IGU
Promoting Earth System Sciences

61st Annual Convention

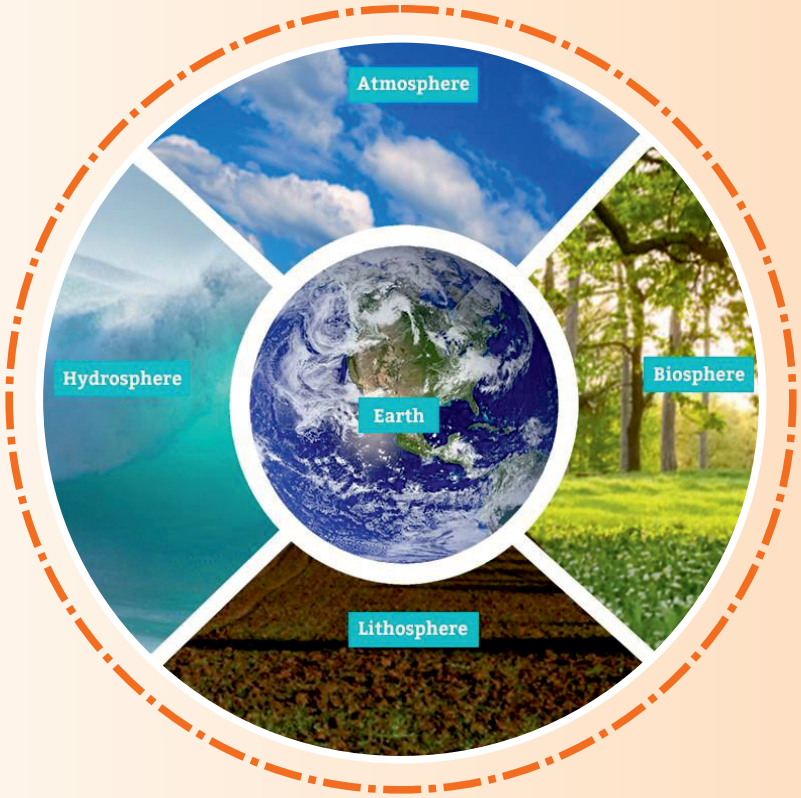
&

Diamond Jubilee Celebration of Department of Geophysics, BHU

on

Advances in Earth System Sciences with special reference to weather and climate

3-5 December 2024



Jointly Organized by

Indian Geophysical Union (IGU), Hyderabad

and

Department of Environment and Sustainable Development
& Department of Geophysics
Banaras Hindu University, Varanasi

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Ministry of Earth Sciences
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- **11** Indian Southern Ocean Expedition
- **2010** Indian Expedition to the South Pole
- **2022** Indian Scientific Reached North Pole
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- **2005** India's *Only Ice- Core Laboratory* established at NCPOR, Goa

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- **Expedition & Operations**
  Antarctica, Arctic, Himalayas, Southern Ocean
- **Polar Sciences**
  Polar Cryosphere & Ice core studies; Past Climate Studies; Remote Sensing; Himalayan Cryosphere
- **Geoscientific Studies**
  Indian Ocean Discovery Program; Indian Ocean Geoid low; Extended Continental shelf Program
- **Deep Sea Exploration and Mapping**
  Mapping of the EEZ ; Hydrothermal Mineralisation Studies; Cobalt Crust

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ABSTRACTS

61st Annual Convention of IGU

&

Diamond Jubilee Celebration of Department of Geophysics, BHU

on

"ADVANCES IN EARTH SYSTEM SCIENCES WITH SPECIAL REFERENCE TO WEATHER AND CLIMATE"

3-5 December 2024

Venue:

Department of Environment and Sustainable Development
& Department of Geophysics
Banaras Hindu University (BHU), Varanasi.

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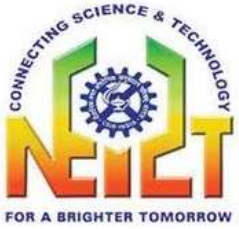
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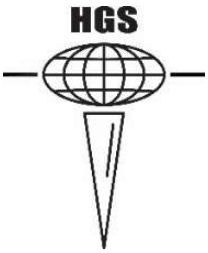
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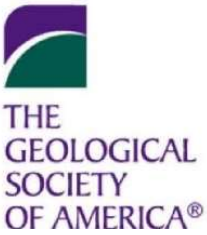

INDIAN GEOPHYSICAL UNION
CSIR-NGRI Campus, Uppal Road, Hyderabad – 500 007

Dear Esteemed Colleagues and Participants,

I am pleased to welcome you to the 61st IGU Annual Convention. Our Union has a proud history of fostering scientific research, collaboration, and knowledge exchange. This conference is a testament to our commitment to advancing the frontiers of science and technology. It is a platform to share our discoveries, discuss emerging trends, and inspire one another in our collective pursuit of knowledge.

The theme of this year's conference, "Advances in Earth System Sciences with special reference to weather and climate", underscores our dedication to addressing some of the most pressing challenges and opportunities in our field. I am confident that the presentations, discussions, and interactions that unfold during this event will contribute significantly to advancing our discipline.

I would like to express my heartfelt gratitude to the organisers, sponsors, and, most importantly, to each of you who have contributed to the success of this conference. Your dedication and enthusiasm for scientific exploration are truly inspiring.

I encourage you all to engage fully in the conference, make new connections, and explore new avenues of research. I am certain that the knowledge and experiences you gain here will benefit your endeavours and contribute to the greater scientific community.

I look forward to the exchange of ideas and the collaborative efforts that will undoubtedly emerge from this gathering. Together, we can positively impact our world through the power of science.

Thank you for being a part of the Indian Geophysical Union and for your unwavering commitment to the pursuit of knowledge.

Wishing you a successful and enriching conference.

Sincerely,

Dr. M. Ravichandran
President
Indian Geophysical Union (IGU)

Office:	**Phone :**	**Grams :**	**Fax :**	**E.mail :**
Secretary	040-27012332;	Geophysics	040-27171564	igu123@gmail.com

CONVENOR MESSAGE

It is with great enthusiasm that I welcome you to the 61st Annual Convention of the Indian Geophysical Union (IGU), to be held at the prestigious Banaras Hindu University campus, Varanasi. This year's convention, themed *"Advances in Earth System Sciences with Special Reference to Weather and Climate,"* promises to be an intellectually enriching event.

As geoscientists, we are at the forefront of addressing some of the most pressing challenges of our time—ranging from climate change and extreme weather events to sustainable resource management and environmental protection. This convention provides a vital platform to share innovative research, explore new ideas, and discuss the latest advancements that are shaping the future of Earth system sciences.

The theme underscores the critical role of geophysics in understanding and mitigating the impacts of weather and climate variability. We aim to foster interdisciplinary collaboration by bringing together experts from diverse fields, including earth sciences, space sciences, and environmental studies, to address these complex challenges.

We are very glad to report that IGU 2024 has garnered an overwhelming reception from scientists, researchers, and students from government departments, universities, research institutes, industry, and civil society in form of more than 300 papers under different topical themes. Scientific programme has accommodated these papers through oral, short oral and poster presentations. In addition, Plenary and lead talks will be delivered by distinguished national and international scientists. We are happy to bring out this "Abstract Volume" containing the contributions.

I encourage all participants to actively engage in the sessions, showcase your research, and contribute to the vibrant discussions that will define this convention. Together, let us harness the power of scientific innovation and collaboration to advance geophysical research for the betterment of society.

We look forward to your participation and to a memorable convention that inspires new ideas and partnerships.

Prof. R K Mall
Convener
61st Annual Convention of IGU

PREFACE

The Indian Geophysical Union (IGU), established in 1963, was founded with the blessings of eminent scientists such as Prof. K.R. Ramanathan, Prof. S. Bhagavantham, Prof. M.S. Krishnan, and Dr. S. Balakrishna. Over the years, IGU has been a significant platform for disseminating knowledge, exchanging ideas, facilitating interactions between young researchers and experienced geoscientists, addressing societal challenges, and deliberating on contemporary topics and phenomena. These efforts contribute to the sustainable development of society while supporting the Earth Sciences community in India.

The progress of IGU has been made possible through the invaluable support of many geoscientists, whose contributions we deeply acknowledge and appreciate. IGU remains committed to encouraging young researchers to enhance their research capabilities and broaden their global perspective. We also urge senior scientists to mentor these young minds, leveraging their extensive experience to guide the next generation.

IGU aims to provide a robust forum for presenting advancements in various disciplines of Earth Sciences. This year, IGU is proud to announce its 61st Annual Convention, jointly organized with the Department of Environment and Sustainable Development and the Department of Geophysics, Banaras Hindu University (BHU), Varanasi, from December 3–5, 2024. The event will focus on Solid Earth, Marine Geosciences, and Atmospheric, Planetary, and Space Sciences. The special theme for this year is "Advances in Earth System Sciences with Special Reference to Weather and Climate." The three-day convention will feature keynote talks, invited talks, award presentations, and sessions encompassing a wide range of Earth Sciences related to the Evolution of the Indian Crust, Earthquake Processes, Geohydrology, Mineral Resources and Fuels, Marine geosciences etc., will be deliberated during the three-day Annual Convention of the Indian Geophysical Union (IGU). The Annual Convention will also address various issues for promoting and developing geosciences in global and regional aspects.

In addition to award lectures and invited talks, more than 300 research papers will be presented during the convention, with over 400 delegates expected to participate. This gathering will foster meaningful interactions between eminent scientists, young researchers, and students. On behalf of IGU, we encourage delegates to submit full papers of their presentations for publication in the *Journal of Indian Geophysical Union* (JIGU) after undergoing a rigorous peer-review process.

We congratulate the winners of the following awards and honours for the year 2024:

IGU–Dr. Harinarain Lifetime Achievement Award

IGU–Prof. K.R. Ramanathan Memorial Lecture

IGU–Krishnan Medal

IGU–Anni Talwani Memorial Prize

IGU–Anni Talwani Memorial Grant for Young Women Researchers

IGU–Prof. Jagdeo Singh and Dr. S. Balakrishna Memorial Grant for student toppers from various universities participating in the annual convention

IGU–Prof. D. Lal Best Paper Award for papers published in *The Journal of Indian Geophysical Union* during 2023–2024.

We extend our sincere gratitude to the Local Organizing Committee, including Prof. S K Jain, Vice Chancellor and Chairman of the LOC; Co-Chairpersons Prof. A.S. Raghbanshi, Director, IESD, and Prof. G.P. Singh, Head, Department of Geophysics; Prof. Sanjay Kumar, Rector, Prof. R.K. Mall, IESD, and Convener, LOC. Their unwavering commitment and efforts have ensured the seamless organization of technical sessions and enhanced delegate participation during award and invited talks.

The IGU Executive Committee expresses its gratitude to:

Prof. Shailesh Nayak, Patron

Dr. M. Ravichandran, President

Past Presidents: Prof. Harsh Gupta and Prof. V.P. Dimri

Vice Presidents: Dr. Prakash Kumar, Dr. A.P. Dimri, Dr. Sushma Rawat, Dr. T. Srinivas Kumar, and Dr. O.P. Pandey, Chief Editor, *JIGU.* We thank the chairpersons of the technical sessions for accepting our invitation to conduct various sessions as per the suggested schedule.

We extend our heartfelt thanks to all Fellows and Members of IGU, technical session chairpersons, and the Executive Committee members for their continued support. We are also deeply grateful to the Ministry of Earth Sciences (MoES), New Delhi, Oil India Limited (OIL), Delhi, Oil and Natural Gas Corporation (ONGC), New Delhi, National Centre for Polar and Ocean Research (NCPOR), Goa, CSIR-National Geophysical Research Institute (CSIR-NGRI), Hyderabad, National Institute of Ocean Technology (NIOT), Chennai, National Centre for Earth Science Studies (NCESS), Thiruvananthapuram, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, National Remote Sensing Centre (NRSC), Hyderabad, CSIR- North East Institute of Science and Technology (NEIST), Jorhat, Indian Institute of Geomagnetism (IIG), Mumbai, CSIR-National Institute of Oceanography (NIO), Goa, Banaras Hindu University, Varanasi for their financial support in organizing this program. Without their contributions, it would not have been possible to conduct this event.

Our sincere gratitude goes to CSIR-NGRI, Hyderabad; NRSC, Hyderabad; AIMIL Ltd., New Delhi; HGS (India) Limited, New Delhi; Complete Instrumentation Solutions Private Limited, Gurgaon; Pan India Consultants Pvt. Ltd., Gurgaon; and Shijay Projects India Private Limited, New Delhi, for setting up stalls to showcase state-of-the-art services and products related to the acquisition, processing/modelling, and interpretation of geoscientific data. We encourage all delegates to visit the exhibition stalls and explore the expertise and infrastructural facilities on display.

Special recognition goes to Mr. Rafique Mohammad Attar, Treasurer of IGU, for his consistent efforts in facilitating the convention's various tasks. Lastly, we thank the IGU office personnel for their invaluable assistance in ensuring the successful execution of the event.

Abhey Ram Bansal

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    *Pradeep Kumar Yadav, Uma Shankar, Sneha Devi

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    *Prahladh Kindangi and Subrahmanyam Mangalampalli

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    *R. B. S. Yadav, A. P. Singh, Rimpy Taya, R. Kumar and T. M. Tsapanos

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    *Ram Krishna Tiwari, Harihar Paudyal

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    *Rekapalli Rajesh, N. Purnachandra Rao and Sandeep Kumar Gupta

79. TECTONIC IMPLICATIONS OF CRUSTAL AZIMUTHAL ANISOTROPY BENEATH GUJARAT, WESTERN INDIA THROUGH PS SPLITTING

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*Renu Yadav and Dinesh Kumar

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*Riya Singh Rathore, Tirtharaj Barman, Swarandeep Sahoo

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*Riya Singh, Pratik Gautam Fulkar, Swapnamita Vaideswaran

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*S Trupti, P Pavan Kishore, KNSSS. Srinivas and HVS Satyanarayana

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*Sanjay K Prajapati, Auchitya Pandey, Anmol Ratan and O P Mishra

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*Sanjit Kumar Pal, Anil Kumar, Anshumali, Rajat Sanyal, Subhendu Mondal, Rajwardhan Kumar, Bidhan Halder, Dharmita Horo, Soma Rani, Sarvesh Kumar Jha

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*Saqib Zia and Nimisha Vedanti

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*Satish Kumar Sinha and Abul Aas

.93. DEVELOPMENT OF MAGNITUDE REGRESSION RELATIONS FOR THE HIMACHAL REGION BY USING OBSERVED AND SIMULATED DATASETS FROM M 4.0-8.0 EARTHQUAKES

*Suraj Kumar Pal, Sandeep, Parveen Kumar, Monika, Pragya Singh, Himanshu Mittal

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*R.K. Dubey and Satish Kumar

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*A.V. Satyakumar and M. Venkateshwarlu

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*S.P. Maurya and Ravi Kant

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*Shashi Kant Sah, Auchitya Kumar Pandey and Sandeep

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*Shib Sankar Ganguli and Prakash Kumar

99. JOINT INVERSION OF MULTIMODAL LOVE WAVE PHASE VELOCITY DISPERSION CURVES USING BAYESIAN NEURAL NETWORKS

*Shreya Hembrom, Rohan Sharma, Niptika Jana, Prosanta Kumar Khan

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*Sudeshna Moharana and Laxmidhar Behera

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*Susmita Goswami and Abhishek Kumar Rai

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*V. Ramya Sri, Biswajit Mandal, K. Laxminarayana, P. Karuppannan

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*Vandana and Naresh Kumar

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*Vaska Lokesh, Pavan Kumar V, Himangshu Paul, Naresh Bandari, Suresh Gudapati, Vijayaraghavan R, and Prakash Kumar

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*Vedprakash Thakur, *Sanjay K Prajapati, Birendra Pratap, Uma shankar, O. P. Mishra Sudipto Bhattacharjee, Arvind Kumar

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Yeshwini Dyagala, Rama Mohan Kurakalva[2], Sravya Sai Guddeti, Eswara Venkata Ravi Kishore Vemana

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*Yogesh K Thorat and M. Venkateshwarlu

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*Dhananjai K Pandey, Sambuddha Misra, Mahesh Halder

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*Dipanjan Das Majumdar; Barendra Purkait; Ashis Kumar Paul

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*Richards Nelson, Jensen Jacob, Maria Ana Desa, Saif Ali Khan

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*Saif Ali Khan, Jensen Jacob, Maria Ana Desa, Richards Nelson

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*Seema Begum, Ranjana Ghosh, Maheswar Ojha, Prakash Kumar

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* Vamdev Pathak, Ethan Lopes and the IODP Expedition 399 Scientists

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*Arti Choudhary, Bharat Ji Mehrotra, Manoj Kumar Srivastava

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*Pradeep Kumar, R. Bhatla, Arti Choudhary

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127. INVESTIGATION OF THE DYNAMICS OF HEATWAVES OVER INDIA

*Shreya Bhowmick and Subhadeep Halder

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Subrata Kundu*, Mala S. Bagiya, S. Gurubaran, Srinivas Nayak[2], N. K. Hazarika, A. P. Dimri

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*Yogesh K. Tiwari, G. Sreenivas, Priyabrata Nandi, Amey Datye, Karuna Rao, Smrati Gupta, Jitender Singh

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*Kshetrimayum Ajit Singh, Maibam Bidyananda, M.A. Khonglah

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*Manisha Chaturvedi and R.K. Mall

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*Anjali Dixit and Animesh Mandal

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*Pratyusha Chanda, Sambuddha Misra, James McManus, Allyson Tessin, Steven M. Bohaty, Gabriele Uenzelmann-Neben, Laurel Childress

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*Sakshi sharma, Arun chakraborty, Abhishek kumar, Vineet sharma

138. EMPIRICAL ORTHOGONAL FUNCTION ANALYSIS OF SATELLITE BASED HYDRO-METEOROLOGICAL OBSERVATIONS FOR DROUGHT SEVERITY IN INDIAN RIVER BASINS

*Sushrita Dutta, Mridul Yadav, G. Srinivasa Rao

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*Yezarla Mahesh, Rekapalli Rajesh, Sandeep Kumar Gupta and N. Purnachandra Rao

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3. FULL WAVEFORM INVERSION FOR IMAGING THE COMPLEX SUBSURFACE STRUCTURE

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*Abhishek Kumar Gupta, Dilip Kumar Yadav, Naresh Kumar

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*Anmol Ratna, Sanjay K. Prajapati, A. Vasanthi

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*Archana Bhagwat Kaotekwar, Masood Ahmad, Sreenivasa Sarma, K. Satyanarayanan and Keshav Krishna

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*Ateet Maurya, Kuldeep Sarkar and Upendra K Singh

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*Atul Saini, Himanshu Mittal, Rajiv Kumar, O.P. Mishra

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*Ayan Dutta, Labani Ray, Nishu Chopra, S. Eswara Rao, Sandeep Kumar Prajapati, Amar Prakashrao Dudhate, Nagaraju Podugu, Neeraj Benny

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*Ayush Chandra, Piyush Sarkar, Akash Chandra

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*Babul Sahoo, Sujit K. Pradhan, Ramesh K. Nishad, Anup K. Sinha, E. Karthikeyan and Gautam Gupta

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*Chinthala Tejaswi and G. Uday laxmi

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*Debeena Nongmaithem, Meghali Baruah and Devesh Walia

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*Faris Hamza, Ritima Das; Utpal Saikia and Himanshu Mittal

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*Ginkala Tejaswi, K. Laxminarayana, Biswajit Mandal, Prakash Kumar

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*Jogpun Pegu, Meghali Baruah and Devesh Walia

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*Kancharla Teja, Dhanam Kusireddi, N Vedanti

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*K. Laxminarayana, Biswajit Mandal, V. Vijaya Rao, P. Karuppannan, Sumer Chopra, Prakash Kumar.

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*K. Mallika, D. Shashidhar and HVS. Satyanarayana

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*K. Satish Kumar, P. Pavan Kishore, K. Swapna Sri, P. Siva Sankar, B. Laxman, V.Ramesh, L.Suri Naidu, Sakaram Gugulothu, M. Shri Hari Rao, K.N.S.S.S Srinivas, G.Suresh, D.Mysaiah, A.K.Pandey

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*K. Swapna Sri, P. Siva Sankar, K. Satish Kumar, D. Srinagesh

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*K.N.S.S.S.Srinivas, M. Srihari Rao, P. Pavan Kishore, H.V.S.Satyanarayana

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*Kartik Gupta, Ayush Kumar, Anbazhagan P

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*Kaviti Swathi, Biswajit Mandal, P. Karuppannan, K. Laxminarayana, P. Mahesh, Prakash Kumar

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*Laraib Abbas and Dip Kumar Singha

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*Lekshmika lal, Biswajit Mandal, P. Karuppannan, K. Laxminarayana, P. Mahesh, Prakash Kumar

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*Madhu Kumari, Kajaljyoti Borah

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INTERACTION BETWEEN THE INDIAN OCEAN DIPOLE AND THE TRIPLE DIP LA-NINA: IMPACT ON INDIAN SUMMER MONSOON

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ABSTRACT

The Indian Ocean Dipole (IOD) a strong modulator of the Indian Summer Monsoon (ISM), as positive (negative) IOD conditions are often associated with above (below) normal ISM. IOD events can arise due to internal variability or can be forced by the conditions in the tropical Pacific Ocean. In this study, we study the interaction of the Pacific Ocean state in with the Indian Ocean for multi-year La-Nina events. It is found that triple dip La-Nina-type conditions, which is a rare occurrence, suppress the seasonal cycle of winds in the tropical Indian Ocean. As a result, large westerly wind anomalies ensue in the central equatorial Indian Ocean and the along-shore easterlies along the Java-Sumatra coast during boreal summer and fall are suppressed. Reduced wind-evaporation-SST feedback and weakening of the mean upwelling in the eastern tropical Indian Ocean causes warming of SST in the eastern Indian Ocean. Such warming is observed to peak in boreal summer during peak monsoon months. A simultaneous cooling of western Indian Ocean SST by a strong cross-equatorial monsoonal flow associated with a strong monsoon can thus cause peak IOD conditions during summer, further complicating the non-linear IOD-monsoon association's prediction. Long-lead forecasts of tropical Pacific conditions are more skillful than IOD. Better simulation of such association in dynamical models will improve the long-lead forecasts of the Indian Monsoon. The frequency of consecutive La-Nina events is projected to increase in a warming world, which can intensify negative IOD type conditions, therefore, compounding the climate risk associated with such extreme events.

Keywords: Indian Ocean Dipole, La-Nina, Indian Monsoon, Long-range forecasting

HYDRO-METEOROLOGICAL ASPECTS OF CLIMATE CHANGE ON WATER RESOURCES: ISSUE OF CONCERN AND EXTREME FLOOD EVENTS

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ABSTRACT

Recent years have seen an increase in global average air temperature as documented by the latest report of Intergovernmental Panel on Climate Change (IPCC, 2023), which clarifies that there's more than 50% chance that global temperature rise will reach or surpass 1.5°C (2.7°F) between 2021 and 2040. Thus, climate change have emerged as a matter of grave concern to water managers and resulted as serious consequences in respect of spatial and temporal distribution of water resources due to disruption in the natural hydrological cycle and erratic rainfall pattern. Moreover, this will also aggravate further in terms of increasing demand for water and energy, changing agricultural practices and increasing industrial activities as well as more extreme flood events in future which would require proper mitigation strategies and assessment accordingly.

Most important part is that flooding pattern is now shifting to driest part of the country due to changing rainfall pattern and since management of Hydrometeorological disasters are challenging task, a composite effort provides opportunity to deal with the situation. Therefore, understanding the possible impacts of climate change on water resources is of utmost importance for ensuring its appropriate management and utilization. This presentation briefly describes study of climate change on water resources for policies and scenario to reduce the negative impacts of climatic change on the water resources and natural environment.

Keywords: IPCC, climate change, Hydrometeorological disasters, water resources

VARIABILITY IN SNOW AND POTENTIAL IMPACT ON THE INDIAN SUMMER MONSOON

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ABSTRACT

Apart from sea surface temperature the other slowly varying boundary condition that governs the Indian Summer Monsoon Rainfall (ISMR) variability is snow cover. The seminal roles of Eurasian Snow (ES) and Himalayan Snow (HS) in the ISMR variability on sub-seasonal and interannual time scales through teleconnections is well documented. However, not much is known about the potential changing relationships between ES, HS and ISMR. The primary reason for that is the lack of long-term in-situ data over these regions which leads to uncertainty in the representation of such processes and teleconnections in climate models. This study presents an in-depth investigation of the biases in the representation of cryospheric processes and the teleconnections in different model-based datasets based on validation against available satellite observations. It is revealed that there is great amount of difference in the representation of the seasonal cycle of snow cover and associated other parameters in model-based data, thus revealing their deficiencies. Snow cover and other associated variables in the model-based data are depleted too early or too late compared to observations. Also, the quantity of monthly mean model-based snow is often much less or the monthly interannual variability is hugely different compared to observations. As a result of these differences the potential teleconnections are falsely represented in state-of-the-art climate models and disables the capacity to accurately represent the impact on sub-seasonal and seasonal time scales. Furthermore, through a decomposition of the snow variables into the fundamental modes of variability and an analysis of long-term trends in snow and the ISMR an attempt is made to quantify the unexplained part of the interannual variability and propose new mechanisms. The first author thankfully acknowledges the support given the UGC, Government of India in the form of research fellowship. The second author gratefully acknowledges the financial support and research infrastructure provided as a Seed Grant under the Institute of Eminence scheme of the Banaras Hindu University.

Keywords: Monsoon, precipitation, snow, sub-seasonal variability, interannual variability, teleconnections

IMPROVING IMDAA REANALYSIS MAXIMUM AND MINIMUM TEMPERATURES WITH MACHINE LEARNING TECHNIQUES

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ABSTRACT

Recent global surface temperature trends have revealed a significant increase in extreme heat events, emphasizing the urgent need for more accurate predictive models. In India, the average temperature rose by 0.88°C between 2000 and 2021, leading to a 27% increase in heat-related mortality and a 24% rise in heatwaves, making them the second deadliest natural disaster in the country.

The Indian Monsoon Data Assimilation and Analysis (IMDAA) is the first high-resolution regional reanalysis of the Indian subcontinent. This initiative, developed through collaboration between the National Centre for Medium Range Weather Forecasting, the Met Office (UK), and the India Meteorological Department, is part of the National Monsoon Mission under the Ministry of Earth Sciences, Government of India. The reanalysis covers the period from 1979 to 2020, aligning with the modern satellite era. However, IMDAA exhibits a warm bias of around 1°C in extreme temperature measurements, highlighting the need for bias correction.

This study employs advanced machine learning (ML) techniques—support vector machines (SVM), random forests (RF), gradient boosting machines (GBM), and multiple linear regression (MLR)—to model and forecast maximum and minimum temperatures across various regions of India. The models were trained on temperature data, with predictors including 6-hourly rainfall, cloud cover, relative humidity, and 10-meter wind speed during the pre-monsoon months (March, April, May, and June; MAMJ) for 1979–2018, and tested on data from 2019–2020. Our analysis of heatwave patterns from 2000 to 2022 shows a marked increase in extreme events, particularly between 2010 and 2020, driven by factors like climate change and rapid urbanization. Traditional numerical weather prediction (NWP) models have struggled to accurately forecast these extremes.

We applied ML techniques to correct the biases in the IMDAA reanalysis of maximum and minimum temperatures, significantly improving prediction accuracy. The GBM and SVM models performed exceptionally well, reducing root mean squared errors (RMSE) substantially. GBM was particularly effective in forecasting maximum temperatures, while SVM excelled in predicting minimum temperatures—except in Hyderabad, where RF outperformed other methods for both extremes. Across all stations, the RMSE improvements ranged from 15% to 65% for maximum temperatures and 15% to 80% for minimum temperatures, though some challenges remained when compared to other techniques.

Keywords: 1. Extreme heat events, Temperature forecasting, Indian Monsoon Data Assimilation and Analysis (IMDAA), Machine learning, Bias correction, Heatwave patterns

SEISMIC SIGNATURES OF CYCLONE COOK

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ABSTRACT

Abstract. Seismograms have been used for many years for analyzing Earthquakes, but Earthquakes appear only as a small portion of the continuous seismic signal. The availability of advanced hardware and software facilities enabled the analysis of seismic noise/ground vibrations, generated by floods, landslides, rockslides, debris flow and volcanic eruptions etc. Here, an attempt has been made to unveil the spectral characteristics of seismic signals generated by "Cyclone Cook", a tropical cyclone formed in the southwestern Pacific Ocean near Vanuatu Islands on April 8, 2017. It travelled in the south-southeast direction with a maximum wind speed of 160km/hr and made landfall in New Caledonia an island in the South Pacific on 9th April 2017. Heavy rainfall and floods occurred in New Caledonia due to the tropical cyclone on 9th and 10th April 2017. The changes in the spectral content of long-period continuous seismic record of nearly 6 days i.e., 7 th April to 13th April 2017 was analyzed to identify the spectral features of Cyclone generated signal at stations situated region. Interestingly, apart from the the intensification of power in the secondary microseism band (~7 sec period), we have noticed large power at period ~3-4 seconds. This specific spectral band is visible from 9th April to 11th April with a strong peak on 10th April. The energy of this band is completely disappeared on 12th April. In addition to the intensification of secondary microseism signal power, it is inferred here that the cyclone Cook has generated characteristic signals at period ~3-4 seconds. Keywords: Seismic Signatures, Cyclone Cook, Spectral Characteristics, Floods, Seismic Record, Long-Period, Microseism Signal

PERFORMANCE OF COUPLED ATMOSPHERE OCEAN MODELLING SYSTEM FOR SIMULATION OF SUPER CYCLONIC STORM KYARR OVER THE ARABIAN SEA

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ABSTRACT

The present study examines the performance of high resolution WRF modeling system coupled with 3D Price-Weller-Pinkel (PWP) ocean model in a Gray zone scale for simulation of super cyclonic storm Kyarr that developed over the Arabian Sea during October 2019. In the study an Advanced Research version of WRF (ARW) model is used for simulations. The model initial and lateral boundary conditions derived from the FNL analysis and integration is considered up to 1 – 2 weeks before the landfall using a double nested domains 15 km and 3 km. The initial conditions for the model was improved through three dimensional data assimilation technique. The model performance was evaluated by using 3 km results and compared with available observational datasets namely best fit data from the Indian Metrological Department (IMD) and CIRA - Cooperative Institute for Research in the Atmosphere. The accumulated rainfall for model simulations are compared with TRMM rainfall. The statistical analysis was also conducted in this study in terms of bias, mean error, and standard deviation, and it exhibited the significance and importance of the prediction of super cyclone.

Keywords: WRF, PWP model, Super cyclonic storm Kyarr, WRF, Arabian Sea

CLIMATE CHANGE IMPACT ON RICE PRODUCTION IN THE UPPER-GANGETIC PLAIN: ADAPTIVE SOLUTIONS

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ABSTRACT

Assessing climate change impact on crop production is essential for ensuring the sustainability of global food systems. This study examines how climate change affects rice yields in the Upper-Gangetic Plain, utilizing the CERES-Rice model alongside high-resolution climate projections from Global Climate Models (GCMs) for the mid-future (2040–2069) and far-future (2070–2099) under SSP2-4.5 and SSP5-8.5 emission scenarios. The results show yield reductions driven by shifts in crop phenology, with losses ranging from 7.5% to 16% in the mid-future. To mitigate these negative impacts, adjusting sowing dates is explored as an adaptation strategy. Simulations indicate that delaying planting to late July or early August can help minimize yield losses by synchronizing crop development with changing climate conditions. The study reveals varying impacts across seasons, with the early and mid-season planting experiencing the most substantial yield reductions. However, the late season shows potential for slight yield increases. Far-future projections under the SSP5-8.5 scenario suggest modest yield gains, with similar slight increases under the SSP2-4.5 scenario. These findings highlight the critical role of targeted adaptation measures, such as adjusting sowing dates, in enhancing rice production resilience. By strategically planning planting schedules, farmers can optimize yields and bolster food security in response to climate change.

Keywords: CERES Model, CMIP6, Elevated temperature, CO_2, Climate Change

HYDROLOGICAL INFLUENCES ON EARTHQUAKE EVENTS IN THE KOYNA RIVER BASIN, WESTERN INDIA

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ABSTRACT

The Koyna region of relatively stable peninsular India presents a unique case where earthquake (EQ) activity has persisted for over five and a half decades, reportedly initiated by the impoundment of Koyna reservoir in 1961. The significant Koyna earthquake of December 10, 1967 (M_L:6.3) is the largest reservoir-associated earthquake ever recorded globally, and the ongoing seismic events in this area are classified as reservoir-triggered earthquakes. In such instances, both tectonic stress and hydrodynamic factors play crucial roles. This article examines the hydrodynamic influences on the EQ events in the Koyna basin, utilizing satellite-based observation, GLDAS-2.2, and in-situ data, along with an analysis of EQ events ($M_L \geq 2.0$) that occurred from August 2005 to December 2017.

The results reveal approximately 167 events in the Koyna region (area: 1884 km^2), with an average focal depth of 7.4 km (range: 1.5-13.0 km). The frequency trend of EQ events remained relatively

stable until 2009, with an average focal depth of ~7.0 km. Subsequently, the frequency increased, with an average focal depth of ~7.7 km, although seismic activity notably declined in the adjacent Warna river basin. Monitoring shallow well hydrograph indicates a rising groundwater level in the Koyna basin. A comparative analysis of rainfall, terrestrial water storage (TWS), evapotranspiration (ET), soil moisture (SM), and river discharge in relation to the EQ events shows a slight upward trend in rainfall, particularly in the north-western part of the basin, which is predominantly forest (~49% of total area, 923 km^2). This region contributes to an estimated 25.6% of monsoon rainfall recharge, estimated using an interaction-based model between rainfall and groundwater levels. It suggests that the natural groundwater reserves in this basin are comparatively higher due to extensive forest cover, which increased hydrological loads, and may induce the EQ events. Conversely, TWS anomalies in the Koyna basin have significantly increased compared to the Warna basin since 2009, potentially correlating with heightened EQ occurrences in Koyna. Similarly, anomalies in ET and SM indicate an increase in ET, along with a rise in SM anomalies (to a depth of 200 cm) during the same period. This suggests a possible impact of hydrological loads on the EQ events. Additionally, the Koyna river stage has risen significantly after 2009, indicating as accumulation of surface water due to increasing rainfall and natural recharge in the Koyna basin.

Keywords: *Earthquakes, groundwater level and satellite-based data, river discharge, hydrological loads, Koyna basin, Western India.*

INTEGRATIVE ASSESSMENT OF AIRBORNE HYPERSPECTRAL, GROUND GRAVITY, AND MAGNETIC DATA FOR BASE METAL MAPPING IN ZAWAR, RAJASTHAN, INDIA

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ABSTRACT

This study utilizes the spectral bands of the Airborne Visible InfraRed Imaging Spectrometer-Next Generation (AVIRIS-NG) sensor to investigate potential zones of base metal mineralization within the Zawar area of Rajasthan, Western India. We updated the lithological boundaries of dolomitic rock, a key host for base-metal mineralization, using AVIRIS-NG images processed through principal component and minimum noise fraction analyses. Match filtering (MF) and constrained energy minimization (CEM) techniques were then applied within these dolomitic boundaries to map ore-bearing dolomite regions, by utilizing their AVIRIS-NG resampled laboratory spectra as endmember. The resulting independent maps from the above methods were subsequently integrated using principal component transformation (PCT) to identify commonalities and thereby highlight prospective areas of base-metal mineralization.

Additionally, lineaments were demarcated through analysis of AVIRIS-NG false colour composite images and geophysical data, including tilt derivative, horizontal gradient from gravity and magnetic data, to elucidate geological structures controlling mineralization. The orientation analysis revealed predominant lineament trends in the E-W and N-S directions. A lineament density map was constructed by integrating lineament data from AVIRIS-NG, gravity, and magnetic sources. The overlap between mineralized zones and high lineament density areas was identified as highly prospective for base-metal mineralization, a conclusion validated by known mineralization and mining locations.

Further analysis of residual anomaly maps derived from bouguer gravity and magnetic data indicated base-metal mineralization primarily occurring along contact boundaries with medium-to-low values and at shallow depths (< 500m) as determined by the source parameter index (SPI). By leveraging the complementary strengths of multiple geoscientific data, this study aims to contribute to the development of robust mineral mapping techniques and support sustainable resource utilization practices in the Zawar region and beyond.

Keywords: Airborne Hyperspectral AVIRIS-NG, Residual Anomaly, Edge Detection techniques, Base Metal, Spectral mapping.

TRACING EVOLUTION OF TROPICAL HIGHSTAND REEFS IN INDIAN SEAS (TETHIS)

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ABSTRACT

Current and future changes affecting climate and ocean systems evoke tremendous challenges for human society with the future rising and accelerating sea level being one of the most critical issues. Nonetheless, we are still facing considerable uncertainties regarding the vulnerability and sensitivity of ice sheets to global warming and the subsequent rise in sea level. The investigation of sea level evolution during past periods of rapid global warming (i.e. rapid sea-level rise) and warmer-than-present conditions (i.e. higher than present sea level) has the potential to extend our current understanding of the involved processes, and thus to provide urgently needed data to feed climate simulation models aiming to frame the rise of sea level in the future.

Shallow-water reefs provide reliable geological estimates of the past relative sea level because biological reef communities live in a sufficiently narrow or specific depth range, and can be used as an absolute sea-level indicator. Furthermore, the potential of coral reefs to be accurately dated enables the establishment of detailed records with timing and amplitude of sea-level variations on a wide range of frequencies ranging from individual seasons to thousands of years. The technological progress in drilling capabilities and radiometric dating techniques over the last 40 years have provided the opportunity to document continuous coral reef records. These records are the window of opportunity to examine sea-level fluctuations and reef accretion rates on various time scales, mostly related to highstands and the late stages of glacial-interglacial transitions. The overall objective of the TETHIS project is to drill into Paleocene to Late Quaternary drowned tropical coral reefs located along the Lakshadweep Ridge (offshore India) and around the Eparses islands (offshore France), in order to analyse past sea-level and environmental changes in the West Indian Ocean. This region is specifically well-suited for the reconstruction of glacial-eustatic sea-level changes due to its great distance ("far-field") to former polar ice sheets.

Combining the results from coral reef terraces which have been drowned at different geological periods in both offshore India and French waters, this collaborative project will provide new comprehensive and accurate records of sea-level, environmental and climatic changes at various time scales. Additional information provided by the study these tropical reef systems will foster our understanding of the link between sea level, atmospheric CO2 contents and warmer climates, during periods marked by higher-than-present sea levels.

CLIMATE EXTREME EVENTS IMPACTS ON FUTURE SOCIO-ECONOMIC SECTORS USING CMIP6 DATA, EAST COAST OF INDIA

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ABSTRACT

Climate extreme events are often impacting the recent world to climate change however regional scale impact is very devasting. To identify the impact of climate extreme events on future socio-economic sector this study used CMIP6 global climate model data in the eastern coast of India. Seven CMIP6 global climate model data was obtain from Copernicus climate data store(ccds) and future socio-economic data took from Tingting wang & fubao sun paper for the two SSPs scenario (SSP2-4.5 & SSP5-8.5) on the basis of resolution. The expert team on climate change detection and indices (ETCCDI) defined indices methodology was used for this study to calculation consecutive dry day (cdd) consecutive wet day (cwd), summer day (su), maximum 5-day precipitation (Rx5Day), warm day (TX90p), very heavy precipitation day (R20mm) to analysis the climate extreme events impacts on socio-economic sector. The result found climate extreme events are fluctuating in the coastal India and its direct impact on socio-economic sector for the two SSPs scenario. Nonetheless, appropriate sustainable development will lessen future climatic extreme events and their effects on the socioeconomic sector to adopt with changing climate.

Keywords: Climate extreme events, adaptation, socio-economic sector, CMIP6, east coast of India

ESTIMATING THE CLIMATE CHANGE STATUS OF THE DISTRICTS OF GANGETIC PLAIN

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ABSTRACT

Climate change is a major global issue that affects the economy, environment, and health systems of nations, with especially strong effects at regional levels. Understanding these impacts at regional scales is crucial for developing adaptation strategies, particularly in the Gangetic Plain (GP), a region known for its fertile soil and high population density. This study evaluates climate change exposure across the GP from 1994 to 2023, focusing on identifying priority districts. Using the Climate Change Variability Index (CCVI) and incorporating 21 variables, the study categorizes highly exposed districts through a weighted sum approach (WSA). A multicollinearity test was applied to ensure the suitability of the variables. The CCVI for each district was determined by averaging normalized value of variables. Results show that districts in the Upper Gangetic Plain (UGP) and Middle Gangetic Plain (MGP) are more exposed (0.38 to 0.52) compared to those in the Lower Gangetic Plain (LGP) (0.29 to 0.38). The higher exposure in UGP and MGP districts is due to factors such as deviations in maximum and minimum temperatures, trends in air temperature, frequency of cold and hot days, heatwaves, severe heatwaves, as well as occurrences of excess and deficient rainfall, simple daily intensity index, and consecutive dry days. Based on the CCVI and WSA derived from this assessment, districts of UGP (i.e., Ghaziabad, Gautam Budh Nagar, Muzaffarnagar, and Shamli etc.) are identified as priority districts for adaptation planning. The identification of climate change

exposed districts will enable policymakers to allocate resources strategically, fostering long-term resilience to climate change.

PREDICTION OF AIR TEMPERATURE OVER INDIAN DOMAIN THROUGH VARIOUS ML MODELS

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ABSTRACT

This study presents a comprehensive evaluation of temperature prediction models over India, utilizing five machine learning (ML) techniques: Linear Regression (LR), Decision Tree (DT), Gradient Boosting, K-Nearest Neighbors (KNN), and Extreme Gradient Boosting (XGBoost). The analysis focuses on temperature anomalies from January 2018 to December 2022 across three regions: North India, Central India, and South India. Detailed time series plots demonstrate XGBoost and KNN models' superior accuracy in tracking actual temperature anomalies, particularly during periods of high fluctuation. Error metrics, including mean absolute error (MAE) and root mean square error (RMSE), reveal significant differences in model performance, with XGBoost achieving the lowest errors and highest predictive accuracy. The kernel density estimate (KDE) plots further corroborate these findings, indicating that XGBoost and KNN provide the most accurate and consistent temperature predictions. These results underscore the efficacy of XGBoost and KNN models in climate data analysis, highlighting their potential for reliable temperature prediction in the India region.

AEROSOL OVER THE NORTHERN INDIAN OCEAN: VARIABILITY AND CLIMATE CONSEQUENCES

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ABSTRACT

Atmospheric aerosols are crucial pollutants that profoundly affect the Earth's climate system through various pathways. The Northern Indian Ocean (NIO) exhibits considerable heterogeneity in aerosol loading, both spatially and temporally driven by continental outflow from nearby arid and semi-arid regions, primarily influenced by wind circulation patterns. Thus, to assess the spatial and temporal variability, trends in aerosols, and their interaction with cloud under different meteorological conditions, long-term aerosol, cloud and meteorological dataset from multiple sources (such as MODIS, MERRA, and ERA-5) has been analysed. An upward trend in Aerosol Optical Depth (AOD) has been observed over the NIO, especially in coastal areas, which is supported by MERRA-2 data showing a rising trend in black carbon (BC) concentration (up to 0.07 $\mu g\ m^{-3}$ per year), indicating a significant contribution from anthropogenic emissions, as further confirmed by five days air-mass back trajectories. An anti-Twomey effect is noted year-round for shallow warm clouds with low liquid water paths (LWP < 70 gm^{-2}), with a distinct Twomey effect occurring during the summer

monsoon. Sensitivity analyses indicate that warm clouds show a positive sensitivity (approximately 0.02 – 0.06) to changes in aerosol index (AI) across the study region. Additionally, basin-wise radiative forcing due to aerosol-cloud interactions reveals that the radiative forcing (RF_{aci}) is higher over the Bay of Bengal (-0.48 ± 0.52 W/m²), compared to the Arabian Sea (-0.41 ± 0.37 W/m²). Further details regarding aerosols, their interactions with clouds, and their radiative impacts will be discussed at the conference.

Keywords: Aerosol, Cloud, Northern Indian Ocean, Anthropogenic Emission, Climate Change

ASSIMILATION OF MICROWAVE IMAGER RADIANCE DATA USING NCUM-R MODEL: SIMULATION OF TROPICAL CYCLONES OVER THE BAY OF BENGAL

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ABSTRACT

An attempt is made to investigate the effects of assimilation of Microwave Imager (MI) radiance observations on simulation of Tropical Cyclones (TCs) using the high resolution 4DVar assimilation technique over Bay of Bengal. Assimilation of GTS observations (CTL) and satellite radiance (SAT) (assimilation of GTS plus GMI and SSMIS, MI radiance) were the two sets of numerical experiments that were conducted. It has been observed that integrating MI radiation can well represent storm structure, trajectory, and intensity. The analysis of temperature and geopotential height increases shown that the SAT experiment may successfully alter the core region of TCs and systematically adjust the position in the model's first approximation. With the axisymmetric eye of TCs, the SAT accurately simulates the strength of large-scale moisture transport from the underlying marine surface as well as the helicity around storms. While the evolution of storm intensity is quite effectively recorded in the SAT experiment, the premature intensification of TCs is reproduced by CTL. The CTL simulations clearly show that the energy cycle can be disrupted by dry air penetrating the inner core of the TC, resulting in a decrease in storm intensity. In CTL simulations, the intensity of TC is hindered by the -ve value of diabatic heating that appears around the storm's centre as altitude increases. This aspect made it very evident that CTL simulations are not accurately capturing the intensity and vertical organization of the TCs. In comparison to CTL, the track forecast of storms is significantly better in SAT simulations. In SAT simulations, the rainfall forecasting accuracy has also improved. The model's ability to anticipate storm structure, velocity, severity, and precipitation are improved overall by the integration of MI radiances.

Keywords: Microwave Imager, 4D-Var Assimilation, NCUM regional Model, Tropical cyclone

ON UNDERSTANDING INDIA'S BIOSPHERIC CARBON SINK POTENTIAL WITH CHANGING CLIMATE

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ABSTRACT

As concerns about global warming and greenhouse gas emissions grow, this study looks at how carbon dioxide (CO_2) is being absorbed by plants and ecosystems in India, focusing on a process called Gross Primary Productivity (GPP). About 30% of CO_2 emissions caused by human activity are absorbed by forests and other land areas. This research explores how changes in land use, climate, and weather conditions affect how much CO_2 plants can absorb.

The study uses FLUXCOM and climate models simulation in the recent past to future period to analyze both past and future CO_2 absorption trends in India, a country especially vulnerable to climate change. Recent data show that the ability of plants in India to absorb atmospheric CO_2 in the form of primary productivity (GPP) has increased. Recent past data from the FLUXCOM experiment shows regional disparity in selected locations of India, while the historical data of CMIP models show an annual GPP growth of 2.37 gC m² per year. The future projections under high emissions scenarios suggest this could rise to about 6 gC m² per year. However, this trend is not uniform across India. Areas like the Northeast, Indo-Gangetic Plains, and Western Ghats are seeing the biggest increases, while some southern regions show little or no growth in the future.

The study also looks at how changes in land use—such as forest loss or crop expansion—affect CO_2 absorption. Additionally, climate models predict that more rainfall could further impact GPP trends. This research helps improve our understanding of how India's ecosystems are responding to climate change, and it emphasizes the need to use real-world data to make climate models more accurate for future predictions.

Keywords: Climate change scenarios; Gross Primary Productivity, CMIP models, Indian region, terrestrial biosphere

INVESTIGATION OF POTENTIAL MECHANISMS OF CHANGES IN INDIAN SUMMER MONSOON RAINFALL

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ABSTRACT

The seasonal cycle and vagaries of the Indian Summer Monsoon Rainfall (ISMR) in the form of floods and droughts on intraseasonal to seasonal time scales adversely impact the country's agricultural and water resources. A better understanding and representation of the physical processes in state-of-the-art Earth System models is highly needed to enhance their capability to simulate the summer monsoon climate to be able to generate more accurate future projections. The accurate representation of different feedbacks, both local and remote in state-of-the-earth climate models remains one of the key challenges to the reduction of errors in precipitation. In this study, multi-

decade simulations of the state-of-the-art NCAR Community Earth System Model v2.2.0 (CESM2.2.0) model with prescribed SST and irrigation activity are evaluated to its fidelity in terms of simulation of the annual cycle, the long-term mean and variabilities of the ISMR on different time scales. An important hypothesis that is proposed by earlier studies and tested through these simulations is the impact of changing ocean-atmosphere and land-atmosphere interactions in the spatio-temporal changes in ISMR in the recent few decades. It is noted that the lack of ocean-atmosphere interactions does indeed contribute partly to the changing rainfall characteristics over the Indian region. Furthermore, it is also revealed that through the inaccuracies in the representation of irrigation practices in the model its potential role in the changing rainfall characteristics is emphasized. To further test these inferences, additional simulations with the CESM2 model with modifications to the model physics and also seasonal simulations with the NCEP CFSv2 operational model are analyzed which lead us to intriguing results. It is inferred that not only the changes in regional SSTs but anthropogenic practices such as irrigation and associated feedbacks may also had played a role in the changing characteristics of ISMR.. The authors gratefully acknowledge the financial support from the Anusandhan National Research Foundation, Government of India and the Earth System Science Organization, Ministry of Earth Sciences, Government of India to conduct this research. The first author also gratefully acknowledges the infrastructural and financial support in the form of a Seed Grant under the Institute of Eminence scheme of Banaras Hindu University to perform this research.

Keywords: Monsoon, precipitation, SST, irrigation, non-linear feedback, climate modeling

METHODS OF REMOTE SENSING TO IDENTIFY THE ACOUSTIC GRAVITY AND SEIMO-ELECTROMAGNETIC WAVES ANOMALIES FOR EARTHQUAKE PRECURSORS

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ABSTRACT

Earthquakes occurs on faults of temblors tend to generate damage, high frequency Acoustic Gravity Waves (AGW) are associated with the roughness of the fault zone. AGW are modulated into the upper atmosphere through generation from various sources, propagation influenced by atmospheric conditions and interaction with different layers of the atmosphere. Other than this, due to piezo-electric effect where rocks under stress emit Seismo-Electromagnetic signal (Waves) SEW. Both the waves interact under certain condition as results many physical and chemical changes take place on earth. In the present research Remote Sensing techniques for detection of AGW/SEW by using various satellite data with inbuilt specialized sensors to developed multi-paramteric monitoring system for earthquake precursors studies.

Keywords: - Acoustic Gravity Waves, Seismo-Electromagnetic Waves, Modulation, Remote Sensing Techniques, Earthquake Precursors

SOLID EARTH GEOSCIENCES

ISOSTASY, CRUSTAL MOVEMENTS AND SEISMIC ACTIVITIES IN LESSER HIMALAYA

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ABSTRACT

If the Earth were an ideal homogeneous spheroid, the gravitational force everywhere on its surface would be same. Any departure from this homogeneity will set in hydrostatic inequilibrium. Consequently, the Earth processes are continuously at work to attain equilibrium as evidenced by erosion, uplift, subsidence and other geological features. These vertical crustal movements often find expressions in isostatic gravity anomalies. Lesser Himalaya offers an excellent example to illustrate this correspondence, where the geodetic measurements along three profiles, (i) Pathankot-Dalhousie levelling line in Punjab Himalaya, (ii) Saharanpur-Dehradun-Mussorie levelling line in Kumaun Himalaya, and (iii) the eastern-most Indo-Nepal leveling line in Nepal Himalaya, are available. Therefore, the gravity data of this region has been analyzed, wherein the isostatic gravity anomaly deduced by Finite Element Method, clearly demarcates the uplift and subsidence zones. Interestingly, it is observed that the general trend along the Pathankot-Dalhousie levelling line showing uplift, is in good correspondence to negative isostatic anomalies. Similarly, along Saharanpur-Dehradun-Mussorie levelling line, the isostatic anomaly north of Dehradun up to MCT, shows a positive trend which corresponds to decrease in elevation. Another important observation of this study is, 1991 Uttarkashi and 1999 Chamoli earthquakes nearer to Main Central Thrust (MCT) and 1986 Dharmashala and 1905 Kangra earthquakes nearer to Main Boundary Thrust (MBT) occurred in the inflexion zones, that is, the cross-over corridor of positive to negative isostatic anomalies. Any tectonic disturbance in such transition zones may sets off large inequillibrium triggering Earth tremors.

DETRITAL ZIRCON ISOTOPIC (U–PB, LU–HF AND O) STUDY OF BARAIL SANDSTONE OF UKHRUL DISTRICT, MANIPUR: IMPLICATION FOR THE PROVENANCE

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ABSTRACT

The Manipur hills of the Indo-Myanmar Range (IMR) have a distinct entity for collision between the Indian and the Myanmar Plates. Detrital zircon isotopic (U–Pb, Lu–Hf and O) study of the Barail sandstone of Ukhrul District, Manipur, is carried out to decipher the provenance, changing geotectonic settings and the probable time constraint on the processes. The studied sample is texturally and mineralogically immature, with probable sources as acidic and metamorphic rock. Zircon U–Pb ages show a wide spectrum ranging from 3001 to 46 Ma with two distinct age populations, an older ranging between 3001 to 500 Ma and a younger between 127 to 46 Ma. The εHf(t) values of the older range between −7 to +13.9, both the rework crust and juvenile nature of the

older source, while the younger group shows a juvenile source (εHf between +6.1 to +13.9). The $\delta^{18}O$ (‰) values ranging between 3.9 to 13.8 imply that the studied zircons have a mixture of mantle-derived and a large degree of partial melting or contamination of crustal materials. The present study shows that the Barail Group sandstone was sourced from multiple rock types, varying ages from Mesoarchaean to early Cenozoic. Implications of these findings on the tectonic evolution of the IMR are discussed.

DEEP LEARNING INVERSION OF ELECTRICAL AND ELECTROMAGNETIC DATASETS

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ABSTRACT

In recent years, machine learning and deep learning techniques have increasingly been utilized to extract patterns and gain insights from geoscience datasets, offering transformative potential for solving complex, nonlinear problems in Earth system science. This work explores the application of deep learning algorithms for the inversion of electrical resistivity and electromagnetic (EM) data, particularly focusing on Electrical Resistivity Tomography (ERT) and Magnetotelluric (MT) datasets.

We investigate the integration of geoscientific contextual cues into deep learning models to enhance predictive capabilities in subsurface resistivity mapping. Specifically, we employ a Variational Encoder-Decoder (VED) network to invert ERT data, leveraging multi-array configurations such as Wenner and gradient arrays to generate more accurate resistivity models. By simulating numerous synthetic models, we train the deep learning network to map apparent resistivity data to true subsurface resistivity. A novel approach using a combination of cGAN-based networks further improves inversion accuracy by fusing data from different array configurations.

In the context of Magnetotellurics (MT), a Multi-Input VED and cGAN-based architecture is proposed to address the nonlinear and ill-posed nature of the inversion process. This method enhances the resolution of subsurface conductivity models, outperforming traditional iterative approaches. This work emphasizes the growing importance of deep learning in geophysical inversion, highlighting its ability to provide detailed, high-resolution resistivity models that can significantly improve Earth subsurface characterization.

Keywords: Deep Learning Inversion; Electrical Resistivity Tomography (ERT); Magnetotellurics (MT); Geophysical Data Modeling

DEPTH TO BOTTOM OF MAGNETIC SOURCES AND HEAT FLUX OVER INDIAN SUB-CONTINENT FROM SATELLITE MAGNETIC DATA

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ABSTRACT

Depth to the bottom of the magnetic sources (DBMS) over the Indian sub-continent were computed from satellite magnetic anomalies employing the equivalent source dipole method. The computed DBMS was found to be relatively shallower over the mobile belts than the cratonic regions. DBMS

can either represent the Curie isotherm depth or a petrological boundary. Where the Curie depth correlates with an inferred velocity or density boundary, it is likely to reflect change in composition, however, where it does not coincide with velocity or density boundary, it may be interpreted as Cuire temperature isotherm. On comparison with the available DSS profiles, we infer that in most of the regions the DBMS represent the Curie isotherm rather than petrological boundary. Curie point depends upon the Curie temperature of 550 – 580°C at which Fe- Ti oxide minerals lose their ferromagnetic property and is reasonable to assume that the lithosphere is virtually non-magnetic below this depth. The remotely sensed magnetic measurements can thus indirectly provide information of temperature at depth within the lower crust that in turn can be translated to give temperature gradients of the region. The heat-flux over the Indian sub-continent was then computed utilizing the Curie isotherm depths, assuming 1D heat conduction, steady state thermal model for the continental crust incorporating available values of thermal conductivity, heat production etc. Computations were made with and without including the heat production term. From the computed heat flow values, we find that by and large the low heat flow zones correspond to the cratonic regions while the high heat flow zones are associated with the mobile belts, Mesozoic sedimentary basins and collision zones. The calculated heat flow values were compared with the available surface heat flow measurements over different tectonic blocks. The results of these will be presented.

INTEGRATED GEOPHYSICAL APPRAISAL OF CRUSTAL CONFIGURATION BELOW CENTRAL PART OF THE EASTERN GHATS MOBILE BELT, INDIA AND ITS IMPLICATION TOWARDS NON-VOLCANIC GEOTHERMAL SPRINGS

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ABSTRACT

The Eastern Ghats mobile belt (EGMB) is a complex orogenic belt, that accommodates several non-volcanic geothermal springs, within Odisha, India. In the present work, acquired local integrated geophysical data and available global gravity-magnetic grid data are utilised in deciphering crustal setup and the thermal regime of the central part of EGMB, hosting four non-volcanic hot springs, namely, Atri, Tarabalo, Deulajhari, and Taptapani, thereby in developing a comprehensive understanding about the evolution of the non-volcanic geothermal system in the stable continental region. Localized integrated geophysical investigation around the hot springs have effectively delineated the near-surface structural settings of these regions (e.g., faults, fracture network etc.). Coincidence of low magnetic anomalies, and low resistivity (or high current density) values at same location indicate the existence of shallow subsurface alteration/fracture zones that controls the flow of geothermal fluids. Regional scale investigations based on global gravity-magnetic data has delineated the deeper structural features and their effect on the geothermal activities of the region. Spectral analysis of magnetic data, heat flow values due to radiogenic crustal elements, and 3D gravity inversion for Moho depth provided a better understanding of the variation of thermal structure (e.g., Curie point depth, heat flow, geothermal gradient) with crustal thickness (e.g., Moho surface) and their correlation with the locations of four hot springs in the study area. The observed Curie depth surface below the study area is shallower than the Moho interface obtained from the 3D inversion. The shallower CPD and higher heat flow correspond to the region encompassing Deulajhari, Atri, and Tarabalo hot springs, near the Mahanadi Shear zone. Presence of low resistive altered zones near to Tarabalo and Atri hot springs are also deciphered based on the local geophysical investigation. Thus, it can be inferred that the shear zone over this region possibly serves as the primary pathway for

thermally heated fluids to the hot springs from deeper sources through the near-surface radiogenic rocks and associated shallower altered zones. On the other hand, Taptapani hot spring lies in a relatively deeper CPD region with lower heat flow values, and the thermal water is probably transported from the nearby shear zone and associated fracture/fault systems from a plausible far-away heat source. Thus, the present study offers a better understanding of the thermal aspects for a part of the EGMB crust and their consequences on the geothermal setup of the study area.

INVERSION OF SELF-POTENTIAL ANOMALIES USING PHYSICS-INFORMED NEURAL NETWORKS FOR MINERAL INVESTIGATIONS

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ABSTRACT

The inversion of self-potential (SP) data is a critical technique for near-surface characterization, including mineral exploration, geothermal studies, and environmental monitoring. Traditional inversion techniques—such as metaheuristic algorithms—offer solutions but may suffer from local minima entrapment. This study introduces a deep-learning-based inversion framework leveraging Physics-Informed Neural Networks (PINNs) for efficient and geologically consistent SP data modeling. We incorporated Monte Carlo dropout to quantify the uncertainty of predictions. This framework can be applied to single and multiple source structures and solves for key subsurface parameters—depth to center, amplitude coefficient, origin location, geometric shape factor, and polarization angle in the restricted class of simple geometric shapes. The stability and efficiency of the proposed method have been examined by several synthetic examples. Multiple and intercalating causative sources were considered in the synthetic and real data cases. In addition, three different real field examples from Germany and India have been successfully applied to ore and mineral investigation and geological structure studies. In general, comparative analyses show that the PINN-based solutions align well with existing field data and literature, showing improved stability and interpretative clarity under noisy conditions and regional background effects.

A REVIEW OF THE MECHANISM OF CRUSTAL DEFORMATION IN GODAVARI FAILED RIFT, INDIA USING GPS MEASUREMENTS

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ABSTRACT

Compared to interplate earthquakes, intraplate earthquakes are not as frequent and large but are responsible for almost equal damage and casualties. The death toll from earthquakes in plate interiors is comparable due to high population density. Earthquakes in stable intraplate regions worldwide occur along the paleozoic failed rift zones. Kutch, Narmada-Son and Godavari are three prominent failed rift zones in India, these are seismically active and have experienced moderate to major earthquakes in the recent past.

Godavari failed Rift (GFR) experienced a moderate earthquake of magnitude M 5.7 in Bhadrachlam on 13th April 1969. To access GFR earthquake-generating potential, the GPS Group of CSIR-NGRI

initiated campaign mode GPS measurements in the year 20** in this region and established 15 sites across the failed rift. The velocity at each site was estimated. It was found that most sites across the failed rift document deformation at the rate of less than 1.5 mm/yr, comparable to the deformation rate of the Indian rigid plate. Two sites showed south-westward motion up to 3.3±0.5 mm/yr. Estimated results show that deformation in GFR is localized. The higher deformation in a few regions could be a result of the effect of pore fluid pressure induced by the past geological episodes of magmatism which may cause a decrease in strength or the deformation may also be ascribed to the mass heterogeneity. The regions with high deformation rates coincide with the relatively high-level low-magnitude seismicity and may imply the occurrence of moderate to large-magnitude earthquakes in GFR in the future. For more precise and accurate measurements of deformation, we have now established 9 permanent sites across GFR, this will allow us to estimate site velocity and internal deformation across the GFR in a more precise and reliable manner. We will model the results of deformation with several models that have been proposed to explain the occurrence of earthquakes in the stable continental and failed rift regions.

Key Words: Crustal deformation**,** Failed rift, GPS measurements

SEISMIC WAVE ATTENUATION AND CRUSTAL HETEROGENEITY ANALYSIS OF EARTHQUAKE SWARMS IN THE PALGHAR REGION, WESTERN INDIA

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The present study investigates the attenuation of seismic waves due to earthquake swarm activity in the Palghar region, located within the hard strata of the Deccan Traps in the Indian peninsula. A dense dataset, comprising 10,200 high-quality earthquake events with magnitudes ranging from $1.5 \leq ML \leq 4.5$, was utilized for the analysis. These events were recorded by six broadband seismic stations in the Palghar region from 2019 to 2022. Body wave attenuation parameters, Qp and Qs, were estimated for each station using the coda normalization method at five different central frequencies ranging from 1.5 to 18 Hz. The results indicate a strong attenuation of body waves in the medium. Spatial variations of Qp and Qs were also mapped to understand the attenuation characteristics below the Palghar region. The estimated Qs/Qp ratios were found to be greater than unity across all frequency ranges and at all stations, suggesting that the crustal structure in the study region is characterized by a high degree of heterogeneity. The obtained values of Q are consistent with those reported in other tectonic regions globally, highlighting the relevance of the findings to broader geophysical studies.

Keywords: Earthquake Swarm, Qp and Qs, Body Wave Attenuation

HYDROGEOCHEMICAL CHARACTERISCS AND IMPACT OF ACID MINE DRAINAGE ON GROUNDWATER RESOURCES IN A COAL MINING REGION OF EASTERN INDIA

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ABSTRACT
Groundwater resources in coal mining areas are known to be vulnerable to pollution and which may have a serious impact on the environment. Groundwater quality studies of coal mining areas are very important due to coal explorations, dumping of huge quantities of overburdens, and subsequently

mixing with the coal mine drainage areas. The objective of this study is to evaluate the major ions, trace elements, and the hydrogeochemical processes involved in the aquifer and also the possible influence of acid mine drainage (AMD), in the coal mining area. The major ions and trace elements concentrations in the groundwater samples were found to be below the permissible limits based on WHO guidelines and suitable for drinking water purposes. The piper diagram shows two major hydrochemical water types represented, such as Ca-Mg-Cl, and Ca-Mg-HCO_3 types. The geochemical evolution of groundwater chemistry is mainly controlled by the natural geochemical processes such as mineral dissolution, rock-water interactions, and mineral precipitation processes. Saturation index studies show that groundwater samples were near saturation to equilibrium conditions with the carbonate phase minerals of calcite ($CaCO_3$) and dolomite ($MgCa(CO_3)_2$); and undersaturated with gypsum ($CaSO_4 \cdot 2H_2O$), and anhydrite ($CaSO_4$) and also with secondary minerals of Fe and Mn of various phases. The heavy metal concentrations in groundwater as Fe, Zn, Al, Mn, Sr, Ni, Cu, Pb, V, Cr, Co, and Cd concentrations. The shorter residence times of groundwater in the bore wells, lower acid mine drainage generating conditions, and the impact of dilution during high base flows are diluting the coal mining drainage streams and making a negligible impact on acid mine drainage. The results from this research work will be helpful for monitoring, long-term protection, efficient management of water resources in the coal mining regions.

