnitude and frequency and the associated epistemic uncertainties. The modelling of earthquake sources utilises various typologies whose characteristics depend on the seismotectonic properties and the information available for the areas surrounding the investigated site.

The GMC includes a comprehensive description of the selection of suitable ground-motion models (GMMs) and their usage in computing the expected shaking at the site given the occurrence of an earthquake rupture with well-defined properties and a description of the epistemic uncertainties connected.

The presentation aims to provide a comprehensive description of the structure and the components of a PSHA input model, and we will outline ways to create them.

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Seismotectonics of the Central Mediterranean Area

The central Mediterranean area is a very active region and from a seismotectonic point of view it can be considered as a quite complex region. It has been struck by several devastating earthquakes and active volcanism is present. It is one of the areas with high seismic hazard and based on the historical earthquake records the area has suffered intensity X or higher several times in the past centuries. The dynamics of this area is controlled by two main tectonic factors: the Nubia–Europe plate convergence and the southeast-ward rollback of the Ionian lithospheric slab which subducts beneath the Tyrrhenian lithosphere. The central Mediterranean area is also characterized by an intermediate and deep seismicity clustered and aligned along a narrow (less than 200 km) and steep (about 70°) Wadati-Benioff zone striking NE-SW and dipping towards the NW down to 500 km of depth.

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Kinematics of Shillong Plateau & Eastern Himalaya Region-the Sites of Great Earthquakes

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Northeast India, three major plates interact along two convergent boundaries: the Himalayas and the Indo–Burma Ranges, which meet at the Assam Syntaxis while there is Holocene upliftment of Shillong plateau. To clarify this tectonic interaction and dynamics, the kinematics associated with August 15, 1950, the M ≈ 8.7 Assam earthquake and 12 June 1897, M=8.5 offer a unique dimension to study the underlying dynamics which devastated the region in various forms. Although no primary surface ruptures were observed, however features obtained from geophysical, geological and geomorphic surveys characterise the region to infer information pertinent to these two great earthquakes. In a process fault scarp could be identified and surface rupture could be estimated. A clear disruption in subsurface lithology infer amount of release of energy due to these great earthquakes. Geomorphic features indicative of tectonic surface uplift and recent active faulting were identified in field reconnaissance surveys guided by satellite image interpretation. Large landslide, debris follow, river avulsion, formation of dead pool of rivers due to uplift of the terrain are the unique features identified through light on kinematics of the region. Existence of widespread features indicate the inversion of bedding plane beside evolution of oceanic crust in entire region mainly in Syntaxial region and Shillong plateau. High-resolution topographic survey identifies co-seismic surface uplifts. Simplest deformation model in which most of the intra-seismic elastic loading refer upliftment during 1897 earthquake by co-seismic and post seismic rupture mainly on western part of Shillong plateau. Monitoring seismicity pattern in best possible statistical approach, quantification of stress and strain blended with geodetic survey as integrated with estimation of geophysical and geomorphic parameters will no doubt unravel the kinematics and seismic hazard assessment of the region.

Recent Large and felt Earthquakes in Northeast India: Seismotectonics and Precursor Appraisal

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The North East Region (NER) of India is marked by the Himalayan arc collision zone to the north and Indo-Burma arc subduction zone to the east. The two arcs meet at the Eastern Himalayan Syntaxis (EHS) zone. The NER produced two great earthquakes Mw $\geq$ 8.0; the June 12, 1897 earthquake (Ms 8.7, revised to Mw 8.0) in the Shillong plateau (SP) intra-plate zone, and the August 15, 1950 Assam earthquake (Ms 8.7, revised to Mw 8.4) in the EHS. The NER also experienced some 25 large (Mw $\geq$7.0) earthquakes since 1869; 19 of these occurred in the Indo-Burma subduction zone, one in the Himalayan collision zone, and five in the intra-plate zone. Out of the five intra-plate large earthquakes, one (1930, Mw 7.1) occurred on the Dhubri fault at the western boundary of the SP, two (1869, Mw 7.4 and 1943, Mw 7.2) in the Assam valley Kopili fault zone, and two (1918, Mw 7.1 and 1923, Mw 7.0) in the Bengal basin.

During the last decade, a strong damaging earthquake (Mw 6.7) occurred on January 3, 2016 near Imphal, the capital city of Manipur, and another strong earthquake (Mw 6.1) occurred on April 28, 2021 in Sonitpur, Assam valley. The centroid moment tensor (CMT) solutions suggest that both the events occurred by strike-slip motion on the Kopili fault. The 2016 Manipur earthquake occurred at the southern end of the Kopili fault, and the 2021 Sonitpur event occurred at the northern end of the fault. In addition, a severely felt moderate magnitude earthquake Mw 5.7 occurred by strike-slip faulting on January 3, 2017 near the capital city Agartala in Tripura. An unusual burst of seismic activity, eight earthquakes Mw 5.0 - 5.9, on the other hand, is recorded in Mizoram during April-September, 2020.We discuss all these recent events in the light of the known active faults and seismotectonic models. Further, the Mizoram seismic activity is examined in the light of precursor swarm hypothesis. An anomalous change in seismicity rate is observed that indicates a precursor for an impending large earthquake in the Mizoram accretionary Indo-Burma Wedge (IBW). The paleoseismic evidences as well as the anomalous higher seismicity in the Kopili fault zone also indicates a possibility of an impending large earthquake in the central segment of the Kopili fault zone in Assam valley. These observations are alarming to assess the seismic hazard risk for disaster mitigation.

The Omega-Theory and the Time-Dependent Earthquake Forecasting

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"Earthquake prediction" has been the goal of unsuccessful empirical research for more than 100 years. Therefore, in the past five decades, many resources were devoted to the earthquake hazard maps based on the statistical and probabilistic approaches, often called the Probabilistic Seismic Hazard Assessment (PSHA). However, in the last two decades, a very successful alternative to the PSHA modeling was found to be application of chaotic synchronization theory in seismology. The pioneering studies on the chaotic synchronizationsin relationship to earthquakes were highly theoretical and lacked the direct applicative power. The turning point was achieved in the last five years based on (1) new advances related to repeating earthquake sequences, (2) developments in the Cosserat theory of faulting and earthquakes, and (3) discovery of the slow solitary waves called strain or tectonic waves. The complete Cosserat theory of faulting and earthquakes was published in 2018, named "the Omega-theory". This new theory offered a unifying mathematical framework to describe and answer the most pressing and unexamined dilemmas of earthquake sequences, chaotic synchronizations and tectonic waves. In the last five years, we developed the so-called Quantectum Earthquake Forecasting System (QEFS) that tests the benefits and limitations of the earthquake forecasting following the Omega-Theory. The QEFS shows that the key to the time-dependent earthquake probabilities and earthquake forecasting is analysis of synchronizations of earthquakes and propagation of tectonic waves through the Earth's crust. The main reason why the classical seismology failed to solve the problem of earthquake prediction and forecasting was related to the fact that the couple stresses in the Earth's crust were not accounted for. Here we present analysis of many recent moderate to large earthquakes. Based on the results of the QEFS, we conclude that earthquakes can be forecasted with high probabilities, and that the earthquake forecasting has finally been solved, both theoretically and practically.

Lithospheric Structure of Himalayan Collision Zone

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The collision of the Indian and Eurasian plates has produced about 2500 km long orogenic belt and a collisional mountain belt, the Himalaya. Numerous studies have been carried out to decipher the subsurface structure under the Himalayan collision zone. These studies have provided structural/lithospheric features cutting across collision zone and also structural variability of the collision zone along strike axis. This presentation plans to review the status of deep crustal and lithospheric structures beneath the Himalaya and Tibetan plateau to comprehend geodynamical model of the India-Eurasia collision zone. Overall, the Moho depth under the southern boundary of the Foreland basin, is in the range of 35-40 km, which gradually deepens following the flexural isostatic compensation and reaches in the range of 75-80 km beneath the northern edge of the collision zone and southern Tibet. The depth of lithosphere-Asthenosphere Boundary (LAB) also increases as Indian plate descent under Eurasian plate; attaining the depth of ~240 km beneath the southern Tibet and relatively thinning beneath the northern Tibet. The general observations of N-S variations in the Moho and LAB depths are common along the collision zone. However, deep of underthrusting Indian Plate, extend of underthrusting and other structural features like Main Himalayan Thrust (MHT) differ from west to east along strike of the collision zone. It is noted that the structural geometries, lithologies, state of stress and the presence of fluids at depth have pronounced bearing on the short-term processes, like earthquake cycles as well as long-term deformation processes and therefore contributes to the earthquake generation to the building of Himalaya.

SGRAPH System for Seismic Waveform Analysis and Source Parameters Estimation

SGRAPH or Seismographer is considered an efficient toolbox for performing the basic waveform analysis and solving the advanced seismological problems. It is an integrated system for maintaining and analyzing seismic waveform data in a stand-alone, Windows-based application. The graphical user interface (GUI) utilities and the Windows functionalities, such as dialog boxes, menus, and toolbars, simplify the user interaction with the data. SGRAPH supports common data formats, such as SAC, SEED, GSE, ASCII, and others. It provides the ability to solve many seismological problems with the built-in inversion tools. It is a combination of numerous tools to handle the waveform data from the raw form to the publication form. SGRAPH package includes the basics of waveform analysis like the zooming, filtering, Fourier transform, correlation, corrections, phase picking, particle motion, etc. In addition, it provides simplified inversion tools for source parameter estimation, Wadati diagram, travel time distance relation, Q-frequency relation, and attenuation parameters. Moreover, simplified tools for hypocentral location and magnitude estimation are also provided. Here I would like to discuss in detail the important tools of SGRAPH system and its modules and how to use SGRAPH to estimate the hypocentral location, magnitude, and source parameters.

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Recent Seismicity and Probability Assessment of Earthquake Occurrence in North East and Himalayan Region

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Northeast India is one of the seismically most active regions in India, i.e., it falls under Zone V which represents the highest seismic risk in the country. This region has been experienced two great earthquakes like the 1897 Shillong (Mw 8.1) and the 1950 Assam earthquake (Mw 8.4) and several large earthquakes (Mw ≥ 7) during last 122 years. Probabilistic approach and number statistical tools have been used by various researchers for finding the future earthquake recurrence rates. Using the earthquake catalogue, Gutenberg–Richter parameter has been estimated to evaluate seismic risk for six different regions: Eastern Himalayan, Indo-Burma region, Bengal Basin, Shillong Plateau, Mishmi Thrust, and Naga Thrust. Assuming that the earthquake occurrence is Poisson model, based on the obtained Gutenberg–Richter (G–R) relations, the probability of occurrence of earthquake of specified magnitude in given time is estimated for six seismotectonic regions. Further in this study, we made an attempt to estimate the probability of earthquake using four known statistical models, namely Exponential, Rayleigh, Weibull, and Pareto. The whole region is divided into six tectonic blocks to estimate the probability of an earthquake (Mw ≥ 5.5) through the maximization of conditional probability of earthquake occurrence. Time intervals for the occurrence of the next large earthquake in the six regions have been estimated by the maximization of conditional probability of earthquake occurrence. Pareto distribution shows the highest conditional probability compared to other distribution although it shows the lowest recurrence time compared to others. Rayleigh shows the lowest conditional probability, and Exponential shows intermediate probabilities in between Weibull and Pareto distributions. Specified four typical probability density models have been validated with the predicted event in Eastern Himalayan and Naga Thrust for earthquake Mw ≥ 5.5 recorded event.

Introduction to the OpenQuake Engine

The OpenQuake (OQ) Engine is the seismic hazard and risk calculation engine developed by GEM in collaboration with a global community of scientists and engineers. The OQ Engine is open-source software written in the Python programming language (the source code is available at https://github.com/gem/oq-engine). Various individuals and public and private organisations use this tool in numerous projects to compute seismic hazards.

The OQ Engine provides the user with many typologies of earthquake sources, a large and up to date library of ground-motion models and a flexible way to define epistemic uncertainties. It also contains a comprehensive library of ground motion models with a large number of models published in the last 20 years. This library can be used independently from the engine to explore various characteristics of these models.

The lecture focuses on describing the main components of the OQ Engine and demonstrates basic usage using some examples.

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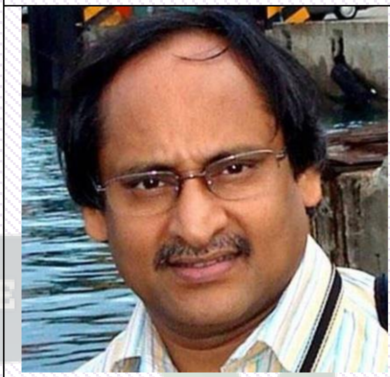
State-of-the-art Seismic Techniques for Advanced Modeling and Interpretation: Solution to some Geoscientific Challenges

Kalachand Sain



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There has been tremendous growth in subsurface imaging from surface seismic data due to the availability of high performance computing systems and acquisition of high-resolution digital data. Some of the advanced seismic tools and their applications are presented here for the delineation of subsurface geologic features with special reference to hydrocarbon exploration in difficult terrains and understanding geo-tectonics. The tools are 2D traveltime tomography, 2D full waveform inversion and prestack depth migration/common reflection surface stack for subsurface imaging; and rock physics modeling for resource assessment; and neural-based seismic meta-attributes for automatic interpretation of subsurface, etc.

More than 50% of global oil is found in Mesozoic sediments. However, a vast part of western-central India is covered by Deccan volcanic rocks below which such sediments are anticipated. Mapping of sub-volcanics has been elusive by conventional geophysical techniques and near-vertical seismic reflection profiling due to inherent limitations. This challenge has been alleviated by wide-angle seismic experiments. We have demonstrated successful delineation of large-scale Mesozoic sediments in onshore Saurashtra, Kutch and Tapti, offshore Kerala-Konkan (KK) basins below the Deccan volcanic rocks by 2D traveltime tomography of wide-angle seismic data. The fine scale structures of such sediments have been delineated later by computationally-intensive state-of-the-art 2D full waveform tomography (FWT) of wide-angle seismic data. The FWT has also been employed for the delineation of fine-scale velocity-structures of gas-hydrate bearing sediments in the Krishna-Godavari and Mahanadi basins, the presence of which were later validated by drilling and coring. Gas-hydrates are considered as the major future fuels of India. We have computed seismic attenuation and showed that this attribute can be used for characterization of gas-hydrates reservoir. We have utilized Rock physics modelling for evaluating resource potential of gas-hydrates.

We shall present an advanced imaging tool - common reflection surface (CRS) stack to demonstrate its ability, over the conventional stacking, in delineating enhanced images of subsurface from vintage seismic data in the Delhi-Aravalli fold belt and Central Indian Tectonic Zone; prestack depth migration in Kutch peninsula to seismic refraction data to shed light on Bhuj (2001) earthquake; and 2 Traveltime tomography in refining the Vindhyan sedimentary basin. This has provided improved understanding on geotectonics that were not evident earlier. We shall also present the application of advanced 'pre-stack depth migration' to seismic data by utilizing tomographic velocity model for delineating improved images of subsurface in the KK basin. Lastly, we shall demonstrate a neural-based approach, first of its kind, for automatic delimitation of subsurface geologic features such as faults, gas plumbing, intrusive (dykes and sills), mass transport deposit, carbonate reefs, channels & levees etc. from surface data to aid advanced interpretation of 3D seismic data with a much reduced human intervention.

New Insights on the Inner Workings of Volcanoes

The understanding of the crustal processes underpinning volcanism has changed dramatically over the past decades. Magma chambers, long envisaged as vats of liquid rock, are inherently elusive in geophysical imaging and this raises questions as to the appropriateness of the investigation techniques or, indeed, the existence of such vats. In this presentation I will review some of the dramatic changes modern volcanology as undergone by drawing from examples of research on active sub-volcanic systems from around the globe. I will focus particularly on 1) the subsurface processes at "zombie volcanoes" which by all accounts should be dead (or extinct) but show signs of surprisingly high levels of activity, 2) the processes underpinning protracted unrest at large caldera volcanoes and 3) the role of external forcing by stress transfer between tectonic and magmatic systems. The examples will highlight the multidisciplinary approaches needed to get an understanding of complex subsurface processes that are hidden from direct observations. I will end with highlighting potential avenues for cross-fertilisation of knowledge (and hopefully also wisdom) from modern volcanology to tackle global challenges related to a rapidly changing environment.

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Shaking is Almost Always a Surprise: the Earthquakes That Produce Significant Ground Motion

Although small earthquakes are expected to produce weak shaking, ground motion is highly variable and there are outlier earthquakes that generate more shaking than expected—sometimes significantly more. We explore datasets of MM 0.5–8.3 earthquakes to determine the relative impact of frequent, smaller-magnitude earthquakes that rarely produce strong ground motion, to rare, large earthquakes that always cause strong shaking. We find that the natural variability of ground motion, combined with the Gutenberg–Richter magnitude–frequency relationship, ensures that most occurrences of any ground motion come from earthquakes of smaller magnitude than expected, often >2 magnitude units smaller. This holds even for very strong shaking (>20%g), suggesting that M<7 earthquakes could be a significant source of damage.

