4th Triennial Congress of
Federation of Indian Geosciences Association
06-08 November 2025
Hyderabad, India

Abstract Volume

Fourth Triennial Congress of Federation of Indian Geosciences Association on Geosciences for Blue Economy - Potential of Indian Ocean along with the 62nd Annual Convention of IGU & 42nd Annual Convention of AHI

06-08 November 2025

INCOIS

Indian National Centre for Ocean Information Services (INCOIS)
Ministry of Earth Sciences, Govt. of India
Hyderabad, Telangana, India

https://figa2025.incois.gov.in

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Federation of Indian Geosciences Associations
4th Triennial Congress
On

Geosciences for Blue Economy-Potential of Indian Ocean
6-8 November 2025

Venue

Indian National Centre for Ocean Information Services (INCOIS), Hyderabad

Sponsored by

Ministry of Earth Sciences (MoES), New Delhi

National Institute of Ocean Technology (NIOT), Chennai

Oil India Limited (OIL Ltd.), New Delhi

CSIR-National Geophysical Research Institute (NGRI), Hyderabad

National Centre for Polar and Ocean Research (NCPOR), Goa

National Centre for Earth Science Studies (NCESS), Thrivendram

Indian Institute of Tropical Meteorology (IITM), Pune

CSIR-North-East Institute of Science and Technology (NEIST), Jorhat

Wadia Institute of Himalayan Geology (WIHG), Dehradun

India Meteorological Department (IMD), New Delhi

Indian Institute of Geomagnetism (IIG), Navi Mumbai

Indian National Centre for Ocean Information Services (INCOIS), Hyderabad

November 2025

Price: Rs. 2000/-

For Copies
Write to:
Secretary General
Federation of Indian Geosciences Associations
CSIR-NGRI campus, Hyderabad -500007


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PREFACE

Earth System Science has evolved as an interdisciplinary field with increased involvement of multiple disciplines covering Solid Earth, Ocean, Atmosphere, Cryosphere, Biosphere and Planetary Sciences, creating the need for a common platform to exchange and interlace visions and activities within the Earth Science community and across allied scientific domains. In this context, the Federation of Indian Geosciences Associations (FIGA) was established in 2014 to bring synergy among Earth scientists and foster collaborative scientific programs of national and international relevance undertaken by different Geo-scientific institutions and associations. Currently, the FIGA comprises eight Geoscience Associations: IGU, GSI, AHI, AEG, SPG, PSI, ISES and OSI as Members, and eight Institutions/Ministries: NCESS, CSIR-NGRI, IIG, MoES, AMD, KDMIPE, WIHG, INCOIS and NCPOR as Patron Members. This initiative aims to unite Geoscience Associations and Institutions on a single stage to address common goals, foster development in geosciences, and contribute to the sustainable growth of society. Recognizing the significant role that Geosciences can play in shaping future, the FIGA had successfully organized three Triennial Congress - the first held at IIT(ISM), Dhanbad (2016), the second at CSIR-NGRI, Hyderabad (2019), and the third at WIHG, Dehradun (2022) in the past. All these had addressed common scientific issues, provided feasible solution to societal challenges and contemporary issues, and brought out documents of outcome that can be used for policy decision.

Oceans covering more than 70% of our planet regulate climate, support ecology, and sustain human life. The oceans around India and the long coast lines play critical role to biodiversity, living and non-living natural resources, green energy, monsoons, climate, excess heat, carbon footprint, natural hazards, water, food chain, trades, tourism, hydrocarbon and unconventional energy resources like gas-hydrates, etc. A sustainable ocean economy may emerge when economic activity remains in equilibrium with the marine and coastal ecosystems, resource exploitation and process dynamics in terms of resilience and human wellbeing for a longer period. The ocean dependent economy continues to prosper in the current era of climate change. Therefore, the fourth Congress of FIGA has been focussed on the Ocean, and the theme has been chosen as *"Geosciences for Blue Economy - Potential of Indian Ocean"*. The 4th Congress, being organized by ESSO-INCOIS and FIGA in Hyderabad during November 6-8, 2025 at the INCOIS campus with the active involvement and support from all other Member Associations and Patron Members of FIGA. The International collaboration embraces participation from the IUGG and AGU.

The key features of this congress include plenary lectures and keynote talks by eminent scientists and professors from abroad and within countries, contributory presentations (both oral and poster), Science & Technology exhibitions, Annual Conventions / General Body meetings of member associations, and Joint Session with the International associations mainly to discuss the role of Geosciences for Sustainable Blue Economy along with sub-themes on Natural Hazards and Energy Resources. Additionally, a Young Scientist Conclave and a Women Scientist Conclave are being organized to provide podiums for emerging researchers to showcase their talents. There will be National Award ceremony, instituted by the member associations, in recognition of outstanding contributions made by both the young and experienced Geoscientists in specific domains of their research. Students will also be recognised for their outstanding academic performances. There is a special coverage too on 'Popularising Ocean Sciences to School Children" in order to inculcate a sense of responsibility into the school going students towards the marine ecosystems and to nurture the curiosity on ocean tides, marine food chains, pollution and climate change with a view to arouse thought process into their mind for the protection of our blue planet.

The Congress begins with a workshop on Sea Level Changes and ends with the Field visits and City tour. The 4th Congress covers several ocean-related topics such as the Coastal Processes, Ocean Dynamics, Marine Heatwaves, Coastal and Ocean Resources, Bio Resources, Coastal Aquifers, Submarine Discharges, Energy Resources, Marine and Coastal Hazards, and Recent Advances and Emerging Tools – Early Warnings, AI/ML.

Over 350 delegates are going to participate in the Congress for deliberations, discussions, and creating networks for progressing their research. More than 230 abstracts have been received, which are spread over different plenary and technical sessions, reflecting the vibrancy and diversity of the geoscience community in India. The young researchers and faculties would be intensely benefitted from the Congress in advancing their research through presentation, receiving feedback from peers, interacting with the experts, networking for collaboration, getting exposure to latest trends of research, understanding societal challenges and technological barriers, and scopes for innovation towards plausible solution. Thus, FIGA plays a very important role not only in percolating knowledge but also encourages young researchers in pursuing Geosciences for the Society in sustainable manner. We have also arranged for 2-mins oral presentation by each poster presenter along with one-hour 15-minutes slot for their poster presentation.

Since FIGA has completed more than 10 years, we have brought out a Compendium, as a milestone outcome, which contains the significant concerns or issues that can be used by relevant ministries to develop their policy documents. This encompasses ocean resources, geological hazards, freshwater management, energy resources, AI in Geosciences, climate change and its impact, critical minerals, Geoscience workforce for socio-economy and, Geosciences for society and urban development.

Organizing such a Congress needs a meticulous planning and involvement of many in different ways. Prof. V.M. Tiwari, President; Dr. M. Ravichandran, President Elect; Prof. Rajendra Prasad, Vice President; Dr. T. M. Balakrishnan Nair, Congress Director; Dr. ASSSRS Prasad, Treasurer; Prof. Harsh K. Gupta, Prof. Shailesh Nayak, Prof. V.P. Dimri and all other esteemed EC Members of FIGA are the main force behind this program. Dr. E. Pattabhi, Mr. Sudheer Joseph, Dr. R.S. Mahendra, Mr. N. Kiran Kumar, and many others of the LOC in organizing this Congress are acknowledged for their untired efforts to make it successful. We shall fail our duty if we do not express our gratitude to respected Prof. A.K. Sood, PSA to Govt. of India, being the Chief Guest, Dr. M. Ravichandran, Secretary, MoES, being Guest of Honour and several distinguished Scientists/Professors for sharing their thoughts, views and current trends of research through deliberations.

No congress takes place without any budgetary support, and thanks are due to different Institutes, Ministries, Organizations, Exhibitors for extending financial and logistic supports.

Wishing the 4th FIGA - 2025 at ESSO-INCOIS, Hyderabad a Resounding Success.

Dr. Kalachand Sain
Secretary General, FIGA

CHIEF GUEST MESSAGE

It gives me great pleasure to convey my greetings to the organizers and participants of the **4th Triennial Congress of the Federation of Indian Geosciences Associations (FIGA)**. The Congress serves as an important platform bringing together geoscientists, researchers, academicians, and industry experts to deliberate on key issues related to Earth sciences, natural resources, and sustainable development.

India's geoscience community plays a vital role in addressing the pressing challenges of our time—climate change, natural hazards, groundwater management, mineral exploration, and environmental sustainability. The collaborative efforts of institutions and researchers through initiatives such as FIGA are essential for developing innovative solutions and informed policies to ensure the responsible use of our planet's resources.

I am pleased to note that the Congress is fostering dialogue among diverse geoscience associations and young researchers. Such engagements will undoubtedly promote interdisciplinary learning, capacity building, and the translation of scientific knowledge into societal benefit.

I extend my best wishes for the grand success of the 4th Triennial Congress of FIGA and hope that the deliberations and outcomes of this event will significantly contribute to the advancement of geosciences in India and beyond.

Prof. Ajay Kumar Sood
Principal Scientific Adviser to the Government of India

सत्यमेव जयते

डॉ. एम. रविचंद्रन
Dr. M. Ravichandran

सचिव
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पृथ्वी विज्ञान मंत्रालय
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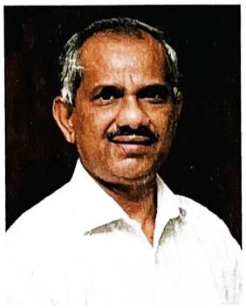

Message of Guest of Honour

I am delighted to learn that the Federation of Indian Geosciences Associations (FIGA) is organizing its 4th Triennial Congress (4TAC) at INCOIS, Hyderabad. The theme of this Congress, bringing together diverse disciplines of Earth Sciences, is highly relevant in the present context of global environmental change and the need for sustainable development.

The Earth Sciences community plays a vital role in understanding our planet's dynamic systems—ranging from the deep Earth processes to atmospheric, oceanic, and climatic interactions. I am pleased to note that FIGA, through this Congress, provides a platform for scientists, academicians, technologists, and policymakers to exchange ideas and collaborate on addressing critical challenges such as natural hazards, climate variability, and resource sustainability.

I extend my best wishes to FIGA, the organizers, and all participants for the successful conduct of the 4th Triennial Congress. I am confident that the deliberations and outcomes of this event will contribute significantly to strengthening geoscientific research and its applications for national development.

(M. Ravichandran)

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MESSAGE FROM THE PRESIDENT FIGA

It gives me great pleasure to extend my warm greetings and best wishes to all delegates, participants, and organizers of the *4th Triennial Congress of the Federation of Indian Geosciences Associations (FIGA–4TAC)*. The Federation, through its member associations, has consistently strived to bring together the Indian geoscientific community on a common platform to exchange ideas, share research insights, and deliberate on the emerging challenges and opportunities in Earth sciences.

The *4th Triennial Congress* serves as a vital forum for fostering collaboration among researchers, academicians, and industry professionals working across diverse branches of geosciences. Advancing integrated geoscientific research is crucial for addressing issues of national and global importance, ranging from natural resource management and environmental sustainability to disaster resilience and climate change adaptation.

I sincerely appreciate the efforts of the Organizing Committee, INCOIS, and all collaborating institutions for successfully hosting this significant event. Their dedication in providing an enriching platform for young researchers to present their work and engage with experts is truly commendable.

I am confident that the discussions and interactions during *4TAC* will generate new ideas, strengthen scientific cooperation, and make valuable contributions to the advancement of geosciences in India.

I extend my best wishes for the grand success of the Congress and hope that its deliberations will inspire collective efforts towards a deeper understanding and sustainable management of our dynamic Earth system for the benefit of society.

Dr. Virendra M. Tiwari
President, Federation of Indian Geosciences Associations (FIGA)

FORWORD

It gives me immense pleasure to extend warm greetings and best wishes to all participants of the Fourth Triennial Congress of the Federation of Indian Geosciences Association (FIGA), centered on the theme "Geosciences for Blue Economy – Potential of the Indian Ocean." The conference comes at a time when oceans are increasingly central to our national growth, climate stability, and planetary well-being.

India, with its 11,100 km coastline and strategic location along the Indian Ocean, is uniquely positioned to leverage marine and geoscientific knowledge for sustainable development. Oceans cover 70% of the Earth's surface, sustaining life, regulating climate, and driving the global economy. The Indian Ocean region, while rich in resources and biodiversity, remains vulnerable to natural hazards such as cyclones, tsunamis, and coastal erosion—necessitating integrated scientific and policy action.

As India advances toward a Blue Economy, the convergence of science, technology, and policy is essential to ensure the responsible use and conservation of ocean resources. The 4th FIGA Conference provides a timely platform for discussions spanning coastal processes, ocean dynamics, climate change, marine resources, energy systems, geohazards, and geoscientific innovations. It also underscores youth engagement and ocean literacy as key pillars for a sustainable future.

This conference aligns with major national missions—Atmanirbhar Bharat, Deep Ocean Mission, India's Blue Economy Vision, and the National Marine Spatial Planning Framework. The marine geoscience sector is instrumental in realizing self-reliance through indigenous technologies in early warning, seabed mapping, mineral exploration, and offshore infrastructure. Internationally, the event resonates with the objectives of the UN Decade of Ocean Science for Sustainable Development (2021–2030).

The Indian National Centre for Ocean Information Services (INCOIS), under the Ministry of Earth Sciences, has been at the forefront of operational oceanography, delivering reliable advisories and multi-hazard early warning services. These initiatives demonstrate how geoscience underpins sustainable development, coastal resilience, and marine ecosystem stewardship.

Ocean science is indeed geoscience—the dynamic interface of land, sea, and atmosphere where tectonics, sedimentation, and biological processes interact. Strengthening geoscientific capacity through collaboration across the Indo-Pacific and Indian Ocean Rim is vital for a resilient and inclusive maritime future.

I congratulate the organizers, scientists, and young scholars for convening this landmark event, which has received over 250 abstracts. May this conference inspire innovation, collaboration, and actionable pathways for geoscience-driven ocean development in India and beyond.

Let us together harness ocean knowledge for society, guided by resilience, equity, and self-reliance—toward a truly Atmanirbhar Bharat.

Best wishes for a successful and impactful conference!

T.M. Balakrishnan Nair
Director, INCOIS

FEDERATION OF INDIAN GEOSCIENCES ASSOCIATIONS (FIGA)

The **Federation of Indian Geosciences Associations (FIGA)** was established in **2014** with the primary objective of bringing together India's diverse geoscience associations under a single umbrella. FIGA serves as a national platform for **coordination, collaboration, and knowledge exchange** among Earth science communities and institutions across the country.

Historically, many of India's notable contributions in geosciences have been the result of individual efforts rather than coordinated institutional or community-based initiatives. Recognizing the need for a **unified cohesive forum** to deliberate on common challenges and opportunities, FIGA was conceived to foster **cooperation, synergy, and shared purpose** among geoscientists and their organizations.

Today, FIGA comprises **nine national associations** and **nine national institutions**, each actively engaged in geoscientific research, education, and outreach. Through their collective expertise, FIGA provides **strategic guidance and advisory inputs** to strengthen the visibility, impact, and societal relevance of geosciences in India.

The federation of Indian Geosciences Associations

Mission

To promote **interdisciplinary geoscience research**, facilitate knowledge exchange among academia, industry, and society, nurture the next generation of geoscientists, and catalyse **collaborative solutions** to national and global challenges related to geohazards, climate, natural resources, and the environment.

Outreach and Engagement

FIGA's outreach initiatives aim to **connect science with society** and build capacity across regions and demographics through:

- **Public lectures and community workshops** on coastal safety, earthquake preparedness, and groundwater awareness.
- **School and college engagement** through field trips, interactive modules, and teacher training programs that inspire early interest in Earth sciences.
- **Media and digital outreach** via explainer videos, newsletters, and social media campaigns translating scientific findings for public understanding.
- **Industry and policy dialogues** through roundtables and policy briefs that translate geoscientific insights into actionable recommendations for decision-makers.

Triennial Congress of FIGA

The **Triennial Congress** is FIGA's flagship event, addressing issues of national and global significance, such as the role of geosciences in achieving the **Sustainable Development Goals (SDGs),** and providing a comprehensive overview of the status, challenges, and pathways forward for Indian geosciences.

Key features include:

- Multi-track scientific programs covering climate, solid Earth, hydrogeology, geotechnical engineering, remote sensing, GIS, and applied geosciences.
- Poster and oral sessions, technical workshops, and exhibitions showcasing institutional initiatives and technologies.
- Special sessions with policymakers, industry leaders, and community stakeholders to foster actionable collaborations.
- Support for students and early-career scientists through **travel grants, mentorship programs, and inclusive facilities.**

Plenary and Invited Talks

At the heart of the Congress are **plenary lectures** and **invited sessions** that highlight emerging science and thought leadership:

- Plenary talks by eminent national and international scientists focusing on integrative and frontier challenges.
- Thematic lectures on cutting-edge methods, research advances, and applications.
- Panel discussions bringing together diverse perspectives from science, engineering, policy, and community sectors.

Young Scientist Conclave

FIGA places strong emphasis on nurturing early-career researchers through:

- A dedicated platform for PhD scholars and postdoctoral researchers to present their work and network.
- Workshops on career development, proposal writing, science communication, and entrepreneurship.
- Mentorship pairing between early-career and senior scientists.
- Awards and travel grants to recognize outstanding research contributions.

Women Scientist Conclave

Committed to **gender equity and professional advancement,** FIGA's Women Scientist Conclave focuses on:

- Promoting leadership development and addressing career barriers for women in geosciences.
- Networking sessions, policy dialogues, and discussions on work–life balance and fellowship opportunities.
- Mentorship initiatives and recognition of women's contributions across research, education, and applied geosciences.

Strategic and Advisory Role

FIGA periodically reviews and deliberates on the **status, challenges, and future directions** of geosciences in India, publishing position papers and strategic recommendations for the benefit of academicians, professionals, researchers, policymakers, and government agencies. Two such reports have already been published in 2016 , reflecting FIGA's thought leadership and advisory influence.

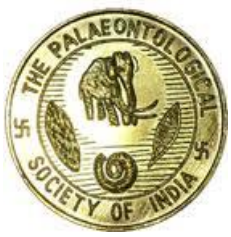
Guiding Motto

Geosciences for Development and Welfare of Society

In pursuit of this vision, FIGA strives to:

- Foster synergy among Earth science associations and institutions.
- Coordinate and promote geoscience research, education, and outreach.
- Enhance training and capacity building in Earth sciences.
- Represent India's geoscience community in national and international forums.
- Strengthen geoscience's societal role through scientific commissions and collaborative initiatives addressing national priorities.

FIGA PATRON & ASSOCIATION MEMBERS



INDIAN GEOPHYSICAL UNION (IGU)

The Indian Geophysical Union (IGU), established in 1963, was founded with the blessings of eminent scientists, including Prof. K.R. Ramanathan, Prof. S. Bhagavantham, Prof. M.S. Krishnan, and Dr. S. Balakrishna. Over the years, IGU has evolved into the premier scientific organization in India dedicated to advancing research, education, and the application of geophysical sciences.

Headquartered at the CSIR-National Geophysical Research Institute (NGRI), Hyderabad, IGU functions as a non-profit scientific society representing professionals, researchers, academicians, and institutions working across various disciplines of Earth and Environmental Sciences — including geophysics, geology, seismology, marine and ocean sciences, hydrology, and planetary sciences.

The progress of IGU has been made possible through the invaluable support of numerous geoscientists, whose contributions are deeply acknowledged and appreciated. IGU remains committed to encouraging young researchers to enhance their scientific capabilities and broaden their global perspectives. It also urges senior scientists to mentor these young minds, sharing their extensive experience to guide the next generation of geoscientists.

The primary objective of the **Indian Geophysical Union (IGU)** is to promote and disseminate geophysical knowledge through scientific research, collaboration, and communication. It endeavours to:

- To bring together all geophysicists active in various disciplines such as seismology, magnetism, meteorology, geodesy, volcanology, oceanography, hydrology, and tectonophysics, and to provide them with opportunities for meeting and discussing current problems of geophysics of the solid earth and the oceans.
- To encourage the study of and research in geophysical problems and to provide a medium for the publication of the results.
- To organize and arrange for the meetings and conferences of the Union and encourage the publication and dissemination of knowledge of geophysics and of important research in various branches of geophysics.
- To cooperate with similar learned societies in organizing and taking part in meetings, symposia, research projects, etc, and to represent geophysics both in the national and international sphere.
- To secure and administer funds, grants, and endowments for the furtherance of research in geophysics.
- To undertake and execute all other acts which shall assist and promote the usefulness, aims, and purposes of the Union.

IGU organizes scientific and societal activities throughout the year by organizing expert talks at various universities, IITs, and institutes. IGU also holds annual conventions, which serve as major scientific gatherings of the geoscience community in India. These events feature keynote lectures,

technical sessions, panel discussions, and exhibitions highlighting advances in Earth and environmental sciences. IGU also publishes scientific abstracts, special volumes, and proceedings to document emerging research trends and innovations.

The research and outreach activities of IGU have significant societal relevance. By promoting studies on solid Earth, marine, space, and planetary sciences, IGU contributes to improved resource management, groundwater assessment, coastal protection, and environmental monitoring — thereby supporting national priorities in sustainability, environmental safety, and resilience. IGU actively engages in outreach and educational programs to inspire young researchers and students through its Student Activities organized at universities, research institutes, and organizations across India. The Young Researchers Program, training workshops, and lecture series provide opportunities for early-career scientists to interact with experts and enhance their skills. IGU also collaborates with universities, research institutions, and government agencies to foster geoscience literacy and public awareness.

Through its sustained efforts over more than six decades, the Indian Geophysical Union continues to play a vital role in promoting scientific excellence, supporting national development, and addressing societal challenges by advancing the geosciences.

ASSOCIATION OF HYDROLOGISTS OF INDIA (AHI)

The Association of Hydrologists of India was instituted in 1981 with the objective of providing a common platform to scientists working on various aspects of hydrology like civil engineering, meteorology, geophysics, geology and remote sensing, environmental engineering and sciences etc., for exchange of ideas and concepts. To realize its objectives a number National / International seminars are organized annually in different locations in the country. From its existence AHI has organized 42 seminars including three international seminars in different parts of India and abroad. Besides to bring awareness in the current trends in the field of Hydrology, monthly AHI webinars are being conducted and found getting good responses from Academic/research institutions. The AHI is an accredited member of the United Nations Committee on Environment and Development (UNCED).

The AHI has the good fortune of having Padmasri Prof. Dr. Harinarayan, a long term director of National Geophysical Research Institute, former Vice-Chancellor of Banaras Hindu University and former Surveyor General of India as its first President. It was also fortunate that Padmabhushan Prof. Dr. P. Koteswaram, the former Director General of India Meteorological Department and well know international expert in Water resources was the first Vice-President of AHI and a long time President of the AHI.