GLOBAL WARMING AND COOLING EVENTS IN THE PALEOGENE: EVIDENCE FROM THE SEDIMENTARY SEQUENCES OF WESTERN INDIA

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ABSTRACT

Cenozoic era was the turning point in the geological history of the Indian subcontinent when India experienced maximum isolation before it collided with Asia and there occurred a great mountain building activity shaping the Himalaya. In the Cenozoic era, the sedimentation commenced in the late Paleocene (~57.9 Ma) in the pericratonic basins of the western India as well as the foreland basin of the western Himalaya those mark the beginning of a major transgression on the Indian subcontinent. We studied Paleogene sequences of the Jaisalmer basin and Jammu-Shimla hills to recognize the evidences of major transgressions and regressions those are forced by major warming and cooling events. For this purpose, we recorded various sedimentary facies based on field and laboratory investigations, and analysed $\delta^{13}C$ and $\delta^{18}O$ on an Isotope Ratio Mass Spectrometer. In the Jaisalmer area, the Cretaceous limestone is directly overlain by the late Paleocene sandstone, whereas the late Paleocene succession occurs unconformably above the Precambrian limestone in the Jammu area. This suggests occurrence of a major transgression during late Paleocene in the Jaisalmer basin as well as the Jammu-Shimla hills. This is supported by a $\delta^{13}C$ and $\delta^{18}O$ excursion at this interval in both the areas. Another transgression occurred at the Paleocene–Eocene boundary with the accumulation of the fossiliferous limestones in many studied sections. We, further, recorded a $\delta^{13}C$ and $\delta^{18}O$ excursion at the Paleocene-Eocene boundary that marks another hyperthermal event in both the basins. It is interpreted that the primary driver for the late Paleocene transgression was the regional tectonics that marks the beginning of the India-Asia convergence. The second transgression has been global and influenced by the global warming at the Paleocene-Eocene Thermal Maximum (PETM). This transgression has been noticed even in the Paleogene sequences of the other continents. During latest Middle Eocene, the Jammu-Shimla hills reveals the presence of red-beds and pedogenic

horizons, including pedogenic calcretes. This succession possesses freshwater fauna, including mammals suggesting a change from marine condition to freshwater condition. Thus, a major regression occurred during latest middle Eocene (41.3-38.0 Ma) that corresponds to global sea-level fall. This regression is global and can be identified even in the Cenozoic basins developed within the African plate. It is interpreted that this regression was driven by the global cooling during latest middle Eocene/late Eocene possibly associated with the nucleation of the Antarctica ice-sheets coupled with the uplift of the Himalaya.

INVESTIGATION OF GROUNDWATER POTENTIAL ZONES IN HARD ROCK TERRAINS OF THE EASTERN GHAT MOBILE BELT, ANDHRA PRADESH, INDIA: INSIGHTS FROM REMOTE SENSING AND GEOELECTRICAL SURVEYS

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ABSTRACT

This research aims to identify groundwater potential zones in the Matchkund River catchment using a combination of geospatial analysis and geoelectrical resistivity surveys. The geospatial approach involves developing a Groundwater Potential Index (GWPI) model by integrating various thematic layers, including geology, geomorphology, slope, lineament density, drainage density, rainfall, land use land cover, and groundwater levels, weighted using the Analytical Hierarchy Process (AHP) in ArcGIS. The GWPI map classifies the study area into poor, moderate, and good potential zones. The good potential zones (12% of the total area, 96.82 km²) are primarily associated with khondalite and migmatite formations, low drainage density, and high lineament density, while the moderate potential zones (51.35%) are found in areas with moderate slopes and drainage density. Poor groundwater zones (36.57%) are characterized by high slopes, high drainage density, and less permeable soils. The second approach involved conducting 271 Vertical Electrical Soundings (VES) to generate spatial distribution maps of aquifer thickness, basement depth, hydraulic conductivity, and transmissivity. Aquifer thickness ranged from 0.012 to 66.3 meters, with thicker aquifers (>21.1 meters) found in the central and southwestern parts of the catchment. High transmissivity values (501–13,800 m²/day) were observed in areas with greater aquifer thickness and intersecting lineaments. These findings provide valuable insights into groundwater exploration, watershed management, and sustainable resource planning in the region.

Keywords: Groundwater Potential Index, Analytical Hierarchy Process, Vertical Electrical Soundings, hydraulic conductivity, Aquifer thickness, Aquifer transmissivity.

SEISMICITY AND FOCAL MECHANISM OF MICRO-EARTHQUAKES AROUND IDUKKI, MADUPETTY, PONMUDI AND IDAMALAYAR DAM SITES, IDUKKI AND ERNAKULAM DISTRICTS OF KERALA STATE

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ABSTRACT

The seismicity pattern, distribution of seismogenic sources and nature of faulting in and around Idukki and Ernakulam districts of Kerala State were investigated by conducting micro-earthquake (MEQ) studies. The micro-earthquake survey has been carried by establishing a temporary seismic network by deploying seven number seismographs at locations Adimaly(ADM), Chinnakanal(CNK), Marayoor(MYR), Karunapuram(KPM), Vagamon(VGM), Idamalayar(IDM) and Ramapuram(RPM) covering Idukki, Madupetty, Ponmudi and Idamalayar dam sites at an interval of ≤ 30 km in the study area. The seismological network was operational with uninterrupted recording of seismic data during the period from 07.12.2021 to 15.03.2022. A total number of 180 earthquakes have been located in and around Idukki and Ernakulam districts of Kerala State. The local magnitude of these earthquakes ranges from 1.0 to 3.1. The concentration of earthquakes during this period are observed mostly in the central, north central and eastern part of the study area (Lat. 9.5-10.5^0 N and Long. 76.5-77.5^0 E). The maximum numbers of earthquakes is observed in central part of the study area. It appears that the earthquakes activities in the central part is bounded between WNW-ESE Periar fault and NWN-SES trending lineament passing close to the Valparai Anaimudi fault and is being separated from the earthquake activities of the southern part of the study area by WSW-ENE trending lineament passing through the central part of the study area. Some earthquake activities are observed along WNW-ESE trending Periar fault, NW-SE trending Valparai Anamudi, and Kottagudi Kokkal Palani Faults. Out of 180 events, 167 events are in magnitude range 1.5 – 3.0. The focal depths of earthquakes lie within the depth range from 7.4 km to 79.5 km and maximum number of earthquakes are originated in the depth range 30-40 km. The estimated b-value of the study area is 1.49 and 1.28 using least square and maximum likelihood methods respectively. The estimated b-value is greater than the normal b-value (1.0) indicates subsurface heterogeneity condition of the region and high rate of small magnitude earthquakes generation from the source region which implies that the region is seismically active and releasing accumulate stress at intermittent interval in the form of micro-earthquakes. The seismogenic sources are identified from trend and cluster of earthquakes in the study area. The composite fault plane solutions of these seismogenic sources are showing reverse, strike slip, normal with strike slip and thrust with strike slip nature of faulting. It appears that earthquakes along the faults and lineaments in the study area due critically close to their failure conditions and changes in pore water pressure is responsible to occurrences of earthquakes. The present seismological study could serve as useful inputs for assessment of earthquake hazard in and around Idukki and Ernakulam districts of Kerala State in geotechnical and societal benefit.

Keywords: Micro-earthquakes, seismicity pattern, seismogenic sources, focal mechanism, and b-value.

ASSESSMENT OF RADON LEVELS IN DRINKING WATER SOURCES AND ASSOCIATED HEALTH RISKS IN GANDHINAGAR, GUJARAT, INDIA

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ABSTRACT

This study focuses on estimating radon concentrations in groundwater to assess the contamination of drinking water with radon-222 (^{222}Rn) in and around Gandhinagar, Gujarat, India. Water samples were collected from 243 sites across an area of approximately 3000 km² and analyzed using the RAD7 device from Durridge Instruments. Samples were stored in 250 ml radon-tight bottles. The results showed radon concentrations ranging from 0.06 to 8.31 Bq/L, with an average concentration of 2.19 Bq/L. The survey revealed that radon concentrations in water were higher in the southeast region of the study area compared to the northwest. Additionally, physicochemical parameters such as pH and total dissolved solids (TDS) were measured alongside radon. The pH values ranged from 7 to 8.4, and TDS levels varied between 400 and 1840 ppm. Cross-correlation analysis between radon concentrations and the physicochemical parameters revealed a non-significant correlation with both pH and TDS. The depth of the bore wells, which ranged from 400 to 1000 feet with an average of 712 feet, was also measured to evaluate its influence on radon contamination. A negative correlation was found between borewell depth and radon concentration, likely due to the minimal influence of basement rocks, given the thick sedimentary deposits (3-4 km) in the region. The radiological risk associated with radon contamination in water was assessed by estimating the dose rates for different population groups in the study area. Infants were found to have the highest dose rates. The annual effective dose did not exceed the WHO-recommended limit of 100 µSv/year at any of the sampling locations, indicating that the radon levels do not present a significant radiological risk to the population of Gandhinagar.

Key words: Water Radon, Physiochemical parameters, Dose Rate, Gandhinagar, Gujarat

INTEGRATING HYDROCHEMICAL AND ISOTOPIC SIGNATURES (Δ^2H, $\Delta^{18}O$) TO ASSESS GROUNDWATER SALINIZATION IN COASTAL AQUIFERS

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ABSTRACT

Groundwater salinization in coastal aquifers has become a growing concern, as it degrades freshwater quality, limiting water supplies for agriculture, and drinking and affecting coastal communities. This study investigates the processes influencing salinization, delineates the extent of saltwater intrusion, and evaluates the freshwater-saltwater interaction within the aquifer of Puri district Odisha, located along the eastern coast of India. An integrated hydrochemical parameters and stable isotopic (δ^2H and $\delta^{18}O$) characteristics of groundwater are taken for this study. Hydrochemical parameters, including major ions (Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}, HCO_3^-), and indicators like Br^- and Li^+, were analyzed to trace the salinization processes. Additionally, the stable isotopic composition of hydrogen (δ^2H) and oxygen ($\delta^{18}O$) in groundwater water was measured to distinguish between different water sources and understand the mixing processes between freshwater and seawater. TDS concentrations vary from 50 to 5400 mg/l. The results reveal different hydrochemical facies exist in the study region, with elevated concentrations of Na^+, Cl^-, and Mg^{2+}, SO_4^{2-} in wells located central part of the study area.

The Br^- and Li^+ also suggest that the mixing of seawater is the major source of higher salinity, but anthropogenic influences, such as agricultural return flow, may also play a role in localized salinization. Stable isotopic analysis of (^2H and ^{18}O) supports these findings, showing enrichment in heavier isotopes in the zone that showing higher chloride as well as bromide content and are plotted close to the isotopic signature of seawater.

PROTRACTED JUVENILE MAGMATISM IN THE MANIPUR OPHIOLITE: EVIDENCE FROM ZIRCON U-PB-HF ISOTOPIC STUDY

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ABSTRACT

The Indo-Myanmar Range represents a relict eastward-dipping subduction zone that runs from the eastern edge of the Himalayan Range. In the Indo-Myanmar Ophiolite (IMO) Belt rodingite is present as discontinuous lenses, dikes, and small to medium-sized blocks in the serpentinised zones of ultramafic rocks. Rodingites are generally metasomatized mafic rocks within serpentinites. The significance of these rocks in the IMO is uncertain due to the lack of geological and reliable age data for their formation. Zircon U-Pb and Lu-Hf studies of rodingite from the IMO belt have been carried out to characterise and elucidate the timing and to decipher the geological implications. Petrography and mineral chemistry indicate that rodingites are composed of grossular garnet, vesuvianite, diopside, tremolite, actinolite, chlorite, albite, prehnite, apatite and sphene (titanite). Our data indicate that the temperature of formation for the investigated rodingites varied from ~435 to ~200 °C. The formation temperature deduced from the mineralogy is consistent with the cooling of an oceanic lithospheric slab.

U-Pb zircon geochronological study shows an age spectrum of 137 to 114 Ma and the εHf values of the dated zircons ranging between +13.4 and +15.3 suggest that the zircons were derived from juvenile magma. The combined zircon geochronology and Hf isotope data suggest a prolonged juvenile magmatism. The evidence of protracted multistage magmatic pulses provides a new perspective on the petrogenesis of the ophiolite belt.

TECTONIC AND STRUCTURAL ELEMENTS OF SOUTHERN GRANULITE TERRAIN, SOUTH INDIA

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ABSTRACT

The Southern Granulite Terrane (SGT), at the southern tip of the Indian shield, is an integral component in the Proterozoic orogens of India. It is a collage of several crustal blocks amalgamated through several tectonic processes. These blocks are demarcated by several shear zones that can be traced across different Gondwana fragments. Characterizing the tectonics and anatomy of shear zones is essential to understand the controlling factors for mineral deposition, igneous activity,

migmatisation, and crustal deformation. In the present study, we utilized terrestrial and satellite-derived gravity data, EMAG2v3 global Earth Aeromagnetic data, and computed gravity gradient to understand structural heterogeneities within geological formations. The Bouguer anomaly and gravity gradients in the region highlight spatial variability of the terrane at different depth scales, and unambiguously decipher the Mayur-Bhavani-Cauvery Shear System (MBCS) and its continuity to a lower crustal depth of 30–40 km, similar to other shear zones. In contrast, signatures of the Achan-Kovil shear zone (AKSZ) and other minor shear zones disappear at shallow depths whereas the Palghat gap, Nilgiris hills, and Coorg block extend up to deeper levels. The derived reduced-to-pole map, however, reveals an extended wide negative magnetic anomaly, which clearly marks the band of low-amplitude anomalies separating SGT from the northern Dharwar craton. The 2-D joint modelling across the NNW-SSE traverses across the SGT covering the major Shear zones (AKSZ, PCSZ, and MBSZ) and EDC, revealing a four-layer crustal configuration constrained by seismic results. The Moho ranges from 36 km to 45 km along the profile, and beneath the Palghat gap. The Moho is upwarping (~5 km) showing positive gravity anomaly caused by high density material (2.80 gm/cc) at intermediate crustal levels. The combined analysis of qualitative interpretation of gravity and magnetic anomalies and joint modelling results clearly distinguishes between different crustal block and their bounding shear zones in accordance with the available tectonic framework.

Keywords: Southern granulite terrain, Shear zones, Crustal blocks, Qualitative interpretation.

MACHINE LEARNING-BASED IDENTIFICATION OF PRE-SEISMIC ANOMALIES FROM SUPERCONDUCTING GRAVIMETER OBSERVATIONS IN KACHCHH, GUJARAT, INDIA

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ABSTRACT

This study examines the potential of using machine learning to identify earthquake precursors from gravity measurements in the seismically active region of Kachchh, Gujarat. External factors such as tidal forces, air pressure variations, polar motion, and hydrological changes complicate the detection of gravity signals specifically linked to seismic events. To overcome this challenge, we applied three advanced machine learning techniques—Random Forest (RF), K-Nearest Neighbors (k-NN), and Extreme Gradient Boosting (XGB)—to predict gravity time series and identify pre-seismic anomalies in gravity time series. Utilizing an extensive nine-year dataset from a superconducting gravimeter, we classified the data according to seismic events occurring within the earthquake preparatory zone, as defined by Dobrovolsky et al. (1979). We employed the windowing technique, segmenting the data into seismic data for testing and non-seismic data for training. Model accuracy was assessed through root mean square error (RMSE), mean absolute percentage error (MAPE), and percentage bias (PB), achieving a correlation exceeding 0.82. For model optimization, we used 300 trees for RF, 800 trees for XGB, and 15 neighbors for k-NN. By applying a threshold of Mean + 2 standard deviations, we detected distinct anomalies prior to significant earthquakes, including the notable M=5.1 event on June 20, 2012, and several smaller local tremors with magnitudes between 3.6 and 4.8. Our findings

revealed that larger earthquakes displayed pronounced pre-seismic gravity shifts, while smaller events showed subtler changes. These gravity anomalies likely stem from various earthquake preparation processes. However, further research is essential to refine classification accuracy and model training. Additionally, integrating automatic anomaly detection techniques could enhance future analyses and provide deeper insights into earthquake forecasting.

Keywords: Machine learning, Superconducting Gravimeter, Model performance metrics, Earthquake pre-seismic signals.

CRUST BENEATH THE IGP AND HIMALAYA

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ABSTRACT

The Indo-Gangetic Plain IGP is characterized by thick sediments, primarily alluvial deposits, which can amplify seismic waves generated by earthquakes in the Himalayan region, which lies north of the plain. The presence of loose sediments can indeed pose significant seismic hazards, mainly due to phenomena like soil liquefaction. These sediments threaten densely populated Delhi and NCR regions, which are 200 km away from the plate boundary of India and the Eurasian plate. Scientists are concerned about people's safety in mitigating damage caused by high-rise buildings and loose sediments in the IGP region. Reliable knowledge of the sedimentary layer's thickness and velocity structure is crucial for investigating buried active faults, understanding significant destruction, and risk assessment. Sedimentary basins are also vital to geo-resources such as hydrocarbon and geothermal energy. This research estimated the structure of the sedimentary layer beneath four stations in the Chandigarh-Ambala region in IGP using the high-frequency receiver function (PRF) technique. The study found that the sedimentary layer thickness varies significantly, with values from 2.0 to 3.0 km beneath the IGP and increasing northward. Shallow shear velocity (Sv) in the column of sediments below the Siwalik Himalaya ranges from 2.8 to 2.9 km/s and is widely utilized for assessing earthquake ground-motion sites. The study provides new perceptions of the Himalayan region's geodynamic processes and seismotectonic structure, allowing for better identification of the earthquake hypocenter and assessment of seismic hazards. The shear wave velocity models estimated from this research can also be beneficial for assessing seismic hazards and earthquake-resistant construction. Estimates of the crustal thickness values from waveform inversion of the PRF at individual stations reveal that the Moho depth varies between 44to 50 km in the Indo-Gangetic Plain. From Siwalik Himalaya to the higher Himalayas, it ranges from 50 to 65 km. The depth of Moho increases from the Indo-Gangetic plain and deepens towards the lesser Himalayas.

Keywords: Receiver function, Inversion, Indo-Gangetic Plain, Crust, Moho depth

APPLICATION OF GROUND PENETRATING RADAR (GPR) STUDIES FOR DETECTION OF CAVITIES/VOIDS IN LIMESTONE MINING AREAS-A CASE STUDY

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ABSTRACT

Ground Penetrating Radar (GPR) techniques have been extensively used in detection of cavities and voids in karstic limestone areas. Detection of cavities and voids is very essential to delineate the major subsurface structural features to prevent disasters and also to improve site assessments. In the present study, GPR response to clayey and air filled cavities is studied to identify the location, estimation of depth and direction of sinkhole channels. One of the most important properties in estimating the depth of cavity/void is dielectric constant of the subsurface medium. Since the dielectric properties of the subsurface medium are different from those of the cavities/voids; they can be detected with the GPR technique. The method is based on the concept that in good quality rock, most of the energy is transmitted, while in low quality rock, the energy is backscattered from the fractures, strata joints, cavities/voids, sinkholes etc. In all, a total number of GPR data was acquired along 31 profiles with 100 MHz and 14 profiles with 400 MHz antenna, covering an area of about 25 hectares in the Nongtrai limestone mining at East Khasi Hills, Shella Bazar, Shillong, Meghalaya. GPR-processed images reflected underground anomalies such as clayey and air filled cavities/voids, sheet joints, weathered zones etc, up to a depth of about 15 m and are presented in the paper. The outcome of the survey substantiates that GPR is an ideal geophysical tool to aid in the detection and monitoring of cavities/voids, sinkholes and other subsurface structural features.

Keywords: Ground Penetrating Radar (GPR), Cavities, Voids, Sinkhole, Karst, Limestone, Dielectric constant.

ACTIVE FAULTS AT KOYNA-WARNA, WESTERN INDIA DELINEATED FROM LOCATIONS AND RELOCATIONS OF MICROEARTHQUAKES

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ABSTRACT

The Koyna-Warna region situated in the Deccan Volcanic Province of western India is one of the popular sites of artificial water reservoir triggered seismicity (RTS). In this study, we investigate the seismic activity for the period from 2015 to 2021 based on recordings from the combined seismic network i.e. a borehole network of eight stations and a surface broad-band network of 23 stations operating in the study region which provided the best possible azimuthal coverage for the seismic zone. A unique set up of borehole stations have provided much constraint on achieving the improved absolute locations of earthquakes. We computed the relocations of earthquakes using the joint hypocentral determination and HypoDD techniques. The refined epicentres provide insights into the kinematics of the fault zones down to a resolution ranging typically as low as 200 m. The distribution of hypocenters suggests that the seismic zone is characterized by N-S, NNE-SSW and NW-SE oriented seismicity trends. Faulting mechanisms are predominantly left-lateral strike-slip on NNE-

SSW segment which is well correlated with the Donachiwada fault zone in the vicinity of the Koyna Dam, while normal faulting events typically occur on NW-SE and NS-trending seismicity clusters and are well correlated with the faults mapped by aeromagnetic and LiDAR studies in the vicinity of the Warna Reservoir. The spatial and depth-section of the seismicity patterns indicate kinematics of sub basalt seismogenic faults of the Koyna-Warna region.

Key words: Koyna, earthquake, borehole, location, fault

INNOVATIVE GEOPHYSICAL METHODS FOR DELINEATING GROUNDWATER AQUIFER ZONES – A CLOSER LOOK AT THE SUSTAINABLE DEVELOPMENT

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ABSTRACT

Groundwater geophysics is a tool for hydrogeology. Access to clean water is a human right and a basic requirement for economic development. The safest kind of water supply is the use of groundwater. Since groundwater normally has a natural protection against pollution by the covering layers, only minor water treatment is required. Detailed knowledge on the extent, hydraulic properties, and vulnerability of groundwater reservoirs is necessary to enable a sustainable use of the resources. Groundwater investigations can be carried out at a regional scale, local scale or site scale. Regional scale investigation is the largest scale for groundwater investigations, which typically encompasses hundreds or thousands of square kilometers. It provides somewhat an overall evaluation of groundwater conditions. Local scale investigation covers an area of a few tens or hundreds of square kilometers. This type of study provides more detailed information about geology, groundwater dynamics, aquifer characteristics and water quality. On the other hand, site-scale investigation is the smallest scale for groundwater investigations, wherein a particular site is involved such as a well field, mining site, waste disposal site, industrial site, etc. Site-scale groundwater investigation provides in-depth field investigations at the site under study. Regardless of the scale of a study, detailed planning is required to make sure that the approaches followed in the study are appropriate for the formulated objectives and that the standard procedures are adopted with utmost accuracy for field and laboratory measurements as well as for the analysis of field and laboratory data.

The exploration of groundwater can be done from the earth's surface locations, which is known as surface investigation. Groundwater exploration can also be done using equipment/instruments extending underground, which is known as subsurface investigation. Surface investigations of groundwater usually do not provide quantitative data/information concerning aquifers or groundwater as obtained from subsurface investigations. Correct interpretation requires supplemental data from subsurface investigations to verify the findings of surface investigations. Although the surface investigations of groundwater provide an incomplete picture or qualitative information of hydrogeologic conditions below the ground, they are usually less expensive and less time consuming than the subsurface investigations (Todd, 1980). The surface methods of groundwater exploration can be classified into two major groups: (a) geologic methods (also called *reconnaissance methods*), and (b) geophysical methods. Geologic methods involve interpretation of geologic data or geology related data and field reconnaissance using *test pits and trenches*, *adits*, *continuous cone penetrometer* and *auger*. They represent an important first step in any groundwater investigation. On the other hand, geophysical methods are *electric resistivity method*, *seismic methods*, *gravity method*, *magnetic*

method, and *remote sensing techniques*, of which *electric resistivity method* is widely used for groundwater exploration. A brief description of the geologic methods and geophysical methods is also provided. The manuscript deals with the scale of groundwater investigation as well as an overview of surface methods and subsurface methods along with case studies of groundwater exploration carried out by Geological Survey of India (GSI) in Sagar Island, Calcutta Metropolis and Central India.

CONCEPTUALIZATION AND UNDERSTANDING HYDROGEOLOGICAL CHARACTERISTICS FROM RESISTIVITY TOMOGRAPHY AND GIS IN CHURU DISTRICT, RAJASTHAN FOR GROUNDWATER PROSPECT MAPPING

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ABSTRACT

We investigated Churu district, Rajasthan for mapping brackish, saline as well as moderately fresh groundwater trapped in saturated sand from the integrated study using geophysics and geospatial mapping to assess the prospect and quality of groundwater resources both in the spatial and depth scale in the area. The study area, Churu where all central and northern regions of the district are primarily covered by aeolian wind-sand (dry sand) and partly by fluvial deposits as brown loose sand having sporadic rainfall with an annual average of <400 mm during the year. But the southern region of the district features some hard rock exposures covered by the Marwar Supergroup, including sandstone, shales and calcareous formations. Quartzite deposits (including mica schist), dolomite and limestone formations can be seen through the hillocks area at the intermediate and extreme south of the Churu district in Rajasthan. Lineaments and faults are concealed in the northern and southern part of the study area. Four blocks in Churu district was studied for detailed subsurface geological mapping as well as for groundwater resources in the arid region of Churu district, Rajasthan. Full waveform Electrical Resistivity Tomography (ERT) high resolution dataset was acquired at 6 villages covering four blocks in Churu. We distinctly mapped thick loose dry sand (aeolian sand) at the near surface layers though it is very difficult to inject the current into the ground. The loose dry sand shows a high resistivity signature with a resistivity varying between ~100 to 526 Ohm.m in the near surface layers as compared to the deeper parts of the various resistivity models achieved in the Churu area. Three major distinct geological layers was clearly mapped with a sharp resistivity contrast among themselves. Clay dominated sand layer is the significant layer, which resulted in the low resistivity environment and is mostly responsible for brackish water having resistivity <10 Ohm.m and saline groundwater with resistivity < 5 Ohm.m in the study area. While the moderately fresh groundwater is limited and is confined within the saturated sand structure with a resistivity between 10 to 20 Ohm.m. It has been found a large variation in groundwater levels varying between 24 m to 105 m bgl in different blocks of the studied villages in Churu district, Rajasthan. Nevertheless, with the help of remote sensing and GIS we demarcated lineaments and faults geological structures, which are the indicator for groundwater prospect scenario from near surface to depths. We also applied Analytical Hierarchy Process (AHP) for Multi-Criteria Decision Making (MCDM) in evolution of thematic maps, which are used for groundwater prospect zonation and thus help in targeting for comprehensive groundwater exploration in the study area.

Keywords: Freshwater-Saline Water interface, Electrical Resistivity Tomography Remote-Sensing & GIS, Groundwater, Churu, Rajasthan

REVIEW ON GRANITIC ROCKS OF KARAGWE ANKOLE BELT (KAB) IN BURUNDI, EASTERN AND CENTRAL AFRICA.

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ABSTRACT

The published geochemical and geochronological data on granitic rocks that have been reported from the Karagwe-Ankole belt (KAB) in Burundi have been synthetised. They are subdivided in S- and A-type granites. The S-type granites (Gr1-3) are widespread and emplaced during ~ 1375 Ma bimodal magmatism that has been ascribed to extensional setting. The intrusion of S-type granites was followed by the Kabanga-Musongati (KM) and Gitega-Makebuko-Bukirasazi (GMB) A-type Gr4 granitoid rocks emplaced locally during ~ 1205 Ma intracratonic magmatism, representing minor additions to the crust in the KAB. To the above-mentioned granites is added the Buraniro A-type granite (dated at ~748 Ma) occurring in the Upper Ruvubu Alkaline Plutonic Complex (URAPC) which has been emplaced under extensional regime associated with Rodinia breakup.

The S-type granites (Gr1-3) are generally characterized by high initial $^{87}Sr/^{86}Sr$ (0.707-0.735) suggesting the crustal contamination or to a lesser extent the composition of their source-region. The Gr4 granites of GMB massifs are characterized by negative εNd (-1.3 to -1.4). This εNd, coupled with low initial $^{87}Sr/^{86}Sr$ values (initial $^{87}Sr/^{86}Sr_{average}$ = 0.702) for the coexisting mafic rocks, points to an ocean island basalts (OIB)-type asthenosphere/lower continental lithospheric mantle origin, with only slight contamination by the lower crust. The granites (A-type) from the KM mafic and ultramafic alignment are slightly different from those of GMB. These are characterized by the initial isotopic ratios ($SrIR_{average}$ = 0.708; $\varepsilon Nd_{average}$ = -7.133) which indicate an older continental lithospheric mantle origin. The granites from URAPC (dated at 748 ± 2 Ma) also exhibit initial $^{87}Sr/^{86}Sr$ ratios and initial εNd values varying from 0.7088 to 0.7214 and from +2.2 to - 4.4 respectively, whereas their εHf (i) values vary from 0.7 to -10.2. These isotopic data of URAPC granites are indicative of a contamination of the mantle-derived magmas with crustal material.

ASSESSMENT OF PLATE MOTION AND INTERNAL DEFORMATION OF THE ANTARCTIC PLATE USING GNSS AND GRACE

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ABSTRACT

The Antarctic continent exhibits substantial spatial variations in deformation due to diverse rheological properties across its sections. These deformations arise from hydrological loading, volcanic activity, tectonic forces, glacial isostatic adjustment (GIA), and contemporary mass changes. To investigate plate motion and internal deformation, we analyzed data from 97 GNSS stations distributed across Antarctica, each with at least five years of observation. Additionally, we incorporated deformation data derived from GRACE over these stations. Our findings reveal that the Antarctic Plate motion ranges from 4 to 22 mm/yr. To examine the internal motion of the Antarctic Plate, we estimated the Euler pole using data from 55 stable GNSS sites located within the Antarctic Plate and found its location at 60.2974° ± 0.26636° latitude, -126.4504° ± 0.21006° longitude, with

an angular velocity of 0.22538° ± 0.0016°/yr. In terms of the internal plate motion of Antarctica, the Northern Antarctic Peninsula shows significant movement, ranging from 2 to 6 mm/yr, particularly near the Ateneo Ice Shelf. This substantial internal motion is likely driven by tectonic processes associated with the subduction of the Scotia Plate, as well as non-tectonic factors such as GIA and recent mass changes. In contrast, the West Antarctic Ice Sheet (WAIS) exhibits rapid movement, with rates around 20 mm/yr near Thwaites Glacier, which is undergoing significant melting. Nearby, Pine Island Glacier shows a velocity of around 8 mm/yr, corroborating recent studies suggesting that glacier loss in West Antarctica may be irreversible, which is cause for concern. However, the interior of East Antarctica remains largely stable, consistent with its characterization as an ancient craton. To further explore the internal deformation of the Antarctic continent, we estimated the strain rate across the Antarctic continent using the velocity data from 97 GNSS stations. Our analysis reveals substantial regional variations in strain. The highest strain rates, around 20 nstrains/yr, are observed in the Antarctic Peninsula, with rates of 2 to 6 nstrains/yr in West Antarctica. Whereas the interior of East Antarctica exhibits minimal strain, though some peripheral regions, such as those near Totten Glacier, show localized strain rates of approximately 3 nstrains/yr. The GRACE data reveal notable deformation, with strain rates of around 3 nstrains/yr. Overall, the results enhance our understanding of the geodynamic processes at play in Antarctica and highlight the critical role of both tectonic and mass-driven changes in shaping the continent's ongoing deformation.

Key Words: Plate Motion, Grace, GNSS, etc.

DETECTION OF LANDSLIDES USING SEISMIC NETWORKS IN GARHWAL HIMALAYAS, INDIA

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ABSTRACT

The Uttarakhand region faces numerous natural hazards and their cascading effects due to its dynamic topography, fragile geology, active tectonics, and impacts of global climate change. Among these hazards, landslides are especially frequent, often triggered by slope instabilities resulting from tectonic activity, heavy rainfall, and human activities. Landslides in this area lead to significant loss of life, infrastructure damage, environmental degradation, and economic impacts. Recent advancements in seismic monitoring technology have demonstrated the robustness of remotely recording landslide events and their cascading effects. To monitor these events, the Environmental Seismology Group at CSIR-NGRI, Hyderabad, has established seismic networks in the Uttarakhand region, focusing on landslide detection and other geohazards. In spite of successful recording, continuous data presents challenges in identifying landslides due to unclear signal phases. Here, we present advanced spectral techniques to enhance rapid landslide detection. By applying global models (Rekapalli et al., 2024), landslide signals are effectively identified in data from Uttarakhand. Preliminary results suggest that this approach is reliable for landslide detection, even when using data from a single seismic station.

Keywords: Uttarakhand, Landslides, Seismic Monitoring, Environmental Seismology, Spectral Techniques.

MAGNETOTELLURIC EVIDENCE FOR A NEW POTENTIAL GEOTHERMAL RESERVOIR IN EASTERN LADAKH

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ABSTRACT

The Ladakh Himalaya is considered to be the most promising region of India for geothermal energy. This region also preserves the imprints of complex subduction/ collision episodes between the Indian and the Eurasian plates. We have carried out a magnetotellurics (MT) study along the Ukdungle – Hanle – Koyul – Fukche transect in eastern Ladakh, which is a geophysically less explored region. Here, we present the upper crustal electrical resistivity structure of this region for assessing the geothermal potential of this sector as well as to decipher the deep reservoirs. 2-D and 3-D modelling of the MT data of 18 sites displays an excellent match between the geoelectric structure and the available geological section. An interesting result from this study is the presence of a large upper crustal conductor (> 0.1 S/m) beneath the Tso Morari crystallines (TMC) at about 4 km depth, an offshoot of which is seen at shallow depths along the Indus suture zone (ISZ). This conductor is also connected to another deep conducting layer that extends northward beneath the Ladakh batholith of about 8-12 km thickness. We attribute this layer to the presence of laterally extensive zone of partial melts that has been postulated beneath the southern Tibet. Thus, this system of connected conductive zones implies the presence of a new potential persistent geothermal resource in eastern Ladakh.

LFLV SEISMIC EMISSION OVER HYDROCARBON RESERVOIR ROCK

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ABSTRACT

Low velocity (300 m/sec) observation was witnessed in oil saturated sand during cross hole seismic experiment in west Siberian field (G.M. Golushubin et al, 1993) of Russia. Further, low frequency (2-4 Hz) spectral high observations were also witnessed in many case studies over hydrocarbon reservoir rock through Low Frequency Passive Seismic (LFPS) technology or Low Frequency Sounding (LFS) technology. We have also noticed both Low frequency (2-4 Hz) and low velocity (355 m/sec, 400 m/sec, 447 m/sec etc.) seismic wave fronts in conventional seismic data acquired over hydrocarbon reservoir rock. Natural oscillations of compressive fluids like oil and gas are assumed at rock fractures. These oscillations with sufficient pore pressure gradient are assumed to be responsible for Low Frequency Low Velocity (LFLV) Seismic Emission over Hydrocarbon Reservoir rock. In oil and gas exploration, structural and stratigraphic traps are being identified using seismic reflection data. It is worth mentioning here that all identified structural or stratigraphic traps may not contain oil and gas. A very few structural or stratigraphic traps will contain oil and gas. We can filter out structural or stratigraphic traps with oil and gas from the all identified structural or stratigraphic traps by using this LFLV Seismic Emission study and thus, we can reduce oil and gas exploration risk.

ROLE OF UNDERPLATING LAYER FOR EVOLUTION OF ALCOCK RISE: INSIGHT FROM SEISMIC REFLECTION AND GRAVITY MODELLING

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ABSTRACT

The Alcock and Sewell seamounts are notable geomorphological features in the Andaman Sea, closely associated with the tectonic development of the Sunda subduction zone. While global geophysical data exists, the nature of the crust beneath these seamounts remains a topic of debate due to the limited availability of local geophysical data. To address this gap, we utilized satellite-derived gravity data and industry-provided multi-channel seismic data to examine the crustal structure beneath the Alcock Rise. Our study involved analyzing three 2D gravity profiles across the Narcondam, Barren, and Alcock rises, as well as a single 2D seismic profile between Narcondam volcano and Alcock Rise. We present forward gravity modeling results in the Andaman Sea, using the seismic-interpreted basement depth as a constraint. The findings reveal variations in crustal thickness from north to south and west to east, with the thickest crust beneath Alcock Rise, measuring ~17 km, including an underplated layer of less than 2 km and sediment less than 1 km thick. Moreover, an underlying layer beneath Alcock Rise appears to play a key role in the formation of the back-arc spreading center, with magma from this spreading contributing to the underplated layer.

A COMPARATIVE ANALYSIS OF FREQUENCY AND AMPLITUDE PARAMETERS FOR EARTHQUAKE MAGNITUDE ESTIMATION IN EEW SYSTEMS

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ABSTRACT

Accurately determining earthquake magnitude within the first few seconds of seismic activity remains a key challenge in earthquake early warning (EEW) systems. In this study, various frequency- and amplitude-dependent parameters are explored and analyzed to establish a regression relationship between these parameters and earthquake magnitude. While τ_c and peak vertical displacement (P_d) are commonly used parameters for magnitude estimation, additional parameters, including amplitude and duration-based measures such as Cumulative Absolute Velocity (**CAV**), Cumulative Absolute Displacement (**CAD**), and Cumulative Absolute Absement (**CAA**), are calculated over varying time windows to further develop regression models. Relationships between magnitude and purely amplitude-based parameters, such as the peak amplitude of the time-windowed spectra following the P-wave arrival and the peak amplitude of the response spectra for the same time window, are plotted for different time window lengths. A dataset of 10,328 records from 396 earthquakes, recorded at 1,915 stations within the Japanese strong motion network, is used for analysis. Where necessary, parameters are calculated by integrating strong motion data in both the frequency and time domains to assess the impact of integration methods on the results. The study found that frequency domain integration slightly improved results for τ_c and **CAA**, while the other parameters showed similar results across both integration methods. Additionally, amplitude-based parameters proved more effective in distinguishing between earthquakes with low and high Peak Ground Acceleration (PGA)

compared to frequency-dependent parameters. Threshold values are calculated for each amplitude-dependent parameter, which could be applied to improve the efficiency of EEW systems.

Keywords: EEW, Magnitude, Amplitude, Frequency, strong motion data

SPECTRAL CORNER FREQUENCY RATIOS FOR DIFFERENTIATING EARTHQUAKES FROM EXPLOSIONS

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ABSTRACT

Micro seismic studies at large dams, power plants and other civil construction areas pose a challenge in discriminating earthquakes from artificially induced human activities such as explosions, quarry blasts etc. Certain similarities in waveforms of earthquakes and explosions make them very difficult to distinguish, especially when there is no recorded information of explosions. The demarcation of explosions from earthquake is challenging and failing to do so can lead to inaccurate evaluations of seismic risks of the study region.

In the present study efforts have been made to differentiate between earthquakes and explosions using spectral corner frequencies and their ratios. The Corner frequency, is a point in a spectrum where the amplitude significantly decreases, is crucial for determining difference between earthquake and explosion. At the corner frequencies of a spectrum, the energy released during an earthquake is distributed over a larger area, whereas in blasts, the energy is released in a more controlled and concentrated narrow area. In this study about 300 seismic events were analysed with magnitudes ranging from 0.8 to 4.0 (ML) which were recorded by the CSIR-NGRI operated micro earthquake monitoring network in the southern mainland of Gujarat. The events recorded, from January 2017 to 2022, were analysed for estimating the P and S waves corner frequencies and their ratios using displacement spectra. The estimations were done with the events recorded from multiple stations and averaged them to improve reliability and accuracy. The corner frequency ratios of earthquake and explosions of similar magnitudes were compared to differentiate the blasts from earthquakes.

In this study, the estimations of corner frequency ratios of P and S exhibited higher in values for earthquakes in comparisons with explosions. The visual inspection of the waveforms corresponding to earthquakes and explosions is also indicating the spectral energy's faster and concentrated decay in the explosions. In conclusion, the spectral corner frequency of P and S and their ratios may become one of the reliable tools for distinguishing seismic events.

Key Words: Earthquakes, Explosions, Spectral analysis, Corner frequency, and Corner frequency ratios.

STATE-OF-THE-ART MACHINE LEARNING ALGORITHMS FOR PREDICTING MISSING LOG

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ABSTRACT

The present study emphasizes the usefulness of machine learning (ML) workflows in predicting missing logs. In petroleum exploration, the sonic log (DT) is mainly used for the calculation of reservoir porosity and for pursuing petro-physical and geological analysis. However, sometimes these logs do not exist in the well record either due to data loss or not recorded at that time. So, predicting these logs is essential for evaluating a better petrophysical analysis and reservoir characterization from existing data.

Using the borehole logs, we have tested the prediction of the sonic log from the density, gamma and resistivity logs using various ML algorithms that include the random forest and XGBoost. It is observed that these ML algorithms could make a quite accurate and reliable prediction of missing logs using other available logs. The correlation coefficient (0.8 to 0.9) between the ML predicted and available logs shows that the ML and associated algorithms play a vital role in the prediction of missing logs, particularly in cases where we have less amount of log data for training unlike the deep learning models, which needs significant amount of data.

CRUSTAL SEISMIC STRUCTURE ALONG MANDVI-MUNDRA PROFILE, SOUTHERN PART OF KUTCH REGION (WESTERN INDIA): PRELIMINARY RESULTS

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ABSTRACT

Kutch basin is an east west oriented peri-cratonic rift basin, located in the northwestern part of Indian subcontinent. This region, bounded by Nagar Parkar uplift in the north, Radhapur arch in the east, and Kathiawar uplift in south, is seismically active associated with lower crustal earthquakes. In recent past, it has witnessed a number of disastrous earthquakes like, 1819 Kachchh (Mw 7.7), 1956 Anjar (Mw 6.0) and 2001 Bhuj (Mw 7.7). In order to study the subsurface structure, a number of DSS studies have been carried out in this region. In the present work, we made an attempt to decipher the deep-seated crustal structure by reprocessing the seismic data acquired along Mandvi-Mundra Deep Seismic Sounding profile by CSIR-National Geophysical Research Institute (Hyderabad). Our initial results indicate a six layer crust, characterize by average velocities, 2.10 km/s (Tertiary) , 4.80 km/s Deccan Trap (Paleogene-Late Cretaceous), 3.60 km/s (Mesozoic sediments), 5.00 km/s (Mesozoic limestone), 5.50 km/s (Mesozoic volcanics), 5.10 – 5.40 km/s (Mesozoic sediments), above the granitic basement which is characterized by a velocity around 5.90 to 6.00 km/s. It is underlain by mid- crustal (Vp: 6.30-6.40) and lower crustal (Vp: 6.80-6.90 km/s) layers, which is further underlain by thick magmatic layer (Vp: 7.10 -7.40 km/s)

above the Moho (around 30 km), which appears to be extremely delaminated due to strong crust-mantle thermal interaction related Deccan and Mesozoic volcanism.

PGE GEOCHEMISTRY OF NIOBIUM ENRICHED BASALTIC ANDESITES (NEBA) FROM THE TSUNDEPALLE GREENSTONE BELT, EDC, INDIA: EVIDENCE FOR NEOARCHEAN SUBDUCTION-COLLISION TECTONICS

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ABSTRACT

The petrography and bulk rock geochemistry, including platinum group element geochemistry (PGE) of the Niobium enriched basaltic andesites (NEBA) of the Tsundepalle Greenstone Belt (TGB) of EDC are studied to understand their petrogenesis tectonic, and geodynamic setting. They show niobium enrichment (Nb-range from 6-12 ppm), with high HFSE/HFSE ratios such as Nb/Ta and Zr/Y, which are in the range of 38-118 (PM=17) and 5.0-5.7 (PM=2.4) respectively compared to the primitive mantle. NEBA shows ΣPGE in the range of 53-168 ppb, with an average of 100 ppb. An average of Au 1274 ppb was recorded in these samples. The studied samples (n=11) show the average PGE contents (in ppb) – Os, Ir, Ru, Rh, Pt, and Pd as 10.4, 4.6, 3.1, 5.4, 30.3, 46.5, respectively. The PPGE enrichment over IPGE with positive Pt anomaly relative to Pd can be observed in their primitive mantle normalized distribution patterns, indicating the role of sulphides in their genesis. They show coherent, bow-shaped PGE fractionated patterns on the primitive mantle normalized spidergrams. The low Cu/Pd ratios indicate the sulphur undersaturation (Cu/Pd ratio in the range of 882-4317; PM Cu/Pd=7000) condition suggests that the sulphide fractionation/removal during melt segregation. Similarly, the Au>Pt>Pd enrichment in these rocks probably indicates mantle metasomatism. The higher (Pt+Pd/Os+Ir+Ru) ratios in the range of 2-7, indicate low-degree partial melting of the protolith. On the binary discrimination system Ni/Cu versus Pd/Ir, the samples plot slightly below the line of partial melting, and the majority are within the layered intrusion field, indicating PPGE-enriched melts. The significant influence of the slab melts in generating these NEBA is evident by their high Sr contents (408-1154 ppm). The petrogenesis of NEBA indicates mantle metasomatism by slab-derived melts in the Neoarchean TGB. The identification of NEBA from TGB supports the predominance of intra-oceanic subduction zone tectonics in the greenstone belts of EDC, which played a vital role in the crustal recycling and gold mineralization in this part of the Dharwar Craton. These studies indicate a series of accretionary tectonics (oceanic island arcs) in EDC which played a vital role in the crustal growth.

Keywords: Tsundepalle Greenstone Belt, PGE, Dharwar Craton, Intra-oceanic Island Arcs

TOMOGRAPHIC IMAGING OF THE CRUST AND GEODYNAMIC IMPLICATIONS OF SOUTHERN GRANULITE TERRAIN (SGT), INDIA

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ABSTRACT

The crustal structure toward south of southern granulite terrain (SGT) is poorly defined leaving an opportunity to understand the tectonic and geodynamic evolution of this high-grade granulite terrain surrounded by major shear and tectonically disturbed zones like Achankovil Shear Zone (AKSZ) and Palghat Cauvery Shear Zone (PCSZ). To develop a geologically plausible crustal tectonic model depicting major structural elements, a comprehensive tomographic image was derived using deep-seismic-sounding (DSS) data corroborated by Bouguer gravity modeling, coincident-reflection-seismic, heat-flow and available geological/geochronological information along the N-S trending Vattalkundu-Kanyakumari geotransect. The final tectonic model represents large compositional changes of subsurface rocks accompanied by velocity heterogeneities with crustal thinning (44 – 36 km) and Moho upwarping from north to south. This study also reveals and successfully imaged anomalous zone of exhumation near AKSZ having transpression of exhumed rocks at mid-to-lower crustal level (20-30 km) with significant underplating and mantle upwelling forming a complex metamorphic province. The presence of shear zones with high-grade charnockite massifs in the upper-crust exposed in several places reveal large scale exhumation of granulites during the Pan-African rifting (~550 Ma) and provide important insights of plume-continental lithosphere interaction with reconstruction of the Gondwanaland.

K*eywords*: Southern granulite terrain; Deep-seismic-sounding; Tomography; Crust; Moho

INTEGRATED GEOPHYSICAL APPROACH FOR DELINEATING THE FAVORABLE STRUCTURAL FOR REE AND ASSOCIATED MINERALIZATION ZONES AT THE CONTACT BETWEEN NONGPOH GRANITE AND GNEISS IN THE ASSAM MEGHALAYA GNEISSIC COMPLEX (AMGC)

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ABSTRACT

The objective of this work is to identify potential rare earth element (REE) mineralized zones at the lithological contact between Nongpoh granite and gneiss in the Assam Meghalaya Gneissic Complex (AMGC), while also assessing base metal and associated mineralization in pegmatite and quartz veins. Geophysical methods have been crucial in mapping structural features such as shear zones, faults, and fractures that often host mineralization.

Regional gravity and magnetic surveys revealed a significant high-intensity magnetic anomaly, correlated with a high gravity zone located 1.5 km northwest of Byrnihat, Ri-Bhoi district, Meghalaya. This area, at the northern edge of the Meghalaya plateau, shows promise for mineralization. The geophysical findings indicate a steep gravity gradient and a broad circular low anomaly, likely related to the structural and lithological contact between granite gneiss, cordierite metapelites, and east-west trending quartz and pegmatite veins.

The high chargeability zone aligns with the magnetic and gravity anomalies, suggesting a structurally favorable area for mineralization at depth within the quartz/pegmatite veins in the granite gneiss.

Trenching and pitting based on the geophysical data yielded core samples from Umprikhola, which recorded 0.24% Ba, 0.14% Cr, 0.1% Sr, and 700 ppm of total REE in diorite. The distribution of total REE shows a positive correlation with trace elements such as W, Th, V, and Nb, particularly in boreholes MEGBRK 3 and 10 at Umprikhola. These findings underscore the potential for significant mineralization in the area, warranting further detailed exploration.

Keywords: REE, Gravity, Magnetic, Induced Polarization, Resistivity and Mineral exploration

GEOELECTRIC CRUSTAL HETEROGENEITIES IN THE SHARDA DEPRESSION, GANGA BASIN

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ABSTRACT

The structural fabric and geology of the Indian plate in the Ganga Basin is masked by deposition of a thick succession of Quaternary and Recent sediments. Geophysical explorations for hydrocarbons have revealed the presence of transverse basement ridges and Cenozoic stratigraphy in the basin but basement depth and the nature of the underlying crust and mantle lithosphere in the northern part of the basin are largely unknown. The Ganga Basin also hosts two super-deep structural depressions, namely the Sharda and the Gandak depressions, bordering the foothills of the Himalaya which are also buried beneath these alluvial sediments. Here, we present the results of 2-D MT inversion along the Bhind (Madhya Pradesh) - Kajariya (Nepal border) profile that traversed the Sharda depression. Significant structural heterogeneity in the Indian basement is suggested by these results. The geoelectric model suggests that the Sharda depression is a multi-stage basin. Further, the study has delineated upper mantle conductors, which we attribute to the presence of fluids/ partial melts. From this study, we infer that lithospheric structure of the Indian plate is highly heterogeneous along this profile.

CRUSTAL STRUCTURES BENEATH KUCHCHH, GUJARAT, USING RECEIVER FUNCTION ANALYSIS

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ABSTRACT

This study is aimed to identify the crustal structures beneath Kuchchh, Gujarat, India using Receiver Function Analysis**.** The receiver function represents the response of an incident teleseismic P wave to the local structure. Using this technique, local structures can be isolated from the effects of deeper structures along the propagation path, as well as from the influence of the source and near-source structures.

As a P-wave travels up through the mantle and hits the Moho, most of the waveform will continue transmitted as a P-wave, while some parts of the waveform will be converted and transmitted as an S-wave. These waves arrive at the seismic stations as responses identified as the Direct P wave and Ps and multiples (PpPs, PsPs, PpSs). The difference in arrival time between the direct P-wave and Ps can give a direct calculation of the depth of the interface. In this study, iterative time-domain deconvolution is employed. A least squares reduction of the difference between the predicted and observed horizontal components is used in iterative time-domain deconvolution. To estimate the crustal thickness (H) and the Vp/Vs ratio (κ) beneath each individual station, we used the H-K stacking method. The study area is located at 23.610^0 latitude and 70.490^0 longitude in Kachchh, Gujarat. Teleseismic data from March 2018 to December 2020 was used to study crustal structures. The study is carried out because the Moho depth may not be constant and varies throughout the region. The P-wave reflection functions (PRFs) for a total of 147 events. The PRF calculation and H-K stacking are performed for the study area (23.610°, 70.490°).

The area of study is located at the Wagad uplift, approximately 117 km from Bhuj in Kachchh. The stacking result shows a Vp/Vs ratio of 1.77, which is slightly higher than the average ratio of 1.73. This indicates a disturbed crustal structure in the region, confirming the complex geology of Kachchh.The H-K analysis from our study reveals a Moho depth of 42 km, indicating that there are trapped magmatic intrusions beneath the crust. Based on the mineralogy classification of rock, the area of study is categorized as intermediate between the felsic and the mafic rocks with Vp/Vs ratio 1.77. Additionally, high Vp/Vs ratios of 1.8-2.05 have also been observed in the Kachchh region.

The increase in the Vp/Vs ratio with increasing crustal thickness explains the increase in the thickness of the mafic lower crust.

KEYWORDS: P wave receiver functions; Teleseismic waves; Crustal structures; Moho depth

BASIN STRUCTURE FROM GRAVITY AND MAGNETIC ANOMALIES IN THE SOUTHERN PART OF K-G BASIN, ANDHRA PRADESH, INDIA

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ABSTRACT

The gravity and magnetic data along the profile across the southern part of the Krishna Godavari-Basin have been collected and the data is interpreted for basement depths. The profile II[1]is taken from Kotturu to Biyyapuppa covering a distance of 70 km. The gravity lows and highs have clearly indicated various sub basins and ridges. The density logs from ONGC, Chennai, show that the density contrast decreases with depth in the sedimentary basin, and hence, the gravity profile is interpreted using variable density contrast with depth. From the Bouguer gravity anomaly, the residual anomaly is constructed by graphical method correlating with well data, subsurface geology and seismic information. The anomaly profile is interpreted using polygon model. The maximum depths to the khondalitic basement are obtained as 2.0km, 1.60 km and 2.50 km at Krishna sub-basin,Bapatla ridge and Nizampatanam sub-basin respectively. The regional anomaly is interpreted as Moho rise towards the coast. The aeromagnetic anomaly profile is also interpreted as charnockite basement below the khondalitic group of rocks using prismatic models.

Keywords: Gravity anomaly, Variable density contrast, Khondalite basement, Magnetic anomaly, Charnockite basement, Moho depth. K-G basin.

POSSIBLE ORIGIN OF MUONG NONG TEKTITES BY A GRAZING IMPACT IN TIBET

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ABSTRACT

Muong Nong tektites found spread over a large area in Indochina contain high concentration of rare elements like lithium and boron, which can be used to trace the target rock. Tibet lake region is known for its lithium and borax deposits along with ultra-high-pressure finds like coesite, stishovite and high-pressure nitrides. Spatial distribution pattern of these tektites, specifically down-range spreading in a narrow fan area, suggest that Muong Nong tektites may have been produced by a grazing impact in Tibet on Indochina border. High concentrations of volatiles like Cl and Br can be ascribed to a chondritic or cometary impactor.

Key Words: Muong-Nong tektites, Asian Tektites, Australasian Strewn field, Asteroidal impact, Ultra high-pressure rocks

INSIGHTS INTO THE CRUST AND UPPER MANTLE STRUCTURE OF THE UTTARAKHAND HIMALAYA BY INVERSION OF RAYLEIGH WAVE GROUP VELOCITY DISPERSIONS

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ABSTRACT

Uttarakhand is located in the central seismic gap of the Himalaya, where accumulated strain due to India-Eurasia convergence has not been released via a great earthquake in the recent past. The seismic structure of the region is crucial in understanding the accumulated stress and seismicity. Previous seismological studies reported a highly heterogeneous velocity structure of the crust. However, the upper mantle structure of the region has not been well-studied. CSIR-NGRI established a seismic network of 52 stations spanning across the entire Uttarakhand Himalaya. In this study, 34 regional earthquakes (M_L>5.5) recorded in the network were analyzed. The Rayleigh wave group velocity dispersions for periods between 10 and 100 s were computed by Frequency-Time analysis. We obtained more than 400 best-quality dispersion curves. The dispersion measurements were inverted to obtain a 1D shear-wave velocity model using a linearized inversion scheme. To reduce the effect of the initial velocity model on the inverted results, inversion was done using ten different initial velocity models varying in layering, thickness, and layer velocities. The 1D velocity model represents the average structure between the event-station pair. Significant shear wave velocity variations were observed, highlighting distinct 1D velocity structures in two zones: Zone I (Garhwal) and Zone II (Kumaon). Zone II showed higher velocities in the upper crust, while Zone I exhibited relatively lower velocities. For instance, seismic velocities in Zone II range from 3.2 to 4.0 km/s, while Zone I

ranges from 3.2 to 3.8 km/s. Within the mid-crust, Zone I velocities drop while Zone II remains the same. Within the upper mantle, the s-velocity is highest at around 55 km depth beneath Zone I, while for Zone II, the peak velocity remains almost constant from 60-90 km depths. Our results are preliminary and require improvement, which will be achieved by surface wave tomography.

Keywords: Uttarakhand Himalaya; Surface wave dispersion; Linearized inversion; 1D Crust and Upper mantle structure; Lateral variation

STRESS ANALYSIS OF THE ROCKS IN AND AROUND CHUMUKEDIMA - PIPHEMA SECTION OF THE BELT OF SCHUPPEN OF NORTHEAST INDIA AND ITS RELATIONSHIP WITH THE OROGENESIS OF THE INDO-MYANMAR RANGES

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ABSTRACT

The Belt of Schuppen of Northeast India having nearly NE-SW trend is reported to be a narrow linear imbricate thrusts system. The study area in the belt is divided into four different segments from west to east so as to make portray a better picture about the stress fields. It is found that in all the segments the majority of the joints are principally of Mode I and Mode II types. From the orientations of the Mode I type joints, the orientations of maximum principal stress, σ_1 in each segment are worked out. The mean orientation of the maximum principal stress, σ_1 of the four segments found out from joint analysis (I = 130°, II = 105°, III = 100° and IV = 100°) agrees well with those determined from conjugate analysis (I = 105°, II = 090°, III = 118° and IV = 083°). The positions of σ_1, σ_2 and σ_3 determined from conjugate fracture analysis reveal that fracture systems of the belt are mainly controlled by strike-slip faulting. The analysis of slickenside lineation data implies that the majority of them are found to have been controlled by a thrust faulting mechanism where the influence of strike-slip faulting is also evident. When each and every conjugate fracture and slickenside data are analysed separately, it is evident that orientation of σ_1 remain more or less constant (even if swinging in the same quadrant) while that of σ_2 and σ_3 inter-change frequently implying that these faults are formed either by reverse (thrust) faulting or strike-slip faulting, or through thrust faulting and reactivation as strike slip faulting due to the interplay of dextral-slip of the Dauki fault and dextral shear deformation of the Indo-Myanmar Ranges.

Keywords: Joints; Conjugate fractures; Slickensides; Belt of Schuppen; Indo-Myanmar Ranges

ESTIMATION OF HIGH FREQUENCY DECAY PARAMETER (K) FOR NATIONAL CAPITAL (DELHI) REGION

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ABSTRACT

The effective attenuation of seismic waves within the crust is generally modeled by the inverse of quality factor (Q). It has now been recognized that the decay of acceleration spectra at high

frequencies could not be explained by whole path attenuation within the crust. The spectrum of earthquake strong ground motions has been found to be attenuated more rapidly at high frequencies above the corner frequency than predicted from the Brune (1970) model. According to Hanks (1982) model the acceleration spectra are flat above the corner frequency as predicted by Brune model and fall off rapidly above a second corner frequency (f_{max}) mainly due to propagation path effects/local site effects. This high-frequency spectral attenuation can be modeled by high frequency decay parameter, Kappa (κ). It is one of the important parameter required in the simulations of earthquake strong ground motions. The research on origin, physical meaning and dependence of 'κ' on various factors like distance and /or source still continue.

The present study deals with the estimation of high frequency parameter, kappa (κ) for National Capital (Delhi) region. This has been estimated from the slope of linear fit above a specific frequency to the log-linear plot of the acceleration spectrum. The strong ground motions of 35 earthquakes recorded at 47 sites has been used for this purpose. The estimated values of 'κ' lie in the range 0.015-0.093 for the various sites of the region. The dependence of estimated Kappa values on distance is not significant. There is a scatter in the variation of Kappa values with magnitude. This indicates that the high frequency decay parameter (κ) is related to site rather than source property in the Delhi region. This may, however, be validated using more data when available for the region.

The estimated values of 'κ' are expected to be useful for the simulation of earthquake strong ground motions which are required for the proper evaluation of seismic hazard of the region.

Keywords: Corner Frequency, Brune Model, Kappa

UTILIZING SEISMIC AMBIENT SURFACE WAVE TOMOGRAPHY TO MAP THE CRUSTAL STRUCTURE IN NORTHEASTERN INDIA

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ABSTRACT

The northeastern region of India is characterized by intricate tectonics, resulting from the Indo-Eurasian plate collision to the north and subduction along the Indo-Burma plate to the east. In this study, we analyse the crustal structure of the area using ambient noise data from twenty permanent and three temporary broadband seismic stations. By cross-correlating ambient noise records, we construct group velocity maps for 6 to 25 seconds. Short-period maps (<10s) highlight important geological features, such as the boundary between undifferentiated granites and Eocene rocks on the Shillong plateau, as well as notable elements of the Bengal basin, Indo-Burma ranges, and the Brahmaputra River valley. At longer periods (>10s), our results indicate that the basement rocks of the Shillong massif are separated from Bengal basin sediments by the northward-dipping Dauki thrust fault, with a consistent dip observed up to ~16s that flattens further north at longer periods. The group velocity maps suggest that tectonic stresses may have played a role in the uplift and expansion of the Shillong massif. Additionally, our findings reveal a gradual increase in crustal thickness within the Bengal basin toward its eastern boundary, suggesting potential oblique subduction along the Indo-

Burmese arc. At a latitude of 25°, variations in velocity within the Indo-Burma region from north to south are associated with thicker crust in the southern Indo-Burma ranges.

Keywords: Ambient Noise Tomography, Surface Waves, Northeastern India

EXPLORING THE CRUSTAL STRUCTURE IN NORTHEASTERN INDIA USING SEISMIC AMBIENT SURFACE WAVE TOMOGRAPHY

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ABSTRACT

The northeastern region of India features complex tectonic activity due to the convergence of the Indo-Eurasian plates in the north and the subduction of the Indo-Burma plate along its eastern edge. This study analyzes the area's crustal structure using ambient noise data from 20 permanent and 3 temporary broadband seismic stations. By cross-correlating ambient noise records, we construct group velocity maps for 6 to 25 seconds. The shorter period maps (<10s) reveal important geological features, such as the boundary between undifferentiated granites and Eocene formations on the Shillong Plateau, as well as notable characteristics of the Bengal Basin, Indo-Burma Ranges, and Brahmaputra River Valley. For longer periods (>10s), our analysis shows that the basement rocks of the Shillong Massif are separated from the Bengal Basin sediments by the northward-dipping Dauki Thrust Fault, which maintains its dip up to approximately 16 seconds but flattens further north at longer periods. The group velocity maps suggest tectonic forces may have contributed to the uplift and expansion of the Shillong Massif. Additionally, our study shows a gradual thickening of the crust in the Bengal Basin towards its eastern edge, implying possible oblique subduction along the Indo-Burma Arc. In the Indo-Burma region, variations in velocity at 25° latitude from north to south indicate a thicker crust in the southern part of the Indo-Burma Ranges.

Keywords: Ambient Noise Tomography, Surface Waves, Northeastern India

AUTOMATED FAULT MAPPING IN THE SCOTIAN BASIN: A COMPARATIVE ANALYSIS OF FAULT-NET AND U-NET MODELS

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ABSTRACT

Accurate fault detection is essential for improving structural interpretations and reducing uncertainty in reservoir characterization. Traditional fault detection methods, which rely on manual interpretation or seismic attributes like similarity, can be effective but are time-consuming and depend on the expertise of the interpreters. In contrast, machine learning (ML) models have revolutionized the process by automating fault detection. Pretrained models such as Fault-Net and U-Net are designed to identify faults with minimal interference from the interpreter. Trained in synthetic and real datasets, these models can generalize to new seismic volumes, associated with unexplored areas. In the present study, a comparative analysis has been performed between the Fault-Net and U-Net based ML models in deciphering and enhanced visualization of the structural features of the Penobscot prospect in the

Scotian Basin, offshore Nova Scotia. This assessment is crucial in understanding whether these automated methods can deliver the accuracy and reliability required for high-stakes exploration such as the Scotian Basin.

Characterized by thick sedimentary sequences deposited from the Jurassic to the Cretaceous periods and varied degree of tectonic activity the Penobscot prospect is an important target for hydrocarbon exploration due to its potential for generation and accumulation. Thus, understanding the fault systems within these formations is crucial, as faults can either facilitate or hinder hydrocarbon migration.

We've evaluated the performance of these pre-trained models on Penobscot data. Fault-Net and U-Net, show varying results depending on the different data conditioning approaches and model architecture.

Fault-Net performed best with the fault enhancement filter, while 3D U-Net achieved the best results using the edge-preserving smoother filter. Comparing the faults detected by these models using the similarity attribute, showed that Fault-Net describes the major faults more continuously, whereas the minor faults are clearer and more continuous and better fitting with similarity using the U-Net model. The study emphasizes the need for suitable data conditioning and model selection to improve fault detection and visualization in complex geological settings like the Penobscot prospect.

A THREE-DIMENSIONAL CRUSTAL GEOELECTRIC IMAGE OF THE WESTERN DECCAN VOLCANIC PROVINCE AND ADJOINING KONKAN PLAINS

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ABSTRACT

The significant geomorphological features of western continental margin of India namely, the Konkan Plains, the coast parallel Western Ghat Escarpment (WGE), and the elevated Deccan plateau, covered by massive lava flows, have their genesis in a sequence of geodynamic episodes. We present the results of a magnetotelluric (MT) study along a 200 km long E-W profile traversing across the western Deccan Volcanic Province (DVP). We have modelled the MT dataset comprising 39 sites by two-dimensional (2-D) and three-dimensional (3-D) inversion algorithms. The geoelectrical model from 3-D inversion is broadly consistent with the 2-D model and reveals off-profile features that include a lower crustal high conductivity zone beneath the DVP. The geoelectric model yields highly resistive fragmented cratonic blocks of the Dharwar Craton, dissected by faults/fracture zones of pre-eruptive times. The moderate-to-high conductivity zone underlying the resistive cratonic blocks possibly represents the relics of the interaction process between the Indian lithosphere and the Réunion plume and a zone of volatile fluids as a result of residual thermal anomaly. The mantle plume-induced thermal and compositional anomalies in the crust can generate differential stresses and activate pre-existing faults due to isostatic adjustments, which could be responsible for the present seismic activity in the old cratonic part of the peninsular India. We further infer that the persistent dynamic topography of the WGE is due to the presence of such fluids at deeper depths and uplifting of a low-to-intermediate strength lithosphere.

GEO-HAZARD INVESTIGATION IN UTTARAKHAND: CHARACTERIZATION BASED ON LOCAL SEISMIC SIGNALS

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ABSTRACT

Geodynamic deformations, gravity-driver instabilities and anthropogenic activities cause geohazard in the hilly terrain. The number of hazardous events is frequent, and some have recently more reoccurrences in Uttrakhand. The ongoing tectonic collision of India-Eurasia deformed the hilly Mountains, causing earthquake occurrence. Although destructive strong and higher magnitude earthquakes are not frequent they cause high destruction and causalities. Uttarakhand Himalaya has experienced many strong earthquakes, the locations of different size earthquakes demarcate the Himalayan seismic belt in the central Himalaya. WIHG has a dense and long-duration seismic network in the Uttarakhand region to characterize earthquake sources, evaluate seismotectonic and explore the crustal structure for the earthquake hazard investigation. On 7 February 2021, the Chamoli region of Uttarakhand was devastated by a deadly rock-ice, rock-fall event that led to a large causality of 200 people and a huge economic loss. The characteristics of seismic data distinguished by debris flow and hitting obstacles produce seismic records in the Uttarakhand that also for the estimations of debris flow speed. We analyzed and verified the seismic signals with field evidence to assess the associated impacts and velocity of dynamic flow.