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Earthquakes in the Heartland: How Energy Production Causes Earthquakes in Unexpected Places

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The central United States is experiencing an unprecedented surge in earthquakes that began in 2001, rising from an average of 21 magnitude 3 and larger quakes and peaking at over 1000 in 2015 alone. This increased earthquake activity is found in just a few concentrated regions around the country, all areas of increased oil and gas production. The largest increase in seismicity has occurred in Oklahoma, where earthquake rates were so elevated that they exceeded the earthquake rate of California each year from 2014 through 2018. Most of this seismicity has been induced by a process known as “wastewater disposal”, which is a process where waste fluids from the oil production process is injected deep underground. Contrary to public perception, only a small percentage of the seismicity increase in the United States is induced by hydraulic fracturing. While hydraulic fracturing has not been responsible for many earthquakes in the United States, it has been connected to many earthquakes in both Canada and China, including multiple M5+ earthquakes in China that resulted in fatalities.

In this presentation, I will cover the evolution of our knowledge of induced seismicity going back to the first induced earthquakes in the 1890s extending to the present. I will explore how these fluid injection processes cause earthquakes and what conditions make fluid injection operations more likely to induce earthquakes. We will also cover recent advances in our understanding of induced earthquakes that include statistical and mechanical methods to forecast induced earthquake rates. These earthquake rate forecasts are also now being employed to estimate the earthquake hazard from induced seismicity.

e- Abstracts from the Participants

A Critical Review on Seismic Evidence for Partial Melt Below Tectonic Plates

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The seismic low-velocity zone of the layer is mostly related to a low-viscosity asthenosphere that encompasses a potential role in decoupling tectonic plates from the mantle. However, the origin of the low-velocity zone remains unclear. Several studies attribute its low seismic velocities to a little quantity of partial melt of minerals within the mantles, whereas others attribute them to solid-state mechanisms close to the solidus or the effect of its volatile contents. Investigations of shear attenuation give further constraints on the origin of the low-velocity zone. On the idea of the interpretation of worldwide three-dimensional shear attenuation and velocity models, here we tend to report partial melt occurring inside the low-velocity zone. We tend to observe that partial melting down to almost 150–200 kilometres to a lower place mid-ocean ridges, major hotspots and back-arc regions feeds the asthenosphere. A little part of this melt remains cornered inside the oceanic low-velocity zone. Melt is generally absent beneath continental regions. the quantity of melt will enhance with plate rate, enhancing considerably for plate velocities of between three centimetres and five centimetres each year. This finding is in line with previous investigations of mantle crystal alignment beneath tectonic plates. Our investigation recommends that reducing viscosity melt facilitates plate motion and large-scale crystal alignment within the asthenosphere. This review is conducted to highlight the seismic evidence for partial melt below tectonic plates.

A Study in Research Advancements Characteristics of Expansive Soil, its Stabilization & Various Aspects in Geo-infrastructure & Buildings- A prospect on Strengthening of Soil-Structure Interaction (SSI)

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This paper focuses on the characteristics of Expansive soil and various methods advancement based on its characterization and ground improvement techniques as per Geotechnical Engineering point of view. Due to the imbibe of small or large fluctuation of water content undergo large volumetric change resulting the seasonal heave, shrinkage, distress and distortion to structures on such soil. It is necessary to understand the behavior of Black Cotton Regur or expansive soil and their interaction with various types of foundation & structures with geotechnical characteristics of swelling, seepage, sensitivity liquidity & plasticity, consolidation & compaction, effective stress & strength issues along with the distribution of clay mineralogy & soil mechanics properties. Therefore, to overcome the structural failure due to soil condition on such soil, the behavioral aspects on various stabilization methodologies has adopted with utilization of novel & sustainable additives of biopolymers & geo-polymers to depict the modification & solidification reaction in soil mix for getting variation in strength characteristics on expansive soil. Due to the improper or un-adjustment of Soil-Structure Interaction (SSI) and the weak characteristics of sub-grade soil results the failure of foundation & its superstructures. It is also noted that the various other factors such as geological & climatic condition, geomorphologic & mineralogical composition of expansive soil affects on performance of foundation & structures. Nowadays, there are various methods has adopted for understanding & controlling of the expansive soil such like- Composition tests for strengthening of soil, Atterberg limit & swelling tests for liquid limit observations, X-ray diffraction test indicates the presence of Montmorillonite on such expansive soil. Again, free swell tests & one-dimensional oedometer swell tests often calculates the swell potential & swell pressure respectively. To control the geotechnical properties on expansive soil, stabilization of soil necessary by treated with CPAM or Cationic Polyacrylamide, lime, fly ash and other polymers.

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A Study on Temporal Variation of Gravity in Sumatra Andaman Region Due to Co-Seismic, Post Seismic Event and Hydrological Factors Using GRACE Mission Solutions: An Approach Using Python and Generic Mapping Tools

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The temporal variations of Earth's gravity are the effect of mass redistribution inside the solid Earth as well as in its geofluid envelop. In this research, we tried to study the temporal variation of gravity in Sumatra-Andaman region both for hydrological effect as well as co-seismic and post seismic effect of 2004, 26th December earthquake; which was followed by numerous aftershocks and also by a large earthquake; the Nias 2005, 28th March event by using GARCE level 2 and Level 3 data provided in terms of spherical harmonic coefficient. In this study, we used three CSR release-6 datasets. The first dataset namely CSR mascon solution with all correction applied which is provided in NetCDF file; we use Python and some libraries namely netCDF4, NumPy, pandas, matplotlib and PIL to analyse and visualise this dataset for the region, where we noticed different positive and negative anomaly in different time. For the processing of CSR Mascon estimation solutions and CSR Grace field geopotential coefficient dataset for the year 2005, we used different modules of GMT and Fast Fourier Transform technique. Here, the first dataset shows temporal negative gravity anomaly in almost (6^0-10^0N, 97^0-100^0E) for the first quarter of the year, and positive anomaly to the last quarter in (10^0-14^0N, 97^0-100^0E). These results can be used to study the hydrology of the region. From the second dataset we found some unstable anomalies for February and anomaly become drastic from March onwards. The most prominent negative gravity anomaly from March is in approximately (6^0-10^0N, 97^0-100^0E) and positive gravity anomaly in the region (8^0-14^0N, 96^0-99^0E) though, this anomaly is not continuous. This result can lead us to the gravity variation due to co-seismic and post seismic event for the 2004 earthquake. These anomalies can be interpreted in terms of afterslip, viscoelastic response of the Earth's mantle or other processes associated with dilatation.

Accounting For Parametric Uncertainty in Ground Motion Models (Gmms)Using Bayesian Framework

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Within India, the current practice of developing region-specific GMMs is working with the recorded strong motion data to generate simplified models that capture complex earthquake phenomena in terms of a simple, functional dependence over its magnitude, source-to-site distance, and site shear wave velocity. The regression techniques used in developing such models consider theinput seismological parameters as exact, not accounting for the uncertainties associated with each parameter (particularly magnitude and shear-wave velocity) arising due to measurements differences. Quantifying and accounting for these input uncertainties is of paramount importance, given that the aleatory uncertainty(sigma) resulting from GMMs has a substantial impact on the hazard results. Thus, GMMs developed using the traditional regression procedure (e.g., least square method) may not capture the actual uncertainty in ground motion prediction. Using a Bayesian framework equivalent to univariate regression treats the input parameters as inexact, incorporating different uncertainties (i.e., distributions) within these parameters. It involves developing a likelihood function (the GMM) with a prior distribution for ground motion as well as input parameters and the regression coefficients. Essentially, this treats every regression parameter as a random variable and not just the ground motion. The prior distribution of coefficients is updated by maximizing the likelihood function given the observed data. When adopted for Indian datasets with sparse data and more uncertainties, this approach will help more accurately to assess the associated uncertainties (particularly epistemic) for seismic hazard analysis studies in the country.

Analysis and Interpretation of Magnetic data in and Around the Kopili Fault

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A geophysical survey is done in the remote North eastern part of INDIA which consists of four sites. Magnetic data is acquired using a layout of 100×80 m area using, Geometrics G-857 portable proton precession magnetometer and a GEM system GSM-19 VLF magnetometer (walking type). The magnetic method of geophysical survey is a useful technique than the expensive seismic methods. In this work, the objective is to estimate the location of the Kopili fault and study the magnetic susceptibility contrast of the targeted fault. As the fault is passing through some remotes areas so the geophysical survey is a bit challenging to conduct. Ground magnetic data is been collected by a Geometrics G-857 proton precession magnetometer. The data set is consists of 20 N-S and one E-W line acquired during the months of January and February, 2020. The real data is been processed for diurnal variation and regional distorting effects. Further these data are reduced to pole (RTP), Euler deconvlution and inversion were employed to characterized the Kopili Fault zone. The Euler deconvolution applied to the RTP data with different structural index vales interpret the dyke, sill, contact and fault structures. This magnetic survey also helps in the interpretation of the magnetic minerals that presents in the rocks in terms of magnetic susceptibility.

Anomalous Variation in GPS Based TEC Prior to the 8 Earthquakes in 2020

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The present paper reports the analysis of GPS based TEC measurements corresponding to 8 earthquakes (M ≥ 6.0) that have occurred in 2019 and 2020 during low solar activity period and quite geomagnetic conditions. The earthquakes are (1) Kashgar, China (39.8353, 77.1084) M- 6.0 on 19 January 2020, (2) Do?anyol, Turkey (38.4312, 39.0609) M- 6.7 on 24 January 2020, (3) Kirakira, Solomon Islands (-10.0929, 161.0606) M- 6.3 on 27 January 2020, (4) Kirakira, Solomon Islands (-10.418, 161.2756) M- 6.0 on 29 January 2020, (5) Kurilâ€™sk, Russia (45.6161, 148.959) M-7.0 on 13 February 2020, (6) Ã–zalp, Turkey (38.4958, 44.3732) M- 6.0 on 23 February 2020, (7) Tual, Indonesia (-7.4887, 131.1196) M- 6.0 on 26 February 2020, (8) Hihifo, Tonga (-16.0252, -172.1911) M- 6 on 17 March 2020. To identify anomalous behaviour of TEC, we compute interquartile range associated with median TEC so as to get upper and lower bound of TEC variation. The results show occurrence of anomalies in VTEC 1-30 days prior to the earthquake.

Anomalous Variation in GPS Based TEC Prior to the 8 Earthquakes in 2020 and 2021

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The present paper reports the analysis of GPS based TEC measurements corresponding to 8 earthquakes (M > 6.0) that have occurred in 2020 and 2021 during low solar activity period and quite geomagnetic conditions. The earthquakes are (1) Kurlisk, Russia (45.6161, 148.959) M-7.0 on 13 February 2020, (2) Severo-Kurilsk, Russia (48.9638, 157.6955) M-7.5 on 25 March 2020, (3) Karlovasi, Greece (37.8973, 26.7838) M-7.0 on 30 October 2020, (4) Namie, Japan (37.7265, 141.7751) M-7.1 on 13 February 2021, (5) Gisborne, New Zealand (-37.4787, 179.4576) M-7.3 on 4 March 2021, (6) Kermadec Islands, New Zealand (-29.6768, -177.8398) M-7.4 on 4 March 2021, (7) Kermadec Islands, New Zealand (-29.7228, -177.2794) M-8.1 on 4 March 2021, (8) Ishinomaki, Japan (38.4515, 141.6477) M-7.0 on 20 March 2021. To identify anomalous behaviour of TEC, we compute interquartile range associated with median TEC so as to get upper and lower bound of TEC variation. The results show occurrence of anomalies in VTEC 1-30 days prior to the earthquake.

Applicability of Site Effect and Anelastic Attenuation for the Simulation of Strong Ground Motion: Case Study of 2017 Mw 5.3 Earthquake in Garhwal Himalaya, India

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Simulation of high frequency ground motion are useful in earthquake engineering as well as for predicting ground motions. In present work, strong ground motion of earthquake M_w 5.3 occurred in Guptkashi, Garhwal Himalaya, India on 6th February 2017 is simulated by implementing stochastic technique. The waveform records of Guptakashi earthquake recorded at strong motion network installed in NW Himalaya is employed for this work. The stochastic method is used to predict high-frequency ground motion by considering ω-square model. To attain more accuracy in prediction of ground motion, record at different recording stations are simulated by using the incorporation of site effect and anelastic attenuation. The stochastic technique provide the simulated record on the hard rock. Therefore, in present work, the observed record is corrected for site effect computed at recording site. Role of anelastic attenuation for the simulation of strong ground motion is also tested for the Guptakashi earthquake. Variable anelastic attenuation in term of quality factor (Q) is used to simulate the record i.e. (1) regional Q established for the Garhwal region and (2) Q for particular recording station at which simulation is made. The characteristics of simulated record in terms of peak ground acceleration, predominant frequency, fourier and response spectra provide best match with observed record after the implication of site effect and Q for individual recording station. Hence, the incorporation of site effect and Q for individual recording station provide more accurate results for simulation, which can be used for designing earthquake resistance structure.

Application of Spatial Techniques for Earthquake Hazard Zonation with Special Emphasis on Guwahati City

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The North east India with its adjoining area is one of the most seismically active zones in the world. During last 100 years, the region has experienced 20 large earthquakes and two mega earthquake during 1897 and 1950 in Shillong and Assam- Tibet border respectively. The magnitude of both these earthquake have been recorded 8.7 on the Richter scale. Since North East India comes under Zone 5, the area is under high degree of risk and vulnerability to high intensify earthquakes. The high seismicity in North East States is due to collision of Indian and Eurasian plate in the North and subduction zone near Indo-Myanmar range (IMR) in the east. The recent earthquake that jolted Assam was about 6.4 Richter scale on 28th April, 2021. Since there were seven aftershocks that were felt after major earthquake, people of North east are in immense fear. Due to the escalating population growth in Guwahati Metropolitan Area, the city is at high risk and vulnerability zone. The paper attempts to delineate the earthquake zones of Guwahati city with respect to Landslide hazard zonation and examining the geological features of GMA by using Remote Sensing and GIS technology. The hazard maps will offer better representation of local specific seismic hazard zones and will help the authorities to frame policies.

Attenuation of Indian Shield Using Lg Waves

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Attenuation studies using Lg phase is an ideal tool to study large-scale crustal variation, as this phase is insensitive of the source characteristics. Lg waves are explained as the multiply reflected shear waves or higher mode surface waves, which are trapped between the free surface and Mohorovicic discontinuity. For the Indian Shield, attenuation studies using Lg waves are scarce. We have used data from 192 earthquakes recorded in 113 seismometers deployed in and around Indian Shield, operated by CSIR-NGRI, NCS and Geoscope. Methodology followed is Two-station method by Xie et al., 2004. Advantage of this method is that it nullifies the effects of source and cancels the geometrical spreading effect. 2421 high quality waveforms obtained after the processing stage is used to invert for Lg Q (Quality factor) and its frequency dependent parameter η in 1 HZ frequency. Results obtained show that Lg Q for the Indian shield varies from 50-650 and frequency-dependent parameter η have an average value of 0.6. The values obtained for the cratonic region, sedimentary region and rift valleys where most of the Indian shield lies, is in broad agreement with the values estimated for other similar tectonic regimes globally by various researchers. Also, we have compared the Lg-Q values with geophysical parameters such as crustal thickness, heat flow and Vp/Vs ratio for the Indian shield. From the trends obtained from the scaling relation, we conclude that the attenuation scenario in the Indian crust is mainly controlled by both composition and temperature.

Chemical Composition of Stars and Their Ongoing Nucleosynthesis

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Stellar nucleosynthesis describes the change in abundances of the chemical elements within stars due to nuclear fusion reactions in the cores and their overlying mantles. Stars are said to evolve with changes in the abundances of the elements within. The enormous luminous energy of the stars comes from nuclear fusion processes occurring in their centers. Fusion powers stars and produces virtually all elements. The fusion of nuclei in a star, starting from its initial hydrogen and helium abundance, produces energy in the form of heat and light and synthesizes new nuclei as a byproduct of the fusion process. Depending upon their age and mass of a star, the energy may come from proton-proton chain (p-p chain) fusion, helium fusion or the carbon cycle. For brief periods near the end of luminous lifetime of stars, heavier elements up to iron may fuse, but the fusion of elements more massive than iron would soak up energy rather than deliver it. While the iron group is the upper limit in terms of energy yield by fusion, heavier elements are created in the stars by another class of nuclear reactions. This nuclear synthesis of elements heavier than iron uses energy rather than supply it. The spectra of a few stars obtained with telescopes are reduced using IRAF reduction package. Analyzing this reduced data the chemical composition of the stars are found out. The nuclear fusion processes that led to the synthesis of the elements are studied.

Cryosphere Changes in the Tibetan Plateau: A Critical Review

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The Tibetan Plateau, is a vast elevated plateau in Central Asia, South Asia and East Asia, covering most of the Tibet Autonomous Region, most of Qinghai, North-western Yunnan, Western half of Sichuan, Southern Gansu provinces in Western China, the Indian regions of Ladakh, Lahaul and Spiti (Himachal Pradesh) as well as Bhutan. It is sometimes termed the "Third Pole" because its ice fields contain the largest reserve of fresh water outside the Polar Regions (contains the world's third-largest store of ice). Melt-water from ice and snow in the Third Pole feeds many of Asia's large lakes and rivers, including the Indus, Brahmaputra, Ganges, Yellow and Yangtze. The Third Pole is one of the most sensitive areas to climate change. It has been considered as the place to observe for early warning signals of global warming (Yao et al., 2019; You et al., 2019). The region has warmed by about 1.8 °C over the past half century, significantly higher than the warming rates for the Northern Hemisphere and the globe mean (Kang et al., 2010; Liu and Chen, 2000; Yang et al., 2014). Rapid glacier changes in the Third Pole may lead to disasters related to natural hazards such as glacier collapse, glacier surging, glacial debris flow, and glacial lake outburst flood (GLOF). Over half of the world's population lives in watersheds of major rivers with mountains sources – from glaciers and snow melt (Kaltenborn et al., 2010). Third Pole cryosphere changes affect regional hydrology, ecosystem and humans living in the entire watersheds.