Further, the organization of an international seminar on Hydrology at Kathmandu, Nepal in 1993 and during April 19-21st 1993 on "Environmental problems and water resources of Himalayan region" in collaboration with the Nepal Geological Society at the Tribhuvan University and the organization of 8th IAHS Scientific Assembly and 37th IAH Congress in collaboration with NGRI at Hyderabad have made an indelible mark in the national and International Hydrological community. The critical appraisal and recommendations made based on the surveys carried out on the status of Irrigation and drinking water tanks in the country and the comprehensive hydrological and medical surveys carried out in CKD affected areas of AP reflects the role and services of science to society.

Realizing the need to bring out a quality journal in Hydrology 'Journal of Applied Hydrology' has been published quarterly since 1988. Since then the journal, with the patronage of the readers and the authors, has been brought out uninterruptedly. The AHI has been establishing a strong relationship with IAHS and been regularly associated with the activities of IAHS for more than a decade. The AHI has been playing a key role in bringing together National Hydrological Associations and became a member of 'National Hydrological Associations' forum created under the aegis of International Association of Hydrological Sciences (IAHS). AHI has represented the NHA meetings held in Iguassu, Melbourne, Gothenburg and Prague and Montreal. The AHI has been the founder member of FIGA and has been actively participating in its endeavors to propagate geosciences at national and international levels by way of conducting AHI conventions and seminars during FIGA 2016, FIGA 2019, FIGA 2022 and FIGA 2025.

The AHI is involved not only in the promotion of Hydrological Education and mentoring of the upcoming hydrologists but also recognized the need to recognize and duly reward the Hydrologists contributed to the promotion of Hydrology. As a part of this endeavor AHI along with CSIR-NGRI confers three awards annually viz., i) NGRI-AHI Life Time Achievement Award in Hydrology, ii) NGRI-AHI Indian National Hydrology Lecture Award & iii) NGRI-AHI Young Hydrologist Award.

The AHI would be taking a leading part in the growth and development of hydrological sciences in India as also its dissemination not only among the scientists but also the larger public. Hydrology is the science of water – needed for all living human beings, animals, creatures, birds and plants.

Adbhyassambhutah Prthvyairasacca

GEOLOGICAL SOCIETY OF INDIA

B. P. Radhakrishna Bhavan, 30/31, 3rd Cross, 1st Main, Byrappa Garden, Kathriguppe, BSK III Stage, Bengaluru 560 085.

Highlights of the Triennium (2022–2025)

Established in 1958, the **Geological Society of India (GSI)** is among the oldest and most respected scientific societies in the country. Beginning modestly with a single annual issue in 1959, the *Journal of the Geological Society of India* has grown steadily and has been published monthly since 1977. It now reaches a wide readership of geoscientists in academia, research institutions, government organizations, and the mining industry in India and abroad.

The Society takes great pride in maintaining an **unbroken record of regular publication** of its Journal — every issue released on time since its inception. A major milestone during the Triennium (2022–2025) was the **transition of the Journal's publishing platform** from Springer to **GeoScienceWorld (GSW), USA**, a not-for-profit organization, effective from **1st January 2024, along with the archived contents**. This strategic shift aims to enhance the Journal's global visibility, accessibility, and impact within the international geoscience community. GSW has also provided option to host the eBooks and the Society has uploaded two dozen selected publications for international visibility and access.

Publications

In addition to its flagship Journal, the Society continues to publish **textbooks and monographs** in geology at highly affordable prices, catering to both professional geologists and students. These publications are produced on a **non-profit basis** as part of the Society's commitment to advancing Earth science education.

During the Triennium, the following volumes were released:

1. *Geology and Mineral Resources of Kerala*
2. *Geology and Mineral Resources of Tamil Nadu and Puducherry (Revised Edition)*
3. *Textbook on Geology of Chhattisgarh*
4. *Geology of Odisha*
5. *Fossils Records of Rajasthan Western India*
6. *Emerging Energy Resources in India*
7. *Palynology in Hydrocarbon Exploration (The Indian Scenario) Part-III*
8. *Basics of Geological Maps and Interpretation*
9. *Rare Earth Element Occurrences and Deposits of India and Strategies for New Discoveries*
10. *Iron Ore Resources of India*

Educational and Training Activities

The Society actively supports capacity-building initiatives for Earth science educators and professionals. In collaboration with the **Geological Survey of India Training Institute, Chitradurga**, a **Training Programme** was organized in **September 2025** for geology faculty members from undergraduate and postgraduate institutions. The programme provided hands-on

training in **geological mapping and mineral exploration**, significantly strengthening teaching and field competencies in academic institutions.

Outreach Activities

Continuing its strong focus on outreach, the Society has sustained efforts to **promote Earth sciences among the younger generation**. A key initiative is facilitating **India's participation in the International Earth Science Olympiad (IESO)**. The programme encourages school students to engage with global challenges such as climate change, natural resource management, and environmental sustainability. In the most recent IESO, held in physical mode at China, Indian students delivered an outstanding performance by securing **seven medals** across various events — a testament to their scientific excellence and the Society's mentoring efforts.

Scientific Programmes

The Society's hallmark **Monthly Scientific Lectures** (held on the **second Wednesday of each month**) continued successfully throughout the Triennium, along with the **Special and Endowment Lectures**. These sessions featured eminent speakers from:

- Central agencies such as **GSI, AMD, NGRI, WIHG, CGWB**, and other government institutions;
- Universities, research organizations, and international scientific bodies.

A total of **34 monthly lectures** and **13 endowment lectures** were conducted in **hybrid mode** during the period under review. In addition, **13 special virtual lectures** were organized, featuring distinguished experts from the **USA, UK, Australia, the Netherlands, and Chile**, covering diverse and contemporary themes in Earth sciences, including climate change and resource sustainability.

Regional Centres

The Society's network of **Regional Centres** has played a vital role in promoting localized scientific engagement. During the Triennium, a new **Regional Centre was established at Bhubaneswar** to serve Fellows and members in Odisha. The Odisha Chapter has been particularly active, having organized two well-attended workshops/seminars since its inception. Other Regional Centres across the country have also remained vibrant, conducting **seminars, workshops, and observances of Earth Day, Environment Day, and Geodiversity Day** each year, thereby promoting environmental awareness and public appreciation of geosciences.

Seminars and Annual Conventions

The **Annual Conventions of the Society**, along with associated **seminars**, were successfully organized during the Triennium at **Dharamshala (2023), Dharwad (2024), and Nainital (2025).**

Each of these events provided valuable platforms for researchers, professionals, and students to exchange scientific ideas, present findings, and deliberate on emerging issues in Earth science.

Through its sustained publishing excellence, educational initiatives, outreach programmes, and scientific engagements, the Geological Society of India continues to uphold its founding mission — **to advance the cause of geosciences and contribute to the nation's scientific development**. The Triennium (2022–2025) has been a period of consolidation, innovation, and outreach, setting a strong foundation for the Society's future growth and service to the geoscientific community.

OCEAN SOCIETY OF INDIA

Launched on March 19, 2006 the primary objective of the Ocean Society of India (OSI) has been to strive for the advancement and dissemination of knowledge in ocean science and technology. The registered office of the OSI is at CMLRE, Kochi. Presently OSI has nearly 900 life members from the length and breadth of India. In addition, we have three Institutional Members viz. NIOT, NCPOR and SIST, and one Corporate Member (Varyatech Private Limited). Currently it has eight local chapters functioning actively at Kochi, Pune, Goa, Chennai, NCR Delhi, Kharagpur, Vizag and Ahmedabad.

In order to achieve its objectives, OSI has several areas of activities. OSI provides avenues for robust technical dialogue across the different disciplines of oceanography through conferences, webinars and panel discussions to broaden communication and share new ideas. Since 2009, biennial conferences of OSI (OSICON) have become the major events of the society and so far, nine OSICONs have been organised. The next OSICON is due to be organised by IITM at Pune in 2027. Apart from biennial conferences, OSI organizes several invited talks by eminent Scientist/Experts from various disciplines.

Through its awards programme, the Society recognizes and celebrates our colleagues' exceptional achievements and contributions to the ocean sciences. Honorary Fellowships is the highest award conferred by OSI on highly distinguished professionals of eminence. Fellowships are awarded to life members of OSI for outstanding contributions to ocean science and engineering. The next category of awards is the Endowment Awards instituted in honour of eminent scientists. OSI has instituted three Endowment Awards so far. The first one is the Dr. D. Srinivasan Endowment Award instituted in loving memory of Dr. D. Srinivasan, former Director of NPOL, and the second Endowment Award instituted is in the fond remembrance of Prof. R. Ramesh, who was a distinguished scientist at the PRL, known for his significant contributions to climate and ocean sciences. OSI has very recently instituted the Alluri Satya Kiran Raju OSI Endowment in loving memory of the Late Sri. Alluri Satya Kiran Raju, an outstanding young coastal engineer. In addition, awards also have been instituted recently to motivate young scientists and early career professionals viz.. Early Career Professional Award in Coastal Oceanography instituted by Prof. P. Vethamony, Dr. R R Rao Woman Scientist Award in Physical Oceanography and Sri. Sundara Ramam Award in Physical Oceanography.

Motivation of young researchers and students through Best Thesis and PG Dissertation awards is an important activity of OSI. Yearly PG Dissertation awards and Biennial Best Thesis Awards are presented in 7 different themes of ocean sciences and technology. In addition, Best paper Awards are presented for presentations in the OSICON.

The society organizes outreach programmes on different aspects related to ocean conservation and sustainable use of ocean resources with the aim of inculcation of the message of a clean beach and pollution free ocean in the minds of students and general public. Beach cleaning programmes covering all maritime states of the country are organised by OSI every year on the occasion of the World Oceans Day and International Coastal Clean-up Day.

'Ocean Digest' - a quarterly online technical publication brought out by OSI is yet another important feather in its cap. With increasing memberships and patronage from leading institutions, the OSI plans to play a dominant role in the advancement and dissemination of knowledge in ocean science and technology in the country. These include playing a pivotal role in the development of human resources in the field, sensitizing school children on ocean sciences, conducting training programmes for policy makers and engineers to alleviate the knowledge gap, sensitizing the local community in creating a litter free coast through tie-up with coastal NGOs, etc.

ASSOCIATION OF EXPLORATION GEOPHYSICISTS

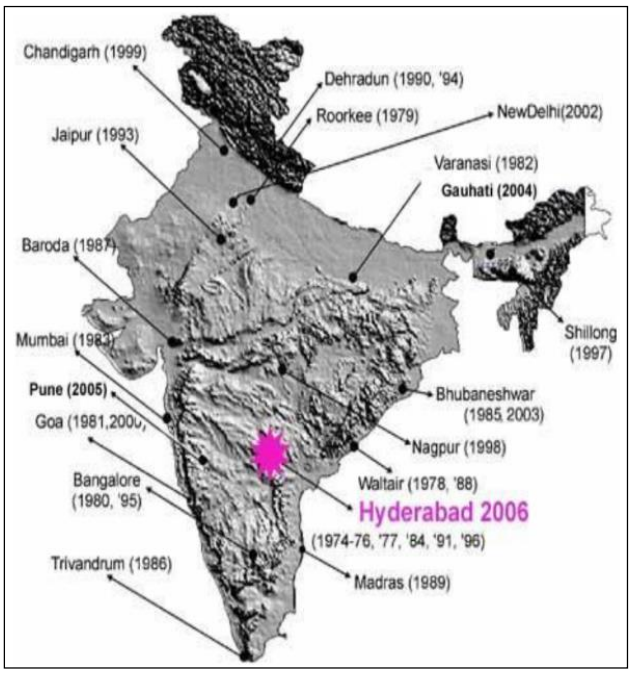
(AEG)

AN OVERVIEW OF THE ACTIVITIES OF THE ASSOCIATION OF EXPLORATION GEOPHYSICISTS (AEG)

AEG was formed in 1974 by Prof. VLS Bhimasankaram, the founder and Head, Department of Geophysics and Centre of Exploration Geophysics, Osmania University, Hyderabad, to encourage young talented Geophysicists Under his guidance as Secretary, AEG was instrumental in developing many young minds those are today eminent Geophysicists of National and International repute. AEG later encouraged students and Research scholars by honouring toppers in University and the best Ph.D. thesis. By collaborating with the industry several projects were taken up by AEG and bridged the gap between Academia, Research institutes and the Industry. Very soon AEG conferences were venue for International participation, exchanging scientific developments and a great platform for Geophysicists and geoscientists. Thus AEG has seen a GOLDEN ERA under Prof. VLS Bhimasankaram.

AEG started publication of the Journal of AEG in 1980. The Journal of Geophysics (JOG) is a quarterly Journal and is currently in its XLV volume. The Journal had a good response and got the ISSN International accreditation and continues to be an internationally reputed Journal. Presently, it is capable to receive and publish online through its website https://aegind.org/. The Journal attracts scientific papers from a large number of earth science institutions in India and abroad. Since inception of the Association more than 4000 papers were presented in the Annual seminars of the association. In addition, research papers were also received directly for publication in the journal. After rigorous reviewing process by experts in India and abroad, so far more than 2000 papers have been published as on date. Over 1000 copies of each issue of the Journal are circulated to AEG members and subscribers in India and abroad until before the COVID-19. Now the journal copies are freely available on its website.

AEG is continuously striving to support and popularise the geo-sciences particularly in geophysics paternity. It has been organising almost every year an event, either a National or International, as Annual Conventions, Conferences, Seminars Exhibitions, focusing mainly on the contemporary issue for mitigating advanced solutions. Periodically, AEG conducts workshops, and guest lectures etc. over webinar for the benefit of younger generations.



The New Executive Body of AEG is on the path of revival using latest publishing tools. The New Executive body of AEG under the leadership of Ms. Sushma Rawat, Director (Exploration), ONGC and President, AEG, has launched e-journal, during November 2024, to have greater accessibility to Geophysicists and Geoscientists across the world.

AEG invites original research papers from geo-scientists of various organisations, research scholars of different Institutions, Mining Engineers, Scientists of Engineering-

Geophysics, Dam Safety and near-surface geophysicists and publish in JOG as per the ISSN guidelines of Journal of Geophysics. https://aegind.org/

The e-journal reaches the far corners of the world AEG welcomes the organizations and the Earth Science Institutions to advertise their products and services in e-JAEG. For details regarding Advertisement Tariff, the advertisers are requested to correspond with Secretary, AEG on Email: aegindiageophysics@gmail.com. Last year during 12-13 December, 2024 AEG has celebrated it golden jubilee year on the special theme on "**Geo-exploration for Critical Minerals and Precious Metals**", at the Tagore Auditorium, Osmania University, Hyderabad during 12th – 13th December, 2024. About 10 oral and 30 postal presentations are displayed in the convention. Souvenir of the extended abstracts and with sponsors' advertisement and the certificate of their participation are distributed to the members.

INDIAN SOCIETY OF EARTHQUAKE SCIENCE (ISES)

Indian Society of Earthquake Science (ISES) was registered on 29.07.2009. It is a relatively new society but going strong rapidly. Meetings of Executive Committee, General Body are regularly held.

OBJECTIVES: (i) To further and popularize the science of earthquakes (ii) To create synergy between different disciplines like Geology, Geophysics and Geotechnical Engineering which lead to understand earthquakes, and also to create synergy between Geoscientists and Engineers.

ACTIVITIES TO ACHIEVE THE OBJECTIVES: Provide logistic support to Researchers, Organize International and National Seminars, Organize Workshops and Training courses for Geosciences and Geotechnical Engineering for Geoscientists, Engineers and students, Organize Lecture Programs, Publish Newsletter, Journal and Special Volumes, Organize Quiz Competitions, Confer Awards, etc.

ORGANIZATIONAL SET UP OF INDIAN SOCIETY OF EARTHQUAKE SCIENCE

Patrons: Secretary, MoES, GOI, New Delhi; and Secretary, DST, Govt. of Gujarat

Executive Committee Members:

President: Dr. B. K. Rastogi,

Vice Presidents: Prof. V.P. Dimri, Prof. Mukut Lal Sharma, Dr. Sumer Chopra
Hon. Secretary: Dr. Abhey Ram Bansal,

Jt. Secretary: 1. Dr. Babita Sharma, NCS, 2.Mr. Md. Rafique Attar
Treasurer: Dr. K. M. Rao, ISR

Council Members:

1.Prof. G.M. Bhat, Kashmir Univ 2.Dr. Naresh Kumar, WIHG 3.Dr. Prakash Kumar, Director NGRI 4.Dr. Prantik Mandal, NGRI 5.Dr. Kapil Mohan, NCS, New Delhi 6. Prof. Pradeep Ramancharla, Dir, CBRI, 7. Dr. Piyoosh Rautela, Ex. Dir, UDMA 8. Dr. Manisha Sandhu, KUK 9. Dr. Yudhbir Singh, JU, 10. Prof. Devesh Walia, NEHU

11. Professor Pervez Ahmad, Kashmir Univ. 12. Dr. A. Vasanthi, CSIR-NGRI

Newsletters: Published 14 Volumes since 2012with ¾ issues/yr

"Bhoo-Kampan", the Journal of ISES is being published since 2014 as one issue/Volume each year

BOOK PUBLISHED

Rastogi B.K., G.C. Kothyari, A. Lurei (Ed.) (2025) Natural Hazards and Risk Mitigation: Natural Hazards in Himalaya and Risk Mitigation, Springer DOI 10.1007/978-981-97-7658-0

ISBN 978-981-97-7658-3, ISBN 978-981-97-7658-0 (e book)

International Symposia on "Advances in Earthquake Science, AES" are being organized since 2011. So far eight such conferences have been held. These have been focused on timely important themes and have been very popular. Venue has been mostly ISR but some at different locations like NGRI- Hyd, Kashmir Univ-Srinagar and CBRI-Roorkee.

The 9th "International Conference on Advances in Earthquake Science AES2026" on "Intraplate and Himalayan Seismology" is being organized during January 23-25, 2026 at ISR. It will be preceded by **1 Day TRAINING WORKSHOP**: Digital data analysis for source mechanism and crustal structure and followed by **Three days Field Trip to Kachchh.**

Sponsors: Seism. Soc. America, Ministry of Earth Sciences (MoES), Dept S&T (GoGuj), National Disaster Management Authority (NDMA).

THE PALAEONTOLOGICAL SOCIETY OF INDIA

Introduction: The Palaeontological Society of India, one of the Premier Scientific Societies of India was established in the Department of Geology, University of Lucknow, Lucknow on 26th January, 1950 under the leadership of late Prof. M. R. Sahni, and other associates. It was registered under the Societies Registration Act 1860 (XXI) in Lucknow on 12/08/1950. The current year of 2025 is its Platinum Jubilee Year.

Since then, the society has been instrumental not only in serving and knowledge dissemination in the field of palaeontology but also protecting and aiding the mutual interests of national and international palaeontologists. It has contributed by organizing field workshops, national and international conferences/meetings/workshops, and coursework(s) along with publishing a journal of international repute 'the *Journal of the Palaeontological Society of India* (JPSI)' in the ambit of palaeontology.

The Society is a Corporate Member of the International Palaeontological Association (IPA), and also a Member of the Federation of Indian Geosciences Association (FIGA).

Office Bearers:

Patrons: Prof. Ashok Sahni, Prof. M.P. Singh, Prof. D.S. Singh, Lucknow

President: Dr. Rajiv Nigam, Goa

Vice Presidents: Prof. Mukund Sharma, Lucknow, Dr. Rajeev Saraswat, Goa

Secretary: Dr. (Mrs.) Anju Saxena, Lucknow

Joint Secretaries: Prof. Ashutosh K Singh (Delhi), Dr. Biswajeet Thakur, Lucknow

Treasurer: Dr. (Mrs.) Purnima Srivastava, Lucknow

Council Members: 9

Activities:

Lectures series organized by PSI: The Society organizes three lectures every year.

i) Prof. R. C. Misra Memorial Lecture
ii) Prof. M. R. Sahni Memorial Lecture
iii) Prof. S. N. Singh Memorial Lecture

Organization of International Fossil Day: The PSI **initiated organising the International Fossil Day (IFD) in India since 2016** (preferably on October 16) to popularise the branch of fossils study, i.e. palaeontology in India. From 2019 onwards several Student / University / Regional Chapters of the PSI and also some Institutes in India are celebrating IFD in 3rd week of October as a week. The idea of celebrating the IFD has been conceived with the aim to spread the joy, fun and interest in the life of the past. The Society encourages museums, universities and institutions to hold

outreach activities with the involvement of students, by delivery of lectures, visits to nearby fossil sites, quiz on fossils and other creative ways to let the people know about fossils.

Platinum Jubilee Activities:

To commemorate its 75 years of active service in supporting palaeontological and stratigraphic research, the society is organizing a Platinum Jubilee conference entitled "Fossils as Earth's Timekeepers" during 29th October 2025 to 31st October 2025 at CSIR-National Institute of Oceanography, Goa followed by a one-day Post Conference field trip under the convenorship of Dr. Rajeev Saraswat, Vice President of the Society. This event aims to bring together academicians and researchers from various disciplines within palaeontology and stratigraphy for collaborative discussion and exchange of knowledge. This will be the first such gathering of professionals working in the diverse areas of palaeontology and stratigraphy in our country. In addition, the Society has organized 4 seminars/workshops in different parts of country as a part of platinum Jubilee celebration in collaboration with the intuitions namely at GSI, Kolkata, Mdel College Sahibganj, Tethys Fossil Museum, Himachal Pradesh and at Wadia Institute of Himalayan Geology.

Awards and Medals: The society also offers following medals and awards in the field of palaentology and allied domains.

1. PSI-M.R. Sahni Gold Medal.
2. PSI-S.N. Bhalla Commemorative Gold Medal: PSI-Sharda Chandra Gold Medal
3. PSI-S.K. Singh Memorial Gold Medal
4. PSI-Mani Shankar Shukla Memorial Gold Medal
5. PSI-Prof. R.C. Misra Life Time Achievement Award and Gold Medal
6. PSI-Dr. Rajiv Nigam Gold Medal
7. PSI-S K Shah Gold Medal
8. PSI-Prabhakar Vishwanath Dehadrai Medal: PSI-Smt. Kamla Bhattacharya Medal

Publication: The Society publishes SCI Journal of the Palaeontological Society of India (JPSI) annually since 1956 (biannually since 2004) beside publishing special volumes and field guide books as and when required. JPSI is a peer reviewed journal which is a Scopus indexed journal with Citation index of 0.6. Since 2023, the journal is published online and Open Access on the website of SAGE. So far, 70 regular volumes have been published. The current issue is Platinum Jubilee Special Volume (70th volume issue 1) 330 pages comprising 23 articles. from Vol. 69, nos. 1 & 2 (year 2024) and is Open Access on the website of the SAGE. Please visit http://journals.sagepub.com/home/jpi for downloading the papers / detailed guidelines for submission of the manuscripts for publication.