Gravity-driver rock instabilities in the hilly terrain are frequent hazards in the monsoon during July-August. Massive landslides occurred in and around Joshimath, Uttrakhand in July 2024 after heavy rainfall. The seismological stations installed in the Joshimath to monitor the subsidence and aftereffects have nicely recorded sizeable landslides within 5 km distance. One massive landslide at midnight of July 15-16 displacing a big chunk downslope for nearly 100 m is recorded by 5 stations of Joshimath. The volume of displaced material, the distance of displacement, and the slope of the landslide govern the amplitude and duration of the seismic record. The low-frequency spectrum of landslides compared to the earthquake data makes seismic records distinct, indicating source characteristics and path propagation convolution. We utilize the shape and duration, spectrogram, and spectrum distinction of the signals to identify the landslide imprints in the continuous seismic records. In addition to the imprints of major landslides, the small vibrations before and after highlight the use of valuable data for the feasibility and development of landslide early warning system.

Keywords: Geo-hazard, Landslide, Earthquake, Rock-Ice Avalanche, Uttarakhand Himalaya

IDENTIFICATION OF QUARRY BLASTS IN THE SEISMIC RECORDS OF CHAMBAL VALLEY, RAJASTHAN BASED ON SPECTRAL ANALYSIS

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ABSTRACT

Differentiating quarry blasts on the seismic records is becoming increasingly challenging due to the rise in human-induced seismicity associated with growing industrial and mining activities. This study focuses on the sedimentary terrain of the Chambal Valley in the Vindhyan Basin, Rajasthan, which

has experienced intense mining because of the availability of economically valuable minerals. Approximately 100 events recorded by the microearthquake network around a power plant between November 2016 and March 2023, with magnitudes ranging from ~ 1.0 to 2.1 (M_L), were analyzed. Due to lack of information on the timing of the blasts, we analyzed spatial and temporal distribution of events, P-wave polarity studies, and spectral analysis of waveforms to identify the quarry blasts. The spatial analysis shows that the events are mainly distributed in the quarry site, and the temporal distribution shows the day time events are significantly higher compare to night time events. P-wave polarity analysis indicated a clear compression on the majority of the first onset of waveforms, which is consistent with blast characteristics. Spectral analysis was also carried out on the amplitude spectrum of the above events. Their maximum amplitude concentrated within a specific frequency band (1-10 Hz), and the amplitude spectrum distribution was non-uniform. The amplitude spectra have shown steep falloff and rapid attenuation. These comprehensive results suggest that most of the events near the quarry site are blasts. We have also analyzed spectral analysis of some of the earthquakes located far from the network and found that the amplitude spectrum is uniformly distributed across all frequency components, sometimes displaying an exponential rise and fall in amplitude with respect to frequency. In this study, we present the analysis to distinguish between quarry blasts and microearthquakes.

Key words: Quarry blast, Microearthquake, Polarity, Spectral analysis.

MANTLE METASOMATISM AND NEGATIVE VELOCITY–DENSITY RELATIONSHIP IN CRUSTAL ROCKS: A CASE STUDY FROM KILLARI EARTHQUAKE REGION

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ABSTRACT

The knowledge of seismic and physical properties of the deep-seated crustal rocks, which are inaccessible to direct observations, are extremely important to interpret various kinds of geophysical and geodynamical observations. We made a detailed geologic, geochemical, seismic and petrophysical study on the 270 m thick 2.57 Ga amphiboloite to granulite facies (5-7 kb) basement column, drilled through below the 1993 Killari seismic zone in the southern part of the Deccan Volcanic Province, which witnessed a disastrous earthquake in 1993. During this study, we observed severe drop in P-wave velocity to the tune of almost 15% in a number of high density basement cores, thereby resulting into a highly unusual negative velocity-density relationship. We attribute this velocity drop primarily to FeO_T enrichment (up to about 23 wt%) during the course of mantle-fluid driven metasomatic reactions, caused by retrogression and exhumation of deep-seated mafic rocks. Mantle metasomatism is a geological process that alters the basic lithological fabric of the rock due to mass-influxing and infiltration of the gaseous fluid-rich hydrothermal solution from the mantle. We noticed pervasive presence of cluster of opaques in thin sections of the rocks, that resulted into sharp increase in density, but at the same time, also caused increase in mean atomic weight, which is intimately connected to lowering of P-wave velocities. SEM studies indicate that most of these opaque minerals are magnetite, apart from a few grains of pyrite and chalcopyrite. We also found almost one to one relationship between FeO_T and the mean atomic weight.

ENHANCING THE QUALITY OF SEISMIC IMAGE WITH CURVED CDP OF CROOKED SEISMIC PROFILE: A CASE STUDY FROM THE ON-LAND SHALLOW SEISMIC DATA, KOVVADA, ANDHRA PRADESH.

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ABSTRACT

Due to the inaccessibility of rugged terrains, logistical and environmental restrictions, and cost limitations of seismic data acquisition, we modify our conventional straight-line acquisition geometry to crooked profiles. The crooked-line geometry is significantly irregular and can give different artefacts, leading to difficulties in Common Depth Point (CDP) stacking. The crooked nature of seismic lines collects data with variable fold and uneven offset distribution with considerable offset-variant time shifts, which affects the signal-to-noise ratio of the data. Irregular distribution of sources and receivers along a crooked profile scatters the midpoint locations from the proposed straight line. Processing of the crooked seismic line with perfect CDP binning can give enhanced geological features in seismic images. In our study, we examined a seismic line acquired at Kovvada, Andhra Pradesh. Due to the inaccessibility through rugged terrains and logistical restrictions, the line was acquired in a crooked geometry path. In this crooked seismic line geometry, the source-receiver midpoints are scattered. The seismic stack section prepared with the CDP gathers of this scattered and irregular CDP geometry shows so much noise. So, we fitted the best possible curve along the source-receiver midpoint scatter plot and compared it with the seismic stack section prepared with an irregular CDP line having midpoints along the seismic acquisition path. The stack section with the curved CDP line was given a better-enhanced image than the stack section with the irregular CDP line.

Keywords: seismic geometry, crooked line geometry, seismic processing, seismic enhancement.

SHEAR-WAVE ATTENUATION MODEL FOR THE HIMACHAL REGION, NW HIMALAYA, INDIA

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ABSTRACT

In this work, frequency-dependent shear-wave attenuation relations are quantified laterally and temporally for the Himachal region, North-West Himalaya, India. The obtained attenuation characteristics have been correlated with the seismic hazard and subsurface crustal variation of the study region. The inversion of strong motion data has been implemented to quantify the attenuation properties in the form of quality factor (Q) values. The attenuation properties are proportional to 1/Q, and frequency-dependent shear-wave quality factor ($Q_\beta(f)$) relations of the form $Q_o f^n$, where 'Q_o' and 'n' describe the level of heterogeneity and seismic activity of the region.

The study region covers the Himachal Himalaya and is selected based on the distribution of the events and recording sites. The study area has a surface area of 189 x 249 km^2 and is defined by a rectangular block as 30.75°N to 33.00°N and 76°E to 78°E. A total of 522 waveforms of strong

motion data are utilized to estimate attenuation characteristics. The study region is divided into 100 small blocks to explore the attenuation variation of the study region. The attenuation properties are explored for six different layers of 5km thickness each up to a depth of 30 km. The obtained attenuation model proposed the low-quality factor values for layers 3 (10-15km) and 4 (15-20 km), which corresponds to high attenuated material at this depth. The depth (~10-20 km) of this highly attenuated material has a resemblance with the intra-crustal high conductive (ICHC) layer identified in its adjacent region. Hence, the high attenuation material suggests the existence of the ICHC layer in the Himachal Himalaya. The obtained $Q_\beta(f)$ model directly reflects the region's seismic hazard as high 'n' value (>0.8) and low Q_o value (< 200) characterize the region as tectonically active and highly heterogeneous. The layered $Q_\beta(f)$ model will improve the simulation results and earthquake source parameters, as this is a vital input parameter for its computation. Hence, precise appraisals of simulated and earthquake source parameters would necessitate a layered $Q_\beta(f)$ model.

Key Words: Attenuation, Quality factor, Himalaya, Inversion, Hazard

PORE PRESSURE ESTIMATION AND MUD WEIGHT OPTIMIZATION FOR SAFE DRILLING IN THE KRISHNA-GODAVARI BASIN

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ABSTRACT

Pore pressure is a critical geomechanical parameter that directly influences mud density during the drilling process. Maintaining mud weight within the range of formation pressure (pore pressure) and fracture gradient is essential to mitigate risks such as kicks, blowouts, well collapse, and loss of circulation. Failure to adhere to these parameters can lead to increased operational costs and, in extreme cases, catastrophic accidents resulting in loss of life and damage to assets. This study aims to estimate pore pressure within water-bearing shale formations and gas hydrate-bearing sand formations across four wells—NGHP-02-17A, 19A, 22A, and 23A—in the Krishna-Godavari Basin. For the water-bearing shale formations, we employed Bower's sonic, Eaton's resistivity, and Eaton's sonic empirical equations to estimate effective stress. In contrast, these empirical models were found inadequate for gas hydrate-bearing sand formations. To address this, we developed a linear model based on pressure-core data that correlates effective stress with depth below the seafloor (mbsf). The estimates generated by the linear model were validated against core data, showing strong agreement across all wells. At the NGHP-02-23 site, in-situ pore pressure was measured using a modular dynamic formation tester (MDT) within the depth range of 270.38 to 271.38 mbsf, yielding a pressure of 28.2 MPa, closely aligning with the estimated pore pressure of 27.8 MPa from the linear model. Additionally, fracture pressures were calculated utilizing Matthew-Kelly and Eaton's methodologies. The mud density of 1.3 g/cc ensures that the mud weight remains safely between pore pressure and fracture gradient, thereby satisfying criteria for safe drilling practices. This study underscores the importance of accurate pore pressure estimation in ensuring operational safety and efficiency in drilling operations.

CRUSTAL STRUCTURE AND TECTONIC EVOLUTION OF THE PRANHITA-GODAVARI RIFT: A COMPREHENSIVE STUDY USING EDGE ENHANCEMENT TECHNIQUES AND 2D GRAVITY MODELING.

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ABSTRACT

The Pranhita-Godavari Rift basin is a significant tectonic feature in peninsular India. The Bouguer gravity anomaly digital grids from the gravity map of India (after NGRI-GSI, 2006) were analyzed to present a detailed discussion of the Pranhita-Godavari rift basin's crustal structure and contribute to understanding its regional geology (i.e., Sediment thickness, depth of the basement, Conrad, and Moho) and tectonics. Using advanced techniques like the horizontal gradient method (HGM), first vertical derivative (FVD), and tilt derivative (TDR), we successfully mapped the regional tectonic features. The identified key lineaments and faults have trends primarily in NW-SE, WNW-ESE, NNE-SSW to N-S, and NE-SW directions.

The depth of the Moho, Conrad, and basement was computed using 2D gravity modeling. The modeling reveals significant findings, including substantial crustal thickening within the rift, with Moho depths ranging from 38.6 km to 41 km, indicating considerable tectonic subsidence and sediment accumulation. Conrad discontinuity depths vary between 18 km and 26 km, reflecting complex crustal deformation associated with rifting processes. Basement depths range from 3.5 km to 6.2 km; the Alluvium, Barakar, Sullavai, and Pakhal sediments are deposited over the Archean basement, highlighting differential subsidence within the rift compared to adjacent cratonic regions. Additionally, several major and newly observed faults were mapped using 3D Euler deconvolution and 2D gravity modeling. The Ahiri-Tippapuram, Godavari Valley, Kinnerasani Godavari, Koddam, and Kolleru Lake faults were identified, extending to the Moho with significant downthrows, indicating varied tectonic activity. These findings provide valuable insights into the tectonic evolution and structural dynamics of the PGR, offering a deeper understanding of rift-related processes and aiding future research in the region.

Keywords: Pranhita Godavari Rift basin, Bouguer anomaly, 3D Euler Deconvolution, Horizontal Gradient Method, First Vertical Derivative, Tilt Derivative, and 2-D gravity modeling.

SEISMOGENESIS AND CRUSTAL HETEROGENEITY REVEALED BY SEISMIC B-VALUE MAPPING AND COULOMB STRESS MODELING DUE TO 2023 TURKEY (MW 7.8 AND 7.5) EARTHQUAKE DOUBLET

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ABSTRACT

On February 6, 2023, southern Turkey and northwest Syria were struck by two major earthquakes with magnitudes of Mw 7.8 and 7.5, rupturing the southeastern Anatolian Fault and the Savrun–Çardak–Sürgü Fault and generating thousands of aftershocks. These catastrophic events led to over

50,000 fatalities and substantial economic losses. The seismogenesis and crustal heterogeneity within the rupture zones were analyzed using spatial mapping of seismic b-values, which reflect the relative distribution of earthquake magnitudes, along with Coulomb stress modeling. The seismic b-values were estimated using a maximum likelihood approach within the framework of the Gutenberg–Richter frequency-magnitude distribution. For this analysis, a well-located earthquake catalog containing over 28,000 seismic events with magnitudes ranging from Mw 1.5 to 7.8 was utilized. This study focuses on estimating seismic a- and b-values, the aftershock decay rate (p-value), and fractal dimension (D-value) to characterize the earthquake sequence's seismogenesis, as well as using stress modeling to visualize the triggering of earthquake doublets and significant aftershocks. To estimate the magnitude of completeness and seismic a- and b-values across the entire rupture zone and in specific sections of the two fault zones, three statistical methods—maximum curvature, best combination, and entire magnitude range (EMR)—were applied. Spatial mapping of seismic a- and b-values for both fault zones and their subsections reveals significant non-uniform and highly heterogeneous medium that correlates with the uneven slip distribution across both faults. The low b-value range of 0.4–1.04 across different depth sections suggests a highly fractured, stressed environment with high deformation rates within the region. Coulomb stress modeling of the earthquake doublets and largest aftershocks, based on the non-uniform slip distribution, demonstrates that these events were sequentially triggered by Coulomb stress transfer from preceding large earthquakes. This study highlights the continued hazard of aftershocks in southern Turkey, underscoring the need for persistent seismic monitoring and preparedness in this earthquake-prone area.

THERMAL STRESS INDUCED FORMATION AND EVOLUTION OF DISCONTINUITIES IN ROCK STRATA AND ITS BEARING ON GEOTHERMAL ENERGY EXTRACTION

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ABSTRACT

In view of limited resources and high demand of conventional fossil fuel based energy as well as huge emission of carbon dioxide in atmosphere which has created lot of complications for climate change. Hence, it is necessary need of society to look on alternative energy resources for future generation usage. Among various renewable and non-renewable energy resources, the geothermal energy is one of them became a burning topic around the world. The geothermal energy is a renewable energy, environmentally sustainable and plentiful thus playing a significant role in dealing with environmental aspects and energy shortages.

The reservoirs of geothermal system is categorized as conventional and non-conventional types. The heat energy extraction from the conventional reservoir is now in practice for production, however such extraction from non-conventional reservoir is still at experimental levels. In general, geothermal energy extraction practices steam or water derived from heated zone deep inside the Earth. The discontinuities are assisted the principal flow and heat transfer paths in the production of heat energy for generation of electricity and other domestic and industrial purposes. The discontinuities (fractures) present in geothermal reservoir are often influenced the geomechanical behavior of rock strata (rock mass) and affect flow and transport of hot fluids for heat energy extraction.

In the expansion process of geothermal energy extraction with respect to time, the rock strata of reservoir are affected by injection of fluid induced accumulation of thermal stress. Such accumulated

thermal stress is responsible for significant changes in the stress field of the reservoir. The change in stress field is accountable for formation and evolution of mechanical discontinuities in addition to preexisting discontinuities in rock strata. Thus, such composite changes in characteristic of rock strata ultimately cause the change in geotechnical characteristics of reservoir. The change in geotechnical characteristics directly influences the overall porosity and permeability of rock strata. Such change in porosity and permeability has pronounced bearing on the extraction of heat energy from geothermal reservoir.

Therefore, the present paper is an attempt to establish the bearing of inherent discontinuities on nucleation, propagation and evolution of mechanical discontinuity rock strata due to change in thermal stress and confinement. The study is based on experiments carried out on sandstone of Upper Kaimur Group of Vindhyan Supergroup exposed in Son Valley, Central India due to its very low anisotropy. For the purpose, the discontinuities present in sandstone stratum were evaluated for assessment of inherent porosity and permeability, and thermal stress induced changes in porosity and permeability of sandstone stratum through observation and estimation of relative damage factor. The outcome of present study may be useful in assessing the geotechnical response of conventional geothermal reservoir for pertinent extraction of heat energy and management of geothermal system.

AN UPDATED PROBABILISTIC SEISMIC HAZARD ASSESSMENT (PSHA) FOR HIMALAYAN SEISMIC BELT (HSB) FROM HISTORICAL AND INSTRUMENTAL EARTHQUAKE CATALOGUES

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ABSTRACT

The Himalayan Seismic Belt (HSB) (25.0° N-35.0° N; 70.0° E-100° E), is recognized as one of the youngest and most seismically active mountain ranges in the world, driven by the ongoing collision between the Indian and Eurasian plates. This tectonic activity has resulted in over twenty major earthquakes exceeding Mw 7.0, and the potential for future large seismic events remains high. Given this significant seismic risk, a thorough and updated seismic hazard assessment for the region is imperative. To address it, a comprehensive earthquake catalogue of 28,360 events has been compiled from diverse international, national, and regional sources. Key seismicity parameters, including the mean seismicity rate (λ), the Guttenberg- Richter (GR) b-value, and the maximum expected magnitude (M_{max}) were derived using the maximum likelihood method. This approach accounts for catalogue incompleteness, improving the accuracy of the seismic hazard analysis. To model the background seismicity the region was divided into areal source zones taking into consideration factors such as focal mechanisms, seismic activity rates, and geological features. The study implemented declustering techniques to reduce aftershock bias and integrated seismogenic source models. The three sets of Ground Motion Prediction Equations (GMPEs) were applied: five for active shallow crust, five for subduction zones, and three for intraplate margin. These models were applied at different depth ranges using a logic tree framework to address both aleatory and epistemic uncertainties. The studies provide predictions for peak ground acceleration (PGA) and spectral acceleration (SA) at 0.2 s to 2.0 s with probabilities of exceedance at 2% and 10% over 50 years at the bedrock level. The study outcomes are presented as hazard curves, uniform hazard spectra, and detailed hazard maps. The updated assessment reveals that the hazard levels in many areas, especially

where significant earthquakes have previously occurred are mainly higher than earlier studies suggested.

Keywords: Himalayan seismic belt, peak ground acceleration, spectral acceleration

FINITE-DIFFERENCE FULL-WAVE MODELING FOR SEISMIC WAVE PROPAGATION IN COMPLEX GEOLOGICAL STRUCTURES USING PERFECTLY-MATCHED-LAYER ABSORBING BOUNDARY CONDITIONS

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ABSTRACT

Seismic wave propagation in complex geological structures plays a very important role to image the target zones of interest for hydrocarbon and mineral exploration. Hence, we have employed a robust and compute-intensive acoustic finite-difference (FD) full-wave modeling for imaging the complex geological structures like Marmousi-II and complex dipping models using both staggered and non-staggered-grid approach. This technique can able to image both small-scale and large-scale structures using two-way wave equations both in time and space. These models are further constrained by the absorbing-boundary-conditions using perfectly-matched-layers (PML) at the bottom and on either side along with a free surface boundary condition on the top to avoid multiples, back-scattered noises, and other spurious arrivals in the synthetic seismic data generated for the Marmousi-II and dipping model. The nature of wave propagation in the complex media are represented by the corresponding snapshots at different time steps along with the synthetic shot gathers generated for both the models required for seismic imaging.

Keywords: Finite-difference modeling; Staggered-grid; Non-Staggered grid; PML; Marmousi-II; Complex dipping model

VARIATION OF FRACTAL PROPERTIES OF SEISMICITY IN THE CENTRAL HIMALAYA AND ADJACENT REGIONS

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ABSTRACT

On April 25, 2015, a 7.6 magnitude earthquake hit central Nepal's Gorkha district, followed by a 7.0 magnitude quake at the Dolakha-Sindhupalchowk border. After the event, the region experienced many tremors, with a notable seismic cluster in 2022-2023. On November 8, 2022, a 5.6 magnitude earthquake struck western Nepal's Doti region, killing at least six people. In this work, the b-value of earthquake frequency–magnitude distribution and spatio-temporal variation of fractal dimension (Dc) of earthquake epicenter distribution are estimated in the region 80°E-89°E and 26°N-31°N. By dividing the region into three subregions, the spatial fractal dimension (Dc) and b-value were determined as follows: for western Nepal and its vicinity (80°E – 82.5°E and 28°N – 30.5°N), Dc is 1.89 ± 0.02 and the b-value is 0.68 ± 0.03; for central Nepal (82.5°E – 85.5°E and 27.5°N – 30°N),

Dc is 1.76 ± 0.01 and the b-value is 0.60 ± 0.05; and for eastern Nepal (85.5°E – 88.2°E and 26.45°N – 28.6°N), Dc is 1.85 ± 0.02 and the b-value is 0.63 ± 0.03.

The spatial-temporal distribution of b-values along five fault zones-Judi fault, Thaple fault, Kathmandu fault, Motihari-GauriShanker fault, and Motihari-Everest fault was analyzed following the Gorkha earthquake, using data from 10,500 events (Mc = 2.0 ML). Notably, the Judi fault, Thaple fault, and Motihari-Everest fault areas exhibited very low b-values of 0.45 ± 0.02, 0.48 ± 0.02, and 0.55 ± 0.04, respectively. During the active period of the Doti earthquake in the western Himalaya and the adjoining region (80.0°E – 83.5°E and 27.3°N – 30.5°N), low b-values (0.68 ± 0.03) and high correlation dimension (Dc) values (1.81 ± 0.02) were observed. This study sheds light on the mechanisms of major earthquakes in the Himalaya, improving our understanding of regional stress and seismic patterns while offering insights into potential future seismic hazards in the central Himalaya.

Keywords: Central Himalaya, b-value, Fractal Dimension, Seismic Hazard

LEARNINGS FROM MW 7.8 GORKHA, NEPAL EARTHQUAKE OF 2015

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ABSTRACT

Learnings from the multiparametric studies done by various investigators for the Mw 7.8 Gorkha Nepal destructive earthquake of 2015 (MMI=IX, focal depth 8.2 km) like strong motion, rupture process, aftershocks and damage caused are highlighted. GPS derived slip rate of 18-20 mm/yr would result into accumulation of 4 m strain capable of causing great earthquakes in some 200 km long segments of Nepal Himalaya which have not ruptured in last 200 yr. The western segment of Nepal Himalaya is one such area. East of 2015 rupture zone, Mw 8.4 earthquake occurred 81 yr earlier. Inferences about earthquake rupturing have confirmed the tectonic / seismogenesis model proposed for Himalaya that the large earthquakes nucleate on the Main Himalayan Thrust (MHT) at its northern locked part near Tibet border and propagate southward and E and/or W.

Low decay rate of 0.6 for damaging aftershocks (M≥4) reflecting into longer duration of 5 months as against 3 months expected for Himalaya. A major aftershock of Mw 7.3 was only 0.5 unit less than the mainshock magnitude than one unit difference generally observed for Himalaya. The reason could be that the large major aftershock had its own rupture zone and aftershock sequence. Four aftershocks of M>6 collapsed several houses weakened by the mainshock. Capability for aftershock forecasting, building evacuation procedure, building inspection and tagging, and building repairs and retrofitting (low-cost solutions) need to be improved to mitigate the earthquake risk. Recorded PGA 0.17-0.19 g at 60 - 70 km distance from the epicentre was half of the expected PGA of 0.35 g may be due to initial slow rupturing and moment release. Strong Sa 600 cm/s^2, PGV 107 cm/s and PGD 139 cm for 4-6s period waves indicate very strong shaking for long-period structures due to amplification of low frequency vibrations on a 650 m deep sedimentary basin. The realization that this high amplification may cause collapse of most of the world's tall buildings has resulted into raised seismic safety factor in designing of sky-scrapers in deep sedimentary basins worldwide. The earthquake caused death of 9000 people, injured over 22,300 and collapsed or severely damaged 800,000 houses/buildings and affected 8M people out of 27M population. Several towns and many villages were flattened in the

entire WNW trending rupture zone of 150 km x 55 km in between the mainshock at the western end and the largest aftershock at its eastern end. However, maximum damage was in WNW trending 75 km x 15 km area around and north of Kathmandu. Here, was the high Moment release with higher rupture velocity. About one fifth of total damage was in Kathmandu city where 5% houses / buildings collapsed. Numerous big and small landslides were mapped along five main roads blocked for several days. The earthquake triggered avalanches on Mount Everest, killing about 30 mountaineers and Langtang valley burying 250 people. Hundreds of heritage buildings, temples and Buddhist stupas were destroyed at UNESCO World Heritage sites. Damage to 95% buildings was due to absence of earthquake-resistant design and deteriorated material in old constructions. Hence, building codes need to be enforced for any small or big construction to minimise risk. Public / students awareness programs should be periodically conducted. The building damage in Kathmandu was localized to specific areas. Seismic microzonation may be carried out to identify areas of high amplification in Kathmandu. A few portions of highway subsided damaging buildings, hence, survey of unsafe roads/ground areas is recommended where subsidence may happen.

LANDSLIDE AND FLOOD MONITORING IN UTTARAKHAND HIMALAYAS USING SEISMIC, INFRASOUND, AND WATER LEVEL SENSORS

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ABSTRACT

The Uttarakhand region, characterized by its dynamic topography and active tectonics, is vulnerable to extreme weather events, and frequently experiences natural hazards such as landslides and flash floods. These hazards cause significant loss of life, damage to infrastructure, and environmental degradation. Traditional monitoring methods are often inadequate in such mountainous terrain, where early detection and continuous monitoring of landslides and river water flow are crucial. Environmental seismology is an emerging field that leverages seismic and other geophysical sensors to monitor and understand a variety of natural processes, like landslides, river dynamics, and geomorphological changes. In regions like Uttarakhand Himalayas, India, which is prone to natural hazards due to its dynamic topography, active tectonics, and climatic influences, Environmental Seismology offers significant potential for real-time monitoring and early warning systems. In this study, we present an integrated approach using seismic, infrasound, and automatic water level stations to monitor landslides and river water flow including floods in the Uttarakhand region. Broadband seismometers and infrasound sensors have been deployed alongside radar-based water level sensors to monitor the Alakananda River and its surrounding terrain. Preliminary results indicate a robust detection of landslides and a strong relationship between seismic signals, infrasound measurements, and water level variations, demonstrating the potential of these methods for landslide and river monitoring and hazard detection. This multi-sensor approach offers a promising avenue for enhancing hazard assessment and early warning systems in vulnerable regions like Uttarakhand in future.

Keywords: Environmental Seismology, Landslides, River Monitoring, Floods, Seismic Sensors, Infrasound, Uttarakhand

TECTONIC IMPLICATIONS OF CRUSTAL AZIMUTHAL ANISOTROPY BENEATH GUJARAT, WESTERN INDIA THROUGH PS SPLITTING

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ABSTRACT

This study presents a comprehensive analysis of crustal azimuthal anisotropy beneath the Gujarat region of Western India, using Ps splitting measurements derived from teleseismic receiver functions. Gujarat, characterized by complex tectonics and the intersection of several structural provinces, offers a unique setting to investigate the anisotropic behaviour of the Earth's crust. In this study, we employed a joint objective function and signal-to-noise ratio (SNR) reliability analysis—an integrative approach utilizing receiver functions from 50 broadband seismic (BBS) stations across the Gujarat region—to estimate crustal anisotropic parameters. The delay time (δt) ranged from 0.1 to 0.7 seconds, and the fast polarization direction varied between 5° and 245°. Weak anisotropy (0.1s–0.2s) was detected at 25 stations, while significant azimuthal anisotropy (0.3s–0.7s) was observed at the remaining 25 stations. Two dominant trends were identified: a north-south (N-S) and an east-west (E-W) orientation in the Kachchh and Saurashtra regions. In contrast, mainland Gujarat and north Gujarat exhibited a northeast-southwest (NE-SW) trend, while the southern region displayed a predominantly N-S orientation. The anisotropic patterns suggest a strong coupling between crustal deformation and regional tectonics, driven by the Indian plate's northward motion and active rifting. These findings provide valuable insights into the ongoing geodynamic processes shaping the Gujarat region, with implications for understanding the broader tectonic evolution of Western India. By mapping crustal anisotropy, this study enhances our understanding of the region's tectonic framework and provides a basis for future studies on seismic hazard assessment, particularly in light of Gujarat's history of significant seismic activity.

Keywords: Azimuthal Anisotropy, Crust Mantle coupling, receiver functions.

ESTIMATION OF SITE CORRECTION TERM BASED ON EMPIRICAL TRANSFER FUNCTION (ETF) FOR THE REGION OF NORTH-WEST HIMALAYA

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ABSTRACT

The site specific simulated earthquake strong ground motions play an important role in proper evaluation of seismic hazard of a region in the absence of recorded waveforms. A number of correction factors need to be incorporated in the simulation techniques in order to generate the realistic ground motions. These include corrections for path attenuation, high frequency attenuation, geometrical spreading, site amplification etc. The site correction term that accounts for site amplification is one of the most important factors that play a crucial role in the simulation technique. In most of the cases, the site responses used in stochastic ground motion simulation technique are simplified and estimated using Horizontal to Vertical (H/V) ratio and/or Standard Spectral Ratio (SSR) techniques. This may lead to uncertainties in the high frequency ground motions.

In the present study, the site correction term based on Empirical Transfer Function (ETF), which is the spectrum difference between the Fourier amplitude spectrum of observed strong ground motion

and simulated ones using stochastic technique, has been estimated for 30 sites in the North-West Himalaya region. The 117 accelerograms recorded at these sites from 10 earthquakes in the magnitude range 3.5-5.5 have been used for the purpose. The stochastic point source simulation technique has been used for the simulation of accelerograms which can be considered as reference rock site simulation to study the site effects. It is found that the simulated time histories with the incorporation of ETF are matching well with those of recorded ones as compared to the simulated accelerograms with incorporation of site effect estimated from H/V ratio technique. The magnitude dependence of ETF is also explored at some of the sites in this study. The spatial distribution of dominant frequency estimated from ETF is presented here. The ETF presented here are useful for the simulation of ground motions from future earthquakes of the region. The similar studies may also be done for other regions of Himalaya.

SITE EFFECT ASSESSMENT OF JOSHIMATH USING HORIZONTAL TO VERTICAL SPECTRAL METHOD

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ABSTRACT

The Joshimath region of Uttarakhand, India, has recently experienced land subsidence in 2023, a major issue in the hilly region. This region lies above vaikrita thrust (MCT-II), the active tectonic feature also experiencing seismic activity. This region lies adjacent to the epicenter zone of the 1999 Chamoli a strong earthquake of the region. To comprehend the seismic behavior to a particular site, and related geological characteristics are examined by analyzing earthquake data gathered from seismic sensors installed across the Joshimath region by the Wadia Institute of Himalayan Geology. We investigated the site effect using HVSR method to understand this important phenomenon of seismic hazard. The resonance frequency given by the HVSR method plays a significant role that may be related to the geological characteristics of site and region. The resonance frequency obtained by analyzing 54 local distance earthquakes lies in the 1.2- 9.0 Hz frequency range. The variation in resonance frequency indicates different geological Setup and diverse characteristics of the site. The findings reveal spatial variations in resonance frequencies, reflecting the heterogeneous subsurface conditions prevalent in the Joshimath region. Low resonance frequencies observed in areas prone to landslides, such as Merag, suggest the predominance of softer and less consolidated geological materials, heightening susceptibility to deformation and instability. Conversely, the sites characterized by higher resonance frequencies, such as the southern reaches of Joshimath, exhibit stiffer geological formations, imparting greater resistance to seismic forces and mitigating landslide risk. With a focus on incorporating hydrological factors into site response dynamics, the study seeks to clarify the relationship between resonance frequencies, geological characteristics, and landslide susceptibility

BACK-REACTION OF UNIFORM MAGNETIC FIELD ON EARTH'S CORE CONVECTION UNDER HIGH THERMAL FORCING

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ABSTRACT

The liquid iron core of the Earth is vigorously convecting due to thermal and chemical buoyancy to generate and sustain geomagnetic fields by dynamo action. Implementing geophysical constraints

such as stable stratification and core-mantle boundary (CMB) heterogeneity can substantially modify fluid flow and heat transfer inside the core, resulting in modifying magnetic field morphology. In the present study, a plane layer convection model is used to investigate the evolution of rotating magneto-convection under various levels of buoyancy forcing, from onset to 50 times supercritical, with an axially imposed uniform magnetic field. Additionally, a thermally stable stratification is implemented near the top plate to mimic the stable layer near the top of the CMB, as inferred from various geophysical investigations such as seismology, geomagnetism, and mineral physics. Consequently, imposition of stable stratification suppresses the flow to the convectively unstable region at lower buoyancy forcing; however, flow penetrates into the stable layer as thermal forcing is enhanced by 10-50 folds. The uniform magnetic field is incorporated in the axial direction, which poses additional stability to the convective flow at a lower supercritical regime, leading to laminar flow. However, the flow becomes semi-turbulent as thermal forcing is enhanced to higher levels. Furthermore, convective heat transfer in the presence of stable stratification at a high thermal forcing is investigated for penetrative magnetoconvection, and compared with the pure supercritical thermal convection, leading to substantial modification in heat transfer efficiency in the presence of the imposed magnetic field.

EVALUATING DIFFERENT SUSCEPTIBILITY METHODS FOR THE JOSHIMATH TOWN

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ABSTRACT

Situated in the district Chamoli, the recent slope stability issues in Joshimath indicated an accelerated slide in a town already reported as "sinking," raising urgent alarms across India. Appearance of cracks around the town in houses and ground has been observed over time. The necessity to understand the deformation signatures and the possible causative factor causing such cracks is of utmost importance. Located in NH 7 Joshimath is a strategic and tourist transit town in Uttarakhand that faces significant challenges due to its complex geology, steep terrain, rapid urbanization, erosion, erratic land-use practices, and changing pattern of rainfall, all of which contribute to frequent landslips. These landslides often result in considerable socio-economic damage, with huge environmental concerns. Therefore, it is crucial to map regions susceptible to landslides for the benefit of local communities. An attempt has been made to prepare a susceptibility map of the Alaknanda Catchment, beginning from Birahi, to Badrinath, via Joshimath. Using GIS and remote sensing techniques, and incorporating field investigations and existing literature, ten causative factors were analyzed: slope, aspect, curvature, lithology, rainfall, land use land cover (LULC), topographic wetness imdex (TWI), distance from faults, roads, and streams. Weights were assigned to each variable based on its influence on landslide initiation, using the Analytical Hierarchy Process (AHP). The landslide susceptibility map was used to classify the study area into very low, low, moderate, high and very high susceptible zones. Of the total area 4% of the area falls under very low risk zone, 33 % falls under low risk zone, 41 % under the class of moderate risk zone, 19 % falls under high and 3% very high risk zone. Additionally, an effort has been made to assess landslide susceptibility in the town using various alternative methods. Thus it is crucial to understand that over time, the susceptibility of a region can change due to increasing developmental activities. Therefore, regular revisions of these maps from time to time are vital. In areas like Joshimath, where geological and environmental factors

make landslides a significant concern, up-to-date landslide susceptibility maps prove to be a handy tool for disaster preparedness, land use planning to minimize landslide-related risks.

MAPPING OF SHEAR WAVE VELOCITIES ALONG HAZIRA-DAHEJ TRANSECT-WEST COAST OF INDIA

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ABSTRACT

The present study is aimed at estimation of shear wave velocities along Hazira-Dahej transect. The shear wave velocities were determined using the multi-channel analysis of surface waves (MASW) along the Hazira-Dahej transect covering about 106km. Total 19 lineaments were identified using the satellite images IRS-P6 (LISS-IV). Geologically, transect passes through mainland Gujarat encountering diverse geological formations like Cretaceous (basalts), Tertiary (Sand stone, clay stone etc) and Quaternary (Alluvium). Physiographically, the mainland Gujarat comprises a vast alluvial plain with hilly terrain (basalts) in the east. The study area lies zone-III according to the seismic zonation of India. This region has encountered significant earthquake the Bharuch earthquake of magnitude 5.2 and is located in the vicinity of tectonically active features like Son-Narmada and West coast faults. Damage due to seismic waves depends on local ground conditions/soil type. Areas along the coast and rivers generally consist of thick layers of soft clay and sand. The soft deposits amplify ground motion thereby increasing the damage during an earthquake. Hence, the shear wave velocity is widely used for evaluating the dynamic behaviour of soil in the shallow subsurface. As V_S is a function of the elastic properties of the medium, it is directly related to the stiffness of the materials. The most important utility of shear wave velocity is to estimate liquefaction hazard potential of an area particularly in seismically active region. The observed shear wave velocities at most of the sites along the study area are in the range of 150m/s-500m/s while for a few locations they range between 300-800m/s. The average shear wave velocities up to 30m (V_S^{30}) were computed using the empirical equations and the sites were classified following the National Earthquake Hazard Programme (NEHRP). The obtained results play a vital role in mitigating the risk for the transect area.

Keywords: shear wave velocity, lineaments, MASW, V_S^{30}

SEISMIC ARRAY IMAGING OF SUBSURFACE STRUCTURE BENEATH THE NATIONAL CAPITAL TERRITORY (NCT), DELHI, INDIA

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ABSTRACT

Delhi, the capital of India with a population of around 20 million, is a rapidly urbanizing hub that faces frequent earthquakes due to its proximity (~200 kms) to the Himalayan belt. Estimating local site effects during seismic events requires detailed imaging of the geometrical and dynamical properties of local sedimentary structures and their resonance behaviour. In this study, we analysed two-dimensional (2D) array data acquired at 33 sites covering all major wards of Delhi and different

lithological setups within NCT, using 7 synchronous recording stations (three components, 3C) arranged in an equilateral geometric pattern with interstation distances ranging from 10 to 120 meters. We present: (1) High-resolution shallow shear wave velocity (Vs) structure using high-resolution beamforming to obtain ward-wise Vs profiles, incorporating both radial and vertical components, rather than the traditional approach of only considering vertical components. This analysis was performed using both frequency– wavenumber (F-K) and Spatially Autocorrelation (SPAC) methods with applying the Neighbourhood Algorithm (NA) over inversion of estimated dispersion curves; (2) Joint inversion of microtremor dispersion curves and horizontal-to-vertical (H/V) spectral ratios to estimate deeper Vs profiles; (3) Comparison of the derived Vs profiles with existing shallow and deep borehole logs (Standard Penetration Test (SPT) N-values) emphasizing uncertainty analysis in the Vs value; (4) Anomalies in the azimuthal dependency of resonant frequencies, which delineate subsurface spatial heterogeneity, with reference to Yamuna river and the Delhi ridge. This ambient noise with reference to Vs estimate under site response study provides detailed, ward-specific subsurface characterization of the NCT Delhi region. This approach may help in addressing the existing knowledge gap in localised sites for better understanding of the nature and extent of shaking during earthquake which may help in assessing earthquake hazard potential of the different wards of NCT-Delhi.

STRUCTURAL INTERPRETATION OF GRAVITY DATA OVER DELHI AND VINDHYAN SUPERGROUPS IN RAJASTHAN

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ABSTRACT

Geologically, the study area comprises rocks of Delhi Supergroup, Bhilwara Supergroup and Vindhyan Supergroup. The Bhilwara Supergroup is represented by the slate, phyllite, meta- tuff, quartzite, dolomite and calc-silicate of Hindoli Group and chlorite mica schist and migmatites of Mangalwar Complex. The Hindoli Group of rocks has undergone green schist facies of metamorphism. The Ranthambore quartzites are intruded in the form of dykes trending NE-SW and NW-SE directions. The regional Great Bounday Fault (GBF) is separating the Bhilwara Supergroup of rocks from the Vindhyan supergroup. The Machri-Raisana Fault running NE-SW direction, which separates the rocks of Delhi Supergroup and the Mangalwar Complex at Machhipura-Batoda.

The Complete Bouguer Gravity Anomalies (CBGA) exhibit an overall variation of 46 mGal, ranging from -77 mGal to -31 mGal. The gravity survey reveals a significant high-gravity zone trending in a NE-SW direction, which aligns with the general geological trend of the Delhi Supergroup. The boundary between the Delhi and Vindhyan Supergroups is also identified through this survey. Notably, this high-gravity zone over the Quaternary sediments (alluvium) is attributed to the presence of high-density materials at shallow depths. The gravity gradient data aids in structural analysis, allowing for the exploration of subsurface geology and estimation of causative source parameters. This gradient distinctly separates the rocks of the Hindoli Group (Bhilwara Supergroup) from those of the Vindhyan Supergroup. Additionally, a prominent gravity low is observed in the western part of the study area, also trending NE-SW, indicating a larger thickness of sediments in that region

The NE-SW trending horizontal gradients are interpreted as the contact or lineament between the Pre-Delhis and the Bhilwara Supergroup (BGC), which is further supported by LISS-III imagery of the study area. The intersecting gravity gradients are significant for mineral exploration, as geologic

contacts represent economically important structures that can be identified using gravity methods. Interpretation of gravity data can be enhanced by understanding both horizontal and vertical gradients, which can be measured accurately for lineament analysis. The region is characterized by major faults trending NE-SW in the southern part and NE-SW to NNE-SSW in the northern part. A comparative study of the geological and generated structural lineaments reveals that these structural features are primarily concentrated within the Bhilwara Supergroup, which includes phyllites, gneisses, schists, and quartzites. The intersection zones could serve as favorable targets for further detailed exploration aimed at locating concealed mineral deposits. The observed gravity linears suggest the presence of structural features at depth.

DEVELOPMENT OF MAGNITUDE SCALING RELATIONS BASED ON PEAK ACCELERATION AND VELOCITY VALUES OF P-WAVE ONSET FOR THE TAIWAN EARTHQUAKE EARLY WARNING SYSTEM

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ABSTRACT

The current magnitude scaling relations based on average period (τ_c) and peak displacement amplitude (P_d) tend to overestimate earthquake magnitudes (M), particularly for events in the M 4.0–5.0 range. This can lead to false alarms by incorrectly surpassing the warning threshold of $M \geq 6$. The aim of this study is to develop new magnitude scaling relations for the Taiwan region using peak acceleration (P_a), peak velocity (P_v) derived from P-wave onsets. The new scaling relations (P_a-M and P_v-M) are then compared to the existing relations (τ_c-M and P_d-M) for 5 earthquakes with magnitudes between 4.0 and 4.9. The comparison shows maximum magnitude differences of 2.32 and 4.41 between the cataloged and predicted magnitudes for the newly developed and existing relations, respectively. The newly developed regression relation predicts the magnitude with relatively higher accuracy below the warning threshold magnitude ($M6$). In contrast, existing relations indicates relatively very low accuracy below the warning threshold ($M6$) for earthquake ($M4.0$-4.9). Additionally, the new relations are tested on 5 larger earthquakes, ranging from magnitude 5.0 to 7.5, revealing a maximum magnitude difference of 0.69 between cataloged and predicted earthquakes, confirming their effectiveness in this magnitude range. These findings highlight the reliability of the new scaling relations, which show greater stability across a broad range of earthquake magnitudes Therefore, incorporating P_a and P_v, along with τ_c and P_d, into Taiwan's EEW system could improve its performance and can play a key role in disaster mitigation of the Taiwan region.

A PRELIMINARY STUDY ON THE CHARACTERISTICS AND MECHANISM OF THE OCT 2023 M 6.2 AND NOV 2023 M 6.4, WESTERN NEPAL EARTHQUAKE SEQUENCE

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ABSTRACT

The recurrence interval of large earthquakes, often spanning hundreds to thousands of years, makes it challenging to directly assess stress accumulation in regions where seismogenic faults are locked

during interseismic periods and exhibit low levels of seismicity. However, the smaller-scale structures in these regions often experience background seismicity, which can serve as a window into understanding the stress conditions within the fault system. These smaller-scale seismic activities are intrinsically connected to the locking behaviour of larger faults, and their analysis can provide important insights into regional stress distribution and tectonic processes. To understand the regional stress in western Nepal and adjoining regions, using the moment tensor inversion, stress field inversion, and fault slip tendency analysis, we examine five recent earthquake sequences (M 5.4–6.4) that occurred between 2022 and 2023. Our results suggest that the tectonic stress regime in this region may have undergone significant changes following the 2015 Gorkha earthquake. The analysis of b-values across the earthquake sequences reveals a notable increase in regional stress levels. This could indicate that stress accumulates within the fault system, with the smaller-scale faults adjacent to larger fault zones acting as sensitive indicators of these changes. Moreover, we observed distinct fluid diffusion-triggered aftershock patterns in the M5.4 and M5.8 sequences of 2022 and the M6.2 sequence of 2023. These patterns suggest that overpressure from deep-seated fluids may continue to be a major driver of seismic activity in this region. Fluid-related triggering indicates complex interactions between tectonic stress and fluid migration within the crust. Despite these observations, our findings suggest that the regional tectonic stress levels have not yet reached the critical threshold necessary to produce larger seismic events. However, the continuing accumulation of stress and fluid migration underscores the potential for future seismic hazards in the area.

SEISMOTECTONIC MODEL OF THE KISHTWAR REGION OF NW KASHMIR HIMALAYA: CONSTRAINTS FROM SEISMICITY AND MOMENT TENSOR

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ABSTRACT

A close network of 15 three-component broad-band seismometers has been operated in the northwest (NW) Kashmir Himalaya to determine the seismotectonic model of the region. We have located 173 local earthquakes ($1.0 \leq ML \leq 4.5$) in the NW Kashmir Himalaya. The earthquake epicenters show clustering of seismic events between the north of main central thrust (MCT) and Kishtwar window trending NW-SE direction along the strike of the Himalaya arc. The travel time inversion of P and S-wave have been used to estimate the 1-D velocity model. The estimated 1-D model consists of eight layers down to a depth of 44 km within the crust having P-wave and S-velocity varying from 5.3 to 7.1 km/s and 2.9 to 4.2 km/sec within the crust respectively. At a depth of 20 km, there is a thin layer with low velocity, which acts as the boundary separating the subducting Indian plate from the overriding wedge. The earthquakes are mostly concentrated at the shallow depth of 5-20 km on or above the mid-crustal ramp in the locking zone beneath the lesser Himalayas. The few earthquakes originating beneath the under-thrusting Indian crust, suggesting that the crust in the depth range of 5-20 km is seismogenic, where the stresses are built up in the inter-seismic period, which is episodic release in the form of micro-earthquakes. The moment tensor results show the study area is dominated by thrust and strike-slip faults dipping in the N to NE direction. The strikes are roughly oriented in the NW-SE direction along the Himalaya arc. The stress inversion shows that the

maximum principal stress axes-oriented NE-SW consistent with the compressional regime along the Himalaya arc, while the intermediate and least principal stress axes are oriented along the NW-SE, direction confirmed a complex tectonic setting in the study area.

UNVEILING HIDDEN ARCHAEOLOGICAL SITES IN EASTERN INDIA: ADVANCING NON-INVASIVE INTEGRATED GEOPHYSICAL APPROACHES

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ABSTRACT

In its initial phase, this study uses machine learning to predict potential archaeological sites in central Jharkhand, India—a region rich in Buddhist, Jain, and Brahmanical heritage. By integrating 12 geoenvironmental remote sensing datasets (e.g., geology, geomorphology, elevation, land use/land cover, slope, aspect, curvature etc.) with a random forest model, the research delineates four archaeological suitability zones: high, moderately high, moderately low, and low. High-suitability areas, covering 20% of the region, are characterized by gentle terrain, fertile soils, and proximity to water, making them favorable for habitation, while rugged, resource-scarce areas, comprising 41%, are least suitable. The model achieves a high predictive accuracy (ROC-AUC score of 88.3%), enhancing its value for heritage preservation and land-use planning.

A site in the Mohane River Valley, identified as a high-suitability zone in the model's results, was selected for in-depth geophysical studies. This area holds key archaeological insights from the Pala period, with finds linked to Brahmanism, Jainism, and Buddhism, including a Buddhist icon of Goddess Tara, now revered as Maa Bhadrakali at the Itkhouri temple. Using non-invasive geophysical methods—magnetic gradiometry and ground-penetrating radar (GPR)—the study mapped the Bhadrakali temple site and its surroundings. Vertical gradient anomaly maps, derivative maps, compact inversion-based magnetic models, and GPR profiles revealed archaeological features, boundaries, and depths ranging from 1 to 4 meters. Strong correlation between magnetic and GPR results validated the accuracy of the findings, offering valuable insights into the site's cultural layers and historical significance. This study demonstrates an efficient and accurate approach for mapping archaeological potential zones from regional to local scales, optimizing both cost and time.

Key words: Mohane River Valley, Remote sensing, Random Forest, Ground-Penetrating Radar (GPR), Magnetic Gradiometry, and Electrical Resistivity Tomography (ERT);

EVALUATION OF CO_2 STORAGE POTENTIAL AND FEASIBILITY OF SEISMIC MONITORING IN THE GANDHAR OILFIELD, CAMBAY BASIN, INDIA

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ABSTRACT

The Gandhar oilfield in Cambay Basin, Gujarat, a major brownfield operated by Oil and Natural Gas Corporation Limited (ONGC), is a pilot site for India's first large-scale CO_2 sequestration project.

This mature oilfield, produced from multi-stratigraphic Hazad Member sandstones of the Ankleshwar Formation, will be undergoing CO_2 Enhanced Oil Recovery (EOR) to extract an additional 15% of residual oil. Recent studies on source-sink matching, petrophysical analysis, reservoir pressure, and minimum miscibility pressure (MMP) have established the field's suitability for CO_2 injection. The study aims to assess CO_2 storage potential and monitor the injected CO_2 using seismic techniques in the Hazad sands and overlying brine-saturated Ardol sands of the Ankleshwar Formation.

A high-resolution 3D geological model of the Hazad and Ardol sands was developed using 3D seismic data and geophysical well logs, provided by the DGH-National Data Repository and ONGC, to estimate the CO_2 storage capacity. Gassmann's fluid substitution theory was applied to model the effects of CO_2 saturation on sonic logs for both the homogeneous and patchy saturation models. Convolutional synthetic seismic modeling was employed to assess the feasibility of time-lapse seismic monitoring in the overburden (Ardol sands). CO_2 plume evolution in Ardol sands was modeled using an analytical solution of axisymmetric gravity currents with an injection rate of 0.5 Mt/year over 6 years, followed by NRMS and repeatability metrics performed on time-lapse synthetic seismogram to establish a 30-day detection threshold for CO_2 injection.

To monitor CO_2 storage in Hazad sands, a poroviscoelastic wave equation was numerically solved, and validated against the Sleipner field geomodel. Full-wavefield synthetic seismograms for both the pre-and post-CO_2 injection demonstrated amplitude attenuation due to Biot-flow and squirt-flow mechanisms. This approach successfully predicted realistic amplitude changes, underscoring the effectiveness of poroviscoelastic theory in tracking CO_2 plume migration and storage in geological formations.

A NOVEL FIELD TECHNIQUE FOR CONSTRUCTING 2D SHEAR WAVE VELOCITY PROFILE FOR SUBSURFACE BY UTILIZING MASW METHOD

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ABSTRACT

Multi-channel Analysis of Surface Waves (MASW) is a commonly utilized geophysical method to obtain shear wave velocity (Vs) profile of the subsurface for seismic site characterization studies. A roll-along seismic data acquisition is followed where surface waves are generated by a seismic energy source and recorded by a linear array of geophones. The dispersion curve, which represents the variation of phase velocity with frequency, is extracted from the surface wave data and inverted to produce a 1D Vs profile for the subsurface. By systematically shifting the source and receiver array along the survey line and repeating this process, multiple 1D Vs profiles are obtained at a regular interval. This 1D Vs profile is located in the middle of the receiver spread. A 2D vertical Vs cross-section is produced by combining all the 1D Vs profiles. The roll-along method generally provides slow coverage and can be time consuming and costly.

A novel survey method is demonstrated that uses common receiver gathers (CRG) instead of common shot gather for dispersion analysis the surface waves from the survey. For a fixed geophone spread, multiple source offsets give reliable phase-velocity dispersion curves that enable us to build shear wave velocity profiles for constructing high resolution near-surface 2D section. Using the common shot gather dispersion analysis, subsurface 2D Vs section is generated beneath the geophone spread. However, the novel method adopted in this study uses surface wave analysis of common receiver

gather to construct 2D Vs section beneath the shot locations. Since this technique requires a series of shots for a given geophone spread, the common receiver gather technique for Vs profiling is cost-effective and time-efficient method. This novel field technique was applied for imaging the subsurface of a test site. It produces a high resolution 2D Vs profile of the subsurface.

DEVELOPMENT OF MAGNITUDE REGRESSION RELATIONS FOR THE HIMACHAL REGION BY USING OBSERVED AND SIMULATED DATASETS FROM M 4.0-8.0 EARTHQUAKES

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The Himachal region is a seismically active area characterized by a thrust system and active faults. It has experienced large earthquakes, including the 1905 Kangra (M7.8) and 1993 Killari (M6.3), causing over 20,000 deaths and extensive damages. Positioned in a central seismic gap, this region urgently demands an Earthquake Early Warning System (EEW) to provide real-time earthquakes magnitude estimation. In this study, we used a modified semi-empirical technique (SET) to simulate P-wave earthquake records. By utilizing both simulated and observed datasets, we developed region-specific magnitude regression relations. This modified SET is validated on the 2019 Himachal earthquake (M4.9), revealing a relatively low root mean square error (RMSE) between the simulated and observed records, confirming the technique reliability. Further, we simulate a total of 15 future scenario earthquakes (M5.0–8.0) at the epicenter of the 2019 earthquake (M4.9) by using modified SET. Additionally, we estimate the EEW parameter average period (τc) and peak displacement amplitude (Pd) based on 58 observed and 200 simulated records. These parameters are extracted from a 3 to 5s P wave onset, corresponding to magnitude ranges of ($4<M\leq6$) and ($6<M\leq8.5$), respectively. Subsequently, we developed magnitude regression relations using both observed and simulated datasets of the estimated parameters. The magnitude prediction errors from these relations are relatively small, ranging from 0.13% to 6.82%. These small errors show the applicability and accuracy of the developed regression relations. Additionally, the lead times for 70 major sites for future scenarios earthquakes ranges from 7 to 165s for locations within 50 to 510 km. This advance warning time can significantly help in disaster mitigation efforts, providing crucial time for residents and authorities in Himachal Himalaya and neighboring regions to take protective measures and minimizing the potential damage and loss.

Keywords: Central seismic gap (CSG), Semi empirical technique (SET), Earthquake early warning (EEW), Simulation, Lead time

INSTABILITY ASSESSMENT OF ROAD-CUT SLOPES ALONG NATIONAL HIGHWAY (NH)-7 AROUND JOSHIMATH IN GARHWAL HIMALAYA, UTTARAKHAND, INDIA

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ABSTRACT

The increasing vulnerability of road infrastructure to landslides in the Himalayas has raised significant concerns, particularly along NH-7 near Joshimath, Uttarakhand, India. Joshimath is considered a holy city and a significant spiritual hub in Uttarakhand, particularly due to its connection with Badrinath, one of India's most revered pilgrimage sites. The study uses advanced geotechnical tools such as Dip's software and the Slope Mass Rating (SMR 1985) system to assess road-cut slopes in this landslide-prone area. The primary objective is to evaluate the stability of road-slopes and identify critical failure mechanisms that could potentially affect transportation routes and nearby settlements. Geologically, the study area falls in tectonically sensitive Garhwal Himalayas which experiences frequent slope failures due to complex geological formations, fragile and deformed rocks, intense rainfall, watershed condition and seismically sensitive in nature. For the purpose, the geotechnical field data were collected through detailed geological studies and slope morphometry, slope stability influencing ground geotechnical parameters such as joint orientations, spacing, separation, aperture, fillings and condition. Dips software was employed to perform kinematic analysis, identifying potential failure modes such as planar, wedge, and toppling failures. The field based data and outcomes of analysis were further integrated with the Slope Mass Raring (SMR) to quantify the stability of slopes and provide a comprehensive hazard assessment.

Results indicate about varying degrees of instability across different parts of road sections in various instability classes such as stable, unstable or partially stable. The major elements influencing the stability of the road-cut slopes in the area are unfavourable joint orientations, weathered rock masses, and steep slope angles. The integration of dips analysis with SMR provided valuable insights into the failure mechanisms and enabled more accurate classification of instability status of road-cut slope in this particular area and applicable in other similar areas of the world.

Keywords: Landslide Hazard, SMR, Kinematic analysis, NH-7, Garhwal Himalaya, Joshimath

ON THE EMPLACEMENT MECHANISM OF LADAKH BATHOLITH FROM ROCK MAGNETISM AND ANISOTROPY OF MAGNETIC SUSCEPTIBILITY

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ABSTRACT

Ladakh Batholith is an integral part of the Trans-Himalayan magmatic arc system. In this study, we present the results of magnetic fabric and mineralogy of the Ladakh batholith, particularly the Leh to Khardhung village section. We collected 84 oriented rock block samples from 14 sites and prepared 672 specimens to analyze the Anisotropy of magnetic susceptibility, Rock magnetic properties, and magnetic mineralogy. Ti-magnetite pseudo-single domains are the primary carrier minerals. Prolate, oblate, and triaxial magnetic ellipsoid are observed and describe normal, intermediate, and inverse fabrics related to magma flow during emplacement. The principal susceptibility axes are well-clustered and independent of their shape factor (T) with a triaxial distribution, indicating well-developed magnetic lineation and foliation. In all three magnetic susceptibility axes, the magnetic lineation (K1) aligns finest with the microscopic flow indicators. AMS investigation shows that the magnetic fabric is consistent with an ~NE-SW trending flow. This study reveals the Ladakh Batholith may have evolved as a result of multi-stage interactions between multiple pulses of coeval mafic and felsic magmas and host Ladakh granitoids.

Keywords: Ladakh Batholith, AMS, Rock magnetism, Khardhung, Magnetite.

EXPLORING SIMULTANEOUS SEISMIC INVERSION THROUGH HYBRID GENETIC ALGORITHMS: A CASE STUDY

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ABSTRACT

In this study, a prestack inversion method based on a hybrid optimization approach combining genetic algorithm (GA) and the quasi-Newton method (QNM) is implemented. Genetic algorithm is a global optimization technique that reliably converges to the global optimum, though it requires significant computational time. In contrast, the quasi-Newton method is a local optimization technique that may converge to either a local or global optimum, depending on the initial model. By integrating these two techniques referred to here as hybrid optimization the strengths of each method can be leveraged while mitigating their respective weaknesses. The methodology developed in this study combines GA and QNM into a unified workflow, using amplitude variation with offset (AVO) data exclusively for prediction. The objective of the optimization is to find the global minimum of the objective function, which measures the misfit between synthetic and observed prestack seismic data. To enhance stability, the inversion algorithm incorporates constraints derived from low-frequency acoustic impedance (Zp), shear impedance (Zs), and density (rho) models. This inversion method has been successfully applied to both synthetic and real data, yielding estimates for Zp, Zs, and rho. These estimates can be further combined to derive additional elastic parameters, which can aid in identifying lithology and fluid content within reservoirs.

Keywords: Seismic inversion ; global optimization; local optimization; elastic parameters

COULOMB STRESS CHANGES AND B-VALUE ANALYSIS FOR SEISMIC HAZARD STUDY IN NW HIMALAYA INDIA

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ABSTRACT

The Northwest Himalayan belt of the Indian subcontinent is one of the seismically active zones due to oblique compression between the Indian and Eurasian plates, which causes thrusting and rotation of faulted blocks. The frequent occurrence of small to big magnitude earthquakes suggests a high level of seismicity in this area. Many major earthquakes have occurred in this research region, including those on October 8, 2005 (MW = 7.6) and March 20, 2008 (MW = 7.1). These huge earthquakes have contributed to the increased seismicity in this study region. This paper uses the change in Coulomb stress (ΔCFF) to calculate the stress perturbation effect of mainshocks. For all faults, the uniform slip model with a constant friction coefficient (μ' =0.4) is used. Additionally, the consecutive fault parameter value (0.05) is taken into account when calculating the ΔCFF. According to this data, the study region's western and northern regions have the highest stress change values. Other crucial parameters, such as b-value, are also taken into account when calculating seismicity in the research location. The maximum-likelihood approach is used to determine the b-value from minimal earthquake occurrences that exceed the magnitude of completeness at a grid spacing of 0.5°×0.5°.

Low b-values are found in the eastern and central parts of the study region, while high b-values are predominant in the north.

Keywords: NW Himalaya, Coulomb stress changes, b-value, Seismicity

LEVERAGING MACHINE LEARNING FOR ADVANCED SHALE RESERVOIR UNDERSTANDING

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ABSTRACT

The petroleum industry relies heavily on applied geophysics to discover unconventional resources in complex geological environments. Conventional approaches often struggle to accurately predict shale production behaviour and reservoir properties. Recent studies show that machine learning (data-driven) can accurately characterize shale reservoirs, outperforming conventional approaches. This has led to an increased application of ML methods for optimizing production and effectively addressing complex reservoir challenges. We present an accurate predictive model based on advanced ML algorithms for estimating TOC content and forecasting production in organic-rich shales. The accuracy was evaluated employing a Taylor diagram, including key metrics like RMSE, MAPE, MAE, etc. A sensitivity analysis was conducted to determine the key predictor variables that significantly impact the model's performance. Additionally, unsupervised clustering was applied to classify similar shale formations from different wells as high or low producers based on their characteristics. Our findings reveal the superior performance of our ML-based model compared to the conventional wireline log-based methods. This study underscores the need for advanced machine learning applications in shale reservoir characterization to reduce risks in resource estimation.

JOINT INVERSION OF MULTIMODAL LOVE WAVE PHASE VELOCITY DISPERSION CURVES USING BAYESIAN NEURAL NETWORKS

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ABSTRACT

Inversion of surface wave dispersion curves is crucial for determining the S-wave velocity profile of the subsurface, a key factor in understanding Earth's structural and material properties. While deep learning methodologies have increasingly been employed for such inversion tasks, existing approaches predominantly rely on deterministic predictions, neglecting the crucial aspect of uncertainty quantification. This study introduces Bayesian Neural Networks (BNNs) to predict S-wave velocity profiles from Love wave dispersion curves, emphasizing probabilistic inference over point estimates. This shift from deterministic predictions provides a measure of confidence in the results. To train the BNN, a synthetic dataset of Love wave dispersion curves was generated from their corresponding S-wave velocity profiles using the Thompson-Haskell method, facilitated by the open-source software Disba. Frequency ranges of approximately 1 Hz to 45 Hz, 15 Hz to 45 Hz, and 30 Hz to 45 Hz were chosen for the fundamental, first, and second order modes, respectively. The trained BNN was then used to generate 1,000 predictions for the same input, allowing for the calculation of the mean and standard deviation across those samples. Uncertainty was represented by

three standard deviations. The mean predictions aligned well with the true models across both the training and test sets, while uncertainty gradually increased with depth. In conclusion, this study demonstrates an application of Bayesian Neural Networks for the joint inversion of multimodal surface wave dispersion curves, marking a significant advancement over conventional deterministic approaches. By explicitly accounting for uncertainty in predictions, our framework underscores the importance of probabilistic modelling in geophysical inversion studies.

MAPPING A RECHARGE PATHWAY IN CRYSTALLINE HARD ROCK TERRAIN USING SEQUENTIAL INTERFERENCE OF ERT AND SP DATA

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ABSTRACT

In crystalline hard rock terrane, geological structures such as faults, fractures, and shear zones play a major role in forming the regolith and ultimately groundwater resources. However, due to an inadequate understanding of these structures and low porosity of the rocks, identifying groundwater recharge pathways is challenging. To understand this, our study focuses on mapping recharge pathways using the combined application of Electrical Resistivity Tomography (ERT) and Self-Potential (SP) methods on a hard rock granitic terrane in the Ambaji Basin, Gujarat India. By integrating the resistivity data from ERT, which highlights subsurface lithology and fractures, with SP data that reflects groundwater flow and subsurface electrical conductivity, we provide a detailed understanding of potential recharge zones. The sequential interpretation of these two geophysical techniques offers a non-intrusive and effective approach to delineate fractures and weathered zones that may act as conduits for groundwater recharge. The findings from this research can improve groundwater management strategies in hard rock terrains, enhancing the sustainable utilization of this vital resource.

Keywords: Crystalline Aquifer, ERT, Self-potential, Groundwater flow

A PERSPECTIVE VISION TO IDENTIFY POTENTIAL TARGET AREAS BY GEOPHYSICAL MAPPING – A CASE STUDY OF MANTRALAYAM KIMBERLITE AREA, ANDHRA PRADESH AND KARNATAKA.

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ABSTRACT

The regional geophysical mapping by gravity and magnetic techniques on the toposheet scale reveal broadly subsurface information of the geological formations, structural and basement related features, which are key factors for the identification of target areas. Integration with the geological and known mineral occurrences data of the area can identify the favourable target areas for further prospecting. These target areas need to be evaluated by the detailed geophysical surveys for delineation of potential zones favourable for emplacement of Kimberlite pipes in the area and ascertain its geometry.

Dharwar Craton comprises four-prominent Kimberlite Fields namely Wajrakarur, Narayanpet, Raichur and Mantralayam. The Mantralayam Cluster of Tungabhadra Kimberlite field collectively comprises six kimberlite pipes. The Peninsular Gneissic Complex (PGC), represented mainly by Tonalite-Granodiorite-Adamellite (TGA) suite of rocks and thin discontinuous bands of amphibolite schist representing Raichur Schist Belt, occupies the study area. Dolerite, quartz reefs and Kimberlite pipes occur as intrusives. By adopting systematic Ground Gravity-Magnetic surveys the structural fabric, target discrimination and favourable areas for location of pipes delineated. Regional gravity and magnetic data of Mantralayam area is interpreted with derived maps such as residual, filters, analytic signal, upward continuation, radial average power spectrum and Euler depth solution maps, to identify the loci for emplacement of kimberlite pipes in the area.