Effect of the External Magnetic Field on Lane Dynamics in Pair Ion Plasmas

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When driven out of equilibrium, many physical systems may spontaneously exhibit many different kinds of pattern formation which are much richer than traditional phase transitions in equilibrium systems and may be extremely challenging to predict, and as such is therefore a very interesting field of research. Lane formation [1] is an important representative of non-equilibrium phase transition. We focus on a 2-D Pair ion (PI) plasma system and explore the lanformation dynamics using Langevin Dynamics (LD) simulation [1], specifically, the influence of an external magnetic field is studied. Our study is based on a plasma model where the ion-ion interaction is described with a screened electrostatic potential characterized by a screening parameter, and the ion-neutral background interaction is described using an overall friction force characterized by a damping factor and a zero-average stochastic collisional term that enables describing the diffusion effect. This model is used to describe the dynamic of a set of N ions subjected to stationary or time varying electric field. More specifically, the authors focused on a self-organization effect where the 'plasma' is structured as a set of lanes that alternatively contain positive and negative ions in presence of external magnetic field. The phase diagram obtained distinguishing a peculiar lane formation-disintegration parameter space. The different phases are identified by calculating the order parameter. The critical electric field strength value above which the lanes are formed distinctly is obtained, a higher value of the electric field strength is required to enter into the lane formation state in presence of magnetic field is observed. The critical value of electric field frequency is found as an increasing function of the electric field strength. This work may be relevant for the understanding of non-equilibrium lane formation phenomena in the naturally occurring PI plasma systems and for their relevance to technological applications that exploit or mitigate self-organization such as in e-ink [2] and microfluidics [2].

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Focal Depth Determination for Moderate Earthquakes in North-Eastern India Using Depth Phases (Pn & Spn) From Local Seismological Network and Waveform Inversion

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Precise focal depth of earthquakes is crucial for better characterising complex tectonic zones, especially where seismogenic faults occur at different depths. Knowing accurate focal depth also allows recalculation of the equivalent magnitude for the reassessment of the mapping of the slip rate deficit and seismic hazard in the complex tectonic region. In the present study, we determined the focal depths using depth phases for earthquakes with magnitude ≥ 3.5 from 2011 to 2018 in the entire Northeast India region. We also validate the focal depths determined from the depth phases using point source waveform inversion. Our study area includes the NE-syntaxis arc to the eastern subduction belt, northern collision thrust belt and its foredeep/foreland area in the southern Brahmaputra plain and prominent Shillong plateau. For computing the focal depth, based on the tectonic setting and existing faults, we divided the region into five significant blocks, i.e. (Himalaya collision zone, Assam Valley, Shillong Plateau, Eastern Himalaya Syntaxis, and Indo-Burmese Wedge). The focal depth variations in the five blocks have been found to vary from 10 km to 15 km, 10 km to 20 km, 10 km to 30, 10 km to 30 km and 10 km to 140 km, respectively, which have been supported from waveform inversion analysis.

Formation of Tertiary Coal and Environmental Degradation due to Surficial Coal Mining in Cherrapunji, Meghalaya

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Present day geological concepts suggest that Global Geotectonics phenomenon influences to set-up the complex tectonic scenario of NE regions of India, with different geological structures, significant stratigraphy and typical physico-chemical environment. All these lead to the formation of various economically beneficial minerals / materials within the whole NE extension of India. The coal-bearing strata were deposited under stable shelf condition along the periphery of the Shillong Plateau. The coal measures are sub-horizontal in attitude. The sedimentary exposures in the area range in age from Late Cretaceous to Eocene and show frequent lithofacies variations. Tertiary coal of Meghalaya is sub-bituminous and non-coking type and used extensively as fuel. Meghalaya has a total coal reserve of 640 million tonnes. Most of this coal reserves are mined unscientifically by rat-hole technique. Due to unscientific coal mining, the water sources of many rivers have turned acidic. Once the coal has been extracted, these mines are abandoned and left exposed in several cases. Mining activities bring water and air pollution, which results the loss of top fertile soil (Lyngdoh et al. 1992). Loss of soil productivity and ground vegetation serve as a signal for eminent transition to a desert like state. Mining sites are inherently unhealthy places to work due to which mine workers and neighbouring people are affected by many diseases, which include influenza, asthma, emphysema, stomach and lung cancer, hypertension. Environmental degradation is marked by the emissions of particulate matter and gases including methane (CH_4), sulphur-dioxide (SO_2), oxides of nitrogen (NO_2) and carbon monoxide (CO). The social impact of mining is also serious. The role of judiciary on Environmental Protection and Human Rights, states that there is a close connection between the protection of both human rights and environment in the context of sustainable development.

Frequency-Magnitude Relation & Hazard Estimation of Western Himalayan Region

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The study aims at making contribution to the current seismological scenario of the Western Himalaya region (31.487-37.005°N; 73.268-79.706°E) essentially important as the place for collision of Indian & Eurasian plate. Due to the subduction around 40-50 millions year ago, more than 2000 earthquakes were observed at various locations from 1980 onwards in Western-Himalaya region and became the symbol of prone earthquake zone. By understanding the lessons of previous earthquakes and other similar hazards there, we will try to estimate the upcoming possible earthquake zones. The frequency-magnitude relation or possibly the precise estimation of b-value will immaculate much knowledge about the current situation, stress-strain pattern and the amount of hazard over there. Variation of b-value with space, time and depth will unfold various assumptions and figure out actual circumstances. Furthermore, this will also bring the idea about the tectonic structure there as well as explain the particular cause for highly seismic active areas. This study will uncover the proceeding situation of near future seismic zones and suggests that if an earthquake hits this NW Himalayan segment in the future, the kind of distress might be huge.

Geomorphology and River Shifting Detection of Jamuna along Dhunat Upazila, Bogra District, Bangladesh

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Bangladesh is mainly formed by alluvial deposits in which riverbank erosion is very often due to regular shifting of river channels. Riverbank erosion has become a common environmental natural hazard in Bangladesh. It has direct impact on the people who are living besides the river. The studied area lies in north-western part of Bangladesh under Dhunat Upazila, Bogra District. Total studied area is about 248.15 km². The present works aim mainly for geomorphological mapping as well as river shifting detection of Jamuna River in the study area. The investigation is based on different multispectral satellite imagery (SPOT, Landsat-MSS, Landsat-TM, Landsat-ETM+ Rapid Eye, Google Earth etc.) interpretations which were used by means of ArcGIS and Erdas Imagine software as well as by field checking. Total 57 augers bore hole had been carried out to understand the lithological sequence of the area on the basis of different geomorphic units. These units are Flood plain, Natural Levee, Abandoned channel, Meander scar, Back swamp, Point bar, Old channel bar, New channel bar, Lateral Bar, Ox-bow Lake, Ephemeral channel and Perennial Channel. The sediment characteristic shows that channel and overbank environmental fluctuation occurred in many times. The channels are frequently shifting because of erosion of old bar and formation of new bar. The overall trend of the present right bankline migration is westward direction. The right bank of the Jamuna River shifted 4.80 kilometer since 1952 to 2018 towards Dhunat Upazila at the average rate of 43.00 meters per year. The shifting of the river is always is not in same rate or intensity. Jamuna entered into Dhunat Upazila, Bogra District around 1990. Comparative study of flood plain losses and bar development in the study area shows that after 1995, the flood plain had been loosed sequentially but bar development had not been followed the sequence. The output of the present research work may be helpful to the decision makers to take the proper mitigation measure regarding river bank erosion.

Lithofacies Analysis and Tectonic Provenance of Surma-Tipam Transitional Sedimentary Sequences Exposed In Parts of Naga Hills, In and Around Chumukedima, North-East India: A Case Study

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Naga Hills- the northern extension of Indo-Burman ranges (IBR) provide an ideal geological setting for understanding the geodynamic evolution of North-East Indian crustal block during late Mesozoic-Cenozoic period. The present study area which falls under Belt of Schuppen provides unique opportunity to study the Surma-Tipam transitional sequences (STTS) of Miocene age. A detailed measurements and study of vertical profile sections were carried out with respect to lithology and six lithofacies are identified: Silty-Shale facies (SLSH), Sandstone-Shale alternate facies (STSH), Fine grained Sandstone facies (FSST), Deformed Mudstone facies (DMST), Medium grained Sandstone facies (MSST) and Hummocky cross-stratified Sandstone facies (HCST). Sedimentary structures preserved in the rock strata include climbing ripples, convolute bedding, trough cross bedding, lenticular & flaser bedding, ripple cross-laminae, herringbone cross-stratifications, hummocky cross-stratifications etc. An attempt has been made to develop facies scheme and interpret the depositional milieu for the STTS. The conceptual model depicts mudflat-mixedflat-sandflat in an intertidal-subtidal setting intermittently influenced by fluvial and storm processes. Tectonic provenance is also studied using heavy mineral contents and petrography for the characterization of source rocks. The heavy mineral suite of STTS dominated by non-opaque varieties include garnet, zircon, chondrodite, staurolite, tourmaline, humite, scapolite, rutile, epidote etc. The overall studies of heavy minerals suite of the STTS indicate compositional immaturity (ZTR Index≈19.09%), intense tectonism and rapid deposition. Petrographic study depicts the Sub-Arkoses to Arkosic Arenite composition of the STTS rocks with some evidences of deep burial diagenesis. Based on the heavy and light mineral suites coupled with the type of topography available in the vicinity of study area, it may be visualized that the sediments were derived from heterogeneous nearby sources like the Himalayas, IBR, the Shillong plateau and Mikir Hills. An overall supply from a recycled orogeny provenance has been envisaged.

Lithofacies Analysis of the Brahmaputra River Channel Bars near Dibrugarh Town, Assam

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Lithofacies are simply different types of clastic or chemical sediments produced by gravity, water, ice, or wind in sedimentary environment. The present study confines to the channel bars of the east to west flowing Brahmaputra River along northern side of the Dibrugarh Town at longitude 94 °54´ 02˝ and latitude 27 ° 29 ´13˝. The present investigation aims to identify various lithofacies associations of the Brahmaputra River channel bars in terms of various sedimentary structures like cross stratifications, facies contacts and their vertical as well as lateral distribution including textural behaviours of the sediments. The braided character of the sediments of the Brahmaputra River is marked by the occurrence of multiple channels with intervening bars and Islands and indistinct bank line. Based on various sedimentary structures like trough, planar and low-angle cross stratifications, horizontal laminations and ripple-drift cross-stratifications including the massive character at some horizons, the present study identifies different lithofacies associations along different cutting sections of the channel bars are found to alternate amongst them. Lithological associations, facies relations, various sedimentary structural and erosional features including sand body geometry suggest sand rich low to moderate sinuosity multiple channel fluvial environment of deposition. Fluctuations in the energy level in the depositional medium is indicated by the fluctuations in the volume of coarser and finer fractions in the samples. The study suggests the deposition of sediments in the basin were the results of the alternation of upper and lower water flow regime , thereby the alternation of higher and lower flow velocity.

Malani Felsic Volcanic Magmastism: A Key to Understand the Magmatic Record of NW Indian Shield

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Malani Felsic Volcanic Magmatism (MFVM) was occurred during the anorogenic episode of Neoproterozoic time in NW Indian shield. The magmatic suites are exposed very well in the region of Tusham, Siwana, Jalor, Jhunjhunu, Nakora and Mokalasar (NW India) and Kirana and Nagarparkar (SE Pakistan). It was considered as third largest felsic magmatism worldwide. The volcano-plutonic rock associations are most spectacular characters of MFVM. The igneous assemblages related to MFVM were operated by many complex geochemical processes i.e. extreme fractional crystallization of mafic magma, low to high degree of partial melting of pre-existed crust, magma mixing, rock-fluid interactions and more. Based on published data and new data sets, a critical review of MFVM is carried out to understand the magmatic record of NW Indian shield during Neoproterozoic time. This time was recorded with large anorogenic magmatic pulses which are very important barcodes of supercontinent i.e. Rodinia. The rift related magmatism occurred during this period was responsible for the rifting of continental part and breakup of Rodinia. Therefore, an attempt has been made here to discuss the suitable mechanism of MFVM and its importance in the reconstructions of palaeogeography of NW peninsular India and adjoining continental parts.

Mangrove Analysis of the Mumbai Region Using Time Series Remote Sensing Data

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Mangroves are a type of intertidal wetland habitat which grows in very complex environmental conditions. The Mangrove system is fragile and is undergoing seasonal changes. The region of Mumbai is densely populated due to a large number of people migrating to the city for their jobs. As a result, urbanization, industrialization, etc. are threatening the existence of the mangrove forests. To monitor these changes, Remote Sensing and GIS serve as valuable tools in providing fast and accurate data. My study is aimed at mapping the changes that have occurred in the mangrove forest around the Mumbai region using the Landsat data acquired from 1975 to 2020. For processing the time series data, commercial ENVI software was used. The time series Landsat images are co-registered to bring them to the same resolution and change detection analysis. In Change Detection and Time Series analysis it was revealed that the year 2015-2020 has the most significant changes. According to the study it has been concluded that in 2015 Mumbai had very less mangrove cover while in the recent year 2020 the mangrove cover has increased and shows moderately dense vegetation. With the help of False Colour Composite (FCC), visual image analysis was done for each particular year. For this purpose, the mangroves were distributed into three classes: dense, sparse and moderately dense. For more accurate results, the FCC images were also compared with 100m Global Land Cover Map. Measures havebeen suggested for the conservation of mangroves of Mumbai on a sustainable basis.

Modification of Semi Empirical Technique of Strong Motion Simulation to Include Site Effect

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The semi empirical technique is one of the most popular and frequently used techniques to simulate strong motion records at hard rock sites. With time, many researchers upgraded this technique to add more rupture complexities and to simulate more realistic ground motion records. Literature survey reveals that many historic earthquakes had caused huge damage due to the site amplification effect (i.e. the 1985 Michoacan earthquake, the 1988 Armenian earthquake, the 1989 Loma Prieta earthquake, 2001 Bhuj earthquake). This strongly demands the incorporation of site term in the existing technique. In view of this, we have introduced the site term in semi empirical technique. The technique is further tested for the 2016 Kumamoto earthquake (M_{JMA} 7.3) occurred on April 16, 2016 (01:25, JST) at a depth of 12 km along the Futagawa fault. Strong motion records have been simulated at various surface sites and finally compared with observed one in terms of root mean square error. The comparison shows that the modified semi empirical approach has efficiently simulated the ground motions at these surface sires. These results will be of high importance to prepare the seismic hazard map of the region.

Natural Hazard Risk and Management in the Aizawl City of Mizoram

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Aizawl is the capital city of Indian state of Mizoram, falls under the Suvey of India Topo Sheet no. 84 A/9 and 84 A/10. The total population of Mizoram is about 12.6 lakhs where nearly 4.5 lakhs (as per aadhar uidai.gov.in Dec. 2020) people are residing in the capital Aizawl, with an annual growth rate of 10.54 percent. Geologically, Mizoram is a part of the southern extension of Surma basin constitutes one of the largest sedimentary basins, represented by the Surma Group of rocks in which Bhuban Formation is the major sedimentary unit well exposed in Aizawl. This succession constitutes a series of approximately N–S trending and longitudinally plunging anticlines and synclines (Ganju 1975; Ganguly 1975, 1983). As a geographical part of the Indo Burmese range, seismicity in various magnitudes is common in Aizawl. The presence of deformation features like faults, folds, lineaments, fractures etc. in the recent sediment demonstrates the ongoing neotectonic activities in the area. The well-known active faults such as Churachandpur-Mao fault, Mat fault, Sylhet fault, Naga thrust etc. plays an important role to trigger the seismicity in the area. The entire topography of the area is hilly and rugged terrain where the average elevation of the hills is about 900 m. The settlement of dense population on the steep slopes and nearly unconsolidated Bhuban rocks in the hilly terrains of Aizawl makes it more vulnerable for any seismically induced hazards like landslides, Rockfalls, liquefaction, lateral spreading, flash flood, urban fire etc. The change in housing pattern from traditional style to modern multi-storey buildings in densely populated areas in the city is a matter of serious concern as it can lead to devastating catastrophes in any major seismically induced events. Unscientific anthropogenic modification of slopes for settlement may also have serious consequences. Further, the NH-54 is the main road for connectivity of Aizawl with the nearest city Silchar of Assam and the road to the only airport at Lengpui are runs through very rugged terrains, any blockage or destruction of these roads may lead to cut in the communication as well as supply of goods to the city. This is likely to seriously hamper the relief & rescue operations aftermath a disaster. In Aizawl, localities like Thuampui, Ramhlun, Rangwamual etc. are frequently suffering from landslides that causes many deaths and destruction of properties. Therefore, adoption of robust seismic and related other hazard mitigation measures is the need of the hour. In this context, detailed seismic microzonation, proper landuse & urban planning may go a long way towards preventing loss of lives and property. Apart from the technological intervention, non-structural measures such as awareness generation, education, preparedness and mass sensitization programs can contribute significantly towards a hazard resilient society in Aizawl.