Members:

At present the Society has 369 Life Members. The society encourages the people to join the society as Life Member/Annual Member who are interested in palaeontology and its allied domains and willing to strive together to promote palaeontology.

PATRONS

CSIR–National Geophysical Research Institute (NGRI), Hyderabad

Established in 1961, the **CSIR–National Geophysical Research Institute (NGRI), Hyderabad**, is a premier Earth science research institution under the **Council of Scientific and Industrial Research (CSIR)**, **Ministry of Science and Technology, Government of India**. The Institute is dedicated to advancing multidisciplinary studies of the Earth's structure, dynamics, and processes to promote sustainable use of natural resources and enhance national resilience to geological and environmental hazards. Guided by its mission to generate scientific knowledge for societal benefit, CSIR–NGRI integrates fundamental research with applied geoscience to address key challenges in resource management, disaster risk reduction, and environmental sustainability. Its research bridges basic understanding of Earth system processes with practical solutions for national development.

NGRI's research is organized under four broad themes:

Geodynamics – Investigating the physical mechanisms governing the Earth's evolution and internal structure through advanced modeling and observational studies.

Earthquake Hazards – Studying seismotectonic processes, crustal deformation, and landslide risk to enhance seismic safety and environmental monitoring.

Natural Resources – Exploring and sustainably managing groundwater, hydrocarbons, minerals, and renewable energy sources using innovative geophysical and geochemical techniques.

Planetary Sciences – Conducting advanced research on the geology and geophysics of terrestrial planets and the Moon to understand the origin and evolution of the inner Solar System.

The Institute's scientific framework comprises **seven major R&D groups** and **twenty-one specialized activities**, covering disciplines such as Seismology, Magnetotellurics, GPS Geodesy, Structural Geology, Controlled Source Seismics, Gravity and Magnetic Studies, Geochemistry, Geochronology, Paleomagnetism, Planetary Geology, Airborne and Shallow Subsurface Geophysics, and Hydrochemistry. NGRI is renowned for integrating field observations, laboratory analyses, and computational simulations to construct comprehensive models of Earth systems. It has conducted extensive studies across the Indian Plate, Himalaya, and Ladakh regions to understand their evolution, metallogenesis, seismogenesis, and resource potential.

NGRI hosts state-of-the-art facilities for high-pressure experiments, isotope and elemental geochemistry, luminescence dating, rock mechanics, and airborne geophysical surveys. Emerging research areas include machine learning in geoscience, data-driven subsurface modeling, and geothermal energy exploration—supported by initiatives such as the **Centre for Geothermal Energy Research** and collaborations with national and state agencies.

With a dedicated team of over 110 scientists, technical staff, and research scholars, CSIR–NGRI maintains a strong publication record in leading international journals and plays a vital role in national programs related to groundwater management, mineral exploration, and seismic hazard assessment. The Institute is also a hub for capacity building, offering training courses, workshops, and outreach programs to nurture future geoscientists and enhance public awareness of Earth science.

Recognized through numerous national honors and fellowships awarded to its scientists, **CSIR–NGRI** continues to advance scientific innovation, interdisciplinary collaboration, and societal engagement—contributing significantly to India's and the world's efforts toward understanding and managing Earth systems, natural resources, and environmental resilience.

LATEST DEVELOPMENTS AT THE INCOIS

The Indian National Centre for Ocean Information Services (INCOIS), under the Ministry of Earth Sciences, continued to strengthen India's ocean services, infrastructure, and technological leadership during 2024–25. This period was marked by transformative advancements spanning high-performance computing, marine observations, ocean forecasting, renewable energy assessment, and operational resilience.

A major milestone was the recent commissioning of the **TARANG High-Performance Computing System** by Dr. M. Ravichandran, Hon'ble Secretary, Ministry of Earth Sciences. TARANG represents a new era in real-time ocean modelling, tsunami forecasting, and AI/ML-driven analytics, empowering INCOIS to deliver high-resolution forecasts and uninterrupted 24×7 operational services.

Building on its commitment to accessible ocean information, INCOIS launched a **district-level Ocean Forecast Advisory Dashboard**, a web-based, CAP-compliant platform that disseminates real-time alerts on high waves, swell surges, and ocean currents. By extending forecast dissemination down to the district level, this initiative has substantially strengthened marine safety and coastal risk communication across India's 11,000 km coastline.

In September 2024, the institute unveiled the **Integrated Marine Energy Atlas**, a WebGIS-based platform detailing the potential of marine renewable energy resources within India's Exclusive Economic Zone. Launched by Dr. M. Ravichandran, this atlas is a first-of-its-kind national repository that supports sustainable energy planning and blue economy initiatives.

Fisheries forecasting saw a major innovation with the introduction of the **Hilsa Fishery Advisory (HiFA)** for the West Bengal coast. Using advanced machine learning algorithms, HiFA predicts Hilsa availability, helping fishers optimize efforts while promoting sustainable harvests. The advisory was inaugurated by Dr. N. Kalaiselvi, Hon'ble Director General, CSIR, and Secretary, DSIR, during INCOIS's 26th Foundation Day celebrations on 3 February 2025.

The same occasion also marked the launch of the **IGORA Ocean Reanalysis Portal**, a benchmark global dataset offering high-fidelity historical ocean information for climate research, extreme event analysis, and policymaking. Together, HiFA and IGORA exemplify INCOIS's drive to merge cutting-edge science with actionable societal services.

Operational systems were further strengthened through the rollout of **SARAT Version 2**, featuring enhanced search accuracy, improved visualization, and user-driven refinements. A training program for the Indian Coast Guard and Airports Authority of India helped ensure the effective use of the system for maritime safety operations. Complementing these upgrades, a **Data Disaster Recovery Infrastructure** with 1.5 PiB of storage was established at IITM Pune, ensuring continuous availability and secure backups of INCOIS's vast oceanographic data holdings.

INCOIS also expanded the scope of its **Tsunami Early Warning System**, extending its capabilities to maritime stakeholders through NAVAREA advisories. This enhancement enables the dissemination of tsunami alerts not only across India but also to 25 countries in the Indian Ocean region—furthering INCOIS's role as a regional hub for ocean-based disaster preparedness.

To improve prediction of coastal inundation and swell surge events, a **Coastal Flood Monitoring System** was set up at Azhimala, Kerala. This real-time observatory will aid the refinement of the Kallakkadal forecasting system and deepen understanding of nearshore hydrodynamics. In parallel, during the **44th Indian Scientific Expedition to Antarctica**, INCOIS successfully deployed a **Slocum glider** in the Southern Ocean—enhancing observations of polar fronts and the dynamics of Southern Ocean water masses.

Modernization efforts extended beyond science to infrastructure. The institute upgraded its **INSAT–GSAT satellite communication systems** and national tide gauge network, achieving 98 percent operational uptime. Smart classrooms and audiovisual facilities were introduced to streamline internal communication and real-time data exchange. INCOIS also released a **Standard Operating Procedure (SOP) for Volcano-Generated Tsunamis**, unveiled by Dr. Jitendra Singh, Hon'ble Minister for Earth Sciences, on 26 December 2024, providing a crucial framework for non-seismic tsunami response.

In addition, INCOIS operationalized an **INSAT-based transmitter** for real-time transmission of XBT/XCTD ocean data, further improving the timeliness of observational inputs to forecasting systems. The institute also advanced its **sustainability agenda** through solar power expansion, energy-efficient infrastructure upgrades, and enhanced connectivity to remote observational stations.

Together, these initiatives reflect INCOIS's continuous pursuit of innovation and resilience—strengthening India's ocean information capabilities, supporting the blue economy, and contributing to global efforts toward sustainable ocean management.

ACTIVITIES OF ATOMIC MINERALS DIRECTORATE FOR EXPLORATION AND RESEARCH (AMD)

Atomic Minerals Directorate for Exploration and Research (AMD) is the oldest unit of Department of Atomic Energy (DAE) and plays a pivotal role in both the front and back ends of the nuclear fuel cycle. AMD was established in 1949 as the Rare Minerals Survey Unit, and later in 1958, it was redesignated as Atomic Minerals Division (AMD) and in 1998 rechristened as Atomic Minerals Directorate for Exploration and Research (AMD). AMD's primary mandate is to: a) Identify, evaluate and augment mineral resources of Uranium (U), Thorium (Th), Niobium (Nb), Tantalum (Ta), Zirconium (Zr), Titanium (Ti), Beryllium (Be), Lithium (Li) and Rare Earth Elements (REE). b) Approve mining plans in respect of atomic minerals under Part-B, First Schedule of The Mines and Minerals (Development and Regulation) [MMDR] Act, 1957, c) Geotechnical investigations for site-selection of DAE establishments. d) Undertake R&D on radiometric instrumentation, analytical technique development for trace and ultra-trace multi-elemental determination, petro-mineralogical characterisation and beneficiation studies of radioactive ores. Over the past seven and half decades, sustained exploration efforts by AMD have established significant resources of uranium and other atomic minerals necessary for India's three-stage Nuclear Power Programme (NPP).

The activities of AMD span across various stages of the nuclear fuel cycle, from exploration and evaluation of atomic minerals (front end), site selection for nuclear power reactors (midcycle), to identification of sites for safe radioactive waste disposal (back end). The front-end exploration programmes are of utmost importance and are carried out in the field with strong laboratory support.

AMD operates from its Headquarters at Hyderabad and implements its exploration programmes through seven Regional Centres located at New Delhi, Bengaluru, Jamshedpur, Shillong, Jaipur, Nagpur and Hyderabad and three Sectional Offices at Visakhapatnam, Thiruvananthapuram and Kolkata. A multi-disciplinary approach involving geological, geophysical, geochemical and drilling investigations is followed for exploration of atomic minerals. The Directorate is well supported by specialized laboratories equipped with stateof-the-art instruments in geochronology, stable isotope geochemistry, petro-mineralogy, XRD, XRF, electron microprobe, mineral technology, radiometric and chemical analysis.

Uranium Exploration

Uranium exploration in India began in 1949 with the discovery of the first mineralized zones in the Singhbhum Shear Zone (SSZ), Jharkhand. Since then, AMD has explored a wide range of geological terranes from the Archaean to the Recent, hosting diverse types of uranium deposits. Using a multi-disciplinary approach integrating geology, radiometry, geophysics, geochemistry and drilling, AMD has identified several uranium provinces of national significance viz., Singhbhum Shear Zone (Jharkhand), southern and northern parts of the Cuddapah Basin (Andhra Pradesh and Telangana), North Delhi Fold Belt (Rajasthan, Haryana), Mahadek Basin (Meghalaya) and Bhima Basin (Karnataka). These areas are in advanced stages of exploration and have yielded substantial uranium resources. Emerging provinces with promising uranium potential include the Chhotanagpur Granite Gneiss Complex (CGGC), Aravalli Fold Belt, Kotri–Dongargarh Belt, Gondwanas, Kaladgi, Vindhyan, Gwalior, Chhattisgarh, Indravati and Shillong Basins. Sustained

exploration in these areas is expected to significantly augment India's uranium resources in the coming years.

As of 2025, AMD has established an in-situ resource of 4,33,800 tonnes U-oxide from 47 uranium deposits spread across eleven (11) Indian states, supporting the fuel requirements of the NPP.

Rare Metal and Rare Earth Elements Exploration

In addition to uranium and thorium, AMD also carries out exploration and prospecting for rare metals (Nb, Ta, Be and Li) and REE (La to Lu, Sc & Y) in different parts of the country. The in-situ and eluvial soils derived from mechanical weathering of host rocks, such as mineralised complex pegmatites, normally contain rare metal minerals namely columbitetantalite (Nb-Ta), beryl (Be) and spodumene & lepidolite (Li). The gravels containing these minerals are collected incidental to prospecting operations. Currently, such collections are in operation in Jharsuguda district, Odisha and Mandya district, Karnataka. Likewise, yttrium bearing heavy minerals (xenotime) concentrate are being collected from riverine placers in Chhattisgarh and Jharkhand.

REE mineralisation has been established in carbonatite and alkaline complexes such as Ambadungar, Chhota Udepur district, Gujarat (LREE-rich) and Siwana Ring Complex, Rajasthan (HREE-rich). AMD continues to intensify its exploration in other promising carbonatite, syenite and acid-basic effusive terrains across the country to locate additional rare metal and REE deposits.

AMD has established 1.29 million tonne (Mt) in-situ REO resource hosted within hard-rock formations, primarily in carbonatite and alkaline complexes of Gujarat and Rajasthan.

Additionally, 1,800 tonnes of Li-oxide resources have been established in pegmatites of Marlagalla, Mandya district, Karnataka. Beach Sand Minerals Exploration The coastal tracts of India are endowed with rich concentrations of heavy minerals in beach sands. These include titanium-bearing minerals (ilmenite, leucoxene, rutile), zirconium (zircon), thorium and REE-bearing minerals (monazite), along with garnet and sillimanite.

Such placer deposits occur in the beach sands of Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra and parts of Gujarat. AMD identifies heavy mineral-rich coastal stretches, conducts resource estimation of individual minerals and provides technoeconomic data for commercial exploitation. Additionally, inland placer deposits in Odisha and Andhra Pradesh and the red-coloured Teri sands of southern Tamil Nadu, also contain significant concentrations of heavy minerals. AMD has been actively carrying out exploration and evaluation in these areas to augment resources of strategic beach and inland placer minerals.

AMD has established substantial resources heavy minerals in the beach and inland placers of Andhra Pradesh, Odisha, Tamil Nadu, Kerala, Maharashtra, Gujarat and Karnataka, as well as in inland placers in parts of Bihar & West Bengal and Teris in Tamil Nadu. The estimated resources include 13.15 Mt of monazite, 706.24 Mt of ilmenite, 35.98 Mt of rutile, 19.75 Mt of leucoxene; 38 Mt of zircon, 217.83 Mt of garnet and 278.48 Mt of sillimanite.

Through its multi-disciplinary exploration, advanced laboratory support and commitment to national energy security, AMD continues to play a vital role in ensuring self-reliance in the atomic mineral resources of India. Its efforts align with the vision of the Department of Atomic Energy to secure indigenous resources for the nation's expanding nuclear power and strategic material requirements.

RESEARCH ACTIVITIES OF IIG

The Indian institute of Geomagnetism (IIG), over decades, has remained steadfast in carrying out research in fundamental and applied research developed strategically covering highly interdisciplinary subjects and address emerging challenges in lithospheric, atmospheric, ionospheric, and magnetospheric sciences. Being primarily an observatory institute, the legacy of the institute has contributed to the unparalled magnetic data collection, analysis over network observatories spread across India. These observatories provide continuous long term geomagnetic data that is of paramount important for investigation of both short term and long term magnetic field changes. All observatories are equipped with indigenously developed proton precision magnetometer, Overhauser magnetometer and fluxgate magnetometer along with revival of Hanle observatory. Successful development and in-house fabrication of India's first Overhauser magnetometer is developed. Geomagnetic data from all these observatories are utilized for carrying out ionosphere, magnetosphere, space weather research etc. Our magnetic observations have showcased remarkable insights to the changes in the magnetic field during super intense geomagnetic storm of May 2024 using coordinated observations from ground based ionosonde, Swarm satellite and GPS based Total electron content (TEC) data.

A landmark achievement has been the progression of the PEERS mission, which, for the first time in India, will deploy a sounding rocket experiment for both electric and magnetic field measurements. This can substantially address the long standing scientific questions of equatorial ionosphere. Initiatives also include balloon based investigations under the BEENS-2 experiment to obtain the stratospheric electric fields and investigation from Tonga eruptions providing information of atmosphere-ionosphere coupling. The indigenous development of table-top-Fabry Parrot Interferometer is an initiative under the 'Atmanirbhar Bharat' that can enable high-quality measurements of thermosphere winds. These efforts make contribution to India's preparedness of space weather research coupling the atmosphere-ionosphere-magnetosphere research.

Significant efforts are made in Solid Earth research using Ambient Noise Tomography and Travel time tomography. Researchers at IIG contributed towards the 3D seismic velocity model for the North-East region which is highly complex from tectonics and seismicity point of view. These models have been instrumental in providing the seismic hazard map under Shillong Plateau, Indo-Burma ranges and Kopili Fault Zones. Sub-basalt imaging studies along the western coast and adjoining shelf have demonstrated the potential of synthetic modelling in improving the interpretation of buried basement structures under thick volcanic sequences, a long-standing challenge in Indian geoscience. Geophysical surveys of Joshimath provided crucial insights in to land subsidence hazards which highlights the integration of resistivity imaging, magnetic measurements and susceptibility analyses for risk mitigation in fragile Himalayan terrains. Investigation from paleomagnetic record have continued to shed light upon on archeomagnetic secular variation curve spanning more than four millennia. Such a reconstruction provides invaluable constraints for global geomagnetic field models.

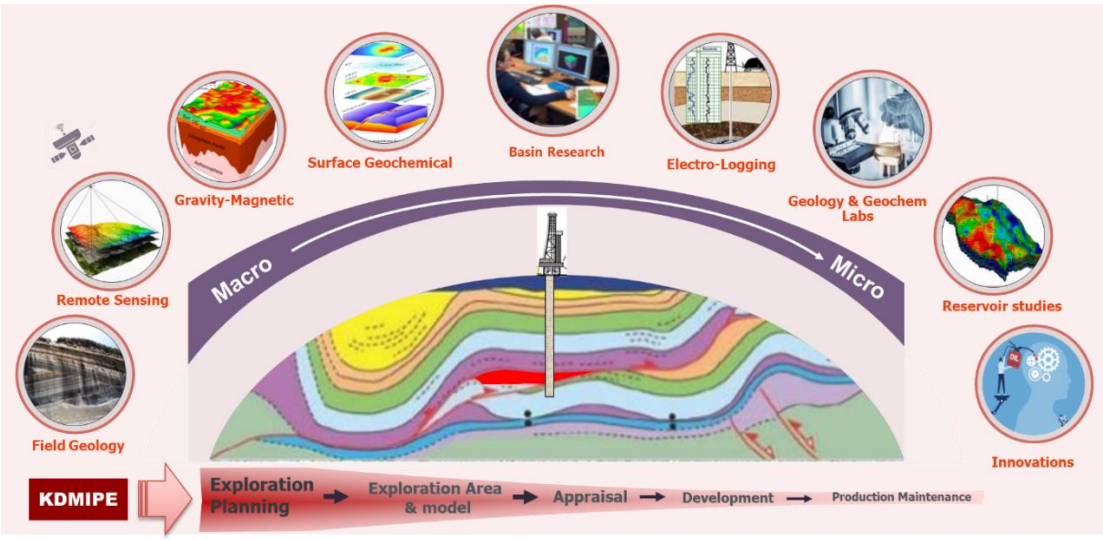
Whether it is pioneering indigeneous instrumentation, refining hazard assesment, mapping pollution, modelling space weather or training the next generation geoscientists, the institute remains at the forefront of research.

KDMIPE

Founded as Research & Training Institute (RTI) in 1962 to provide geo-scientific support to the exploratory efforts of India's National Oil Company, ONGC, the Institute was rechristened as Keshava Deva Malaviya Institute of Petroleum Exploration (KDMIPE) on 19th December 1981 in the memory of the founding father of Indian Petroleum industry - Late Shri Keshava Deva Malaviya. The Institute, having highly experienced geoscientists and technical officers, is the nodal agency for multidisciplinary synergistic basin analysis and domain specific research in hydrocarbon exploration. Equipped with state of- the-art facilities, software and cutting-edge technologies, the Institute caters to the exploration needs of all the petroliferous basins which are currently under active exploration in India as well as overseas besides scouting the opportunity in Frontiers through R&D approach. KDMIPE also provides consultancy services in areas of geosciences in general and exploration specifics to national and international oil companies.

Focus Areas

- Establishing hydrocarbon potential of sedimentary basins and development of exploration models
- Expanding exploration horizon in underexplored/ unexplored basins and carving out blocks for bidding.
- Exploration for Unconventional Resources (CBM, Gas hydrates, Geothermal, CCUS etc.)



Core functioning areas and Capabilities

The core strength of the institute is as under:

- Geochemistry Laboratories
- Basin Research, Petroleum systems modelling, Resource appraisal and Petroleum economics
- Reservoir simulation and thermodynamic studies
- Non-seismic techniques
- Petrophysics formation evaluation, Reservoir characterization, Geomechanical modeling
- Geology laboratories, unconventional and remote sensing

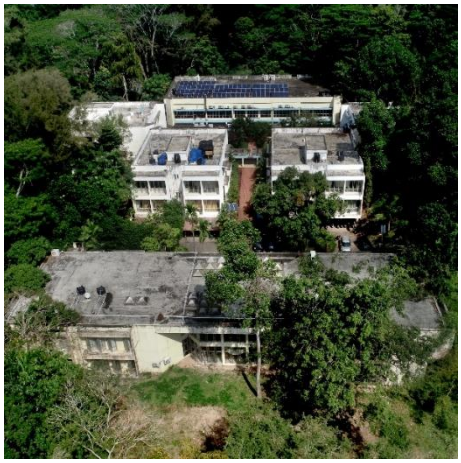
The major functional domains of the institute are as under:

- Basin Analysis
- Petroleum System Modelling
- Structural Modelling
- Sequence Stratigraphy
- Petroleum Economics
- Resource Assessment
- Sedimentology
- Biostratigraphy
- Geochronology
- Remote Sensing and Geomatics
- Organofacies Characterization
- Reservoir Fluid Finger Printing and Migration Modelling
- Inorganic Geochemistry
- Geochemical and Microbial Surface Prospecting
- Multi-mineral Petrophysical Modelling
- NMR Spectroscopic Analysis
- Geomechanical Analysis
- Non-Seismic Geophysical Techniques
- Productivity Enhancement
- Reservoir Performance Analysis
- Unconventional Resources
- Gas Hydrate
- Carbon Capture Utilization & Storage (CCUS) laboratory

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES (NCESS)

(An autonomous institute under the Ministry of Earth Sciences, Government of India)

Akkulam, Thiruvananthapuram, Kerala - 695011



The National Centre for Earth Science Studies (NCESS), formerly known as the Centre for Earth Science Studies (CESS), was established by the Government of Kerala in 1978 to conduct multidisciplinary studies in the field of earth sciences. CESS was taken over by the Ministry of Earth Sciences, Government of India, on January 1, 2014, and has been renamed the National Centre for Earth Science Studies (NCESS).

NCESS has demonstrated strategic leadership in earth science research, addressing issues that help understand the Earth in its entirety, from its evolution to the present state of overexploitation of its resources, through several programs. Over the decades, NCESS has expanded its research areas and fields of activity in line with developments in science and technology, and to address societal needs in environmental and disaster management. As a constituent R&D centre of the Earth System Science Organization (ESSO) of the Ministry of Earth Sciences, NCESS is mandated to undertake multidisciplinary research on the solid Earth and its applications. The recent initiatives reflect a strong alignment with national priorities in climate resilience, disaster risk reduction, and resource sustainability.