Detailed integrated geophysical surveys have delineated the geometry of kimberlite pipe MNK-1 as 150 x200 m, in the form of a gravity 'low' closure (0.6 mGal), occurring at the intersection of two zones aligned in NW-SE and NNE-SSW direction, Electromagnetic high conductivity with a relief of 100 ms/m (horizontal dipole with T-R coil separation of 10 m), Resistivity mapping adopting gradient array technique (C 1 C 2 =500 m, P 1 P 2 =10 m) indicate a low resistivity of 130-400 ohm-m and a magnetic low in the vicinity of the pipe.

Key words: Geophysical mapping, Kimberlite, Mantralayam, Dharwar Craton

TECTONIC EVOLUTION OF SOUTH REWA BASIN, CENTRAL INDIA INFERRED FROM 3-C WIDE-ANGLE SEISMIC DATA

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ABSTRACT

We have delineated the crustal structure of the south Rewa basin in the Central India using 3-C wide-angle seismic data acquired along the N-S trending 155 km long Hardi-Samatpur deep seismic profile. This region exhibits a complex geological structure characterized by large-scale tectonic activities including faulting, folding as well as formation of horsts and grabens in the basement. The modelling and inversion of 3-C wide-angle seismic data indicate the presence of thick Gondwana sediments hidden below the Deccan basalts and complex geological structures with steeply dipping basement faults along with significant upwarping of Moho beneath the Narmada-Son-Lineament (NSL). The basement is highly distorted forming a large depression in which thick (average 3 km) low-velocity Gondwana rocks are deposited having P- and S-wave velocity (Vp and Vs) of 4.0 km/s and 2.36 km/s, respectively. The corresponding granitic basement has relatively high P- and S-wave velocities of Vp (5.9-6.0) km/s and Vs (3.45-3.55) km/s exposed near NSL and toward south of the profile. The sub-basement structure delineated having lateral velocity variation of both Vp (6.45-6.52 km/s) and Vs (3.70-3.72 km/s) at a depth of 2.5-8.2 km. A crucial finding is the presence of a thick low-velocity-layer (LVL) in the mid-crust characterized by low velocities of Vp (6.0 km/s) and Vs (3.6 km/s) confined at a depth of 13.0-17.5 km suggesting fluid entrapment due to the magma activities. The lower-crust is delineated at a depth of 17.2-20.8 km having lateral velocity variation of Vp (6.9-7) km/s and Vs (3.94-4.10) km/s, respectively. The Moho upwarping (38.5-44.5 km) has also been corroborated with thick layer of mafic underplating confined in the lower-crust at a depth of 25-30 km having substantially high P- and S-wave velocity zone (Vp of 7.30 km/s and Vs of 4.22 km/s).

Keywords: South Rewa; 3-C Wide-angle seismic data; Basement; Vp and Vs; Underplating; Moho

THE ROLE OF GEOTHERMAL ENERGY IN ADVANCING INDIA'S CLIMATE CHANGE MITIGATION GOALS

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ABSTRACT

The search for indigenous, renewable, environment-friendly, and sustainable energy resources has continuously increased globally during the past few decades. Geothermal energy is one such ubiquitous source of energy, having the potential to become an alternate energy resource due to reduced carbon footprints. This study is focused on the geothermal springs located in the low-enthalpy geothermal provinces of Odisha and compares them with other major geothermal provinces in India. Water-rock interactions and mixing significantly influence subsurface water quality around these thermal springs. Reservoir depths, temperatures, and fluid circulation patterns have been estimated, contributing to a better understanding of the geothermal system dynamics in this tectonically active region. The estimated reservoir temperatures and reservoir depths are of the order of 150±10°C, and 2.11±0.2km; 120±5°C, and 1.71 ±0.17km; 100±5°C and 1.13±0.13km; 110±5°C and 1.37±0.32km for the Himalayan, west coast, West Bengal and the Odisha geothermal systems, respectively. To further assess the geothermal energy potential, we analyzed eight critical parameters that directly or indirectly indicate the presence of geothermal energy, i.e., heat flow, thermal gradient, Curie point depth, lithology, basement depth, crustal thickness, seismicity, and fault density. These parameters were integrated into a multi-criteria decision-making framework utilizing the Analytical Hierarchy Process (AHP) model to assign relative weights. We find that heat flow emerged as the most significant factor, with a weight of approximately 0.252, followed by Curie point depth (~0.195) and thermal gradient (~0.173). Our analysis indicates that the geothermal province in the Himalayas (including the NW and NE regions), SONATA lineaments, central parts, and some parts of the west coasts and Mahanadi graben may have better geothermal energy prospects than other geothermal provinces. We find that ~14.86% and ~21.98 % of the region have extremely high geothermal potential. About ~ 27.18 % of the region has medium geothermal prospects, whereas ~ 11.78 % and 24.20 % of the region have very low to low potential for geothermal energy. The expanded utilization of geothermal energy will not only support local economies but also promote sustainable practices across multiple sectors. Moreover, harnessing geothermal power in India can effectively reduce CO2 emissions, achieve India's net-zero target by 2070, and foster local economic growth and energy resilience.

GHAZIPUR LANDFILL CONTAMINATION TRENDS ASCERTAINED BY GROUNDWATER QUALITY MONITORING AND ANALYSIS

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ABSTRACT

The eastern part of New Delhi, is facing groundwater contamination, due to the loading of garbage over the Ghazipur landfill site. Water samples for a hydrologic cycle were collected from bore wells,

surface sources, and hand pumps in and around the study area, followed by a comprehensive analysis of water quality parameters. The assessment included the examination of total dissolved solids (TDS), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), carbonate (CO3), bicarbonate (HCO3), chloride (Cl), sulphate (SO4), nitrate (NO3), and fluoride (F), which were visualized using spatial maps and Piper diagrams.

We analysed 11 parameters during the pre-monsoon and post-monsoon periods of 2023. The results indicated that, except for calcium, 10 parameters exceeded permissible limits in several post-monsoon samples, according to BIS standards. In the pre-monsoon season, parameters such as magnesium, potassium, sulphate, nitrate, and TDS also surpassed permissible limits, while calcium, sodium, chloride, carbonate, bicarbonate, and fluoride remained within acceptable levels. Piper plots revealed that during the post-monsoon period, most samples exhibited a Na-K type, reflecting the dominance of sodium in the groundwater. Pre-monsoon samples showed a similar trend, predominantly falling within the sodium type classification.

Spatial maps generated using ArcGIS illustrated that the highest concentrations of contaminants were found in and around the landfill area. Notably, groundwater quality in the northern and northwestern parts of the landfill exceeded BIS standards, while the eastern region displayed lower concentrations, remaining below permissible limits. A comparison of pre- and post-monsoon data revealed that the concentrations of most elements were higher post-monsoon. This suggests that leaching of contaminants into the groundwater occurs during the monsoon season, highlighting the urgent need for monitoring and remediation efforts in the area.

Keywords: Landfill contamination, Groundwater quality, Spatial maps, Piper method

SEISMIC IMAGING OF A SEDIMENTARY BASIN OF INDIA

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ABSTRACT

This study presents an imaging analysis of the structural configuration of a sedimentary basin in India, using Landmark's Promax software for seismic data processing. Various seismic processing techniques were employed to enhance the imaging of the basin's internal structure. The seismic section reveals that the basin thickens to approximately 1.5 seconds two-way travel time (TWT) in the northern region and gradually thins to about 1 second TWT in the southern area. The seismic imaging shows thick sedimentary layers directly overlying the basement, providing insight into the sediment accumulation history. Notably, a diffraction hyperbola is observed in the central part of the image, which is interpreted as indicative of a fault zone. Additionally, a series of north-dipping

reflection fabrics are present beneath the basement in the southern section, suggesting the presence of thrust structures in the region. These seismic reflections highlight potential areas of hydrocarbon deposits, emphasizing the basin's prospective hydrocarbon reservoir potential.

Keywords: Two-way travel time (TWT), Sedimentary basin, Diffraction hyperbola.

COMPARATIVE STUDY OF SEISMIC WAVE ATTENUATION IN THE GARHWAL AND KINNAUR HIMALAYAS, NORTHWEST INDIA

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ABSTRACT

This study investigates the attenuation characteristics of seismic waves in two geologically significant regions of the northwest Himalayas—the Garhwal and Kinnaur Himalaya. By analyzing frequency-dependent quality factors (Q), including P-wave (Qα), S-wave (Qβ), and coda wave (Qc), we aim to understand the distinct seismic behaviors and energy dissipation patterns in these regions. The dataset includes 216 earthquakes ($2.5 \leq Mw \leq 5.0$) recorded between January 2008 and November 2015 by 7 broadband seismic stations in the Garhwal Himalaya. Additionally, 1985 earthquakes ($2.5 \leq Mw \leq 5.0$) from the same period were analyzed, recorded by 10 broadband seismic stations in the Kinnaur Himalaya. Both sets of stations are operated by the Wadia Institute of Himalayan Geology, Dehradun. This research focuses on deriving attenuation relationships using Qc, Qα, and Qβ across different tectonic zones, applying the single backscattering model (Aki and Chouet, 1975) and the extended coda normalization method (Yoshimoto et al., 1993). In the Garhwal Himalaya, the quality factors were found to be $Qc = (122 \pm 32)f(1.08\pm0.09)$, $Q\alpha = (85 \pm 11)f(1.06\pm0.06)$, and $Q\beta = (100 \pm 6)f(1.03\pm0.02)$. In contrast, the Kinnaur Himalaya exhibited lower quality factors for P-wave but higher for S-wave, with values of $Qc = (101 \pm 22)f(1.15\pm0.06)$, $Q\alpha = (66 \pm 3.4)f(1.11\pm0.04)$, and $Q\beta = (125 \pm 7)f(1.10\pm0.02)$. These results indicate that the Kinnaur Himalaya experiences higher attenuation, particularly for S-waves, suggesting greater seismic energy dissipation compared to the Garhwal Himalaya. The contrasting attenuation profiles point to significant geological and tectonic differences between these regions. In the Kinnaur Himalaya, the steeper frequency dependence and higher attenuation likely stem from crustal heterogeneities, while the Garhwal Himalaya reflects more stable seismic wave propagation. These findings contribute to refining earthquake hazard models and inform risk mitigation strategies in these seismically active regions of the Himalayas.

Keywords: Quality factor, Earthquake Hazard, Seismic wave attenuation, Frequency Dependence

SOURCE PARAMETER ESTIMATION AND SCALING RELATIONS FROM SMALL TO MODERATE EARTHQUAKES IN THE UTTARAKHAND HIMALAYA FOR ENHANCED HAZARD ASSESSMENT

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ABSTRACT

It is necessary to understand how earthquakes generate, especially in regions like the Uttarakhand Himalaya. Mostly great earthquakes in Himalaya region are given the highest attention as they contribute to maximum destruction. However, smaller earthquakes are also important in understanding the earthquake genesis. Determining source parameters are a useful way to understand the earthquake source. CSIR-NGRI established a seismic network consisting of 54 broadband seismological stations across Uttarakhand Himalaya. We obtained waveform data from 153 earthquakes, with magnitude ranging from 2.0 to 5.2 M_L, recoded in this network from 2017 to 2021. We analysed the S-wave spectra of these events, with window lengths ranging from 2 to 4 seconds, corresponding to their respective magnitude ranges. Based on previous studies, we applied attenuation correction specific to the Uttarakhand Himalaya. In this study, we used the Python module *SourceSpec*, which applies Brune's model to calculate the seismic moment (Mo) and corner frequency (fc) from the spectral data of each waveform. These findings allow us to estimates new relationship between each parameter. These results lead to understanding of the physics behind smaller earthquakes. We found that the average seismic moment (Mo), source radius (r), and stress drop ($\Delta\sigma$) varied from 6.5×10^{14} to 3.1×10^{17} N-m, 170 to 880 meters, and 0.06 to 1.6 MPa, respectively. While previous studies primarily focused on major earthquakes, our study highlights the significance of smaller tremors that frequently go unnoticed.

Keywords: Uttarakhand Himalaya, Source Parameters, Earthquake Hazard, Small to Moderate Earthquakes

EARTHQUAKE SOURCE PARAMETERS OF MODERATE TO SMALL EARTHQUAKE AND SCALING RELATIONSHIPS IN THE WESTERN HIMALAYA: SEISMIC HAZARD IMPLICATION

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ABSTRACT

The Northwest Himalayas experiences frequent seismic activity, with numerous moderate events occurring over the past century, leading to several disasters. In the present study, we conducted a comprehensive analysis of the source parameters for 125 earthquakes with local magnitudes (ML) ≥ 4.0 that occurred in the northwest region during the period from 2013 to 2019. We analyzed the P and S wave spectra using Brune's source model to investigate the self-relation and self-similarity of earthquakes in the area. The digital seismograms used in this study were recorded by sixteen permanent broad-band stations at hypocentral distances between 10 and 327 km. The average ratio of P/S wave corner frequency is found in the range of 1.1-1.9, suggesting a higher corner frequency for the P wave. The static stress drops range from 0.1 and 136 MPa with a median value of 9.8 MPa (98 bars). The obtained seismic moments range from 7.49×10^{14} to 1.15×10^{18} Nm ($4.0 \leq Mw \leq 6.0$). The source radii are between 388 and 7073 m. we established a linear relationship between local and moment magnitudes. The scaling relations obtained indicated a slight deviation from self-similarity. High-stress drops observed in some events suggest elevated frictional strength and lower strain rates within faults, while lower stress drops may indicate general fault weakness. Although a definitive correlation between seismic moment and static stress drop was not observed universally, some events with lower seismic moment values also demonstrated lower stress drops. Furthermore, the corner

frequency decreased with increasing seismic moment, with a slight depth dependence observed; shallower events tended to have higher corner frequency values than deeper ones. While there wasn't a clear depth dependence of stress drop values, a more pronounced depth dependence of seismic moment was observed, indicating that deeper events generally have larger seismic moment values in our study area. This implies that large earthquakes could still leave significant stress on faults, potentially leading to future events.

The present study also reveals that Mw is lower than ML for all earthquakes with magnitudes > 4.0. The coefficient of determination of the magnitude fit scale is found to be 0.91, which indicates the fit is good. Therefore, it is concluded that the newly derived magnitude scale is more consistent than the currently used ML scale for the study region

Keywords: Northwest Himalaya, seismicity, stress drop, earthquake scaling, seismic hazard

THE STRUCTURAL MAPPING OF THE EASTERN INDIAN SHIELD: INSIGHTS FROM AEROMAGNETIC DATA

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ABSTRACT

The Eastern Indian Shield, encompassing the Singhbhum Craton, Singhbhum Mobile Belt, Chhotanagpur Gneissic Complex and Eastern Ghats Mobile Belt, is a geologically complex region with distinct tectonic histories and lithological characteristics. It hosts numerous fault and shear zones that are crucial in shaping the tectonic framework and controlling mineralisation. This study aims to investigate the structural inheritance of the Eastern Indian Shield using aeromagnetic data. A variety of advanced analysis and interpretation techniques are applied to the amplitude corrected reduced to pole aeromagnetic data like analytical signal, horizontal gradient, tilt angle, and Centre for Exploration Targeting (CET) to delineate faults, shear zones and lineaments. The results reveal major fault systems with E-W, ENE-WSW, NE-SW, WNW-ESE and N-S orientations, indicative of complex tectonic processes influencing the geodynamic process of the Eastern Indian Shield. The 3D Euler deconvolution and CET analysis are used to delineate their depth and relationship with the mineralisation. Depth estimates from Euler deconvolution indicate that these faults extend from less than 1km to over 11km, highlighting their deep crustal penetration. The CET analysis reveals zones of increased structural complexity, which coincide with areas of known mineralisation, suggesting a robust structural control over mineral distribution. These findings control a better understanding of the tectonic framework of the Eastern Indian Shield and provide valuable insights for future mineral exploration efforts.

EVALUATION OF HEAVY METAL CONTAMINATION OF GROUNDWATER AROUND RAICHUR THERMAL POWER PLANT, KARNATAKA, INDIA

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ABSTRACT

Heavy metal contamination in groundwater poses a severe risk to human health near coal-based thermal power plants, as these toxins can enter our bodies through water. The objective of this study is to evaluate how thermal power plants are affecting water quality of nearby areas. The current study has attempted to evaluate heavy metal contamination of groundwater quality around the Raichur Thermal Power Station (RTPS). Twenty-seven (27) groundwater samples were collected around RTPS within 10 km radius. The samples are analysed for heavy metal concentrations such as arsenic, iron, cobalt, manganese, nickel, copper, chromium, cadmium, lead and zinc using ICP-MS. Preliminary results reveal that arsenic and lead were found to beyond the permissible for drinking purposes according to the WHO and BIS maximum permissible limits of 10µg/L. Lead (Pb) was found in the range of 0.70-19.62 µg/L with a mean concentration of 10.53 µg/L. 59% of samples tested are outside the domain of standard guidelines indicating unfit for drinking purpose. This study further suggests seasonal variability of heavy metal concentration and characterization of fly ash is required to assess source of contamination.

Keywords: Heavy metal pollution, Thermal Power Plant, Groundwater, Drinking water, Raichur, India

PRELIMINARY ROCK MAGNETISM AND PALEOMAGNETISM RESULTS FROM WESTERN DHARWAR MAFIC DYKES, SOUTHERN INDIA

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ABSTRACT

A study has been carried out using Paleomagnetism and rock magnetism as a proxy on mafic dykes from Arehalli area in the Late Archean Western Dharwar craton, southern India. 12 oriented block samples from 2 sites of NNW-SSE oriented dykes were collected and the results are presented here along with previously reported data on dyke swarms from Western as well as Eastern Dharwar craton. Measurement of magnetisation versus temperature curves yielded thermomagnetic curves which are nearly reversible and irreversible with magnetite as remanence carrier for Arehalli dyke. Day plot indicate that most of the samples are having Pseudosingle domain nature. The Paleomagnetic results from 2208 Ma Arehalli dykes give mean declination of 17° and mean inclination of 57° (Precision parameter (k) = 14.67, Circle of confidence (α_{95}) = 12.33°) and the corresponding paleopole obtained at 61.49°N, 104.85°E (semi-axis of the ellipse of confidence (dp) = 12.88° and semi-axis perpendicular to the great circle (dm) = 17.82°) for Arehalli dykes respectively. The updated Apparent Polar Wander Path (APWP) for Dharwar craton from obtained poles from this study fills the gap in APWP. Six well constrained key paleopoles from 2.37 Ga to 1.89 Ga periods of previous studies suggested that Dharwar craton has a rapid drift rate from 26° to 53° paleolatitude along with a clockwise rotation (~40°) during 2235 Ma to 2216 Ma and the overall drift of 70° took place during 2235 Ma to 2207 Ma. Current results support previous work between 2216 Ma to 2207 Ma, suggest that craton has rapid drift rate during 2208 Ma to 2207 Ma from 61° to 53° Paleolatitude.

MARINE GEOSCIENCES

WEATHER ABILITY OF BASALTIC ROCK IN WATER – ROCK INTERACTION AND ITS IMPLICATION IN EROSION HAZARD EVALUATION OF COASTAL ZONES

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ABSTRACT

Weathering is the breakdown of rocks due to physical and chemical phenomena under the influence of atmospheric and hydrospheric factors. The changes resulting from weathering is a product of the interplay of structure and type of parent rocks, groundwater, climate, topography, organisms and time. The mineralogy, structure, and discontinuities of rock strata are elements that controls the pattern of water-rock interact.

The basalt is a basic rock widely exposed in different parts of continents and coastal regions of the world. It is commonly comprised of minerals like pyroxenes, olivine and plagioclase feldspar. These major constituents of basalt are more susceptible to weathering assisted quick and huge fragmentation of geoground.

Coastal erosion is the loss of coastal landforms as a result of net removal of sediments/ bedrocks from the coastal zones due to impact of waves and currents actions, and other related processes. The coastal erosion is one the sever hazards related to coastal stability and management.

In basaltic cliff zones the initial steps of erosion is principally controlled by the weathering of such rock. Therefore, the present study is an analogous attempt to understand the weatherability of basaltic rock generally exposed near the marine water -rock interaction zones in majority of coastal areas.

For the purpose, different basaltic layers have been studied in a small central part of country. The study area is bounded by latitude $N18^0$ 26' 02" - $N18^0$ 17' 00" and longitude $E73^0$ 51' 11" - $E73^0$ 87' 00". The prepared samples from the collected specimens from different exposed zones of area were used for estimation of various weathering sensitive parameters of basaltic layers of the area. Ultimately results were utilized for evaluation of weatherability of basaltic rock for their implications in coastal zone erosion evaluation.

The results may be suitable to establish a concept for pertinent planning and manage the coastal zone from erosion hazard.

SINGLE-CHANNEL SHALLOW SEISMIC STUDY OF COASTAL EVOLUTION AND SUBSURFACE STRUCTURES OFF PURI, ODISHA

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ABSTRACT

The Odisha coast, located along the eastern margin of India, has undergone significant geological transformations due to tectonic activities, sea-level fluctuations, and sediment dynamics, particularly during the Last Glacial Maximum (LGM) and Holocene periods. This study investigates the subsurface structures and coastal evolution off Puri, Odisha, using seismic survey data, isochron and

isopach maps, and geomorphological insights. The seismic survey, conducted during Geological Survey of India's ST-289 cruise, identified paleo-shelf breaks, transgressive-regressive sequences, and heavy mineral deposits, offering a detailed understanding of sedimentary processes. Key reflectors, such as R1 and R2, represent submerged shorelines and erosional surfaces formed during periods of sea-level change. Isochron maps revealed a consistent southward-dipping seafloor and significant reflectors indicating phases of transgression and regression, while isopach maps illustrated variations in sediment thickness linked to past environmental conditions. These findings highlight a dynamic depositional environment shaped by glacial-interglacial cycles and fluctuating sea levels. The study also explores the implications of these geological features for coastal management. Areas with thick sediment deposits are identified as more stable, whereas thin or eroded zones are vulnerable to coastal erosion and sea-level rise. This study emphasizes the need for adaptive coastal management strategies to mitigate risks associated with climate change, such as rising sea levels and increased storm intensity. Understanding the subsurface structures and sedimentary processes of the Odisha coast is crucial for developing sustainable coastal protection measures and safeguarding vulnerable communities and ecosystems.

IODP GIANT PISTON CORING IN DEEP-SEA JAPAN TRENCH TO ADVANCE SUBDUCTION ZONE PALEOSEISMOLOGY

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ABSTRACT

The sediment supply to the deep ocean basins is sensitive to the topography, oceanography, and tectonics of the surrounding region and provides crucial information on the paleo-geographic, and paleo-climatic histories. It is widely recognized that the giant earthquakes that occur along intra-oceanic subduction frontiers have the potential to induce massive tsunamis. Consequently, large-scale mass movements from continental shelves to the deep sea are triggered. Such bulk movements of sediment finally end up in nearby hadal oceanic trenches that act as terminal sinks for sediment as well as particulate and dissolved organic carbon. Deciphering provenance in deep-sea sedimentary successions is particularly valuable because they record a continuous history of the surface processes that contributed to their accumulation. Therefore spatio-temporal analyses of sediments retrieved from the hadal oceanic trenches could provide a unique opportunity to document genesis and sediment provenance and above all a precise account of event stratigraphy. Collectively, this information is vital in deciphering the precise seismic history of continental margins.

The International Ocean Discovery program (IODP) expedition 386 successfully drilled and retrieved 29 Giant Piston cores at 15 sites (total core recovery of about 831.19 meters) from record breaking 7-8 km deep trenches. The Japan Trench is an instrumental site for “Submarine paleoseismology” and the signature of seismic hazards (e.g., earthquakes) is well preserved in the upper Pleistocene to Holocene stratigraphic succession. Here we present early results from the giant piston coring in the 2011 Tohoku-Oki mega earthquake (Mw=9) zone along the Japan Trench (JT). Through our analysis of seafloor geophysical and sub-seafloor sedimentological and geochemical data, we learn that the associated tsunami triggered extensive mass remobilization from the shelves to the deep-sea trenches through the expanded canyon systems formed by flexural bending of the subducting Pacific plate.

Knowledge about the origin of the JT sediment and their remobilization is important for resolving mechanisms of plate boundary earthquakes and the evolution of continental crust.

MORPHOLOGICAL CHANGES THROUGH BEACH PROFILES DURING SEASONS OF 2023 AND 2024 ALONG VISAKHAPATNAM, EAST COAST OF INDIA

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ABSTRACT

Costal erosion is one of the major problems for our country showing its adverse impact on both coastal structures and on the costal population. The seasonal morphological variations along the beach are mainly influenced by the waves, tides, ocean currents and also by anthropogenic activities (dredging, building of groins and jetties etc.) to some extent. The City of Visakhapatnam has a coastline of about 48 km from Bheemunipatnam to Yarada, which is highly dynamic and continuously subjected to both erosion and deposition throughout the year. To understand these morphological and seasonal variations along the beach, 10 stations were selected along the Visakhapatnam coast. Beach Profiles were carried out bimonthly (twice a month) at these locations along with the collection of Littoral data during Pre-Monsoon, Monsoon, Post-Monsoon of 2023. Detailed Volumetric estimations were done to quantify the changes in all components of beach i.e. Foreshore, Berm, Backshore and Dune. Our current research article mainly focuses on the identification of major erosion and deposition prone zones along the Visakhapatnam coast and correlate the Net erosion and deposition patterns. Beach profiling data revealed that the southern coast of Visakhapatnam city from Yarada to South of Submarine was mainly effected by Net erosion (ranging from 10215 m^3 to 1277 m^3 based on base profile) during both Pre-Monsoon and Monsoon of 2023 time with the much intense erosion during the July to August months of Monsoon 2023 due to high wind and wave activity and net deposition (1800 m^3 to 500 m^3) in NE monsoon of 2024. In contrast to this the Northern coast of Visakhapatnam city from Rushikonda to INS Kalinga was characterized by Net deposition (11174 m^3 to 1522 m^3 based on base profile) from Pre-Monsoon to Monsoon time of 2023 and net erosion (1500 m^3 to 400 m^3) in NE monsoon of 2024. Bheemili station at the Northern tip of Visakhapatnam coast was subjected continuous increasing erosion, this is due to local embayment of the Bheemili coastline which resulted in localized erosion.

Key words: Coastal Changes, Erosion, Deposition, Visakhapatnam coast.

COASTAL DUNE VULNERABILITY ASSESSMENT: A GIS-BASED APPROACH FOR SUSTAINABLE SHORELINE MANAGEMENT IN ODISHA, INDIA

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ABSTRACT

This research utilizes the Dune Vulnerability Checklist (DVC) to evaluate the conservation status and pinpoint disturbance events along the Odisha coast, Bay of Bengal. The coastline under investigation, measuring 124 km, was systematically divided into 111 dynamic segments through the application of GIS-based shoreline segmentation techniques. The DVC consists of 71 variables categorized into four

distinct indices: dune morphology, marine influence, seaward surface character, and anthropogenic influence, along with one index for protection measures, each rated on a scale from 0 to 1. The Coastal Dune Vulnerability Index (DVI) is determined by aggregating the four Vulnerability Indices, whereas the DVI/PM ratio categorizes segments into states of equilibrium, necessitating maintenance or protection, or indicating stability. The findings indicate that there are 35 km of stable shoreline, 23.195 km that require maintenance and seasonal monitoring, and 52.67 km exhibiting signs of degradation that demand comprehensive protection and stringent legislative measures. This study establishes a framework for identifying at-risk coastal zones and formulating specific management approaches, thereby enhancing the efficacy of coastal dune preservation and promoting sustainable shoreline management within the area. This research illustrates the effectiveness of the DVC in assessing intricate coastal systems and provides significant insights for decision-makers and environmental managers responsible for coastal protection and adaptation to climate change.

CHARACTERISTICS OF THE MAXIMUM DURATION AND MAXIMUM INTENSITY MARINE HEAT WAVES OVER THE BAY OF BENGAL IN RECENT PERIOD

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ABSTRACT

The disastrous effects of marine heatwaves (MHWs) on fisheries, coastal communities, and marine ecosystems have made them a major environmental danger due to the changing global climate trends. This work explores some of the critical aspects of recent MHWs that eventuated in the Bay of Bengal (BoB), their characteristics, and their impacts on atmospheric, oceanic, and biogeochemistry variables. In this study, we have identified two major MHWs that eventuated over the BoB region (89°E-95°E, 16°N-22°N) during the recent years. These two major MHW events are characterized based on maximum duration and maximum intensity. We found that the maximum duration MHW event that occurred in 2020, spanned for 117 days with highest intensity of 1.73 °C. Meanwhile, the maximum intensity MHW event that occurred in 2022, lasted for 18 days with intensity of 3.07 °C. During the maximum duration (maximum intensity) MHW event the average values of latent heat flux, shortwave radiation, and net heat flux are found to be about -90 (-75) W/m^2, 190 (250) W/m^{2,} and 50 (125) W/m^2 respectively. The values of chlorophyll, net primary productivity, phosphate, dissolved oxygen, and nitrate are found to be decreasing while the values of silicate increased slightly during the maximum duration MHW (2020) event. During the maximum intensity MHW (2022) event, except Phosphate, the values of other biogeochemical variables are found to be decreasing.

Keywords: Marine Heat Wave; Chlorophyll; Biogeochemistry; Marine Environment; Net Heat Flux

MAGNETIC SPECTRAL ANALYSIS AND GRAVITY INVERSION FOR ASSESSING THE GEOTHERMAL CHARACTERISTICS OF THE ANDAMAN-NICOBAR SUBDUCTION ZONE

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ABSTRACT

The thermal structure of Earth's crust is a key factor influencing geodynamic processes such as plate tectonics, seismic activity, and hotspot volcanism. Thus, gaining a deeper understanding of thermal conditions is crucial for interpreting various geological processes and the rheological characteristics of the crust. Surface heat flux measurements provide direct insights into the thermal structure of the crust but are expensive and practically difficult for large scale studies. The spectral analysis of magnetic anomaly data is an indirect method which can be used to estimate the geothermal regime of a region. Spectral analysis of magnetic anomalies enables the determination of the depth to the bottom of the magnetic source, referred to as the Curie Point Depth (CPD), from which heat flow can be inferred. In this study, we conduct radially averaged spectral analysis of magnetic data of Andaman-Nicobar Subduction Zone (ANSZ), a region characterized by significant geothermal variability. The results indicate shallow CPDs in the back-arc basin and volcanic arc, while deeper CPDs are observed along the Ninetyeast Ridge (NER), the forearc, and the trench. Heat flow values are correspondingly higher in the back-arc region and lower along the NER, trench, and forearc. Discrepancies between CPD-derived depths with respect to seismic and gravity inversion Moho estimations highlight the complexity of the subsurface structure. Nonetheless, spectral analysis of magnetic data provides critical insights into the crustal thermal regime and rheological properties. These findings have significant implications for identifying tectonic weak zones, potential geohazard risk areas, and regions favourable for geothermal energy exploitation.

INTEGRATED GEOPHYSICAL ANALYSIS IN THE KRISHNA-GODAVARI OFFSHORE BASIN: RIFTING, STRUCTURE, AND GEOTHERMAL REGIME

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ABSTRACT

The Eastern Continental Margin of India was formed due to the separation of India from Antarctica in the Early Cretaceous. Detailed investigations along the ION1000 seismic profile running off Krishna-Godavari basin have indicated it is a magma-poor, upper-plate passive margin. Despite several interpretations made along this profile, the rift architecture has not been investigated in relation to the surrounding geology. Further, the curie depths and geothermal regimes were never inferred in this region. In this study we have used magnetic, gravity and multichannel seismic data to understand the rifting mechanism, subsurface configuration and geothermal regime. Detailed investigation of the various interpretations along the ION1000 profile facilitated reviewing the various rifting concepts and integrating them to generate a base model. Further, the ION1200 seismic profile has been investigated by way of both qualitative and quantitative analysis. Magnetic data in the study area was subjected to radially averaged spectral analysis to obtain curie depths which in turn were used to obtain the heat flow. Gravity data was used to infer the Moho depths by non-linear inversion technique. Qualitative analysis of the ION1200 profile provided a detailed description about the various structural domains associated with rifting. Quantitative analysis yielded the amount of tectonic subsidence and residual depth anomalies. Anomalous subsidence and outer marginal collapse can be inferred in the exhumed domain. Further, there is no evidence of overthickened crust along this profile. Heat flow computed from magnetic analysis is higher than the measured values probably due to the presence of thick sediment load.

CAPILLARY PRESSURE EQUILIBRIUM THEORY FOR MODELLING HETEROGENEOUS AND PARTIALLY SATURATED SEDIMENT

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ABSTRACT

Lithological heterogeneity may result in variations in saturation because various lithology inside a reservoir can have varied capacities based on the volume of pore spaces and permeability under the circumstances of capillary equilibrium. We investigate this fact by modelling a reservoir in which we can control the lithological unit distribution and determine the associated relationship between velocity and saturation applying the Capillary pressure equilibrium theory (CPET). We can determine the saturation for any region of a reservoir by utilizing the suitable velocity-saturation curve for the nearby lithological unit, provided that the reservoir is in a state of capillary equilibrium. Our calculated velocities for these models show how lithological variation-induced heterogeneous saturation can lead to a dependency of velocity in relation to saturation. It is discovered that various lithological units distributed as patches result in an observable and nearly constant velocity fluctuation in the P-wave velocity across the full saturation range. On the other hand, the response of a homogeneous reservoir exhibits a drop in velocity at very low gas saturations (close to 100% water saturation) and remains constant after that. Moreover, our modelling of a heterogeneous reservoir consisting of clean-sand and shaly-sand shows velocity increases suddenly at 40% water saturation when shaly-sand is of 10%, and the overall velocity increases with the increase of the volume fraction of shaly-sand. Modelling of a reservoir of multiple lithology shows that the responses tend to be patchy type as the heterogeneity increases and the number of steps that indicates the increase of velocity with saturation are equal to the number of lithology in the model. Finally, in order to evaluate free-gas, we apply the CPET to the sediment that contains free-gas beneath the gas hydrate-stability zone in the Krishna Godavari basin. At Site NGHP-02-20, the free gas saturations calculated from our modelling is about 20%, and at Site NGHP-02-24, it is about 30%.

Keywords: Rock physics; Capillary-pressure; heterogeneity; Porosity; Permeability; Lithology; Saturation; Free-gas

APPRAISAL OF GEOPHYSICAL APPLICATIONS FOR DEMARCATING THE SALINE WATER INTRUSION IN COASTAL AQUIFERS OF SOUTHERN INDIA

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ABSTRACT

To investigate the pathways for saline water intrusion into fresh water aquifers the Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) have been pooled for Nagapattinam area of Southern India. The study area has two river sub-basin Uppanar River Basin (URB) and Cauvery River Basin (CRB). ERT carried out in URB shows very low resistivity ranging from 0.003 Ohm-m to 1.5 Ohm-m at shallow depth indicating saline water, whereas the resistivity

ranges away from the river stream are 1.7-5.0 Ohm-m. Cauvery river basin shows resistivity range varying from 3.6 Ohm-m -150 Ohm-m indicating a salt-fresh water mix. Similarly, few GPR profiles were carried out along ERT profiles to confirm the saline water intrusion and its pathway. Besides, the hydro-chemical study reveals the same signature of saline and fresh water zones in both river basins. Water samples collected during field investigation show high Total Dissolved Solids content near URB and CRB river coarse. ERT data was correlated with GPR data to distinguish fresh and saline water zones more accurately. URB has more saline water zones at shallow depth nearer to river coarse and intermediate depth of saline water zones away from the river coarse, while CRB is having fresh water towards the inland.

Keywords: Electrical Resistivity Tomography (ERT), Ground Penetrating Radar (GPR), Uppanar River Basin (URB) and Cauvery River Basin (CRB).

INSIGHTS INTO THE MAGNETIC HISTORIES RECORDED WITHIN THE ATLANTIS MASSIF: PALEOMAGNETIC RESULTS FROM IODP EXPEDITION 399

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ABSTRACT

International Ocean Discovery Program (IODP) Expedition 399 recovered rocks from the Atlantis Massif, a well-studied oceanic core complex located along the Mid-Atlantic Ridge. Shipboard paleomagnetic and magnetic fabric property analyses were conducted on samples collected from the massif's central dome, Site U1309, as well as from its southern footwall, Site U1601. Preexisting Hole U1309D was deepened by 83 meters to a total depth of 1498 meters below the seafloor (mbsf). These newly recovered rocks record a primary natural remanent magnetization (NRM) inclination averaging −25.7° ± 12°. Alternating field (AF) demagnetization experiments of up to 50 mT yielded a steeper average inclination of −34.4°. Magnetic intensity values in this hole ranged from 0.02 to 3.81 A/m, with a mean of 0.90 A/m.

At site U1601, Holes U1601A and U1601C were drilled to depths of 60.6 mbsf and 1267.8 mbsf, respectively. Samples from Hole U1601A recorded an average NRM inclination of −22.2° ± 13.5°, and those from Hole U1601C an average inclination of −26.7° ± 32.8°. Low AF demagnetizations for both holes (~10–15 mT) effectively removed low-coercivity drilling overprints, shifting inclination values closer to the expected geocentric axial dipole (GAD) inclination of −49°. Additionally, the remanences remaining after stronger AF fields (>40 mT) likely reflect a more complex remanent history. The magnetic intensity in Hole U1601C peaked at a value of 17.9A/m. The most magnetically intense intervals of this hole were recorded within sections of serpentinized peridotites, suggesting high-temperature, magnetite-forming hydrothermal alteration. Anisotropy of magnetic susceptibility (AMS) data reveal predominantly oblate magnetic fabrics downhole. These data could support observations of more high-temperature, ductile-like deformation in gabbroic rocks and more brittle-like deformation in ultramafic rocks. Hole U1601C particularly demonstrated horizontal magnetic flow, as indicated by K_{min} clustering, with the greatest anisotropy in deformed gabbro units around 200 and 600 mbsf. This comprehensive paleomagnetic analysis advances our understanding of magnetic intensity distributions and crustal processes at slow-spreading ridges, and future work may further constrain the extent of the massif's tectonic rotation.

ATMOSPHERIC, PLANETARY & SPACE SCIENCES

EXPLORING DIACHRONIC VARIATION IN SUNSHINE HOURS ACROSS SOUTHERN INDIA: A COMPREHENSIVE THREE-DECADE ASSESSMENT

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ABSTRACT

The assessment of diachronic variation in sunshine hours of seasonal cyclic trend over the last three decades has been conducted in present study. The study focuses on different regions of India such as East coast (Chennai, Bhubaneswar, Kolkata, Machilipatnam); West Coast (Thiruvananthapuram, Goa, Mumbai); Central Inland (Indore, Nagpur, Hyderabad), for the period of 1988 to 2018. The Indian topography and climatic condition are very dynamic. The climatological variable like SSH is depending upon cloud cover extent in the atmosphere. Due to indigenous meteorological variation in latitudinal and temporal scale, Twomey effect shows pronounce impression particularly in Pre-monsoon, monsoon and post-monsoon seasons. The study reveals thirty years uniformly declining SSH in east coast, west coast and central inland of India at the significance level of 95% with Sen's slope value of -1.61 to -2.72. Some cities of selected region show insignificant decline trend with Sen's slope of -0.29 to -1.21. However due to meteorological variation in latitudinal and temporal scale post-monsoon season of central inland shows insignificant positive Sen's slope of value 0.50. Seasonal variations are depicting the effect of local monsoon. Further, seasonal anomaly analysis results are also depicting consistent declining trend in SSH for three major geographical location of India except post-monsoon of central inland. These findings underscore the imperative of incorporating climatic variables while studying SSH seasonal trends and devising sustainable renewable energy strategies to ensure the long-term viability of solar energy source.

Keywords: Sunshine hour, diachronic variation, seasonal anomaly

MAGNETIC MONITORING OF ENVIRONMENTAL POLLUTION USING NAP TEXTILE IN VISAKHAPATNAM CITY, ANDHRA PRADESH, INDIA.

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ABSTRACT

This study conducts a magnetic analysis of 80 suspended particulate dust samples in Visakhapatnam (Vizag) to identify hazardous pollution levels and differentiate between areas affected by traffic and industrial activities. A novel sampling technique, termed the Textile Sampling Method, was employed to collect suspended particles (SP). The correlation coefficient between the SP weight obtained using this method and the traditional High-Volume Sampler (HVS) was found to be R=0.99. Variations in magnetic susceptibility (k) helped distinguish pollution sources throughout the city, primarily influenced by local pollution. The percentage frequency dependence susceptibility (kfd%) values ranged from 3% to 9%, indicating a significant presence of ultrafine magnetic grains in the particulate matter (PM) across various sampling locations. Higher kfd% values were observed in areas with heavy traffic, suggesting that vehicular emissions contain a greater proportion of ultrafine superparamagnetic (SP) grains compared to those found in industrial zones. The magnetic mineralogy of the suspended dust is predominantly characterized by a magnetite-like phase, with hysteresis parameters for some samples resembling those typical of pseudo-single domain magnetite.

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analysis of selected samples revealed extremely high concentrations of heavy metals such as Mn, Zn, Pb, Cr, and Cu, exceeding permissible limits. The correlation of kfd% with Cr and Ni was significant at P=0.05, and there was also a strong correlation between magnetic susceptibility (k) and Cr, Mn, and Ni, indicating that magnetic parameters are responsive to the spatial distribution of heavy metals. The variation in kfd% is interpreted as a reflection of the relative degree of human health hazard zones.

AIR QUALITY AND AGRICULTURAL OUTPUT: ANALYSING THE IMPACT OF POLLUTANTS ON CROP YIELDS

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ABSTRACT

The continuous rise in air pollution is increasingly impacting agricultural productivity, posing a significant challenge to food security. This study, conducted in districts of Sonbhadra and Varanasi in Uttar Pradesh, India, focuses on understanding the effects of air pollutants on wheat crop yields. Using Moderate Resolution Imaging Spectroradiometer (MODIS) and Modern-Era Retrospective Analysis for Research and Applications, version 2 (MERRA-2) model data at 0.5°×0.625° resolution from 2000 to 2024, the study examines these pollutants' impacts. Historical wheat yield data were sourced from the Ministry of Agriculture's Directorate of Economics and Statistics (https://aps.dac.gov.in/APY/Index.htm). Graphical analysis reveals a negative correlation between air pollutants and wheat crop yield, indicating that increased pollution levels are associated with lower yields. Air pollutants, hinder photosynthesis and plant growth, contributing to reduced crop productivity. By analyzing the temporal and spatial variations of pollutants, the study assesses their impact on wheat production. The analysis of air mass backward trajectories is performed using HYSPLIT model during Pre-monsoon, Monsoon, Post-monsoon, and Winter seasons to identify the regions from which aerosols are transported. Continuous air quality monitoring is crucial for identifying pollutant thresholds and developing strategies to mitigate their harmful effects. This data-driven approach can inform policies, promote sustainable agriculture, and ensure food security by minimizing the adverse effects of air pollution on agricultural output.

Keywords: Air pollutants, Remote Sensing, Wheat Crop, Correlation, Hysplit

ROLE OF DIFFUSIVITY RATIOS ON THE ONSET OF THERMO-CHEMICAL CONVECTION AT THE EARTH'S CORE

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ABSTRACT

Geomagnetic fields are generated by dynamo action in the Earth's core, driven by thermo-chemical convection that derives energy from secular cooling and light elements differentiation from the inner core. The inner core boundary (ICB) has a high temperature and high concentration of light elements (S, O, Mg, Ni). In contrast, the core-mantle boundary (CMB) has a relatively low temperature and low light element concentration. This leads to thermal and chemical instability, which results in

double-diffusive convection (DDC). The outer core convection inside and outside the tangent cylinder (TC) is ageostrophic and geostrophic, respectively. The convective flow inside the TC of the Earth's inner core is believed to be strongly dependent on axial (z) direction. In the present study, the plane layer convection model is used to investigate thermo-chemical convection inside TC by varying thermal and chemical diffusivity ratios. As a result, a change in chemical diffusivity ratios by retaining the thermal diffusivity ratio to a fixed value reduces buoyancy force more than pure thermal convection, leading to flow destabilization. Additionally, various rates of rotation are incorporated to study the rotating double-diffusive convection (RDDC) results in delay of convective onset and enhancement in convective length scales. Furthermore, at high diffusivity ratios, the critical buoyancy force varies rapidly with chemical diffusivity, while it remains invariant at low diffusivity ratios. Under rapid rotation, the transition of convective flow from oscillatory to stationary occurs as the chemical diffusivity ratio enhances while it remains stationary at low diffusivity ratios. Overall, the qualitative and quantitative characteristics of rotating thermo-chemical convection for various diffusivity ratios are found to be similar to those obtained inside the TC of the Earth's core.

INVESTIGATION OF THE DYNAMICS OF HEATWAVES OVER INDIA

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ABSTRACT

The unprecedented increase in the frequency, intensity and duration of heatwaves over the Indian region in the recent decades has been a reason for serious concern for agricultural productivity and the well-being of human beings. Investigation of the mechanism of heatwave initiation and persistence is essential for their accurate prediction in the short-range to extended range timescale. Although large-scale SST anomalies have been known to be the causative factor, large-scale atmospheric circulation changes and associated teleconnections triggered by anomalous land surface state may also initiate heatwaves. Once initiated, the persistence of anomalous atmospheric high-pressure systems that favour the occurrence of heatwaves along with coupling with the land surface states can further aggravate their impacts. Soil moisture anomalies can have a significant impact on local temperature and humidity leading to the initiation and/or intensification of heatwaves along with atmospheric circulations. This study explores the various causative factors of heatwaves during the pre-monsoon and monsoon seasons over India using circulation and land surface data and investigates the role of their coupling. Observational in-situ, reanalysis and satellite data have been used to quantify the anomalous soil moisture conditions prior to the occurrence of heatwaves of different intensities and the associated atmospheric conditions. It is noted that the observed severe heatwave cases are often preceded by deficit soil moisture anomalies and anomalous geopotential changes. The severity depends on the persistence of the atmospheric circulation anomalies. Our comprehensive analyses suggest that accurate atmospheric and land surface initialization and the representation of land-atmosphere feedback in operational models can significantly improve heatwave forecasts. The authors gratefully acknowledge the financial support given by the Science and Engineering Research Board, Department of Science and Technology, Government of India to conduct this research. The first author also gratefully acknowledges the infrastructural and financial support in the form of a Seed Grant under the Institute of Eminence scheme of Banaras Hindu University to perform this research.

Keywords: Heatwave, Atmospheric Circulation, Geopotential Height, Teleconnections, Soil Moisture Precursor, Climate Model

VARIABILITY OF FAIR-WEATHER ATMOSPHERIC ELECTRIC FIELDS IN THE EASTERN HIMALAYAN SYNTAXIS

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ABSTRACT

This study examines the variations in the fair-weather atmospheric electric field (AEF), referred to as the potential gradient (PG), recorded at Namsai (27.69° N, 95.85° E) in the Eastern Himalaya Syntaxis. The analysis is based on data recorded over 99 fair-weather days between November 2017 and April 2019. The aim of the study is to evaluate the general characteristics of PG in the Namsai region and explore the detection of seismic-related signals in PG variations. The findings reveal that the mean diurnal variation of PG under fair-weather conditions shows a peak at ~14:00 UT. Seasonal analysis indicates that PG values are highest during the winter months, followed by the equinox, and lowest in summer. These PG variations are analyzed in relation to meteorological factors, including temperature, relative humidity, pressure, and wind speed, which were recorded simultaneously. The observed PG fluctuations are attributed to changes in local meteorological conditions, air pollution levels, and the geographical features of Namsai, such as the nearby Brahmaputra river and surrounding forests. Notably, a significant PG anomaly was observed prior to the Mw 6.4 earthquake that struck a blind fault near the Main Central Thrust in the Himalayas on November 17, 2017. A sharp, bay-shaped negative anomaly in PG lasting about two hours was detected approximately seven hours before the earthquake. The amplitude of this anomaly exceeded the monthly mean diurnal PG variations during fair-weather days, and no significant meteorological changes were recorded on that day. This suggests that the anomaly was likely related to seismic activity rather than local weather conditions. The study not only provides valuable insights into the general variability of PG during fair-weather days in this region but also highlights the AEF measurements as a potential indicator of seismic activity, possibly serving as precursory signals several hours before an event.

DECODING GREENHOUSE GAS EMISSIONS VARIABILITY AND ASSOCIATED CLIMATE CHANGE IN INDIA : INSIGHTS FROM IN-SITU OBSERVATIONS AND MODEL SIMULATIONS

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ABSTRACT

CDIAC estimated that India's fossil-fuel CO2 emissions rose from 189 TgC in 1990 to 508 TgC in 2009, with coal-based power generation increasing from 55% in 2005 to 72% in 2023. While this rise in anthropogenic GHG emissions may be partially offset by vegetation uptake, a deeper understanding of emissions variability is crucial. Using a high-resolution transport model and surface, aircraft, and satellite data, we deployed an inversion system to study natural and anthropogenic

methane emissions in India. A top-down modeling study from our research estimates India's CH4 emissions at 24.2 ± 5.3 Tg yr^{-1}, 19.2% higher than the BUR-3 estimate of 19.55 Tg yr^{-1}. In contrast, the EDGAR (v4.3.2-2012) estimate of 32.6 Tg yr^{-1} is approximately 39% higher than emissions reported by India's BUR-1 (19.8 Tg yr^{-1}), BUR-2 (20.05 Tg yr^{-1}), and BUR-3 (19.55 Tg yr^{-1}). Another top-down study based on our observations indicated that average CH4 emissions in India during 2010-2015 were 22.0 (19.6–24.3) Tg yr^{-1}, consistent with the BUR-1 report submitted to the UNFCCC. To better understand GHG variability in India, we have established multiple observation sites across the country. These include in-situ measurements of CO2, CH4, CO, and H2O concentrations, as well as δ13C of CO2 and CH4, and δ13C, δ17O, and δ18O of CO2. Observation sites include Sinhagad (since 2009), Pune (since 2016), and a 72-meter tall tower in central India (since 2023). Additionally, carbon flux monitoring systems have been deployed across diverse ecosystems, including a 50-meter tower at Kaziranga National Park, a 30-meter tower in the Pichavaram mangrove forest in Tamil Nadu, a 25-meter tower in the Nainital forests, and at island sites. This study provides a comprehensive synthesis of observations and modeling efforts aimed at understanding GHG emissions variability and its connection to climate change in India.

YOUNG RESEARCHER PROGRAM

CONUNDRUM OF SUSTAINED SEISMICITY AND LOW DEFORMATION IN THE KOYNA WARNA REGION, INDIA

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ABSTRACT

The low magnitude, clustered in a small region of 20×10 km^2, and sustained seismicity of the past more than five decades in the Koyna Warna region, located in the western part of the stable continental region (SCR) of the India plate, is considered to be triggered by the reservoir impoundment. However, the causative mechanism of earthquake occurrence is not known. Here we present the results of a decade-long continuous GPS measurements from the region which imply tectonic deformation rate of 0.2-0.3 mm/year in the region. This is intriguing that such a low rate of deformation, which is significantly less than the average intraplate deformation of the India plate (1-2 mm/year), is responsible for the seemingly high seismicity Koyna Warna region. The deformation rate corresponds to a slip rate of ~2 mm/year on the seismologically inferred faults in the region. Interestingly, the annual seismic moment release in the Koyna Warna region is consistent with the geodetically estimated strain rate, which implies that the seismicity in the region is driven by the slip on the faults where the earthquakes are clustered. As more earthquakes occur during the retention of high water in the reservoirs, we surmise that the reservoir loading reduces strength on the faults which under very low tectonic strain rate fail to cause sustained but low magnitude seismicity.

Keywords: Crustal deformation, Intraplate earthquakes, Triggered seismicity

INTEGRATING QUANTUM-ENHANCED CLUSTERING WITH UNSUPERVISED DEEP LEARNING FOR IMPROVED FIRST ARRIVAL DETECTION IN SEISMIC RECORDINGS

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ABSTRACT

Determining the detection of first arrivals in recordings of small magnitude earthquakes is essential for effective seismic monitoring and analysis, as these are crucial for accurately localizing and estimating the magnitude of the seismic events. While seismic networks typically capture high-quality data, the detection of small magnitude events is often obscured by various types of noise, which hampers our analysis. To address these challenges, here we employ two-step method to identify the first arrival P-wave: initially, the time-frequency mapping of raw seismograms is performed using the Generalized S-Transform (GST). Following this the CNN-based unsupervised deep learning approach is used to extract optimal deep encoded features from the time-frequency map without the need for labeling data. Subsequent analysis involves deriving statistical and transformational metrics from both the deep encoded features and the original waveform. These metrics are then combined to create an enriched feature space.Quantum clustering is then strategically applied to this combined feature space to identify patterns or clusters that distinguish between useful waveform sections and non-useful ones. This selective identification and segmentation facilitates the determination of first arrival times within the relevant sections.The effectiveness of this method was first validated on a suite of

synthetic data contaminated with various levels of noise, and subsequently on observed data from the STEAD global datasets and seismic stations from the Jammu and Kashmir Himalaya. The method proves effective even in low signal-to-noise ratio conditions, highlighting its utility in first arrival picking for field data. We found that the obtained results are consistent, with reduced computing costs, and demonstrate an increased accuracy in detection compared to conventional ML approaches.

Key words: Quantum Computing, Qubits, Unsupervised Deep learning, Quantum Clustering, First arrival Detection

ASSESSING CRUSTAL DEFORMATION AND EARTHQUAKE HAZARD IN KASHMIR VALLEY, NORTHWEST HIMALAYA, INDIA: INSIGHTS FROM GPS-BASED STRAIN RATE ANALYSIS

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ABSTRACT

Kashmir Valley is one of the most tectonically active intermontane basin in northwest Himalaya. The region is deforming rapidly due to collision of India and Eurasia tectonic plates and build-up high rate of crustal strain and is prone to produce megathrust earthquakes. In the present study, a detailed measurement of current deformation and the strain build up rate has been carried out through sixteen GPS stations distributed throughout the Kashmir Himalaya from Pir Panjal Range through Greater Himalayan Range to Zanskar Range. The recorded GPS data at the sites is evaluated, together with neighbouring stable international GNSS stations, to estimate the daily accurate positioning of the sites. The acquired site velocity in India fixed reference frame has been utilized to calculate the principal strain rates and rotation rates using the triangulation method. The estimated site velocity further characterises the principal strain rates and the prevailing plate convergence rate. The strain rate analysis suggests that the Kashmir Himalaya is a under compressional tectonic regime with an average rate of -7.2×10^{-8} strain/yr. Focal mechanism solutions and average γ_{max} show that the Kashmir region is dominated by the northeast-southwest compressional stress regime. The maximum dilatation strain value of 21.4×10^{-8} strain/year indicates that the northeast of Kashmir region is accumulating maximum crustal strain. Using the Okada's formulation, we have estimated the plate convergence rate of 12.74±1 mm/yr and the locking width of 160±20 km (brittle segment) of basal detachment (or Main Himalayan Thrust) in the Kashmir region. The slow slip rate (12.74 mm/yr) on the basal detachment (MHT) in the Kashmir region suggests that earthquake recurrence intervals may be prolonged. The locked frontal portion of the MHT is wider in Kashmir as compared to the central Himalaya. The strain budget analysis, slow slip rate, wider locked zone indicates that the Kashmir region has potential to produce disastrous future earthquakes.

Keywords: Earthquake, Kashmir Valley, Strain, Pir Panjal Range, Triangulation

MINERALOGICAL STUDY OF LAMPROPHYRES OF GARO HILLS DISTRICT: PETROLOGICAL SIGNIFICANCE

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ABSTRACT

The different types of granitoid of Meghalaya massif, Northeast India, are widely studied; however, studies on the mafic intrusive dikes intruded are lacking. Lamprophyre rocks are intruded as small intrusive in the granitoid host rocks. The intrusive lamprophyre sample was collected from the Garo Hill District of Meghalaya—petrographic studies of the rock show porphyritic-panidiomorphic texture. The rock comprises phenocrysts of clinopyroxene, amphibole, and minor biotite. The groundmass comprises more K-feldspar, plagioclase, carbonates, apatite, pyrite, chlorite, rutile, titanite, etc. The mineral chemistry of clinopyroxene is diopside, and amphibole is magnesio-hastingsite (Ti < 0.50) with SiO_2 of 46 – 49 wt.%. Most of the studied phenocryst phases are zoned. The mineralogical assemblage and absence of olivine indicate the studied lamprophyres are vogesite. The photomicrograph of clinopyroxenes shows a core-rim zoning pattern. P-T conditions were estimated for the rocks studied using the phase chemistry of the studied clinopyroxene equilibrium.

A COMPARISON OF DIFFERENT DEEP LEARNING ALGORITHMS FOR DOWNSCALING CMIP6 GLOBAL CLIMATE MODELS MAXIMUM TEMPERATURE OVER INDIA

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ABSTRACT

The outputs of the global climate models (GCMs) has a very coarse resolution, which is unsuitable for regional level modelling and impact analysis. Global climate models need to be downscaled at a local/regional scale to determine the impacts of climate change on Maximum Temperature (Tmax) responses. The rate of increasing in Tmax e is one of the primary concerns of the world as it impacts the agriculture, livelihood, health, and economy of any country which are more pronounced a local level. Statistical Downscaling Model is a powerful model for climate change assessment. In this study, two novel Deep learning models, named Bidirectional long short-term memory network (BiLSTM) and Gated recurrent unit (GRU) are used to downscale CMIP6 GCMS models data (1.25°× 1.25° coarse resolution) Tmax at a regional scale of 0.5° × 0.5° spatial high resolution for the period 1951–2010 over the India. Downscaling is a critical step to bridge the gap between large-scale climate information and local-scale impact assessment. The results showed that, BiLSTM method performs better than GRU in downscaling of all GCM model datasets when evaluated against observed Tmax data from the India Meteorological Department (IMD) in terms of RMSE, MAE, correlation along with and spatiotemporal variability. Overall, the study concludes that BiLSTM approach is thus a powerful tool for downscaling (performs better than GRU) daily temperature and can potentially be leveraged to downscale climate, and earth system data for India with best hyper

parameter tuning. Hence, we propose to utilize a deep learning framework based on BiLSTM for downscaling GCMs dataset at a finer resolution.

Keywords: CMIP6, Maximum Temperature, Deep learning, Downscaling

SEISMIC ENVELOPE DRIVEN BROADBAND ACOUSTIC IMPEDANCE INVERSION USING END-TO-END DEEP SEQUENTIAL CONVOLUTION NEURAL NETWORK

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ABSTRACT

Acoustic impedance is an important elastic property, which allows estimation of petrophysical parameters such as porosity, lithology, etc. However, with conventional bandlimited seismic data, inverted impedance is often bandlimited, which restricts on low and high ends of the frequency spectrum. This study presents the use of seismic envelope with the objective of extracting low-frequency information to obtain broadband acoustic impedance inversion from poststack seismic data. In this work, we extract low-frequency components embedded within seismic trace envelope and employ them to reconstruct the long-wavelength background model without reliance on low-frequency sources that may be inaccessible or prohibitively costly. Furthermore, we integrate instantaneous phase data to mitigate the degradation of phase information inherent in a seismic envelope alongside bandlimited post-stack seismic datasets. To effectively assimilate the derived seismic envelope and instantaneous phase along with the bandlimited seismic data into the impedance inversion process, we utilize a comprehensive end-to-end deep sequential convolutional neural network. The designed deep learning-based model consists of series of convolution and recurrent neural networks. The proposed methodology has evaluated on synthetic benchmark datasets derived from the Marmousi2 and SEAM 2D subsalt Earth models. Findings of the present work accentuate the superiority of the proposed approach in obtaining broadband impedance from bandlimited seismic data thereby in recovering deeper geological features with respect to conventional approach. The proposed framework offers a robust resolution for broadband impedance inversion by employing an end-to-end regression-based unified deep learning model. Furthermore, this research primarily highlights the importance of seismic envelopes to significantly enhance the estimation of low-frequency components of the impedance model. In addition, the incorporation of instantaneous phase enhances the lateral continuity of the reflectors. Thus, the obtained broadband impedance from this study holds considerable significance in quantitative estimation of elastic properties thereby enhanced reservoir characterization.

IMPACT OF OFF-AXIS (LOW TEMPERATURE) HYDROTHERMAL PROCESSES ON SEAWATER LITHIUM AND POTASSIUM CYCLE: INSIGHT FROM AGULHAS PLATEAU POREWATER STUDY

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ABSTRACT

In the marine realm, low-temperature hydrothermal processes, viz. altered ocean crust (AOC) formation during seawater-basalt interaction outside the spreading ridge axis, results in the formation of multiple types of Li, K, Mg and Fe bearing marine authigenic clay minerals (MAAC). Over the geological time scale, seafloor MAAC formation consumes seawater alkalinity and releases CO_2 to the ocean-atmosphere reservoir; thus, playing a critical role in modulating the global carbon cycle, and ocean chemistry. The impact of these processes is recorded by the change in concentration and isotopic composition of key alkali and alkaline earth metals in seawater. For example, the preferential removal of the lighter isotope of Li (^{6}Li) by AOC and MAAC leads to the observed ^{7}Li enrichment of seawater. Modern seawater (31‰) is ~16‰ heavier than the flux-weighted average isotopic composition (~15‰), of its input.

In the present study, we have examined the concentration and isotopic composition of Li and K in the marine sediment pore water from two IODP sites (U1579 and U1580), located at Agulhas Plateau (Large Igneous Province: LIP). The primary objectives are to understand (i) the potential diagenetic reactions occurring in the sedimentary archive of Agulhas Plateau and (ii) the role of sub-seafloor LIP alteration in modulating the seawater chemistry and the global carbon cycle. Our results from Site 392-U1579 suggest a possible clay transformation mechanism from smectite to K bearing celadonite/glauconite due to interaction with old seawater (~60 Ma). In contrast, at Site 392-U1580 which is located at a depression between two basement highs and contains volcanoclastic sediments, the adsorption of Li on existing clay surface (smectite) exerts a more important control on the pore water Li. Overall, the results demonstrate highly contrasting subsurface clay formation mechanism between two proximal sites due to differences in their sedimentation rate, porosity, and diffusion. Our study highlights the potential of clay authigenesis, and transformation in generating significant CO_2 flux that should be considered for any future research on ocean alkalinity enhancement experiments.

ANALYSIS OF HEAT WAVES AND HEAT STRESS OVER INDIA DURING CYCLONE REMAL USING SYNOPTIC FEATURES.

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ABSTRACT

Tropical cyclones (TCs) and heatwaves are significant extreme events that profoundly affect human societies and natural environments. Enhanced TC activity over warm oceanic areas can elevate atmospheric heat transfer, potentially intensifying the severity of heat waves in adjacent regions and

increasing heat stress levels. This study investigates the relationship between Cyclone Remal, which occurred over the Bay of Bengal in May 2024, and subsequent heatwave conditions over the Indian region followed by increased Heat stress. Utilizing data from the Indian Meteorological Department (IMD), ERA-5, and NGFS reanalysis datasets, we have analyzed heat stress using the Universal Thermal Climate Index (UTCI) during heatwave conditions. Our findings reveal that from May 24 to May 28, 2024, Bihar and eastern Uttar Pradesh experienced moderate to very strong heat stress, with temperatures exceeding 40°C followed by heatwave over the northwestern and central parts of India. Synoptic factors such as high-pressure systems and low-pressure zones significantly influenced temperature and humidity patterns, exacerbating heat stress conditions. Deviations in wind speeds and specific humidity highlighted the complex relationship between cyclonic activity and the dynamics of heatwaves. This study gives a scientific analysis of how heatwave conditions intensified during Cyclone Remal in India. Keywords: Tropical Cyclone; Heat Waves; Heat Stress; UTCI

EMPIRICAL ORTHOGONAL FUNCTION ANALYSIS OF SATELLITE BASED HYDRO-METEOROLOGICAL OBSERVATIONS FOR DROUGHT SEVERITY IN INDIAN RIVER BASINS

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ABSTRACT

Droughts have become more frequent and intense globally due to climate variability, rapid urbanisation, and population growth. Hence, monitoring drought has become crucial because of its broad implications on natural systems, agricultural production, food security, and the economy. This study employs four key drought indices to analyse drought severity over a 21-year period (2002-2023): GRACE/GRACE-FO-based Drought Severity Index (GDSI), Combined Climatologic Deviation Index (CCDI), self-calibrating Palmer Drought Severity Index (sc-PDSI), and Standardized Precipitation and Evapotranspiration Index (SPEI). In addition, the spatial and temporal extent of droughts is assessed using Empirical Orthogonal Functions (EOF) and drought frequency analysis respectively. The results reveal prominent regional variations in drought trends across major Indian river basins. Notably, the northern Indian basins, specifically the inland drainage area of Rajasthan, the Ganga, and the Indus basins exhibit both a longer temporal duration of drought events and a larger spatial extent compared to the basins in central and southern India. Comparative analysis of the four drought indices highlight the interaction between climate-driven factors and human activities in shaping drought severity. Although changing precipitation patterns have key contribution to droughts, anthropogenic factors-such as urbanization, water mismanagement, and land use changes-play a relatively dominant role in enhancing drought conditions, particularly in northern and northwestern basins. Keywords: GRACE/GRACE-FO; CCDI; Drought Characterisation; Indian river basins; EOF analysis

MACHINE LEARNING CLASSIFIER FOR AUTOMATIC LANDSLIDE DETECTION USING SPECTRAL FEATURES

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ABSTRACT

Effective landslide monitoring is crucial for early detection and timely warnings, helping to mitigate damage and protect lives. Traditional methods like remote sensing and IOT-based in-situ measurements provide valuable data but are often limited by accessibility and resolution. Landslides generate distinctive seismic signals, offering an alternative method for real-time monitoring using local seismic networks. However, the success of seismic monitoring for early warning depends on the timely detection of the landslide seismic signals from the continuous data. Commonly available manual and statistical approaches using STA/LTA for discriminating the landslide-generated seismic signals are not optimal for parametrization and hence don't suit early warning purposes. Recent advances in artificial intelligence (AI) and machine learning (ML) have enabled the scope for automatic detection and classification of landslide-generated seismic signals. However, the appropriate selection of features for these AI/ML algorithms again plays a crucial role for successful detection. By analysing the temporal and spectral features of the seismic waveforms, we decided to use Power Spectral Density (PSD) and its characteristics as optimal features in the machine learning algorithm to distinguish landslide seismic signals from those of earthquakes and background noise. Here we attempt to develop the machine learning classifier based on Random Forest and Support Vector Machine algorithms using seismic global waveform data of 28 landslides. Interestingly both the models have achieved more than 98% accuracy in discriminating between landslides in the continuous seismic data. These findings demonstrate the global applicability of PSD-based classifiers for real-time discrimination of landslide seismic signals for monitoring and early warning.