Observational Study of Microearthquakes Located in Higher Himalayan Region India

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In Higher Himalayan region, a cluster of seismicity consisting of 73 local events ($1.0 \leq M_L \leq 4.1$) recorded between 2009 and 2014 has been studied. The earthquakes are recorded by 12–station digital teleseismic array 'Seismological Network around Tehri region' deployed around Tehri region. The network is funded by Tehri Hydro Development Corporation India Limited, operated and maintained by Department of Earthquake Engineering, IIT Roorkee, India. The earthquakes hypocentral and epicentral parameters are evaluated in order to observe the characteristics of earthquakes occurring in the region. The upper crust is found seismically more active as majority of events are located in depth range 5 to 10 km. The seismic moment increases with source radii in the range 172 to 395 m. The seismic moment increases with stress drop in the range 1 to 10 bars. As the events are located in vicinity of Main Central Thrust, most of the earthquakes ($1.2 \leq M_W \leq 3.8$) show low stress drop due to faults unable to sustain strain due to rocks in Higher Himalayan region.

On Seismo-Electromagnetic Activity Prior to M_W 6.4 Kopili Fault Earthquake 2021

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An earthquake, M_W 6.4, occurred on 28 April 2021 in the vicinity of the northern flanks of the Kopili Fault Zone. The earthquake caused widespread surficial implications, predominantly in the form of liquefaction in the contiguous alluvial expanses and landslides in the adjacent high relief topography. Polarization Ratio Analysis (S_Z/S_H) was carried out using ultra low frequency induction coil magnetometer data in the frequency range of 0.03 to 0.1 Hz, for a period comprising 15 days prior and post the event, to study seismo-elecromagnetic activities, if any, associated with the event. The data recorded was well within the strain radius of the event with favorable index of seismicity. The temporal variability of the S_Z/S_H exhibit negative correlation with global geomagnetic activity, K_P. Statistically robust upper benchmark of standard deviation (SD) added with m $(m + SD)$ is considered to decipher three enhancements in S_Z/S_H ratio. Two enhancements are observed on consecutive days, i.e. on 21 and 22 April, 2021, which are 7 and 6 days prior to the credible event, respectively and the third enhancement is observed on 6 May, 2021. All the three enhancements in S_Z/S_H are identically observed in S_Z/S_X. However, S_Z/S_Y reflected additional enhancements, which may be disregarded due to its positive correlation with global geomagnetic activity. While no such enhancements are observed during the campaign period, the one 8 days post the event raise questions on the role of instrumental artifact

Preliminary Investigation of Stress Transfer of the June 22nd, 1939 Accra Earthquake (M=6.5) of Ghana and its Implication on the Sub-Sahara West African Region

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The June 22nd, 1939 Accra earthquake (M=6.5) of Ghana is one of the most important earthquake in sub-Sahara West African region. The waveform inversion of Yarwood and Doser (1979) suggested that the earthquake was composed of two events. The smaller event (6.1 Mw) occurred 9.5s before the onset of the larger event (6.4 Mw). The smaller event has a focal mechanism that suggests it occurred immediately north of the intersection of the Akwapim and Coastal Boundary fault. This study resolved the static Coulomb Failure Stress (CFS) change onto the finite fault models of the 6.4 Mw and 6.1 Mw earthquakes by USGS and its effect on associated receiver faults. Aftershocks were poorly spatially correlated with the enhanced CFS condition after the 6.4 Mw main shock and was explained to correlate with release of seismic energy from the associated secondarily stressed prominent strike-slip (Akwapim) fault and strike-slip (coastal boundary fault). Abrupt termination of the northeastward propagation of 6.1 Mw rupture surface was due to interaction with the strike-slip coastal boundary faults. The existing intersection between the Akwapim and Coastal boundary faults favored the enhanced CFS to generate the next major event of 6.4 Mw due to deflection of motion transmitted from the seismically active fractured zones in the mid-Atlantic ridge (boundary between the African plate and the South-American plate).

Probing of L and X Discontinuities Beneath the Indian Shield and Himalaya Using Receiver Functions Analysis

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Seismologically, X-discontinuity has been mostly detected in active subduction and hotspot regions and L-discontinuity in continental regions. For the Indian shield and Himalaya, a systematic search for identification of these discontinuities has never been conducted. In order to image the X and L discontinuities, a total of 13,510 high quality receiver functions from 51 broad band stations are used. Differential slowness stacks are also used to separate the conversions from multiples. The results reveal that these discontinuities are sporadic and intermittent, occurring at average depths of 300 km (X) and 230 km (L) beneath the Indian shield and Himalaya. These discontinuities neither bear a clear tectonic affinity nor have any correlation with the transition zone discontinuities. We suggest that the observed widespread X-discontinuity beneath the Indian shield owes its origin to two mechanisms, that is, Orthoenstatite to high pressure Clinoenstatite transformation which shifts to lower pressures (~2 GPa) due to the presence of water (0.13 wt% H_2O) in $MgSiO_3$ and coesite-stishovite transition occurring at 8–11 GPa due to excess silica in an eclogitic component derived from the Tethys oceanic lithosphere subducted during lower Eocene. The identification of such a discontinuity could allow tracking of subducted material within the upper mantle providing a measure of mantle geochemical heterogeneity. The occurrence of L discontinuity, as well as its depth variability, may be explained by a transition from an anisotropic lithosphere to a more isotropic material in the continental lithosphere.

Recent 5.1-6.0 Magnitude Northern-Earthquakes—Impacts in Bangladesh

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During April-July 2021 period three moderate to strong earthquakes occurred in the north of Bangladesh that jolted some parts of it. The quakes were 05 April (5.1), 28 April (6.0) and 07 July (5.2), and mainly jolted the north-western (covered with Pleistocene soils and Holocene sediments), northern (mostly Holocene sediments) and north-eastern (Plio-Pleistocene and Holocene sediments) parts of the country. The maximum intensity in the country, III-IV i.e. weak to light shaking, was from 6.0 magnitude earthquake. Although there was no casualty, but buildings were shaken and residents were panicked. These earthquakes occurred at nearly the same latitudinal settings, about 350 km apart, and within the Himalayan Frontal Thrust domain. Distances between the epicenters of the earthquakes and the Dhaka seismic center were 403, 397 and 242 km respectively. It is noteworthy that two earthquakes of magnitudes 7.1 (1930) and 6.9 (2011) occurred in this region. Because of geologic and tectonic continuity the country experienced shaking although they occurred beyond our territory. Based on limited data and information viz. newspaper, TV news, websites and limited personal interview; these observations, geoscientific explanations and conclusions were made. However, there is ample scope to do meaningful research of geologic significance using these moderate-strong earthquake data. Results would provide us better understanding about the on-going tectonic processes and response characteristics of alluvial soils to such seismic events which are important for seismic risk reduction activities in such a vast alluvial terrain towards the benefit and safety of the people of this region.

Role of Shallow-Focus Earthquakes in Relation to the Deformation Mechanism of the Indo-Myanmar Ranges

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The Indo-Myanmar Ranges (IMR) of NE India are active subduction mountain ranges in the scale of global tectonism characterizing an island arc type of oblique subduction process. The tectonic implication through the geological, superficial structural, and tectonic lineament analysis is the result of convergent activity between the Indian plate and Myanmar plate. The stress regime derived from the field study, supported with the superficial structural and tectonic features and lineaments studies, suggest WNW-ESE compression and NNE-SSW extension directions compatible with the geological and tectonic setting of the IMR. Fault Plane Solutions' study suggests a variable stress pattern throughout the ranges with a change in focal depth. In the entire depth range, the orientation of three principal stresses suggests NNE-SSW contraction and E-W expansion direction, which contradict the stress pattern derived from the superficial structural and tectonic features and lineaments; and the resulted deformation mechanism of the IMR. But further analysis of fault plane solutions in depth-wise manner reveal that the deeper earthquakes of 50km or more focal depths shows NNE-SSW contraction and E-W expansion. In contrast, shallower earthquakes of focal depth ranging between 20-50km suggest a mixed type of stress pattern. The Ultra-shallow earthquakes of focal depth less than 20km show nearly E-W compression and N-S extension suggesting a compatible stress pattern with the superficial structural and tectonic features and the shear couple crustal deformation mechanism of the IMR. This may be explained by the westward push of the Myanmar Microplate on the interaction with the Indian plate.

Sedimentary and Tectonic History of Sitapahar Anticline, Bangladesh

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The Sitapahar anticline is situated in the western extended part of Indo-Burma Ranges (IBR) which is also the youngest part of these ranges named Chittagong Tripura Folded Belt (CTFB) (Hossain et al., 2014).Tertiary sedimentary rocks like Surma Group (Bhuban and Bokabil formation) and Tipam Sandstone are well exposed in this region. The Surma Group (Bhuban and Bokabil formation) is the oldest exposed tertiary rocks deposited during Miocene time overlain by the late Miocene to Pliocene Tipam Group. Some sedimentary structure like bidirectional crosses bed within sand lenses describe that the depositional environment of Surma Group was marine deltaic as well as alteration sandstone and shale remarks the marine transgression and regression. The uplifting of CTFB was also started at the Miocene time. On the other hand the depositional environment of Tipam Group was fluvial. Tipam Sandstone was deposited after the upliftment process had started. Plio–Pleistocene Dupi Tila Sandstone overlying in the Tipam Group (Sikder and Alam, 2003). Dupi Tila Sandstone shows channel filling and flood plain deposits. So, depositional environment of Dupi Tila formation was identified as high-sinuosity meandering river systems (Johnson and Alam, 1991). Before Dupi Tila, Girujan Clay formation which is a part of Tipam Group was deposited. Dupi Tila and Girujan Clay both of this formation was deposited within the synclinal part of these ranges.

Sedimentological Study of the Palaeocene-Eocene Rocks of Jaintia Group, Shillong-Shella Road, East Khasi Hills District, Meghalaya

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The studied rock sequences include the Shella Formation of the Palaeocene-Eocene age and Kopili Formation of the Upper Eocene age belonging to the Jaintia Group occurring around the Shillong-Shella area of East Khasi Hills district of Meghalaya. From petrographic study, the constituents of the sandstones have been identified as quartz, feldspar, rock fragment, mica, chert, matrix and cement. They have been classified mainly as arenites. The matrix of the sandstones are mostly argillaceous and siliceous and some are ferruginous while the cementing materials are ferruginous or siliceous. Calcite cement is also observed in a few of the sandstones. Limestones are classified as biomicrite type. The presence of fossil assemblages including Nummulites, Calcareous algae and Alveolina indicates shallow marine conditions of sedimentation. The heavy minerals recorded are zircon, tourmaline, rutile, kyanite, garnet, chlorite, mica and opaque. Geochemical analysis of major oxides of the Shella sandstones indicates moderate weathering in the source area and felsic rock dominated source for the source rocks. From the XRF analysis, the Shella sandstones have been classified as mainly arenite (arkose, subarkose, quartzarenite and sublitharenite) while a few are also greywacke. Geochemical studies have determined the tectonic setting of the Shella sandstones as mainly passive margin and indicated quartz richness of the source rocks of the studied sandstones. Source rock evaluation of the shales revealed the presence of Type-I kerogen which is derived from algal debris and has the highest petroleum generation potential.

Seismic Response Spectra of Shillong City Derived From Shear Wave Velocity Structure and Ground Motions of 2016, Mw~6.7 Manipur Earthquake

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Shillong plateau has been a focal point for the seismologists to comprehend the structural exercises of the seismically inclined North-Eastern district of India (NER India). Being encircled by a few complex structural spaces involving plate limit regions, NER India has been encountering quantities of moderate to huge tremors, which likewise remembers two great earthquakes for last 125years. Response of the soil strata of an area towards an impending seismic wave is a significant bparameter to appraise the conceivable ground shaking during an event. In this investigation, we have attempted to contemplate the ground movement created due to 4th January, 2016, Mw~6.7 Tamenglong earthquake and to evaluate the site response of the Shillong city, Meghalaya. Non-Linear Earthquake Site Response Analysis (NERA) is performed by using shear wave velocity profiles of five sites of Shillong city and Strong Motion Accelerogram information. Response parameters like spectral acceleration (SA), ground acceleration (GA), relative velocity (RV), amplification ratio and the amount of maximum stress accumulation are determined for each of the study site and are correlated with the local site geology. Results are presented in terms of plots of SA and RV respectively with period and frequency. Peak SA and Peak GA are found to be varying in the respective ranges of 0.37g-0.99g an 0.1g-0.32g for the five sites

Seismotectonic Lineament Analysis over Parts of Togo-Benin-Nigeria (TBN) Shield Using Bouguer Gravity

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This study carried out a seismotectonic analysis of parts of the TBN shield by delineating and characterising crustal discontinuities using EGM 2008 bouguer gravity data. This was with a view to understand the significance of the discontinuities to the seismicity of the area. Three dimensional (3-D) Euler deconvolution and horizontal gradient magnitude (HGM) at varied upward continued layer were applied on the filtered bouguer gravity data to highlight crustal discontinuities and determine their dip directions. The result showed that 89 lineaments were mapped as faults/fractures from the gravity data. The lengths of the lineaments range from about 6.2 to 94.3 km. The prominent fault/fracture trends were in the N-S and NNE-SSW directions with less dominant trends in the NE-SW and NW-SE directions. The prominent N-S trend pattern aligns with the general N-S foliation strike emplacement across the shield. The Lagos-Ibadan-Ijebu-Ode fault system was delineated and identified to have close proximity to locations of previous earth tremors within the sheild and therefore might be associated to those events.

Source Parameters of Small to Moderate Magnitude Earthquakes in the Siang Valley of Arunachal Pradesh, Northeast India: Its Tectonic Implications

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Continental collision between India and Asia is an example of mountain building on a large scale leading to the formation of the Himalaya. The northeastern region of India is the seismically most active region of the world. Investigation of micro and low magnitude earthquakes in the Siang valley of the NE Himalaya were performed to evaluate the relationship between earthquake source, seismicity, stress drop, tectonics, and structure. The seismic events were recorded by a dense digital network of eight broadband seismic (BBS) stations in 2019 in Siang Valley of Arunachal Pradesh. The earthquake source parameters using spectral analysis were calculated for refined epicenters obtained by local earthquake ($1.0 \leq ML \leq 5.9$). The estimated source parameters vary from 0.042 to 88.5 bar, 2.30×10^{11} to 3.26×10^{15} Nm and 116 m to 554 m for Stress drop ($\Delta\sigma$), seismic moment M_0 and source radius respectively. The highest stress drop obtained from Mechuka earthquake is 88.5 bars, seismic moment of 3.26E+15Nm and source radius of 554 m. High stress drop in the Siang Valley indicates that earthquake of 23rd April 2019 is associated with high strength material which accumulates high strain. Low stress drop indicates the existence of brittle material to be easily broken releasing the energy due to earthquake occurrence. The estimated source parameters will be useful in estimations of crustal strength and calibrating the coefficient of the local earthquake in Siang Valley and its adjoining regions. The magnitude of completeness for the Siang Valley seismic network of Arunachal Pradesh is 2.8, with the b-value of 0.99 and a-value of 4.065.

Spatial Variation of b-Value and Analysis of Seismicity of Seismic Hazard Assessment for Northern India

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Our study region lies from a latitude of 28° to 37° North to a longitude of 72° to 82 ° East. This part lies in the proximity of Himalaya, which is considered seismically as the most active region in the world and has suffered numerous large earthquakes in the past. The northern India lies in the vicinity of several complex network of faults, thus makes it more vulnerable to seismic risk. A comprehensive homogenized earthquake catalog was prepared from 1900 to 2020 (120 years) within the above mentioned latitudes and longitudes. The two different window methods (viz. Gardner and Knopoff (1974): Urhammer (1986)) and clustering method (viz Reasenberg (1985)) were employed for declustering of earthquake Catalog. The completeness of earthquake catalog with respect to (w.r.t) time was checked by statistical (Stepp, 1972) as well as by graphical Mulargia and Tinti (1985) or Visual Cumulative (CUVI, 1985) methods. The completeness of data w.r.t magnitude is checked through Maximum Curvature Method (MAXC), which comes out to be same for all the three catalogs. The value of magnitude of completeness (Mc) is 4.5. The b-value shows the inconsistency of stress levels in the crustal heterogeneity. Some previous well known studies have explained spatial and temporal variations of b-value, but at that time large earthquakes were missing in those studies. In this study, we have prepared the spatial distribution maps for the above three catalogs and we tried to look into the variation of b-value for different regions of northern India. The Kashmir earthquake (2005) having magnitude 7.6 releases the accumulated stresses inside the earth, thus reduces the b-value at that region, which is clear from our results of spatial distribution of b-value maps. The Haryana region has highest value of 'b', Kangra-Chamba region and Kumaon-Garhwal Himalaya having the least value of 'b'. This study can be very useful for seismic hazard analysis for the northern part of India. Figure 1 shows the spatial variation of b-value in and around norsthern India.