Vision: To excel in solid earth research and its applications.

Mission: Foster multidisciplinary research in emerging areas of solid earth science and provide services by utilizing the knowledge for earth sciences applications, and generate leadership capabilities in selected areas.

Publication Impact: From 2014 to 2024, NCESS published 550+ papers (450+ in SCI journals).

Significant Achievements in the recent past:

- The Solid Earth research of NCESS has advanced our understanding of the Precambrian Indian Shield, providing insights into the banded iron formations of the Bundelkhand Craton, the geodynamic history of the Southern Granulite Terrane, and the sedimentation timeline in the Cuddapah Basin. The studies also link the metamorphic evolution in Prydz Bay, East Antarctica, to the East Gondwana assembly. Seismological studies along the Western Ghats support the rifting model for its evolution, and studies on the Indian Ocean Geoid Low unravelled the causes responsible for the anomaly. Recent establishment of a seismological observatory in Larsemann Hills, East Antarctica, aims to bridge knowledge gaps in subsurface structures and deformation in Princess Elizabeth Land (PEL).
- NCESS's Critical Zone Observatories (CZO) network studies climate and human impacts on hydrological and biogeochemical cycles in peninsular India. Three operational CZOs in Kerala and Tamil Nadu monitor diverse variables and are being developed as calibration/validation sites for satellite missions, focusing on groundwater recharge, soil properties, weathering, and carbon cycles. Research on streamflow and flood prediction in peninsular India utilized machine learning models and hydrochemical sensors to make daily and monthly streamflow predictions, as well as to assess flood susceptibility. Seasonal storm analysis revealed strong correlations between storm responses and properties, enhancing disaster preparedness.
- The research on Indian Springs assesses thermal and cold-water springs in Southern Kerala, Dakshina Karnataka, Maharashtra, and Gujarat. The studies showed that the discharge of cold springs in Kerala is 12-fold greater than that of Karnataka springs. Research in the Tungabhadra River basin has revealed the impacts of pollution on water, sediment, and soil quality.
- NCESS developed a Video-based Beach Monitoring System for India, focusing on rip channels, coastal erosion, flooding, and enhancing safety and disaster management. NCESS undertook scientific cruises to the Arabian Sea, the Bay of Bengal, and the Andaman Sea to collect sediment archives, and also identified the enigmatic deposition feature, the Alleppey Terrace, on the southwestern continental margin of India
- Analysis of sediments from the eastern Bay of Bengal reveals that sea-level changes have a greater influence on Bengal Fan sedimentation than monsoon rainfall, providing insights into depositional conditions and early diagenetic processes.
- The national network project on Submarine Groundwater Discharge (SGD) identified 112 potential sites and 12 zones along India's coastline. Phase II of the study aimed to reconfirm SGD zones, quantify flux, and assess carbon and nutrient loads, thereby validating SGD in 9 zones and 5 sites.
- The atmospheric research in NCESS investigated extreme precipitation events that evolved through warm rain initiation and mixed phases, including a bright band. The study on lightning activity in tropical southern India reveals that southwest India has a significant lightning hotspot, and aerosols play a crucial role in modulating inland lightning activity. An AI/ML model for lightning prediction was developed in southwest India.

NATIONAL CENTRE FOR POLAR AND OCEAN RESEARCH

The National Centre for Polar and Ocean Research (NCPOR) stands as India's premier institution advancing multidisciplinary research in the Antarctic, Arctic, Himalaya, Southern Ocean, and the deep seas of the Indian Ocean. Guided by its vision to understand how the cryosphere shapes the global climate and to explore India's deep-sea resources responsibly, NCPOR continues to strengthen its scientific, logistical, and governance frameworks while deepening international collaborations.

In Antarctica, NCPOR successfully completed 44 expeditions to Antarctica, generating crucial insights into cryosphere dynamics, extreme weather events, and ice-shelf stability. The Indo–Norwegian SENS project conducted pioneering sub-ice investigations on the Nivlisen Ice Shelf using hovercraft-based seismic and radar surveys to map bathymetry, ice thickness, and subglacial cavities. Inland campaigns from Bharati Station retrieved firn cores and conducted GPR–GNSS traverses to assess coastal ice-core representativeness, while environmental baselines and biosecurity assessments were initiated under the Indian Antarctic Act around Maitri. Continuous oceanic and atmospheric observations through the Prydz Bay mooring observatory and autonomous gliders enhanced understanding of benthic habitats and sea-ice decline. Collaborative studies in the Larsemann Hills produced new Holocene climate records, and the Southern Ocean expedition conducted multidisciplinary frontal sections, aerosol and greenhouse gas soundings, and circumpolar studies under safe and compliant logistics.

In the Arctic, India transitioned to year-round operations at the Himadri research station from late 2023, enabling continuous environmental monitoring. The IndARC-6 mooring was successfully deployed in August 2024, extending the oceanographic time-series and revealing key patterns of warming, salinification, and Atlantification in the fjords. Long-term atmospheric observations highlighted increasing rainfall dominance, aerosol variability, and late-season Kongsfjorden blooms linked to ocean heat loss and convective mixing. Teleconnection analyses confirmed the influence of Arctic sea-ice anomalies on the Indian monsoon. The program expanded with upgraded instrumentation at Ny-Ålesund, redeployed moorings, extended biogeochemical observations, and deep permafrost sampling in the Canadian Arctic to study microbial risks.

In the Himalayan cryosphere, basin-scale assessments revealed accelerated glacier retreat and proglacial lake expansion in the Chandra Basin. Modeling studies showed that increased temperature amplifies melt unless compensated by substantial precipitation gains, while empirical relations were developed for estimating discharge in ungauged glacierized basins. Joint field campaigns in the eastern Himalaya extended long-term monitoring of weather, hydrology, and glacier mass balance across multiple basins, strengthening understanding of regional hydrological processes and water security.

Under the Deep Ocean Mission (DOM), NCPOR achieved transformative progress in marine geosciences and technology. Surveys along the Central and Southwest Indian Ridges identified 24 potential polymetallic sulphide sites and, for the first time, imaged a living hydrothermal vent system with active chimneys, plumes, and biota. Ancient seafloor massive sulphide deposits dating back 144,000 years were discovered, providing insights into oceanic crust evolution. Studies reported mantle degassing along the Southwest Indian Ridge with elevated helium and methane levels, while biodiversity surveys discovered new deep-sea sponges and corals. Within India's Exclusive Economic Zone, detailed swath mapping revealed a major submarine channel–levee system in the lower Bengal Fan, and geophysical studies refined the crustal architecture of the

Andaman region. Research under the Indian Ocean Geoid Low (IOGL) project produced a new ocean–Earth interaction model using ocean-bottom seismometer data, improving understanding of lithospheric dynamics and cyclone behavior.

In operations and data management, NCPOR completed 378 scientific cruises with ORV *Sagar Kanya* and advanced IT modernization with the launch of the National Polar Data Centre (NPDC) and the Indian Polar Meteorological Data Portal. The NPDC now supports near-real-time AWS data ingestion, an online proposal system, and AI/ML integration for polar science, while submitting the Data Governance Quality Index report to NITI Aayog. Construction of a next-generation all-weather research vessel is underway at GRSE Kolkata, alongside approved replacements for *Sagar Kanya* and *Sagar Sampada*.

In the realm of governance and outreach, NCPOR operationalized the Indian Antarctic Act, 2022, establishing the Committee on Antarctic Governance and Environmental Protection (CAG-EP) and implementing a national permitting system that has processed multiple permits. The hosting of the 46th Antarctic Treaty Consultative Meeting (ATCM-46) and 26th Committee for Environmental Protection (CEP-26) at Kochi in 2024 reaffirmed India's leadership in Antarctic science diplomacy. NCPOR also represented India in several international forums, including SCAR, COMNAP, AFoPS, the Arctic Circle Assembly, and the International Ocean Discovery Program (IODP), and signed MoUs with Norway, Germany, Russia, and the UAE. National outreach initiatives included active participation in IISF, Sci-FFI 2025, educational workshops, student visits, beach clean-ups, and celebrations of national events across all research stations, reinforcing NCPOR's commitment to scientific social responsibility. NCPOR is developing India's first Polar and Ocean Museum as a major public outreach initiative, which includes an advanced 'Science On a Sphere' (SOS) 3D visualization system to display global Earth system data.

Through these integrated advancements in polar science, deep-sea exploration, infrastructure development, governance, and public engagement, NCPOR continues to position India at the forefront of global efforts to understand and sustainably manage the Earth's polar and ocean systems.

WADIA INSTITUTE OF HIMALAYAN GEOLOGY (WIHG)

The Wadia Institute of Himalayan Geology (WIHG) at Dehradun is an autonomous research Institute of the Department of Science & Technology, Govt. of India, which was established in 1968. It has been pursuing basic research to unravel the orogeny of majestic Himalaya and to provide an improved understanding of seismogenesis, geodynamics, climate-tectonic interaction, biotic evolution, ores/minerals forming processes, glacial dynamics, fluvial system, geo-hazards (landslides, flash floods, avalanches, earthquakes), geo-resources (minerals, ore bodies, hydrocarbons, cold/hot springs), anthropogenic impact, etc. towards the well-being of the population and safeguarding the properties and structures in the Himalaya and adjoining areas.

The research activities to understand the mountain building processes and shed light on the above themes are based on observations and modeling of different sets of data on structural geology, petrology, geochemistry, paleontology, biostratigraphy, sedimentology, glaciology, hydrology, geomorphology, engineering geology, seismology, gravity & magnetic, seismic, well logs, environment & engineering geology, quaternary geology, remote sensing, etc.

The institute is equipped with sophisticated analytical facilities like LA-MC-ICP-MS, Stable Isotope Mass Spectrometer, EPMA, ICP-MS, XRF, SEM, XRD, Raman Spectrometer, TL/OSL, Magnetic Susceptibility meter, etc., run by competent scientists and technicians. It has state-of-the-art geophysical data acquisition, processing, modeling, and interpretation laboratories coupled with the AI/ML Centre of Excellence for Geosciences data. The analytical and laboratory facilities are being utilized by the scientists of WIHG as well as researchers from state and central universities, other institutes, and organizations. It has as many as 75 Broad Band Seismographs and 25 Acceleragraphs spread over Himachal Pradesh, Uttarakhand, Punjab, Haryana, and Arunachal Pradesh states, and Jammu & Kashmir and Ladakh Union Territories. Around 20 GPS instruments are installed in Himachal Pradesh and Uttarakhand states, and Jammu & Kashmir and Ladakh Union Territories.

The Institute has been nurturing a unique set up to perceive changes in subsurface properties that may lead to earthquake precursory study in the Himalayan region by hoisting and monitoring an integrated 'Multi- Parametric Geophysical Observatory (MPGO)' at Ghuttu in Tehri district of Uttarakhand. The institute also provides consultancy services for engineering projects, drinking & ground water surveys, natural hazards, road and rail alignments in the Himalaya and adjoining regions.

The institute serves as a National Centre of excellence in Himalayan Geoscience Education and Research; provides training and produces Ph.Ds in the field of Geosciences; collaborates with Universities, Industries and other Institutes on Himalayan Geosciences; maintains a modern Geological Museum decorated with varieties of rocks, minerals, and fossils of the Himalaya for Education; conducts outreach programs for Science Education and Geo-hazards awareness; organizes illustrious Award Lectures and National/International Seminars, etc.

During the glorious journey, a few scientists have brought accolades with the Padma Awards, many researchers with the National Geosciences Awards, Academy Fellowships, and Young Scientists Awards. The vision of WIHG is “Questing for Himalayan Seismogenesis, Geodynamics, Geo-Hazards, Climate Variability, and Geo-Resources through Geoscientific study to fulfill the Societal Needs and pursue Basic Sciences”.

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

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[ABS-0078]
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Dr. Bijayananda Dalai*, Dr. Prakash Kumar

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Arasarathinam Dennis*, Chockalingam Muthiah Ramakritinan, Lakshmanan Senthilnathan

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Satish Chandra Verma*, Prabha Pandey, Anand K. Pandey

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Satyamesh H Tiwari*, Mala S Bagiya, Satish Maurya, Kosuke Heki, Subrata Kundu, S Gurubaran, A P Dimri

[ABS-0100]

ASSESSING CLIMATE CHANGE IMPACTS ON SORGHUM YIELD¿WUE DYNAMICS ACROSS TELANGANA AGROCLIMATIC ZONES-

Mrinalini Srivastava, R.K Mall*

PLENARY TALKS

FOLLOWING THE GULF STREAM AND ITS EDDIES OVER THE PAST 45 YEARS (1980-2024): A SYNOPTIC PERSPECTIVE AND A FEW NEW INSIGHTS

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.The Gulf Stream is one of the strongest western boundary currents in the world ocean carrying significant heat affecting weather, ecosystems, marine transport and climate. It has been monitored by satellite and in-situ observational platforms for decades. Continuous synoptic observational analysis (2-3 times a week) for over 45 years (1980-2024) for the Stream and its eddies have been made available to us, which resulted in multiple recent studies on its variability and yielded new insights. First, the annual formation rate of the warm core rings almost doubled from eighteen to thirty-three with a regime shift around 2000 (Gangopadhyay et al., 2020). Second, two new types of eddies other than the well-known pinch-off rings are discovered. To the north of the Stream, the smaller and shallower aneurysm-type anticyclones are mostly abundant to the west of the New England Seamount Chain (Silver et al., 2022). Similarly, to the south of the Stream, hook-type cyclones are discovered and documented to all along the Stream (Jensen et al., 2025). Their implications for renewed understanding of ecosystems, fisheries, data assimilation and real-time forecasting are highlighted. Finally, we will dive into possible related research opportunities for the Arabian Sea and the Bay of Bengal.

Gangopadhyay et al. 2020, JGR-Oceans.
Silver et al., 2022, JGR-Oceans.
Jensen et al., 2025, Sci. Rep.

ANDAMAN-NICOBAR SUBDUCTION SYSTEM AND ANDAMAN SEA: NATURAL HAZARDS TO NATURAL RESOURCES

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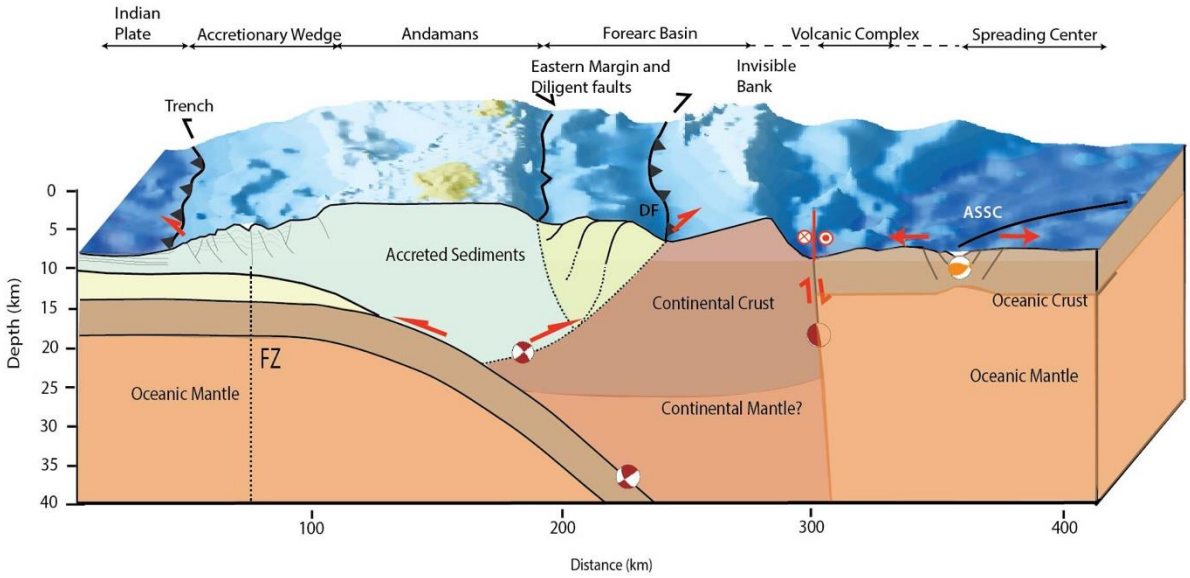
The disastrous 2004 Indian Ocean Tsunami, caused by the rupture of the whole Andaman-Nicobar forearc segment, is still vivid in our memory. This was further reminded by the 2025 Myanmar earthquake, retelling us that natural hazards in this region are never far away. On the other hand, the Andaman Sea is an enigmatic feature, hosting all the main features associated with plate tectonics. It is bounded by the Andaman-Nicobar Islands in the west and the Malaya Peninsula in the east. It hosts a hydrocarbon producing Mergui Basin in the southeast, an elongated 800-km-long East Basin in the east, active spreading centres and transform faults separating volcanic plateaus of Alcock and Sewell Rises. Thick sediments from the Irrawaddy River system from the Myanmar blanket the spreading centres and the transform faults, changing their thermal regime, and hence magmatism and hydrothermal circulation, which may lead to formation ore deposits. It also hosts a volcanic arc, which envelopes active strike-slip faults, and might be volcanic hazards, but also a source of geothermal energy. The actively deforming Andaman forearc basin is carpeted with gas hydrate reflectors, indicating a wide-spread presence of methane in the region, potential for natural resources, but may also have positive feedback on global warming. The Andaman-Nicobar Islands lie on an arc-shaped ridge, resulting from the oblique subduction of the Indian Plate in the west and a continental backstop in the east, a fragment of the Malaya Peninsula, which floors the Andaman forearc sedimentary basins. The presence of Bengal-Nicobar fans in the Bay of Bengal has led to the formation of a thick and wide forearc accretion wedge between the Islands and the subduction front. There is, however, an oval-shaped 120x50 km subsiding basin between Little Andaman and Car Nicobar Islands, suggesting that something pulling it from below. The presence of ~95 Ma old ophiolites on the Andaman Islands indicate the Island has a complex geological history and even might contain a fragment of continental crust. At the subduction front, the Ninety-East Ridge (NER), a 5000-km-long linear feature in the Indian Ocean, is subducting obliquely. The NER itself is deforming, attested by the 2010 Mw 7.5 strike-slip earthquake, and hence changing the dynamics of subduction. Contrary to its oceanic/volcanic origin, there are thick pre-Bengal Fan sediments, suggesting that the northern segments of the NER might have continental affinity, and hence may have hydrocarbon potential. Therefore, Andaman-Nicobar region is a very fascinating scientific target, encompassing all facet of plate tectonics, a natural laboratory to understand subduction to ocean spreading processes, but also relevant to society because of its natural hazard and resource potentials, and effect on climate.



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AUSTRALIAN GEOSCIENCE AND THE BLUE ECONOMY: REFLECTIONS FROM THE PERSPECTIVE OF SCIENTIFIC OCEAN DRILLING

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Australia supports geoscience contributions to the Blue Economy through several national initiatives.

The National Collaborative Research Infrastructure Strategy funds programs vital to understanding ocean processes: the Integrated Marine Observing System deploys diverse ocean monitoring equipment; AuScope provides geoscience tools, data and analytics; the Marine National Facility offers 300 days of research vessel time annually; and the proposed CoastRI initiative aims to build a national coastal observing and modelling capability.

The National Marine Science Committee is finalising a National Marine Science Strategy (2025–2035) to coordinate high-quality marine science aligned with priorities from intergovernmental processes (e.g. UN SDGs, IPCC), governments, industry, NGOs, communities, and First Nations peoples.

Ocean Decade Australia, a not-for-profit NGO, fosters partnerships across academia, government, industry and community to advocate for a sustainable Blue Economy—balancing human benefits from ocean resources with the need to protect ecosystems.

Despite geoscience's longstanding role in underpinning Australia's economy, its future is challenged by low public awareness of its importance to economic prosperity and environmental sustainability. A recent report from the Australian Academy of Science, "Australian Science, Australia's Future: Science 2035", warns of insufficient geoscientist training. A related report from the Australian Geoscience Council suggests that this deficiency in training reflects a lack of awareness of geoscience as a field of study.

Scientific ocean drilling also has a role to play in supporting the Blue Economy. Over nearly six decades, international scientific drilling programs have generated insights into climate variability, ocean health, and submarine hazards. Sub-seafloor samples and data are also critical for establishing environmental baselines and tracking human-induced changes, both of which are key to sustainable ocean resource use.

Continued collaboration under global ocean science programs, like those conducting scientific drilling, is important for nations like Australia and India with large marine jurisdictions, especially amid complex global geopolitics.

OCEAN WARMING, LAND ICE MELT AND SEA LEVEL RISE: THE ROLE OF SPACE OBSERVATIONS

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Being a consequence of ocean warming and land ice melt, sea level rise is one of the best indicators of current climate change. Since the early 1990s, sea level rise is routinely measured by a series of high-precision altimeter satellites. Their observations have shown that the global mean sea level is not only rising, but is also accelerating. Other space-based and in situ observing systems (GRACE space gravimetry and Argo automatic floats) have allowed to quantify the contributions of land ice loss and ocean warming to sea level rise, hence assess closure of the global mean sea level budget. Satellite altimetry has also revealed strong regional variability in the rates of sea level change, a result of the redistribution of heat and fresh water by the ocean circulation, mostly driven by internal climate variability. New observational challenges are now emerging, among these, accurate monitoring of sea level changes along the world coastlines. In this presentation, we summarize the most up-to-date knowledge about sea level changes at global, regional and local scales, and discuss the various causes of the observed changes.

KEYNOTE ADDRESS

MANAGING COASTAL DEVELOPMENT UNDER CLIMATE CHANGE

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Coastal areas provide ecosystem services that support livelihoods, tourism, resilience to natural hazards, and host key infrastructure. India with 9 coastal states and 4 union territories with a coastline of 11,099 km has distinct geomorphology with sandy beaches, sand dunes, lagoons, and large river deltas in east coast, and narrow plains between the Western Ghats and the Arabian Sea on the western coast with a wider continental shelf with vertical cliffs, backwaters, enclosed bays, estuaries and. Indian coast faces multiple pressures due to coastal development, land use conversion, port expansion, damming and sand mining have altered natural sediment dynamics, contributing to shoreline erosion. Climate change, including sea-level rise, intensifying cyclones, and changing wave regimes, which further increased the exposure of coastal communities and infrastructure to hazards. Estimates indicate that nearly 33.6% of the coastline is eroding, 26.9% is accreting, and 39.6% remains relatively stable.