IGU-ANNI TALWANI MEMORIAL GRANT FOR WOMEN RESEARCHERS

DEEP LEARNING-BASED MODEL FOR GROUNDWATER QUALITY PREDICTION IN KANYAKUMARI DISTRICT, TAMIL NADU, INDIA.

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ABSTRACT

In this study, a Deep learning-based model, Stochastic Neural Network (SNN) which excels in handling uncertain and complex data is customized to predict groundwater quality in Kanyakumari District, Tamil Nadu, India where groundwater is considered to be a critical source for drinking and agricultural purposes. The SNN model, enhanced by Monte Carlo Dropout captures the stochastic nature of the data and provides reliable predictions by simulating multiple possible outcomes, making the model ideal for groundwater quality prediction. A range of groundwater quality indicators, such as pH, EC, TDS, etc. were used to train the model. Rainfall patterns were found to have a considerable impact on water quality over a ten-year period, emphasizing the importance to include seasonal data into prediction models. Hence, Rainfall data was also included in order to evaluate its impact on groundwater quality. The deep learning model demonstrated its effectiveness with 95% prediction accuracy. The model's capacity to distinguish between classes were evaluated by the Classification Report, Receiver Operating Characteristic (ROC) curves, Area Under the Curve (AUC) values and the confusion matrix. In addition to this, Cross-validation (CV) was employed to confirm the model's performance and also to test the reliability of the results. This study provides an efficient method that can assist in sustainable use of groundwater resources and can safeguard public health.

Key Words: Deep learning, Groundwater quality prediction, Rainfall, Stochastic Neural Network, Kanyakumari District, Public Health.

STRATIGRAPHIC CORRELATION ASSESSMENT USING FRACTAL ANALYSIS OF GEOPHYSICAL LOGS: A CASE STUDY FROM UPPER ASSAM SHELF, INDIA

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ABSTRACT

Abstract We implemented fractal analysis approach to examine rock strata in hydrocarbon reservoirs, offering insights into subsurface geology by analyzing patterns in geophysical logs. Utilizing two key techniques—correlation dimension and multifractal detrended fluctuation analysis— we assess self-similarity and long-range correlations in the logs, which reflect the unique formation characteristics of the rock layers. The method was applied to the Bhogpara oil field in the Upper Assam basin, enabling the creation of a fractal-based signature for each rock formation. The correlation dimension, ranging from 1.98 to 1.13, allowed us to rank the rock layers as follows: Girujan > Tipam > Barail > Kopili > Prang > Narpuh > Lakadong-Therria. Additionally, the spectrum width, which indicates the complexity and heterogeneity of the layers, varied from 0.70 to 2.04, leading to the ranking: Kopili > Prang > Narpuh > Barail > Girujan > Tipam > Lakadong-Therria. This fractal-based method helps identify common patterns across different wells, highlighting the continuity of subsurface formations, and also detects variations in layers across different regions. Furthermore, it links the observed fractal patterns to the depositional environments of the rocks, such as lakes, shallow seas, and river systems, each associated with varying fluid conditions. Our findings indicate that the petroliferous formation exhibits the lowest fractal dimension and displays weak multifractality. Overall, this research

enhances stratigraphic correlation through fractal analysis, improving subsurface characterization and aiding in the identification of reservoirs, particularly in geologically complex regions, thus making exploration efforts more efficient and reliable. (Words: 244) Keywords: Fractals, Stratigraphic correlation, Borehole geophysics, Assam –Arakan Basin

FULL WAVEFORM INVERSION FOR IMAGING THE COMPLEX SUBSURFACE STRUCTURE

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ABSTRACT

Full Waveform Inversion (FWI) is a powerful computational technique in seismic imaging that produces high-resolution models of the subsurface, crucial for understanding complex geological formations. Traditional seismic imaging methods, such as seismic tomography and migration, are limited by their reliance on simple ray approximations, resulting in reduced resolution particularly in areas where the Earth's subsurface is complex. Whereas, FWI aims to get full information on seismic waveforms even when Earth's geological structure is complex. FWI utilizes the full wave equation to iteratively minimize the difference between data acquired in a seismic survey and synthetic data generated from a wave simulator with an estimated velocity model of the subsurface. The FWI framework incorporates a wave simulator for forward modelling the anticipated data and an adjoint simulator for updating the model based on the data misfit. The optimization of the misfit function is conducted using local methods such as conjugate gradient or Gauss-Newton techniques, and global optimization methods like simulated annealing or genetic algorithms, enhancing the method's ability to refine subsurface imaging significantly. We applied FWI to synthetic data of diverse geological models, including flat layers, inclined layers, synclines, and the complex Marmousi model. Our findings show that FWI significantly improves resolution in imaging these complex subsurface structures. However, despite its advanced capabilities, FWI faces significant challenges, notably cycle skipping and high computational costs. Cycle skipping occurs when the initial model significantly differs from the true model, leading to inaccurate results. The method also requires substantial computational resources to process and simulate large volumes of data effectively.

Keywords: Seismic Imaging, Full Waveform Inversion, Complex Geological Structure, Forward modeling, Inclined layers, Cycle Skipping.

INFERENCE TO TECTONIC AND SOURCE OF THE PANAMIK-CHANGLUNG GEOTHERMAL FIELD FROM DIMENSIONALITY ANALYSIS OF MAGNETOTELLURIC DATA

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ABSTRACT

The Panamik geothermal field in Ladakh is recognized as one of the most prominent geothermal sites in the northwest Himalayas. It is located in the Shyok-Nubra valley, sandwiched between the Ladakh Batholith to the S-SW and the Karakoram Batholith to the N-NE, in the northwestern Trans-Himalayan region of India. Its geoelectric properties have been investigated using Magnetotelluric (MT) Method. We acquired Broadband (BBMT) and Long-Period (LMT) measurements at 34 locations covering a 30 km profile aligned with the ~N45°W Karakoram Fault, which crosses the Panamik and Changlung hot springs. Since the profile closely follows the regional geological strike,

analyzing the dimensionality and directionality of the MT impedance tensors is crucial for interpretation. The Sounding curves and pseudo-section maps of apparent resistivity and phase reveal a highly conductive region in some central stations along the profile at longer periods. The dimensionality and directionality analysis results suggest insights into the tectonic setting of the study area. The phase tensor and skew parameters indicate predominantly 3D structure, with some 1D and 2D behavior at shorter periods. The strike direction, obtained from the phase tensor azimuth and Groom-bailey decomposition through the entire period range, is approximately N45°W, corresponding with the Karakoram Fault's geological strike. Moreover, real part of Parkinson induction vectors indicates the presence of a NE-SW oriented conductive feature across most of the frequency bands. At longer periods, the high magnitude of the induction vectors suggests a highly conductive zone towards the northeast direction, also identified by seismic velocity studies as a serpentinization zone with high velocities. The existence of a high conductive anomaly, the 3D nature observed at longer periods, and the magnitude of the induction arrows all imply a probable association with the source of the geothermal field.

Keywords: Magnetotellurics, Panamik-Geothermal, Dimensionality, Phase tensor, Geoelectric strike

POSTER PRESENTATIONS

SOLID EARTH GEOSCIENCES

INTRA AND INTERPLATE DEFORMATION OF SHILLONG PLATEAU AND INDO-BURMESE ARC USING GPS MEASUREMENTS

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ABSTRACT

The Northeast India region, classified as Seismic Zone V, is highly susceptible to seismic hazards, primarily due to the Indo-Burmese Arc (IBA), Shillong Plateau, and Himalayan Arc. Despite extensive studies on these tectonic features, the Indo-Burmese subduction zone remains a focal point for seismotectonic research due to the absence of large or great earthquakes. The tectonic processes of the IBA, especially regarding the Indian plate's convergence beneath the Burma sliver and its seismic potential, continue to be debated. Conversely, the Shillong Plateau has not experienced a significant seismic event since the great Assam earthquake of 1897 (Mw 8.1). Also, as an intra-plate tectonic feature, the significant deformation exhibited by the Shillong Plateau, unlike the relatively stable interior of the Indian Plate, makes this region a fascinating area for tectonic studies. The proximity of these regions to densely populated areas in Northeast India, Bangladesh, and Myanmar necessitates comprehensive seismic hazard assessments. This study focuses on the Shillong Plateau and the Indo-Burmese Arc to analyze their crustal deformation and develop a more refined tectonic model for both regions, thereby enhancing our understanding of their roles in regional geodynamics. This refined model aims to provide better constraints on seismic hazard assessments. GPS data is utilized for this analysis with the GAMIT/GLOBK software, and crustal deformation is modeled using TDEFNODE software [McCaffrey, 2002]. The models from this study highlight variations in cross-margin locking and strain accumulation, which will aid in assessing the earthquake potential of various faults in Northeast India. This study also incorporates the thrust front proposed by Betka (2018), which posits that the up-dip segment of the BMT intersects the surface farther east of the deformation front previously identified by Imam and Hussain (2002), along a shallow décollement. Considering the possibility suggested by their study that a rupture from any BMT earthquake could extend to either the thrust front or the deformation front, its implication on the potential seismic hazard for each scenario is assessed separately. Thus, two models were generated in this study: one where the surface deformation of the IBA extends to the deformation front at ~90.5°E, and another to the thrust front at ~91.5°E (Betka et al,2018). The analysis reveals that the Shillong Plateau, bounded by the Dauki fault, Kopili fault, Dhubri fault, and Main Himalayan Thrust (MHT), acts as an intra-plate block with Dauki fault velocities ranging from 3.5 to 6.4 mm/yr. The Bangladesh megathrust slip rate ranges from 7 to 6 mm/yr, with a locking width of 105 km and 204 km for the respective models. In both scenarios, the downdip edge is near the Tripura-Mizoram border. The Churachandpur-Mao Fault (CMF) exhibits a slip rate of 8 to 10 mm/yr, primarily in a dextral strike-slip manner, with a maximum locking depth of 5 km. These findings are critical for understanding the seismic potential of the northeast India region.

ESTIMATION OF SOURCE PARAMETERS AND SCALING RELATIONSHIP OF THE LOCAL EARTHQUAKES IN THE CENTRAL SEISMIC GAP NW HIMALAYA, INDIA

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ABSTRACT

In the past decade, the seismicity in the Garhwal Himalayas has been recorded by eight three-component broadband seismographs (BBS) deployed all along the Garhwal Himalayan Seismic Belt (GHSB). In this study, we estimated the source parameters of 52 local earthquakes of Mw 1.56-3.30 using a 3-month seismicity catalog and the recordings of the broadband seismographs in a shear wave spectral inversion. This iterative inversion technique is based on Brune's (1970) ω-square circular source spectral model. The modeled source parameters, including corner frequency (fc), source radius (r), stress drop (Δσ), seismic moment (Mo), and moment magnitude (Mw), varied in the ranges of 1.3-11.58 Hz, 117.6 -1054.4 meters, 0.01 -36 bar, 2.83E+11-1.33E+14 N-m, and 1.56-3.31, respectively. The scaling relation between fc and Mo is obtained as $Mo=4E+13\ fc^{-2.6}$ N-m/s^3 while between Mo and Δσ the relation is found to be as log (Δσ) =0.60 log (Mo)-17.35 and Mo vs. radius, $Mo =3E+9\ r^{1.24}$ .The relation between Mw and Mo is obtained as $Mo =E+10\ Mw^{7.51}$, where and other relations are obtained as follows: $(\Delta\sigma) = 0.0268\ Mw^{4.7894}$ $fc =1102.7\ r^{-0.948}$, Depth (d) = $9.699\ (\Delta\sigma)^{-0.11}$. These scaling relationships derived from our current study could enhance earthquake hazard modelling for the Garhwal Himalayan region. This, in turn, could allow earthquake engineers to construct more resilient buildings in the area.

Keywords: damping factor, source parameters, Levenberg Marquardt inversion, scaling relationships, Uttarakhand Himalayas.

ASSESSMENT OF SURFACE DEFORMATION IN THE CHAMBAL - YAMUNA RAVINE ZONE OF THE MARGINAL GANGA PLAIN BY PS-INSAR TECHNIQUE

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ABSTRACT

The marginal Ganga plain (MGP) is situated at the northern end of the exposed Bundelkhand craton. The Chambal region of the MGP is characterized by a highly complex network of gullies and ravines, forming badlands along the Chambal, Yamuna, and Betwa rivers and their tributaries. The deep incision of these rivers and the presence of badlands serve as compelling indicators of neotectonic activities in the MGP. Also, the rivers within the Chambal - Yamuna ravine area show a significant change in their flow directions. These observations imply that the subsurface tectonics is playing a major role in this area and it should manifest in the form of surface deformation. To understand the tectonic processes in the region, we are estimating surface deformation, if any, by using PS-InSAR technique and delineating the subsurface structure by magnetotellurics. We have estimated surface deformation rates using the Sentinel SLC data of May 2017 to January 2020 period. In this analysis, descending orbital images were utilized to derive the Line of Sight (LoS) velocities. Preliminary results yield maximum subsidence and uplift rates of -37.9 mm/yr and 16.84 mm/yr, respectively in the direction of LoS. These results shall be complemented by the ascending LoS velocities to derive the vertical deformation rates.

UNDERSTANDING CHARACTERISTICS OF STRONG GROUND MOTION THROUGH STOCHASTIC SIMULATION

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ABSTRACT

The stochastic simulation method is a simple and powerful tool for simulating high-frequency ground motions by combining parametric or functional descriptions of the ground motion's amplitude spectrum with a random phase spectrum modified by the duration of motion and earthquake magnitude. The fundamental component of the stochastic simulation is the ground motion spectrum, which includes the contributions of the local site effects (amplification and near-surface attenuation), the seismic source (seismic moment and stress parameter), and wave propagation (an-elastic attenuation and geometrical spreading). The assumptions for each term of the spectrum of the ground motion in the simulation are referred to as the theoretical equations or scaling relationships. However, simulation of the ground motion requires a proper selection and estimation of the above-mentioned parameters and scaling relationships in the target region. Therefore, this study aims to generate theoretical seismograms, which provide a good opportunity to explore the effects of source, path, and site terms on characteristics of ground motions. Results from various tests done on sensitivity and associated uncertainties of the above-mentioned terms (source, path, and site) are found crucial for accurate prediction of ground motion parameters and consequent estimation of seismic hazard levels.

RADIOGENIC HEAT PRODUCTION, THERMAL CONDUCTIVITY AND DENSITY FOR THE GRANITOIDS FROM NORTHERN PART OF THE EASTERN DHARWAR CRATON, PENINSULAR INDIA: IMPLICATIONS IN GEOTHERMAL STUDY

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ABSTRACT

Granitoids are prevalent in many geothermal fields, especially for Enhanced Geothermal System (EGS). Therefore, understanding their thermophysical properties, such as radiogenic heat production, thermal conductivity and density are essential for determining heat flow, heat storage capacity of the rocks, and thermal modelling of the region.

In the present study, systematic investigations were carried out in the laboratory to determine thermophysical properties of the granitoids from the northern part of the Eastern Dharwar Craton on 31 samples. Petrographic and geochemical studies were carried out to characterize the samples before performing thermophysical investigations. The Coarse to medium grained granitoids are mainly composed of quartz, alkali-feldspars, and plagioclase. Pyroxene, amphiboles, biotite, apatite, sphene, and opaque minerals are found in minor phase. Geochemical data indicates that the granitoids fall in the granite to granodiorite field, and show calc-alkaline trend. Most of the granitoids are metaluminous and few are peraluminous due to presence of amphiboles and feldspars.

Thermal conductivity of the studied granitoids vary in a broad range (1.6 to 3.5 Wm^{-1} K^{-1}), and the granites have higher values than granodiorites. While density shows broad range (2610 to 2830 kg m^{-3}), it is generally higher for granodiorite than for granite. Considering spatial variation, Huzurabad region shows higher thermal conductivity and lower density, while Warangal region shows lower thermal conductivity and higher density. Thus, both rock type wise and spatially, thermal conductivity tends to have inverse relationship with density. Heat production exhibits a very broad range (0.3 to 6.5 μW m^{-3}), while being lower for granodiorite and higher for granite.

Results indicate that the granitoids having higher thermal conductivity is more capable of heat transfer, while those with greater density retain heat for longer periods. These characteristics suggest that the specific granitic compositions may be suitable for geothermal applications. Further, the thermophysical data of the present study will be useful for thermal modelling of the region.

PROPAGATION OF GROUNDWATER POLLUTION ALONG THE MUSI RIVER

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ABSTRACT

The perineal River Musi is flowing from the heart of the city and dividing into Hyderabad and Secunderabad. Every day the River Musi is carrying loads of domestic and industrial waste (effluents) along with water. The groundwater quality is assessed by detecting abnormal concentrations of elements. The sustainability of the ecological system is under threat due to higher stagnates permissible limits. The discharge of industrial effluents and domestic waste into the Musi River are the main source of pollutants in groundwater. Added to this the slow movement of river water accumulates huge some of effluents and due course precipitates the pollutants.

The adverse impacts on local water bodies and shallow aquifers with untreated and or partially treated waste water used for irrigation have been significantly noted. This effect is pronounced in the vicinity of Musi River making the ground water unsuitable for domestic or agricultural purposes. Hence, there is an urgent need to find a solution to this problem with a suitable plan and an achievable strategy. Bio-remediation in the surface water bodies could check the depletion and contamination of aquifers for sustainable use. This can be achieved with an experimental strategy of excessive plantation along the river banks.

Keywords: perineal, sustainability, Bio-remediation, pollutants, effluents

JOINT INVERSION OF GRAVITY AND MAGNETIC DATA USING DEEP LEARNING: A DATA-DRIVEN APPROACH

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ABSTRACT

Joint inversion of gravity and magnetic data is a critical method for subsurface characterization in geophysical exploration, providing a more comprehensive understanding of the Earth's subsurface by simultaneously interpreting multiple geophysical datasets. Traditionally, these techniques have relied

on physical models and optimization algorithms, which may be computationally intensive and limited by assumptions about subsurface properties. However, with the advent of deep learning, a data-driven approach can now be applied to joint inversion, revolutionizing the interpretation of gravity and magnetic data.

In this approach, a convolutional neural network (CNN) is trained to learn the complex relationships between gravity and magnetic surface observations and their corresponding subsurface models, such as density and magnetization distributions. The gravity data, which represents mass distribution, and the magnetic data, reflecting subsurface magnetization, are treated as input features. The density and magnetization models serve as output predictions. To accurately model the forward physics, kernel operators are integrated into a custom loss function, ensuring consistency between predicted and observed data.

By incorporating both datasets into a unified framework, this method enhances the resolution and reliability of subsurface models, reducing ambiguities inherent in individual data inversions. The deep learning model efficiently handles the non-linearity of the inversion problem and learns intricate patterns from large datasets, offering a promising solution for real-time geophysical exploration.

This data-driven joint inversion technique has significant potential for applications in resource exploration, environmental studies, and geological structure analysis, providing a robust, scalable, and faster alternative to traditional inversion methods.

APPLICATION OF DEEP LEARNING (USING ARTIFICIAL NEURAL NETWORK & LSTM) IN THE GPS TIME SERIES DATA

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ABSTRACT

GPS data is widely used for navigation, surveying, and environmental monitoring, but it often suffers from missing values due to signal disruptions or ecological conditions. Common interpolation techniques, such as linear, polynomial, and spline methods, are generally employed to fill these gaps but often fall short when dealing with the complexities of time series data. This study investigates the use of machine learning models, particularly Artificial Neural Networks (ANN) and Long ShortTerm Memory (LSTM) networks, to better estimate missing values in GPS data for the North, East, and Vertical components. Our findings show that LSTM models outperform ANNs and traditional methods, achieving significantly lower Root Mean Square Error (RMSE) values, ranging from 0.0018 to 0.1082 mm. Among conventional interpolation methods, K-Nearest Neighbours (KNN) provided the best results for the North and East components. In contrast, linear interpolation was most effective for the Vertical component with an RMSE of 0.4051 mm. However, even the best-performing traditional methods were surpassed by deep learning approaches, highlighting the potential of LSTM models for more accurate GPS data interpolation. The study suggests that these models could be scaled up and enhanced with ensemble techniques, making them a powerful tool for improving GPS data accuracy across various applications. Supporting evidence from recent research also demonstrates that neural networks, particularly LSTM models, consistently deliver superior results in GPS error prediction and data interpolation. Keywords: GPS; Time Series Data; ANN, LSTM

GEOHAZARDS AND RISK ASSESSMENT

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ABSTRACT

Geological and environmental conditions that may lead to widespread damage or risk are termed as geohazards by UNESCO. When geohazards meets vulnerability, it results in Natural disasters. It is important to understand the phenomena, causes and risk assessment of geohazards since they claim huge number of life and have social and economic impact, with year 2023 alone claiming 86,473 lives worldwide and affecting 93.1 million people. Geohazards may be broadly classified into: Endogenous and Exogenous hazards with Volcanic eruption, Earthquake, Landslide belonging to the former and Cyclones, Lightning, Hailstorms (Infrequent events), Floods, Droughts, Cold waves, Heat waves (Cumulative Atmospheric Hazards) in the latter. Geohazards risk may be measured by their physical characteristics, likelihood of occurrence or consequences. Inherent factors such as lithology, geological structure, slope and external factors like seismicity, vulcanicity, cloud burst etc. affects the formation of hazards. It therefore becomes important to have hazards identification, vulnerability and risk analysis to have preparation and mitigation measures. Five models have thus been developed: Statistical models (assess the relationship between environmental factors and hazard occurrence based on historical data) Deterministic (simulate specific scenarios based on known conditions, focusing on worst-case outcomes), Dynamic (continuously update hazard assessments based on real-time or near-real-time data to predict short-term risk), Probabilistic (estimate the likelihood of various hazard events occurring over a specific time period) and Hybrid Hazard Model (to assess and manage geohazards such as earthquakes, landslides, floods, tsunamis, and cyclones). Statistical models are basically used for landslides and flood prediction with Frequency Ratio model, Weights of Evidence, Logical Regression. Deterministic models are used for geohazards such as Earthquake (Deterministic Seismic Hazard Assessment) and flood (Hydrological Models) whereas Dynamic Models are useful in prediction of Cyclones (Numerical weather prediction-Global Forecast System and Weather Research and Forecasting) as well as Earthquake (Real-Time Earthquake Information System) and Flood Frequency Analysis. Probabilistic Model is useful for Seismic Hazard Assessment and Tsunami Hazard Model. These models help in prediction and therefore early warning, preparation of evacuation plan, mapping of risk zones and tracking become possible. Understanding of the phenomena help in mitigation measures such as slope modification, improved drainage, excavation and filling are helpful to prevent landslides. Strategies such as adopting Consequence Tool set and HAZUS-MH helps in understanding the potential adverse economic and social impact of geohazards by hazard modelling output in the form of risk zones. Efforts like these are vital since they help in community awareness, lower-level decision making, preparation of rescue and rehabilitation plans for disadvantageous social groups.

DELINEATION OF CRUSTAL STRUCTURE BENEATH THE NORTHERN REGION OF CENTRAL INDIAN TECTONIC ZONE USING GLOBAL GRAVITY DATA

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ABSTRACT

The Central Indian Tectonic Zone (CITZ) is a Proterozoic-aged accretionary belt between the North Indian block (NIB) and the South Indian block (SIB), aligned in an E-W direction within the central

Indian subcontinent. This study aims to reappraise the crustal configuration, thereby the tectonic evolution of the region extending from the southern part of the Bundelkhand craton up to the north of the Central Indian Shear (CIS), i.e., the region comprising of the Son- Narmada North fault (SNNF), Son- Narmada South fault (SNSF), and Tapti North Fault (TpNF). Global gridded free-air gravity and topography data is used to obtain the complete Bouguer anomaly, that is further utilized for regional-residual separation using upward continuation filtering technique. The 50 km upward continued regional gravity anomaly shows an E-W trending high gravity anomaly in the area outlining the southern margin of the Bundelkhand craton and the southeast corner of the study area. Similar gravity highs are seen in the residual gravity anomaly obtained from the 50 km upward continued regional anomaly. This implies that high-density features occur at both near subsurface depths and deeper crustal levels. The E-W high regional gravity anomaly corresponds to a thick, high-density underplated layer above the Moho underlying the region south of the Bundelkhand craton, also encompassing the Vindhyan basin rocks. The high regional gravity anomaly observed in the SE corner of the study area corresponds to the occurrence of the Deccan traps and possibly an upwarped Moho due to the Deccan volcanism. The gravity highs observed in the residual anomaly map correspond to the volcanogenic Bijawar sequences lying along the southern margin of Bundelkhand craton, and the Deccan traps occurring SW of the craton, and the SE region of the study area. The 2D forward gravity model, along the Hirapur-Mandla profile, using prior geophysical and geological information, delineates the existence of a high-density underplated layer below the Vindhyan basin sequences extending up to the SNNF. The region south of the SNSF reveals an upwarped Moho, possibly due to the Deccan volcanism. The southerly dipping SNNF and SNSF, and southward thinning of the Bundelkhand basement are observed in the model. These indicate that the Bundelkhand basement extends beneath the region north of the CIS, and eventually undergoes a southward subduction under the SIB across the CITZ. The present work provides insight into the crustal structure below the region north of the CITZ, further aiding in understanding the role played by this region in the geological past of the Indian landmass.

ANALYSIS OF TECTONIC IMPLICATIONS USING B, P, D VALUES, AND COULOMB STRESS MODELLING DURING THE 2015 NEPAL EARTHQUAKE SEQUENCE

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ABSTRACT

An earthquake of magnitude M_w 7.8, having an epicentre 80 km northeast of Kathmandu, struck the Pokhara area in central Nepal, causing widespread damage. After 16 days, a second earthquake with a magnitude of M_w 7.3 followed the mainshock. The focal mechanism solution and the distribution of aftershocks show that the earthquake happened on an oblique thrust fault that was orientated towards the NW-SE. In this study, we used estimated statistical seismological parameters such as the spatial fractal dimension D-value, the aftershocks temporal decay p-value, the b-value of the G-R relationship, and co-seismic stress modelling to analyse the tectonic implications and earthquake triggering during this sequence. The mainshock occurred in a highly stressed region and the sequence included greater magnitude aftershocks because of the large size asperities within the rupture zone, according to the estimated b-value of 0.56. The slow decrease of aftershock activity indicated by the low p-value of 0.91 is likely an indication of limited surface heat flux. In the fault zone

less surface heat results in longer stress relaxation times. A random spatial distribution and a source consisting of a two-dimensional plane filled with fractures are indicated by a spatial fractal dimension value (D-value) of 1.88. Using the slip model, the estimated coseismic Coulomb stress shows a butterfly pattern, and the majority of aftershocks occur in the enhanced Coulomb stress zone. This implies that the majority of aftershock activity has been caused by the transfer of positive Coulomb stress as a result of the mainshock's coseismic slip. This also validates that the Nepal earthquake raised the possibility of a large aftershock that occurred on 12 May 2015. For future seismic hazard assessments and risk mitigation in Nepal and the adjacent areas, the estimated results of this study may be helpful.

Keywords: *Static earthquake triggering, Coulomb failure function, b-value, Omori law, Nepal earthquake.*

INSAR AND GRAVITY ANALYSIS OF COSEISMIC DEFORMATION FROM THE 2023 MW 7.8 TURKEY EARTHQUAKE: IMPLICATIONS FOR FAULT DYNAMICS AND TECTONIC UPLIFT IN EASTERN ANATOLIA

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ABSTRACT

Surface deformation caused by earthquakes is critical for understanding the development of geological structures and assessing seismic hazards in active tectonic regions. In this study, we estimate the co-seismic surface deformation and associated slip resulting from a devastating earthquake of magnitude Mw 7.8, which struck near Pazarcik, south-central Turkey, on February 6, 2023. The epicenter was located at 37.174°N and 37.032°E, approximately 34 km west of Gaziantep. This earthquake caused extensive damage to infrastructure and claimed over 50,000 lives. It was followed by a series of aftershocks, including a significant Mw 7.5 event that occurred about 95 km northeast of the mainshock. The systematic analysis of time series analysis of twelve Sentinel-1A SAR images, acquired from December 2022 to May 2023, revealed a substantial displacement consequent to both the mainshock and the aftershock. Further, the comprehensive 3D displacement field was derived by combining line-of-sight (LOS) and along-track offset deformation, which helped in obtaining the precise phase measurements near the surface rupture. Our co-seismic model indicates that the slip during this doublet earthquake was concentrated along a small segment of the fault, with a marked reduction in slip at both ends, which could be due to geometric variations along the fault. In addition, the analysis of high-resolution satellite gravity data of this region indicates that the eastern part of the Anatolian Plate characterized by a broad high-order positive residual gravity anomaly is neo-tectonically uplifting. Similarly, the presence of series of low gravity closures trending northeast to southwest within this gravity high zone, indicate that this region may be undergoing in-land rifting, resulting into the reactivation of the East Anatolian and Surgu faults, which are the site of main event and subsequent aftershocks. This gravity anomaly is consistent with the observed InSAR data, which depicts a small NW-SE trending graben. This graben structure aligns well with the focal mechanism solutions for the events, suggesting distinct faulting styles with different orientations

GEOCHEMISTRY OF UPPER KRISHNA RIVER SEDIMENTS IMPLICATIONS OF SOURCE ROCK WEATHERING TO CHEMICAL CHARACTERISTICS OF SEDIMENTS

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ABSTRACT

Krishna River is one of the large rivers of Peninsular India that originates in the Deccan volcanic province and passes through diverse geological formations before draining into the Bay of Bengal. We have carried out detailed geochemical investigations of bed sediments from the upper reaches of Krishna River to infer weathering conditions and the depositional environment of sediments. The results suggest their origin is mainly from the chemical weathering of basaltic rocks. The average chemical compositions of major oxides (in wt%) are, SiO_2 – 47.9; Al_2O_3 - 13.4; Fe_2O_3 - 11.6; TiO_2 – 4.3; MgO - 4.0; CaO - 9.1; Na_2O - 0.5; K_2O - 0.5 and MnO - 0.2 %. The relatively higher concentrations of alkaline earth elements and low value (57) of the Chemical Index of Alteration (CIA) suggest an incipient chemical weathering environment of source rocks. Moreover, limited depletion of Ca suggests its climate insensitivity and decoupling of Ca and Sr in bed sediments indicates mineralogical control.

High concentrations of most trace elements (e.g. V, Cr, Ni, Co, Sc, Zr, Y, Zn, Nb, etc.) indicate weathering of mafic minerals present in basaltic rocks of Deccan Trap. The average concentrations of these trace elements are maximum in upper Krishna sediments, intermediate in the middle part, and minimum in sediments of lower reaches. Significantly high concentrations of V were also observed in upper Krishna sediments (ranging from 1072 to 3625ppm), indicating its accumulation on sedimentary particles. Under reducing conditions, Vanadyl ions readily adsorb on particle surfaces, showing abnormally high values in upper Krishna sediments relative to their source rocks. A strong relationship between iron (Fe) and titanium (Ti) in sediments suggests their co-occurrence in weathering-resistant minerals. It could also be due to the scavenging of Ti by Fe oxy-hydroxides during the weathering of Deccan basalt. The REE pattern shows characteristics of sediments derived from the weathering of basaltic rocks. However, the light REEs show greater fractionation than the heavy REEs. A strong relationship between TiO_2 and total REEs suggests control of titaniferous minerals on the REE geochemistry of upper Krishna River sediments.

ORE BODY CHARACTERIZATION THROUGH GRAVITY DATA INVERSION USING THE ANT LION OPTIMIZATION ALGORITHM

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ABSTRACT

The gravity method is a widely-used geophysical technique essential for interpreting subsurface structures in mineral and ore exploration. By measuring variations in the Earth's gravitational field, geophysicists can infer the presence of geologic structures, including ore bodies, based on their density contrasts with surrounding rocks. Traditionally, gravity inversion has been applied using various optimization techniques to estimate key parameters like depth, location, and geometric shape of the ore bodies. These parameters are crucial for understanding and characterizing subsurface

mineral deposits. In this study, we apply the Ant Lion Optimizer (ALO) algorithm, inspired by the ant lion's hunting strategy, for gravity data inversion in ore and mineral exploration. The ALO algorithm consists of five key steps: ant's random walk, trap building, ant entrapment, ant catching, and trap re-building, each mimicking a phase in the natural hunting process of antlions. With proven capabilities in both exploration and exploitation, ALO excels at avoiding local optima and achieving fast convergence, making it a powerful tool in gravity inversion tasks. The ALO algorithm's inversion technique is not only user-friendly but also quick, precise, and robust when applied to gravity data. The algorithm's effectiveness was first validated using synthetic models, both noise-free and noisy, representing ore body geometries. Subsequently, the method was tested on the real-world field dataset from mineral-rich regions, producing accurate estimations of critical parameters, such as depth, origin location, amplitude, and geometric shape of the causative bodies. The outcomes, verified against geological and drilling information, demonstrated the stability and effectiveness of ALO for geophysical inversion. The results confirm that the proposed approach is well-suited for mineral and ore body exploration, providing reliable and efficient solutions for geophysical investigations.

Keywords: Gravity data; Global Optimization; Ant Lion Optimizer algorithm; Ore explorations; Model parameterization

EXPLORING THE THRESHOLD-BASED EEW PARAMETERS AND THEIR CORRELATION WITH PEAK GROUND PARAMETERS PGA AND PGV

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ABSTRACT

The damaging potential of an earthquake is related to its peak ground parameters, such as Peak Ground Acceleration (PGA) and Peak Ground Velocity (PGV). The goal of this study is to establish threshold values for various seismic parameters that can be derived from the initial few seconds of seismic data, specifically from varying time windows immediately following the P-wave arrival. By identifying when these thresholds are crossed, we can predict the likelihood of high PGA and PGV values, which are strong indicators of an earthquake's destructive capacity. For this study, we analyzed a dataset comprising 5,246 records from 327 earthquakes that occurred between 1996 and August 2024, all recorded by the Japanese strong motion networks, K-Net and Kik-Net. The analysis shows a good correlation between Peak Cumulative Absolute Velocity (P_{CAV}), calculated using the mathematical approach developed by EPRI in 1988, and the PGA. This correlation improves as the time window increases. In contrast, the PGV shows a better correlation with P_{CAV} calculated using a different mathematical approach developed and evaluated in this study. The findings suggest that by combining the threshold values derived from these parameters, it is possible to improve the effectiveness of earthquake early warning systems, particularly in issuing timely warnings about potentially damaging earthquakes. This approach allows for more accurate predictions of high ground motion and can significantly contribute to mitigating the impact of seismic events on populations and infrastructure.

Keywords: PGA, PGV, Cumulative Absolute Velocity, Earthquake Early Warning

GEOTHERMAL POTENTIAL OF LADAKH: THERMOPHYSICAL PROPERTIES OF GRANITOIDS AND IMPLICATIONS FOR SUBSURFACE THERMAL STRUCTURE

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ABSTRACT

Ladakh, situated in the northwestern Himalayas, stands out as one of the most promising regions in India for geothermal prospect. Despite of its huge geothermal potential, thermal structure is not well constrained till now. Constructing a robust thermal structure of the subsurface in this region will require accurate thermophysical data on granitoids, which constitute one of the most abundant and significant rock types in this region. Granitoids are generally coarse-grained felsic plutonic rocks, encompassing a broad spectrum from tonalites to syenites.

To characterize granitoids of the study region, geochemical and petrographic analyses were done on 50 granitoid samples before detailed laboratory measurements of thermal and physical properties, including saturated thermal conductivity, density, and porosity. Based on total alkali-silica diagram, the granitoids were classified into alkali granite, granite, granodiorite and syeno-diorite. The thermal conductivity of the samples showed a wide range, from 1.9 to 4.0 $Wm^{-1}K^{-1}$, with alkali granite exhibiting the highest values and syeno-diorite the lowest. Density values varied between 2640 and 2770 kg m^{-3}, with highest for syeno-diorite and lowest for alkali granite. The porosity values for all samples were exceptionally low (<2%), consistent with typical granitoids. The above variations in thermophysical properties reflect the mineralogical and lithological diversity within the granitoids of the region. Further, thermal conductivity shows negative correlation with density.

The thermophysical properties identified in this study provide essential inputs for constructing accurate thermal models of Ladakh's subsurface. These findings will aid in assessing the region's geothermal potential while also offering broader insights into the crustal dynamics and tectonic processes shaping the Himalayas.

QUANTIFICATION OF MICROFRACTURES IN INDIAN GONDWANA SHALE: AN IMAGE PROCESSING APPROACH

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ABSTRACT

Unconventional energy sources such as shale oil and gas are increasingly acknowledged as viable alternatives to traditional fossil fuels in the oil and gas industry, as these reservoirs offer a substantial hydrocarbon supply. The porosity and permeability of shale are often influenced by the network of microfractures. Therefore, profound knowledge of the microfractures and their fracture network connectivity is crucial as well as a prerequisite for optimum extraction of resources. To understand these characteristics of unconventional reservoirs like shale, this study involves the utilization of high-resolution scanning electron microscopy (SEM) imaging techniques to capture the detailed microstructure of Indian Gondwana shale samples. These microscale-level images provide an

unprecedented view of the shale matrix, enabling analysis of the surface morphology and distribution of microfractures and shed light on the intricate details that influence fluid flow and reservoir behavior. Furthermore, for enhanced visualization, these SEM images of shale samples are explored using image processing for microfracture detection and quantification of various fracture attributes, such as fracture density, fracture node, their distributions, geometrical pattern, and fracture network connectivity. The SEM images of two shale samples A and B were analyzed utilizing the proposed approach, which showed a clear difference in microfracture characteristics in terms of fracture density, patterns, node type, and connectivity. Sample A shows low fracture density with limited connectivity, indicating a higher proportion of isolated (I) nodes. In contrast, Sample B has a denser, more interconnected fracture network, with more intersecting (X) and abutting (Y) nodes, suggesting higher fluid flow capacity and greater susceptibility to fracturing under stress, offering insights into permeability in the shale formation. The quantitative and qualitative analysis results for both samples align closely with the visual features observed in the SEM images, validating the image processing's effectiveness and thereby aiding in quantifying the fluid flow potential of unconventional reservoirs.

A PRELIMINARY ROCK MAGNETISM, PALEOMAGNETISM, AMS AND PALEO INTENSITY STUDIES OF MALWA PLATEAU, NORTHERN DECCAN TRAPS, INDIA

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ABSTRACT

A preliminary Rock magnetic, Palaeomagnetic, Paleointensity, Anisotropy of Magnetic Susceptibility (AMS) and Petrological study was performed on the 34 oriented block samples collected form 7 sites over the Malwa plateau of the northern part of Deccan traps. The natural remanent magnetization (NRM) intensity and AMS was measured on 201 standard sized specimens. The mean NRM, magnetic susceptibility and Q-ratios were found as 6.61 A/m, 2981 x 10^{-5} SI unit and 7.31 respectively. The rock magnetic studies indicate the presence of magnetite and Ti-magnetite grains, primarily in the SSD and PSD size ranges. High Q-ratios and S-ratios suggest a thermo-remanent origin and dominance of ferrimagnetic minerals. Low REM values confirm that, those samples are free from lightning-strike contamination, and inter-parametric ratios support fine-grained magnetic mineral compositions. In paleo directional measurements, Detailed AF demagnetization study was performed on selected 26 specimens representing seven sites to isolate the Characteristic remanent magnetization (ChRM) directions. The mean declination, Dm=180.06 and mean inclination Im=33.5 (a95 = 7.89^0; k= 17.22). The Virtual Geomagnetic Pole (VGP) position of Malwa plateau was calculated as λ= -48.75, and ϕ=75.65 (DP =5.11, DM =8.98). The preliminary paleo-intensity results using pseudo-Thellier method on 26 specimens from Malwa plateau has been found to be 41.15 µT. The AMS study were performed on 174 specimens of Malwa flows samples. AMS indicates two types of magnetic grains distribution as: (1) Prolate and Oblate shaped magnetic grains distributed in equal proportion (2) presence of more prolate than oblate shaped magnetic grains in these studied samples through Flinn and Jelinek plots. Petrological study carried out in 7 thin sections representing 6 different sites of Malwa plateau shows presence of plagioclase laths, pyroxenes and opaque minerals. Most of the photomicrograph study shows small to medium sized clinopyroxene (cpx) grains arranged in between medium grain plagioclase (plg) laths, showing nesophitic texture.

Keywords: Paleomagnetism, Paleo intensity, anisotropy of magnetic susceptibility (AMS), Malwa Plateau, Deccan Volcanism.

CHARACTERISATION OF THE CAUSES OF MERIEMA LANDSLIDE NEAR NAGALAND UNIVERSITY, MERIEMA CAMPUS, INDIA – A STRUCTURAL AND GEOTECHNICAL APPROACH

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ABSTRACT

The Meriema Landslide is a kind of circular failure where unconsolidated materials comprising mostly of broken rock masses of shale are found moving downslope *en-masse*. The bedrock where this landslide occurs comprised of shale belonging to Disang Group. To decipher the causes of such kinds of slumping down of pieces of broken rocks *en-masse* geological, structural and geotechnical investigations are carried out. It could be established that majority of the joints are radial to the length of curvature surface of the crown of the landslide. It is also observed that the majority of the joints also dip at high angle mostly clustering between 60-80°.The maximum thickness of overburden above the failure surface at the deepest point (before slide) from the circular surface of the crown is also found out with the help of total station survey. The maximum vertical pressure the rocks suffered at the deepest point is then calculated which comes out to be 0.701MPa. Comparing this value with average shear strength of 8.32 MPa for samples of the bedrock found out from geotechnical investigations, it is learnt that the rock didn't fail on account of the load. In the rainy season during incessant rain the rocks are saturated with water and filled all the open spaces of the joint planes with water making the friction reduced considerably and hence the body of jointed rock mass above the failure surface could not withstand the weak shear stress. The broken pieces of rock masses could slump down over the circular surface of failure developed because of mosaic of closely spaced numerous joint planes dipping at various angles and directions. The Meriema Landslide is thus considered to have been controlled by lithology and structure.

Keywords: Meriema landslide. Disang shale. Joints. Circular surface. Weak shear stress.

HARNESSING EARTH'S HEAT: GEOTHERMAL PROSPECTING THROUGH GEOPHYSICAL METHODS

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ABSTRACT

India’s increasing energy demands are prompting a transition from fossil fuels to renewable energy sources, with geothermal energy being one of the emerging options. Geothermal energy is a renewable resource that comes from the Earth's internal heat. This heat is produced by both the planet's core and the natural decay of radioactive materials, and it is stored in rocks and fluids deep below the Earth's surface.

Geophysical surveys are the most important tools for identifying underground geothermal potential. Geophysical techniques like gravity, magnetic, seismic, magnetotelluric, and electrical resistivity surveys are employed to investigate the physical properties of the host rock.The interpretation of this data helps determine the structural dimensions of geothermal reservoirs and assess the hot fluid content within them.

Seismic and electrical methods are geophysical techniques used in geothermal exploration to investigate subsurface structures and identify geothermal reservoirs. Seismic surveys offer detailed structural information, while electrical surveys reveal fluid content and temperature variations. By combining data from both, a clearer picture of the geothermal reservoir and its potential can be obtained.

Through the use of geophysical methods key parameters such as temperature, fluid content, and the size of geothermal bodies, paving the way for efficient energy extraction can be assessed. With the increasing demand for renewable energy, utilising the Earth's heat through advanced geophysical methods offers significant potential for sustainably and efficiently meeting future energy requirements.

LITHOFACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENT OF LATE CRETACEOUS MAHADEK FORMATION IN PARTS OF SOUTHERN SHILLONG PLATEAU, MEGHALAYA

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ABSTRACT

Late Cretaceous sedimentation in Shillong Plateau, northeast India is represented by the deposition of the Mahadek sediments. These sediments are comprised of alternate medium to coarse grained sandstone, minor clay, and conglomerate horizon overlain by the calcareous litho-units of Langpar Formation of Cretaceous–Paleocene age. A total of six lithofacies namely, matrix-supported horizontally stratified gravel facies (Gh), trough bedded sandstone facies (St), planar cross-bedded sandstone facies (Sp), horizontally bedded sandstone facies (Sh), gritty sand facies (Sg) and laminate shale facies (LSh) have been identified using two vertical profile sections (VPS) measured and recorded in parts of southern Shillong Plateau, Meghalaya. Presence of planar and trough cross stratifications and overall coarsening upward sequence, indicate deposition in a delta plain of marginal marine setting. Keywords: Lithofacies; Depositional Environment; Late Cretaceous; Mahadek Formation; Southern Shillong Plateau

MAPPING HEAT FLOW AND TECTONIC ACTIVITY IN THE CAMBAY GRABEN: ITS CORRELATION WITH GEOTHERMAL ENERGY EXPLORATION

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ABSTRACT

The Cambay Graben, located in western India, is a tectonically active region with significant geothermal energy potential. The correlation between heat flow and tectonic activity in this area provides valuable insights into the viability of geothermal energy exploration. This study aims to map heat flow anomalies across the Cambay Graben and analyze their correlation with fault systems and seismic activity, ultimately identifying regions with high geothermal potential. By integrating geospatial data, the potential region for geothermal exploration within the Cambay Graben will be highlighted. The heat flow data, seismic activity data and tectonic fault maps are utilized using ArcGIS is used for this purpose. Seismic data and fault line distributions are analyzed to identify

areas where tectonic activity enhances geothermal potential thus, incorporating basic spatial analysis techniques to correlate heat flow anomalies with subsurface geological structures. Results obtained in the study suggests that regions within the Cambay Graben exhibiting higher heat flow correspond to areas with significant tectonic activity, particularly along major fault lines. These zones are identified as having the greatest potential for geothermal energy development. The study is expected to provide a clear visualization of geothermal hotspots and their relationship to the region's complex tectonic framework. By identifying high-heat-flow areas linked to tectonic activity, the study offers valuable insights for future geothermal exploration and sustainable energy development in India.

RELOCATING EARTHQUAKE IN NORTH-EAST REGION

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ABSTRACT

Northeast India, which is tectonically active with intricate subsurface structures, tends to pose specific challenges in locating earthquake hypocenters. The ambiguous picture of the Moho discontinuity that exists renders the problem of reliable location of earthquake hypocenters particularly difficult due to sparse seismic station coverage in the region. The task is, however, undertaken in the present study to formulate more reliable earthquake location techniques by constructing depth-based and time-based Moho maps to identify with great precision if the earthquake hypocenters are lying in the upper crust, lower crust, or near the Moho.

The methods include both relative and absolute earthquake relocations. Relative relocation methods, including XCORLOC, HypoDD, and GrowClust, can enhance hypocenter estimates using adjacent events but are less successful in areas with low station density. Absolute techniques with approaches of Hypoinverse, Hyposvi, and NLL all cater more appropriately to the region of Northeast India. NLL is particularly advantageous due to its non-linear, grid-search algorithm, which accounts for the complexities of seismic wave behavior and geological variability that help to provide more accurate estimates of hypocenter locations; thus, we can establish whether an earthquake is being generated in the upper crust, lower crust, or close to the Moho discontinuity.

The enhanced Moho maps developed will substantiate a better understanding of regional subsurface structures, fault systems, and seismicity. The accuracy thus improved in the locations of hypocenters will be very useful for understanding the tectonic processes shaped in Northeast India that will consequently improve the assessment of seismic hazards.

Keywords: Northeast India, earthquake relocation, NonLinLoc (NLL), hypocenters, Moho ambiguity, upper crust, lower crust, seismic catalog, sparse seismic network.

AN INVESTIGATION OF THE STRESS FIELD AND SEISMOTECTONICS OF THE 2015 GORKHA EARTHQUAKE, BASED ON SEISMICITY PATTERNS, FOCAL MECHANISM SOLUTIONS, STRESS INVERSION, AND B-VALUE ANALYSIS

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ABSTRACT

The Gorkha earthquake, occurred on 25th April, 2015 with a magnitude of Mw 7.8 was the first major earthquake (Mw >7) that ruptured the MHT since the 1934 Mw 8.2 Bihar-Nepal earthquake. The rupture propagated eastwards for about 120 km on MHT. It was followed by a number of aftershocks in the region. On 12th May, 2015, another earthquake of magnitude Mw 7.2 struck 75 km NE of Kathmandu, just about the eastern extremity of the Gorkha earthquake rupture. Here, we aim to analyze the variations of several key parameters, prior, post and the duration of the main two events, such as seismicity pattern, b-value, focal mechanism solutions and stress fields. We estimated the stress field in term of principal stress orientations for three time periods: 1) before the Mw 7.8 event, 2) between the two events, and 3) after the Mw 7.2 event for a latitude range of 27.0°N to 28.5°N and longitude range of 84.5°E to 86.5°E. We compiled a total of 65 focal mechanism solutions from various sources. We observed a high plunge angle for σ_1 between the events which suggests a possible stress release period between the events and stress accumulation period before and after the two events. The stress inversion results indicate that the maximum principal stress (σ_1) direction remained consistent across different periods. However, the intermediate (σ_2) and minimum (σ_3) principal stresses were more scattered and did not follow a uniform pattern prior to the main earthquake, but became confined to a narrower region after the main event. We also analyzed the variations in b-value across the segments and for every 100 aftershocks, finding no consistent trend. The b-value was lower between events compared to the pre- and post-mainshock periods. Moreover, we established a local empirical relationship between the magnitude types M_L and mb for the study area.

DEEP SEISMIC IMAGING & MODELLING OF MOHO OF INDIA SHIELD: A REVIEW

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ABSTRACT

This review offers a comprehensive analysis of the Moho discontinuity across various regions of India, utilizing seismic data from multiple studies. The Moho, marking the boundary between Earth's crust and mantle, shows considerable variation in depth and characteristics across different tectonic settings within the Indian subcontinent. Deep seismic studies conducted by the CSIR-NGRI across different parts of the Indian shield reveal diverse crustal thicknesses: in the Proterozoic orogenic Aravalli–Delhi fold belt, the Moho lies between 38 and 50 km; in the Vindhyan basin, it ranges from 40 to 44 km; beneath the Kachchh basin, it varies from 35 to 45 km; and in Central India, it is delineated between 40.5 and 44 km. In the West Bengal basin, the Moho depth ranges from 28 to 37

km, while it reaches 40 km in the western Dharwar craton and 43 km in the eastern Dharwar craton. Additionally, it is mapped at a depth of 39 km in the Nallamalai Fold Belt, 45 km below the Nellore Schist Belt and Eastern Ghats Belt, and 40 km in the Achankovil Shear Zone, Southern Granulite Terrain. These findings indicate no direct correlation between crustal thickness and the age of the crustal block; rather, Moho depth is influenced by thermorheological properties, magmatism, and the tectonic history of the region. By synthesizing existing research, this review contributes to the understanding of Moho's role in India's tectonic evolution and provides insights into the geodynamic processes shaping the Indian shield. The review also highlights knowledge gaps, suggesting directions for future seismic studies in underexplored regions of India.

Keywords: Moho discontinuity, tectonic evolution, velocity contrast, Indian shield.

SEISMOLOGICAL LOCATION OF MONSOONAL LANDSLIDES IN ARUNACHAL PRADESH: ROLE OF NETWORK GEOMETRY

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ABSTRACT

A landslide is a rapid movement of unstable rocks, soil, ice, water, etc, under the influence of gravity. The risks associated with a landslide have escalated in recent times due to the changing climate and population expansion in unstable terrains. Real-time monitoring of landslides using optical and remote sensing methods is often not possible because of the long passing time of satellites over a region and cloud cover. In this respect, recent studies demonstrated that continuous monitoring using seismological instruments provides tremendous scope to early detect such events. Seismic signal characteristics of landslides are different than earthquakes and are often identified as spindle-, cigar-, or triangular-shaped energy with a gradual onset. However, not all landslides pose a threat. Hence, the location is as important as the detection. A landslide does not have clear P- or S-arrivals, which are used for earthquake location. Therefore, its location requires a careful and meticulous seismic analysis. Moreover, its locations are very sensitive to factors such as velocity, frequency, and station coverage. In this study, we test the role of network geometry on the accuracy of the location of medium-sized landslides. CSIR-NGRI operated a network of seismological stations in Arunachal Pradesh from 2009 to 2021, with reconfiguration of the network in 2016. Recently, in 2022, a close-spaced network was established within the capital city of Arunachal Pradesh. We analyze 3 landslides, which were reported to cause destruction to life and property, but were recorded during different network configurations. We locate these landslides by a grid-search method, in which the energy is back-projected to different grid points, and the best location is obtained where maximum energy is concentrated. Our analysis reveals that the locations are precise for all network configurations. However, the accuracy is highest for a close-spaced network, followed by a regional network with array-type configuration, and least for regional profile-mode networks.

Key words: Landslide; Seismic location; Arunachal Pradesh; Network configuration; Back-projection

SEDIMENTOLOGY AND DIAGENESIS OF THE MIDDLE EOCENE CARBONATE DEPOSITS OF THE SHILLONG PLATEAU, NORTH-EAST INDIA (EASTERN TETHYS)

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ABSTRACT

Larger benthic foraminifera (LBF) exhibit notable abundance and diversity in the Palaeogene carbonate sediments of Meghalaya, Northeast India, yet their significance from a palaeoenvironmental perspective has often been overlooked. LBF play a crucial role in both modern and fossilized shallow marine, tropical carbonate environments, serving as key indicators for biostratigraphy and palaeoenvironmental reconstructions. The turnover of larger foraminifera (LFT) during the Palaeocene-Eocene transition is particularly significant, influencing their evolutionary patterns across various regions of the world, including the Eastern Tethys. In the present study, middle Eocene carbonate rocks are divided into six microfacies (MFTs): Alveolinid Algal Packstone, Alveolinid-Nummulitid RudstoneGrainstone, Discocyclina Algal Rudstone-Packstone, Nummulitid Algal PackstoneGrainstone, Nummulitid Grainstone, Nummulitid Algal Rudstone-Packstone. Assessing the palaeoenvironmental parameters provides valuable insights into the seascape of this Eastern Tethyan region. Microfacies analyses suggest deposition in an oligotrophic nutrient regime facilitated the rapid evolution and dominance of LBF. Six microfacies clustered into an inner ramp, middle ramp, and outer ramp environments. The diagenetic overprints of these limestones are characterized by several key diagenetic features, including cementation, micritization, compaction and dissolution. These diagenetic processes occurred in marine phreatic, meteoric phreatic, and burial diagenetic environments.

Keywords: Microfacies, Palaeoenvironment, Middle Eocene, Carbonate Deposits, Shillong Plateau

HIGH-RESOLUTION SEISMIC IMAGING OF THE INDIAN COAL FIELD, USING 2D SEISMIC REFLECTION DATA

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ABSTRACT

Seismic image enhancement plays an essential role in improving the accuracy and reliability of subsurface interpretations, especially in complex geological settings such as coal fields. This study focuses on the application of seismic image enhancement techniques in a coal field in India, using 2D seismic reflection data using Vibroseis as a source. Coal-bearing formations typically present significant challenges for seismic imaging due to their highly heterogeneous nature, causing strong attenuation, scattering, and complex wave propagation effects. To address these issues, advanced seismic processing techniques, including noise suppression, deconvolutions, and frequency filtering, were applied to enhance the quality of the seismic images. The study demonstrates the effectiveness of these techniques in improving signal-to noise ratio (S/N) and resolving critical subsurface features, such as fault structures and coal seam continuity. The enhanced seismic images offer better insight into the structural and stratigraphic complexities of the coal field, supporting more accurate exploration and resource estimation. The results provide a foundation for improved decision-making in coal exploration and extraction activities in India.

Keywords: Vibroseis, seismic imaging, deconvolution, coal field, reflection.

SEISMIC IMAGE ENHANCEMENT WITH THE COMMON REFLECTION SURFACE (CRS) STACK METHOD AND ITS BASIN CONFIGURATION FROM THE KACHCHH RIFT BASIN, NW, INDIA

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ABSTRACT

The Kachchh rift basin, located in northwestern India, was formed during different stages of the rifting/breaking process of the Gondwanaland during the Mesozoic era. The seismic reflection profile passes through the Great Rann of Kachchh, Banni sub-basin, Kachchh mainland uplift, and coastal sub-basin from north to south. Imaging the basement structure along these geological features, especially from a complex geological region, has been challenging. The Common Reflection Surface (CRS) stack is an alternative seismic imaging technique for multicoverage reflection data compared to the conventional common midpoint stack (CMP). It is an automatic stacking process, which does not require explicit knowledge of stacking velocity. This CRS stack is beneficial when the data quality is poor and foldage is low. When comparing the CMP stack with the CRS stack, the CRS technique provided clearer resolution of the basement structure and Mesozoic sediments' thickness, while improving reflector continuity. The major findings from CRS processing reveal the basement configuration of the three sub-basins, the Great Rann of Kachchh, Banni, and coastal basins. They show a significant variation in the thickness of various sedimentary layers and a marked topographic irregularity in the Precambrian basement. The thickness of sediments varies from 150 m to 6.5 km from north to south, indicating the thickening of the basin to the south. The Great Rann of Kachchh contains thin sediments of around 600 m, while the Banni basin exhibits several faults of a typical rift basin with 3.8 km thick sediments. The coastal basin has 6.5 km thick sediments along with the Deccan volcanic deposits. This study provides the first imaging of basin inversion within the Banni sub-basin, where faults of the Banni basin are transformed into strike-slip or high-angle reverse faults during the inversion process.

Keywords: Common reflection surface stack, rifting, basin inversion, basement structure, Mesozoic sediments.

RECENT SEISMICITY AT KOYNA-WARNA, WESTERN INDIA

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ABSTRACT

Reservoir triggered seismicity (RTS) continue to occur at Koyna-Warna, a famous site for RTS globally. Seismicity for the period 2015 to 2021 is presented in this study. The analysis of the data from the combined network i.e. surface broadband network and borehole network is utilized for the analysis. The correlation between reservoir water levels and seismicity is continue to exist. A significant improvement in the estimation of locations of earthquakes is achieved since high quality

data has been acquired from the borehole data. Several microearthquakes are getting recorded on the borehole network, these microevents are absent on the surface data. We have carried out the frequency-magnitude distribution of earthquakes for the above duration and it was found the detection capability has been increased to magnitude as low as - 0.9 and the completeness of magnitude (Mc) to be 0.1. Recently an earthquake of Mw 3.8 occurred on 19 February 2024. An analysis of sequence of M~4 and above earthquakes since 1967 has shown that only a few earthquakes of magnitude exceeding 4 have been occurred in the last 12 years, however the micro-seismicity continues to occur at this region.

Keywords: Borehole, Seismicity, earthquakes, network

INTEGRATED GEOPHYSICAL STUDIES FOR IDENTIFICATION OF KARSTIC CAVES - A CASE STUDY FROM CUDDAPAH BASIN, SOUTH INDIAN SHIELD

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ABSTRACT

The Cuddapah basin is one of the Proterozoic basins of India and consists of a thick pile of sediments. The most carbonate rocks of the basin are associated with Vempally (Cuddapah supergroup) and Narji, Koilakuntla formations (Kurnool group). The Belum, Bugga, Bhandhrapalle (Kolimigundla sector); Panchalingeshware swami, Karva Balli Guha (Dhone Sector), Yaganti caves, Bila sorgam (Yaganti sector); Kothalla Guhalu, Errabadi (Betamcharla sector) are the examples of naturally developed caves in the Cuddapah basin. Mapping of these Karstic caves in Carbonate rock may provide clues to hazards, drainage resources and viable inputs for archaeological studies. In the present study, an integrated geophysical (Microgravity, MASW, GPR and ERT) studies are employed at the Belum caves region to understand the geophysical responses over the caves in the Indian region and its extension. Geophysical data was collected along the two orthogonal profiles (400 m and 150 m) over the known Belum caves area with a close station interval of 2.5 m. The Joint interpretation along the two orthogonal profiles shows existing cavities having a thickness of ~10 m with low residual gravity amplitude (0.05 mGal), shear wave velocity (750 -1500 m/s) and resistivity (230 to 500 Ωm). Further, it is represented as vertical discontinued zones in GPR images. It is revealed from the integrated analysis that the existing voids/channels/passages are associated with massive limestone underlain by a quartzite at depth.

MAPPING OF SECONDARY POROSITY ZONES USING MULTICHANNEL ANALYSIS OF SURFACE WAVES (MASW) TECHNIQUE - A CASE STUDY FROM MANASA, MADHYA PRADESH, INDIA

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ABSTRACT

Hard rocks (Vindhyan and Deccan volcanic province) have a deficit in primary porosity, and the occurrence of the groundwater mainly depends on the secondary porosity structures like fractures, joints, and shear zones, which are developed by weathering and fracturing. The delineation of these zones in the subsurface tends to search for new potential groundwater zones. In the present study, a shallow geophysical technique, Multi-channel Analysis of Surface Waves (MASW), is used to identify these structures that are favourable for the mapping of weathered zones near Manasa, Madhya Pradesh. Vindhyan subgroup rocks are intruded by the Deccan basalt flows. The resultant 1D and 2D shear wave velocity sections of nine sites exhibit the layered sequence of shale, sandstone and quartzite and associated fractured zones in terms of shear wave velocity up to a depth of 40m correlated with the available borehole information. The present study provides insight into the potential understanding of the existing geological formation for groundwater exploration by using the MASW technique.

BOREHOLE GEOPHYSICAL INVESTIGATIONS FOR DELINEATION OF FRACTURES IN GRANITIC ROCK IN HYDERABAD, INDIA

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ABSTRACT

Geophysical logging studies were carried out by using full suite of logging probes for identification of significant fractures in two shallow boreholes separated by 10 m distance with depths of 60m and 80m are located in hard rock terrain at CSIR-NGRI campus, Hyderabad. The geophysical logging provides in situ properties and highlight the fractures/fracture zones evidently in boreholes of hard rock mass. In logging probes, Acoustic Televiewer (ATV) is an advanced probe, which records image of the borehole wall along with its orientation and provides information regarding detection of fractures and casing of the borehole. Further, these fracture zones are reflected with reduced sonic velocities. Considerable diminution in resistivity log and enhancement of borehole diameter through caliper log have suggest the existence of fractures at various depths. It is clearly designated that the full wave sonic, caliper and resistivity logs characteristically reveal anomalies adjacent to both individual fractures and fracture zones. The studies were conducted in boreholes with standardized logging probes to obtain qualitative results and to compile the borehole data with data sets of other geophysical techniques. The log data are very well correlated with acoustic televiewer image and shear wave velocity image obtained from MASW studies. The geophysical logging method provides high resolution information for identification and characterization of fracture zones in hard rock terrain which can be utilized as a normal standard technique in civil engineering applications and further selection of suitable structural design parameters against natural hazards.

Keywords: Geophysical logging, Full Wave Sonic, Caliper, Acoustic Televiewer, hard rock terrain, fractures.

GEOLOGY: THE STUDY OF EARTH'S BUILDING BLOCKS

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ABSTRACT

Geology, the scientific study of Earth, is grounded in understanding the characteristics of minerals and rocks, the fundamental building blocks of our planet. Minerals, with their distinct properties like cleavage, fracture, hardness, color, streak, and luster, form the basis of rocks. Rocks are classified into three primary categories: igneous, sedimentary, and metamorphic, each formed through unique processes.

Igneous rocks, such as granite and basalt, originate from the cooling and solidification of molten rock (magma or lava). Sedimentary rocks, like sandstone, shale, and limestone, are formed by the accumulation and compaction of sediments over time. Metamorphic rocks, such as marble and quartzite, result from the transformation of existing rocks under extreme heat, pressure, or chemical fluids.

The rock cycle, a continuous process of transformation, demonstrates how these different rock types can be interconnected. Weathering, erosion, deposition, and transportation break down rocks into sediments, which can later form sedimentary rocks. Heat and pressure can transform sedimentary or igneous rocks into metamorphic rocks, and the melting of any rock type can produce magma, leading to the formation of new igneous rocks.

Understanding the characteristics of minerals and rocks is essential for various fields, including geology, mining, and environmental science. By studying the composition and formation of Earth's materials, scientists can unravel the planet's history, predict natural hazards, and discover valuable resources.

DEVELOPMENT OF MATLAB BASED ALGORITHM FOR ESTIMATION OF SHEAR MODULUS AND DAMPING COEFFICIENT FROM DOWNHOLE ARRAY RECORDS

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ABSTRACT

Accurate estimation of dynamic soil characteristics is vital for evaluating site response in earthquake-resistant design. Our approach leverages System Identification techniques to analyze site response under dynamic loading, focusing on soil as the system and utilizing acceleration data from downhole arrays in seismically active regions. We developed a MATLAB algorithm that processes strong motion records at various depths, applying corrections to minimize noise and instrument error. The algorithm calculates shear stress and strain at each layer using a 1D wave equation, producing shear stress-strain curves that reveal multiple hysteresis loops. An automated process isolates each loop, enabling curve-fitting techniques to estimate the damping coefficient and shear modulus. Outliers caused by extreme frequency components are then removed, refining the analysis. G/Gmax and damping ratio (D) are plotted against strain amplitudes, offering insights into soil behavior. Validated against Taiwan's Lotung Downhole Array Data, the algorithm showed a minimal 2-3% variation from

in-situ measurements. This tool efficiently computes soil parameters within 2-3 minutes for a single event across all three motion components, allowing for rapid seismic assessments. Additionally, it can extend to three-dimensional analysis, incorporating nonlinear soil-structure interactions and pore pressure effects, making it a valuable resource for seismic design and earthquake hazard mitigation

Keywords : Downhole data analysis, Soil Dynamics, System Identification, MATLAB, Shear Modulus, Damping Coefficient,

SEISMIC IMAGING OF THE MESOZOIC KACHCHH RIFT, NW, INDIA, AND ITS BASEMENT STRUCTURE

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ABSTRACT

The Kachchh rift, characterized by complex tectonics and seismicity, presents significant challenges in subsurface imaging due to its heterogeneous geological composition. A 2-D seismic reflection study was carried out along a 100 km north-south profile from the north of Bela uplift to Enthal Talav. This profile passes through the Bela and Wagad Uplifts and several east-west oriented faults, including the Gedi fault, North Wagad fault, South Wagad fault, and Kachchh Mainland fault. The data was processed and the present study identified the surface extension of Gedi, North Wagad, South Wagad, and Kachchh mainland faults from shallow seismic reflection data, up to 3 s two-way time (twt). The basement configuration is well demarcated at 1.0 s twt, with a subhorizontal reflection band corresponding to a depth of 1.5 km. The Mesozoic sediments with 2.9 km/s velocity are directly lying just above the crystalline basement with a velocity of 5.8 km/s. Additionally, this study's preliminary observations suggest that the Kachchh Mainland fault extends further eastward.