Strong Ground Motion Prediction for a Potential M_w7.1 Event in the Dhubri Fault Zone in Northeast India

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Present-daystrain rate measurement with highest extensional and shearstrain rates in northeast India, observed near the Dhubri fault, are considered to be favourable for strike-slip faulting events. Our analysis shows that the source zone is capable of producing a M_w7.1 earthquake, similar to the 1930 earthquake of Dhubri region. We simulated the hazard scenario for a similar event using stochastic simulating (SS) technique. Strike, dip and depth of the target event is inferred from the analysis of recent events occurred near the Dhubri region. Shear wave velocity, density and stress drop of the source zone is taken to be 3.6 km/s, 2.8 g/cc and 100 bars respectively. The path and near surface attenuation are considered using published Q and kappa value of the region. The site amplification at the site of simulation is evaluated using H/V technique. The simulation result shows, maximum PGA of 333gals near to Dhubri due to such event. The source zone may witness intensity between VII-VIII (in Modified MercalliIntensity scale). Cities located within a distance of 60 km from the epicentre may experience ground acceleration between 150 to 333 gals. Other cities located in the distance range of 50 to 200 km from the epicentre may witness ground acceleration of 30 to 150 gals. The cities located more than 200 km away from the epicentre are expected to experience low ground shaking.

Study of the Pre-Earthquake Signatures in the Ionosphere Using GPS Data

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Precursor in the ionosphere before Mw 7.2, El Mayor Cucapah, Mexico earthquake of 04-04-10 has been analyzed in the present study. TEC (Total Electron content) variation in the ionosphere were detected using dual frequency Global Positioning System (GPS) data and was correlated with the impending earthquake. The anomaly in TEC variations were detected statistically considering previous 15 days continuous data and were named positive and negative as and when TEC crosses the statistical upper and lower boundary limits. The GPS data from the nearest station to epicenter viz; IID2 and P500, suggest anomaly on 07-03-10 (negative), 10-03-10 (positive), 25-03-10 (positive), 31-03-10 (positive), 01-04-10 (negative) and 02-04-10 (negative). Disturbance Storm time (dst) and Planetary Solar (Kp) indices were checked to rule out the effects of geomagnetic storm and solar flare conditions during the TEC observations period. Each anomaly days were studied in detail utilizing GPS data (about 227 GPS stations) that falls under the EPZ (Earthquake Preparation Zone). It is seen that the stations that are closer to the epicenter shows higher TEC concentrations towards the epicenter in case of positive anomaly. Conversely, TEC concentration decreases towards the epicenter in case of negative anomaly.

Study of the Seismogenic Stress Regime in Tibetan Plateau

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The Tibetan Plateau which was formed due to the collision of Indo-Eurasian plates, is one of the most seismically active regions in the world. The tectonic stress regime is examined by the stress tensor inversion. The focal mechanism solutions are used to determine the stress pattern and to investigate the different tectonics stress regime occurring in the area. Some 600 focal mechanism solutions are used for stress tensor inversion by the Michael and Gauss methods. The results of focal mechanism solutions shows that some area is dominant in strike-slip faulting whereas some area is showing normal and thrust faulting as well. The average result for stress tensor inversion shows that the principal maximum stress axis in NNE-SSW direction and the least principal axis in ESE-WNW direction.

Tectonic and Geotechnical Review for Rational Seismic Risk Assessment for Bengal Basin System, Bangladesh

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Bengal Basin System (BBS) is a complex and dynamic natural laboratory due to its complex geological-setting and active depositional basin in a syntaxis of differential stresses from three tectonic plates. BBS is the world's youngest active delta building system fully controlled by the regional and distal tectonic influences. The Bengal basin is divided into stable shelf (with multi-fractures and discontinuities, both vertical and horizontal), undulated basement and the buried continental slope, suddenly drops down to the twelve miles abysmal topographic trench formed of crushed remnants of oceanic crust pushed and dumped during the last stage of continental drift. The terrain analysis portrayed a unique westward sinusoidal progression of the folds due to steady and uniform compressional stresses from the east with a convergence vector (~N27°E). A rational assessment of seismic threats is determined from the locations, depths, intensity of local, regional seismicity, differential tectonic stresses and energy impact. Amplification factors are predicted from the average shear wave velocity to a depth of 30 m (Vs30), and a 3D case study on site-specific earthquake hazard characterization of Dhaka Megacity presented. Present study indicates crustal segmentation both lateral and vertical that later weakened stress exertion and will not produce earthquakes >7.5M. Probabilistic Seismic Hazard Maps (PSHA) is presented for ground motion parameters, were estimated and presented for a modern seismic zonation map of Bangladesh for an improved geo-engineering and structural engineering design options, construction practices,factors of safety in respective geological environment, maintenance and continuing improvement of Bangladesh National Building Code.

Textural Appraisal of Extra-peninsular Gondwana Sandstones of Kalijhora, West bengal, India

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Sandstones of the extra-peninsular Gondwana basins located in Kalijhora, West Bengal was evaluated to understand the reflections from textural attributes. Kalijhora hosts a part of the extra-peninsular Late Palaeozoic Gondwana equivalent rock sequence in the Lesser Himalayan region of Darjeeling-Sikkim Himalaya. Known as the 'Rishi Group', these rocks are homotaxial with the Damuda Group of Peninsular Gondwanas and belong to Permian age. The sedimentary column of Kalijhora is largely arenaceous and trend roughly ENE-WSW to WNW-ESE trend. Being in the vicinity of the MBT the impacts are quite prominent on the rocks. The exposed rocks are largely sandstone, shale and coal. The arenaceous units are found as dark grey, grey, buff coloured and a little bit recrystallised. Grey sandstones along the river bed host variable calcareous ingredients. Kalijhora sandstones bear signatures of fluvial and near shore environment. The sediments were laid down in energy condition that was not that high. Sediments were probably derived from two or more varied sources. The sandstones depict a strong tendency of clogging in the riverine and deltaic environment in a broad spectrum. The main mode of transportation for the sandstones seems to be combination of traction, saltation and suspension mechanism with prominence of saltation mode. Impact of beach environment is evident as two saltation sub populations are seen and remarkably saltation sub-population 'B' has the worst sorting which is an indicator of a turbid like situation. Finer fractions also play a critical role in the medium grained Kalijhora sandstones which are largely poorly sorted, positively skewed and leptokurtic. Furthermore, addition of fines to the coarser main mode suggests the occurrence of temporary turbid like condition in the otherwise calm depositional environment. This may be also related to a minor transgression phase.

The Meteorological Assessments in Thiruvallur District, Tamilnadu, India (Using GIS)

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Meteorology is a branch of the atmospheric sciences with a major focus on weather forecasting. They are described and quantified by the variables of Earth's atmosphere: temperature, air pressure, water vapour, mass flow, precipitation, cloudy, sunny, wind speed, wind rose, cyclone, satellite and the variations and interactions of those variables, and how they change over time. Different spatial scales are used to describe and predict weather on local, regional, and global levels. The average rainfall of the district is 1104 mm. Out of which 52% has been received during Northeast monsoon period and 41% has been received during Southwest monsoon period. Rainfall projections for Thiruvallur It is also noted from the map that the major decrease of rainfall is found in the north western part of the Thiruvallur district. Climate Like other parts of Tamil Nadu, hot climate prevails during the months of April and May and humid climate during the rest of the year except in December, January and February when it is slightly cold. Out of this about 50 % is received during north east monsoon period and about 40 % is received during south west monsoon period. The average temperature of the district is a maximum of 37.9°C and a minimum of 18.5°C. They give good indications of typical climate patterns and expected conditions (temperature, precipitation, sunshine and wind). The simulated weather data have a spatial resolution of approximately 30 km and may not reproduce all local weather effects, such as thunderstorms, local winds, or tornadoes. In this study, geographic information system (GIS) were using for the Applications and Maps.

The Seismo-tectonic Settings of North-Eastern Part of Bangladesh and Surrounding Areas

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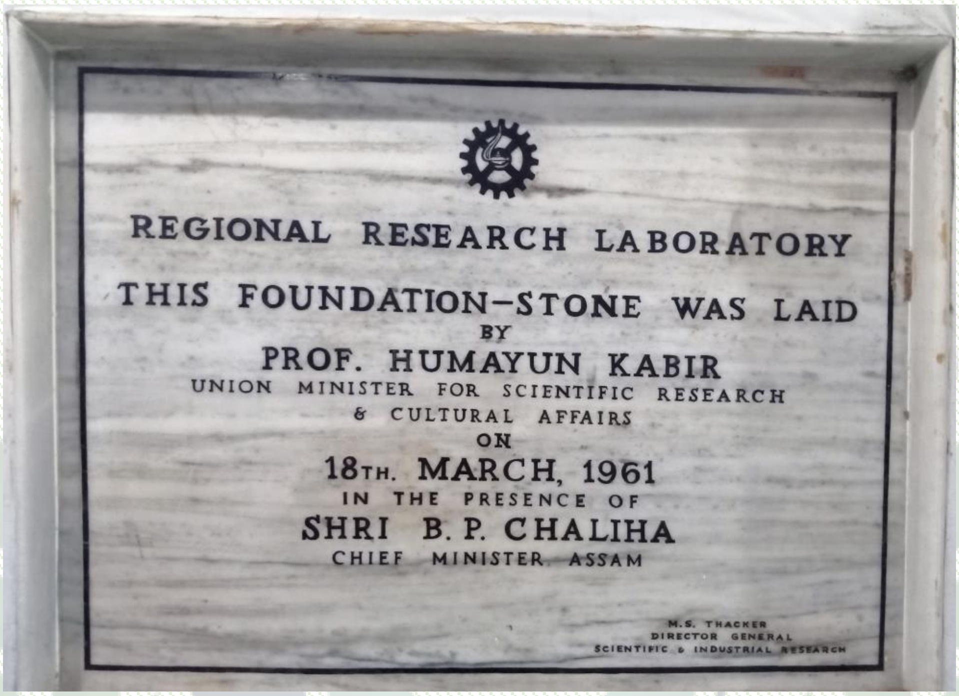
Bangladesh lies close to the boundary of two active plates; the Indian plate in the west and the Eurasian plate in the east and north. For this situation, Bangladesh has always been threat of minor to strong earthquakes. Geoscientists has identified five devastating earthquake zones within Bangladesh and surrounding areas on the basis of Geology and tectonics. These are Bogra, Tripura, Shillong, Dauki and Assam. From the historic earthquake data, those zones had produced catastrophic earthquakes (>7). Bogra fault is a gravity fault which is close to Bogra town and adjacent of Jamuna River. From Paleogene to Neogene, the Bogra fault was active due to the deposition of alluvium that prepared the Bogra graven. For possessing the Tertiary deposits, Tripura area has the records of moderate magnitude earthquake. The Dauki fault zone is a 300 km long north dipping reverse fault situated along the Meghalaya-Bangladesh border which is still considered as a major threat for earthquakes. Notable earthquake was originated here was the Cachar earthquake of 1869. The most important active fault zone is known as Assam fault zone. About 379 number of earthquakes were felt here in the last 118 years. The well-known “Great Assam Earthquake” occurred below the Shillong Plateau in 1897. The magnitude was in Richter scale 8.0. Those two plates have been locked for many years at the foot of the Himalayas which is storing energy. The recent series of earthquakes in Sylhet and surroundings shows we are approaching to a mega earthquake, some scientists argue.

GSTD Overview

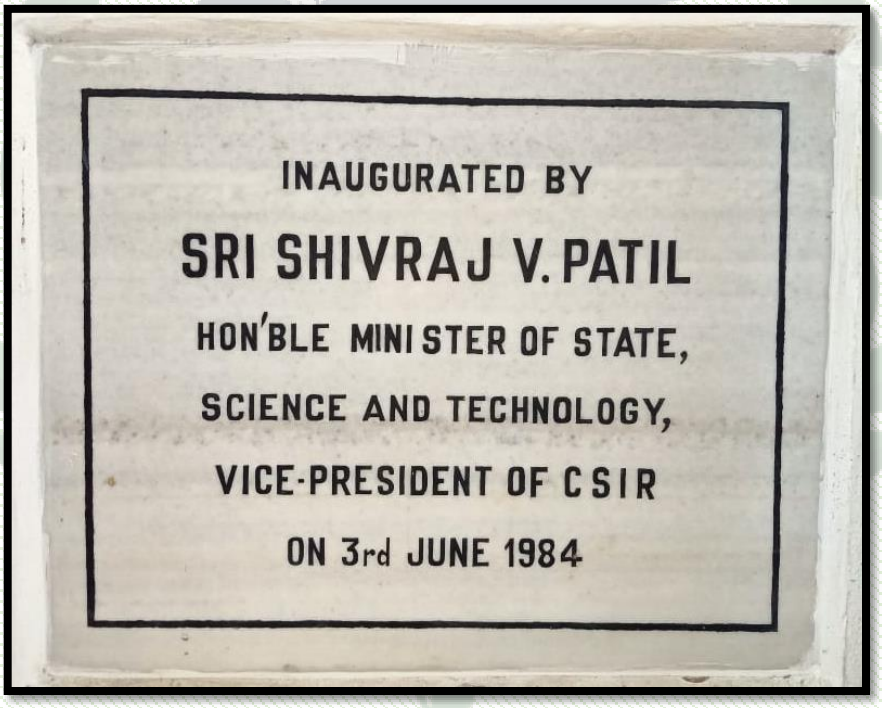
CSIR-NEIST Jorhat: At a Glance



Memorial plate of inauguration of the then Regional Research Laboratory by then Union Minister for Scientific Research & Cultural Affairs, Prof H Kabir in the presence of then Chief Minister of Assam, Mr. B P Chaliha on 18th March, 1961

CSIR- North East Institute of Science and Technology, a constituent multi-disciplinary laboratory of Council of Scientific and Industrial Research (CSIR), New Delhi, is a leading R&D institution of NE India. Initially it was known as Regional Research Laboratory. The institute was established in the year 1961 under the instrumental leadership of late Jaananayak Debeswar Sarmah, a popular freedom fighter and statesman from Jorhat, Assam. Presently, NEIST is a full-fledg ed multidisciplinary research institution having research areas like Advanced Computation and Data Science, Medicinal Chemistry, Natural Products Chemistry, Synthetic Organic Chemistry, Biotechnology, Infectious disease, Communicable and Non-communicable disease, Medicinal, Aromatic and Economic Plants, Geoscience, Cellulose, Membrane Technologies, Pulp and Paper, Material Science, Coal, etc. The major thrust of R&D activities of the institute has been to develop indigenous technologies by utilising the immense natural wealth of India. Over the years, the laboratory has generated more than 100 technologies in the areas of Agrotechnology, Biological and Oil Field Chemicals of which about 40% were of commercial success culminating in setting up of various industries throughout the country. The laboratory also developed expertise in the areas like Natural Products Chemistry, drug and drug intermediates, VSK cement, Plant Technology, Agro-technologies, Petroleum Microbiology and Petrochemicals, Crude oil transportation, Paper and Paper Products, beneficiation Chemicals, ecology and environmental studies, Geotechnical investigations, foundation design engineering, soil and building materials etc. In the last couple of decades, the institute has also produced more than 200 Ph.Ds. to cater the skilled human resource needed for this region. Many Ph.Ds. of this institute are doing well in industry and academia in India and abroad. The institute also supports economically poor bright students for Mentorship Program. Currently the institution is equipped with state-of-the-art instruments and infrastructure to carry out research in frontier areas of science and technology. A Common Facility Center (CFC) under the STINER (Science and Technological Intervention in North East India) project funded by Ministry of Development of North Eastern Region (MDoNER), Govt of India has been established at NEIST. The main goal of the project is to bring all the relevant proven technologies to the people of North Eastern Region (NER), more particularly to farmers and artisans community, so that the quality of their profession can be boost up through science and technological intervention. During the unprecedented situation of COVID-19 across the globe that sent the academic scenario throughout the country into doldrums, the institute organized a unique Summer Research Training Program 2020 (SRTP) through online mode and received an overwhelming response from over 16000 participants. Many webinars were organized under the aegis of SRTP-2020 which were attended by many eminent scientists and distinguished people from the scientific community. SRTP-2020 helped to revitalize the academic ambience by dissolving the lull created by the pandemic in the academics of the nation and to uplift the constructive spirit among the students fraternity of the country. The North East Institute of Science and Technology (NEIST) also organised the 1st International Virtual workshop on Global Seismology and Tectonics (2020) to ward off the stagnancy created in the academic scenario of the nation due to COVID-19 pandemic and this endeavour succeeded in enriching the scientific fraternity with an extra dose of knowledge and motivation.The virtual event was met with a great success with over 1000 participants and 16 eminent speakers who delivered talks in the workshop. The training program for Drug Discovery Hackathon 2020, an initiative of MHRD's Innovation Cell, was conducted by the institute. A COVID-19 research laboratory has also been set up in the institute premises to facilitate COVID-19 testing facility in the entire region. Under the CSIR-AROMA mission, the institute has planned to set up "Multilocational Trial & Regional Research Experimental Farm" across the North East. CSIR-NEIST is a premier research institute of NE India and continues to strive towards brilliance with its mandate of nurturing excellence in basic & applied research and to put to effective use the immense material resources of North Eastern region and to provide R&D inputs for developing the economy of the NE region in particular and the country in general.

Geoscience & Technology Division: A journey begins



Memorial plate of inauguration of the Geosceince and Technology Division by then Minister of State, Science and Technology and Vice President of CSIR.

The Geoscience and Technology Division of CSIR NEIST-Jorhat (formerly RRL Jorhat) was established in 1984. Seismic monitoring has been one of the major activities of the department since its inception. Analog seismic network with a strong coverage of the entire NE India was established and maintained until its upgradation to digital system and now a seismic network of 27 online/real-time VSAT seismic observatories with Broadband seismograph allows for robust monitoring of seismicity and allied seismic research. The high resolution seismic broadband stations covering entire 8 (eight) states of Northeast India called North East Wide Area Seismic Network (NEWSN) has been setup to intensify seismic monitoring on a real-time basis to observe the present seismicity and to understand the geodynamics of the region. Apart from broadband seismic station, densification of strong motion accelerograph (SMA) stations and high precision GPS stations have been undertaken in a phase manner to intuitively perceive the dynamics of the complex tectonic activities of NE India.