Coastal development needs an integrated approach to balance human needs with environmental protection that combines scientific research with community engagement to build resilience against climate change. Integrated Coastal Management (ICZM) plans aims to enhance both ecological health and socio-economic well-being while promoting development. It is a comprehensive framework for balancing human activities to achieve sustainable development by managing land use, protecting natural habitats, and preparing for hazards like erosion and flooding. Such plans are being prepared in India with notification of Coastal Regulation Zone (CRZ 1999), recently it has been amended in 2019 with a view to conserve and protect the unique environment of coastal stretches and marine areas, besides livelihood security to the fisher communities and other local communities in the coastal areas and to promote sustainable development based on scientific principles taking into account the dangers of natural hazards, sea level rise due to global warming. While ICZM address the overall framework, Shoreline Management (SMP), a subset of ICZM is instrumental in

preserving the integrity of natural ecosystems, addressing the challenges posed by climate change, and protecting the area's rich cultural and historical legacies. Through a judicious blend of planning, regulation, and community engagement, the SMP embodies a forward-looking vision for sustainable coastal management, underpinning efforts to enhance environmental stewardship, economic vitality, and social welfare along the shoreline. Shoreline Management plans are prepared for southern coastal states with newly evolved framework, by integrating coastal development with geomorphology, coastal processes, conservations of bio-shields, socioeconomics. The framework allows to draw policy intervention based on various options for coastal protection/conservation, including Nature based Solutions.

CAN WE OVERCOME CLIMATE CHANGE WITH THE SAME THINKING THAT CREATED IT?

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This presentation examines the multifaceted challenges of climate change, tracing them to both natural feedbacks within the Earth system and the philosophical foundations of modern development. It explores how disruptions across the atmosphere, hydrosphere, lithosphere, cryosphere, and biosphere have intensified climate variability, while human progress since the Industrial Revolution—though transformative—has also produced severe environmental consequences. Global milestones such as the 1972 Stockholm Conference and the 1992 Rio Earth Summit shaped environmental governance, yet despite the Kyoto Protocol and the Paris Agreement, the world remains on track for up to 2.7°C of warming by century's end. The presentation questions whether the Western worldview—rooted in mechanistic science, competition, and material growth—can solve the crises it has created. Drawing on thinkers like Arnold Toynbee and climate activist Al Gore, it calls for a reorientation toward Eastern philosophies that emphasise harmony, interconnectedness, and restraint. Ancient Indian thought, especially the Ishavasya Upanishad, offers a holistic vision that values renunciation over consumption. Supported by historical economic insights from Angus Maddison, it suggests that sustainable progress once thrived under alternative paradigms. Ultimately, it urges a transformation in education—from the right to education to the right education—anchored in ethics, character, and social responsibility as foundations for true sustainability.

HIMALAYAN CRYOSPHERE AND RISING HAZARDS IN A CHANGING CLIMATE

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Himalayan glaciers are unique in many respects, with complex environmental settings of immense socio-economic importance. Thawing Himalaya has a strong impact on the downstream environment, the stability of slopes, water availability, human health and sustainable development the region. To generate long-term in situ data and to answer critical questions related to the interplay of glacier mass balance, its impact on downstream hydrology and glacio-hydrological hazards, NCPOR has a long-term integrated programme on Chandra basin in Western Himalaya. Our studies have revealed that most glaciers in Chandra Basin have experienced a continued loss of ice mass during the last decade. Since retreating glaciers create many potentially vulnerable lakes in a warming climate, we have also mapped the lakes in Chandra basin. While a majority of them are supra-glacial lakes, there exists many moraine-dammed, bedrock-dammed and ice-dammed lakes, many of which are continuously expanding in tandem with the retreat of the glaciers. Among these, the glacial lakes Samudra Tapu and Gepang Gath glaciers have been expanding dramatically since the last decade and may turn

hazardous in future. Our studies suggest that the presence of proglacial lakes plays a significant role in intensifying ice mass loss from Himalayan glaciers, strongly regulating their overall evolution.

OCEAN NON-LIVING RESOURCES

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The ocean provides a large number of valuable natural resources containing both living and non-living resources. It provides food, organisms, metabolites, microbes with potential in pharmaceuticals, nutraceuticals and cosmetic, used for transportation, a source of recreation, contains vast mineral deposits rich in critical metals, polymetallic nodules and massive sulfides, manganese, copper, nickel, iron, and cobalt and crude oil, gases and methane hydrates and renewable energy in terms of salinity gradient, ocean thermal energy, wave, tide, current, wind and solar energy and. Critical metals like Ni, Co, Cu, and Cd are of significant interest due to their essential applications in advanced technology, renewable energy systems, electric vehicles, and biomedical devices. The vast reserve of poly-metallic nodules containing Mn, Ni, Cu, Co, on the sea floor, hydrothermal sulphide deposits enriched in REEs and PGEs on the constructive plate margins and cobalt crust over seamounts are a few examples of economic deposits of critical metals in the sea. India explored 4 million square kilometres of the open Indian Ocean and estimated around 383 million metric tons of Mn nodules containing about 95, 4.5, 4.5 and 0.5 million metric tons of Mn, Ni, Cu and Co in about 7500 km2. An extensive effort is being made to develop technology to exploit these resources under the Deep Ocean Mission launched by the Ministry of Earth Sciences, Government of India. In addition, the ocean contains a gigantic reserve of critical metals in dissolved form: 1.2, 8.6, 2.5, 13, 231, 0.5 and 4.3 billion tons of Cu, Ni, V, Mo, Li, Co and U, respectively, much higher than the known terrestrial reserve. Therefore, under the current crisis in land-based mining, the scientific investigations need to be carried out with the objective of in-situ extraction of metals from the sea for future energy security and a sustainable environment.

Keywords: Ocean resources, non-living resources, critical metals, Poly metallic nodules, Sulfides

NATURE-BASED SOLUTIONS FOR COASTAL RESILIENCE AND BLUE ECONOMY GROWTH IN INDIA

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India's extensive coastline, spanning 13 coastal states and union territories, is increasingly vulnerable to climate change, sea-level rise, and anthropogenic pressures, threatening both coastal livelihoods and ecosystem services. Nature-based solutions (NbS) — including

mangrove restoration, coral reef rehabilitation, seagrass conservation, and wetland management — offer cost-effective strategies to enhance coastal resilience while supporting the blue economy through fisheries, tourism, and carbon sequestration. This study presents a state-wise overview of NbS initiatives across India, highlighting key case studies such as mangrove restoration in Gujarat and Pichavaram (Tamil Nadu), wetland rejuvenation in Kerala and Odisha, coral reef rehabilitation in Gulf of Mannar and Lakshadweep, and integrated estuarine management in Andhra Pradesh and West Bengal. The findings underscore that multi-sectoral approaches combining ecosystem restoration, community participation, and livelihood support deliver sustainable ecological and socio-economic benefits. Cross-cutting lessons emphasize the importance of site-specific ecosystem interventions, adaptive management, long-term monitoring, and integration with blue-economy development strategies. This synthesis provides a framework for policymakers, coastal managers, and stakeholders to scale NbS across India, fostering climate-resilient and economically vibrant coastal communities.

ENERGY LANDSCAPE: HYDROCARBONS, RENEWABLE RESOURCES AND NATURAL HYDROGEN IN INDIA

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India's diverse geological and coastal environments offer a unique opportunity to co-develop traditional hydrocarbons with renewable and unconventional sources such as geothermal, wave, tidal, wind, and natural hydrogen energy. This study highlights a systems-based approach to mapping and developing these resources, emphasizing geological controls, technological readiness, and the potential for hybrid energy corridors. Advances in subsurface imaging and machine learning now allow simultaneous assessment of reservoirs, geothermal gradients, and hydrogen-generating lithologies, while offshore basins such as the Andaman–Nicobar and western continental margin offer promising sites for coupling wave- tide dynamics with subsurface storage or hydrogen recovery. The study underscores the need for cross-disciplinary workflows integrating petroleum geoscience, environmental monitoring, and data analytics to maximize resource efficiency while minimizing environmental footprint. By leveraging India's sedimentary basins, ophiolitic belts, and coastal zones as complementary assets, this research envisions a resilient energy landscape where oil and gas infrastructure supports the emergence of renewable and natural hydrogen economies.

GAS-HYDRATES: A CLEAN AND HUGE ENERGY PROSPECT FOR INDIA

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The gigantic energy requirement of the world including India is typically met by fossil fuels (coal, oil and natural gas), burning of which has been ascribed to the global warming and climate variability. This has urged for the usage of green and renewable energy resources as a remedial measure. However, no revolution has taken place in the non-fossil fuel sectors. It has been predicted that fossil fuels or hydrocarbon energy resources will remain as the main energy provider for the socio-economic growth of any country. Hence, we require to foster low-carbon energy supply and strengthen the gas-based technology through gasification of traditional fossil fuels. Gas-hydrates, which are ice-like crystalline substances of methane gas (99.9%) and water molecules, have enthralled the geo-scientific community due to their natural occurrences along the outer continental margins and major future potential energy resources for energy-deficient countries like India. Being methane as the main constituent, gas-hydrates are the cleanest hydrocarbon energy resources. The water depth, sea-bottom temperature, total organic carbon, sediment thickness, rate of sedimentation, geothermal gradient imply that shallow sediments along the Indian margin are good hosts for gas-hydrates. Analysis of seismic data reveal signatures of gas-hydrates in large quantity mainly in the Krishna-Godavari (KG) basin. Besides KG basin, the Mahanadi basin and the Andaman region also show evidences of considerable amount of gas-hydrates. The methane within gas-hydrates has been prognosticated to be more than 1500 times of country's present natural gas reserve, which can make India energy self-reliant and meet the UN initiatives of 'affordable and clean energy' (SDG-7) and 'climate action' (SDG-13). Successful test productions in Canada, USA, Japan and China provide pronounced hopes and have boosted Indian National Gas Hydrates Program for similar testing, particularly in the KG basin. Thus, we need to delineate the most prospective zones of gas-hydrates, and develop novel approaches for their characterization, and understanding mode of occurrences, petroleum system of gas-hydrates i.e. the genesis and migration of fluids/gas and their accumulation, kinetics of gas-hydrates, and quantitative assessment based on geoscientific data. It is also needed to delineate the critical parameters of the reservoirs, perform laboratory experiments and field simulation studies in augmenting the viable production technology. Here we shall bring out the status of gas-hydrates research and development in India and elsewhere with regard to their exploration and exploitation.

ACCELERATING COMBINED IMPACTS OF RAPIDLY INCREASING DAILY RAINFALL AND HEAT EXTREMES OVER INDIA

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Both daily rainfall extremes and heat extremes are rapidly increasing over India, and studies quantify that socio-economic loss due to climate and weather variability may rise to 10% of GDP in India by the end of the century. In monsoon regions of tropics like India, the focus needs to shift to humid heat stress events (HHSE) whose frequency is an order of magnitude

larger than the dry ones. As a result of increase in the mean surface temperature over the country and associated increase in moisture content in atmosphere, the mean Humidex is exceeding 45OC during the summer months from 2000 s. Hence, the potential outdoor productivity loss (POPL) increases by 20-fold in recent decades compared the decade of 1940-1949. In a recent study, we show that we may have a crossed a tipping point in productivity loss and health cost increase due to HSSE exposure. The frequency and intensity of both daily rainfall extremes and HHSEs have started increasing at a faster rate from 2000 s and the combined impacts is accelerating the weather induced socio-economic loss. We find that the rainfall extremes tend to cluster during the active phase of the monsoon intraseasonal oscillation (MISO) while the humid heat stress extremes could occur in all phases of MISO in small numbers but has a large cluster in the break phase of the MISO. For example, the extreme rainfall events may be 20 during the season while extreme humid heat stress days may be 110 over the NEI. This implies that during the rainy season, the region one experiences either an extreme rain event or must work outdoor under an extreme humid heat stress exposure every day. The clustering by the MISO may provide a basis to develop a medium-range forewarning system for both rainfall extremes and humid heat extremes

Keywords: Extreme Rainfall events, Extreme humid heat stress events, Potential Outdoor Productivity Loss, Monsoon Intraseasonal Oscillations

FROM VULNERABILITY TO RESILIENCE: PROTECTING INDIA'S COASTAL POPULATIONS

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India's 11,098 km long coastline is home to millions of people whose livelihoods and safety are intricately linked to the ocean. However, increasing exposure to natural hazards such as cyclones, storm surges, coastal erosion, sea-level rise, and Tsunamis has exacerbated their vulnerability. Rapid urbanisation, habitat degradation, and climate change further compound the risks faced by coastal communities. Addressing these challenges requires a paradigm shift from reactive disaster management to proactive resilience-building. There is an urgent need to develop strategies that strengthen coastal resilience through integrated approaches combining early warning systems, community-based disaster preparedness, ecosystem restoration, and sustainable coastal zone management. Strategies need to be developed to tap the potential of technological advancements, such as high-resolution modelling, real-time observations, and decision support tools, in reducing risk and enhancing adaptive capacity. Furthermore, the current situation emphasises the importance of policy interventions, capacity building, and participatory governance in empowering communities to safeguard their lives and livelihoods. By integrating scientific innovation, traditional knowledge, and policy frameworks, India can transition its coastal populations from the current state of vulnerability to one of resilience, ensuring long-term sustainability and security in the face of evolving oceanic and climatic threats.

Keywords: Coastal Vulnerability, Natural Hazards, multi hazard resilience, disaster risk reduction.

CLIMATE CHANGE IMPACTS ON AVALANCHES, GLOFS AND LANDSLIDES - GRAVITY OF EMERGING ISSUES

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The Indian Himalayan region is frequently affected by large-scale mass movement processes such as Rock/Snow/Ice avalanches, GLOFs, debris flows, etc. River channels play an important role in enhancing the mobility through huge entrainment and phase transitions, which are responsible for an unexpected rise in the destructive potential of the events. This talk will aim to present an effective and operational framework for Mapping, Modelling & Monitoring of extreme weather mass movement processes such as avalanches, GLOFs, debris flows, etc. in the Indian Himalayas for Hazard-Risk-Vulnerability assessment towards development of early warning, mitigation and management strategies. The motivation for this talk is drawn from a number of such disasters in recent past such as Ladakh-Leh flood & debris flows (2010), Kedarnath Disaster (2013), Chamoli Rock Ice Avalanche (2021), Sikkim GLOF (2023), Joshimath Land Subsidence (2023), Wayanad debris flow (2024), Mana (Badrinath) Avalanche (2025), Dharali (Uttarakhand) debris flow (2025) etc. The main focus of the proposed study is to quantify & forecast, monitor & measure and mitigate & prepare towards extreme weather mass movement processes of Himalayan hazards. The specific scopes encompass: (a) Large-scale hazard indication mapping along the major rivers and tributaries, (b) Vulnerability & Risk assessment of the habitats, population, developmental projects & other infrastructures and facilities, (c) Evaluation of the large scale mass movement processes, entrainment, & phase transitions along the flow path and their effect on runout and (d) Real time monitoring and mitigation strategy. The technical challenges and scientific considerations for such effort lie in extreme climatic conditions, unprecedented precipitation (snowfall & rainfall), inaccessibility to the higher reaches/potential release zones, absence of quantitative data on past events and absence of monitoring and early warning strategy.

Keywords: GLOF, Landslides, Climate change

GLACIER-RELATED HAZARD AND RISK IN THE HIMALAYA

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Climate change is dramatically reshaping high mountain environments, exposing communities to increasingly frequent, intense, and complex disasters. Accelerated glacier melt, destabilization of permafrost, and shifting precipitation regimes are driving a rise in cascading hazards including landslides, glacial lake outburst floods (GLOFs), and flash floods that

threaten lives, livelihoods, and critical infrastructure. A stark example is the 2023 South Lhonak Lake GLOF in the Sikkim Himalaya. Triggered by the collapse of a massive lateral moraine into the lake, this event unleashed a destructive flood wave that devastated the Teesta River basin, destroyed hydropower installations, and displaced thousands. Such catastrophes underscore the urgent need to better understand how climate change amplifies hazard chains in mountainous regions many of which are home to remote and highly vulnerable populations. This talk will explore the disaster risks in high mountain communities, drawing on recent events as critical warnings. It will highlight the pressing need for early warning systems, adaptive policy frameworks, and resilient infrastructure planning to safeguard these landscapes and the communities.

Keywords: Glacier Hazards, Himalaya, Permafrost, Risks

SPACE BASED OBSERVATIONS OF GEOHAZARDS: NISAR: UNVEILING EARTH S DYNAMICS WITH L- AND S-BAND RADAR

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NISAR, short for NASA-ISRO Synthetic Aperture Radar, is a collaborative achievement between India and the US, which encompasses end-to-end development of the payloads, satellite, its launch, data products and incredible science out of it. It is the first mission to have dual-frequency measurements in L- and S-bands, both in standalone as well as synchronous operation modes. The unique feature of this SAR configuration is its imaging capability in high-resolution, yet wide swath (240km) SweepSAR mode a capability not available with any other conventional SAR systems flown till now. Born out of Decadal Survey by the US in 2007, the mission addresses the factors driving the climate change and determination of its impact, by study of dynamics of ecosystems, solid-earth and cryosphere. Though the initial configuration was based on L-band SAR by JPL/NASA, a collaboration with ISRO was formalized in 2014 with the observatory augmented with S-band SAR by SAC/ISRO. Another hallmark of this mission is its repeat-pass interferometry and polarimetry capability, which makes the study of above mentioned dynamics possible. After a successful launch on July 30, 2025 from Sriharikota, NISAR is currently in its commissioning phase, expected till end of Oct-2025. Thereafter, the data products will be released and mission will be entering Science Cal/Val phase for a period of 5 months. Subsequently, regular science operations will commence. To meet the envisaged objectives, a large number of science and application products are planned to be generated by ISRO Science team and hosted on Bhoonidhi portal of NRSC/ISRO. Another noteworthy contribution of this mission is its free and open data policy, which enables data access to broad scientific community for several other science products and cater to more derived applications. The talk would address all the above mentioned activities in greater detail.

Keywords: NISAR, Synthetic Aperture Radar, SweepSAR, Earth dynamics

OF METEOTSUNAMI AND TSUNAMI-GENERATED IONOSPHERIC DISTURBANCES WITH EMPHASIS ON THE 2022 TONGA VOLCANIC ERUPTION

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Atmospheric and ionospheric responses to large-scale oceanic disturbances are increasingly recognized as valuable proxies for monitoring extreme geohazard events. This study presents a comparative analysis of ionospheric disturbances generated by meteo-tsunamis and conventional tsunamis, with a special focus on the exceptional atmospheric oceanic coupling triggered by the January 15, 2022, Hunga Tonga Hunga Ha'apai volcanic eruption. Unlike classical tsunamis generated by tectonic displacements, meteo-tsunamis originate from atmospheric pressure perturbations, such as squall lines or explosive volcanic eruptions, and can induce gravity waves that reach the ionosphere. The 2022 Tonga eruption produced both a tsunami and a Lamb wave-driven global meteo-tsunami, providing a rare opportunity to study their respective ionospheric signatures under a common origin but differing propagation mechanisms. Using GNSS-TEC observations, we attempted to distinguish key characteristics of the induced Total Electron Content (TEC) anomalies. The Tonga event exhibited ionospheric perturbations globally, with wave-front speeds exceeding 300 m/s, significantly surpassing the typical tsunami-induced TEC perturbations. Our comparative analysis reveals that meteo-tsunamis induce broader and faster-propagating ionospheric disturbances in all directions dominated by acoustic and Lamb wave coupling. In contrast, seismic tsunamis generate localized and relatively delayed and directional TEC responses primarily through gravity wave mechanisms. This study highlights the importance of distinguishing between these ionospheric signatures for rapid characterization of tsunami sources and demonstrates the potential for using the ionosphere as a real-time diagnostic tool in global hazard monitoring systems. The insights from the Tonga eruption provide a benchmark case for enhancing ionospheric-based early warning frameworks and improving our understanding of air-sea-ionosphere coupling processes.

Keywords: Meteotsunami, Tsunami, Ionospheric Disturbance, 2022 Tonga Eruption, GNSS-TEC, Lamb Waves, Atmospheric Coupling, Geohazards

INTERPRETABLE AND EXPLAINABLE AI/ML FOR GEOSCIENTIFIC DATA

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Applications of artificial intelligence (AI) and machine learning (ML) algorithms are increasingly popular in geoscientific data analysis due to their inherent skill to accommodate multiple features at the input level and uncover hidden patterns in the data and emulate complex (nonlinear) data-model relationships from examples via supervised/unsupervised and/or

reinforcement learning for classification, regression and prediction. Yet, many AI/ML models are used as "Black boxes" focusing on the output prediction, in that it is not always required to understand fully or partially why a model reaches up to its prediction or how the internal workings of the model contribute to the model's output, further, to build robust and trustworthy AI/ML-based predictions. Here we demonstrate how AI/ML has been evolved and has become an essential tool for predictive analysis and enhanced interpretation of model's prediction using interpretable and explainable methods (e.g., Shapley additive explanations (SHAP), accumulated local effects(ALE), statistical performance measure etc) to gain deep insight into the role of feature relevance (explicit influence of each to model's output) and feature importance (probable role of each to the model's quality) to the prediction. We believe that AI/ML and/or with interpretable and explainable framework can become an essential promising tool to the problem of geo-exploration/mapping of subsurface faults/geological structures, and thrust zones namely, *Kohima Synclinorium*, Naga and Disang thrust, and Eastern boundary thrust of NE India and complex geo-pressure/pore-pressure modelling at oceanic environment of IODP based on the present analysis as case studies.

Keywords: Explainable AI; Machine learning; Deep learning; Ensemble learning, Applied Geophysics; Interpretable ML.

SPACE WEATHER INVESTIGATIONS: RECENT TRENDS, CONTRIBUTIONS AND FUTURE DIRECTIONS

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Space weather relates to the conditions at Sun and its dynamic interaction with Earth's ionosphere and atmosphere systems. They are generated as a result of transient eruptions like solar flares, Coronal mass ejections (CMEs), Corotating Interaction Regions (CIRs), Solar proton events (SPEs) which can generate geomagnetic storms and substomrs, impacting different region of Earth. These conditions can impact the performance and reliability of both space borne and ground-based technological systems. The Earth's magnetosphere-ionosphere (M-I) system, which directly gets influenced by the space weather impact, responds dynamically to various inputs of energy from the Sun, delivered through solar radiations including the EUV and X-rays or transient solar eruptions. The interplanetary magnetic field (IMF), an extension of the solar magnetic field, travels with the solar wind and interacts with the Earth's magnetosphere. Although the Earth's ionosphere is shielded from the direct impact of the solar wind by geomagnetic field lines, during periods of southward IMF, when solar magnetic field lines merge with the Earth's geomagnetic field lines, high-latitude ionosphere experiences direct entry of particles from solar wind and magnetospheric origin, leading to geomagnetic storms and substorms. Understanding and quantifying the variability in the ionosphere thermosphere system during geomagnetically quiet and disturbed times is therefore crucial in view of our growing dependence on technologies which are directly impacted. A case study of a super intense geomagnetic storm of May 2024 has been investigated thoroughly

which shows the dramatic changes in the Earth's magnetic field and related regions which are influenced. Investigating how this disturbed-time variability manifests under varying solar wind energy inputs during geomagnetic storms over Indian longitudes is of great interest. Using conjunction observations from satellite, ground station, and machine learning tools and simulation, the quantification of these disturbances are addressed in different regions of Earth's geosphere.