Keywords: Seismic imaging, Basement structure, Mesozoic sediments, Uplift

DELINEATION OF LANDFILL SITE USING ERT, MASW, AND SPT DATA

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ABSTRACT

Geophysical methods are important tools for the delineation of a site and for predicting the susceptibility of a site to any hazard such as earthquake, landslide, liquefaction, etc. Geophysical methods such as electrical resistivity tomography (ERT) and multi-channel analysis of surface waves (MASW), etc. are useful to detect and delineate a landfill site. The current study has detected a landfill site in IIT (ISM) Dhanbad using electrical resistivity tomography and multi-channel analysis of surface waves (MASW).

For ERT, the Wenner-Schlumberger and dipole-dipole electrode arrays have been used to acquire data of the 71-meter-long profile with a spacing of 1.5 meters. This provided a depth of approximately 15 meters. The data for MASW has been acquired using 24 geophones with a spacing

of 2 meters. The sampling interval was 0.5 milliseconds, and the record length was 0.125 seconds. With the help of MASW, shear wave velocity has been obtained.

The standard penetration test (SPT) is an invasive method of geotechnical investigation. It gives an idea of the soil's shear strength in terms of blow count. The standard penetration test (SPT) data of the study area has been obtained from the Central Public Works Department, Dhanbad. The integrated interpretation using ERT, MASW, and SPT data shows that soil in the upper region of the site. There is a sudden spike in shear wave velocity as well as in SPT data, which is further substantiated by the ERT model. This suggests the possibility of a landfill site subjected to the study area in the past.

LITHOFACIES MODELLING FROM WELL-LOGGING DATA IN HPHT KRISHNA - GODAVARI BASIN USING MACHINE LEARNING ALGORITHMS

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ABSTRACT

Krishna – Godavari (KG) Basin is a complex poly-historic basin on the east coast of India. The basin extends for about 45,000 km^2 from onland to deep water. KG Basin is characterized by the echelon horst and graben system and consists of more than 5km thick sedimentary deposits with an age range from Late Carboniferous to Recent with proven hydrocarbon repositories. As a high-pressure high-temperature (HPHT) basin, our study area lies in the deen dayal field of the KG basin in the shallow offshore region, where temperatures can reach up to 170 °C and formation pressures exceed 10,000 psi. Lithofacies identification is the fundamental step for reservoir characterization. These HTHP conditions have severely affected the lithofacies through diagenetic alterations, resulting in authigenic clay formation, physical compaction, grain contact dissolution, quartz and calcite cementation, and labile grain dissolution, the presence of radioactive sandstone and high-pressure facies making it time-consuming, laborious and challenging to identify lithofacies manually. To handle this large amount of well log data with complex lithofacies we leverage the advantages of Machine Learning (ML) algorithms to overcome these limitations. We first preprocessed our well log data and then obtained the most relevant input features for our ML model, then combined three well log datasets and split them into training and test datasets. Using algorithms like K-Nearest Neighbors (KNN), Decision Tree (DT), Random Forest (RF), Support Vector Machine (SVM), and eXtreme Gradient Boosting (XGB) we trained our model on the training dataset and tested it on the test dataset. The model was evaluated using precision, recall, F1- score, and accuracy; based on these metrics, the hyperparameters were optimized to get the best model performance. We have also tested our model on two blind well log datasets, which showed promising results.

IDENTIFICATION OF NEAR VERTICAL FAULTS THROUGH REVERSE MOVEOUT PHENOMENON: A SEISMIC REFLECTION STUDY OF THE KACHCHH REGION, WESTERN INDIA

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ABSTRACT

The Kachchh region in western India is recognized as one of the most seismically active intraplate earthquake zones in the country, with the 2001 Bhuj earthquake revealing the existence of several faults and previously unknown hidden fault systems. To further investigate and map these fault structures, we conducted the first deep seismic reflection study in the region. The primary aim was to identify and characterize the hidden faults responsible for ongoing seismic activity. A key phenomenon observed during this study is the reverse moveout, wherein back-scattered seismic reflections from fault walls, particularly from normal faults, travel faster and arrive earlier at distant geophones compared to reflections from sedimentary layers. This effect, indicative of the presence of fault zones, was exploited as a diagnostic tool for identifying fault systems in the region. Our study involved analysing multiple shot gathers, and we observed numerous unprocessed back-scattered reflection phases that exhibited clear characteristics of reverse moveout. The direct identification of these phases, without the need for extensive seismic data processing, strongly suggests the presence of normal fault structures. This is significant as it provides a straightforward method for fault identification in the Kachchh region, which is crucial for understanding the region's seismic hazards. The results of this study confirm the presence of reverse moveout phenomena in the Kachchh region, reinforcing the interpretation of active faulting. These findings contribute to a better understanding of the tectonic framework and earthquake potential in this geologically complex region.

Keywords: Intraplate earthquake, hidden fault, reverse moveout, back-scattered reflection

NE INDIA: UNDERSTANDING ITS LITHOSPHERE THROUGH LOVE WAVES

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ABSTRACT

Understanding the structure at the lithospheric depths has a direct implication on resolving the complex geodynamics underplay. The northeast of India has diverse tectonic units from Archean (Shillong plateau) to Cenozoic (Himalayan orogeny) actively participating in various dimensions of collision as continental underplating to subduction, reshaping the structure and its various features, coupled with the tectonics in the region.

Seismological and geodetic studies illustrate a very complicated tectonic regime and refine image of the lithospheric discontinuities at vertical cross-section. The limitation lies in lateral resolution.

This work aims to understand the shallow subsurface's velocity architecture which are important tools for resolving the shallow crust. The objective is to produce high resolution (0.5°-1.0°) surface wave tomography images at short (1-15 s) and at long periods (15-100 s) using earthquake data.

We use seismic data records from 17 broadband stations deployed in the region between 2011-2016. A total of 55 events of Mw >= 5 recorded in epicentral distance 40-200 are used to calculate dispersion curves. Average 1-D fundamental mode Love wave group velocity calculated for 20 s to 80 s period measurements are used for tomography. We present Love wave group velocity tomography maps resolving the structure to a degree of 0.5-10. The calculation adapts to a better resolution degree for better ray paths coverage. Additionally the checker-board tests are performed to ascertain these resolutions. The tomographic images show good correlation to the local geological and tectonic units. The lower periods demonstrate shallow structure as low-velocity material in the sedimentary cover and basins, whereas high velocity in the shillong plateau. At lower crustal periods the structure emerges as high velocity in the younger portions whereas comparatively lower velocities within the older PreCambrian parts. Overall the velocity maps resolve the individual tectonic units in terms of high and low velocity structures within the region.

COBALT ENRICHMENT IN PYRITE FROM AN ALTERED MAFIC DOLERITE DYKE IN THE SIROHI AREA, ARAVALLI CRATON, INDIA: MECHANISMS AND IMPLICATIONS

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ABSTRACT

Cobalt-bearing pyrite in mafic dolerite dykes from the Sirohi region of the Aravalli Craton is an important example of mineralization caused by both volcanic and magmatic processes. This study investigates the formation mechanisms, geochemical properties, and economic consequences of cobalt enrichment in pyrite, with a focus on the substitution of cobalt for iron during sulfide crystallization and alteration.

The development of cobalton-pyrite occurs in two distinct stages, beginning with magmatic crystallization and followed by volcanogenic-hydrothermal alteration. During the emplacement of dykes, mafic magmas derived from the mantle undergo cooling and crystallization, during which sulfur and iron are incorporated into the formation of pyrite (FeS_2). In this initial phase, cobalt, which is concentrated within the mafic magmas, replaces iron in the pyrite structure, resulting in the creation of a primary magmatic sulfide phase. The subsequent hydrothermal phase, influenced by volcanic activity, further facilitates the incorporation of cobalt. Hydrothermal fluids, rich in sulfur and trace metals such as cobalt and nickel, infiltrate fractures and faults within the solidifying dolerite dykes. This process enhances the cobalt content in pyrite, particularly through metasomatic alterations, where cobalt preferentially replaces iron in the crystal lattice. This alteration is essential for increasing the cobalt concentration to the observed levels, which range from 1 wt% to 7.50 wt%.

EPMA analysis of cobalton-pyrite within these mafic dykes indicate cobalt concentrations ranging from 4 wt% to 7.50 wt%, while iron concentrations fluctuate between 40 wt% and 47 wt%, and sulfur levels vary from 47 wt% to 53.50 wt%. The cobalt-to-iron ratio in the pyrite is remarkably elevated at 111.52, signifying a substantial enrichment of cobalt in comparison to nickel, a characteristic feature of volcanic-related hydrothermal systems. The observed negative correlation between cobalt and iron concentrations, illustrated in Fe-Co plots, implies competitive substitution during the crystallization of pyrite. As the cobalt content rises, the iron content diminishes, indicating a selective incorporation

of cobalt throughout the development of the magmatic-hydrothermal system. This geochemical interaction is crucial for comprehending the distribution of metals during the formation of pyrite and its subsequent alteration. The elevated cobalt levels, coupled with the negative correlation with iron, support the hypothesis that cobalt became increasingly enriched as hydrothermal fluids evolved during the later stages of magmatism.

The volcanogenic and magmatic origins of cobalton-pyrite in the Sirohi mafic dolerite dykes reflect a complex interplay of magmatic crystallization and hydrothermal altera. These findings contribute to a broader geological understanding of the metallogenic potential of the Aravalli Craton and support further exploration efforts for cobalt and other critical minerals in the region.

EARLY HISTORIC TO MEDIEVAL PERIOD ENVIRONMENTAL MAGNETIC RECORD OF SEDIMENTS FROM VADNAGAR ARCHAEOLOGICAL SITE, WESTERN INDIA

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ABSTRACT

Vadnagar is an archaeologically important town in the Mehsana district of North Gujarat (India), known for its rich cultural heritage. Archaeological excavations at Vadnagar revealed a continuous sequence of seven successive cultures from early historic to medieval times. In the parlance of the environmental magnetic studies, various properties like magnetic susceptibility (χ_{lf}), susceptibility of anhysteretic remanent magnetization (χ_{ARM}), Saturation isothermal remanent magnetization (SIRM), and their interparametric ratios χ_{fd}%, ARM/SIRM, χ_{ARM}/χ_{lf}, SIRM/χ_{lf}, S-ratio, Soft IRM, and HIRM were determined for sediment samples collected for a ~15.9 m sediment section at Vadnagar. The χ_{lf} values during 318 yr BP-1070 yr BP vary between 18.05 and 92.30 × 10^{-8} m^3 $kg^{-1,}$ and from 1175 yr BP to 1800 yr BP, the values range between 9.4 and 67.2× 10^{-8} m^3 kg^{-1}. χ_{fd}% indicates the proportion of superparamagnetic (SP) grains. The formation of SP grains is mainly due to pedogenesis or fire activity. The high χfd % (3.58 to 23.5) values for the sediments suggest that the samples have a high SP and fine-grained magnetic mineral content. Isothermal remanent magnetization and thermomagnetic curves for selected samples indicate magnetite and hematite (small contribution) are the main contributing magnetic minerals. This 15.9 m sediment section was characterized by a high concentration of magnetic minerals (high values of χ_{lf}, $\chi_{ARM,}$ and SIRM) and a fine magnetic grain size (high χ_{ARM}/χ_{lf} and ARM/ SIRM values) till 1070 yr BP. On the other hand, from 1175 yr BP to 1800 yr BP, the sediment section is characterized by low magnetic susceptibility values, primarily contributed by coarse-grained magnetic minerals. The investigation aims to understand the climatic variations in the provenance of the magnetic minerals, thus deducing the periods of wet and dry climates respectively from the magnetic studies and gaining an insight into the Paleoenvironmental conditions of the Vadnagar.

FAULT SLIP MODEL OF TURKEY-SYRIA EARTHQUAKE, 6TH FEBRUARY, 2023 USING GPS AND INSAR OBSERVATIONS

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ABSTRACT

The 6th February 2023 Kahramanmaras, Turkey Syria earthquake (Mw 7.8) and its largest aftershock (Mw 7.6), which occurred within 12 hr of mainshock, caused huge casualty and heavily damage in the region. The geodetic signature of strain build-up in the region had reported in past studies that depends on the geometry of sub-surface structure and rheology. Hence, characterization of the 6th February 2023 Kahramanmaras earthquake is important for better seismic hazard assessment and understanding of the present-day tectonics in the region. In the present study, we have analysed the Synthetic Aperture Radar (SAR) data prior and after the earthquake and generated the interferogram to capture the coseismic shift through the Interferometric Synthetic Aperture Radar (InSAR) techniques. We used GMTSAR approach to process the interferogram images and to generate the phase filtered images. The wrapped image of surface deformation obtained after reduction of atmospheric and topography affect. Further SNAPHU method applied to get unwrapped image and finally geocoded the results. We inverted the InSAR derived coseismic shift along with the reported coseismic shift at Global Positioning System (GPS) stations located in the region using GBIS technique and estimated the slip on the fault. We generated 10E+6 solutions and reported an optimal fault slip of ~4.5 m of strike-slip and 0.05 m of dip-slip in the rupture zone.

Key words: Turkey-Syria earthquake, GPS, InSAR, Fault, GMTSAR, Coseismic.

UNVEILING THE FORMATION OF DAMMED PALEOLAKES IN THE UPPER SATLUJ BASIN, HIMACHAL PRADESH

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ABSTRACT

In the dynamic Himalayan mountain system, landslides are a prevalent geomorphic force that has far-reaching consequences. Although the direct impact of these events on mountain communities is evident, the initiation of a cascade of effects by many landslides is a significant secondary consequence, with the creation of landslide-dammed lakes being a significant outcome. The Ropa Valley of Himachal Pradesh, a massive paleolake deposit has formed, measuring approximately 120m in thickness and 500m in width. Another noticeable paleolake deposit of around 60m thick and approximately 500m wide is located in the Moorang Valley. The valley is investigated for hydrodynamics analyses, and morphotectonics using satellite imagery, and geological and topographic data to understand the drainage networks surrounding the dammed lake. We aim to enhance our understanding of the ways in which the drainage network and landscape are substantially altered by surface processes and topographic change. The morphotectonic indices and parameters including the Steepness index (Ksn), Valley-width to height ratio (Vf), Stream Length Gradient Index (SL-Index), and Hypsometric Integral (HI) values suggest the valley is significantly influenced by tectonic activity. Optically Stimulated Luminescence (OSL) samples were collected to establish the

chronology of the paleo-lake deposits. The obtained ages are 29 ± 2 ka, 27±2 ka and 26 ± 2 ka providing a chronological framework for the paleolake deposits. This comprehensive analysis not only unravels the region's history of surface processes rather also sheds light on the interplay of tectonic forces, landslides, and river dynamics contributing to a deeper understanding of the complex landscape evolution in the Himalaya during the transition climate.

AN IN-DEPTH STUDY OF HIGH-FREQUENCY ATTENUATION PARAMETER KAPPA (K) UTILIZING SURFACE AND BOREHOLE DATASETS IN THE VOLCANIC REGION OF KYUSHU, JAPAN

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ABSTRACT

This study examines the high-frequency attenuation parameter, kappa (κ), using strong motion data from the 2016 Kumamoto earthquake, obtained via the KiK-net network, to understand seismic wave behaviour in the volcanic region of Kyushu. The analysis focuses on κ beneath the volcanic area, evaluating both surface and borehole data to discern the influence of site conditions and regional attenuation. At 21 surface stations, the site-specific attenuation parameter (κ0) was calculated. A correlation between κ 0 and the average S-wave velocity in the top 30 meters (V S30) was observed, where κ 0 decreases as V S30 increases. Borehole data were used to further estimate the region-specific S-wave quality factor (Q s) and zero-distance kappa (κ 0). The relatively obtained low Q s values, coupled with higher κ 0 values, are likely due to the region's extensive volcanic activity. The κ values are calculated from both horizontal (κ H) and vertical (κ v) components for borehole and surface data for comparison. This relative comparison indicates that κ H and κ v are nearly equal in borehole conditions. In contrast, at the surface, κ H exceeds κ v , suggesting that horizontal components are more affected by site conditions. These findings align with previous studies, underscoring significant attenuation within Kyushu's volcanic regions. The estimated kappa values are vital for future site-specific seismic hazard assessments in the area, providing essential insights into how volcanic conditions influence seismic wave attenuation.

SUBSURFACE FOLD ESTIMATION FROM SEISMIC REFLECTION DATA USING CNN ALGORITHM

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ABSTRACT

Subsurface structural information is crucial for understanding the reservoir properties of an area. Folds are considered one kind of reservoir if they consist of certain properties necessary to hold and oppose the migration of hydrocarbon. They are geological structures that form when rock layers bend

under extreme pressure, often due to tectonic forces. These formations may create natural traps where oil and gas accumulate, making them valuable targets for exploration and production. Additionally, impervious folds aid carbon sequestration by sealing and storing large amounts of carbon dioxide. Conventionally, detecting folds in subsurface data involve manual interpretation of seismic sections, a method that, while being effective, is time-consuming, requires specialized interpretation knowledge, and can be prone to ambiguity. To improve the accuracy and efficiency of this process, deep learning techniques, particularly Convolutional Neural Networks (CNNs), have become increasingly valuable. CNNs are well-suited to recognize complex patterns in images, making them a suitable tool to identify subsurface geological features from complicated seismic sections. In this approach, the process begins by labeling post stack synthetic seismic images with folds, which are then used to train the CNN model. Over time, the model learns to distinguish between areas with and without folds and can predict their locations in the seismic datasets with increased accuracy. This approach not only reduces the time required for fold detection but also minimizes ambiguities. As the model processes more data, its performance continues to improve, offering a progressive tool for enhancing both energy exploration and climate change efforts.

INVESTIGATING ARCHAEOMAGNETIC INSIGHTS FROM HARAPPAN CIVILIZATION AT LOTHAL, GUJRAT

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ABSTRACT

Archaeomagnetism integrates archaeological and geophysical methods to investigate Earth's core processes by examining variations in the geomagnetic field. Archaeological materials, volcanic rocks, and sediment formations serve as valuable proxies for reconstructing the geomagnetic field's temporal changes, providing insights into its historical dynamics. The current research focuses on geomagnetic field intensity during the Harappan civilization, the oldest known civilization in India. A total of 17 archaeological artefacts from Lothal, Gujarat, were subjected to comprehensive rock and archaeomagnetic analyses. Rock-magnetic studies reveal key information on the magnetic properties of these artefacts, including magnetic concentration, grain size distribution, mineral composition, and thermal stability. The samples contain ferrimagnetic minerals, particularly magnetite, with grain sizes ranging from single-domain to pseudosingle-domain states. The Curie temperature analysis, determined to be between 580-590°C and predominant reversible curves through temperature-dependent magnetic susceptibility (χ-T) measurements, indicates the presence of thermally stable magnetite and the absence of mineralogical transformations, respectively. These findings suggest that the artefacts contain thermally stable minerals that are well-suited for reliably recording the intensity of the ancient geomagnetic field. The geomagnetic field intensity was estimated using the Thellier-Thellier method (1959) with modifications by Coe (1978), assessing the relationship between the loss of natural remanent magnetization (NRM) and the gain of thermoremanent magnetization (TRM), using Thellier GUI software. Corrections for cooling rate and anisotropy of thermoremanent magnetization (ATRM) were applied, and the corrected intensities were averaged to obtain a mean archaeointensity value dating back to around 1850 ± 100 BCE. This novel archaeointensity data provides critical insights into the geomagnetic fields of both early civilizations and geological processes of the distant past.

GEOCHEMICAL ANALYSIS OF NARMADA RIVER SEDIMENTS: IMPLICATIONS FOR CHEMICAL WEATHERING AND CLIMATE DYNAMICS

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ABSTRACT

Surface weathering and erosion processes, particularly chemical weathering, are critical in shaping Earth's landscapes and influencing global climate dynamics by acting as a natural carbon sink through the consumption of atmospheric CO_2. Silicate weathering, over extended periods, plays a crucial role in removing CO_2 from the atmosphere, thereby impacting oceanic carbonate saturation levels and sustaining Earth's habitability. Rivers serve as conduits for eroded materials and contribute in understanding denudation rates of continental crust and silicate weathering processes. While physical erosion rates can be estimated through annual sediment loads in rivers whereas, chemical weathering rates necessitates river chemistry data or sediment geochemistry studies. In this study, we analysed river-borne sediments from the Narmada River using Wavelength Dispersive X-Ray Fluorescence (WD-XRF). Our findings indicate that the Chemical Index of Alteration (CIA) for the Narmada basin ranges between 64 to 90, suggesting moderate to high chemical weathering across all samples. Additionally, we calculated the Chemical Index of Weathering (CIW), Plagioclase Index of Alteration (PIA), and Ruxton Ratio (R), all indicating consistent results regarding weathering intensity. Plotting relationships among oxides revealed significant correlations, particularly between TiO_2 and Fe_2O_3 (r^2=0.85) which is similar as in the upper Godavari region. Notably, previous studies on the Narmada basin identified evapotranspiration and calcium super-saturation of river water as limitations when using dissolved phases for analysis. Our study corroborated this by showing a dispersed plot with no correlation of Na_2O, CaO and MgO with other immobile oxides. This comprehensive analysis not only enhances our understanding of the Indian peninsula's geological processes but also aids in revising CO_2 consumption rates for the Deccan Trap region, thereby contributing valuable insights into Earth's climate system dynamics and long-term CO_2 sequestration trends.

APPLICATIONS OF REVERSE TIME MIGRATION TO IMAGE COMPLEX GEOLOGICAL PROBLEMS

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ABSTRACT

Seismic imaging is a powerful method for mapping subsurface structures and properties through the analysis of seismic data. Among various seismic imaging techniques, Reverse Time Migration (RTM) stands out as an effective approach for imaging the complex geological features, as it operates by solving the two-way wave equation, enabling the simulation of both forward propagation of seismic waves from the source and backward propagation of recorded data from the receivers. Reverse time migration has the ability to retrieve accurately migrated images of complex subsurface structures by imaging the multicomponent seismic data. By cross-correlating these wavefields at each depth level, RTM captures primary and multiple reflections often missed by conventional migration techniques. In

this study, we investigate the applications of RTM to synthetic data from different complex geological models, including simple flat layers, dipping layers, thrust faults, synclines, and the challenging Marmousi model. For all models, RTM successfully recovers the reflectors with high resolution and effectively images steeply dipping structural deformations, showcasing its strength in handling complex geometries. Additionally, our models representing a highly heterogeneous and structurally complex subsurface, demonstrates RTM's ability to handle strong velocity contrasts in both directions. We thus demonstrate the applications of the method in retrieving from simple to complex geological subsurface structures.

Key words: Seismic Imaging, Reverse Time Migration (RTM), Finite-Difference, Wavefield Cross-Correlation, Complex Geological Structures, Dipping Layers

3D INVERSION OF MAGNETOTELLURIC DATA ALONG A NORTH-SOUTH PROFILE IN THE WESTERN ARUNACHAL HIMALAYA FOOTHILLS

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ABSTRACT

The Himalayas, one of the most seismically active regions in the world, were formed through the tectonic collision and ongoing underthrusting of the Indian Plate beneath the Eurasian Plate, resulting in significant crustal shortening accommodated by major thrust faults. The Himalayan Frontal Thrust (HFT), the youngest of these faults, marks the southern boundary of the mountain range. To image the HFT in the Arunachal Himalaya, we collected magnetotelluric (MT) data from nine stations along a 35 km transect between Tezpur and Bhalukpong using Phoenix MTU-5A instruments. The time series data were processed to derive impedance and tipper estimates across a period range of 0.004 to 110 s. Following the dimensionality analysis of the MT responses, we applied 3D inversion using ModEM software on the supercomputer of the Russian Academy of Sciences. The study area was discretized into a core grid of 1.1 km, padded with 12 cells on all sides, with the vertical grid cell size increasing from 40 m at the surface. The grid consisted of 64 horizontal cells, 41 vertical cells, and 48 vertical cells in total. For the initial model, we assigned a resistivity of 250 Ωm for depths up to 100 km and 100 Ωm for the layers below that. We conducted 14 inversion runs, adjusting parameters such as input data subsets, error floors, initial damping factors, model covariance, and others. In all inversion models, key features were consistently observed, although their extents and resistivity values varied. Our preferred inversion model achieved a RMS value of 1.3 after 72 iterations. To visualize the inversion results and track their evolution, we developed custom Python software. The final geoelectrical model, extending to a depth of 45 km, provided a detailed electrical resistivity image of the HFT, buried beneath a thin layer of conductive Quaternary alluvial deposits. The geometry of the thrust fault appeared as a distinct boundary separating the resistive Indian crust from the highly conductive Siwalik sediments.

This research was supported by the Joint RSF-DST Research Project No. 24-47-02016. The field MT data were collected with the assistance of IIG, Navi Mumbai, India.

NUMERICAL SIMULATION OF GEOTHERMAL RESERVOIRS IN INDIA BASED ON LITERATURE DATA

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ABSTRACT

Geothermal energy is emerging as a sustainable alternative to fossil fuels due to its low carbon emissions. While traditional hydrothermal systems were once prominent, attention is now shifting toward next-generation geothermal technologies, particularly, hot dry rock systems. These systems can harness higher temperatures from deeper formations and operate in reservoirs with low porosity and permeability, providing a continuous power supply. Numerical simulations are essential for understanding the thermo-hydro-geomechanical behavior of these systems, aiding the development of Enhanced/Engineered Geothermal Systems (EGS).

In India, EGS development faces several challenges, including limited subsurface data, the absence of supportive government policies, and economic hurdles. Our research addresses these barriers by synthesizing existing literature to identify potential EGS sites and conducting numerical simulations to assess their feasibility. Using fully coupled 3D geomechanics, fluid flow, and thermal simulator, we conducted a 30-year preliminary simulation on a simplified low porosity-permeability rock model. The results showed stable pressure and temperature conditions, indicating suitability for EGS.

Moving forward, we plan to incorporate more geological complexity and additional flow constraints to improve model accuracy. By enhancing our simulations, we aim to better assess the viability of EGS deployment in India and contribute to the country's clean energy transition.

Keywords: Geothermal Energy, EGS, Numerical Simulation, Thermal Simulator

GEOMECHANICAL RISK ASSESSMENT IN CO_2 STORAGE: UNDERSTANDING SEAL FAILURE AND WELLBORE STABILITY

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ABSTRACT

The geomechanical seal analysis is an essential aspect of CO_2 sequestration risk assessment. By developing a 1D Mechanical Earth Model (MEM) using well data in the Caswell sub-basin, Browse Basin, Western Australia, this analysis focuses on evaluating the integrity of the caprock for containing injected CO_2. The 1D MEM integrates well log data, core measurements, and stress profiles to characterize the subsurface mechanical properties, including vertical, minimum, and maximum horizontal stresses, along with formation strength parameters. These elements provide a foundation for understanding stress variations and the behavior of the subsurface during CO_2 injection.

Seal intervals are selected based on petrophysical analysis, and near-wellbore stresses are analyzed through stereonets, radial, and circular sections to identify critical stress conditions such as tangential, axial, and radial stresses. The Mohr-Coulomb failure criterion is applied to evaluate the risk of wellbore breakouts, helping to determine the safe operational limits for injection. This analysis also

includes mud weight sensitivity plots, derived from the MEM, which are crucial for optimizing drilling and maintaining wellbore stability under varying pressure regimes. Tornado uncertainty plots offer a risk-based sensitivity analysis, highlighting the impact of different geomechanical parameters on seal integrity.

This integrated approach, based on a detailed 1D MEM, offers valuable insights into the mechanical stability of the caprock and wellbore, ensuring the safe containment of CO_2 in subsurface formations. By addressing the potential for caprock failure, the study enhances the reliability of CO_2 sequestration, helping mitigate risks of leakage and ensuring the long-term viability of storage projects.

Keywords: 1D Mechanical Earth Model (MEM); CO_2 sequestration; Geomechanical seal analysis; Wellbore stability

THERMOMECHANICAL MODIFICATION OF CRUSTAL AND LITHOSPHERIC THICKNESS IN NORTHWEST INDIA: AN INTEGRATED GEOPOTENTIAL MODELLING APPROACH

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ABSTRACT

One of the most fundamental elements in the solid Earth studied by the different disciplines of geoscientists is the lithosphere. Understanding the tectonic processes that regulate the growth of Earth's continents requires a thorough understanding of the architecture of the subcontinental lithospheric mantle. The northwest Indian Shield is a thermo-tectonically challenging region and demands extensive research. Although multiple studies applying distinct geophysical proxies have contributed much to our understanding, more is required concerning the complex structure of the deep crustal and lithospheric mantle. Instead of investigating various datasets separately, this study adopted an integrated modelling technique which utilised three data sets (gravity, geoid, and topographic data) and thermal parameters to generate a Moho and LAB architecture for the northwest Indian shield. Our modelling result suggests that the crust is 33 to 39 km deep in the Saurashtra and Kachchh regions, gradually increasing to around 40 km beneath the Jaisalmer region. The deepest Moho, at 42-45 km, is beneath the Aravalli-Delhi fold belt and Indo-Gangetic plain. A 41-44 km crustal thickness is observed underneath the Bundelkhand craton. Under the Saurashtra and Kachchh regions, the lithosphere-asthenosphere border (LAB) is 115-145 km deep and remains comparable under the Barmer-Pokharan region, which is 130-160 km deep. The Aravalli-Delhi fold belt has a moderate LAB depth (~140 km), while the Bundelkhand craton has a deeper LAB (175-185 km) that extends over 200 km below the Indo-Gangetic plain. An atypically thinned lithosphere, together with the possible presence of lower density in the subcrustal upper mantle region beneath the Saurashtra, Kachchh, and Aravalli-Delhi fold belt, suggests a genetic relationship between the evolution and thermal modification of the mantle lithosphere of this region.

GEOPHYSICS IN ACTION: EXPLORING GEOTHERMAL RESOURCES FOR SUSTAINABLE ENERGY

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ABSTRACT

Geothermal energy refers to the production of energy using the internal heat of the Earth's crust. This heat comes from the radioactive decay of minerals and continual heat loss from the earth's original formation.

Geothermal energy, a sustainable and renewable resource, offers a viable solution for meeting global energy demands while reducing carbon emissions. This study explores the utilization of geophysical methods in the exploration and assessment of geothermal energy resources. By employing techniques such as seismic surveying, magnetic resonance imaging, and electrical resistivity tomography, to delineate subsurface geological structures and identify potential geothermal reservoirs.

Geophysical methods play a key role in geothermal exploration since many objectives of geothermal exploration can be achieved by these methods. The geophysical surveys are directed at obtaining indirectly, from the surface or from shallow depth, the physical parameters of the geothermal systems.

Seismic and electrical methods are geophysical techniques used in geothermal exploration to investigate subsurface structures and identify geothermal reservoirs. These methods provide valuable information about the physical properties of the Earth's interior, helping to locate areas with geothermal potential. These methods are often used together to provide a more complete understanding of geothermal systems.

Seismic surveys offer detailed structural information, while electric surveys reveal fluid content and temperature variations. By combining data from both, a clearer picture of the geothermal reservoir and its potential can be obtained.

Geophysical methods provide critical data on temperature gradients, fluid flow, and reservoir characteristics, enabling more accurate predictions of resource viability. This paper highlights where innovative geophysical approaches have successfully identified geothermal hotspots, improved resource management, and minimized exploration risks.

IMAGE GUIDED FUZZY CONSTRAINED DC INVERSION USING SPATIALLY VARIABLE MIXED *LP* NORMS

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ABSTRACT

In this paper, we present an advanced method for improving 2D resistivity models using a fuzzy-constrained inversion technique for direct current (DC) data. Our approach combines spatially varying L_p norms and structural constraints guided by images, making it more effective at distinguishing between different geological units. By incorporating fuzzy c-means clustering within the inversion, the technique achieves more accurate identification of subsurface features.

We use four gradient-based constraints to capture resistivity changes both along and across structural boundaries, improving the clarity of the subsurface image. The inversion process, developed in MATLAB, extends traditional L_1 and L_2 norm methods by applying L_p norms individually to each part of the model. This allows for varying levels of smoothness or sharpness in different areas, addressing the inherent challenges of geophysical inversion.

The algorithm works in two stages: it starts by solving the problem using the standard L_2 norm, and then switches to more flexible L_p norms for each component, providing better local control over the inversion process. To maintain stability and improve convergence during this switch, gradients are dynamically adjusted within a Gauss-Newton framework.

To further improve the resistivity model, we introduce an image-guided technique that uses structural information from high-resolution geophysical data or expert geological knowledge. By applying directional smoothing constraints based on structure tensors and pixel similarities from guiding images, the method ensures that the inversion preserves both continuous and discontinuous resistivity features. The result is a more efficient and accurate representation of the subsurface, making this method highly effective for studying complex geological environments.

Keywords: Numerical modelling; Inverse theory; L_p norm; DC resistivity

SEISMIC P-WAVE VELOCITY MODELLING USING DEEP LEARNING ALGORITHM FOR SUBSURFACE INVESTIGATION

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ABSTRACT

Seismic velocity modelling plays a crucial role in geophysical exploration, especially for understanding subsurface geological formations. My research focuses on predicting the P-wave velocity model from Common Midpoint (CMP) seismic gathers using deep learning algorithms, particularly Convolutional Neural Networks (CNN). Accurate velocity modelling is essential for proper subsurface interpretation, and selecting the correct velocity is vital for this process. In this study, I used Madagascar, an open-source seismic software, along with Python, to generate synthetic seismic data from Root Mean Square (RMS) and interval velocity models. This synthetic data was then used to train and test the CNN algorithm. The aim of this research is to improve the understanding of complex geological settings, as CNN models can learn and capture the non-linear relationships present in seismic data. By predicting P-wave velocity from CMP gathers, we aim to enhance the accuracy of subsurface interpretation, particularly in regions with intricate geological structures. Traditional methods for velocity model prediction often struggle to account for real-world complexities. However, deep learning approaches, such as CNNs, have demonstrated superior performance in handling these challenges. My research focuses on generating sufficient synthetic seismic data to effectively train the deep learning model, ensuring higher accuracy in velocity predictions. The initial phase of the study involved implementing 1D velocity variations in CMP gathers, followed by generating synthetic seismic gathers for CNN model training and testing. The results indicate promising performance in predicting velocity models. This approach paves the way for more precise subsurface exploration and interpretation.

SITE CHARACTERIZATION FOR SEISMIC HAZARD ANALYSIS THROUGH AMBIENT NOISE MEASUREMENTS OF GORAKHPUR CITY, INDIA

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ABSTRACT

Gorakhpur city has experienced several high-intensity tremors due to ongoing seismic activity in the Himalayan region. Therefore, site characterization of the city is crucial for better assessing seismic hazard analysis. Ambient noise measurements were conducted at 360 single-station sites and four array sites. The horizontal-to-vertical spectral ratio (HVSR) analysis shows that the predominant frequency varies between 0.434 and 1.02 Hz, with the amplitude increasing toward the north, reaching a maximum amplification of 4.8. Array measurement analysis using high-resolution frequency wavenumber (F-K) methods was performed to estimate the surface wave dispersion curve. Surface wave dispersion curves were inverted to obtain the 1D shear wave velocity profile of the subsurface layers. The shear wave velocity (Vs) of the soft soil, up to a depth of 20 m, ranges from ~200 to 280 m/s. Additionally, the second layer shows a shear wave velocity ranging from ~400 to 550 m/s, representing very dense soil, while the third layer is rock, with a shear wave velocity exceeding 1200 m/s up to 100 m depth. The observed shear wave velocity models correspond to soil classifications ranging from soft soil to very dense soil and bedrock.

"GRAVITATIONAL AND MAGNETIC FIELDS TO INFER SUBSURFACE STRUCTURES AND PROCESSES"

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ABSTRACT

Gravity and magnetic fields are powerful tools for investigating subsurface structures and processes, offering insights into geological formations, resource distribution, and tectonic activity. Gravitational field variations, caused by density contrasts in the Earth's crust and mantle, allow geophysicists to identify features such as sedimentary basins, volcanic structures, and fault lines. By analyzing gravity anomalies, researchers can infer the shape and density of subsurface materials, aiding in resource exploration, such as oil, gas, and minerals.

Magnetic field measurements reveal information about the Earth's magnetic properties. Magnetic surveys can delineate geological structures, identify mineral deposits, and track tectonic plate movements. Techniques like aeromagnetic surveys provide high-resolution data over large areas, enhancing our understanding of regional geology.

Integrating gravitational and magnetic data through geophysical inversion techniques further refines subsurface models, allowing for a more comprehensive interpretation of geological features.

Additionally, the analysis of these fields is essential for assessing natural hazards, such as earthquakes and volcanic eruptions, by revealing stress concentrations and fault mechanics. The ability to non-

invasively map and monitor subsurface structures enhances not only our fundamental understanding of Earth processes but also informs resource management and environmental protection efforts.

Gravity and magnetic field studies serve as crucial methodologies in geophysics, enabling the inference of subsurface structures and processes that shape our planet's geology, support resource exploration, and hazard assessment strategies. Through ongoing technological advancements, these methods continue to evolve, providing deeper insights into the Earth's inner workings.

DETERMINATION OF SHEAR WAVE VELOCITY USING AMBIENT SEISMIC NOISE ASCRIBED TO NATIONAL SEISMOLOGICAL NETWORK FOR SITE RESPONSE CHARACTERIZATION

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ABSTRACT

The National Seismological Network of India monitors seismic activity across the country, comprising 162 seismic stations at diverged geological formations. These stations are located in diverse geological formations and tectonic environs. We analyses the ambient seismic noise data obtained from this national network. These analyses were performed to characterize site beneath each seismic station, as geological formations significantly influence seismic wave propagation and amplification. We extracted elliptical Rayleigh wave from the ambient noise recordings and inverted it for shallow subsurface structure. A detailed examination shows that the shear wave velocities for the uppermost 20 meters range from 300 to 500 m/s. Velocities increase between 20 and 100 meters to 600 to 1000 m/s; beyond 100 meters, they stabilize around 1200 to 1500 m/s. The average shear wave velocity for the upper 30 meters (Vs30) is in the range of 230 – 780 m/s at seismic station sites across India. Hard rock sites show a velocity > 360, while soft soil sites have a velocity of < 360 m/s. Our analysis reveals that Vs_{30} beneath the seismological stations predominantly falls into Class-C, as per NEHRP classification. Class-C Soil, which ranges from 360 m/s to 760 m/s, suggests compacted material that provides reliable seismic data with minimal amplification of seismic waves. In some locations, however, the stations fall under Class-D, indicating softer conditions with shear wave velocities between 180 and 360 m/s, which may be less suitable for installing seismic equipment. The V_{S30} values obtained from the elliptical Rayleigh wave modeling are validated with available lithologies, and a good correlation is noticed. Overall, the distribution of seismic stations across various geological formations in India allows for comprehensive monitoring of seismological signals and analysis of seismic activity. Our study confirms that these stations are robustly installed at all sites across the country, and the data recorded is suitable for regional seismic station modeling. We suggest the installation of seismometers at some depth below the surface, particularly at low shear wave velocity sites, may substantially reduce short-period noise in earthquake recording.

Keywords: Geological Formations; Elliptical Rayleigh Wave; Site Response; Seismic Station; Shear wave velocity

A DEEP LEARNING ASSISTED SOURCE-SEPARATION APPROACH FOR EARLY AFTERSHOCK DETECTION USING SINGLE STATION DATA

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ABSTRACT

After a major earthquake, early aftershocks provide crucial data about the main event's source and fault structure. However, their detection is complicated by overlapping signals from the main shock and subsequent aftershocks, obscuring vital information and impeding our understanding of earthquake behavior and future predictions. While signal processing techniques used for source separation have significantly evolved for multi-station settings over the years, the options remain relatively limited when dealing with single-station recordings. We propose a deep learning architecture using Dual Path Recurrent Neural Network (DPRNN) for separating early aftershock signals in single-station seismic recordings. The DPRNN is directly applied to the time-domain data, leveraging the temporal structure of the signals without relying on additional feature extraction. This allows the network to capture the subtle differences between overlapping events effectively. We train the neural network on a large dataset of earthquake recordings. In this study, we utilize seismic data from the STanford EArthquake Dataset (STEAD) and the KiK-net, ensuring a diverse dataset that encompasses a broad spectrum of seismic events. We further optimized the seismic signals from STEAD by employing pre-processing techniques through instrument response removal, component normalization, and extraction of vertical channels, which are subsequently resampled for computational efficiency. Additionally, we incorporate strong motion data from KiK-net specifically focusing on seismic events related to the 2023 Ishikawa earthquake, which had significant numbers of recorded early aftershocks. The efficacy of our model is also evaluated using real-time acceleration data. The L2 error during different testings affirm the satisfactory performance of our model. This single-station methodology proves especially beneficial in the field of planetary seismology. Despite having constrained instrumentation, this approach is highly effective in precisely separating sources for a variety of seismic events, including moonquakes, marsquakes, and tremors from other planets.

2D MAGNETOTELLURIC DATA INVERSION USING DEEP LEARNING

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ABSTRACT

The inversion of 2D magnetotelluric (MT) data is a complex, nonlinear, and ill-posed problem. The traditional gradient-based optimization techniques reconstruct the subsurface resistivity model by minimizing a predefined penalty function. However, they struggle to capture full non-linearity between the observed data and the model and can get stuck in local minima. The global optimization techniques can bypass this issue, but they are computationally very demanding especially for higher dimensional problems. The deep learning (DL) methods present a promising alternative by effectively capturing the inherent non-linearity in the data leading to more accurate predictions of subsurface resistivity distribution. However, the data-driven approach's effectiveness hinges on the similarity of training and test data's statistical patterns. In the field data, this assumption often falls short, requiring

additional training to adapt parameters. In this study, we present a DL-based inversion scheme using resistivity model augmentation and MT2DUnet++ to improve generalization of DL-based supervised MT inversion.

APPRAISAL OF POTENTIAL MINERALIZATION IN THE WAJRAKARUR KIMBERLITE FIELD, INDIA: NEW INSIGHTS FROM RECENT GEOPHYSICAL DATASET

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ABSTRACT

This study investigates the Bouguer Gravity Anomaly (BGA) and magnetic anomalies in the Wajrakarur Kimberlite Field (WKF), located in Anantapur, Andhra Pradesh, India, a significant area for kimberlite exploration within the South Indian Kimberlite Province. The WKF is characterized by distinct gravity highs and lows situated between the Closepet Granite (CG) and the Cuddapah Basin (CB), along with notable gold-mineralized zones found in the Ramagiri-Penakacherla Greenstone Belt (RPGB) and the Jonnagiri Greenstone Belt (JGB). The study primarily focused on identifying shallow geological structural features, such as granite structures and fault/shear zones, at a depth range of 3 to 4 km. Additionally, an analysis of the magnetic data indicates the presence of lineaments-oriented NW-SE, NE-SW, and E-W, which align with geological structures, implying the existence of kimberlite intrusions. The Gold mineralization is primarily found in the gravity highs of RPGB, JGB, and the concealed gravity high (GH3), as well as along the cross-sections of lineaments. Furthermore, concentrations of Rare Earth Elements (REE) are noted between two gravity highs along the eastern margin of CG. These findings enhance our understanding of the geological framework of the WKF and its mineralization potential, providing valuable insights for future exploration efforts.

Keywords: Gravity, Magnetic, Gold, REE, Mineralization, Kimberlite, Wajrakarur Kimberlite Field, Eastern Dharwar Craton.

PETROGENESIS OF GLIMMERITE AND MELTEIGITE XENOLITHS WITHIN NONGCHRAM CAMPTO- TINGUAITE ROCK, EAST GARO HILLS DISTRICT, SHILLONG PLATEAU, NORTHEAST INDIA

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ABSTRACT

Numerous early cretaceous alkaline dykes intruded into neoproterozoic porphyritic granites and leucogranites along the Nongchram fault zone. The presence of glimmerite and melteigite xenoliths within the Camptonite–tinguaite hybrid rock offers a unique perspective on deep magmatic processes and the evolution of alkaline igneous systems. This study focuses on the petrography, mineral chemistry and in-situ trace element geochemistry of pyroxenes from the glimmerite and melteigite xenoliths to understand their source and petrogenesis of the host rock. A rare occurrence of glimmerite xenoliths consists coarse-grained, equigranular assemblages (4.8 mm in size) containing biotite (1.93 mm), pyroxene (2.13 mm), ferro dolomite, rutile, and ilmenite. The xenolith is

surrounded by needle shaped – sodic-ferro rich pyroxenes ,while melteigite xenoliths shows a different mineral chemistry , having pyroxene, pseudo- nepheline (altered to analcime), rutile. The hybrid nature of the host camptonite-tinguaite dyke indicates mixing of magma. In-situ trace element geochemistry of pyroxenes reveals significant enrichment in LILEs such as Ba and Sr, as well as LREEs like La and Ce, suggesting an enriched mantle source. The negative Y anomaly and Lu enrichment indicate high-pressure garnet stability during partial melting, supporting a deep mantle origin of both xenoliths. Geothermobarometric indicating varying depths of origin for these xenoliths. The geodynamic implications of these findings suggest that the glimmerite and melteigite xenoliths are mantle-derived, likely formed through the interaction of the Kerguelen plume with a subduction-modified lithosphere. The presence of orogenic signatures in the xenoliths and anorogenic signatures in the host campto-tinguiate suggests a complex tectonic setting, with contributions from both plume and subduction-modified sources. The mineral composition as well as the thermobarometric study of clinopyroxenes from both the host and the xenoliths, suggest multiple shallower magma chambers composed of camptonitic and tinguaitic magmas which were activated by different magmatic pulses, thereby forming a complex magmatic plumbing system.

GEOLOGICAL, GEOMORPHOLOGICAL AND GEOPHYSICAL EVIDENCE OF SABILPUR ACTIVE FAULT, NW HIMALAYA

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ABSTRACT

Remote sensing and Geographic Information Systems (RS & GIS) are among the most effective tools for geomorphic investigations. Geomorphology is pivotal for identifying various landforms and, consequently, discerning faults in hilly terrains. Morphometric indices, such as the longitudinal profile SL-index, Steepness index, Hypsometric curve, and integral, chi gradients, are employed to delineate possible faults. This investigation utilizes morphometric analysis and electrical resistivity techniques to provide a comprehensive assessment of the Sabilpur Active Fault (SAF). A quantitative approach to morphometric indices underscores the potential presence of faults in the region. Additionally, an Electrical Resistivity Tomography (ERT) survey has been executed to validate the activity of the Sabilpur Active Fault. The analysis of various geomorphic indicators, including stream deformations, offsets, and relative displacements, further corroborates the existence of the Sabilpur Active Fault.

Keywords: Remote sensing & GIS, Morphometry, Sabilpur Active Fault, Electrical Resistivity Tomography.

SURFACE STRAIN RATES, SEASONAL LOADING AND TEMPORAL GRAVITY CHANGES IN THE DOON VALLEY THROUGH GPS AND GRAVITY MEASUREMENTS

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ABSTRACT

Dehradun or the Doon Valley is a NW-SE trending intermontane valley of ~80 km length and a width of ~ 20 km is bounded by the Main Boundary Thrust (MBT) at its north with Mussoorie ranges of the

Lesser Himalaya and the Himalayan Frontal Thrust (HFT) at its south with sprawling Siwalik Hills. The Doon valley is also bounded by the Yamuna and the Ganga Tear Fault systems at its west and the east sides respectively. To study the intermontane basin effects on the temporal surface deformation and its characteristic nature of temporal density changes in the Doon valley, we explored data from WIHG permanent GPS stations and other published velocities with acquired long period (300 sec) temporal gravity at different sessions using a relative gravity meter in WIHG.

Results from the estimated principle axis of strain rates from the least square analysis of crustal velocity gradients with optimum grid density shows that in the Gangetic plain and at the south of HFT the E-W extensional deformation is well correlated with the arc parallel movement of the HFT. However, the Lesser Himalayan rocks immediately at the north of MBT shows maximum compressional strain of ~50 nano-strain/a. While in the Quaternary alluvium filled Sub-Himalayan region the strain rate is near zero as like the abysmal shallow crustal velocities and uplift rates. During the monsoon period, the valley subsides due to the hydrological loading, and it rebounds during the summer season and this seasonality is clearly observed in the GPS time series of surface displacement. The spectrum analysis of processed long period temporal gravity data after tidal and other corrections shows the waxing and waning of gravity signals of about half a milliGal which is in correlation with seasonal changes with phase shifts. Thus we infer that the observed periodicities in the deformation and gravity signals, apart from the diurnal trends and the boundary fault control, are likely produced by the basin controlled strain diffusing density flow of fluids in the sub-surface pore space of the Doon alluvium.

INTEGRATED GEOLOGICAL AND GEOMECHANICAL SITE CHARACTERIZATION OF LEIGH CREEK COAL MINE FOR SUSTAINABLE UNDERGROUND COAL GASIFICATION

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ABSTRACT

This study presents a comprehensive evaluation of the geological and geomechanical characteristics of the Leigh Creek Coal Mine in South Australia, with the objective of assessing its suitability for Underground Coal Gasification (UCG). Given the rising global energy demand, UCG offers a promising and sustainable method for extracting energy from coal while mitigating environmental impacts. The research involves a detailed coal rank analysis, emphasizing the quality and characteristics of the coal to determine its gasification viability. Geological assessments focus on the integrity and stability of the coal seams, critical factors for ensuring safe and efficient UCG operations. The study also incorporates geomechanical evaluations to identify potential risks associated with the gasification process. Key parameters such as coal seam thickness, depth, and permeability are analyzed to establish optimal conditions for UCG implementation. The assessment aims to identify and evaluate any geological features that may influence the effectiveness and safety of gasification activities. Additionally, stratigraphic modelling and the integration of well log data enhance the understanding of the subsurface environment, providing insights into the geological framework that governs the coal seams. By systematically identifying and analyzing essential geological and geomechanical factors, this research contributes to the development of a robust framework for risk management in UCG operations.

The findings from this study not only highlight the potential of Leigh Creek Coal Mine for UCG but also emphasize the need for careful consideration of geological and geomechanical parameters to ensure safe and effective energy extraction. This research aims to inform future UCG projects, ensuring that energy extraction processes align with sustainable practices.

Keywords: Underground Coal Gasification; Geological assessment; Geomechanical analysis; Coal seam; Risk management.

EVALUATION OF GEOCHEMICAL CHARACTERISTICS OF THE TAPTAPANI THERMAL SPRING IN GANJAM DISTRICT, ODISHA.

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ABSTRACT

This study shows the hydrogeochemical characteristics of the Taptapani thermal spring (TTS), located along the lineament in Eastern Ghats Granulite terrain.For this study water samples were collected during the month March, 2021. The spring is naturally sulphurous, and the gas gives the air a sulphurous odour. The various physicochemical parameters such as pH, temperature, electrical conductivity(EC), total dissolved solids (TDS), total hardness (TH), major ions(Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, F^{-}, SO_4^{-}) and trace elements (Fe^{2+}, Cr^{3+}, Zn^{2+}, Cd^{2+}, Cu^{2+}, Mn^{2+}, Ni^{2+}, and Pb^{2+}) were measured.The results reveals that the discharge of the thermal spring shows slightly basic in nature (pH: 7.2) Its temperature (42˚C) lies above the ambient temperature because the high geothermal gradient supplies the deep circulation of meteoric fluids, which attain a high temperature before reaching to the surface.The total dissolved solids (TDS) and electrical conductivity of the thermal spring water are 243.3 mg/l and 380.1µS/cm respectively. The thermal spring water belongs to Na-HCO3 type. The geochemical characteristics of the thermal spring water depends on the lithology of study area. Among the all major ions,Na^{+} dominate the cation budget, while HCO_3^{-} dominate the anion budget. The concentration of trace elements of the thermal spring lies within the permissible limit as per BIS (2012) and WHO (2011) standards.

Key Words: Taptapani thermal spring; Hydrochemistry; Trace elements

CMIP6-BASED EVALUATION OF WATER AVAILABILITY AND POTENTIAL EVAPOTRANSPIRATION TRENDS IN VARANASI

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ABSTRACT

Using modelled data from the CMIP6 Multi-Model Ensemble (MME) and observational data from the India Meteorological Department (IMD), this study assesses spatial and temporal trends of Water Availability (WA) and Potential Evapotranspiration (PET) over the Varanasi region. T1 (1954–1984) and T2 (1985–2014) were the two time periods examined in order to evaluate the coherence and

inconsistencies between observational and model data. In both datasets, the results show an important connection between PET and WA, with higher PET values correlated with more water availability in the area. While the CMIP6 model projected similar increases in the northern region, the IMD data spatially showed higher WA and PET in the southern sections of T1.

The northern and northeastern regions of T2 displayed greater values for both datasets, despite the CMIP6 model's tendency to overestimate WA and PET. Although there were some overestimations and spatial shifts, the CMIP6 model did a good job of capturing the general hydrological dynamics of the area. The study emphasizes the significance of PET as a major factor influencing water availability and indicates that, while more work is required for localized accuracy, the CMIP6 model is a valuable tool for comprehending regional hydrological dynamics. These findings highlight the need for better model inputs and future projections with substantial implications for studies on the influence of climate change on water resources.

Keywords: Water Availability; Potential Evapotranspiration; CMIP6; Varanasi.

FEASIBILITY OF JOINT ESTIMATION OF SEISMIC ATTENUATION USING SHALLOW EARTHQUAKES AND AMBIENT NOISE

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ABSTRACT

The coda of the dominant surface wave phase contains information about how seismic waves attenuate by traveling through the shallow underlying medium, and this is quantified as the coda Quality factor (coda-Q). In the past, the coda of the surface waves from large magnitude earthquakes was used to estimate coda-Q. More recently, it has been demonstrated that the coda of the ambient noise cross-correlations can also be used to estimate coda-Q, even in tectonically active environments. In this study, we explore the conditions in which the coda-Q determined from earthquake waveforms and ambient noise cross-correlations are nearly similar. To this aim, we use the waveform data from stations in Greece, a region with one of the highest recorded seismicity in Europe. Using polarization filters, we identify surface waves in local earthquake waveforms recorded at a station and then use their coda to estimate coda-Q. From inter-station paths similar to the earthquake-receiver path, we estimate coda-Q using the envelope of ambient noise cross-correlations. We repeat the estimation of coda-Q for different values of parameters related to earthquake-receiver and inter-station paths. This experiment gives us an idea about the limit of applicability of joint estimation of coda-Q using both ambient noise and earthquake records. Results from this analysis will be useful for improving sampling resolution in areas with sparse station density, although a greater number of earthquakes, particularly submarine tectonically active regions.

MODELLING OF 1D DC RESISTIVITY AND TEM DATA FOR DEEP AQUIFER DELINEATION IN THE SEDIMENTARY FORMATION OF MARWAR SUPERGROUP

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ABSTRACT

There is an increasing water crisis in the arid region of northwest India mainly due to low precipitation and groundwater overexploitation, especially in the Jodhpur and Jaisalmer districts of Rajasthan. In some places, the water table has gone beyond 100 m depth below the ground surface. According to the CGWB 2022-23 report, more than 10 meters of water level decline in a year was recorded in a few villages viz., Ghana Magra in Jodhpur district. As the water levels are falling significantly deep, it is necessary to explore the deep aquifers to meet the groundwater demands for agricultural, industrial, and domestic purposes.

We have conducted a synthetic simulation, constructing a five-layer model with available lithostratigraphy and resistivity information of the different formation layers in the study area. The first layer is wind-blown alluvial sand (~ 20 m) having a resistivity of 100 ohm-m. The underlying layers of sedimentary formations of Marwar Supergroup are made up of respectively from the top: (i) Nagaur sandstone (~ 100 m, 400 ohm-m), (ii) Bilara limestone (~ 50 m, 150 ohm-m), and (iii) Jodhpur sandstone (~ 200 m, 40 ohm-m) resting over the highly resistive (~1500 ohm-m) rhyolite/granitic basement rocks. We carried out a forward simulation using SimPEG code for the above model to generate the electrical and transient electromagnetics (TEM) sounding data. We added 5 % random noise to the synthetic data. Later, these data sets were inverted considering a smooth layered model i.e. 20 layers with exponentially increasing thicknesses against depth and uniform resistivity of ~ 10 ohm-m. The TEM showed good sensitivity for the Bilara limestone and deep conductive aquifers associated with Jodhpur sandstone. On the contrary, the electrical method showed better sensitivity to the resistive formation of Nagaur Sandstone and the basement rocks. The combined analysis of TEM and VES results incite an improved understanding of the deeper aquifers and resistive basement rocks.

Keywords: 1D, TEM, VES, Synthetics, Sedimentary formations

SEISMIC ATTRIBUTE ANALYSIS AND VISUALIZATION TOOL FOR GEOBODY IDENTIFICATION AND SUBSURFACE INTERPRETATION

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ABSTRACT

In geophysical exploration, understanding subsurface structures is crucial for informed decision-making. The Seismic Attribute Analysis and Visualization Tool, an open-source platform, addresses this need by offering a user-friendly graphical interface that enables researchers, geoscientists, and engineers to analyze and interpret seismic data more effectively. Designed for accessibility and depth, the tool integrates a comprehensive set of seismic attributes—including coherence, dip, energy ratios, and a new unsupervised clustering feature for geobody identification based on the semblance attribute. This clustering capability utilizes DBSCAN (Density-Based Spatial Clustering of

Applications with Noise), allowing users to detect distinct geological bodies within 3D seismic data without labeled data.

A key strength of the tool lies in its seamless integration of advanced methodologies. It incorporates spectral decomposition and wavelet transforms, enabling the examination of frequency-dependent characteristics within seismic data. These techniques provide deeper insights into subsurface structures and material properties by revealing patterns that traditional analysis might overlook. Users can also apply frequency filters such as Butterworth and Chebyshev to refine data, enhancing clarity and resolution. This flexibility allows users to focus on specific frequency ranges, which is essential for identifying subtle geological features and reducing noise.

The tool's intuitive graphical user interface (GUI) simplifies typically complex processes in seismic analysis. Users can upload seismic files, filter frequencies, and generate both 2D sections and 3D visualizations, including spectrograms and window-based frequency spectra. These visualizations offer clear, detailed representations of seismic attributes—from coherence maps to dip models and frequency shifts—assisting users in precisely interpreting subsurface formations. The interactive clustering feature based on the semblance attribute further enables users to visually segment and identify distinct geobodies within the seismic volume, expanding the tool's application in resource exploration and geological characterization.

The platform's focus on interactive, real-time visualization enhances data interpretation and decision-making. By enabling users to interact with seismic data directly and intuitively, the tool facilitates faster analysis and more confident exploration decisions. Users benefit from on-the-fly visual feedback, which clarifies complex patterns and relationships within the data, making it easier to interpret seismic attributes effectively.

As a robust, open-source platform, the Seismic Attribute Analysis and Visualization Tool provides comprehensive attribute analysis, unsupervised clustering, and enhanced visualization. By simplifying complex calculations and supporting intuitive exploration, this tool empowers researchers and professionals to derive actionable insights from seismic data, driving advancements in geophysical exploration and reservoir characterization.

HYDRO GEOPHYSICAL ASSESSMENT OF GROUNDWATER POTENTIAL ZONES AND RECHARGE MECHANISM IN RESILIENT FOREST COMMUNITIES: A CASE STUDY FROM SADHANA FOREST, TAMIL NADU

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ABSTRACT

In semi-arid and tropical regions, groundwater is a crucial resource for sustaining ecosystems and human life. Sadhana Forest, located in Auroville, Tamil Nadu, covers approx. 70 acres of Tropical Dry Evergreen Forest (TDEF) and focuses on reforestation and sustainable water management. This region experiences significant seasonal rainfall variations, influencing groundwater recharge and soil erosion. In this study, Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) were used to delineate subsurface structures and evaluate groundwater potential and recharge zones at

various locations within Sadhana Forest. Resistivity profiles were conducted using Wenner-Schlumberger and Dipole-Dipole arrays with a depth penetration of 50 m. below ground level (bgl), and revealed three-layer geoelectrical structures. The resistivity values vary from <1 Ω·m to >345 Ω·m. Low resistivity (<10 Ω·m) zones at depths of up to ~8 m. bgl indicate saturated clay-rich sediments and suggest significant moisture retention or the presence of shallow groundwater. Moderate resistivity values observed for the second layer are associated with saturated sandy clay or weathered zone, with limited groundwater recharged and potential. High resistivity in the deeper layer indicates fractured bedrock or dry and partially saturated sandy layer, which may enhance the potential for groundwater recharge. Joint application of the GPR, using 100 MHz and 40 MHz antennas, provided high-resolution images of the shallow subsurface. GPR results confirmed an unsaturated sandy soil layer of thickness ~2 m. A high-moisture content layer (~8 m thick) indicated a saturated clay layer, followed by weathered zones that support groundwater recharge potential. The subsurface information acquired by GPR is consistent with ERT results. These non-invasive techniques provide an effective alternative for identifying groundwater potential and recharge zones while maintaining the forest's environmental integrity.

Keywords: Sadhana Forest, Electrical Resistivity Tomography (ERT), Ground Penetrating Radar (GPR), Sustainable Water Management

A PHYSICS-INFORMED DEEP LEARNING BASED METHOD TO ESTIMATE THE PETROPHYSICAL PROPERTIES FROM THE POSTSTACK SEISMIC DATA

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ABSTRACT

Petrophysical property inversion plays a vital role in reservoir characterization, allowing for the estimation of subsurface properties such as porosity, water saturation, and volume of shale. Traditional methods often depend on deterministic or geostatistical approaches, which are dependent on the assumptions about geological structures, stratigraphic layering, expected variation physical properties and data complexity. While supervised machine learning techniques have been explored, they face challenges like a limited number of wells and corresponding basic wireline logs and therefore the predicted petrophysical outputs may not align with physical or geological principles. In this work, we present a self-supervised physics-informed deep learning neural network model which is capable of estimating petrophysical properties directly from seismic data with minimal well data information. The model is trained on synthetic datasets and incorporates a low frequency prior trend to guide the inversion process. By embedding domain knowledge through physics-based constraints, the model enhances the accuracy of prediction while preserving geological realism, offering a more robust solution for subsurface reservoir property estimation.

Keywords: Reservoir characterization, Supervised machine learning, Physics informed deep learning.

SPATIO-TEMPORAL VARIATION OF B-VALUE IN THE SEISMICALLY CLUSTERED ZONES OF HIMALAYA

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ABSTRACT

The ongoing collision between the Indian and Eurasian plates in the Himalaya leads to frequent earthquakes, exemplified by the recent 2015 Gorkha earthquake and the 2022/23 earthquakes in western Nepal. This study identified high-clustered zones in the Himalaya, defined as four rectangular regions spanning west to east, focusing on areas with significant earthquake clustering and magnitudes. Seismic data are taken from International Seismological Centre (ISC) catalog for the period 1964 to 2022. A total 7172 number of earthquakes are downloaded and de-clustered with 95% confidential level and depth error 2 km. Of the total dataset, 3,932 earthquakes fell within the designated zones. The b-values for the respective zones were calculated as 0.67±0.02 with Mc=3.6, 0.70±0.02 with Mc=3.6, 0.80±0.03 with Mc=3.8, and 0.72±0.03 with Mc=3.9. Zone 3 (85° to 89°E and 26.5° to 29°N) shows greater stability in its b-value compared to other regions but reflects a lower stress level, likely due to stress release from the Gorkha earthquake in 2015. In Zone 2 (80° to 85°E and 27.5° to 31°N), the bvalue variation with depth differs notably from other regions. An increase in the b-value at a depth of 35 km may indicate the presence of fractured materials, likely resulting from smaller, frequent earthquakes. The b-value in Zone 1 (75° to 80°E and 30° to 34°N) has shown a gradual decrease over time, while the region has yet to experience a major earthquake, raising potential concerns about accumulating seismic stress. This study, through a comparative analysis of b-value and stress levels, raises concerns about the potential for a large earthquake in the Himalaya. Keywords: Himalaya, b-value, Seismic activity, Stress, G-R relation.

THERMOCHORNOLOGICAL CONSTRAINTS OF THE EXHUMATION OF THE LESSER HIMALAYAN TECTONIC WEDGES ALONG YAMUNA VALLEY NW-HIMALAYA, INDIA.