The division publishes the Annual Seismological Bulletin and maintains the Seismic Database for NE India. Publication of yearly seismological bulletin by CSIR NEIST since 1982 has been the source of many research publications and research problems pertaining to PhD thesis. The division also provides routine update on earthquake hazard related information through our institutional webpage and issues near real-time mail notification.

Seismic vulnerability assessment of the populated cities & urban areas in NE India is another major program of the division. The division has initiated work for hazard-risk-vulnerability assessment of Shillong and greater Guwahati on priority basis. Estimation of expected earthquake ground motion parameters is the main aim of seismic microzonation. Microzonation maps provide basic inputs for designing new infrastructure or retrofitting of the existing ones. Till date, the division has completed the Phase – I microzonation of greater Guwahati and Agartala cities and is ongoing for Dimapur. Seismic site-ampilfication and vulnerability study of Shillong city has also been carried out.

The Division has also taken up scenario development program where government engineers, architects and geologists were given hands on training on rapid visual screening through which school/college buildings and public halls, hospitals and other lifeline structures were examined based on civil design & building typology, age of construction, geological locations (vicinity of active faults) and rock types etc so that necessary retrofitting designs can be applied to minimize the risk associated. In association with NDMA and SDMA, the division tries to assess multi – state earthquake disaster preparedness and evaluate the State/District Disaster Management Plans with an aim to identify gaps and generate the greater level of awareness in community about the seismic vulnerability of the region. It is to generate awareness amongst the stakeholders and community about possible impacts of an earthquake of high magnitude and to facilitate inter-departmental and inter-state coordination in order to ensure organized and structured mechanism during the time of disaster.

Since last two decades, the division has been carrying out several international collaborative projects with Institute like, Institute of Physics Earth, Moscow, Earth Observatory of Singapore, Singapore, Strasbourg University, France and NORSAR, Norway pertaining to various Seismological and Tecto-

Geodynamics of North Eastern India. The division actively participated in the 18th Indian Scientific Expedition to Antarctica to carry out projects related to Earth Sciences as wintering over.

A Multiparametric Geophysical Observatory (MPGO) station is also set up in Tezpur, Assam, under the GTTD for earthquake precursory studies. The site within a very close proximity of the Kopili fault in Shillong Plateau bears a potential source of large-scale magnitude earthquake. The MPGO aims to derive proper understanding of the earthquake generation process, its mechanism, its prediction in form of precursory signal studies. It is designed to record precursory signals resulting from stress-induced changes in density, magnetization, resistivity, seismic wave velocity, fracture propagation, crustal deformation, electromagnetic and radon gas emission as well as fluctuations in hydrological parameters.

The division also provides consultancy service to private and public sector enterprises using the in-house state-of-the-art instrumentation facility. Several such consultations have been rendered for diverse applications, such as seismically resilient construction design, site-specific response study, geophysical investigation for environment impact assessment, etc. A few notable examples include geophysical investigation in and around Baghjan well blow out site, site-specific response spectrum and estimation of site-specific response spectrum and geophysical survey along proposed connectivity between Gohpur (NH-52) and Numaligarh (NH-37).

The division has also recently started hosting an annually recurrent virtual workshop in global seismology and tectonics (IVWGST) which is conceived to facilitate interactive learning sessions for the students and academicians from eminent geosciences personalities across the globe. The workshop is conducted under the aegis of diamond jubilee year of CSIR NEIST.

Instrumentation Facility Available at GSTD:

- Seismic Network of 27 Online / Real-time VSAT Seismic Observatories
- Strong Motion Accelerograph Network
- Ground Penetrating Radar with 200 Mhz, 100 Mhz, 50 Mhz Antenna
- Global Positioning System Network
- 48 channel Seismograph (MASW)
- Differential GPS
- Proton Precession Magnetometer
- Very Low Frequency Electromagnetic System

- Optical Microscopy, Optical Image Analyzer, MPV-III
- Ultra Low Frequency Induction Coil Magnetometer
- Magneto telluric System
- Radon Monitoring System
- 1D and 2D Electrical Resistivitimeter
- Fluxgate Magnetometer
- Overhuaser Magnetometer
- Total Station Theodolite

Former Head of the Geoscience & Technology Division

Dr. T.K. Dutta

Dr. Madan Mohan Saikia

Dr. M.V.D. Sitaram

Dr. Ranju Duarah

Dr. Saurabh Baruah

Dr. Manoj K. Phukan

Former Scientists of GSTD

Dr. R.N. Sarmah

Dr. Satopadhya

Dr. Anil Malkani

Dr. Paban Kumar Bora

Dr. Chandan Saikia

Dr. Prabhat Kotoky

Dr. R.K. Mrinalinee Devi
(DST Women Scientist)

Sumana Goswami
(DST Woman Scientist)

Present Staff of GSTD (As on Sept-2021)

Dr. Saurabh Baruah
(Chief Scientist)

Dr. Manoj K. Phukan
(Senior Scientist)

Dr. Sangeeta Sharma
(Senior Scientist)

Dr. Bijit Kumar Choudhury
(Senior Scientist)

Dr. Santanu Baruah
(Senior Scientist)

Dr. Debasis D. Mohanty
(Scientist)

Dr. Chinmoy Rajkonwar
(Scientist)

Mr Pradip Dutta
(Senior Technical Officer)

Mr S.M. Bhattacharyya
(Technical Officer)

Former Technical Staff of GSTD

Name	Grade
Mukul Borkotoky	Group-III
Keshab Chandra Deori	Group-III
RK Buragohain	Group-III
Prabitra Pran Sarma	Group-III
Paresh Kalita	Group-III
Bharat Buragohain	Group-III
Ajit Kumar Hazarika	Group-III
Om Prakash Sahu	Group-III
Gubin Chandra Bora	Group-III
Nilim Neog	Group-III
Ram Kr. Borah	Group-III
Manoj Kr. Das	Group-III
Thanu Ram Ligira	Group-III
Bakul Borah	Group-III
Dilip Kumar Pathak	Group-III
Arup Saikia	Group-III
Dilip Bordoloi	Group-III
Dulal Chandra Sahu	Group-III
Ananta Kumar Dutta	Group-III
Rajib Borpuzari	Group-III
Boloram Pegu	Group-III
Khogen Bhorali	Group-III
Deba Kumar Phukan	Group-II
Jogendra Nath Hazarika	Steno
Nobin Chandra Patra	Steno
Tulsi Ram Sarmah	Group-I
Budhan Borah	Group-I
Khoya Chandra Teron	Group-I
Nagen Bora	Group-I

List of PhDs Produced from GSTD CSIR-NEIST

Sl. No.	Name of the Recipient	Year	Name of the Supervisor	Institution	Title of Thesis
1	Kabita Goswami	1984	Dr. M M Saikia	Dibrugarh University	Geochemistry of The Barail Group of Rocks In Upper Assam Valley And Naga Hills With Special Reference to its Oil, Gas And Coal Bearibity.
2	Prabhat Kotoky	1986	Dr. M M Saikia (Joint Supervisor)	Dibrugarh University	Sedimentological Studies around Siju, Meghalya with Special Emphasis on Limestone.
3	G John	1989	Dr. M V D Sitaram	Dibrugarh University	Travel Times of Longitudinal Waves for the Earthquake in and around North East India.
4	Anil Baruah	1994	Dr. R N Sharma	Dibrugarh University	A Geochemical Study of The Toxic Substances in The Soil Water System Around Rudrasagar Oil Field, Assam, India
5	Mrinmayee Barua	1996	Dr. M V D Sitaram	Gauhati University	Body Wave Investigations of North East India.
6	Minati Das	1997	Dr. M M Saikia	DIbrugarh University	A Study on The Depositional Environment of Tipam Reservoir Sandstones in a Part of Jorajan Oil Field, Assam Basin
7	Nripen K Baruah	1997	Dr. P Kotoky	Gauhati University	Study of Heavy Metal Distribution in the River Basin - A Case Study, Jhanji River, Assam.
8	Baby Baruah	1998	Dr. P Kotoky	Dibrugarh University	Petrochemical Study of the Lakadong Limestone of Cherrapunjee and Mawamluh Areas, Khasi Hills, Meghalaya.
9	Jyotish Baruah	1998	Dr. P Kotoky	Dibrugarh University	The Jhanji River Basin: Assam/Nagaland - A Fluvio-geomorphological and Geochemical Appraisal.
10	Dilip Kr Yadav	2002	Dr. M V D Sitaram	Dibrugarh University	Seismotectonics of Arunachal Himalayas.
11	R K Bordoloi	2003	Dr. P Kotoky	Dibrugarh University	Environmental Geochemistry around Jorhat - A Case Study.
12	Paban Kr. Bora	2004	Dr. M V D Sitaram	Dibrugarh University	A Study on Local Richter Magnitudes and Signal Durations of Earthquakes in and around North East India.
13	Devojit Bezbaruah	2005	Dr. P Kotoky	Dibrugarh University	Hydrogeomorphological Appraisal of the Brahmaputra River Channel from Majuli to Kaziranga, Assam.
14	Devojit Hazarika	2006	Dr. Saurabh Baruah (Joint Supervisor)	Dibrugarh University	Attenuation of Coda Wave and Wave Form Analysis for North Eastern Region of India with Special Emphasis on Seismotectonics of Chedrang Valley, the Rupture Area of 1897 (M=8.7), Great Earthquake.
15	K K Borthakur	2006	Dr. P Kotoky	Dibrugarh University	The Bhogdoi River Basin - A Fluvio-geomorphological and Geochemical Assesment.
16	M K Dutta	2007	Dr. P Kotoky	Dibrugarh University	Dhansiri River Channel, Assam - A Geomorphologic Attribute.
17	B Baruah	2009	Dr. P Kotoky	Dibrugarh University	Environmental Studies around Makum Coalfields, Margherita.
18	Dipok Kr. Borah	2010	Dr. Saurabh Baruah	Dibrugarh University	Estimation of Crustal Discontinuities Using Digital Seismic Waves in Shillong-Mikir Hills Plateau of Northeastern India.
19	Saitluanga Sailo	2011	Dr. Saurabh Baruah (Joint Supervisor)	Mizoram University	Seismic Study of the Mat and Sylhet Faults in the Surma Valley, Northeast India.
20	Santanu Baruah	2012	Dr. Saurabh Baruah	Dibrugarh University	Waveform Modeling and Stress Tensore Inversion for Simultaneous Determination

					of Source Mechanism and Current Stress Regime in Northeastern India.
21	Rajib Biswas	2013	Dr. Saurabh Baruah	Dibrugarh University	Seismic Ambient Noise Analysis: It's Application to Evaluate the Site Characteristics of Shillong City.
22	Dipika Pandey	2014	Dr. Saurabh Baruah (Joint Supervisor)	IIT, Roorky	Local Earthquake Tomography and Attenuation Characteristics of Northeast Indian Region.
23	Bijit Kr. Chowdhury	2018	Dr. Saurabh Baruah (Joint Supervisor)	Gauhati University	Study of 3-D Velocity Structure by Seismic Tomography and Lg Wave Attenuation in Northeastern India
24	Eluyemi Edekunle Ayodeji	2018	Dr. Saurabh Baruah	AcSIR	Seismic Hazard Assessment in Nigeria Through Integrated Approach on Seismotectonics, Geophysical and Remote Sensing Studies to Identify Suitable Site for A Major Construction in Nigeria.
25	Goutam Kashyap Boruah	2019	Dr. Saurabh Baruah (Joint Supervisor)	Gauhati University	Shear Wave Velocity from Dispersive Characteristics of Rayleigh Type Surface Waves and Study of Ground Motion Parameters Aimed at Seismic Hazard Assessment of Greater Shillong City
26	Himanta Borgohain	2020	Dr. Saurabh Baruah (Joint Supervisor)	Dibrugarh University	Seismotectonics and Neo-Tectonic Activity of Chedrang Valley and its Vicinity, the Rupture Area of 1897 (M~8.7) the Great Assam Earthquake and its Possible Correlation to the Seismic Vulnerability of Tura City in Western Garo Hills, Meghalaya
27	Timangshu Chetia	2020	Dr. Saurabh Baruah	AcSIR	Development of Impirical Models on Earthquake Predictability Based on Mulptiple Geophysical Observations.
28	Antara Sharma	2020	Dr. Santanu Baruah	AcSIR	A Study on Seismic Anisotropy of the Crust in Relation to Localized Tectonics Stress Pattern in Shillong-Mikir Plateau and its Vicinity of Northeast India.

List of Completed (C) and Ongoing (O) Projects at GSTD, CSIR-NEIST until date

Sl No.	Project No.	PI/Co PI	Name of the Project	C/O	Budget
1	GAP0163	Prabhat Kotoky	Geo-chemical assessment of fluoride content in rock/ soil/ water systems in karbianglong district, assam	C	805547
2	GAP0187	Prabhat Kotoky	Study of fluoride contents in the water system of jorhat district, assam, and creation of a fluoride database.	C	2400000
3	CNP0441	Ranju Duarah	Delineation of active tectonic lineaments in and around Chungthang HE Project, North Sikkim	C	5561000
4	CNP0445	Ranju Duarah	Seismicity in and around DEMWE (Lohit Hyo Electric Project) Arunachal Pradesh	C	5561000
5	CNP0466	Ranju Duarah	Micro earthquake studies for the Lower Kapili Hyo Electric Project (120MW), Assam	C	4000000
6	GAP0115	Ranju Duarah	Brod band seismic network in North East india	C	
7	GAP0117	Ranju Duarah	Estimation of radon and its progeny using solid state track detectors in and around the oil and coal deposits of upper assam: related health hazard and impact on life supporting systems	C	225000
8	GAP0135	Ranju Duarah	Source zone characterization & site amplification behaviours in seismic microzonation	C	4976800
9	GAP0142	Ranju Duarah	On-line/ real time seismic network for disaster nitigation on ne india	C	42600000
10	GAP0173	Ranju Duarah	Extended vsat network for real time seismic monitoring in NE India	C	9696000
11	GPP0288	Ranju Duarah	M 8.7 Shillong 1897 Earthquake Scenario: NE Multi-state Preparedness Campaign	C	62035000
12	GPP0301	Ranju Duarah (PI-NEIST Component)	Advance Research in Engineering & Earth Sciences: Data Intensive Modeling & Crowd Sourcing Approach	C	
13	CNP0380	Pabon Kr Bora	Geomicrobiological reconnaisance investigation for hyocarbon prospecting in ganga velley	C	1542962
14	GPP (DST Woman Scientist Scheme)	R K Mrinalini Devi ***Mentor:*** Pabon Kr Bora	Active Tectonics of the Meizoseismal Region of the 1950 Assam-Arunachal Earthquake(M>8) on the frontal part of Arunachal Himalaya.	C	
15	GPP (DST Woman Scientist Scheme)	R K Mrinalini Devi ***Mentor:*** Pabon Kr Bora	Active Tectonics & Paleoseismic Studies, using Geophysical parameters, along the Mountain Frontal part of Eastern Syntaxial Bend, Lower Dibang Valley and Lohit Districts, Arunachal Himalaya.	C	
16	CSIR-SRF	Dilip K Yadav ***Mentor:*** MVD Sitaram	Seismotectonics of Arunachal Himalayas	C	
17	GAP0171	Saurabh Baruah	Modeling of earthquake source and ground motion in cheang fault and its vicinity through broadband instrumentation: an approach towards the estimation of earthquake hazard in NER, India	C	6611000
18	GAP0701	Saurabh Baruah	Financial support for payment of ta/da and other related expenses for the first meeting of pac & gmc on seismicity programme scheduled for 5th & 6th march 2008	C	710000
19	GAP0724	Saurabh Baruah	A short term course on computational methods for source characterization and stress field analysis	C	755800
20	GAP0734	Saurabh Baruah	A short term course on Computational methods for Receiver Function Analysis	C	685000
21	GPP0273	Saurabh Baruah	Literature survey of available Earthquake Hazard Assessment Studies related to North Eastern Region	C	1780000
22	GPP0275	Saurabh Baruah	Seismic Vulnerability Assessment of major cities in North East India.	C	18425000
23	GPP0294	Saurabh Baruah	Setting up of the Multiparametric Geophysical Observatory for monitoring of Earthquake precursor in Mikir Hills Plateau, Assam	C	40524263