Key words: *Space Weather, Geomagnetic storm, magnetosphere-ionosphere coupling*

SUSTAINABLE SOURCES OF DRINKING WATER IN SALINE COASTAL AQUIFERS

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Coastal regions of India are increasingly experiencing stress on freshwater availability due to seawater intrusion, overexploitation of groundwater, land use and land cover changes, and climate-induced sea level rise. The resulting salinization of coastal aquifers has critically undermined the sustainability of drinking water sources, particularly in deltaic and estuarine environments. This paper demonstrates the potential of Submarine Groundwater Discharge (SGD) and River Bank Filtration (RBF) as sustainable, nature-based approaches for augmenting potable water supply in saline coastal aquifer systems. Integrated investigations involving geophysical surveys, geochemical analyses, sea surface temperature data, and isotopic tracers delineated the fresh–saline groundwater mixing interfaces, revealing that SGD zones function as potential low-salinity discharge windows. Seven such prospective SGD zones were identified along the Odisha coastline. Further, at the Varaha River site in Andhra Pradesh, Electrical Resistivity Tomography (ERT) and numerical modelling using MODFLOW were employed to simulate groundwater flow dynamics and optimize well configuration and pumping strategies for sustainable extraction through RBF. Simulation and MODPATH particle tracking results indicated that approximately 61% of the extracted water originated from the river through bank filtration, while the remaining portion was derived from groundwater. Flow modelling further optimized the pumping duration to maintain the quality of bank filtrate water, with an optimum rate of 31.2 m^3/h for 5 hours daily during the monsoon period. The performance and water quality assessment of the RBF system confirmed that the technique is a viable option for producing safe drinking water even from ephemeral river systems influenced by saline coastal aquifers. Together, SGD and RBF represent effective nature-based solutions (NbS) for mitigating freshwater scarcity in coastal regions, reducing dependence on energy-intensive desalination and minimizing ecological impacts. The findings provide a robust scientific framework for developing hybrid coastal water supply systems that advance national goals of water security and sustainable coastal aquifer management under changing climatic conditions.

Keywords: Submarine Groundwater Discharge (SGD), River Bank Filtration (RBF), Coastal Aquifers, Sustainable Water Supply, Numerical Modelling

EARTHQUAKE CYCLE IN ANDAMAN SUMATRA SUBDUCTION ZONE

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The concept of plate tectonics, as applied in the subduction zones, implies that earthquake processes may be quasi-periodic. Accordingly, the crustal deformation during earthquake cycle (namely, the interseismic, coseismic and postseismic phases of deformation) may also be quasi-periodic. Thus studying the phases of deformation may lead to better understanding of earthquake processes and geodynamics, and assessment of earthquake hazard, in terms of earthquake recurrence interval. In the Andaman Sumatra region, using GPS measurements of crustal deformation, we now have a good estimate of all the phases of deformation through earthquake cycle. The GPS measurements in the interseismic period clearly provide evidence of strain accumulation in the region. Similarly, GPS measurements of coseismic deformation helped in robustly estimating the size of the earthquake, and rupture parameters. Currently the region is undergoing intense postseismic deformation. The modelling of which provides constraints on the rheology of the region and the other geodynamic processes contributing to deformation. Putting all these estimates of deformation and the processes involved, we estimate a recurrence interval of about four hundred years for giant earthquakes in the region.

ABSTRACTS

COASTAL AND OCEAN PROCESSES

COASTLINE CHANGES, SEDIMENT TRANSPORT, AND INTEGRATED MANAGEMENT

[ABS-0031]

SEDIMENT TRANSPORT AND HIGH TIDE LINE CHANGE ANALYSIS ALONG THE VIZIANAGARAM DISTRICT, ANDHRA PRADESH

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Understanding Sediment Analysis and Shoreline change and High tide line (HTL) dynamics is essential for effective coastal management, particularly along rapidly evolving coasts such as Vizianagaram district, Andhra Pradesh, India. This study integrates field surveys, computer aided modelling and geospatial technologies to quantify sediment accretion and erosion along each transacts to examine the morphological changes in Pre-Monsoon and Post-Monsoon at selected locations of Chinthapalli, Tippalavalasa and Kancheru of Vizianagaram district and shoreline evolution over 24-year period (2000-2024) and to predict future HTL positions for the next two decades. A critical component of this study was the demarcation of the surveyed locations using DGPS data. The mapped HTL was compared with the extracted normal shoreline positions, revealing significant differences in spatial extent that highlight the vulnerability of certain stretches. From Observations Chinthapalli and Tippalavalasa sectors demonstrated net accretion of 36,453 m3 and 37,577 m3 annually, whereas Kancheru exhibited persistent erosion at 10,453 m3 per year. The primary drivers of sediment redistributed were driven by seasonal reversal of longshore currents flowing northeast to southwest during the northeast monsoon and reversing during the pre- and southwest monsoon. Using the Digital Shoreline Analysis System (DSAS), predictive modelling indicated sustainable future landward migration of the HTL under prevailing conditions. If trends continue, several vulnerable zones along the Vizianagaram coast are projected to experience pronounced shoreline retreat within 10-20 years, posing risks to infrastructure and coastal communities. This integrated approach, combining beach profile analysis, 3D modelling of profiles, ArcGIS shoreline mapping and DGPS-derived HTL demarcation, demonstrates the effectiveness of multidisciplinary tools for shoreline monitoring and prediction. The finding provides critical inputs for coastal zone management, emphasizing the need for proactive strategies such as shoreline protection measures, managed retreat in sensitive areas, and stringent regulation of development activities near HTL.

Keywords: Keywords: Shoreline Evolution, High Tide Line, DGPS Survey, HTL mapping, DSAS

[ABS-0077]

RISING SEA LEVELS AND ITS IMPACT ON THE COASTLINE BOUNDARIES- A TEASER FOR THE EARTH SCIENTISTS

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Abstract It is always fascinating to see the satellite map of the earth on Google Earth where in we see the continents surrounded by oceans and seas with beautiful coastlines. The continental shelf, a part of the continent, appears to have been submerged under the sea, in the geological time scale. The sea levels are rising due to melting of ice caps in Antarctica and other polar regions due to global warming. The sea level rise results in shrinking land area of the continents. Recent studies indicate that the sea level is rising along the Indian coastlines by upto 4 millimetres per year. Even by taking the rise of 1 mm per year, there will be 1 metre rise at least in 1000 years Dwaraka in the west coast of India submerged under water about 5000 years ago is the best evidence. At this minimum rate of 1.mm per year sea level rise, India lost about 400000 square kilometres of coastal land area in the past 100000 years. At that same time, Sri Lanka and India appear to have been connected by land, without sea water in between. In less than 5000 years, one has to see a major part of Bangladesh as a continental shelf, as its average elevation is less than 5 meters. This analogy can also be extended to note that Australia and Tasmania were connected on similar lines of India and Sri Lanka.Moreover, detailed geophysical and geochemical studies are envisaged to make reliable predictions on the impact of sea level rise on continental land areas.

Keywords: Sea level rise, India, Australia

[ABS-0101]

MAGNETIC FINGERPRINTING OF SEDIMENT SOURCE-TO-SINK PROCESSES IN A TROPICAL ESTUARINE SYSTEM

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Magnetic minerals are ubiquitous in fluvial, estuarine, coastal and shelf systems and potential recorders of geological, climatic and sedimentary processes. This study focusses on tracing of source-to-sink processes in a complex tropical estuarine system of Goa, west coast of India using environmental magnetism and sedimentological methods. Comparison of magnetic properties of source rocks, soils, fluvial, estuarine, and marine sediments in an estuarine system indicate large variability in properties of magnetic minerals (content, grain size, mineralogy), clastic sediment grain size and their distribution pattern. Bulk magnetism is mainly dominated by ferri-and antiferromagnetic minerals of detrital origin. Distribution maps of magnetic minerals (interms of magnetic mineral content, coercivity, grain size) and clastic grain size in

different sub-environment of the estuary helped to identify the magnetite-rich zones and to understand the sediment transport system. We noticed that active magnetite enrichment takes place in tidal channel network of the estuarine system, which further feeds the magnetic particles into the nearshore and marine region. A systematic trend of loss of clastic sediment grain size coupled with progressive fining of magnetic crystal size in estuarine surficial sediments through source-to-sink can be reconciled with the underlying hydro-and sediment dynamics which constrained the overall sediment transport. Our approach of integrating magnetic and clastic grain-size data can be successfully developed to establish a conceptual model of hydro-and-sediment dynamics for tropical estuarine system.

Keywords: Tropical Estuaries, Magnetic Minerals, Environmental Magnetism, Source-to-Sink Processes

[ABS-0071]

SIDE SCAN SONAR IMAGE CLASSIFICATION FOR MAPPING SAND MINING FEATURES IN THE CHAPORA RIVER, GOA

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Sand mining in riverine systems poses significant geomorphic and ecological challenges, necessitating advanced methods for monitoring and impact assessment. As part of environmental and geomorphological investigations in the Chapora River, Goa, high-resolution side scan sonar (SSS), single-beam bathymetry, seismic profiling, and sediment sampling were undertaken along ~26-line km of the channel. The side scan sonar mosaics revealed distinct geomorphic and anthropogenic features, including sand ripple marks, sand bars, exposed rock outcrops, bridge pillars, and zones of active sand extraction. Notably, excavation imprints attributable to two distinct mining practices Type I (linear trenches), Type II (circular pits), debris, cohesive sediments and river banks were observed, reflecting variations in extraction techniques and their morphological footprints. To improve feature identification, pixel-based image classification was performed using ilastik, an interactive learning and segmentation toolkit. Originally developed for microscopic imaging, ilastik was adapted for acoustic imagery to automatically classify and map seafloor features. This approach enabled systematic categorization of multiple classes, including sand ripple fields, rocky outcrops, structural obstructions (bridge pillars), active mining zones (Types I and II), and additional geomorphic elements. The integration of automated classification with geophysical data enhanced the accuracy of riverbed mapping and facilitated objective delineation of mining-affected zones. The study demonstrates the potential of coupling geophysical surveys with advanced image segmentation techniques for riverine resource mapping. By providing spatially explicit datasets on sand distribution, mining footprints, and associated features, this work contributes to baseline inventories for environmental monitoring, sustainable sand resource management, and mitigation planning for anthropogenic impacts in fragile river ecosystems.

Keywords: Sand Mining, Side Scan Sonar, Image Classification

[ABS-0233]

ASSESSMENT OF COASTAL MORPHOLOGICAL VARIATIONS DURING THE YEARS 2023 TO 2025 ALONG THE VISAKHAPATNAM COAST

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Coastal degradation poses a growing threat in India, affecting infrastructure and the livelihoods of coastal communities. Along the 48 km Visakhapatnam coast (Bheemili to Yarada), seasonal beach changes are driven by waves, tides, currents, and human interventions like dredging and jetty construction. Bimonthly beach profilings are conducted at ten sites for three years i.e. during 2023,2024 and 2025 Pre-Monsoon, Monsoon, and Post-Monsoon seasons, combined with littoral data, revealed significant morphological shifts. The southern coast (Yarada to Submarine) saw major erosion in the year 2023, especially during the months of July August and sediment deposition occurred in the year 2024. The northern stretch (Rushikonda to INS Kalinga) gained sediment in the year 2023 but eroded in the year 2024. Bheemili consistently showed erosion, likely due to its embayed nature. These findings identify key erosion and deposition zones, aiding future coastal planning and management.

Keywords: Shoreline dynamics, Sediment loss, Sediment gain, Coastal surveys, Visakhapatnam shoreline.

[ABS-0090]

TRACING PROVENANCE TO POLLUTION: REVIEWING RARE EARTH GEOCHEMISTRY OF INDIAS EAST COAST.

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India s eastern coastline hosts extensive estuarine and mangrove systems where Rare Earth Elements (REEs) record both natural processes and human impacts. This review compiles and analyzes existing research on their distribution and geochemical behavior, highlighting implications for sediment provenance, pollution sources, and coastal biogeochemical cycling. REE patterns are generally flat but show notable element-specific variations. Cerium (Ce) anomalies range from absent to distinctly negative or positive, with negative anomalies linked to Ce scavenging and the reduction of insoluble Ce(IV) to soluble Ce(III) under alkaline, reducing conditions, and positive anomalies reflecting alternative geochemical processes. Europium (Eu) anomalies vary from slightly negative to positive, suggesting changing redox conditions and diverse sedimentary inputs. Gadolinium (Gd) anomalies span approximately 0.8 to 1.22, with distinctive signatures reported from sites such as Pichavaram, Nagavali, Vamsadhara, and Subarnarekha. Collectively, these datasets reveal a coastline influenced by

both natural sedimentary inputs and localized anthropogenic activities, allowing differentiation of river-dominated systems from those impacted by aquaculture and industrial effluents.

Keywords: Rare earth elements, East Coast, mangroves, estuaries.

[ABS-0213]

THE ROLE OF FRINGING CORAL REEFS IN SHORELINE EROSION AND ACCRETION: A REMOTE SENSING STUDY OF LAKSHADWEEP

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Coastal ecosystems worldwide have experienced intensified human interaction, driven by shifting infrastructure and ecosystem stresses, with reef-related processes being a primary cause of morphodynamic alteration in island systems. In this study, we examine intra-annual shoreline variation on selected Lakshadweep islands in India to understand the localised coral reef-initiated effects on coastal stability. The research utilises multi-temporal satellite data to analyse seasonal changes over the coral-lined shores from 1991 to 2025. Shorelines were delineated using the semi-automated Normalised Difference Water Index (NDWI) and Modified NDWI (MNDWI), which were then enhanced through Otsu thresholding and image segmentation processing. Tidal corrections maintained positional precision and reduced errors by utilising datasets sourced from the Archiving, Validation, and Interpretation of Satellite Oceanographic data (AVISO), thereby completely delineating shoreline lines for analysis. Shoreline change analysis employed measures from the Linear Regression Rate (LRR) to determine temporal trends. This enables the inter-annual evaluation to capture the dynamic, seasonally dependent, and reef-mediated reactions to variations in wave climate, thereby transcending static assessment. This research provides a comprehensive characterisation of the function of coral reef systems in Lakshadweep in relation to coastal processes. It also encompasses knowledge of key components in sustainable coastal zone management and reef protection, as well as adaptation procedures to climate change and spatial planning in island development. It may even be suggested that the findings from this study contribute to understanding the processes of erosion, accretion, and coral decline in the Lakshadweep atoll. Remote sensing, in conjunction with reasonably appropriate tidally corrected periodicity of observations, would provide reliable and valuable data, increasing the accuracy and quality of data for long-term monitoring of reef and coastal systems, including informing the decision-making of coastal managers.

Keywords: MNDWI, NDWI, Tidal Correction, Shoreline Change Rate

[ABS--0114]

MONTHLY AND SEASONAL EVALUATION OF WAVE SPECTRA ALONG THE WEST COAST OF INDIA

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The west coast of India, bounded by the Arabian Sea is subject to highly dynamic wave regimes shaped by monsoonal winds, long-period swells originating from distant sources, and locally generated wind seas. The region exhibits distinct seasonal variability: the southwest monsoon produces strong winds and high-energy waves, whereas the northeast monsoon shows comparatively weaker conditions. The wave parameters from global reanalysis datasets perform well in deep waters, their reliability in shallow and intermediate waters requires validation against insitu measurements. Among available approaches, wave spectral analysis, especially 2D wave spectra, provides the most comprehensive means to evaluate the distribution of wave energy across frequencies and directions for any coastal region. ERA5, with its enhanced spatial (31 km) and temporal (hourly) resolution over ERA-Interim, has become the preferred dataset for coastal wave studies. This work evaluates this 2D wave spectra against buoy measurements off Honnavar for 2014 2015, at daily, monthly, and seasonal timescales. On the daily scale, ERA5 successfully reproduced dominant swell directions and broad spectral trends, though it consistently underestimated energy and showed slight directional shifts relative to observations. Monthly comparisons showed better match than daily analyses. Seasonally, ERA5 performed well during the southwest, accurately representing the unimodal, swell-dominated wave field and associated high-energy levels, although with a tendency to broaden the frequency direction spread. On the contrary, during the pre- and post-monsoon transition periods, measured spectra frequently exhibited a bimodal structure representing the coexistence of locally generated wind-seas and long-period swells. ERA5 was able to capture the general energy trends but underestimated the distinct separation between spectral peaks, instead of producing a smoother energy distribution. These findings highlight the value of spectral-scale validation in coastal regions and highlight ERA5 s effectiveness for applications ranging from coastal hazard mitigation and port operations to long-term wave climate assessments under changing climatic conditions.

Keywords: 2D wave spectra, ERA5, moored buoy, ocean waves, spectral analysis

[ABS-0065]

MULTI-SENSOR SATELLITE OBSERVATIONS OF SUSPENDED SEDIMENT CONCENTRATION ALONG THE CENTRAL WEST COAST OF INDIA

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Suspended sediment concentration (SSC) of estuaries and coastal waters plays a pivotal role in managing sediment budgets, coastal stability, primary productivity, and ecosystem condition.

SSC is highly dynamic and governed by tidal mixing, riverine input, coastal erosion, and hydro-meteorological forcing. While in-situ measurements provide point data with high accuracy, they are insufficient to quantify the overall spatio-temporal variability in these complex systems. Remote sensing has proven to be an effective alternative, with ocean colour sensors such as Ocean Colour Monitor (OCM), Moderate Resolution Imaging Spectroradiometer (MODIS), and Sea-viewing Wide-Field-of-view Sensor (SeaWiFS) enabling SSC mapping on a large scale. However, their low spatial resolution limits their use for optically complex nearshore waters and estuaries where high-resolution sediment processes dominate. Over the last few years, advances in high-resolution multispectral sensors have significantly improved SSC retrieval in such environments. This study integrates data from multiple sensorsï ½Landsat-8 Operational Land Imager (OLI), Sentinel-2 Multi-Spectral Instrument (MSI), and ResourceSAT 2/2A Advanced Wide Field Sensor (AWiFS)ï ½to study suspended sediment dynamics along the central west coast of India, including the Goa coastal waters (2014ï ½2020) and Zuari estuary (2016ï ½2022), complemented with intensive AWiFS monitoring (2020ï ½2022). Coastal application-specific algorithms were utilised to retrieve SSC estimates, and satellite-retrieved estimates were cross-checked with in situ laser-based particle size distribution and concentration measurements. Validation indicated a very high correlation (Rï ½ = 0.89) of SSC from AWiFS-derived SSC with in situ measurements, establishing the sensor's viability for operational monitoring. Results document SSC gradients of upstream sections of rivers (15ï ½18 mg/l) through the estuary (8ï ½12 mg/l) into coastal waters adjacent to the estuary (5ï ½10 mg/l). The study highlights the advantages of using multiple satellite platforms to gain insight into the suspended sediment fluxes, sediment management and strengthening of coastal resilience in rapidly changing environments.

Keywords: Suspended Sediment Concentration (SSC), Landsat-8 OLI, Sentinel-2 MSI, ResourceSAT2/2A AWiFS and central west coast.

[ABS-0045]

SEA SURFACE WAVE ASSESSMENT DURING CYCLONE "BIPARJOY" IN THE ARABIAN SEA

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Periodically, the Arabian Sea is considered one of the most productive aquatic environments and also experiences several extreme conditions, like cyclones, storms, etc. The vigorous nature of cyclones in the Arabian Sea poses a threat to open ocean resources, ecosystems, and habitats, as well as their vulnerability along the coastal belt, especially on the west coast of India. The extreme weather conditions bring significant hazards as a result of energetic sea surface wave activity along the coastal zone, particularly in the low-lying regions. It's crucial to assess the social, economic, and environmental scenarios caused by such extreme weather conditions that impact drastically in a short-term period. The Extremely Severe Cyclonic Storm "Biparjoy" was one of the wake-up calls that persisted from 6th June to 18th June, 2023, in the Arabian

Sea. The coastal city, Mumbai, is one of the highly affected zones that were identified during this cyclonic phase. Globally, the sea surface waves have been examined through in-situ observation, reanalysis, and satellite altimeters for exhibition of real-time sea state. The present study aims to examine the cyclone-induced sea surface waves during "Biparjoy" in the coastal water off Mumbai, using in-situ observations, reanalysis data, and satellite altimetry. The sea surface wave was recorded by the Datawell Wave Rider Buoy deployed at a water depth of 10 m, located approximately 6 km from the shore, as well as from the ERA5 reanalysis data and satellite altimeters, namely Jason-3, Sentinel-3A, Sentinel-3B, and CryoSat-2. During this phase, our findings exhibited that ERA5 reanalysis significant wave height underestimated at a rate of 47% as compared to in-situ measurements that recorded up to 4.14 m, while that was 42% with the satellite altimeters. Further, the degree of closeness of ERA5 mean wave period (Tm) and peak wave period (Tp) to in-situ data exhibited overestimation and underestimation at a rate of 19% and 6%, respectively, while the ERA5 waves were propagating with an average (maximum) shortcoming of 14Â° (34Â°). Therefore, enhancing the degree of practicality in the multiway observation for projecting the sea state in a realistic form would significantly improve the effectiveness of risk reduction management plans against extreme events for both coastal and open ocean applications, contributing to the achievement of Sustainable Development Goals.

Keywords: Coastal Wave; In-situ Observation; Reanalysis Data; Satellite Altimeters; Mumbai Coast

MARINE GEO DYNAMICS

[ABS-0036]

DECOMPOSITION OF GEOCENTRIC SEA-LEVEL RISE IN THE MARITIME CONTINENT REVEALS A TECTONIC FINGERPRINT

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The islands of the Maritime Continent (MC) are highly vulnerable to sea-level rise driven by a range of barystatic, sterodynamic, and tectonic processes. Co-seismic and inter-seismic deformation can modify sea surface height (SSH) through seafloor displacement and gravitational changes associated with crustal mass redistribution, yet the long-term impacts of these processes on SSH remain poorly understood. Here we compare satellite altimetry observations of SSH over the MC (1993 2021) with model-based estimates of the major contributors to SSH change. We predict spatio-temporal patterns of SSH change associated with glacial isostatic adjustment (GIA) and with gravitational, rotational, and deformational (GRD) effects arising from recent changes in polar ice sheets, glaciers, and terrestrial water storage. These predictions draw on contemporary reconstructions from GRACE data, glacier mass balance models, and global hydrological datasets. Sterodynamic SSH variations are

estimated from ocean reanalysis products, and the associated ocean mass redistribution is used to compute ocean GRD. The combined contribution of these processes accounts for most of the observed SSH change across the MC. However, we identify an anomalous SSH trend northwest of Sumatra that is not attributable to sterodynamic or GIA/GRD processes. This rate anomaly coincides with GRACE-derived long-term geoid change near the 2004 M9.1 Indian Ocean earthquake rupture zone. We interpret this signal as the first observational evidence of gravitational perturbations to geocentric SSH induced by subduction processes.