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ABSTRACT

Mio-Pleistocene thermochronological records from FT zircon-apatite ages in the NW-Himalaya India, specifically within the Yamuna Valley of Uttarakhand, exhibit spatial heterogeneity in exhumation rates. This study employs apatite-zircon fission track (AFT-ZFT) thermochronology to elucidate the exhumation histories of the Purola Klippe and Kharsali Window in the Garhwal regions of the Himalayas. A total of 20 fission track cooling ages were estimated along an approximately 40 km transect perpendicular to the orogen, spanning the Yamuna and Purola traverses. AFT ages in both Yamuna and Purola traverses exhibit a similar range, from 3.6 ± 0.5 to 5.3 ± 1.0 Ma (Yamuna Traverse) and 3.9 ± 0.6 to 6.2 ± 1.1 Ma (Purola Traverse), with corresponding mean ages of 4.47 ± 0.7 Ma and 4.62 ± 0.77 Ma. In contrast, zircon fission track ages display a broader range, spanning 3.1 ± 0.1 to 5.6 ± 0.3 Ma with a mean age of 4.54 ± 0.2 Ma (Yamuna Traverse) and 9.2 ± 0.5 to 13.2 ± 0.6 Ma with mean age 10.86 ± 0.48 Ma (Purola Travers). Tectonic processes exert a dominant

control on exhumation patterns in the NW-Himalaya. Specifically, rapid duplexing in the Kharsali Window region drives accelerated exhumation between 5 to 4Ma, whereas the Purola Klippe exhibits slow exhumation. Following the emplacement of the Purola Klippe, ZFT data indicate that it has remained relatively inactive since the Late Miocene (ZFT age: 10.86 Ma). However, AFT ages exhibit a flat trend across the area. It indicates a uniform vertical uplift since the Pliocene time.

RAYLEIGH WAVE GROUP VELOCITY VARIATION IN INDO-BURMA RANGES AND NORTH-EAST INDIA

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ABSTRACT

Imaging the heterogeneous lithospheric structure of the Indian plate underthrusting beneath the North-Eastern Himalaya and subducting in the east beneath the Burmese arc directly regulates the region's geodynamics and, as a result, its tectonics. The current understanding in the region is restricted due to resolutions spanning over a larger zone. In order to better resolve the regional structural heterogeneities, it is imperative to improve the resolution of the lithosphere and its lateral disposition under different structural units. These findings will shed light on the geodynamics underlying the transcontinental sinking of the Indian and Burmese plates, as well as sediment deposits in North-East India and the Indo-Burma Ranges. Tomographic investigations using surface wave data from earthquakes in Northeast India and Indo-Burma offer an avenue to image the lithosphere. Rayleigh wave group velocity tomography, in its fundamental mode, is utilized to look into the structure and geodynamics of North-East India and its surroundings. Our resolution is higher than that of prior studies since there is a good coverage of stations in and around the region, resulting in dense source-receiver pair ray cross paths. This tomography study indicates a higher Rayleigh wave group velocity in the northern region of the IBR than in the south which connotes the idea of thicker sediments in the Bengal Basin thin from west to east, and that the varying composition of crust from north to south. The northern Indo-Burma Range is composed of ophiolite sequences, metamorphic rocks and volcanic arcs reflecting the a history of oceanic crust being thrust under the continental crust, whereas the southern part of IBR is characterised by the sedimentary basins and less volcanic activity compared to north. Both the Shillong Plateau and the Mikir Hills exhibit low velocity at lower periods but high velocity at higher periods, indicating the presence of sediments in upper layers.

TO STUDY THE CONCENTRATION LEVEL OF RADON GASES FOR EARTHQUAKE PRECURSORS

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ABSTRACT

Radon gas emission is one of the reliable link for investigation of earthquake precursor studies, present work is focused on Radon concentration variations associated with four seismic activities. Its behavior is particularly notable before seismic events with elevated concentrations in expanding zones and decreased levels in compression zones near the epicenter. In this research Alaskan region is

consider for monitoring the radon concentration levels which exhibit significant fluctuations before the earthquake. Present result recorded radon levels of thoron gas which shown the anomalous behaviour during the impending earthquakes. However, high variability of radon concentrations and external environmental influences concluded that extensive long-term monitoring is needed to establish predictive system.

SPATIAL DISTRIBUTION OF RADIOELEMENT ABUNDANCES AND RADIOGENIC HEAT PRODUCTION IN THE PROTEROZOIC CHOTANAGPUR GRANITE GNEISS COMPLEX, EASTERN INDIAN SHIELD: INSIGHTS INTO GEOTHERMAL POTENTIAL AND GEODYNAMIC EVOLUTION

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ABSTRACT

Radiogenic heat production is an important parameter for understanding Earth's geological processes, as it plays a significant role in shaping the crustal thermal structure, driving tectonic activity, and influencing resource exploration. It is also vital for geothermal energy exploration and contributes to assessing and mitigating environmental impacts related to heat flow and geodynamic evolution.

The study region, Proterozoic Chotanagpur Granite Gneiss Complex (CGGC), is an extensive ENE–WSW trending high-grade metamorphic terrain, covering approximately 80,000 km² in the Eastern Indian shield. It is bordered by the Quaternary Gangetic alluvium to the north, Rajmahal basalt to the northeast, Singhbhum mobile belt to the south and Mahanadi Gondwana basin to the west. The Koel-Damaodar Gondwana basin, which divided the CGGC into northern and southern belts, formed an intracratonic rift during the Upper Palaeozoic era. The northern belt is designated as the Daltonganj-Hazaribagh-Dhanbad-Dumka belt, whereas the southern belt is known as the Palamau-Gumla-Ranchi-Purlia belt. Both the belts are composed of granite, granitic-gneiss, migmatites and granulites, along with numerous metasedimentary enclaves with different proportions. This diverse lithological composition makes the CGGC a key region for studying crustal evolution, tectonic processes, and thermal study of the Eastern Indian Shield.

In the present study, radioelement abundances were measured on 280 samples covering major rock types from the CGGC, using a laboratory gamma-ray spectrometric set-up. The average radioelements and heat production show a wide range: thorium goes up to 120 ppm, uranium up to 29 ppm, potassium up to 9.4%, and heat production up to 12.7 μWm^{-3}. The spatial distribution of radioelements and heat production show that the northern belt of the CGGC is associated with mostly low to intermediate values, while in the southern belt associated with mostly intermediate to high values. The observed spatial distribution can also be correlated with major geological formations, tectonics and geothermal potential of the regions.

RISKS ASSOCIATED WITH GROUNDWATER QUALITY OVER VARUNA RIVER BASIN, UTTAR PRADESH, INDIA

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ABSTRACT

The present study includes an approach to determine the groundwater quality and associated human health risks of the Varuna River basin, Uttar Pradesh, India. The study aims to aid improvement in multimodal groundwater management approaches of the area as the place experiences expansion in population along with anthropogenic activities. The study area is situated over the central alluvial Gangetic zone. The silty shallow aquifers are unconfined and coarse; sandy-gravel deeper aquifers are semi-confined. The chemical constituents represent that maximum samples are alkaline, fresh, and hard in the study area according to pH, TDS, and TH. The abundance of major ions is $Na^+ > Ca^{2+} > Mg^{2+} > K^+$, and $HCO_3^- > Cl^- > SO_4^{2-} > NO_3^- > F^-$. Piper diagram shows that Ca^{2+}–Mg^{2+}–HCO_3^- facies are dominant during both seasons. The EWQI (Entropy Water Quality Index) ranks 45% (pre-monsoon) and 50% (post-monsoon) of samples as an excellent category. However, the non-cancerous health risk assessment shows children are more susceptible to fluoride and nitrate contamination. The calculated Hazard Health Index displays the order of Children > Females > Males. The principal cause could be an inadequate resistive capacity of children, followed by the females and males. Therefore, there is a need to maintain the judicious use of groundwater and limit anthropogenic activities to prevent contamination and sustainability.

Keywords: Groundwater, Multi Influencing Factor (MIF), EWQI (Entropy Water Quality Index), bidirectional long short-term memory (BLSTM), Varuna River basin

UNDERSTANDING THE CRUSTAL VELOCITY STRUCTURE OF WESTERN TIBET USING FAST MARCHING SURFACE TOMOGRAPHY

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ABSTRACT

The Tibetan Plateau, formed by the collision between the Indian and Eurasian plates, presents unique geological and tectonic features, with Western Tibet remaining relatively understudied compared to the eastern region. We are addressing key knowledge gaps in understanding the crustal velocity structure of Western Tibet by utilizing group velocity to map the geometry of subducting Indian Plate and assess its influence on regional tectonics. In this study we are exploring the group velocity variations and identifying crustal heterogeneities that could indicate different rock types and fluid content.

The primary method employed is Fast Marching Surface Tomography (FMST), applied to the group velocity data collected from 34 stations within the Y2 Network (2007-2011). We are analyzing approximately 2000 earthquakes with the epicentral distance ranging from 300 to 1,200 Kilometers. For each event, we have picked dispersion curves to extract group velocity variations over a range of periods. The approach of Rayleigh wave group velocity inversion tomography is enabling us to map

and identify the fault zones, including the Karakoram Fault, and understanding the crust-mantle interaction.

The study reveals unique findings including a detailed crustal velocity structure, with a focus on the crust-mantle boundary (Moho) lying at a mapped depth of 55-82 km and attains a depth of 82 km north of Indus-Yarlung suture (IYS). Interpretation of this study refers that the eclogitized Indian lower crust extends up to the central Lhasa Block (LB). The study also provides insights into the dynamics of the Karakoram Fault and the extent of the Indian Plate's under-thrusting beneath the Tibetan Plateau.

3-D DENSITY AND SUSCEPTIBILITY STRUCTURE OF NORTH SINGHBHUM MOBILE BELT: IMPLICATIONS ON CONCEALED SULPHIDE MINERALIZATION

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ABSTRACT

The western North Singhbhum Mobile Belt (NSMB) is crucial for exploring concealed gold (Au) deposits, particularly along the Babaikundi–Birgaon and Lungtu–Parasi lineaments. Previous studies have identified significant gold prospects within various geological formations, including quartz–mica schists and phyllites. This study employs an integrated approach using 3D inversion and bi-dimensional ensemble empirical mode decomposition (BEEMD) methods, utilizing Bouguer gravity and aero-magnetic data. It also incorporates drill hole data, geochemical studies, and regional gravity and magnetic datasets to enhance the understanding of subsurface structures favorable for gold mineralization. The results reveal six high-density and six high-susceptibility bodies, suggesting significant geological features indicative of mineralization. Notably, the identified density and susceptibility models correlate with known gold deposits, providing insights into potential new zones of interest. Three new prospective zones (PZ-I to PZ-III) were delineated based on the integration of geophysical data and geochemical anomalies. PZ-I and PZ-II lie within the Chandil Formation, while PZ-III is at the contact of the Chandil and Dalma Formations, exhibiting favorable characteristics for gold mineralization. Our findings highlight the importance of shear zones as conduits for gold-bearing fluids, supporting the supercrustal metamorphic model. The identification of density/susceptibility gradient zones along key lineaments may guide future exploration efforts. Overall, this study enhances the understanding of subsurface conditions and provides a framework for identifying new targets for gold exploration within the NSMB.

VARIATIONS IN RADIOELEMENT ABUNDANCES AND RADIOGENIC HEAT PRODUCTION OF VARIOUS VOLCANIC ROCKS: THERMAL AND GEODYNAMIC IMPLICATIONS.

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ABSTRACT

Volcanic rocks vary in a wide range from rhyolite to andesite based on the concentrations of SiO_2 (%). The sequence is as follows. Rhyolite (>65%), Comendite (>60%), Dacite (55-65%), Trachyte (50-60%), Andesite (50-55%). In the present study, we have analysed the global geochemical datasets for the above volcanic rocks, including Deccan Trap, Central India and Bundelkhand Craton from the Indian shield, to obtain radioelement abundances (Th, U, K) and calculate radiogenic heat production. Based on the Zr/TiO_2 versus Nb/Y diagram, we have characterized the studied volcanic rocks. In Indian data, for the rhyolite, Th, U, and radiogenic heat production fall within the observed global range, however K falls on the higher side. Rhyodacites, on the other hand, exhibit a wide range of K but show lower Th, U, and radiogenic heat production compared to global data. Andesite shows low radiogenic heat production because of its extremely low Th, U. Trachyandesite has high Th, U, and moderate K. The rhyodacite and rhyolite have comparable K, rhyodacite has extremely low Th and U, which ultimately leads to lower radiogenic heat production. In contrast, comendite produces a lot of heat with very less K and moderate to high Th and U.

The present study indicates that globally for all volcanic rocks, radioelements vary in a wide range due to their difference in mineralogical composition. Further, there are variations within each volcanic rock, depending upon their tectonic setting (e.g. rift or subduction zones), and formation processes (e.g. fractional crystallization, multiple eruption of lava). As a result, a comprehensive and systematic study is essential to accurately access the radiogenic heat production of the volcanic rocks, which are important components for thermal modelling in any geothermal region.

OVERTURNING NATURE OF THE SUBDUCTING SLAB IN THE ANDAMAN AND SUMATRA SUBDUCTION ZONE: A NUMERICAL STUDY USING ASPECT

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ABSTRACT

The Andaman and Sumatra subduction zone presents a unique tectonic behavior characterized by the overturning of the subducting slab, which distinguishes it from more typical subduction zones. This study delves into the complexities of this phenomenon through high- resolution numerical simulations conducted with the Advanced Solver for Problems in Earth's ConvecTion (ASPECT) software. Our simulations, which span a geological timescale of 15 million years, reveal intricate details about the dynamics of the subducting Indo-Australian plate. The relatively young and buoyant plate, with a density of 3000 kg/m³, interacts with the curved and segmented geometry of the subduction zone, leading to a unique stress distribution and slab dynamics. The thermal structure, influenced by a serpentinized mantle wedge with a low thermal conductivity of 1 W/m·K and a density of 2950 kg/m³, further complicates the subduction process by altering the thermal gradient and buoyancy

forces. Additionally, the trench rollback rate of 5 cm/year, hydration and serpentinization processes, and variable viscosity ranging from 1e20 to 1e22 Pa·s, contribute to the slab's deformation and overturning. The ambient mantle flow, modeled with a gravitational force of 9.81 m/s², interacts with the subducting slab to generate torques and forces that drive the slab's overturning nature. The high-resolution capabilities of ASPECT allowed us to capture these fine-scale features and long-term dynamics, providing valuable insights into the region's tectonics. This study not only enhances our understanding of the Andaman and Sumatra subduction zone but also has significant implications for seismic hazard assessment and geodynamic research. Future work will focus on incorporating three-dimensional models and exploring the impact of additional factors such as fluid migration and mantle flow on subduction dynamics.

Keywords: Subducting slab, Andaman and Sumatra subduction zone, numerical simulation, ASPECT, tectonic dynamics, seismic hazard.

ANALYSIS OF HIGH-RESOLUTION AEROMAGNETIC DATA FOR STRUCTURAL MAPPING AND SEARCH OF POLYMETALLIC SULFIDES IN AMBAJI SHEAR ZONE AREA, GUJARAT, NW INDIA

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ABSTRACT

The Ambaji granulite terrane located at the southern part of the Aravalli – Delhi Fold Belt (ADFB) is known to have potential for polymetallic sulphides. It is bounded by the Kui - Chitraseni, Surpagla and Kengora faults. Here, an attempt has been made to understand the magnetic characteristics of the ambaji granulite terrane and associated structural features from aeromagnetic data. The nature of shearing and associated structural features has been well demarcated from the aeromagnetic data. The contacts between the pelitic granulite, calcareous granulite, mica schist and amphibolites have been delineated. Further, several granitic intrusives have been identified in terms of magnetic anomalies with varying amplitudes. Analytical maps of the aeromagnetic data have brought out the NE-SW, NW-SE, N-S and E-W trending magnetic lineations which might be geological lineament/faults. The polymetallic ore deposits that are confined in the study area are probably along the structural lineaments and indicate that the study area is structurally controlled. The present study provides insights into the magnetic structural fabric associated with lineaments/faults in and around the Ambaji shear zone area. Interpretation of these magnetic anomalies in terms of subsurface structural variations suggests that the study area has experienced different crustal agglomerations.

Keywords: Aeromagnetic, Ambaji granulite terrane, Shear zone, Lineaments, Faults.

CHARACTERIZING EARTHQUAKE SOURCES: PARAMETER ESTIMATION FOR HAZARD MITIGATION

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ABSTRACT

Earthquake source parameters, such as seismic moment, fault dimensions, rupture area, and stress drop, are crucial for understanding the mechanics of seismic events. These parameters provide

insights into the energy release and the dynamics of faulting processes during an earthquake. This study analyses the data of 150 earthquakes recorded at 33 stations, utilizing techniques such as spectral analysis and empirical Green's function methods. In this study we have estimated seismic moment (M_0), corner frequency (f_c), source radius (r) and stress drop (Δ_s) for all the earthquakes occurring in the Northwestern Himalayas between 2011 to 2016 using Seisan software. Then using linear regression, we have derived the correlation between seismic moment and corner frequency along with the correlation between seismic moment and stress drop for the northwestern Himalayas.

Keywords: Stress drop, Earthquake, Source Parameters, Northwest Himalayas

DATA-DRIVEN FULL WAVEFORM INVERSION (FWI): A PROMISING APPROACH FOR A ROBUST AND GENERALIZED INVERSION

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ABSTRACT

Full Waveform Inversion (FWI) is a sophisticated seismic processing technique used to derive high-resolution subsurface images from seismic measurements. Accurate imaging of subsurface elastic properties is crucial for reservoir characterization, exploration, and engineering applications. FWI has garnered significant attention in the oil and gas industry in recent years because of advancements in acquisition technologies and computational power. However, traditional Physics-based FWI is non-linear, ill-posed inverse problem, making it highly sensitive to the initial model and prone to cycle-skipping problems due to the lack of low-frequency content in seismic data. Additionally, it is computationally expensive, as it requires iterative optimization, with the wave equation being solved at each iteration using finite difference methods. In this study, we propose a data-driven FWI approach that integrates Convolutional Neural Networks (CNNs), such as encoder-decoder architectures, with the FWI framework. The CNN is trained to regularize the inversion process by learning an inverse operator that directly maps seismic data to velocity models. This regularization mitigates the ill-posed nature of traditional FWI and accelerates the process, as neural networks are inherently suitable for great parallelization, making the inversion more efficient and robust. Therefore, our purpose is to present a comparative study between the traditional Physics-based FWI and the Data-driven FWI.

CRUSTAL STRUCTURE ESTIMATION IN THE KUMAUN HIMALAYAS USING GRAVITY MODELLING

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ABSTRACT

A gravity profile survey was conducted across the Kumaun Himalaya, from the Indo-Gangetic Plain (IGP) to the Main Central Thrust (MCT) zone, India. The region exhibits diverse geodynamic behavior, encompassing a variety of complex seismically active fault zones. To investigate this

tectonic system, gravity measurements were conducted along a ~229 km transect, with station spacing of approximately 2 km across the Indo-Gangetic Plain (IGP) and 1 km within the Himalayan region. The profile data is constrained by incorporating results from previous geophysical and geological studies, power spectrum analysis, gravity separation techniques, wavelet analysis, and 2D forward modeling to generate a subsurface image of the study area. Given the geological complexities, spectral analysis is performed separately for the IGP and Himalayan segments. In the IGP, two dominant layer interfaces were identified at depths of 39 km and 5 km, corresponding to the Moho and the Indo-Cratonic Basement, respectively. Similarly, the power spectrum of the Himalayan segment revealed the Moho at a depth of 46 km and the Main Himalayan Thrust (MHT) at 10 km. Gravity isolation techniques are employed, incorporating existing geophysical and geological information, to separate individual gravity responses related to the tectonics of the Himalaya. This approach also enabled the identification of gravity effects from the upper crustal region, including major fault and thrust zones. The computed residual gravity anomaly prominently highlighted key tectonic structures. Inversion of the residual anomaly provided insights into the geometries of fault and thrust zones. Our model indicates a northward-dipping Moho, with depths ranging from ~39 km to 46 km, and the derived geometry of the MHT clearly reveals a ramp structure. The proposed density model effectively delineates the geometries of various crustal structures across the Kumaun Himalaya, offering new insights into the upper crustal fault zones.

A SPATIOTEMPORAL STUDY OF EARTHQUAKE OCCURRENCE WITH HYDROLOGICAL DATA: A CASE STUDY FROM DELHI-NCR

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ABSTRACT

Irrespective of the tectonic setting hydrological factors play an important role in influencing earthquake activity of region. Utilizing satellite-based hydrological data from GRACE, GRACE FO, and CHIRPS, we analysed the spatial and temporal distribution of earthquakes in relation to groundwater levels and rainfall patterns of Delhi-NCR. Our findings reveal a significant decline in groundwater levels at an average rate of 4.596 cm/year, despite relatively stable rainfall trends, suggesting a predominant anthropogenic influence on groundwater extraction. Spatial analysis demonstrates a correlation between earthquake distribution and hydrological conditions, with a higher concentration of earthquakes in areas characterized by higher rainfall and groundwater levels. Temporal analysis indicates a complex relationship between earthquake occurrence and hydrological factors. While no direct correlation was observed with GRACE or CHIRPS time series data, a pattern emerged: earthquakes in the northern region tend to peak after periods of elevated groundwater loading, whereas those in the southern region correlate more closely with rainfall patterns. This pattern aligns with the geological characteristics of the region, as alluvium thickness decreases, and rock exposure increase from north to south. Our research highlights the importance of considering hydrological factors in earthquake hazard assessment and suggests that anthropogenic activities affecting groundwater resources may play a significant role in modulating seismic activity within the Delhi-NCR region.

Keywords: Groundwater, Rainfall, Earthquake, loading.

INFLUENCE OF HETEROGENEOUS THERMAL STRUCTURE ON THE ONSET OF CONVECTION IN THE PRESENCE OF MAGNETIC FIELD AT THE EARTH'S CORE

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ABSTRACT

Earth and other planetary bodies in our solar system sustain a magnetic field that originated from the dynamo action in the interior. The convection-driven dynamos derive energy from the secular cooling of the inner core, and the heat flow from the core to the mantle is controlled by the core-mantle boundary (CMB). From various geophysical investigations, such as seismology, geomagnetism, high pressure and temperature mineral physics, it has been observed that the heat flow at the top of the CMB is inhomogeneous such as low heat flow beneath the central Pacific and south of Africa, and high heat flow beneath the East Asia, Australia and America. In the present study, the back reaction of magnetic fields on the onset of convective instability inside the inner core tangent cylinder is investigated by incorporating various laterally varying thermal structures at the top plate of a plane layer convection model. Different orientations of imposed magnetic fields of various strengths have been implemented under various rotation rates to constrain the evolution of convective length scales at the onset. Consequently, localized convective flow clusters have been developed in the regions of heat flow higher than the mean heat flux as a consequence of imposed laterally heterogeneous thermal structures. Additionally, convective clusters have developed with both odd and even orders of thermal heterogeneity, resulting in laterally asymmetric and symmetric structures respectively. As a result of rapid rotation, small-scale columnar rolls are formed in a weak magnetic field, regardless of the magnetic field orientation. However, under a strong magnetic field with a horizontally imposed magnetic field, large-scale convection rolls are developed. Furthermore, an increase in magnetic field strength results in enhancement in the delay of convective instability.

DYNAMIC TRIGGERING IN THE JAMMU AND KASHMIR, WESTERN HIMALAYA REGION DUE TO INDIAN OCEAN EARTHQUAKE, 2012

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ABSTRACT

Dynamic triggering of earthquakes and tremors refers to the phenomenon where seismic waves generated by a distant earthquake affect a local fault system, potentially inducing further seismic activity. This study investigates the occurrence of dynamic triggering in the seismically active Jammu & Kashmir region of the northwestern Himalayas, a region characterized by complex tectonics and high seismicity. We analyzed seismic data from a selection of teleseismic events that occurred over the last decade to assess the prevalence of dynamic triggering in this area. Our study focuses on eight significant seismic events from 2011 to 2015, specifically choosing those events where the dynamic stress was greater than or equal to 5 kPa. Our findings indicate seismicity triggered by the April 11, 2012 (Mw 8.6) Indian Ocean earthquake, with possible signs of triggering from the 2011 Tohoku event as well. Our analysis identified triggering in the region. We found that the dynamic triggering predominantly takes place near the Main Central Thrust (MCT), a major structural feature in the region, indicating a heightened sensitivity of this fault system to external seismic influences. The minimum dynamic stress of the order of 40 kPa seems suitable for triggering in the region, which is higher compared to other seismically active regions, which may reflect the unique geological and tectonic characteristics of the area.

ADVANCES IN EARTH SYSTEM SCIENCES WITH SPECIAL REFERENCE TO WEATHER AND CLIMATE

PROJECTED SHIFTS IN THE INDIAN SUMMER MONSOON: A CMIP6-BASED ANALYSIS

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ABSTRACT

This study investigates projected changes in the Indian summer monsoon (ISM) under different climate scenarios using the CMIP6 multi-model ensemble (MME) approach. By focusing on the complex interactions between the ISM and surface energy components, the analysis includes rainfall, latent heat flux (LHF), sensible heat flux (SHF), and the Bowen ratio to gain deeper insights into how these elements influence monsoon behavior. Using data from the SSP2-4.5 and SSP5-8.5 scenarios across historical (1981-2010), near-future (2031-2060), and far-future (2071-2100) periods, the study identifies key spatial and temporal changes in rainfall, temperature, and surface flux patterns. The findings reveal notable shifts in LHF, SHF, and the Bowen ratio, with Central India (CI) and the Western Ghats (WGs) emerging as potential climate hotspots. In CI, projected increases in SHF relative to LHF suggest a shift toward drier conditions, with SSP5-8.5 indicating a higher risk of heatwaves and dry spells due to increased sensible heat. Conversely, coastal areas like the Bay of Bengal (BoB) and Arabian Sea (AS) exhibit a strong LHF response from rising sea surface temperatures, potentially amplifying monsoonal rainfall.

Keywords: Indian Summer Monsoon; CMIP6; latent heat flux; sensible heat flux; Bowen ratio; regional climate impacts.

ENHANCING CLIMATE PROJECTIONS: OPTIMIZING CMIP6 MODELS AGAINST IMD RAINFALL DATA FOR RELIABLE EXTREME EVENT FORECASTING IN INDIA

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ABSTRACT

This study evaluates the performance of CMIP6 climate models against observed IMD rainfall data, revealing that many models fail to accurately capture historical precipitation patterns. Consequently, the reliability of future projections derived from these models is called into question. To enhance model accuracy, we employed both global and local optimization algorithms aimed at minimizing root mean square error (RMSE) and bias. This optimization process significantly improved model outputs, aligning them more closely with observed data. Additionally, we conducted projections of extreme weather events, such as droughts and floods, over India. The findings underscore the importance of model optimization in producing more reliable climate projections, ultimately contributing to better preparedness and mitigation strategies for extreme events in the region.

Keywords: Global & Local Optimization Algorithm, RMSE, BIAS, CMIP6 Models, Rainfall

MULTI-HAZARD ASSESSMENT IN THE DHAULIGANGA RIVER BASIN: INTEGRATING HYDROLOGICAL, METEOROLOGICAL, SEISMOLOGICAL, AND REMOTE SENSING DATA

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ABSTRACT

The Dhauliganga River Basin is increasingly vulnerable to a range of hazards, including glacial lake outbursts, extreme rainfall events, landslides, and landslide lake outburst floods, as well as other glacier-related hazards. These events pose significant risks to both the local environment and communities. Ice-rock failures do not occur suddenly; they are preceded by multiple progressive nucleation phases during which the relaxation or rearrangement of material leads to creep, accelerating over time before a major rupture occurs. This gradual process highlights the importance of early detection and monitoring. Monitoring surficial dynamics in the Himalaya is both challenging and costly, complicating scientific research efforts. This gap in real-time monitoring underscores the need for comprehensive hazard assessment strategies. Our focus is on the Chamoli region, identified as one of the most vulnerable and hazard-prone areas in the northwestern Himalaya. On February 7, 2021, a substantial rock-ice mass detached from the Raunthi peak, located at an altitude of 5600 meters in the Chamoli district of Uttarakhand. This event illustrates the urgency of understanding the dynamics of ice-rock interactions and their potential hazards. In the aftermath of the Chamoli disaster, we are prioritizing the monitoring of unfelt activities and anomalies associated with hazards in potentially endangered zones. We also plan to deploy multi-parametric instruments, including automatic weather stations (AWS), broadband seismometers (BBS), automatic water level recorders (AWLR), and infrasound arrays for real-time monitoring and integrated analysis. This approach aims to provide early warnings against hazards in the Himalayan terrain. The establishment of a dense network of sensors will facilitate the collection of high-quality data and critical information, paving the way for improved disaster mitigation and societal benefits. By integrating hydrological, meteorological, seismological, and remote sensing data, we aim to develop a comprehensive understanding of the multi-hazard landscape in the Dhauliganga River Basin.

Keywords: Dhauliganga River, glacial lake outbursts floods, extreme rainfall events, landslides

RECORD BREAKING HEATWAVE (HW) OF 2022 OVER THE NORTHWEST HIMALAYAS (NWH) OF INDIA

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ABSTRACT

The NWH, characterized by extreme climatic conditions and vital water resources, is significantly vulnerable to the impacts of climate change such as HWs. We detected the record-breaking HWs of 2022 over the NWH and identified the primary causal drivers responsible for this event using multiple reanalyzed datasets. We investigated the spatiotemporal variations of temperature (including T_{max}, T_{min}, TX90p and Warm Spell Duration Index), precipitation, Standardized Precipitation Index,

Outgoing Longwave Radiation (OLR), surface and upper atmospheric circulation anomalies. These anomalies exhibited spatial homogeneity, where the regional temperature extremes responded coherently to large-scale atmospheric circulations. The regions of high temperature extremes were triggered by the warm air advection, presence of a persistent anticyclonic ridge and extreme temperature conditions at 500 hPa. Additionally, the snow melted at an alarming rate throughout the NWH during March-May. We find high OLR and record high temperature anomalies as the primary factors driving this rapid snowmelt.

QUANTIFYING CO_2 STORAGE POTENTIAL IN THE KRISHNA-GODAVARI BASIN: A SEISMIC-DRIVEN APPROACH

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ABSTRACT

This study presents a comprehensive evaluation of the Krishna-Godavari Basin's potential for carbon dioxide (CO_2) storage. Leveraging state-of-the-art seismic modeling and petrophysical analysis, we have developed high-resolution subsurface models that accurately characterize reservoir properties, including pay zone thickness, porosity, and water saturation. By integrating well data and seismic inversion techniques, we have successfully identified optimal injection sites and estimated the basin's CO_2 storage capacity. Our findings demonstrate that the Krishna-Godavari Basin possesses significant potential for carbon sequestration, providing valuable insights and methodologies for advancing CCS initiatives in India. This research contributes to the nation's efforts to mitigate climate change through secure and sustainable CO_2 storage solutions.

Keywords: CO_2 Storage, Krishna-Godavari Basin, Reservoir Characterization, Capacity Calculation, Carbon Capture and Storage (CCS), Seismic Model-Based Inversion, Petro physical Analysis, Subsurface Modeling, Effective Storage Capacity.

GEOSPATIAL-BASED RIVER MORPHOMETRIC ANALYSIS FOR EFFECTIVE WATERSHED MANAGEMENT: A CASE STUDY OF A HILLY TERRAIN CATCHMENT.

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ABSTRACT

This study uses geospatial technologies to analyze the morphometry of the Matchkund River catchment in Andhra Pradesh. The results show that the basin area is 802 Sq. km, and the minimum and maximum topographical elevations are 844 m and 1677 m respectively. It consists of the 6th highest stream order. The results indicate the steep to moderate slopes up to the 5th order and the relatively flat topography in the 6th order streams. The length of overland flow is 0.36 km, which denotes a mountainous terrain with shorter surface runoff inside the watershed. The form factor value is 0.439, indicating the present study area is an elongated shape of the basin. The bifurcation ratio value varies from 2 to 5.8, it indicates the higher value of R_b and represents the mountainous region. The infiltration number 0.548, which is very low, indicates higher infiltration. The catchment exhibits

a low drainage density value of 0.724. It is because of the highly resistant permeable subsoil. This might indicate a less-developed drainage system, slower runoff, and a landscape with fewer channels. The low stream frequency of 0.757 km/km^2 in the study area suggests a sparse network of streams relative to the area of the basin. The drainage texture value is 2.01 of the catchments indicating the coarse drainage texture with permeable soils and less groundwater potentiality. This low drainage texture value suggests that the stream segments are shorter compared to the basin's perimeter. This might imply a more irregular or trellis-like drainage pattern, with streams having more bends and twists. The high relief ratio of 1948 in the catchment indicates significant elevation variation within the basin relative to its average elevation. It suggests a rugged terrain with substantial differences between high and low points, indicating a mountainous environment with steep slopes. The hypsometric integral value <0.5 in the catchment area indicates a landscape that is more incised or dissected, with a higher proportion of elevations far from the base level. This might indicate tectonic activity or recent uplift. These analyses provide valuable information for researchers, hydrologists, geomorphologists, and environmental managers to make informed decisions and implement effective strategies for watershed management and environmental protection in the Matchkund River catchment.

Keywords: Geospatial Technologies, Morphometric Analysis

MODELING THE IMPACT OF POLAR ICE CAP MELTING ON EARTH'S ROTATION AND MOMENT OF INERTIA: A NUMERICAL AND THEORETICAL APPROACH

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ABSTRACT

A hypothetical mathematical model has been proposed to study the melting of polar ice caps, which in turn impacts Earth's moment of inertia and rotation. The differential equations governing planetary rotation coupled with mass transfer, reshaping, and the conservation of rotational angular momentum and energy have been simultaneously solved. The effects of Chandler wobble and free core nutation on the rotation axis drift has been partially considered which in turn modifies the moment of inertia and the speed of rotation. A finite difference based approach has been employed for the solution of the differential equations, constrained by some real observations such as global mean sea level rise and length of day (LOD) variation data. Mathematical stability analysis is conducted to ensure the stability of the schemes. A simplified theoretical model has also been developed incorporating certain assumptions simplifying the complex and long-term effects of polar ice cap melting. Both numerical and theoretical results are compared in terms of spatial and temporal global as well as regional sea level rise data as well as polar ice distribution data observed by the satellites. The direct and indirect effects such as changes in wind patterns, ocean currents, equatorial bulging, and the impact on Earth's surface and interior dynamics have also been studied additionally.

SUBSURFACE OCEAN CHARACTERISTICS AND THEIR IMPACT ON INDIAN MONSOON ADVANCEMENT: AN ORAS5-BASED STUDY (1992-2017)

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ABSTRACT

The monsoon system over the Indian Peninsula is significantly influenced by the complex interplay between the Indian Ocean and atmospheric conditions. This research investigates how potential temperature and salinity levels in the Indian Ocean vary during the monsoon's advancement phase. To analyse these patterns, we examine daily averages from the European Centre for Medium-Range Weather Forecasts' (ECMWF) Ocean Reanalysis System 5 (ORAS5), spanning 1992-2017. The study specifically explores how oceanic characteristics, including sea sub surface temperature and salinity, affect the timing, strength, and length of monsoon seasons. Prior to monsoon advancement, the Indian Ocean exhibits notable variations in potential temperature and salinity distribution. The Arabian Sea, in the western Indian Ocean, shows elevated salt concentrations in its upper subsurface waters. In contrast, the eastern Indian Ocean's Bay of Bengal demonstrates markedly lower salinity levels at similar depths. This east-west salinity contrast becomes less pronounced at greater depths, primarily due to the freshwater influx from rivers flowing into the Bay of Bengal. Highest potential temperature has been observed up to 20 meters depth and slightly later in fast advancement year than slow advancement year. Salinity between 60 to 80 meters depth in region R1 (AS) and R3, R4 shows different in nature. Contrast in temperature and salinity between AS and BoB has been observed higher in fast advancement year shows greater evaporation in 2005 than 2002 and wind play crucial role in transferring moisture all over India.

Keywords: Indian Ocean, Summer Monsoon, Potential Temperature, Salinity.

CLIMATE CHANGE AND ITS EFFECTS

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ABSTRACT

Climate change is the term used to define the long-term changes in the temperature and weather, which may be natural or human-induced. During the last two centuries, human activities have influenced climate change, mainly due to greenhouse gas emissions and the burning of fossil fuels. India’s temperature has increased by around 0.7 C since 1901. The increase in temperature has affected living beings. Climate change results in extreme events like floods, droughts, and cyclones, affecting around 80% of the country's population. Due to the increase in temperature, ice in higher regions melts fast and sees level increases, which is a major concern for the coastal region. Around 18% of the world's population lives in India. Climate change can be reversed by the optimal use of ACs and freezers, planting more trees, sequestration of Co_2 from industries, hydrogen fuel for vehicles, and renewable energy sources.

UNDERSTANDING EXTREME RAINFALL PATTERNS IN THE DHAULIGANGA BASIN: CHALLENGES FOR MANAGEMENT AND HAZARD RESPONSE

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ABSTRACT

The Himalayan region, renowned for its stunning landscapes and ecological significance, is increasingly facing heightened climatic vulnerability. Factors associated with this vulnerability, such as shifts in rainfall patterns, cloudbursts, flash floods, and accelerated glacial retreats, have become significant concerns in the Indian Himalayan region. This study analyzes extreme rainfall events, incorporating intensity analysis to quantify and understand the variabilities in the Dhauliganga basin of Chamoli district, Uttarakhand. The results will be compared with available published data to provide a comprehensive understanding of these trends. Cloudburst events at higher elevations in Uttarakhand are crucial for understanding the patterns of flash floods and recurrent landslides. We employed open-source data from the GIOVANNI Earth Data network to examine the spatio-temporal dynamics within the Dhauliganga basin. The IMERG TRMM data, recorded over a 24-year period (2000–2024), was meticulously analyzed for the monsoon months of June, July, and August. Our results indicate that the intensity of extreme rainfall and cloudburst events reached its highest levels in 2021, 2022, and 2023. To mitigate and predict the consequences of hydro-meteorological hazards, we detail climate vulnerability and its impacts through various seasonal and annual data plots in the subsequent sections.

Keywords: Dhauliganga basin, Monsoon, cloudburst events, Satellite based observations

CLIMATE CHANGE: A GLOBAL CHALLENGE

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ABSTRACT

Climate change, driven primarily by human activities, presents a complex and pressing global challenge with far-reaching consequences. Rising greenhouse gas emissions, predominantly from the burning of fossil fuels, are trapping heat in the Earth's atmosphere, leading to a warming planet. This warming has triggered a cascade of environmental and societal impacts, including extreme weather events, rising sea levels, ocean acidification, biodiversity loss, food insecurity, and economic losses. Addressing climate change necessitates a comprehensive and coordinated global response that encompasses both mitigation and adaptation strategies. Mitigation efforts focus on reducing greenhouse gas emissions to limit future warming, while adaptation strategies aim to adjust to the impacts of climate change that are already occurring or expected to occur in the future. Energy transition, energy efficiency, carbon capture and storage, forest conservation, and afforestation are key mitigation strategies. Infrastructure development, agricultural practices, coastal protection, and public health measures are essential adaptation strategies. A holistic approach that integrates mitigation and adaptation is crucial to effectively address the multifaceted challenges posed by climate change. The urgency of climate change demands immediate and ambitious action from governments, businesses, and individuals worldwide. By working together, we can mitigate the worst effects of climate change and build a sustainable future for generations to come.

EMISSION OF FINE PARTICULATES FROM FOREST FIRE USING SATELLITE DATABASE

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ABSTRACT

Global forests face unprecedented fire activity and severity, with mega fires erasing years of emissions reductions and threatening life and infrastructure. This study used 2017 MODIS L3 Global Land Cover product (MCD12Q1) data to assess Hindu Kush Himalayan forest cover in 2017, classifying land types from evergreen forests to savannas and estimated $PM_{2.5}$ emissions via the VIIRS-based Fire Emission Inventory. The VIIRS-based Fire Emission Inventory (VFEI, Version 0) is innovative among top-down approaches, providing daily emission fluxes at a high resolution of 0.005° (0.5 km). Forest fires in Hindu Kush Himalayan region were found to emit 0.40 Tg yr^{-1} of $PM_{2.5}$ annually. $PM_{2.5}$ emissions from fires showed a statistically insignificant annual decrease (-0.02 yr^{-1}) with 94% of emissions (0.57 Tg) occurring from February to May, primarily in March. A distinct peak is observed during March across all years, in 2017, the highest emission was recorded at approximately $3.6*10^8$ followed by $2.9*10^8$ in 2020, $2.8*10^8$ in 2018, $2.7*10^8$ in 2019, and $2.1*10^8$ in 2021. The months of February to April consistently account for 80-90% of the total annual emissions. After the March peak, emissions decline dramatically, dropping to below $0.5*10^8$ by May, and remaining nearly negligible from June to November. A minor increase in emissions can be observed in December for some years, though the values remain small in comparison to the March peak. This pattern suggests that the majority of fire activity is concentrated in the early spring, driven by regional climatic or land-use factors, with March being the dominant month for fire-related emissions throughout the study period. Other studies have reported that the annual $PM_{2.5}$ emissions from open biomass burning across South and Southeast Asia, excluding the northern regions of the Hindu Kush Himalaya (70°-130° E, 0°-28° N), amount to approximately 4 Tg, with a significant portion attributed to peat fires in Indonesia and Malaysia. This study highlights the significant role of forest fires in trace gas emissions, emphasizing the need for monitoring and improved fire management strategies in South Asia. Understanding their impact on atmospheric carbon cycling is crucial for effective climate mitigation and adaptation.

Kewords: VFEI, MODIS, emissions, VIIRS, $PM_{2.5}$

AN ASSESSMENT OF EXTREME PRECIPITATION EVENT OVER SOUTHERN WESTERN GHATS BASED ON IN-SITU OBSERVATIONS AND HIGH-RESOLUTION MODEL SIMULATIONS

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ABSTRACT

The study evaluates an extreme rainfall event that occurred in the Southern Western Ghats, at High Altitude Cloud Physics Observatory (HACPO; 10° 9′ 19.94″ N, 77° 1′ 6.65″ E, 1820 m above MSL)

in Rajamallay Munnar Idukki, Kerala during 6 to 10th August 2019. Using high-resolution WRF model simulations, we analysed heavy rainfall through schemes such as the Betts-Miller-Janjic (BMJ), Modified Tiedtke (MT), KIM Simplified Arakawa-Schubert (KSAS), and a newer Tiedtke (NT). Model is initialized with ERA-5 and National Centers for Environmental Prediction (NCEP) reanalysis data for the period 6 to 10 August 2019. The rainfall simulations were compared with in-situ rain gauge observations over the region. The insitu observations reported that an extreme precipitation of 220.5 mm and 425.7 mm was noted on August 7 and 8, respectively. BMJ model has captured the extreme precipitation occurred on August 8 which was up to approximately 448 mm while the observed is 425.7 mm. Even though, an overestimation of rainfall is observed in the BMJ scheme using ERA-5, but propagation and peak intensity is found better with BMJ compared to other three models. The four models were weak in capturing the low precipitation zones over the region. The extreme rainfall simulation using NCEP dataset showed an overestimation in all four schemes except for August 8. The study shows that schemes are having a bias for simulating the extreme rainfall in the elevated terrains of Western Ghats. For better performance an appropriate parameterization of schemes will help in efficient weather forecasting in the regional scales.

SOURCE CHARACTERIZATION AND SEDIMENT TRANSPORT IN THE GANGOTRI GLACIER BASIN, GARHWAL HIMALAYA

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ABSTRACT

The Gangotri Glacier is the largest glacier in the Uttarakhand Himalaya and serves as the source of the Ganges, one of the world's most prominent rivers, providing significant water and sediment supply. The glacier is heavily covered with debris, which is likely the primary source of suspended sediments. Enhanced glacial melt due to rising temperatures accelerates erosion, while intense monsoon precipitation increases sediment mobilization downstream. Understanding the sources of these sediments and how they are transported is crucial for analyzing their role in natural hazards such as floods and glacial lake outburst floods (GLOFs). In this study, we aim to identify the sources of sediment in the Gangotri Glacier system and understand the processes involved using techniques such as granulometric analysis, mineralogical assessments through X-ray diffraction (XRD), and geochemical profiling via inductively coupled plasma mass spectrometry (ICP-MS). These assessments will determine sediment composition and provenance in the studied region. The accumulation of sediment not only alters the flow and characteristics of downstream rivers but also increases the intensity of flooding and glacial lake outburst events. Our findings underscore the need for integrated monitoring of both sediment transport and hazard risks in the Himalayan region, particularly as climate change accelerates these processes. The dynamics of sediment have significant implications for natural hazards. An enhanced sediment load in Himalayan Rivers raises the risk of aggradation, alters river morphology, and increases flood potential during monsoon seasons. Additionally, sediment-laden meltwater affects water quality and poses challenges for hydropower infrastructure and agricultural activities reliant on glacier-fed rivers. This study emphasizes the necessity for continuous monitoring of sediment production and transport in the Gangotri Glacier to inform regional disaster preparedness and adapt to the ongoing impacts of climate change.

Keywords: Himalaya, Gangotri Glacier, Debris, Suspended Sediment

COMPREHENSIVE MULTI-PARAMETRIC APPROACH FOR EARTHQUAKE PREDICTIONS AND EXPLORING THE LITHOSPHERE-ATMOSPHERE-IONOSPHERE INTERACTIONS FOR IMPROVED SEISMIC FORECASTING

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ABSTRACT

Present study explores the utility of multi-parametric approach for earthquake prediction, the phenomenon of coupling between the Lithosphere, Atmosphere, and Ionosphere (LAIC) over the active geological faults which can induce remarkable changes in the physical parameters of earth's environment. Due to p-holes theory of stressed rock can emit radon gases in and around the fault zone which may be responsible for modulations of seismic acoustic waves and produce changes in many physical parameters. In this investigation results shown that radon gas emissions are responsible for LAIC phenomenon. Integrated multiple parameters are shown variations just few days before the impending earthquakes. A result highlighted the values of physical parameters for improving earthquake early warning systems and provides a deeper understanding of seismic dynamics and their associated perturbations. The methodology definitely offers a promising pathway for future earthquake forecasting and hazard mitigation efforts.

UNDERSTANDING EXTREME RAINFALL AND TEMPERATURE EVENTS IN INDIA: TRENDS, IMPACTS, AND ADAPTIVE STRATEGIES.

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ABSTRACT

India is increasingly facing the challenges of extreme and erratic rainfall and temperature events, such as intense heatwaves, unseasonal floods, and prolonged droughts in recent years which have far-reaching implications for the country's ecosystems, economy, and public well-being. This study aims to examine the patterns of these extreme weather phenomena, their causes, and their socio-economic impacts, with a particular focus on the rising frequency and intensity of heatwaves and unseasonal, heavy rainfall across various regions.

The study identifies trends in temperature and rainfall extremes over the past three decades by analyzing historical data on daily maximum temperatures, minimum temperatures, and precipitation. The major drivers behind the anomalies obtained in the trends are identified as global warming, land use changes, and anthropogenic influences caused by urbanization which have been analyzed through time-series analysis along with extreme event modeling and the spatial mapping of various parameters using GIS further highlighting the geographic variability in these events, particularly the increasing unpredictability of the monsoon system and the growing intensity of heatwaves in northern and central India.

By providing a comprehensive overview of India's evolving climate patterns, this poster presents critical insights into how erratic weather is reshaping the country's landscape and proposes practical steps for building adaptive capacity to mitigate future risks.

OCEAN-ATMOSPHERE INTERACTIONS: A VITAL CONNECTION TO WEATHER AND CLIMATE

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ABSTRACT

One of the main components of Earth's climate system is the complex interaction between the ocean and atmosphere. These two fluid giants are inseparable, exchanging mass, momentum, and energy in a never-ending cycle that has a significant impact on long-term climatic variability and worldwide weather patterns.

As a huge heat sink, the ocean absorbs and retains enormous amounts of solar heat. Through processes like evaporation and conduction, this heat is released into the atmosphere, affecting circulation patterns, humidity levels, and air temperature. Furthermore, the main source of atmospheric moisture, which is necessary for precipitation, is the ocean. The water vapor that condenses to create clouds and rain is produced by evaporation from the ocean surface. By removing carbon dioxide from the atmosphere and assisting in climate regulation, the ocean is also an essential component of the global carbon cycle. Ocean acidification and other adverse effects, however, can result from excessive carbon emissions. Ocean currents carry heat and moisture around the world, affecting atmospheric circulation and weather patterns. As a result, ocean currents and atmospheric circulation patterns are intertwined. The El Niño-Southern Oscillation (ENSO), a significant climate event in the tropical Pacific that is influenced by interactions between the ocean and atmosphere, is a good example.

Sea surface temperatures rise and heatwaves become more extreme as a result of the ocean's increased absorption of heat from the atmosphere due to the ongoing increase in greenhouse gas emissions. Coastal towns are at risk due to sea level rise brought on by this warming. Ocean currents, which can alter weather patterns and have an impact on extreme occurrences, are also being impacted by climate change. Ocean acidification, which damages marine ecosystems, is caused by the ocean's absorption of carbon dioxide from the atmosphere. These interrelated processes demonstrate how urgently climate change must be addressed in order to safeguard our planet and future generations.

TECTONO-CLIMATIC DRIVEN OROGRAPHIC PRECIPITATION AND RELATED EXTREME EVENTS IN THE WESTERN HIMALAYAS

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ABSTRACT

Extreme weather events and disasters are increasing in parts of the Himalayas. The objective of this study is to understand tectono-climatic controls on orographic precipitation and related extreme events in selected regions of the Western Himalayas (Jammu & Kashmir, Himachal Pradesh, and Uttarakhand, India). In the given tectonic setting of the study area, this study identifies vulnerable areas prone to extreme events. Here, it is observed that areas affected by tectonic disturbances, which experience significant increases in precipitation and temperature, exhibit high erosion rates and

extreme events. Analysis of ERA5 (European Centre for Medium-Range Weather Forecasts) datasets using the Mann-Kendall (MK) test indicates increasing precipitation trends during the monsoon and post-monsoon seasons in Uttarakhand, while Jammu & Kashmir and Himachal Pradesh show increases during the monsoon. To investigate tectono-climatic influences on orographic precipitation and extreme events, four representative river basins are selected: Sutlej, Chenab, Alaknanda, and Bhagirathi. The Sutlej basin exhibits the highest erosion rate at 2.87 mm/yr, followed by 1.47 mm/yr at Joshimath in the Alaknanda basin. Areas like Doda, Joshimath, and Uttarkashi, near tectonic disturbances, show significant subsidence and high incidences of landslides. The river profile steepness in the downstream towards north of Himalayan front shows upliftment in Higher Himalaya (HH) due to reactivation of MCT or reduction in erodibility accounting to change in lithology and decline in precipitation. The combined analysis of river swath profiles, erosion rates, precipitation patterns, thrust faults, and orography reveals direct links with the spatio-temporal variation of disasters like landslides, subsidence etc. These landslides are localized in areas with high precipitation and elevations between 500 and 2500 meters, with slopes of 20-40°. This study underscores the strong relationship between extreme events in the Himalayas, intense precipitation, high erosion rates, and tectonic activity, establishing the tectono-climatic controls of such events in the Western Himalayas.

Keywords: Extreme events, Orographic Precipitation, Main Central Thrust (MCT), Western Himalayas

DECADAL EVOLUTION OF URBAN HEAT ISLAND INTENSITY IN INDIA USING REMOTE SENSING AND GOOGLE EARTH ENGINE

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ABSTRACT

The Urban Heat Island phenomenon is a critical issue, as urban areas possess higher temperatures than the consecutive rural areas. As the most populous country in the world, India is facing a rapid rate of Urbanization and has experienced significant urban growth in the past two decades, leading to consequential changes in land use and land cover (LULC) and numerous other adverse effects, including increased energy consumption and exacerbated greenhouse gas emissions (GHGs). This study investigates the urban heat island effect in India from 2002 to 2022 using remote sensing and advanced computing technology of the Google Earth Engine (GEE) platform. The aim of this research is to quantify UHI intensity and its temporal change using MODIS (MOD11A1) dataset and various LULC (ESA World cover and MCD12Q1) datasets. This analysis highlights the trends in land surface temperature (LST) and alterations in LULC as LULC and LST studies are fundamental to understanding, quantifying, and mitigating the UHI effect. The entire landmass of India is studied to circumscribe diverse climatic and urbanization patterns as there is a lack of comprehensive studies examining the trend of UHI Intensity across the entire country. This work focuses on the peak summer months in India, i.e. April, May and June when the temperatures are typically the highest across the country. Studying the effect of UHI in peak summer months provides critical data and insights that are essential for effective urban planning. In this scholarly effort, urban and rural masks are applied to extract the mean temperature for these areas, which are further utilized in calculating

UHI intensity and LULC data are used to categorize rural and Urban areas. This study highlights a notable decrease in UHI intensity from the year 2002 to 2022. The findings of this paper encourage further investigation into the possible reasons for these results.

IMPACT OF CLIMATE CHANGE ON THE POTATO PRODUCTION IN WEST BENGAL: DEVELOPING AN ADAPTATION STRATEGY

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ABSTRACT

Climate change consequences have severe impact on agriculture. That adversely affects the yield of the staple crops of the country. Indian agriculture plays a significant role in the country's economy. Hence, impact assessment of climate change on the production of staples in the country is essential. Multi-model climate projects have been popularly used in the quantification of the climate change consequences on the crop yield. In the present study, we have used the SUBSTOR- Potato model embedded in DSSATv4.8 for the impact assessment of climate change on potato production in West Bengal under climate change scenario SSP2-4.5(intermediate emission) and SSP5-8.5(very high emission) for mid-future (2040-2069) and far-future (2070-2099) time periods. We have analysed the impact of rising temperature conditions from the baseline time period on the yield as well as the phenology of the crop. Further, we have observed the impact CO_2 fertilisation under varying CO_2 concentrations under different climate change scenarios. Reduction in the yield up to 27 and 28% under SSP2-4.5 and SSP5-8.5, respectively, in the 2050s is projected under baseline CO_2 conditions. However, an increase is predicted under transient CO_2 concentration. Therefore, to deal with the reduction in yield shifting of sowing date has proven to be an effective adaptation strategy.

Keywords: Climate Change, Agriculture, Potato, SUBSTOR-Potato, CO_2, CO2 fertilization, CMIP6, Adaptation

ASSESSING THE INFLUENCE OF TEMPERATURE FLUCTUATIONS ON SNOW COVER DYNAMICS IN THE HIMALAYAN REGION OF HIMACHAL PRADESH UTILISING IMD AND MODIS DATA

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ABSTRACT

In the Himalayan region of Himachal Pradesh, India, this study examines the correlation between temperature fluctuations and the Normalised Difference Snow Index (NDSI) between 1990 and 2023. We examine seasonal and annual temperature changes and their relationship to NDSI using a mix of temperature records from the Indian Meteorological Department (IMD) and snow cover data from the Moderate Resolution Imaging Spectroradiometer (MODIS). A thorough evaluation of the interaction between temperature variations and snow cover patterns is made possible by the MODIS NDSI data, which provides insights into snow cover dynamics, and the IMD data, which supplies a reliable, ground-based record of temperature changes. The findings show a distinct trend of rising

temperatures in recent decades, which has led to notable reductions in snow cover throughout the area. The largest associations between temperature increases and lower NDSI values are found in the winter and spring, indicating that warming may have an effect on seasonal snow melt patterns and glacier retreat, and improves knowledge of how the Western Himalayas' snow cover is changing due to climate change and emphasises how urgently adaptive measures are needed to mitigate the effects on local hydrology and ecosystems.

Keywords: Climate change, LST, NDSI, IMD, MODIS.

UNDERSTANDING VEGETATION HEALTH DRIVERS IN THE INDO-GANGETIC PLAIN: A CLIMATE CHANGE PERSPECTIVE

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ABSTRACT

Vegetation dynamics in the Indo-Gangetic Plain of India are undergoing significant transformations due to climate change-induced variations in environmental parameters. This research examines the complex interplay between vegetation health and key climatic factors through a comprehensive analysis of satellite-derived data over the decade 2013-2023. The study investigates the relationships between the Normalized Difference Vegetation Index (NDVI) and three fundamental climate variables: Land Surface Temperature (LST), Soil Moisture (SM), and Precipitation. The study area encompasses diverse land use categories, including agricultural zones, forest covers, and urban developments, offering a comprehensive framework for understanding climate-vegetation interactions. Analysis reveals distinct seasonal patterns in vegetation health, with peak NDVI values observed during winter, followed by monsoon, post-monsoon, and pre-monsoon periods. Statistical evaluation demonstrates that LST exhibits a more robust correlation with NDVI compared to soil moisture and precipitation patterns. These outcomes enhance our understanding of climate-vegetation dynamics in the Indo-Gangetic Plain, providing essential information for developing effective environmental policies, optimizing agricultural strategies, and implementing climate adaptation measures. The findings contribute significantly to the growing body of knowledge on regional climate change impacts and their implications for vegetation stability.

Keywords: Normalized Difference Vegetation Index, Soil Moisture, Precipitation, Land Surface Temperature

INNOVATIVE HYDRO-GEO-SYN MODEL FOR ASSESSING HYDROLOGICAL DROUGHT IN THE CHITRAVATHI RIVER BASIN, INDIA

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ABSTRACT

The primary objective of this research is to develop and implement the innovative Hydro-Geo-Syn model for assessing hydrological drought in the Chitravathi River Basin (CRB). This model

introduces a novel approach that integrates hydro data - such as rainfall, vegetation indices (NDVI, NDSI, NDTI), and land surface temperature (LST) with geo data, including geological, geomorphological, soil type, stream orders, drainage density, lineaments, and land-use patterns. The "Syn" represents the synthesis of these diverse datasets to provide a holistic understanding of hydrogeological drought. The methodology employed involved the combination of remote sensing, GIS techniques, and field data to generate the Hydrological Drought Index (HDI). This index categorizes the study area into six drought severity zones: extreme, severe, moderate, mild, no drought, and waterbody zones. The assessment revealed that 12.51% of the CRB suffers from extreme drought, concentrated in the southern and southwestern regions, while 19.90% is under severe drought conditions. Moderate drought areas, covering 24.56%, demonstrate a higher recovery potential with immediate conservation efforts, whereas mild and no drought zones occupy 23.45% and 17.40% of the basin, respectively. The directional analysis, a key component of the Hydro-Geo-Syn model, highlights the variability of drought severity across different regions of the basin. Areas in the south and east were identified as more vulnerable to severe drought, whereas the north and northwest regions exhibited relatively better hydrological conditions, emphasizing the need for direction-specific drought mitigation strategies. The Hydro-Geo-Syn model's comprehensive integration of hydrogeological parameters provides the research community with a powerful tool for assessing drought in complex semi-arid environments. Its capacity for detailed spatial analysis and drought prediction offers critical insights for policymakers, and researchers, facilitating sustainable water management and land-use planning in drought-prone regions.

Keywords: Drought, Hydro-Geo-Syn, Vegeta tion Indices, Geological, HDI.

ASSESSING THE SNOW WATER EQUIVALENT AND SNOWMELT RATES IN SIKKIM HIMALAYAS IN THE CONTEXT OF CLIMATE CHANGE

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ABSTRACT

India, a mega biodiverse agrarian nation, is heavily influenced by the monsoon and the Himalayas. The glacial region of the Hindu Kush Karakoram Himalaya (HKH), known as the " water tower of Asia," stores vast amounts of water in the form of ice and snow, second only to the polar ice caps (Adnan et al., 2017). With global temperatures rising and glaciers receding at an accelerated rate, Sikkim has become the second most vulnerable Indian state to climate change due to its reliance on glaciers and stream power. This study focuses on the impact of climate change on snow water equivalent (SWE) and snowmelt rate in the Sikkim Himalayas from 1979 to 2017. It examines the temporal variation of melt rate and associated melt amounts through degree-day modeling. The results show an increase in the average decadal rate of SWE and Degree Day Factor (DDF) for the months of March to August in the Sikkim Himalayas over the period 1979-2017, with the exception of the 2009-2017 decade, indicating the impact of global warming. The average decadal temperature trend for the Sikkim Himalayas from March to August during 1979-2017 shows a significant increase, with a coefficient of determination of 0.91. This trend suggests an increase in humidity, cloudiness, and climate change due to the accelerated greenhouse effect in recent decades. The rate of

snowmelt is crucial for flood forecasting, extreme weather events, agriculture, and optimal water resource management.

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

ROLE OF CLIMATIC CONDITIONS ON MALARIA TRANSMISSION IN CHHATTISGARH STATE OF INDIA THROUGH A MODELLING STUDY

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ABSTRACT

India represents 3% of the global malaria burden, therefore malaria is a major cause of health concern in India especially in the remote forested areas of the country. The study includes the use of VECTRI (VECToR borne disease community model of International Centre for Theoretical Physics, TRIeste) model whose physics and associated parameters are based on the life cycles of the key vector, namely, *Anopheles gambiae* and parasite *Plasmodium falciparum*, is a mathematic dynamical model that accounts for the influence of population and climatic conditions, malaria transmission dynamics is investigated for a second most highly endemic region in India which is state of Chhattisgarh.

The model is calibrated over the region of Chhattisgarh for the time period of 20 years from 2000-2019. The results shows the transmission along with malaria incidence are seen more in the months from July to September (JJAS) but highest malaria transmission is found in August and September. On linking temperature and rainfall to malaria vector abundance and disease incidence have yielded varied results in different districts in Chhattisgarh. The malaria transmissions are found to be more endemic in the following districts such as Baster, Dantewada, Sukma, Bijapur, Narayanpur, Kondagaon, Raigarh, Jashpur, Balrampur, Bemetara and Baloda- Bazar.

Keywords- EIR, Rainfall, Temperature, *Anopheles gambiae* and *Plasmodium falciparum*

IMPACT OF CLIMATE CHANGE ON POTATO YIELD IN INDIA UNDER WARMING SCENARIOS

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ABSTRACT

As potato is a key crop in the country, evaluating the impact of climate change on their yields is essential. This study examines how climate change might affect potato production by analyzing outputs from various Regional Climate Models (RCMs) under different scenarios for two future periods: 2040-2069 (mid-future) and 2070-2099 (far-future). The analysis focuses on five major potato-growing states in India, utilizing the SUBSTOR-Potato model along with downscaled future climate data to project potential impacts. The findings indicate increase in both maximum and

minimum temperatures under all warming scenarios. With baseline CO_2 concentrations, potato yields are anticipated to decrease by 3.6% to 17.5% in the mid-future and by 0.1% to 15.2% in the far-future under optimistic scenarios. In pessimistic scenarios, yield reductions could range from 2.4% to 20.5% in the mid-future and 0.3% to 20.5% in the far-future. Conversely, when considering elevated CO_2 levels, potato yields are projected to increase by 28.7% to 36.5% under optimistic scenarios and by 34.4% to 35.9% under pessimistic scenarios for both future periods. Overall, future climate conditions combined with higher CO_2 levels are expected to positively impact potato yields across all states, with Madhya Pradesh seeing the highest increase (+36.5%). Without considering CO_2, most states are likely to face negative impacts, except for Madhya Pradesh. Although there are some uncertainties related to the choice of crop models and RCMs, these findings provide valuable insights for policymakers, which are essential for formulating effective strategies to maintain and improve potato production in India.

Keywords: Potato, DSSAT–SUBSTOR-Potato Model, Climate Change, Multi-Model Projection, Impact Assessment, CO_2 Concentration.

ASSESSING THE URBAN HEAT ISLAND PHENOMENON IN NORTH INDIA

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ABSTRACT

Urbanization is having a major impact on environmental conditions and land use, particularly in North India, where densely populated urban areas are hotter than the surrounding rural areas due to the Urban Heat Island (UHI) effect. This phenomenon amplifies climate-related risks, including heat stress and health concerns, and alters precipitation patterns, leading to challenges such as urban flooding and water scarcity. This study assesses the historical trends in temperature (Tmax, Tmin) and precipitation patterns over the past three decades (1991-2023) to quantify the impact of UHI in Northern India. Using temperature and precipitation data from the Indian Meteorological Department (IMD), along with urbanization metrics such as population growth and land expansion, we employ the Semi-Parametric Generalized Additive Model (GAM), to reveal trends, anomalies, and spatial variability in UHI intensity (UHII) across urban landscapes. Our analysis integrates Geographic Information System (GIS) tools to map temperature distributions and precipitation shifts, identifying correlations between urban expansion and rising temperatures. The findings highlight significant changes in temperature and rainfall distribution, which reflect the influence of urbanization on local climate. This research contributes a detailed understanding of historical UHI patterns and provides a foundation for evaluating urban climate impacts, informing strategies to mitigate adverse effects on rapidly growing cities.

Keywords: Urbanization, Urban Heat Island, Climate Change, UHI Intensity.

AI-DRIVEN REAL-TIME EMISSION INVENTORY SYSTEM FOR HIGH-RESOLUTION WRF-CHEM MODELING: INTEGRATING DEEP LEARNING OBJECT DETECTION WITH ATMOSPHERIC SCIENCE

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ABSTRACT

This study presents an innovative approach to creating a dynamic, AI-based emission inventory system for use with the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem), designed to simulate vehicular and other anthropogenic emissions at satellite-detectable resolution. The methodology leverages state-of-the-art deep learning-based computer vision models, primarily employing YOLO (You Only Look Once) architectures (v8-v10) and T-Rex, for high-precision object detection. Through extensive data collection, model training, and fine-tuning, the system achieved significant improvements in detection accuracy, with F1 scores increasing from an initial 0.15 at 0.131 confidence to 0.72 at 0.414 confidence. A custom pipeline converts model outputs into netCDF files storing latitude, longitude, and vehicular count data, enabling real-time processing and visualization of emission patterns. The resulting system offers unprecedented temporal and spatial resolution in emission estimates, facilitating more accurate short-term air quality forecasts and deeper insights into urban emission dynamics. This research not only enhances WRF-Chem simulations but also bridges the gap between AI technologies and atmospheric science methodologies, potentially improving urban air quality management and environmental policy-making. Future work will focus on expanding the system's capabilities to non-vehicular sources and further improving detection accuracy in challenging environmental conditions.

TEMPERATURE TRENDS OBSERVED OVER INDIA IN RECENT DECADES

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ABSTRACT

Global warming, coupled with rapid socioeconomic development, has heightened the risk of both regional and global disasters. In India, annual heatwaves (HWs) have resulted in significant fatalities and economic losses, with an alarming upward trend. This study examines the spatiotemporal dynamics of heatwaves in India from 1981 to 2023, utilizing gridded maximum temperature and specific humidity datasets. An innovative heatwave evaluation algorithm, which accounts for humidity's impact on human health and the unique characteristics of heatwaves in India, was applied to classify daily heatwave states into light, moderate, and severe levels. Our analysis reveals a significant increase in both frequency and duration of heatwaves across all levels, characterized by earlier onset and later termination. The study identifies substantial regional variations, with the highest heatwave frequency observed in the northwestern, northern central, and northeastern regions. These findings underscore the critical need for enhanced scientific and technological strategies to bolster national and regional disaster mitigation efforts and adapt to the challenges posed by extreme climate events.