24	GPP0375	Saurabh Baruah (co-ordinator)	Assessment of Air, Water and Soil Quality in Baghjan Oil Blowout Site and its Vicinity, Tinsukia, Assam	O	8140000
25	ILTP	Saurabh Baruah Member: Santanu Baruah	Modelling and estimation of strong ground motion parameters aimed at seismic risk reduction (Indo-Russian Collaborative project)	C	
26	ILTP	Saurabh Baruah (Co-PI) Member: Santanu Baruah	Geological structure and source characterization of earthquake originated in NER, India through wave form modelling (Indo-Russian Collaborative project)	C	
27	Indo-France	Saurabh Baruah (Co-PI) Member: Santanu Baruah	Determination of Crustal Structure of Shillong Plateau and Mikir hills using tomo-DD technique (Indo-France Collaborative Project) (CSIR-NEIST and University of Strasbourg)	C	
28	Indo-Singapore	Saurabh Baruah Member: Santanu Baruah Sangeeta Sharma	Study of the rupture of the 1950 Assam Earthquake (Indo-Singapore Collaborative Project) [CSIR NEIST and Earth Observatory of Singapore]	C	
29	Indo-Norway	Saurabh Baruah Member: Santanu Baruah Sangeeta Sharma	Earthquake Risk Reduction on the Indian Subcontinent-EQRisk (Indo-Norwegian Collaborative Project) [CSIR NEIST and NORSAR, Norway]	C	
30	GPP (DST Woman Scientist Scheme)	Sumana Goswami ***Mentor:*** Saurabh Baruah	Seismotectonic Study of Andaman Sumatra Region through Stress Tensor Inversion (2009-2011)	C	
31	Faculty Development Programme For Colleges - UGC	Dipok K Bora ***Mentor:*** Saurabh Baruah	Estimation of Crustal Discontinuities Using Digital Seismic Waves in Shillong-Mikir Hills Plateau of Northeastern India.	C	
32	CSIR-JRF and SRF	Rajib Biswas ***Mentor:*** Saurabh Baruah	Seismic Ambient Noise Analysis: It's Application to Evaluate the Site Characteristics of Shillong City.	C	
33	CSIR-TWAS JRF and SRF	Eluyemi Edekunle Ayodeji ***Mentor:*** Saurabh Baruah	Seismic Hazard Assessment in Nigeria Through Integrated Approach on Seismotectonics, Geophysical and Remote Sensing Studies to Identify Suitable Site for A Major Construction in Nigeria [May, 2014 to April, 2018]	C	
34	OLP2005	Manoj Kr Phukon	Seismic hazard assessment in Northeast India through multidisciplinary approach	O	
35		Manoj Kr Phukon	Seismotectonics of NE India and adjoining region with emphasis on seismic hazard assessment	O	
36	GPP0308	Manoj Kr Phukon	Site characterization and seismic vulnerability studies of Greater Shillong	C	1980000
37	GPP0326	Manoj Kr Phukon	Seismic Microzonatin of Greater Dimapur, Nagaland	C	1950000
38	CNP475	Manoj Kr Phukon	Seismological and geophysical investigation at the Baghjan well blowout site and its vicinity, Tinsukia, Assam	C	
39	GPP0364	Manoj Kr Phukon (Co-PI)	A comprehensive approach in understanding the acid mine ainage problem of Makum coalfield and its management	O	4564240
40	GPP (DST Woman Scientist Scheme)	R K Mrinalini Devi ***Mentor:*** Manoj Kr Phukan	Tectonic Evolution of the Mishmi Metamorphic Complex in the Eastern Syntaxial Bend w.r.t. Morphotectonic & Neotectonic implications in Arunachal Himalaya.	C	
41	DST-INSPIRE-JRF	Anwesha Dutta Hazarika ***Mentor:*** Manoj K Phukan	Geomorphic Responses to The Evolution of The Naga-Patkai Range: A Study on Active Tectonics	O	--
42	GPP0300	Sangeeta Sharma	Estimation of ground motion parameters in Shillong Mikir Hills Plateau from Acceleration time history of Earthquake events originated in NE India.	C	1490000
43	GPP0354	Sangeeta Sharma	Estimation of Ground motion parameters and development of a new attenuation relation from the earthquakes originated in and around North East India	O	3757120

44	MLPFBR0005	Bijit Kumar Choudhury (PI-NEIST Component)	Earthquake Hazard Studies in Moderate and Severe Seismic Zones of India (EHIND)	O	27200000
45	CSIR-RA	Santanu Baruah	Geophysical Approach towards Earthquake Precursor Studies in the Shillong-Plateau Supplemented by Change in Focal Mechanism Solutions as a Precursory Phenomenon [April, 2012 to March 2014]	C	
46	GPP0302	Santanu Baruah	Crustal Anisotropy studies for Shillong-Mikir Plateau with subsequent determination of velocity structure of NE India [2015-2019]	C	864000
47	CSIR NEIST & Dalhouise University	Santanu Baruah (PI-NEIST Component)	Paleoseismic Studies Along the Himalayan Front [2017-19]	C	
48	GPP0368	Santanu Baruah	Effect of Change in Coulomb Stress on Gutenberg-Richter law for the seismicity of North East India Region [2019-till date]	O	660000
49	CNP477	Santanu Baruah	Estimation of Site-specific Response Spectrum for the Proposed Road Connectivity Between Gohpur(NH52) to Numaligarh(NH37)	C	2925692
50	CSIR-NEIST and Pachhunga University College	Santanu Baruah (PI-NEIST Component)	Active Fault and Seismotectonic studies by Seismic Monitoring in and around Mizoram State in NER India (Collaborative Project between CSIR-NEIST and Pachhunga University College, Aizwal)	O	2000000
51	DST-RFBR	Santanu Baruah (Member)	Three Dimensional Seismic Structure & Seismicity in the Himalayan Region [DST (project no. INT/RUS/RFBR/P-156)] (IIT-Roorkee; Institute of Petroleum Geology and Geophysics, Siberian Branch of Russian Academy of Sciences,Russia and CSIR-NEIST)	C	--
52	CSIR	Santanu Baruah	To preserve, process and analyse of old Analog Seismograms which are still lying unused of CSIR-NEIST	0	--
53	DST-AIRTF GAP0784	Maria Rosalita Pujiastuti Sudibyo *(Institut Teknologi Sumatera, Indonesia)* ***Mentor:*** Santanu Baruah	Iterative Joint Inversion of Stress along Palu-Koro Fault System for Earthquakes recorded in 2012-2018 [August, 2019 to January, 2020]	C	--
54	DST-AIRTF GAP0788	Nur Saadah Binti Abd Majid *(University of Malaya, Malaysia)* ***Mentor:*** Santanu Baruah	The earthquakes behavior around the world in the perspective of spatial statistics [December, 2019 to May, 2020]	C	--
55	CSIR-SRF	Chandan Dey ***Mentor:*** Santanu Baruah	Studying Interaction Between Electric and Magnetic Field Variation in Relation to Seismotectonics of Kopili Valley	O	--
56	DST-INSPIRE-JRF	Nabajyoti Molia ***Mentor:*** Santanu Baruah	A Study on the Seismic Tomographic Model: A window into Sub-surface Structure of North-East India Region	O	--
57	GPP0352	Debasis D Mohanty	Active Geodynamics, Evolution, Structure and Deformation analysis of Indo-Burman Wedge	C	1500000
58	DST-INSPIRE-JRF	Poulommi Mondal ***Mentor:*** Debasis D Mohanty	Architecture of the lithospheric dynamics beneath the northeastern Himalaya	--	
59	CSIR-NET-JRF	Satya Priya Biswal, ***Mentor:*** Debasis D Mohanty	Continental scale deformation patterns beneath Northeast India and probabilistic hazard estimation	O	

List of Conference/Seminar/Training Programme organized at GSTD-CSIR-NEIST

SL No.	Title	Convenor	Duration
1	1st meeting of PMC on seismicity programme of MoES, GOI	Dr Saurabh Baruah	05-06 March, 2008
2	Computational Methods for Source Characterization and Stress Field Analysis	Dr Saurabh Baruah	21-26 March, 2014
3	RVS of Masonry and RCC buildings	Dr Ranju Duara	15 & 16 June, 2014
4	Computational Methods for Receiver Function Analysis	Dr Saurabh Baruah	16-22 November, 2015
5	International Earth Science Olympiad-2017	Dr M R K Devi	--
6	International Earth Science Olympiad-2018	Dr M R K Devi	--
7	Recent Developments in Civil and Earthquake Engineering – RDCEE-18	Dr Debashis D Mohanty (Co-convener)	9th April, 2018
8	An Interactive Session on very Low Frequency Electromagnetic System Invited Expert: Prof. S P Sharma, IIT-Kharagpur	Dr Santanu Baruah	2-6 July, 2018
9	Training on Basic of earthquakes and Engineering Participants: students of NIT-Agartala	Dr Santanu Baruah Dr. Manoj K Phukan	04-08 February, 2019
10	Proton Precession Magnetometer Participants: students of M.Tech. (Geophysics) of Dibrugarh University	Dr Santanu Baruah	July, 2018
11	Hands on Training on Proton Precession Magnetometer (PPM) Invited Expert: Prof. S K Pal, IIT-ISM Dhanbad	Dr Santanu Baruah	11 & 12 November, 2019
12	Advancement in Seismology Invited Expert: Prof. J R Kayal	Dr Santanu Baruah	09-12 January, 2020
13	International Virtual Workshop on Global Seismology and Tectonics 2020	Dr Santanu Baruah	14-25 September, 2020

Photo Gallery

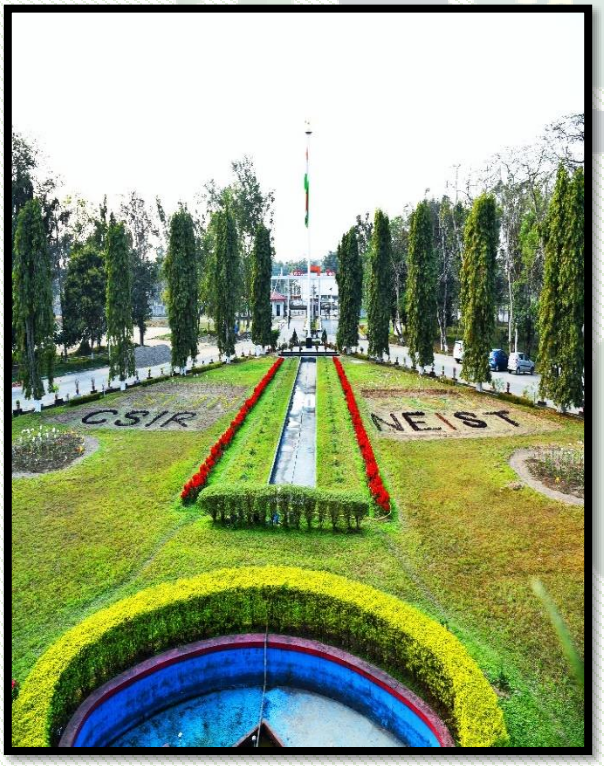
PHOTO GALLERY

A picture of the beautiful Administrative Building of CSIR-NEIST contrasting with amazing surroundings

Statue of Late Jananayak Debeswar Sarmah unveiled by Dr. Madhu Dixit, RC Chairperson, CSIR-NEIST in the presence of Dr. G Narahari Sastry, Director, CSIR-NEIST on the occasion of Diamond Jubilee year (2021) of CSIR-NEIST. Late Debeswar Sarmah was an Indian politician. He was elected to the Lok Sabha, the lower house of the Parliament of India, as a member of the Indian National Congress.

CSIR-NEIST has new areas of great scenic beauty. The night view of the illuminated Fountain in front of the Central Library of CSIR-NEIST add a worth.

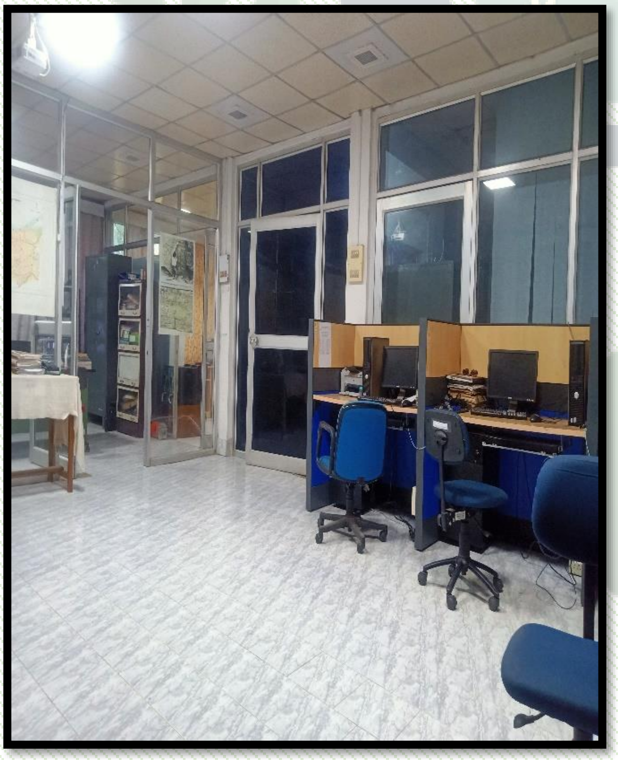
Architecturally prominent Main Entrance of CSIR-NEIST which is known as Gate No.2



From up here one can get a bird's eye view of the CSIR NEIST main garden

Among the CSIR-NEIST's attractive features is a beautiful auditorium, built and named in the honour & fond memory of Late Dr. J. N. Baruah, former Director of CSIR-NEIST & a prominent scientist & educationalist from Assam

The location of CSIR-NEIST is definitely it's biggest asset: on the east side of it, a nice view of Geoscience and Technology Division (GSTD)



Ergonomically designed Prefabricated Portable Interiors for the Researchers of GSTD

The long corridor that lead to the GSTD meeting room usually filled with perhaps intent individuals, standing and sitting, some taking notes, others with few buried faces in computer screens

Digital Seismic Telemetry System comprising digital telemetry remote stations located at 27 different sites of North East India and an on-line event detection and data recording station at CSIR-NEIST Jorhat [operated during 1990 - 1998]

Antique Pieces of receiver antennas of Seismic Telemetry System (right) and VSAT system (left) installed at the terrace of GSTD building

Obsolescent component of Analog seismograph at the museum of GSTD, CSIR-NEIST for demonstration among the school/college students

A view of the Central Recording System for the earthquakes of the eight North Eastern states of India through Wide Area Seismic Network (NEWSN) operated by GSTD, CSIR-NEIST

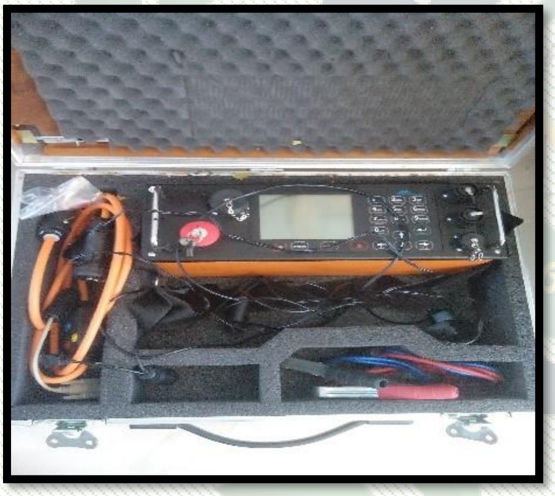
A remote Seismic station located at Umium, Shillong of Meghalaya with VSAT connectivity operated by GSTD, CSIR-NEIST Jorhat. Dr. Ranju Duarah, former Chief Scientist and Area Co-ordinator is seen in checking the status of the system.


A state-of-art Multiparametric Geophysical Observatory (MPGO) set up by GSTD, CSIR-NEIST with the financial aid from Ministry of Earth Sciences (MoES), Govt of India located at Tezpur, Assam. Eight different geophysical equipments are in operation in 24X7 mood, which can record Earth's different inherent parameters that are being used for earthquake precursor studies of North East India region.

Fibre reinforced insulating dome at the instrumentation site of the MPGO, housing different magnetic and electric field sensors of different Geophysical equipments. The site is selected in such a way that it is far away from any magnetic materials, electrical cables etc. which may hamper the recording of electric and magnetic field of Earth

a

b



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An outlook of the Instrumentation facility at MPGO, Tezpur: a) component Broadband seismograph system; b) Strong Motion seismograph; c) 2D Resistivity meter; d) Global Position System; e) ULF magnetometer logger with real-time field recording; f) console and sensor of Overhauser magnetometer system

A Multichannel analysis of surface waves (MASW) system with 48 Channel Seismographs. MASW is a seismic exploration method for determination of near-surface shear wave velocity profiles based on analysis of horizontally travelling Rayleigh waves.

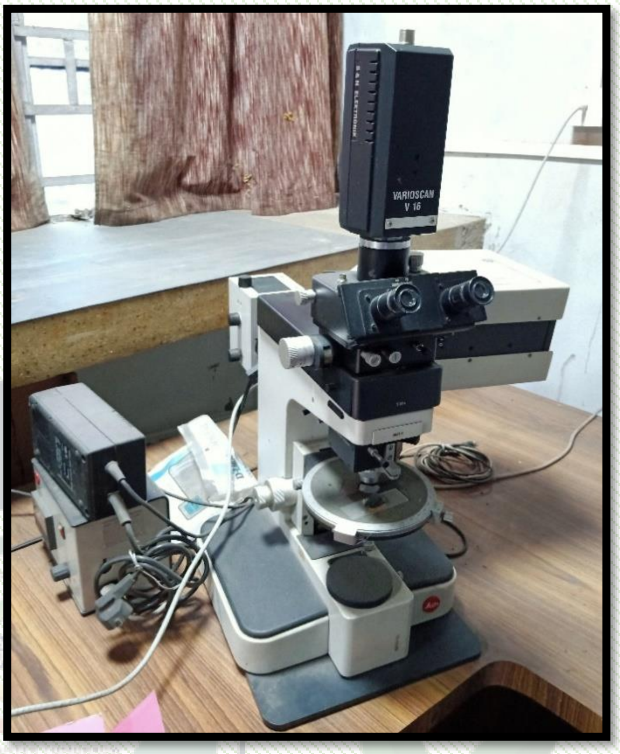
Highly versatile Very Low Frequency (VLF) Electromagnetic System of GSTD. VLF is a geophysical ground probing technology that utilizes VLF signals in the 15 to 30 kHz range normally used for communication with submarines. The signal generated is suitable for making geophysical measurements globally.