Keywords: Sea-level rise, sterodynamic changes, GRD fingerprints, Subduction tectonics

[ABS-0093]

SEISMIC EVIDENCE OF DEEP CRUSTAL HYDRATION IN THE CENTRAL INDIAN OCEAN BASIN

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The Central Indian Ocean Basin (CIOB) constitutes one of the most complex and dynamic geodynamic domains on Earth, sculpted by the interplay of long-term plate convergence, diffuse intraplate deformation, and hotspot activity. Its present configuration traces back to the early mid Cretaceous rifting between Antarctica and India, which initiated the formation of the Indian Ocean. The protracted rift-to-drift evolution of the Indian Plate was further modulated by repeated interactions between coeval mantle plumes and spreading centres, leaving a lasting imprint on the basin s tectonic and magmatic architecture. In 2015, a ~420-km long wide-angle reflection and refraction seismic profile was acquired in the CIOB using 12 nos. of 4-component ocean bottom seismometers (OBSs) south off Sri Lanka, which lies in close proximity to the Indian Ocean Geoid Low. This multicomponent OBS has provided us the opportunity to integrate the different components for investigating the processes driving intraplate deformation, lithospheric hydration, and tectonic evolution. In this study, we employ P- and S-wave arrivals recorded by these12 OBSs to construct high-resolution seismic tomography models for both P- and S-wave velocity structures. From these models, we derive spatial variations in the Vp/Vs ratio and corresponding estimates of Poisson s ratio. The results highlight pronounced anomalies within the deep crustal section, where Poisson s ratios (ν) exceed 0.29 in the lower crust. Such elevated values provide compelling evidence for extensive hydration of the crust, most plausibly facilitated by the infiltration of seawater along pervasive fracture and fault systems. This hydration process modifies the mineralogy and fabric of crustal rocks, reducing seismic velocities, enhancing ductility, and significantly altering the bulk physical properties of the lithosphere. Our findings underscore the critical role of fluid rock interactions in governing the mechanical behaviour of the oceanic crust and their broader implications for intraplate deformation and seismicity in the Central Indian Ocean Basin.

Keywords: Central Indian Ocean Basin, deformation, hydration, seismic

[ABS-0202]

TECTONO-MAGMATIC CONTROLS ON NEAR-AXIS SEAFLOOR EVOLUTION AT THE CENTRAL INDIAN RIDGE: FINE-SCALE GEOMORPHOLOGY AND ITS GEODYNAMIC INSIGHTS

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Goa, India The interplay between tectonic faulting and magmatism fundamentally controls the structure and evolution of spreading centres. At the southern Central Indian Ridge, with its intermediate spreading rate, this interaction manifests through the co-development of fractures and volcanic centres. We examine an ~50 km² area at ~23.50°S, 69.40°E using ultra-high-resolution Autonomous Underwater Vehicle (AUV) bathymetry and backscatter data to characterise the coupling between tectonic extension and magmatic supply. Semi-automated fracture identification reveals 1,564 faults and 169 fissures, defining a system in the growth stage with emerging coalescence. Fault dip patterns show coexisting west- and east-dipping populations, likely associated with tectonic extension and magmatic intrusions, respectively. Spatial variations in fracture density, mapped via kernel density estimation, highlight clusters of concentrated strain, many coinciding with eruptive centres. Terrain classification indicates that most of the surveyed area is hummocky and volcanically overprinted, reflecting strong coupling between faulting and resurfacing processes. Apparent tectonic strain, estimated from fault scarps and fissures, shows that ~19% of the extension forming the young seafloor is accommodated by tectonic activity. Strain partitioning is evident: ~25% of the measured strain occurs on east-dipping faults, probably linked to dike intrusions rather than pure extension, while the remaining strain on west-dipping faults is underestimated due to lava flows burying pre-existing structures. Integration with regional geophysical data provides insights into magmatic episodes and the broader geodynamics of this ridge segment

Keywords: Central Indian Ridge, Seafloor morphology, Tectono-magmatic interactions, Fracture system, AUV Bathymetry

[ABS-0067]

ACTIVE FAULT MAPPING IN THE OFF-NICOBAR ISLANDS, ANDAMAN SEA USING LOCAL EARTHQUAKE DATA

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Following the devastating megathrust earthquake on December 26th, 2004, the Off-Nicobar region experienced a series of earthquake swarms in 2005, 2014, 2015, and 2019, indicating persistent tectonic unrest and possible reactivation of fault systems. To investigate the origin of these seismic events and to map active fault systems and magma dynamics, the CSIR National Institute of Oceanography carried out a passive Ocean Bottom Seismometer (OBS) experiment in the eastern offshore area of the Nicobar Islands, in the Andaman Sea. Between

October 10th, 2023, and January 20th, 2024, We deployed eight high-quality broadband OBS units equipped with four components (X, Y, Z, and pressure) and five ocean-bottom geophones. We report seismicity and mapped active faults in the Off-Nicobar region for the first time using local earthquake data recorded by OBS. A total of 610 small-to-moderate sized (1.0< ML<4.5) earthquakes were located during our OBS deployment period in the study region. The spatial distribution of relocated epicenters clearly delineates the ~N-S oriented Andaman Nicobar Fault (ANF) and the NW-SE oriented Seulimeum Fault (SLF), a northern strand of the Great Sumatra Fault and a N-S oriented trend T1. The seismicity pattern indicates that ANF is seismically active from east of Nicobar Islands to Andaman Islands and the SLF extends northward to approximately 8 degree north, where it closely parallels the volcanic arc. The observed spatial correlation SLF and the volcanic arc indicates a pronounced tectono-magmatic coupling, likely driven by the interplay between strike-slip faulting and subduction-related magmatic activity. The depth distribution of earthquake hypoceters reveals that both the ANF and SLF are seismically active down to 30 km depth. The ANF, and SLF collectively accommodate tectonic strain and control regional deformation regime.

Keywords: Ocean-Bottom Seismometers, Off-Nicobar Islands, Seismicity, Active faults, Volcanic arc

[ABS-0066]

OVERVIEW OF HIGH-RESOLUTION MARINE GEOPHYSICAL INVESTIGATIONS ALONG THE CENTRAL INDIAN RIDGE, INDIAN OCEAN: SEGMENTAL STRUCTURE AND CRUSTAL VARIABILITY

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A 750 km segment of the Central Indian Ridge (CIR) between 3oS and 11oS has been investigated to understand the processes driving oceanic crust formation and its subsequent evolution, using detailed marine geophysical data. High-resolution multibeam bathymetric mapping has revealed twelve ridge segments and seven distinct ridge-transform intersection (RTI) highs, located at inside-corner tectonic settings. Three of these RTI highs are interpreted as oceanic core complexes or megamullion structures. Magnetic modeling confirms that the CIR is a slow spreading ridge, with full spreading rates ranging from 27 to 38 mm/yr. Magnetic anomalies are traceable up to anomaly 3 across over the past 0-4 Million years. Additionally, gravity data have been analyzed to further characterize the underlying crustal structure. The computed mantle Bouguer anomalies (MBA) and the residual mantle Bouguer anomalies (RMBA) reveal significant variability along ridge segments, which are separated by both transform and non-transform discontinuities. Both transform faults and non-transform discontinuities are characterized by thinner crust. Crustal thickness along the ridge axis, estimated from RMBA, average around 5.23 km. Notably, the longer linear segments L and N exhibit up to crustal thickening of up to 7.8 km towards their centers. Diffuse plate boundaries are broad zones where the effects of plate interaction are complex and the boundaries are not

clearly defined. At several locations on the northeastern flank of CIR, deviations from the typical ridge-parallel seafloor fabric have been observed. These anomalies are interpreted as potential indicators of a diffuse plate boundary zone between the India and Capricorn plates, affecting the newly formed ocean floor. Additionally, clusters of higher-magnitude earthquake events (Mw 5 to 9) have been recorded within this divergent deformation zone, further supporting the presence of active tectonic processes in the region.

Keywords: Central Indian Ridge; Indian Ocean; Magmatic; Tectonic; Gravity; Magnetics; Multibeam bathymetry; Seismicity

[ABS-0128]

SUBSURFACE ANOMALIES BENEATH THE CENTRAL INDIAN OCEAN BASIN

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The Indian plate has undergone a long tectonic journey since its separation from Gondwanaland. Its protracted rift-drift motion has rendered several enigmatic features in the Central Indian Ocean Basin (CIOB). In this study, we used Ocean Bottom Seismometers (OBS) and utilised the fundamental-mode Rayleigh wave group velocity, as it is generally well excited by shallow-focus earthquakes. We considered earthquake records with magnitude>4.5 that occurred at depth<50 km at regional/teleseismic distances. The fundamental model Rayleigh wave group velocity is observed over a period range of 12 to 300 s. The observation reveals a significant decrease in group velocity at an intermediate period (60-180 s) along the profiles beneath the CIOB. The inverted model shows a significant reduction in shear wave velocity underneath the base of the lithosphere (i.e. 22-24 km Lithosphere-Asthenosphere boundary). The anomalous low-velocity zone (LVZ) is observed at a depth interval of ~90 km to ~160 km. Quantitatively, a ~18% reduction in shear wave velocity is observed in the vicinity of the LVZ along the P2 (~3.7 km/s) and P3 (~3.73 km/s) profiles, compared to the velocity of the overlying lid. Our results suggest the possible presence of ~2% melt fraction, excess temperature of ~230ï ½C, and maximum ~1% anisotropy in the CIOB, particularly beneath the Capricorn plate. However, the other profile reveals the relatively lesser melt fraction. The supplementary presence of extra melt fraction along the P2 and P3 profiles can be associated with an unextracted melt fraction, in conjunction with the northward movement of the Indian plate and appended by plume-lithosphere interaction, can account for the formation and persistence of an anomalous LVZ in the upper mantle beneath the CIOB region. Our result also favours the possibility of the west-to-east channel flow and strong anisotropy beneath the Capricorn plate.

Keywords: Ocean bottom seismometer, Surface wave, low-velocity zone and Mantle processes

[ABS-0141]

OBSERVED HIGH FREQUENCY VARIABILITY OF COASTAL CURRENTS AROUND THE INDIAN SUBCONTINENT.

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Coastal currents play a vital role in regulating regional climate and driving biogeochemical processes in the coastal ocean. Variability in the coastal currents impact a wide range of sectors such as fisheries, offshore industries, shipping sector etc. While seasonal and intraseasonal variability in coastal currents have been studied extensively (Shetye & Shenoi, 1988; Shankar, 2002; Amol et al., 2014, Mukherjee et al., 2014), high-frequency variability (HF, <25 days) remains largely unexplored in the Indian waters. This study investigates the HF variability in coastal currents around the Indian subcontinent using long-term observations from Acoustic Doppler Current Profilers (ADCPs) deployed at both shelf and slope locations. Hourly, quality-controlled, de-tided currents were rotated into alongshore and cross-shore components. Spectral analysis reveals pronounced HF current variability across the Indian subcontinent, with stronger energy on the continental shelf compared to the slope. Within the HF band, quasi-biweekly oscillations (16 24 day, 8 16 day), quasi-weekly oscillations (2 8 day), and internal waves (2 h 2 day) are identified. Quasi-biweekly oscillations are consistently strong and exhibit clear seasonal modulation in northern locations (Goa, Mumbai, Gopalpur, Visakhapatnam), whereas southern regions (Kollam, Kanyakumari, Cuddalore, Kakinada) display weaker seasonality. In contrast, the quasi-weekly band shows little seasonal variation. Among shelf sites, Kakinada exhibits the strongest HF variability, while Cuddalore is the weakest. Strong coherency across locations reveals the presence of coastally trapped waves (1 4.4 m/s) during the summer monsoon. On the shelf, faster propagation suggests shelf waves, while in-phase oscillations indicate the influence of large-scale wind forcing. Subsurface signals are also significant, sometimes surpassing surface variability. Occasional vertical phase propagation are also observed. In summary, significant HF coastal current variabilities exist along the Indian subcontinent, spanning multiple frequency bands. They exhibit propagatory patterns, vertical propagation, and strong subsurface variability, likely driven by combination of local and remote forcing mechanisms.

Keywords: ADCP, Coastal currents, Indian subcontinent, High frequency variability, Shelf and Slope currents, Wave propagation, Subsurface current variability.

[ABS-0183]

SEISMOTECTONIC ANALYSIS AND VOLCANIC-TECTONIC INTERACTIONS IN THE ANDAMAN-NICOBAR SUBDUCTION ZONE

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The Andaman-Nicobar region experiences frequent earthquake swarms that reflect a complex interplay between tectonic deformation and magmatic activity. Comprehensive seismotectonic analyses from 1960 to 2024 show that most swarm sequences are concentrated around the Andaman Sea back-arc basin and the Alcock Rise. Focal mechanism solutions indicate predominantly normal faulting with occasional strike-slip components, consistent with extensional deformation in a back-arc tectonic setting. Calculated b-values range from 1.09 to 2.17, with higher b-values and normal faulting events interpreted as indicators of magmatic or volcanic influence, supported by the presence of active and dormant submarine volcanoes in the region. Recent studies provide strong geophysical evidence for subsurface magmatic processes, suggesting that ascending magma from deep reservoirs interacts with the regional fault system to generate swarm-like seismicity. The March 2014 Nicobar swarm, for example, exhibited both tectonic and volcanic signatures, right-lateral strike-slip faulting, elevated b-values (~1.39), and shallow crustal sources, further supporting the hypothesis of magma-driven fault activation. These observations suggest that earthquake swarms in the Andaman-Nicobar arc result from the interplay between stress perturbations induced by major tectonic events and episodic magmatic intrusions. The regional sliver fault system likely serves as a conduit for ascending magmatic fluids, promoting swarm activity along zones of pre-existing crustal weakness. Distinct spatio-temporal migration trends, bimodal b-value distributions, and the close association with volcanic centers collectively point to a dual volcano-tectonic origin for these swarms. This integrated interpretation contributes in understanding of crustal deformation and seismo-volcanic coupling within subduction-related back-arc systems, also, strengthens the scientific basis for regional seismic and tsunami hazard assessments.

Keywords: earthquake, swarm, magma, b-value

[ABS-0198]

DISCOVERY OF ACTIVE HYDROTHERMAL VENTING IN THE SOUTHERN CENTRAL INDIAN RIDGE

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Hydrothermal vents are locations of primal significance as it stand crucial in understanding the seafloor processes, in terms of creating specialized ecological habitats as well as providing valuable mineral resources. Here, we report the discovery of active hydrothermal venting at the southern Central Indian Ridge (69.240 E, 23.360S), Indian Ocean, at water depths of 2700-

3000m. The hydrothermal activity was identified in 2024 using a suite of sensors mounted on a Hugin Superior Autonomous Underwater Vehicle (AUV) surveying at an altitude of 55 m above the seabed. Hydrothermal plumes were observed in the water column as high-intensity backscatter in the multibeam echosounder data. Overall, 13 individual plumes were identified in the water column backscatter data. Correlated temperature anomalies in the CTD sensor onboard the AUV further confirmed the hydrothermal activity. Analysis of the high-resolution (1m) bathymetry of the vent field showed the presence of prominent axial volcanic ridge features and rift valleys running in a northeast-southwest direction. The vent field occurs on the flank of an axial ridge feature, typical of spreading ridges. An extensive presence of basalt mound clusters and volcanic fissures were seen adjoining the vent fields, highlighting the predominantly magmatic nature of the region. The active vent field occurs in the proximity of the MESO zone, an inactive basalt-hosted sulfide field where the episodic nature of hydrothermal venting has been established through radiochronological investigations. It is proposed that the region has continuous hydrothermal circulation with adequate magma supply owing to the formation of a basalt-hosted vent system; the emplacement of which is controlled by tectonic factors resulting in this episodic behavior of hydrothermal venting and opening of the current vent locations.

Keywords: Hydrothermal Vent, Central Indian Ridge, Tectono-magmatism, AUV survey

[ABS-0120]

SEISMIC IMAGING THE INDIAN OCEAN GEOID LOW REGION USING AMBIENT NOISE TOMOGRAPHY

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The Indian Ocean Geoid low (IOGL) is a prominent negative geoid anomaly located south of the Indian subcontinent, with a prominent magnitude of -106 m, making it the largest geoid depression observed globally. Various studies have investigated its origin, proposing different mechanisms. Some studies attribute it to the upper mantle heterogeneity, specifically low-density anomalies, while others suggest a combination of low velocity anomalies in the upper mantle and high-velocity anomalies in the lower mantle. Despite numerous geodynamic models attempting to explain its origin, a consensus remains elusive, largely due to the limited availability of high-resolution seismic imaging beneath the vast oceanic region. Recent progress has been made with the deployment of a linear array of passive ocean bottom seismometers (OBSs), which has significantly advanced the understanding of deep mantle structures beneath the Ocean. Although the IOGL is believed to be influenced by deeper mantle structures, the lithosphere and uppermost asthenosphere are crucial to understand how deeper mantle processes manifest at shallower depths. We employ ambient noise tomography (ANT) to develop three-dimensional shear wave velocity models using the Rayleigh wave dispersion data in the period range 5 80s. The dispersion measurements are estimated from cross-

correlation functions (CCFs) computed between the station pairs, which include the 17 linear stations deployed during IOGL Phase-I, and 4 nearby land-based seismic stations. The inversion shear velocity results contribute to understanding the expression in the lithospheric and upper asthenosphere structure due to the deeper mantle processes in the Indian Ocean region.

Keywords: Indian Ocean Geoid low (IOGL), Ocean bottom seismometers (OBSs), ambient noise tomography, and seismic imaging.

[ABS-0091]

UNRAVELLING THE CONTROLS ON DEEP CHLOROPHYLL MAXIMA ACROSS SOUTHERN INDIAN OCEAN FRONTS

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Southern Ocean fronts, are circumpolar transition zones between water masses. While primarily controlled by the eastward-flowing Antarctic Circumpolar Current (ACC), their paths and intensity are significantly shaped by wind and the underlying ocean floor. To investigate the pronounced physical and biogeochemical variability within the Southern Indian Ocean sector, four Bio-Argo floats were deployed across its key frontal zones during 33rd Indian Scientific Expedition to Antarctica (33-ISEA). Using high-resolution, multi-year datasets from these Bio-Argo profiling floats, this study explores the mechanisms regulating the formation and variability of Deep Chlorophyll Maxima (DCM) across the Subtropical Front (STF) and Polar Front (PF) key features influencing productivity and ecosystem structure in this unique region. Our results demonstrate marked contrasts between the STF and PF: the STF is characterized by warmer, saltier, and more stratified surface waters with shallower mixed layers, leading to persistent and elevated DCMs (median 1.55 mg/m³ at 42 m) throughout the year. In contrast, the PF exhibits colder, fresher waters, deeper mixed layers, and weaker stratification, resulting in deeper (median 78 m) and less intense DCMs (median 0.88 mg/m³) that display strong seasonality tied to winter mixing and reduced light penetration. Statistical analysis reveals robust correlations between DCM features, mixed layer depth, and photosynthetically active radiation (PAR), indicating that the interplay between light availability, wind-driven mixing, and water column stability governs phytoplankton biomass accumulation below the surface. This study highlight how the Southern Indian Ocean's unique oceanographic and geological settings shape its regional biogeochemistry and marine ecosystems. These findings are crucial for improving climate models, particularly for carbon sequestration, and for understanding the region's influence on global climate systems.

Keywords: DCM, Chlorophyll , Southern ocean

[ABS-0009]

MONSOONAL AND DEPTH-RESOLVED VARIABILITY OF PARTICULATE ORGANIC CARBON IN THE BAY OF BENGAL.

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Particulate Organic Carbon (POC) is a vital component of the global carbon cycle, linking surface ocean productivity to deep-ocean sequestration through the biological carbon pump. However, its variability in the Bay of Bengal remains poorly constrained due to strong monsoonal forcing and freshwater influence. In this study, we investigate monsoonal (pre- and post-monsoon) and depth-resolved distributions of POC along the southwest Bay of Bengal, based on in-situ observations collected during February 2024 (post-monsoon) and July-August 2024 (pre-monsoon) from four coastal transects (Nagapattinam, Pazhayar, Mahabalipuram, and Chennai). POC concentrations were consistently higher during the pre-monsoon (128-404 mg C m^{-3}) than the post-monsoon (62-182 mg C m^{-3}), reflecting enhanced phytoplankton productivity under stratified conditions. Depth profiles revealed maxima at the surface and Deep Chlorophyll Maximum (DCM), with sharp declines toward 100 m driven by remineralization processes. Regional differences were evident, with Pazhayar and Chennai showing elevated POC influenced by freshwater and nutrient inputs, while Mahabalipuram exhibited lower, more oligotrophic conditions. These results demonstrate that POC dynamics in the southwest Bay of Bengal are primarily regulated by monsoon-driven stratification, freshwater inflow, and biological activity, with implications for coastal carbon export, sequestration, and regional carbon budgets. This study provides new insights into the role of monsoon-influenced marginal seas in regulating the marine carbon cycle.

Keywords: Keywords: Particulate Organic Carbon, Chlorophyll, Deep Chlorophyll Maximum, Phytoplankton

[ABS-0006]

SPATIAL VARIATIONS OF AIR-SEA HEAT FLUXES OVER THE NORTH INDIAN OCEAN

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To observe the spatial variations of Air-Sea Heat Fluxes (ASFs) over the North Indian Ocean (NIO), this study has been undertaken. For this, monthly high resolution (0.25°×0.25°) Surface Latent Heat Flux (SLHF) and Surface Sensible Heat Flux (SSHF), 10 m wind speed (WS), Sea Surface Temperature (SST), 2-m air temperature and dew point temperature and surface pressure data for the period 1979-2022 have been obtained from ERA5. The spatial pattern of SLHF and SSHF across the NIO and its subregions show significant spatial heterogeneity. The

broad sub-regions of the NIO namely, the BoB and the AS show different heat fluxes. The SLHF over the AS is higher than the BoB with a maximum over SWA, near the Gujarat and Maharashtra coasts, around Sri Lanka and a minimum along the Arabia coasts. On the other hand, the SSHF is higher over the BoB than the AS with a maximum over the Andaman Sea, the SEB, ECB, and the SEA and a minimum along the Somalia and Arabia coasts. Similarly, the variations of bulk parameters can also be observed across the NIO and its sub-regions. The BoB shows a higher sea-air temperature gradient than the AS with a maximum over the Andaman Sea, the SEB, the ECB, and the SEA and a minimum near the coasts of Arabia and Somalia. Likewise, the AS shows higher WS and sea-air specific humidity gradient than the BoB with maximum WS in the WCA and SWA and maximum specific humidity gradient near the coastlines of Gujarat and Maharashtra, as well as over the SEA, NWB, and coastal regions of North and South Andaman Sea. The spatial pattern of SSHF closely follows the pattern of the sea-air temperature gradient, whereas the spatial pattern of SLHF is more complex and depends on both WS and specific humidity gradients.