Keywords: heatwave; frequency; onset and termination; heatwave level; regional difference

GEOMECHANICAL ANALYSIS FOR FEASIBLE CO2 STORAGE IN DEPLETED GAS FIELD

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ABSTRACT

Geomechanical modelling is very essential step in geological CO2 storage program such as minimize the potential risk for CO2 leakage through fracture pathway, injection planning, wellbore stability, sealing capacity, etc. The objective of this study is to investigate and simulate geomechanical responses induced by CO2 injection in Reindeer gas field, as part of Carbon Capture and Storage (CCS) Pilot Project in Western Australia. This study commences with the development of a 1D geomechanical model, focusing on fundamental parameters such as principal stresses (overburden stress, maximum and minimum horizontal stresses, pore pressure), various elastic properties (Poisson's ratio, Young's modulus) and rock mechanical properties (Rock strength, UCS) in the study area. These elements will provide a fundamental understanding of the geological and mechanical behaviour of the depleted gas field. Subsequently, a 3D geomechanical model will be constructed to encompass a more comprehensive representation of spatial interactions and structural complexities. Future research will then explore the impact of temperature variations on geomechanical properties through simulations. By advancing from a 1D to a 3D model and incorporating temperature effects through coupled Thermo-Hydro-Mechanical (THM) simulations, this study aims to enhance our understanding of potential risks and optimize strategies to mitigate CO2 leakage, ultimately supporting the success of the CCS Pilot Project.

Keywords: Carbon capture and storage**,** 1D geomechanical model, UCS, Thermo-Hydro- Mechanics.

IMPROVED SIMULATION OF SEVERE THUNDERSTORMS THROUGH ENHANCED COUPLING BETWEEN MODEL PHYSICS AND DYNAMICS

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ABSTRACT

Accurate forecasting of extreme weather events like the initiation and life-cycle of severe local thunderstorms and lightning activity during the pre-monsoon season with high-resolution numerical models remains a challenge. A model's representation of land-atmosphere (LA) feedback processes through the planetary boundary layer (PBL) remains a source of uncertainty due to a lack of high-resolution observations and accurate representation, especially over the Indian region. To address this question using high-resolution WRF-ARW model-based sensitivity experiments, this study demonstrates that the appropriate representation of the boundary layer processes in the model can cause significant differences in the simulation of thunderstorm characteristics including precipitation and cloud microphysical processes. Apart from the land surface models in the WRF model, whose sensitivity has been tested in various studies, the PBL schemes also depict a range of skills in capturing the precipitation and microphysical profiles over different regions of India. Incorporating further modifications in the turbulent eddy-mixing characteristics in the model, it is further demonstrated that improved representation of surface and boundary layer processes in high-resolution

numerical models can have a significant impact on the initiation and life-cycle of these deep convective events. This novel model development study over India quantifies for the first time that the accurate representation of land-atmosphere feedbacks in high-resolution numerical models through the PBL has a profound impact on the forecasting skill of extreme weather events like pre-monsoon thunderstorms. This study greatly improves our understanding of different land-atmosphere feedback processes in high-resolution models needed to better forecast the initiation and intensification of thunderstorms and associated parameters. The authors gratefully acknowledge the financial support given by the Earth System Science Organization, Ministry of Earth Sciences, Government of India to conduct this research.

Keywords: Extreme weather events, thunderstorm, turbulent eddy, diabatic heating, deep convection, numerical modelling

MONITORING NASHA BUGYAL LAKE'S EXPANSION AND GLOF THREATS IN DARMA VALLEY, UTTARAKHAND, USING GEOSPATIAL OBSERVATION.

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ABSTRACT

Climate change is profoundly impacting the Himalayas, a geologically young and fragile region that is highly sensitive to even minor shifts in climate. The ongoing warming trend has led to significant glaciological changes, resulting in the formation, expansion, and disappearance of various glacial lakes. Among these, the most hazardous lakes pose serious threats to downstream communities and infrastructure. In this study, we critically analyze the progress in Glacier Lake Outburst Floods (GLOF) research, focusing on the dynamic changes in Nasha Bugyal Lake, a proglacial lake in Darma Valley, Kumaun Himalayas, Uttarakhand. We have evaluated the GLOF risks associated with this lake using multi-temporal satellite imagery collected over the past 30 years. Our analysis, based on high-resolution satellite data spanning three decades, reveals that the lake's surface area has expanded by approximately 50%, a substantial increase. Although the initial expansion rate was rapid, it has slowed in recent years. This study employs advanced remote sensing techniques to quantify changes in lake morphology and correlate them with regional climatic trends and glacial melt rates. By assessing the lake's expansion, we evaluate the potential for future GLOF events. This research enhances our understanding of glacial lake expansion and provides a foundation for future studies aimed at developing risk management strategies for potential GLOFs, using expanding glacial lakes as case studies.

Keywords: GLOF, Nasha Bugyal Lake, Darma Valley, Proglacial Lake, Himalaya.

MARINE GEOSCIENCES

EXTENDED CONTINENTAL SHELF (ECS) PROGRAM OF INDIA

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ABSTRACT

The Extended Continental Shelf (ECS) program of India, aimed at delineating its maritime boundaries beyond 200 nautical miles, is a significant undertaking with far-reaching implications for its economic and strategic interests. The program aims to enhance the nation's sovereign rights over natural resources on or beneath the seabed in accordance with the United Nations Convention on the Law of the Sea (UNCLOS). Article 76 and Annex II (Statement of Understanding) of UNCLOS outline the rules for establishing the outer limits of the continental shelf beyond 200 nautical miles. Coastal states are required to submit compelling scientific and technical data to the Commission on the Limits of the Continental Shelf (CLCS) to determine these limits. India's ECS program integrates marine geology and geophysics to assess the extent of the country's continental margin, which includes the physiographic shelf, slope, and rise. Extensive marine geophysical surveys were conducted in two phases from 2002–2004 and 2014–2015. After comprehensive data processing and interpretation, which included rigorous quality checks and analysis, India filed its first partial submission to the CLCS on May 11, 2009, under Article 76. In October 2019, a sub-commission was established to evaluate India's submission, and the sub-commission is currently actively examining the compliance. The data collected as part of this program will also provide critical insights into the sustainable exploration and management of marine resources. This initiative positions India as a significant player in the global maritime arena, thereby contributing to the nation's strategic and economic development. Keywords: Extended continental shelf (ECS), United Nations Convention on the Law of the Sea (UNCLOS), Maritime Boundaries, Marine Geology and Geophysics, Commission on the Limits of the Continental Shelf (CLCS)

NON-LINEAR PRINCIPAL COMPONENT ANALYSIS FOR IMPROVING SIGNAL-TO-NOISE RATIO OF SEISMIC STACK

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ABSTRACT

Stacking the seismic data is the simplest way of improving the signal-to-noise ratio and is accomplished by summing the seismic traces from different shot records that have a common reflection point to form a single trace. The weighted stacking method gives good-quality seismic images than conventional stacking. Further, the weights calculated from the principal component analysis give more robust results than the other conventional weights. Principal component analysis is widely used in seismic data processing and interpretation as it can extract useful signals based on a low-rank decomposition method by solving an optimization problem with a low-rank constraint. However, the Principal component analysis is a linear method, and it can map the data to linear PCs only, causing an information loss in the seismic stack if the data are not exactly flattened during NMO correction. To address this problem, we propose an improved method of seismic weighted stacking using an auto-associative neural network-based Non-Linear Principal component analysis method, wherein the principal components are generalized from straight lines to curves. In this

method, the seismic gathers are mapped into non-linear principal components using the Encoder network and then they are mapped back into the data domain by the decoder. We applied our method to synthetic data and offshore field data. The proposed method provides enhanced reflections and resolution than conventional stacking and Principal component analysis -weighted stacking methods.

Keywords: Seismic, Signal Processing, Principal Component Analysis, Weighted stacking.

OCEAN BASIN EVOLUTION

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ABSTRACT

Around 71% of the Earth's surface is made up of oceans, which are enormous saltwater bodies. Over billions of years, a variety of geological processes and events have combined to create their intricate shape. They are continuously evolving because to a confluence of biological, tectonic, and geological forces.

In geological processes, plate collisions construct trenches, seafloor spreading enlarges seas, volcanic activity produces new structures, and erosion changes basin characteristics. Ocean basins are more than 200 million years old, and biodiversity is likewise influenced by age. The scientific theory of plate tectonics describes how the lithosphere, the uppermost layer of the Earth, gets separated into massive, inflexible plates that move slowly over time. At their borders, these plates interact, resulting in volcanic activity, earthquakes, and the creation of mountains and ocean basins.

Alfred Wegener's continental drift, plate tectonics, and the development of an accurate theory of geology provide historical context. Proof Fit of continental shorelines, similarities in fossils across continents, paleomagnetism indicating drift, and alignment of gemological traits all lend credence to the theory. Understanding the evolution of ocean basins will have an impact on resource management, climate, and marine ecosystems.

MARINE RESOURCES

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ABSTRACT

Marine resources are the physical and biological entities found in the ocean that are useful to humans. Marine resources, encompassing a diverse range of biological and non-biological entities, play a crucial role in global food security, and environmental balance.

Biological resources form the cornerstone of marine ecosystems. Fish, crustaceans, and mollusks have been harvested for food since time immemorial, providing essential protein and nutrients to billions of people worldwide. Rising water temperatures, acidification, and low oxygen levels can combine with natural ocean cycles to create extreme marine events. Marine heat waves, dead zones, and coral bleaching are just a few examples of these events, which are projected to become more common and severe. Extreme events can harm marine ecosystems and communities connected to these systems. For example, a large heat wave off the West Coast in 2014 shut down crab fisheries

and starved baby sea lions. Produced waters from oil and gas extraction are a major source of petroleum hydrocarbon pollution. These waters are released in coastal and offshore production areas, and can contain dissolved components and dispersed crude oil.

The convection current—the circulating path of hot water rising and cold water sinking—transfers thermal energy by actually moving the warmer water to a new area.

Coral reefs suffer from sedimentation and pollution which hampers the growth of the micro-organisms, but also suffers from over-fishing and rapacious collection in many parts. Mangrove forests experience massive felling.

In conclusion, marine resources are essential for human survival and prosperity. However, the unsustainable exploitation and degradation of these resources pose serious threats to both marine ecosystems and human societies. To ensure the long-term health of our oceans and the benefits they provide, it is imperative to adopt sustainable practices, including responsible fishing, marine conservation, and the development of renewable marine energy technologies.

EXPLORING GRAVITY, MAGNETIC AND MORPHOLOGICAL FEATURES IN THE KRISHNA-GODAVARI OFFSHORE BASIN, INDIA

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ABSTRACT

The Krishna-Godavari (KG) offshore basin is one of India's most petroliferous basin which is located in a passive margin with a deltaic and sedimentary environment. It was formed as a result of continental rifting and seafloor spreading involving the Indian, Antarctic, and Australian plates. The basin is bordered by the Eastern Ghats Mobile Belt (EGMB) to the northeast, the Pranhita-Godavari (PG) graben to the northwest, the Cuddapah basin to the west, the Palar-Pennar basin to the south, and the deep waters of the Bay of Bengal to the east, covering an area of approximately 45,000 square kilometers, both onshore and offshore. The Krishna and Godavari rivers contribute large volumes of sediment to the basin, creating ideal conditions for significant hydrocarbon accumulation. The CSIR-National Geophysical Research Institute (NGRI) has acquired multi-channel seismic (MCS) data in the KG offshore basins to identify and delineate gas hydrates and other hydrocarbon deposits.

This study focuses on understanding the geological history, tectonic settings, structures and formations of the KG offshore basin using gravity, magnetic, and morphological data along the KG offshore region covering 37 seismic reflection profiles. Marine bathymetry, free-air gravity and magnetic data are used, calibrated, conditioned and corrected to prepare composite bathymetry, bouguer gravity and magnetic reduce to pole (RTP) grids. The bathymetry grid reveals a consistent dip toward the deep ocean while along the coastal the bathymetry has relatively less variation. The seabed morphology indicates various surface features such as canyons, dipping slopes, mud volcanoes, pockmarks, gas seepages and footprints. Bouguer gravity values range from 160 to 240 mGal, with a lower trend towards the northeast, likely due to high sedimentation and a deeper basement, as confirmed by seismic reflection profiles. Magnetic trends highlight the geological continuity between the Eastern Ghats Mobile Belt (EGMB) and the offshore KG basin with the Continent-Ocean Boundary (COB) marking the seaward extent of the granulitic belt. The presence of

charnockites and granitic gneisses in both regions suggests that these formations extend into the offshore areas with coastal trends indicating a structural and compositional link between onshore and offshore geology.

Keywords: KG basin, morphology, gravity and magnetic anomalies, interpretations

GAS HYDRATE SATURATION EVALUATED THROUGH ROCK PHYSICS MODELING AND ELECTRICAL RESISTIVITY METHODS AT SITES NGHP-02-18 AND NGHP-02-25 IN THE KRISHNA-GODAVARI BASIN.

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ABSTRACT

There are several methods available for estimating gas hydrate and free gas saturation. which vary depending on the characteristics and distribution of gas hydrate within the sediment. The presence of gas hydrate in sedimentary formations leads to a sudden increase in sonic velocity and resistivity, which can be used to estimate gas hydrate saturation. We used resistivity data based on Archie's empirical equation and Indonesia equation for estimating gas hydrate saturation. Further, gas hydrate saturation has been estimated using effective medium rock physics model derived from the empirical models of Wyllie and Wood. Well log data for NGHP-02-18 and NGHP-02-25 were gathered during the National Gas Hydrate Program expedition-02 (NGHP-02) in Area B of the Krishna Godavari Basin. Gas hydrate primarily spans the depth intervals of 307 to 325 meters below seafloor (mbsf), with a maximum concentration of about 45% by electrical resistivity methods and 50% by rock physics modelling. Estimations of gas hydrate saturation based on the electrical resistivity method, employing density-derived porosity and electrical resistivity logs from Archie's empirical formula, exhibited lower saturation levels compared to those derived from the Indonesia method. The combined observations from the rock physics modelling and electrical resistivity approximation indicated relatively high gas hydrate concentrations at the specific sites within the Krishna Godavari Basin. Further analyses revealed that at NGHP-02-18 and NGHP-02-19, gas hydrate saturation ranges between 45% and 50% in two distinct zones namely, the layered zone and the fractured zone providing higher and lower concentrations of gas hydrates respectively. The gas hydrate saturations estimated from all these methods are found in good agreement.

Keywords: Gas Hydrate; National Gas Hydrate Program (NGHP) expedition; Rock Physics Model; Electrical resistivity methods

DATA-DRIVEN ACOUSTIC IMPEDANCE INVERSION USING WELL LOG DATA BASED ON TOTAL VARIATION REGULARIZATION

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ABSTRACT

Acoustic impedance (AI) inversion is an effective tool to extract rock-physical properties from recorded seismic data. It plays a crucial role in seismic interpretation as well as reservoir

characterization. Many kinds of additive regularization techniques have been proposed to obtain impedance profiles with a relatively high resolution or to take the lateral information of the model into account. However, determination of a proper regularization parameter is time consuming. When one of recursive inversion schemes is employed to obtain the AI, the spatial coherency of the estimated reflectivity section may be damaged through the trace-by-trace processing. Meanwhile, the results are sensitive to noise in the data or inaccuracies in the generated reflectivity function. To overcome the above disadvantages, in this study, we utilize a data-driven inversion scheme to directly invert the AI from seismic reflection data. Initially, we establish a nonlinear objective function of the AI model by using total variation (TV) regularization. Next, we solve the nonlinear impedance inversion problem via the alternating split Bregman iterative algorithm. Due to consideration of seismic attenuation in the equation, the inversion approach is deployed into the nonstationary reflection data avoiding the drawbacks brought by the energy-compensation processing (e.g., inverse Q-filtering). We have investigated the performance of the method on synthetic seismic data as generated from sonic and density log, after converting both the logs from depth to time domain. This technique can be used to capture a unique AI solution without strong discontinuity. Furthermore, it is insusceptible to the quality of the input data.

Keywords: AI inversion, Total variation, Seismic attenuation

2D GRAVITY AND MAGNETIC ANOMALY MODELING OF THE CARLSBERG RIDGE, NW INDIAN OCEAN: INSIGHTS INTO LITHOSPHERIC STRUCTURE AND TECTONIC PROCESSES

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ABSTRACT

The Carlsberg Ridge, situated in the north-western Indian Ocean, is an active mid-ocean ridge characterized by a slow spreading rate (half-spreading rates of 11 - 16 mm/yr). It serves as a site of new crust formation and hosts hydrothermal field with two vents: Wocan-1 (active) and Wocan-2 (inactive). These vents indicate the presence of valuable minerals such as Zn, Fe, and Cu, highlighting the region's significance for studying crustal structure, tectonic processes, and variations in hydrothermal activity at different spreading rates, heat flow, and mineral resource exploration. Despite its importance, limited research has focused on the Carlsberg Ridge, with no detailed studies on its crustal structure. This study aims to address that gap by analyzing free-air gravity (FAG) and bathymetry data from satellite altimetry (Sandwell data) and ship-borne measurements to investigate the ridge's crustal characteristics.

For 2D modeling, we incorporated prior knowledge from a seismic refraction study conducted at the Mid-Atlantic Ridge (FAMOUS area, 37°N), a geologically comparable setting. In the absence of local seismic data, we utilized the CRUST1.0 Earth model, which provides detailed information for each 1°×1° grid cell. Using the GM-SYS module in Oasis Montaj Geosoft, we modeled several profiles, each approximately 200 km long, across the Carlsberg Ridge. The gravity anomaly was initially simulated based on the geometry and density of individual crustal layers and was iteratively refined to achieve the best-fit model.

Our results demonstrate a satisfactory fit between the observed and synthetic data, with an acceptable RMS error of less than 6 mGal. The gravity models along the traverses indicate significant variation in crustal thickness - approximately 8 km near the ridge, decreasing to about 5.5 km on the NE flank away from the ridge axis, and about 4.2 km on the SW flank. The Eastern Somali Basin is characterized by a thin crystalline oceanic crust (~4 km) compared to its conjugate, the Arabian Basin, where the thickness ranges from 5 to 6 km. This supports the existence of ridge propagation along the paleo-Carlsberg Ridge during the Early Tertiary, leading to asymmetric crystalline crustal thickness accretion in these conjugate basins, influenced by the activity of the Réunion Plume.

The magnetic anomalies along the traverses reveal three distinct zones: (i) a zone of relatively high-frequency, short-wavelength anomalies over the axial region of the Carlsberg Ridge, indicating younger crust; (ii) a zone of well-developed Early Tertiary magnetic anomalies in both the Arabian and Eastern Somali Basins; and (iii) a relatively quiet magnetic zone between these two regions, suggesting a hiatus in spreading activity. Based on these findings, we present a comparative analysis of the crustal configuration and magnetic patterns of the study area's major structural features and discuss its tectonic evolution.

Keywords: Carlsberg Ridge; Free-Air gravity and magnetic anomaly; Arabian Basin; Eastern Somali Basin; Crustal thickness; Reunion Plume.

ASSESSING TSUNAMI IMPACT ON INDIA'S WESTERN COASTLINE THROUGH COMPUTATIONAL WAVE MODELING NUMERICAL MODELLING OF TSUNAMI WAVE

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ABSTRACT

"This study employs numerical modelling to analyse tsunami wave propagation along India's western coastline, focusing on sites in Gujarat, Mumbai, Goa, and Karnataka (Karwar and Mangalore). The simulation uses the TUNAMI N2 code, incorporating fault parameters from existing literature, bathymetric data from ETOPO2 and GEBCO databases, and topographical information from SRTM for run-up calculations. The 6-hour simulation examines tsunami wave characteristics, including arrival times, wave amplitudes, and environmental impacts. Multiple scenarios were modelled by varying the dip and strike angles to analyse changes in wave directivity. Detailed time series analyses and wave height measurements were conducted, particularly along the Gujarat coast. Results indicate varying arrival times and wave amplitudes across locations: Gujarat's Gulf of Kachchh (2-5.30 hours, 1-2.5m amplitude), Mumbai (4.45 hours, 2m amplitude), Goa (3.08 hours, 1m amplitude), Karwar (3.12 hours, 1m amplitude), and Mangalore (3.36 hours, 1m amplitude). These findings align with historical records and published data from the 1945 tsunami genic earthquake along the Makran Subduction Zone."

Keywords: Numerical Modelling, Western Coastline, Fault, Bathymetric Data

ATMOSPHERIC, PLANETARY & SPACE SCIENCES

RESONANCES OF THE RED PLANET: THE SAGA OF MARSQUAKE S1222A

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ABSTRACT

Marsquake are seismic events occurring on Mars, analogous to earthquakes on Earth. These events provide crucial insights into the internal structure and geologic activity of the Martian crust and mantle. The NASA InSight mission has been pivotal in detecting and analyzing seismic activity on Mars, with many events, one notable event being the S1222a Marsquake. This mission's findings have expanded our understanding of Martian seismology, offering a glimpse into the planet's geodynamic processes.

Our spectral analysis of the S1222a marsquake (M_W=4.7) estimated different source parameters of this marsquake. With the help of Brune's omega square model, we calculated source parameters like corner frequency, seismic moment, source radius, stress drop, and moment magnitude. Our analysis indicates that a corner frequency ranges between 2.6-2.7 Hz, seismic moment ranges from 8.84×10^{15} - 1.21×10^{16} N-m, source radius ranges from 633- 912 m, Stress drop ranges from 5.10- 9.13 MPa, and moment magnitude range from of 4.5-4.8.

In conclusion, the analysis of S1222a marsquake enhances our knowledge of Mars' interior structure and seismic activity. Future research could focus on refining the models used for interpreting seismic data and exploring the correlation between surface geology and seismic sources. Such studies are vital for improving our understanding of the planet's tectonic behavior and assessing potential seismic hazards. These results provide valuable data for characterizing the seismic source and understanding the propagation of seismic waves on Mars.

A COMPARATIVE ANALYSIS OF BLACK CARBON CONCENTRATION IN URBAN AND RURAL REGIONS OF THE HIMALAYAS IN UTTARAKHAND, INDIA.

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ABSTRACT

Our Earth's atmosphere contains gases and aerosols—tiny particles suspended in the air—originating from both natural sources (like desert dust and sea salt spray) and human activities (such as fossil fuel combustion and biomass burning). Aerosols interact with solar radiation through scattering and absorption, with Black Carbon (BC) being a key absorber of visible solar radiation. BC, the optically absorbing component of carbonaceous aerosols, is a major anthropogenic component of the atmospheric aerosol system and a significant contributor to global warming, second only to CO_2. Although BC constitutes only a small fraction of the total aerosol mass, it has a substantial positive radiative forcing effect on the Earth's atmosphere. Furthermore, BC has been found to affect the monsoon in Asian countries and contribute to the heating of elevated regions such as the Himalayan–Tibetan plateau.

This study compares BC mass concentrations in two different locations of Uttarakhand, i.e. Dehradun, an urban site and MPGO Ghuttu, a more rural mountainous site during the period from January to March 2022, to assess the influence of altitude, human activities, and weather on BC levels. Both the stations offer contrasting environments to assess how BC concentration varies due to local atmospheric conditions. At Dehradun, overall mean BC concentration was 3.370 μg/m³, with 0.952 μg/m³ (~28%) from biomass burning (BC_{bb}) and 2.417 μg/m³ (~72%) from fossil fuel (BC_{ff}) combustion. On the other hand, at MPGO Ghuttu, the mean BC value was observed to be 1.500 μg/m³, with 0.508 μg/m³ (~34%) from BC_{bb} and 0.992 μg/m³ (~66%) from BC_{ff}. These findings reflect the higher impact of urbanization in Dehradun whereas the mitigating effect of altitude and less human influence at MPGO Ghuttu.

To reduce BC's climate and health impacts, stricter regulations on fossil fuel use, cleaner energy alternatives, and better management of biomass burning are essential. Continuous BC monitoring in diverse regions can improve our understanding of its variability and support more effective climate mitigation strategies.

EVOLUTION OF DROUGHT AND FLOOD PATTERNS ACROSS INDIA AND ITS SIX DISTINCT HOMOGENEOUS REGIONS USING CMIP6 FRAMEWORK

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ABSTRACT

Extreme weather events occur with greater frequency and intensity than typical events, and they are a major contributor to significant damage to our society and agriculture. Some extreme weather events such as heavy precipitation, very heavy precipitation, heat waves, cold waves, drought, flood, cyclones etc. have widespread adverse impacts on human and its belongings. As an agrarian country, extensive study of extreme weather events over India are very important, we consider drought and flood events because of it has devastating effect on agriculture. So, our center of attentions are drought and flood events that occur during Indian summer monsoon rainfall season (JJAS) over India and its six homogeneous regions viz. North west India (NWI), North central India (NCI), North east India (NEI), West Peninsular India (WPI), East Peninsular India (EPI), South Peninsular India(SPI). In this study we use 14 historical simulations of sixth phase of Coupled Model Intercomparison Project (CMIP6) and two future emission scenarios Sheared socio-economic Pathways (SSPs) SSP2-4.5 and SSP5-8.5 and IMD observational precipitation data. The performance of CMIP6 models is determined by using different model evaluation metrics as correlation coefficient (CC), standard deviation (SD), root mean square error (RMSE), normalized root mean square error (NRMSE) and Interannual variability score (IVS). Drought and flood years are estimated using Standardized Precipitation Index (SPI), Standardized Precipitation Evapotranspiration index (SPEI) etc.

Keywords: Extreme weather events; Indian summer Monsoon Rainfall; Standardized Precipitation Index; Standardized Precipitation Evapotranspiration Index; Coupled Model Inter-comparison Project.

IMPACT OF ATMOSPHERIC CIRCULATION ANOMALIES ON EXTREME WET AND DRY YEARS IN THE INDIAN SUMMER MONSOON

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ABSTRACT

This study investigates extreme wet and dry events driven by atmospheric circulation patterns in the Indian summer monsoon rainfall(ISMR). We used IMD and various reanalysis data products spanning 1981–2022. Here, we utilized the various Empirical orthogonal function (EOF), along with its principal component (PC) analysis and various statistical methods such as coefficient of variation (CV) and correlation Coefficient (CC) and precipitation concentration index (PCI). This analysis reveals significant increasing variability in rainfall from western to eastern India. However, a dominant pattern is captured by the first mode of the EOF which explains 14.9% of the total variation, and six extremely dry and nine extremely wet years are identified.Composite Analysis during wet periods indicated patterns of converging or diverging velocity potential, alongside vertical velocity variations in the lower and upper troposphere. These conditions facilitated upward vertical motion. Conversely, dry years exhibited contrasting atmospheric phenomena. Furthermore, we identified a negative correlation between the Nino 3.4 index and the first principal component (PC1), and a positive correlation between Nino 3.4 and the second principal component (PC2).The study underscores that predictive factors for Indian summer monsoon rainfall forecasting include Indian Ocean Sea Surface Temperatures (SST), the Nino 3.4 index, Mascarene High Sea Level Pressure (SLP), Indian Ocean 850-hPa westerly winds, and vertical velocity anomalies. These elements interact to influence the strengthening and distribution of the monsoon precipitation, These findings underscore the understanding of the monsoonal extremes and further implications for weather forecasting.

Keywords: ISMR, EOF, PCI, Extreme wet and dry Events, Nino 3.4 Index

AEROSOLS DIRECT AND INDIRECT IMPACT

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ABSTRACT

A comprehensive study of aerosol scattering and absorption characteristics were investigated at an ancient Indian city Varanasi in the eastern Indo-Gangetic Basin (IGB) during the period from January 2019 to December 2021 using different in-situ measurements. The scattering coefficient (σsp at 525 nm) varied between 0.58 and 1198.97 Mm−1 (mean~72.92±134.47 Mm−1) during the entire study period, which was about ten times higher than the absorption coefficient (σabs at 525 nm ~41.94 ±40.70 Mm−1). Seasonally, σsp and σabs were substantially higher during the winter/post-monsoon periods. The magnitude of SSA (at 525 nm) varied between 0 and 0.84 (mean: 0.52 ± 0.30). Further, the magnitude of scattering Ångström exponent (SAE) and back-scattering Ångström exponent (BAE) showed a wide range from -1.08 to -0.58 and -0.16 to 5.04 respectively which suggests large variability in aerosol sizes and emission sources. Relatively higher aerosol backscatter fraction (b at 525 nm) during the monsoon (0.33 ± 0.02) suggests more inhomogeneous scattering, associated with the coarser dust particles. However, lower value of b during winter (0.17 ± 0.01) is associated with more isotropic scattering due to dominance of smaller size particles. This is further confirmed with

the estimated asymmetry parameter (AP at 525 nm), which exhibits opposite trend with b. The aerosol optical parameters derived from this study were incorporated into a radiative transfer model to estimate aerosol radiative forcing. The resulting radiative forcing and atmospheric heating rates will be presented in the final results. Keywords: Scattering coefficient, Ångström exponent, Back-scattering Ångström exponent, Asymmetry Parameter, Radiative forcing

ANALYSIS OF HEAT WAVES, HEAT STRESS, AND THE IMPACT OF AIR POLLUTANTS IN THE SIX MAJOR CLIMATIC ZONES OF INDIA

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ABSTRACT

This study explores the rising intensity, frequency, and duration of heat waves and related heat stress across six climatic zones in India Arid, Semi-arid, Montane, Humid subtropical, Tropical wet, and Tropical wet and dry over 31 years (1990-2020). Using the Universal Thermal Climate Index (UTCI) and Humidity Index (HD), we assessed heat stress through daily maximum temperature, humidity, wind speed, and solar radiation data. Results reveal an increase in heat wave events, particularly in the Semi-arid, Montane, and Humid subtropical zones, with moderate heat stress in the Tropical wet zone. Significant thermal stress impacted the eastern coastal regions of the Tropical wet and dry zones, while discomfort was highest in the Arid, Semi-arid, and Humid subtropical zones from May to July. Among cities, Delhi reported more frequent heat waves than Kolkata, Chennai, and Mumbai, though Chennai showed the highest risks of extreme heat stress due to its humidity. Using Heat-wave-Intensity-Duration-Frequency (HWIDF) curves, we found that the Arid zone experienced the most intense and prolonged heat waves, Historical conditions show increased risks of prolonged heat waves, particularly in the Humid Subtropical. Our analysis highlights the significant influence of human-caused warming on the likelihood and severity of intense heat waves. Air quality analysis (2010-2023) showed worsening PM2.5 and PM10 levels during heat waves, especially in Arid, Semi-arid, and Humid subtropical zones, with lower pollution in Tropical wet and Montane areas. The study also identified rising CO2 and GHG emissions, correlating with increased heat wave frequency. The Semi-arid zone and Delhi were the most polluted, while the Montane zone and Thiruvananthapuram had the lowest pollution. These findings underscore the growing influence of climate change on heat waves and air quality in India.

THE CHANGING CO_2 DYNAMICS OVER INDIA: A STUDY OF LONG-TERM SPATIAL AND TEMPORAL VARIATION

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ABSTRACT

The increasing levels of carbon dioxide (CO_2) in the atmosphere are a significant driver of climate change, and understanding its spatial and temporal variation is critical for policy and mitigation strategies. This study investigates the changing dynamics of CO_2 over India from 2003 to 2012, using data from the Atmospheric Infrared Sounder (AIRS). India, as a rapidly industrializing nation, has

experienced significant fluctuations in CO_2 concentrations, influenced by both anthropogenic activities and natural processes. The study utilizes a long-term dataset to analyze spatial and temporal variations in CO_2 across diverse climate regions of India. Spatial mapping and time-series analysis were employed to identify regional trends, hotspots of CO_2 accumulation, and seasonality effects on CO_2 distribution. Results indicate a noticeable increase in CO_2 concentrations over the decade, with certain regions, particularly industrialized zones and urban clusters, showing higher rates of CO_2 accumulation. Seasonal variations were evident, with higher concentrations during the winter months due to temperature inversion and reduced atmospheric mixing. In contrast, monsoon periods exhibited lower CO_2 levels due to enhanced vegetation and higher rates of carbon sequestration. These findings underscore the importance of region-specific strategies for CO_2 mitigation, particularly in areas with high emissions. The study contributes to a better understanding of India's CO_2 dynamics, providing critical insights for policymakers to address emissions at both national and regional levels. Future research will extend this analysis to more recent data, allowing for a comprehensive understanding of India's evolving carbon landscape.

SEASONAL STUDY OF ATMOSPHERIC AEROSOL PARAMETERS USING AERONET OVER INDO GANGETIC BASIN FROM 2011-2020

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ABSTRACT

Aerosols, a significant component of Earth's atmosphere, pose challenges in understanding their effects on climate, health, and atmospheric chemistry due to their complex composition. These particles, which can be solid or liquid, vary greatly in terms of size, phase, and chemical makeup. This study provides a comprehensive analysis of aerosol parameters over the Indo-Gangetic Basin (IGB) from 2011 to 2020, utilizing data from the Aerosol Robotic Network (AERONET). The IGB, a region of immense environmental importance, experiences considerable seasonal variations in aerosol composition and concentration, influenced by both natural and human activities. The study focuses on two locations within the IGB, Kanpur and Gandhi College, and examines the seasonal trends in Aerosol Optical Depth (AOD), Angstrom Exponent (AE), and Single Scattering Albedo (SSA). These parameters are crucial for understanding the role aerosols play in the atmosphere and their impact on climate.

In Kanpur, the pre-monsoon season is marked by elevated Aerosol Optical Depth (AOD) levels, primarily driven by dust storms and industrial emissions, indicating a higher concentration of aerosols that affect both air quality and climate. During the monsoon, AOD levels decrease as rainfall washes away aerosols. Similarly, at Gandhi College, AOD peaks during the pre-monsoon and winter months due to agricultural burning and local emissions, with a reduction in AOD during the monsoon. The Angstrom Exponent (AE), which provides information on aerosol particle size, shows seasonal variation. In Kanpur, higher AE values during the pre-monsoon suggest the presence of smaller particles from dust storms, while lower AE values during the monsoon point to larger particles, likely from rain-induced processes. At Gandhi College, AE variability reflects changes in aerosol size distribution and composition, influenced by seasonal sources like agricultural burning and local emissions. The study also highlights intermediate Single Scattering Albedo (SSA) values at both locations, indicating that aerosols are moderately absorbing and scattering, with a mixture of types

that either reflect or absorb sunlight. The SSA values being neither too high nor too low underscore the complexity of aerosol composition in the region, where multiple natural and human activities contribute to the aerosol load, affecting the atmosphere and climate. Overall, aerosols play a critical role in the atmosphere, particularly in their ability to affect the Earth's radiation budget by scattering and absorbing sunlight. The seasonal analysis of aerosol parameters offers valuable insights into the interplay between natural processes, human activities, and atmospheric dynamics in shaping aerosol behavior over this region.

ATMOSPHERIC GRAVITY WAVES GENERATED BY LARGE VOLCANIC ERUPTIONS: EMPHASIS ON GENERATION MECHANISM

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ABSTRACT

Volcanic eruptions are dynamic geological events that not only shape the earth but also have profound effects on surrounding atmosphere. The explosive release of energy and matter during eruptions perturbs the atmospheric equilibrium thus generating variety of waves. The sudden upthrust of large amounts of volcanic ash and gases emitted with high energy from Plinian volcanic eruptions can overshoot the tropopause triggering the generation of Atmospheric Gravity waves (AGWs). Generally, these AGWs were observed as concentric circular waves, having alternate dark and light bands, with wavefronts moving radially outwards. The centre of these concentric circular gravity waves lies approximately near to the volcanic epicentre which shows its lithospheric origin. In this study, based on the multisensory instruments on-board AIRS and Suomi NPP satellites, we show here the presence of AGWs at various atmospheric altitudes after three large volcanic eruptions. The signature of AGWs at mesospheric heights was confirmed in SABER measured Temperature perturbations. The increase in H_2O ,as measured by MLS instrument, leads to the modification in thermal equilibrium of the atmosphere which thus triggers the generation of AGWs. This study provides a unique example of Lithospheric-Atmospheric coupling by discussing the AGWs after large volcanic eruptions and their possible generative mechanisms.

CLIMATOLOGICAL PATTERNS AND ATMOSPHERIC DYNAMICS DURING THE INDIAN SUMMER MONSOON

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ABSTRACT

Over several decades, the examination of fundamental variations in meteorological conditions has played a crucial role in understanding the dynamics of the Indian Summer Monsoon (ISM), which significantly impacts the socio-economic landscape of India. This study explores the spatial and temporal fluctuations of key meteorological elements during the ISM, utilizing NCEP/NCAR reanalysis datasets spanning 70 years (1948–2017). The analysis covers climatological trends, early and late monsoon phases, and multidecadal intervals, focusing on six distinct regions: Northern India (NI), Central India (CI), Southern India (SI), the Arabian Sea (AS), the Bay of Bengal (BoB), and the

Equatorial Indian Ocean (EIO). Employing statistical methods such as the standardized anomaly index for surface temperature, rainfall,and zonal and meridional winds (at 850 and 200 hPa), along with temporal analysis using the Mann- Kendall trend test, the study reveals significant variability in the ISM dynamics throughout the study period. The results highlight marked shifts in the standard deviation and coefficient of variation of the meteorological variables, indicating substantial early-late phase and multidecadal modulations. Noteworthy findings include an alarming increase in multidecadal variability and trends in surface temperatures, particularly pronounced in Northern, Central, and Southern India, with temperature increases in the range of 0.5–1.0°C. The study also identifies intensified early-late phase and multidecadal variability in precipitation over the Bay of Bengal, the Equatorial Indian Ocean, and Southern India, with average precipitation increases ranging from 1 to 3.5 mm/day. Conversely, there is a reduction in mean rainfall patterns, which correlates strongly with rising surface temperatures and a weakening of surface zonal winds, particularly over the Bay of Bengal, Indian Ocean, Southern India, and Central India. This attenuation of wind circulation has profound implications for atmospheric systems like the Somali jet and

the low-level jet (LLJ) during the ISM season. Furthermore, meridional winds at both surface and upper levels show a notable enhancement over the Arabian Sea and the Equatorial Indian Ocean. The most recent decadal anomalies (2008–2017) raise concerns, as decreasing trends in precipitation and wind circulation at 850 and 200 hPa are observed across all regions. The findings suggest that alterations in meteorological parameters and their distribution have resulted in an asymmetrical pattern in the ISM, likely driven by ongoing climate changes.

Keywords: ISM, Mann-Kendall test, Low level jet.

FOREST FIRE DYNAMICS AND METEOROLOGICAL INFLUENCES ACROSS DIVERSE ECOSYSTEMS

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ABSTRACT

Forest fires are necessary for some ecological processes but can be extremely harmful to biodiversity, the environment, and local people. The present research offers a systematic analysis of the dependency of forest fires on weather variables in twelve regions with distinctly different ecological and environmental characteristics. Such fires are not only natural phenomena but are also developing trends, this study gives an overview on how daily weather including precipitation, soil moisture, wind speed, relative humidity and temperature affects the fire frequency, area, and intensity.

The combination of statistical methods with high-resolution spatio-temporal approach is used to specify the major climate conditions which may increase the level of fire risk in these different areas. For example, while the temperature is high and the wind is strong on sites with low soil moisture content, the likelihood of fire ignition and spread intensity is high. This work further explores the influence of fire and its spread across different environments and explore how rainfall events can limit its spread but can only assist in certain settings.

The experiments highlight key climatological features and thresholds associated with increased forest fire vulnerability, thus enabling the identification of at-risk times and conditions. It provides a basis for developing predictive fire models that may be able to help in the anticipatory management of forests with strategies for prevention, mitigation, and resilience.

This work is important for regional planning, particularly in areas that frequently experience fire, as they serve as a plan for the effective management of a forest fire, resource allocation, and climate adaptation strategies specific to various ecological contexts. By exploring these twelve different areas, the research provides a broader view of how shifting weather patterns inform fire dynamics and offers critical lessons for the management of forests in the context of the changing climate.

Keywords: forest fires, Risk, climate data, Ecological disturbances

SEISMIC WAVEFORM CHARACTERISTICS OF LANDSLIDES RECORDINGS

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ABSTRACT

Landslide monitoring plays a critical role in evaluating landslide risk, involving comprehensive data collection on factors such as landslide extent, movement patterns, surface topography, hydrometeorological parameters, and failure surfaces. This data spans a variety of temporal and spatial scales, ranging from localized site-specific observations to broader regional and global assessments. However, challenges persist due to inaccessible terrain and the limited spatiotemporal resolution of existing approaches, which raises concerns about the effectiveness of real-time monitoring. A recent advancement in passive seismology offers an innovative solution by enabling the detection of landslides through seismic signals. Despite the complexities of differentiating landslide events in real-time, researchers have focused on identifying the unique seismic characteristics of landslides, leveraging the stability and robustness of seismic network-based monitoring systems. In this study, we analyse seismic recordings of landslides obtained from global data repositories, specifically examining their statistical and frequency properties. We analyse spectrograms to explore the frequency characteristics of landslide waveforms. Additionally, we assess the statistical attributes of landslide-related seismic waveforms. This approach would facilitate real-time detection of landslide waveforms by analysing these waveform statistical characteristics and the frequency distribution of power. The study helps to enhance our understanding of seismic landslide detection, contributing valuable insights toward more effective and timely landslide monitoring.

ESTIMATING EARTHQUAKE NUCLEATION DEPTH AT THE ANDAMAN SUBDUCTION ZONE FROM HEAT-FLOW VALUES

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ABSTRACT

The Andaman subduction zone is a tectonic area where the Indo-Australian plate moves beneath the Eurasian plate. This oblique subduction results in two types of motion: vertical thrusting at the plate boundary and horizontal slipping along a fault. These movements cause significant seismic activities, including earthquakes and tsunamis. This study relates the surface heat flow to the depth of the brittle-ductile transition and the thickness of the seismogenic layer using a thermo-rheological model comprising a viscoelastic half-space characterized by Maxwell rheology and viscosity that varies with temperature. Estimation of earthquake nucleation depth is calculated by equating maximum and minimum differential stress. Maximum differential stress is obtained from depth-dependant Newtonian viscosity and geotherm, computed using surface heat flow. Minimum differential stress is a function of pore fluid factor. Earthquake nucleation zone is estimated to be at a depth of 20km, which is comparable with the past seismological observations from that area.

Key Words: Heat flow values, Temperature Gradient, Depth-dependent Newtonian Visc

ASSESSMENT OF GROUNDWATER QUALITY FOR DRINKING PURPOSE – A CASE STUDY FROM RAMAYAMPATTI LANDFILL SITE, TIRUNELVELI, TAMILNADU, INDIA.

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ABSTRACT

Groundwater is one of the important sources of fresh water widely used among the global population because of its quality since it is believed to be safe under the surface. When it comes to drinking water for humans, groundwater quality is crucial. Rapid urbanization, industrial revolution, population growth and disturbing the cycle of the environment, the groundwater quality mutates. Hence it is important to monitor the quality of the groundwater. The area surrounding two kilometres nearby Ramayanpetti landfill is taken as the study area for this current study. Groundwater samples were collected at 22 different sites which comprises of bore well, open wells and hand pumps. The physical and chemical parameters such as pH, electrical conductivity (EC), Total dissolved solids (TDS), calcium, magnesium, sodium, potassium, bicarbonate, chloride and sulphate were studied using various analytical techniques for examining the status of groundwater quality in the study area. Based on the groundwater quality measurement the majority of the sample is falls under the non-suitable category for drinking purpose due to the landfill leachate contamination. The spatial distribution maps of the above mentioned parameters using the ArcGIS gives more detailed insights about the research.

Key words: Groundwater,EC,TDS, ArcGIS

POSSIBILITIES FOR ENTRAPMENT OF NATURAL GAS IN THE BASEMENT FORMATION OF JAISALMER SUB-BASIN AND CAPTURE THE SCOPE FOR IDENTIFICATION OF GEOSEQUESTRATION IN THE SAME FORMATION

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ABSTRACT

Rajasthan basin forms the eastern flank of Indus geosyncline and is divided into three sub basins namely Jaisalmer basin, Bikaner-Nagaur basin and Barmer-Sanchor basin which are separated from each other by basement ridges. Current study has been conducted in the Jaisalmer sub-basin area. The Jaisalmer sub- basin is a pericratonic shelf bounded by the Devikot-Nachna uplift towards the east and southeast and the Barmer high marks its southern limit. The basin deepens towards north and west at a gentle dip of 3 to 5 degrees and merges with Indus basin. Three major structural trends are observed in this area such as NE-SW (Aravalli grain), ENE-WSW / E-W and NW-SE (Dharwarian grain). It shows structural complexity in the study area. In the current study, is focussed on the Basement formation deposited Precambrian age. The formation comprises with meta-sedimentary reservoir rocks composed of quartzite and slate-phyllite. Overall, the basement is tight though the analysis of computed porosity. Capture the potential gas bearing section and identification of the probable zones for geosequestration with in the basement formation are the aim of the currents study. Identification of suitable Rock type and capture the extension of required rock types are most challenging aspects in this study. The significant part of the current study depends on quantitative interpretation (QI) of rock physics and petrophysical analyses. The second crucial part of this study depends on a proper analysis of ultra-low frequency component of the available seismic data and capture the related trend from the well log data to establish the suitable rock type character between well and seismic. Finally, an integrated study of the wavelet charecterization over a 27 Hz iso-frequency component from the post-stack seismic data and its related structural component shows encouraging result of this study. The study shows a few layers silty sand with in the Precambrian basement does have potential for hydrocarbon exploration whereas structural components related to suitable rock type provides information about possibilities of geosequestration in the basement formation of the Jaisalmer sub-basin. However, 4D seismic and advanced well information are required for the actual demarcation of the Geosequestration in the study area.

Keywords: Rock physics; Quantitative Interpretation; Precambrian Basement; Geosequestration

EXAMINING THE RELATIONSHIP BETWEEN VOLCANIC EMISSIONS FROM THE ANDAMAN-SUMATRA REGION AND ATMOSPHERIC POLLUTION IN DELHI: A NEW PERSPECTIVE.

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ABSTRACT

Incidents stranding of whale and their subsequent mortality are reported from the Andaman Sea region. Our investigation into the potential causes of these occurrences has involved a thorough

analysis of available seismological and GPS data. Notably, the timing of significant earthquakes has been found to correlate with variations in Zenith Total Delay (ZTD). The observed changes in ZTD also seem to be linked to 'Nilam' cyclone event in the Bay of Bengal on October 2016. The stranding events of whales appear align with the periods of underwater volcanic activity in the Andaman region during this period. Which elevated temperatures and released toxic materials that contributed to the mortality of the whales. The volcanic gas emissions apparently affected the respiratory systems in whales.

Additionally, the presence of toxic substances in the water adversely affected their organ functions, as whales absorb nutrients through their skin. Given that the whales possess oxygen-rich bodies, any impairment in lung functions can result in oxygen loss and increased mass, prompting their movement towards the shore. We infer that the underwater volcanic activity may be a significant factor contributing towards the death of these marine animals. Similarly, major cyclonic events, such as 'Ockhi', which are closely associated with volcanic activity, have also resulted in air pollution that adversely affects the health of populations in various regions of the Indian subcontinent, particularly in Delhi and its surroundings.

Key words: GPS, Whales, Zenith Total Delay, Earthquakes, Underwater volcanism, Andaman Sea-Sumatra

MAPPING OF THE ELECTRICAL RESISTIVITY STRUCTURE BENEATH THE CHOTANAGPUR GRANITE GNEISS COMPLEX: INSIGHTS FROM A 3-D MAGNETOTELLURIC STUDY

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ABSTRACT

The Proterozoic Chotanagpur Granite Gneiss Complex (CGGC) is a significant geological unit situated in the eastern part of the Indian Shield, bordered by the Gangetic alluvium to the north, Singhbhum Craton (SC) to the south, and, the Rajmahal Traps along the north-eastern margin. An east-west oriented North Singhbhum Mobile Belt (NSMB) marks the boundary between the CGGC and SC. The CGGC spans approximately 100,000 km², extending about 200 km north-south, and 500 km east-west. It is mainly characterized by medium- to high-grade metamorphic rock formations. The timing, mechanisms of magmatism, metamorphism, and metallogeny in the region remain inadequately understood. To examine the impact of mantle or deep crustal magmatic processes, a detailed magnetotelluric survey is being conducted across the CGGC. This research aims to enhance our understanding of the subsurface's electrical conductivity, shedding light on the effects of mantle-derived magmatism and subduction on the region's crustal structure. The study utilizes data from 16 magnetotelluric stations to map the crustal resistivity structure. Based on 3-D inversion modeling, the study reveals a resistive upper crust extending to a depth of around 5 km and several conductive

features in the mid-crust. Conductive zones with resistivities ~10 ohm-m are identified between depths of 5-15 km. The presence of subduction-related magmatic fluids plays a crucial role in the mid-crust's low-resistivity characteristics. Fluids released from the subducting slab lower the melting point of overlying mantle rocks, enabling partial melting and the upward migration of molten material, enriched with volatiles like carbon. The resistive nature of the upper crust is attributed to its granite and gneiss composition. The observed low-resistivity features in the mid-crust are likely linked to carbon-rich magmatic fluids.

CONTROL OF REGOLITH THICKNESS BY BEDROCK ARCHITECTURE AND SUBSURFACE WATER PATHWAYS – RESULTS FROM THE PRANMATI BASIN, THE HIMALAYAN CRITICAL ZONE

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Tectonically active Himalayan mountain belt exhibits steep slopes and dissected topography dominated by overall compressive tectonic forces. These mountain slopes have coarse-textured thin soil cover with low water-retaining capability and are highly prone to erosion. Soil erosion is primarily driven by factors such as heavy rainfall, deforestation, landslides, agricultural activities on slopes and ongoing tectonic processes. These activities not only impact downstream ecosystems but also affect the critical zone, the interface where atmosphere, geosphere and biosphere are interacting. We have carried out an Electrical Resistivity Tomography (ERT) study and estimated the Storage Potential Index (SPI) for the Pranmati critical zone of the Alaknanda basin, Lesser Himalaya, to comprehend the erosion pattern, sediment transport and depositional processes by characterizing the underlying bedrock and associated regolith. Six ERT profiles have been laid in the catchment at two locations: one at a flat grassland while the other in a cultivated field situated on a steep hill slope (> 250). The study area is a part of the Baijnath klippe consisting of quartz-biotite gneisses with layers of quartz mica-schist enclosed by thrust faults. The 2-D electrical resistivity sections in the downslope grassland show a thick regolith (> 10 m) and higher SPI value. The resistivity sections in the crop field site yield a very thin layer of regolith (< 2 m) and a lower SPI indicating significant soil erosion. From the study, we propose that water-rock interaction facilitated by shallow-level subsurface water circulation acts as a potential source for weathering of the bedrock and the thick regolith. These observations suggest that the bedrock architecture and water channel paths within the critical zone together control the regolith thickness and hence development of deep critical zone.

SEISMIC WAVE ATTENUATION AND CRUSTAL HETEROGENEITY ANALYSIS OF EARTHQUAKE SWARMS IN THE PALGHAR REGION, WESTERN INDIA

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The present study investigates the attenuation of seismic waves due to earthquake swarm activity in the Palghar region, located within the hard strata of the Deccan Traps in the Indian peninsula. A dense dataset, comprising 10,200 high-quality earthquake events with magnitudes ranging from $1.5 \leq ML \leq 4.5$, was utilized for the analysis. These events were recorded by six broadband seismic stations in the Palghar region from 2019 to 2022. Body wave attenuation parameters, Qp and Qs, were estimated for each station using the coda normalization method at five different central frequencies ranging from 1.5 to 18 Hz. The results indicate a strong attenuation of body waves in the medium. Spatial variations of Qp and Qs were also mapped to understand the attenuation characteristics below the Palghar region. The estimated Qs/Qp ratios were found to be greater than unity across all frequency ranges and at all stations, suggesting that the crustal structure in the study region is characterized by a high degree of heterogeneity. The obtained values of Q are consistent with those reported in other tectonic regions globally, highlighting the relevance of the findings to broader geophysical studies.

Keywords: Earthquake Swarm, Qp and Qs, Body Wave Attenuation

ADVANCING LITHOSPHERIC IMAGING IN SOUTHERN AFRICA: A JOINT INVERSION OF ELECTROMAGNETIC AND SEISMOLOGICAL DATA USING THE NATURE INSPIRED ALGORITHMS

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The tectonic landscape of Southern Africa is shaped by ancient cratons bordered by Proterozoic fold belts, playing a critical role in the region's lithospheric dynamics, such as magma ascent, rifting, and extension cycles. This study advances subsurface geophysical modeling by introducing a joint inversion approach for magnetotelluric (MT) and receiver function (RF) data, utilizing the a nature hybrid algorithm combining Particle Swarm Optimization with Grey Wolf Optimization. This approach leverages both MT and RF datasets to provide a high-resolution, 1D model of the region's resistivity and velocity structures. The algorithm improves model reliability and mitigates non-uniqueness issues by ensuring structural consistency between MT and RF datasets, a critical factor for accurate lithospheric imaging. Synthetic and field data from the Southern Africa region demonstrate the algorithm's robustness, while a posterior Bayesian probability density analysis provides confidence intervals for model parameter uncertainty. Results reveal complex lithospheric structures, including conductive anomalies and stable, high-resistivity zones, reflecting the intricate tectonic evolution of Southern Africa. This methodology not only enhances our understanding of lithospheric architecture but also promises applicability to various geophysical inverse problems, underscoring the potential for joint inversion frameworks to redefine subsurface exploration.

INVITED AND AWARD TALKS

CLIMATE CHANGE AND ENERGY SCENARIO: INDIAN PERSPECTIVES

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ABSTRACT

Since energy is the main driver for socio-economic growth, a lot of efforts is being made to explore an alternate to fossil fuels as a remedial measure of combatting carbon footprint in the present climate change consequence. Though there lies a tremendous scope in the renewable/green energy sectors but no breakthrough has taken place. Till date 80% of world's gigantic energy demand is met by fossil fuels. So, we have a complex scenario to have (a) secured resources for reliable and affordable renewable/green energy or (ii) gradual transition to a low-carbon and environment-safe energy supply. If we have to depend on fossil fuels, which is the case for the next a few more decades according to the report of International Energy Agency (2021), then as per UN's initiatives of carbon neutrality by 2050 and net zero carbon emission by 2070, we have to strengthen the carbon capture, utilisation and sequestration (CCUS) experiments. Since the exploration of hydrocarbons at ease is almost over, we need to venture into difficult terrains such as fold thrust belts or foreland of the Himalaya, sub-volcanic regions in the central-western India, deep and ultra-deep waters. On the other hand, unconventional hydrocarbons such as gas-hydrates, shale gas/oil, coal bed methane, and renewable geothermal springs are considered major energy resources of India. The Science-Technology-Innovation interface is required to tap these resources in an economically affordable and sustainable manner. Availability of diverse kinds of energy resources and varying necessity in different parts, India offers an encouraging scenario for the development of hybrid technology by combining two or more diverse type of energy resources such as solar and/or wind with geothermal or ocean energy as a plausible solution to the impact of climate change. All these aspects will be discussed in the presentation.

NEW INSIGHTS INTO THE CRUSTAL STRUCTURE OF THE GANGA BASIN FROM A DECADE OF MAGNETOTELLURIC EXPERIMENTS

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ABSTRACT

The Himalaya and the Ganga foreland basin form a coupled system whose geodynamic evolution depends on the structural, compositional, and thermomechanical heterogeneities of the lithosphere between the peninsular shield and the collision front, besides the plate tectonic forces acting in this convergent environment. The lithospheric structure of the Himalaya has been mapped for many segments along its arc. However, only scanty information is available on the lithospheric structure of the Ganga basin. Therefore, we have carried out systematic magnetotelluric (MT) experiments in the Ganga Basin to map its crustal structure. Our efforts of a decade have brought out new information about the crustal heterogeneities of the Indian plate masked by thick alluvial sediments. Some salient results, emerged from our studies, are:

- Identification of a concealed block of the Bundelkhand craton much to the north of its presently known northern limit. The areal extent of this new block is about 0.82 times the area of the exposed Bundelkhand craton.
- Termination of the northward progression of the Faizabad Ridge into the Himalaya along its NNE strike.
- Identification of a concealed Proterozoic rift basin (> 30 km thick) in the Sharda Depression and electrical conductors in the lithospheric mantle of the Ganga Basin suggesting possible presence of a significant conductivity anomaly at deep lithospheric levels.
- Northward continuation of the Aravalli Delhi Fold Belt in the Ganga Basin as a collage of nearly vertical conductive and resistive blocks, the boundaries of which coincide with major inferred tectonic features. In conjunction with the MT models from the Garhwal Himalaya, these results imply spatially highly heterogeneous nature of the crust of the Kumaun - Garhwal Himalaya.

These results shall be useful in improving our understanding of the role of the fabric of the Indian plate in creating the along-arc variations in the deformation, seismicity and mountain building processes of the Himalaya.

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Seismic Data Acquisition Systems

THE DAQLINK SERIES OF SEISMOGRAPHS: THE FASTEST SELLING SEISMOGRAPHS IN INDIA!

DAQlink-5 Seismograph: A Standard DAQlink-5 24-Channel and 48-Channel Seismograph with High Speed, Compact Size & Low Power!!


Standalone DAQlink-5 Unit


V-Scope Data Acquisition Software

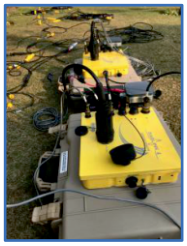

DAQlink-5 Field Deployment


Stacked DAQlink-5 Unit

Distributed DAQlink-4 Seismograph: A Standard DAQlink-4 24-Channel Seismograph with internal, high-speed, network extenders to allow for expandability up to unlimited number of channels!!


Standalone DAQlink-4 Unit


V-Scope Data Acquisition Software


DAQlink-4 Field Deployment

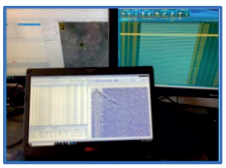

Distributed DAQlink-4 Unit

DX-6 Seismograph provides all the features NOT found in nodal acquisition systems… and it does NODAL RECORDING too!

- Real Time Command and Status ✓
- Real Time Quality Control ✓
- Real Time Data Collection ✓
- Simultaneous Active and Passive Recording ✓
- Automated deployment (Cable and Wi-Fi network options) ✓


DX-6 Seismograph


DX-6 Field Deployment


Advance Software

Sigma4 & Sigma4+ Seismographs are the most advanced, field-proven acquisition system for seismic acoustic monitoring!

- Autonomous operations using internal storage ✓
- Real Time Status, Command & Control ✓
- Real Time Data & Status (using Wi-Fi, cellular or cabled network option) ✓
- Sigma4+ with new streamlined light-weight case design ✓

Sigma4 Unit

Sigma4+ Unit


Sigma4 Field Deployment

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A trusted system integrator since 1985, supports hydrography, oceanography, defense and more. With 290 experts, we offer 24/7 support and innovative solutions to extensive Indian clientele.

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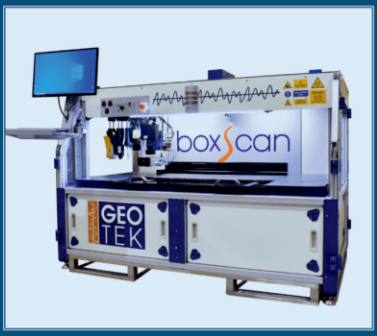

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- Ground Coupled/Air Coupled GPR
- Underwater GPR & Drone GPR
- Engineering Seismograph and Pile testing Device
- Multi-Channel Geophysical Resistivity Meter
- Broadband/Short Period Seismometer
- Strong Motion Accelerometer
- Structural Health Monitoring Sensors
- 3D IOT Crack and Tilt Sensors
- Autonomous 3D GNSS Monitoring Systems
- GNSS System for Monitoring and Early Warning of Displacement
- Earthquake Warning and Reaction Systems
- Underground Water Pipeline Leakage Detection Systems
- Unmanned Aerial Vehicle (UAV)

OUR RANGE OF SERVICES:

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- Subsurface Utility Mapping Survey
- Archeological Survey (High/Low Frequency GPR) • Electrical Resistivity Tomography / Imaging 2D/3D Seismic Refraction Survey
- Gravity and Magnetic Survey
- Passive Seismic Tomography
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National Centre for Earth Science Studies

Ministry of Earth Sciences, Government of India

The National Centre for Earth Science Studies (NCESS) is an autonomous research institute under the Ministry of Earth Sciences (MoES), Government of India. The vision of NCESS is to excel in understanding the deep internal and surface processes of solid earth, its interactive mechanism with the hydrosphere and atmosphere, and to address various scientific issues of concern to the society. The institute hosts a state-of-the-art laboratory infrastructure which enables multidisciplinary research in emerging areas of solid earth research in the country. The Centre has made significant contributions in the fields of geodynamics and deep interior of Earth, palaeo-climate, surface processes, interplay between surface and subsurface processes, coastal hydrodynamics, landslides and land subsidence, coastal erosion, submarine ground water discharge, coastal zone management and cloud physics.

Scientific Groups

NCESS functions under six scientific groups, viz.,

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

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

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

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

Marine Geoscience Group (MGG) focuses on understanding of waves, currents, sediment transport and their effects on beaches and nearshore, and the national network project on Submarine Groundwater Discharge to quantify the amount of groundwater discharge through coastal aquifers.

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

Scientific Infrastructure

NCESS is equipped with laboratory facilities, viz.,

X-ray Fluorescence, EPMA, , Isotope Geochemistry Facility with LA/MC-ICP-MS, Petrology Laboratory, Thin Section Preparation Laboratory.

Palaeomagnetism laboratory and Resistivity imaging system required for study of internal / surface processes.

Seismological Observatories with 7 broadband seismographs for earthquake and crust-mantle studies.

Fluid inclusion laboratory with Raman spectrometer coupled to microscope.

Critical Zone Observatories (CZOs) at Munnar, Attapadi and Aduthurai, IRMS.

Central Chemical Laboratory with LC-MS/MS, GC-MS/MS, MP-AES, GC, UHPLC, AAS, UV-Vis-NIR Spectrophotometer, etc.

Sedimentology Laboratory, X-ray Diffraction laboratory, SEM-EDS, Particle Size Analyzer Laboratory, Marine Laboratory, etc.

High Altitude Cloud Physics Observatory at Munnar, Mid Altitude Observatory at Braemore and NCESS Campus Observatory.

Central Geomatics Laboratory with Remote Sensing and GIS facility.

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

CSIR- National Geophysical Research (CSIR-NGRI) established in 1961, with a vision for the pursuit of earth science research, which strives for global impact and its application for optimizing sustainable societal, environmental, economic benefits for the Nation. CSIR-NGRI carries basic and applied research in the fields of Geophysics, Geology, Geochemistry and Geochronology

Overview

Research : From academic to field stations, research is lifeline of CSIR-NGRI. Excellent laboratory and infrastructure to carryout cutting-edge research in Hazard, Water, Energy, Geodynamics, Minerals. It is supported by High Computing facility.

Academic : A large number of PhD programs are running with vibrant campus life. It has two hostels with canteen facility.

Campus– Performances, events, fitness center, Club, gym facility and dispensary within the campus.

Knowledge Center : One of the largest libraries in India in Geosciences. It subscribes to 102 research journals and holds more than 20000 books.

Publications : ~ 5000 SCI research papers, ~ 1260 technical reports, more than 100 books, 31 patents.

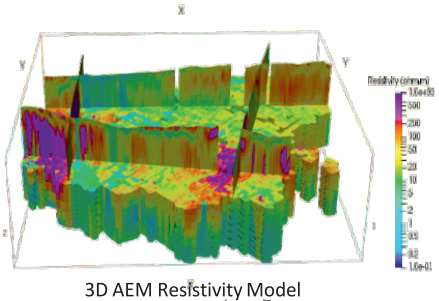
Significant Achievements

- Pioneer in Airborne Geophysical Research in India
- Gravity Map Series of India (GMSI)
- first indigenous airborne geophysical instruments
- Largest Seismological Network across the country
- Expertise of sub-Basalt imaging for oil and gas exploration
- Simulation of deep Earth processes and magnetic field

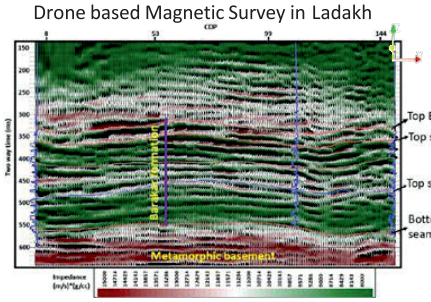
Future R&D

- ✓ Geological Hazard Assessment – Early Warning System
- ✓ Water Security – Sustainable Groundwater Resources Management
- ✓ Energy Security- Hydrocabon, Uranium, Geothermal
- ✓ Mineals – Lithium and REEs
- ✓ AI/ML for Geosciences

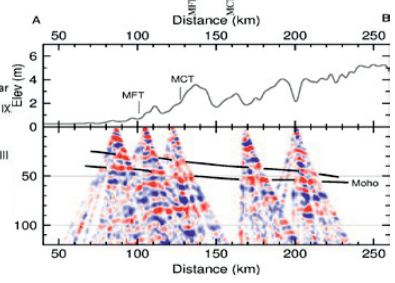
Drone based Magnetic Survey in Ladakh



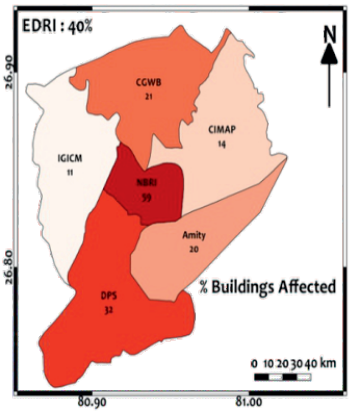
3D AEM Resistivity Model



3D Seismic Data for CBM Exploration



Seismic image of the Moho in Kashmir Himalaya



Earthquake Risk Map – Lucknow

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