A sophisticated Proton Precession Magnetometer (PPM) System of GSTD. A proton magnetometer, also known as a proton precession magnetometer (PPM), uses the principle of Earth's field nuclear magnetic resonance (EFNMR) to measure very small variations in the Earth's magnetic field, allowing ferrous objects on land and at sea to be detected.

Training session on Proton Precession Magnetometer at CSIR-NEIST organised by GSTD. The training was imparted to the M.Tech. (Geophysics) students of Dibrugarh University & M.Tech. (Civil Engg.) students of NIT-Agartala during 2018.

A Ground Penetrating Radar (GPR) of GSTD. Ground-penetrating radar is a geophysical method that uses radar pulses to image the subsurface. It is a non-intrusive method of surveying the sub-surface to investigate underground utilities such as concrete, asphalt, metals, pipes, cables or masonry.

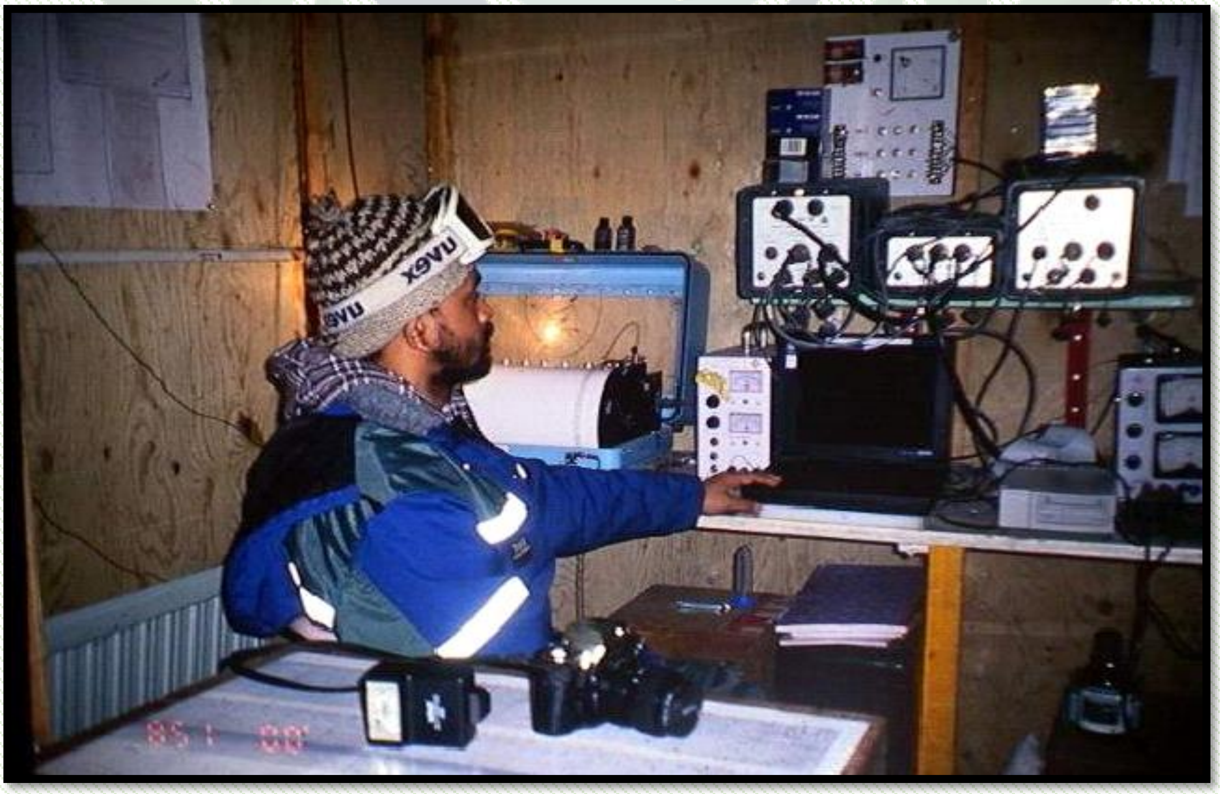
Dr. Manoj K. Phukan, Senior Scientist and Mr. Sausthov M. Bhattacharyya, Technical Officer of GSTD, CSIR-NEIST conducting Geophysical survey using GPR (Ground Penetrating Radar) at CSIR-NEIST premises for detection of underlying water pipes, cables etc.



Petrographic microscope facility at GSTD, CSIR-NEIST for mineralogy studies: Stereo Microscope & Leit3 Microvid Microscope. A petrographic microscope is a type of optical microscope used in petrology and optical mineralogy to identify rocks and minerals in thin sections.

A Seismic station installed at College of Teacher Education, Rongkhon, Tura, Meghalaya with the financial assistances from MoES, Govt. of India.

Dr. Saurabh Baruah at Maitri Station of Antarctica during the 18th Indian Antarctic Expedition (IAE). Dr. Baruah was the second Assamese to visit Antarctica for a scientific expedition.



Dr. Saurabh Baruah at work in the seismic station of Antarctica. His instrument could record one rare shallow focus earthquake originated at Antarctica.

A group photo of the team members of CSIR-NEIST with French geologist Prof. Paul Tapponnier and other scientists from Earth Observatory of Singapore & Strasbourg University, France in the year 2013. The field work was carried out in Arunachal Himalaya in connection with the Indo-Singapore Collaborative Project on the Study of the rupture of the 1950 Assam Earthquake. [CSIR-NEIST and Earth Observatory of Singapore].

Geological field visit to Indo-Bhutan border during 2018 (L) and 2019 (R) in connection with the CSIR-NEIST and Dalhousie University, Canada collaborative project on Paleoseismic Studies Along the Himalayan Front. Prof. Djordje Grujic, Dalhousie University and Dr Santanu Baruah, CSIR-NEIST were the team-leaders.

During a Geophysical survey at a site transecting Kopili Fault Zone which was conducted using VLF and PPM in 2020. The Kopili fault zone is a 300-km northwest-southeast trending fault. It is extending from the western part of Manipur to the tri-junction of Bhutan, Arunachal Pradesh and Assam.

Group photo of the team of geoscientists and researchers from GSTD, CSIR NEIST undertaking geophysical survey at the Baghjan OIL well blow out site for investigation of Environmental impact in 2020. The 2020 Assam gas and oil leak, also referred as the Baghjan gas leak, is a natural gas blowout that happened in Oil India Limited's Baghjan Oilfield in Tinsukia district, Assam, India on 27 May 2020. The blowout occurred at Well No. 5 in the Baghjan Oil Field, resulting in a leak of natural gas. The leaking well subsequently caught fire on 9 June 2020,[1] and resulted in three deaths (Officially), large-scale local evacuations, and environmental damage to the nearby Dibru-Saikhowa National Park and Maguri-Motapung Wetland.

Group photo taken at a survey site related to geophysical investigation of proposed tunnel under the Brahmaputra River. This is the first time that India will be constructing an under-river tunnel, Hindustan reported and it will close to the Chinese border. It will be longer than the under water tunnel being built by China below the Taihu Lake in Jiangsu province, it further reported. The proposed tunnel in India is going to be very important strategically as it will provide year-long connectivity between Assam and Arunachal Pradesh. It will also help in transporting military supplies and ammunition as vehicles will be able to zoom past the tunnel at 80 kmph, Hindustan reported.The National Highways and Infrastructure Development Corporation Limited (NHAIDCL) has roped in America's Louis Berger company; in fact, the central government had approved its detailed project report in March, reported Hindustan. (Dr. G Narahari Sastry, Director, CSIR NEIST, Dr. Jatin Kalita Head, RPBD & Dr. Santanu Baruah, PI along with other staff are seen) (2021)

Dr. G Narahari Sastry Director, CSIR NEIST and Dr. Jatin Kalita Head, RPBD taking an overview of survey operations related to geophysical survey of proposed tunnel under the Brahmaputra River. The project was undertaken by GSTD, CSIR NEIST under the leadership of Dr. G. Narahari Sastry, Director, CSIR-NEIST.

The Conference room of CSIR-NEIST, a large, ornate chamber known as the Director's Conference Room, where delegates can seat, at the tables arranged along three sides of a square, with an inner row of seats arranged in the same way.

During the 1st Project Monitoring Committee (PMC) Meeting of MoES, Govt. of India held at CSIR-NEIST coordinated by GSTD during 5-6 March, 2008. Dr H K Gupta, the then Chairman, PMC, MoES; Dr. P G Rao, the then Director, CSIR-NEIST; Dr. B K Bansal, the then Advisor, MoES were also seen.

A group of eminent statesmen of GSTD & Dibrugarh University during a meeting held at GSTD, CSIR-NEIST (from L to R: P. Kotoky, P.K. Bora, R. Duarah, M.M. Saikia, S. Goswami & S. Baruah)

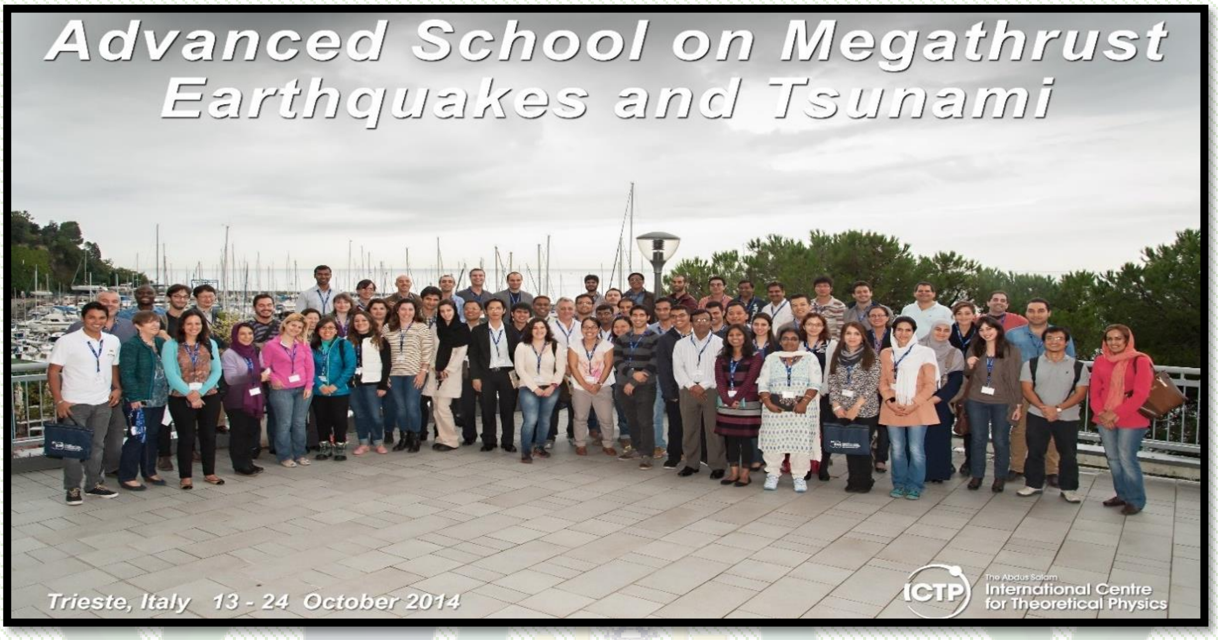
National Science Day celebration on 6th March 2008 at CSIR-NEIST. Dr. P G Rao, the then Director, CSIR-NEIST and Dr. H K Gupta, the then RC-Chairman, CSIR-NEIST were seen. Dr. Gupta was invited as the Chief Guest of the function. National Science Day is celebrated in India on 28 February each year to mark the discovery of the Raman effect by Indian physicist Sir C. V. Raman on 28 February 1928. For his discovery, Sir C.V. Raman was awarded the Nobel Prize in Physics in 1930.

Departmental seminar of GSTD (Photograph taken in 2009). [Standing: Partha Kalita; 1st Row L to R: P Kotoky, P K Bora, S Baruah; 2nd Row L to R: B K Choudhury, Santanu Baruah, Sangeeta Sharma, Sumana Goswami, Priyanka Duarah; 3rd Row L to R: D K Bora, Rajiv Biswas, Saitulunga, Aditya Kalita; 4th Row L to R: Mukul Borkotoky, Bharat Buragohain; Pradip Dutta]

During a meeting held at GSTD, CSIR-NEIST in connection with the Indo-Russian Integrated Long Term Programme of Cooperation (ILTP) programme. ILTP in Science & Technology between India and Russian Federation is one of the most exhaustive bilateral collaborative R&D programmes, covering all aspects of science and technology. [L to R: S Baruah; R Duarah; Sargei Ariefev & Ruben Tatovosian from Russian Academy of Sciences, Moscow, Russia; Rima Chatterjee, IIT-ISM Dhanbad; Sumana Goswami; Sohini Roy, Jadavpur University, Kolkata; S Kalita, Gauhati University; Naba Gogoi, CSIR-NGRI; D K Bora; Manichandra SANOUJAM from Manipur University]

Santanu Baruah & Rajiv Biswas of GSTD, CSIR-NEIST attending a short term training programme on Magnetotelluric System held at North Eastern Hill University (18th- 22th June, 2010).

During a review meeting in connection with the MoES sponsored project titled “Setting up of Multiparametric Geophysical Observatory held at MPGO, Tezpur . Experts from Ministry of Earth Science & CSIR-NGRI along with scientists of CSIR-NEIST visited MPGO, Tezpur.



Dr. Santanu Baruah & Dr. Bijit Kumar Choudhury of GSTD, CSIR-NEIST attending 12 days workshop on "Megathrust Earthquakes and Tsunam at Trieste, Italy (2014) organized by The Abdus Salam International Centre for Theoretical Physics

Dr. Bijit K. Choudhury attending a training program on "Role of technology in community level disaster mitigation for scientists and technologists" at LBSNAA, Mussoorie (2018).

Dr. Santanu Baruah, Dr Sangeeta Sharma & Dr. Goutam K. Boruah of GSTD, CSIR-NEIST participating in DST sponsored Training Programme on "Basic Geophysical Techniques" held from 17th-25th January 2015 at ISM Dhanbad.

Dr. Goutam K. Boruah & Mr. Papu Kumar Das of GSTD, CSIR-NEIST participating in SERB-DST sponsored training program on "Earthquake Hazard: Basic Approaches, Field Investigations & Modelling" at the School of Innovative & Community Development, SMVD University, Katra, Jammu & Kashmir (10-16th Nov, 2015)

Dr. Goutam K. Boruah & Mr. Devakrishna Gogoi of GSTD, CSIR-NEIST attending an MoES sponsored short term course on "Geoinformatics in Earthquake Studies" at IIT, Roorkee (1-5th November, 2016)

Dr. R K Mrinalinee Devi, Dr. Goutam K. Boruah, Dr. Antara Sharma & Mr. Devakrishna Gogoi of GSTD, CSIR-NEIST attending a National Seminar on "Geology, Geochemistry, Tectonic, Energy & Mineral Resources of NE India" at Nagaland University, Kohima (9th November- 11th November, 2016)

Dr. Debasis D. Mohanty, Dr. Goutam K. Boruah and Miss Poulommi Mondal of GSTD, CSIR-NEIST attending "16th Annual Meeting of Asia Ocenia Geosciences Society, 2019" at Suntec City, Singapore (28th July- 2nd August, 2019)

Students from IIT-Kharagpur and Dept of Physics, Sibsagar College attending a Brainstorming session at CSIR-NEIST, co-ordinated by GSTD

Prof. J R Kayal , former Dy DG, GSI (in the middle) and Dr. Sebastiano D'Amico, University of Malta being felicitated by Dr Santanu Baruah at GSTD. An interactive meeting was organized among the scientists and research scholars of GSTD, CSIR-NEIST for future collaborative work (2020).

Visitors from University of Malaya, Malaysia (Ms Nur Saadah Binti ABD Majid and Mr ABD Majid were interacting with the scientists of GSTD, CSIR NEIST (2020).

Dr. Santanu Baruah felicitating Dr. R.B.S. Yadav, Kurukshetra University with an Assamese traditional bell metal Xorai at GSTD, CSIR NEIST. Brainstorming session was organized among the scientists and research scholars during his visit in 2020.

Dr. G. Narahari Sastry, Director, CSIR-NEIST welcoming Prof J R Kayal, Former Dy DG, GSI (2nd from R) and Dr. S D'Amico, University of Malta, Malta (2nd from L) to CSIR-NEIST.

A group of scientists and research scholars from GSTD during a seismic survey using 48 channel Seismograph system at Negheriting, Dergaon, Golaghat

During a field training programme on Proton Precisson Magnetometer with the guidance from Prof. Sanjit Pal, IIT-ISM-Dhanbad at the Negheriting Shiv Mandir, Golaghat

List of Participants

Sl No.	Full Name	Email Address	Name of your Institution / Organization presently working / last attended	Country
1	A. K. M. Khorshed Alam	akmkhorshed@gmail.com	Formerly Geological Survey of Bangladesh	Bangladesh
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41	ABUZAR GHAFFARI	puraini56@gmail.com	CENTRAL UNIVERSITY OF KARNATAKA	INDIA
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