Keywords: SLHF, SSHF, NIO, BoB, diurnal variation

[ABS-0008]

INITIATION OF BIVALVE SHELL CALCIFICATION UNDER OCEAN ACIDIFICATION: INTEGRATING INSIGHTS FROM SHELL TO CELL

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The formation of initial bivalve shell is sensitive to ocean acidification, encoding the basis of shell formation and environmental information. Here, we demonstrated how the initial shell building processes were affected under various acidified conditions. With decreasing pH, larvae showed smaller shells and higher incidences of deformity. Shell elemental and isotopic profiles suggested that larvae almost exclusively used seawater dissolved inorganic carbon to calcify and exhibited diminished ability to maintain the calcifying fluid homeostasis. Compared to those reared at pHNBS 8.1, larvae exposed at pHNBS 7.7 downregulated the expression of genes related to transport of calcification substrates and regulation of carbonate chemistry, all of which were subsequently upregulated at pHNBS 7.4. This integrated finding advances the application of sclerochronology by providing insights into the initial shell formation, a crucial phase that is overlooked in sclerochronological studies, particularly in how environmental stressors affect the interpretation of geochemical proxies in adult shells.

Keywords: Ocean acidification, Sclerochronology, Bivalves, Ruditapes philippinarum

CLIMATE CHANGE - SEA-LEVEL CHANGES, MARINE HEATWAVES

[ABS-0224]

ANTARCTIC SEA ICE AT RECORD LOWS: OCEAN: ATMOSPHERE DYNAMICS AND CLIMATE IMPLICATIONS

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Antarctic sea ice is a key regulator of global climate, ocean circulation, and ice shelf stability. While Antarctic Sea Ice Extent (SIE) showed modest growth from 1979 to 2015, recent years have experienced unprecedented declines. Satellite observations indicate record-low SIE in consecutive years, with February 2022 reaching 2.16×10^6 km² (43% below climatology) and February 2023 declining further to ~1.7×10^6 km², the lowest in the satellite era. This study investigates the coupled ocean–atmosphere processes driving this rapid loss, emphasizing regional and seasonal variations. The Weddell Sea and Amundsen–Bellingshausen Sea (ABS) regions exhibited the steepest reductions, linked to anomalous surface and subsurface ocean warming (up to 300 m) since 2016. Transition from a rare "triple-dip La Niña" to a warming ENSO phase in 2022–2023 strengthened westerly winds, increased open-water exposure, and accelerated ice retreat near the western Antarctic Peninsula. Concurrently, strong positive Southern Annular Mode (SAM) conditions and lower stratospheric cooling influenced atmospheric circulation. Enhanced lower-tropospheric warming and positive net heat fluxes facilitated sustained heat transfer from the Southern Ocean, further amplifying ice melt. These results underscore the interplay of oceanic heat uptake, atmospheric variability, and large-scale teleconnections in driving Antarctic sea ice decline, with critical implications for ice shelf stability, global sea level rise, and climate feedbacks. Continued monitoring and improved polar process representation in climate models are essential for projecting future SIE under ongoing climate change.

Keywords: Climate Variability, Ocean Warming, Heat Flux Anomalies, Climate indices

[ABS-0205]

CLIMATE CHANGE-INDUCED CHANGES IN PRODUCTIVITY IN A HIGH ARCTIC FJORD ON THE WEST SPITSBERGEN SHELF: A PROCESS ANALOGY WITH THE COASTAL BAY OF BENGAL

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Rapid climate change is transforming the coastal and ocean processes of the High Arctic, profoundly influencing productivity and ecosystem functioning. The West Spitsbergen Shelf (WSS), located along the Atlantic gateway to the Arctic Ocean, is a climatically sensitive region where warm, saline Atlantic Water (AW) interacts with cold Arctic waters and glacial melt.

Kongsfjorden, an open fjord on the WSS, exemplifies this interaction, where surface freshening from glacial discharge overlies intruding AW at depth, creating a sharp halocline and stable stratification that regulate biological productivity. This hydrographic configuration closely resembles conditions in the coastal Bay of Bengal (BoB) during the southwest monsoon, where large riverine freshwater input overlies warm, saline subsurface waters advected from the Arabian Sea. In both systems, freshwater-induced stratification limits vertical nutrient supply, but episodic wind or convective mixing events can break this barrier, triggering short-lived productivity enhancements. Using in-situ observations and an ecosystem (ROMS NPZD) model, we investigated how climate-driven ocean atmosphere interactions modulate productivity in Kongsfjorden. The year 2014 emerged as exceptionally warm, with chlorophyll concentrations exceeding 12 μg L^{-1}, far above the typical summer maxima of 2 4 μg L^{-1}. While the early bloom in 2014 was linked to nutrient-rich AW advection, a remarkable late-summer/autumn bloom was sustained by convective mixing triggered by enhanced oceanic heat loss. The surface-intensified AW inflow warmed the upper layer, and concurrent atmospheric cooling increased the air sea temperature gradient, promoting vertical overturning that replenished nutrients despite low light levels. This process-based similarity between Kongsfjorden and the BoB highlights the universality of freshwater saltwater interactions and their control on productivity in stratified coastal systems. As Arctic warming intensifies glacial melt and Indian monsoon variability alters freshwater input, both regions are likely to experience amplified stratification mixing feedbacks with significant ecological consequences.

Keywords: Chlorophyll, Atlantic water, Surface warming, Sensible feat flux, Ocean heat loss, Convective mixing

[ABS-0038]

THE PROJECTED CLIMATE CHANGE INDUCED EXTREME SEA LEVELS AND COASTAL VULNERABILITY ALONG THE INDIAN COASTS

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As part of the Deep Ocean Mission of the Ministry of Earth Sciences, INCOIS has prepared a report on the sea level rise and its extremes and also assessed the associated coastal vulnerability along the Indian coasts. It presents a comprehensive assessment of future sea-level rise and its implications for coastal India and the associated vulnerable maps for the 11 selected locations along the Indian coast. Using global climate models and probabilistic methods, the report projects that relative mean sea levels (RMSL) along the Indian coastline could rise by 0.62 m (Visakhapatnam) to 0.87 m (Bhavnagar) under SSP5-8.5 (high emission scenario) by 2100, whereas extreme sea levels along the Indian coasts and islands are projected to rise between 0.68 m (Chennai) and 1.12 m (Bhavnagar). Further, Indian coastal regions north of 13N are seen as more vulnerable to extreme sea-level change, with the Gulf regions off

Gujarat and the northern coasts of the Bay of Bengal experiencing the largest changes in tidal maxima and climate extremes.

Keywords: Sea level projections, Coastal Vulnerability

[ABS-0007]

DARKENING THE ICE, WARMING THE SEAS: ARCTIC AEROSOLS AND THEIR IMPACT ON CLIMATE

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Arctic aerosols play significant role in modulating regional and global climate dynamics; however, their impacts remain one of the largest uncertainties in climate modeling. Black Carbon (BC) aerosol is of particular concern due to its dual influence on the atmosphere and cryosphere. BC in the atmosphere absorbs solar radiation, contributing to atmospheric warming. When BC deposits over snow and ice, it reduces surface reflectivity (albedo), accelerating melting and amplifying Arctic warming- a process known as Arctic amplification. This has a crucial impact on global sea-level rise and marine heatwaves. In order to understand the variability in Arctic aerosols and their climatic impacts, the National Centre for Polar and Ocean Research, India, has established the POLar AERosol NETwork (POLAERNET), with long-term monitoring at Ny-Ålesund, Svalbard (78.91°N, 11.89°E). Under the program, long-term and continuous measurements of BC mass concentration, aerosol scattering, and aerosol size distribution are being undertaken using seven-channel Aethalometer, integrating nephelometer, and Aerodynamic Particle Sizer spectrometer. These high-resolution measurements provide critical insights into the temporal variability of BC and its interactions within Arctic atmospheric. The observations reveal significant variability in BC concentrations, reflecting influences from both long-range transport of pollutants and local sources. Seasonal variations show that black carbon (BC) concentrations peak in winter and spring, while the biomass burning (BB) contribution peaks in summer due to vegetation fires. BC masses are largely influenced by long-range transport from mid-latitudes. The lowest BC and BB values observed in 2022 were linked to higher precipitation, fewer vegetation fires, and reduced episodic pollution events. The long-term dataset generated under POLAERNET will be helpful for constraining uncertainties in climate models, validating satellite observations, and quantifying anthropogenic influences over the Arctic region. By advancing our understanding of aerosol-climate interactions, these efforts contribute to improving future projections of Arctic change and its global implications.

Keywords: Black Carbon, POLAERNET, Biomass burning, Arctic

[ABS-0225]

LINKING THE ARCTIC AND THE INDIAN MONSOON: UNDERSTANDING CROSS-LATITUDE CLIMATE INTERACTIONS

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Arctic sea ice is declining at an accelerating rate, serving as one of the most visible indicators of global climate change. This loss of ice not only transforms polar environments but also alters atmospheric circulation patterns that extend far beyond the Arctic. Understanding how high-latitude variability affects tropical systems, such as the Indian summer monsoon, is essential for improving seasonal climate prediction. This study integrates satellite observations and coupled climate model simulations. Statistical analyses reveal a robust linkage between spring Arctic sea-ice concentration (SIC) and the leading mode of Indian summer monsoon rainfall (ISMR) variability, derived using singular value decomposition. Observations show a significant negative correlation ($r \approx -0.25$, $p < 0.10$) between ISMR and Arctic SIC, with stronger regional relationships over the Central Arctic ($r \approx 0.51$, $p < 0.01$) and the Barents–Kara Sea ($r \approx -0.39$, $p < 0.01$). Composite circulation patterns indicate that years with high SIC are marked by pronounced anticyclonic anomalies extending from western Europe to the western Pacific, enhanced easterly upper-tropospheric jets, and intensified rainfall over northwestern and peninsular India. Conversely, low SIC years are characterised by weakened jets, anomalous subsidence, and deficient monsoon activity. Multi-model ensemble simulations from CMIP5 and CMIP6 reproduce these covarying structures, accounting for approximately 30–43% of the observed covariance. These results demonstrate that Arctic sea-ice variability modulates large-scale circulation through a circumglobal teleconnection, emphasising its growing role in shaping tropical monsoon behaviour and highlighting the need to incorporate Arctic climate signals into regional prediction frameworks.

Keywords: Teleconnections, Climate Variability, Seasonal Prediction, Satellite Observations, Climate Modeling

[ABS-0188]

MARINE HEATWAVES IN THE SOUTHERN OCEAN AND THEIR ROLE IN AIR-SEA INTERACTION

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Marine heatwaves (MHWs) are prolonged periods of anomalously warm ocean temperatures exceeding the 90th percentile threshold. This study examines MHWs in the Southern Ocean from 1982 to 2022, revealing pronounced spatial and temporal variability in their frequency,

intensity, and duration. MHWs occurred more frequently (≈0.4 events per decade) and with greater intensity north of 65°S, particularly during summer, with a sharp rise after 2008 linked to anthropogenic warming. Climate modes such as El Niño and the Indian Ocean Dipole (IOD) notably enhanced MHW activity in the Ross Sea during spring and autumn. A major 2013 MHW event exemplified extreme subsurface warming, with temperatures reaching 6.2 °C at 120 m depth, indicating vertical heat propagation and increased ocean heat content. These results highlight the strong coupling between oceanic and atmospheric processes driving MHW variability and provide critical insights into the Southern Ocean s response to ongoing climate change.

Keywords: Marine heatwaves, Southern Ocean, Climate indices, Air-sea interaction

[ABS-0169]

WINTER WARMING IN AN ARCTIC FJORD LINKED TO INTRASEASONAL FJORD SHELF EXCHANGE

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Understanding wintertime processes in Arctic fjords is critical for projecting glacier response and their contribution to future sea-level variability under a changing climate. However, direct observations during the polar night remain scarce. Using three years of mooring data from Kongsfjorden (2014 2017), we report a marked subsurface warming of ~1.6 °C between the winters of 2014 2015 and 2015 2016, accompanied by pronounced intraseasonal variability during November 2015 January 2016. Wavelet analysis reveals enhanced spectral energy in the 8 45 day band for both temperature and along-fjord currents, with strong coherence, indicating advective transport of warm Atlantic Water (AW) from the adjacent West Spitsbergen shelf as the dominant driver. An EOF analysis of 250 hPa geopotential height anomalies further identifies an atmospheric circulation pattern (EOF Mode 3) that is strongly coherent with the fjord s 80 m temperature, suggesting that large-scale atmospheric forcing modulates transient southerly disturbances, thereby facilitating episodic AW intrusions into the fjord.

Keywords: Sea-level variability, Arctic, Fjord dynamics, Atlantic Water, Intraseasonal variability, Winter warming

[ABS-0019]

DELINEATING CO2 PLUME BOUNDARY AND RESERVOIR HETEROGENEITY USING SEISMIC INVERSION DERIVED ACOUSTIC IMPEDENCE AND VP/VS CUBES

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The Sleipner CO_2 storage project in the North Sea offers a valuable opportunity to study plume migration and reservoir heterogeneity using time-lapse seismic methods. This research aims to map the CO_2 plume boundary and evaluate reservoir variability through seismic inversion of

acoustic impedance and Vp/Vs cubes derived from Sleipner baseline and 4D monitoring seismic surveys, calibrated with logs from injection well 15/9-A-16 and monitor well 15/9-13. Seismic inversion provided high-resolution acoustic impedance and elastic property estimates, which were integrated with rock physics analysis to interpret reservoir changes caused by CO_2 injection. Acoustic impedance anomalies were used to distinguish CO_2-saturated zones from brine-bearing intervals, while Vp/Vs variations revealed lithological controls and fluid substitution effects within the Utsira Formation. Time-lapse analysis highlighted the spatial and temporal evolution of the injected plume, improving constraints on its geometry and migration pathways. Reservoir heterogeneity was further assessed by combining well log data with inversion-derived attributes to capture vertical and lateral variations in lithology and fluid distribution. The findings show that using both acoustic impedance and Vp/Vs cubes provides greater sensitivity to CO_2 saturation and heterogeneity patterns than conventional amplitude-based seismic methods. This integrated approach enhances monitoring accuracy, supports better predictions of plume evolution and reservoir performance, and contributes to ensuring long-term storage security and verification in geological carbon storage projects.

Keywords: Sleipner Field, CO_2 plume monitoring, seismic inversion, acoustic impedance, Vp/Vs ratio, reservoir heterogeneity, 4D seismic

[ABS-0121]

SOLID EARTH DYNAMICS AND THE RESPONSE OF POLAR ICE SHEETS TO SEA LEVEL CHANGE

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The thermal and mechanical structure of the solid Earth is fundamental in regulating how polar regions respond to ice mass changes, directly impacting the development and stability of the Antarctic and Greenland ice sheets. These ice sheets' variation affects sea level projections, but significant uncertainties remain due to limited understanding of Glacial Isostatic Adjustment (GIA) processes. Accurately quantifying GIA uplift rates, especially in Greenland and Antarctica, requires constraints on Earth's rheology, lithospheric thickness, and ice load history. Geophysical observations such as rock density, velocity, temperature, and water content support the assessment of subsurface properties, improving knowledge of Geothermal Heat Flux (GHF) and GIA. Geodetic data reveal bedrock uplift and ice dynamics, while seismic velocities indicate thermal variations: seismically slow (hotter, thinner lithosphere, lower mantle viscosity) mantle regions like southeast Greenland and West Antarctica show more rapid GIA uplift, compared to colder, thicker lithosphere in East Antarctica and northern Greenland. These structural variations ultimately influence bedrock response, ice sheet evolution, and sea level change. Our lithospheric models and effective elastic thickness results explain the present-day melting of ice sheets in Greenland and Antarctica.

Keywords: Lithosphere, Glacial Isostatic Adjustment,Glacial Isostatic Adjustment, Antarctica, Greenland

COASTAL AND OCEAN RESOURCES

MINERAL RESOURCES - PLACER DEPOSITS, POLYMETALLIC NODULES, MARINE MINERALS

[ABS-0011]

Critical Mineral Potentiality Along Beach Placers in India: An Overview

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A sustainable blue economy provide benefits for the current and future generations; protects, restore and maintains diverse productive and resilient ecosystem. This is based on clean technologies, renewable energy and circular economy. Among the ocean resources, mineral resources are one among them and very vital for country economy. Among the minerals, critical minerals have a global demand due to their key components in critical and strategic applications and also plays a key role for country economy and security. Critical minerals are the foundation of contemporary industrial economies, enabling technological advancements and boosting economies. They are defined as a set of naturally occurring elements that have diverse irreplaceable industrial applications but confront supply-related vulnerabilities either in the form of their limited geographic occurrences or sourcing challenges. As far as India is concerned, Government of India in June, 2025 has notified a list of twenty-four (24) critical minerals. India, with a coastline of nearly more than 11,000 km and 2.30 million.sq.km of EEZ is endowed with selected critical mineral resources in the form of placers like titanium minerals (ilmenite, rutile, leucoxene), zirconium minerals (zircon) and REE mineral (monazite). Nearly 12% of the critical minerals listed are confined to beach placers. The Indian States holding this kind of minerals are Andhra Pradesh, Odisha and Tamil Nadu along East coast whereas Kerala and Maharashtra on the west coast. Among the onshore resources, nearly 1/3rd of the resources are confined to State of Andhra Pradesh. The controlling factors for the concentration of these minerals are favourable provenance, climate (tropical to sub-topical), pronounced draining patterns followed by coastal process like wave, wind and seal level changes. In this paper; the author discusses about the present resources and Production to Reserve Ratio (PRR) of these minerals with reference to Global status.

Keywords: Blue economy, Critical minerals, Beach placer deposits, sea level changes, overview

[ABS-0058]

CRITICAL AND STRATEGIC MINERALS IN INDIAN COASTAL PLACER DEPOSITS AND MARINE CRUSTS & NODULES

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The growing demand for critical and strategic minerals (CSMs) is due to their requirements in high-tech electronics, telecommunications, transport, defense, food security, green energy and

advanced technology fields. In this regard, CSMs resources hosted in beach sand deposits along the eastern, southern and southwestern coastal stretches of India and those hosted in marine crusts and nodules assume significance. Work carried out by various institutes (GSI, AMD, IREL, NIO, NCPOR, IMMT, Universities, etc.) over the years revealed significant results. Various CSMs which have significant concentrations along the coastal deposits include REE (monazite), Ti (ilmenite: 50-60% TiO2, up to 0.50% V2O5; leucoxene: up to 70% TiO2; rutile) and Zr (zircon). Apart from La and Ce, monazite from beach placers deposits of Odisha, Andhra Pradesh, Tamil Nadu and Kerala coasts contain (average) 10% Nd2O3, which is in great demand for permanent magnets for renewable energy. Focused work mainly on polymetallic Fe-Mn crusts and nodules in the Central Indian Ocean below the ocean surface also yielded encouraging concentrations of CSMs like REE, Co, Cu and Ni. Interestingly, besides Mn (18-36 Wt.%) and Fe (5-15 Wt.%), the nodules contain very high amount of Cu (up to 1.86 Wt.%), Ni (up to 1.54 Wt.%) and Co (up to 0.40 Wt.%). The REE concentrations in Fe-Mn crusts from Afanasy Nikitin Seamount revealed 1209 ppm Ce (average), which is higher compared to Ce content (718 ppm) in mid-Pacific seamount nodules. Besides Fe-Mn crusts and nodules from Indian Ocean (REE upto 2511 ppm), crusts and nodules from Andaman Sea also contain attractive amounts of REE (up to 1900 ppm), with high Ni (upto 7860 ppm) and Co upto 2213 ppm) contents, besides Ru, Rh, Pd, Os, Ir and Pt. In view of the economic CSMs concentrations, recently India signed an agreement with International Seaboard Authority for deep-sea mining exploration.

Keywords: Critical and strategic minerals, Coastal placer deposits, Marine crusts and nodules, India

[ABS-0203]

EPISODIC EXPLOSIVE MAGMATIC DEGASSING OF HELIUM-3 AT 67.67°E, EASTERN SOUTHWEST INDIAN RIDGE

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Crustal accretion at the eastern Southwest Indian Ridge (eSWIR) is governed by highly magmato-tectonic regime, where mantle detachment faulting dominates, resulting in peridotite-rich crust interspersed with localized gabbroic intrusions. Volcanic centres are spatially restricted (10 20 km wide) and characterized by anomalously thick crust (~13 km), attributed to episodic magma injection. Recent investigations into dissolvedethane concentrations in deep waters along the eastern SWIR have identified a hydrothermal field at 67.67°E, associated with three distinct hydrothermal plumes at varying depths: Plume 1 (2300 3150 m), Plume 2 (3600 4100 m), and Plume 3 (4200 4500 m). Plume 1 is particularly notable for its unusual vertical extent (~700 m), elevated turbidity (up to 0.09 NTU), and a significant decrease in oxidation-reduction potential (up to 20 mV), all indicative of an event-type hydrothermal plume. Exceptionally high helium-3 values (112% above a 13% background) further support recent magmatic degassing in this region. Despite these strong hydrothermal signals, methane

(6.64 nmol/kg) and manganese (19.53 nmol/L) concentrations in Plume 1 are relatively low. However, the helium-3 to heat (0.014 mol/J) and manganese to heat (0.04 nmol/J) ratios are consistent with values observed in other event plumes, reinforcing the interpretation of recent and possibly transient magmatic activity beneath the ridge.

Keywords: Hydrothermal plumes, Southwest Indian Ridge, Mantle degassing

[ABS-0207]

DEEP CRUSTAL STUDY IN THE INDIAN SHIELD: A REVIEW

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Controlled Source Seismology (CSS), employing artificially generated seismic energy to record near-vertical reflections, refractions, and wide-angle signals, has emerged as a key approach for imaging both shallow and deep crustal structures of the Indian Shield. Analyses of historical and recent CSS datasets have greatly enhanced our understanding of the geodynamic framework and tectonic evolution of major geological provinces, including the Southern Granulite Terrain (SGT), Dharwar Craton, Aravalliï ½Delhi Fold Belt, Central Indian Tectonic Zone (CITZ), Kutch Basin, and the northwestern Himalaya. In the SGT, a four-layered crustal model reveals a 5ï ½7 km thick low-velocity zone and an overall crustal thickness of about 45 km with a 3ï ½4 km Moho uplift, indicating Proterozoic compression and subsequent Phanerozoic reactivation. The Dharwar Craton exhibits Moho depths increasing from ~35 km to ~42 km and a high-velocity lower crust (7.0ï ½7.1 km/s) up to 10 km thick. Across the CITZ, an ~8 km Moho offset beneath the Central Indian Suture and opposing dipping reflections signify block heterogeneity and suture reactivation. The Bastar Craton shows a Moho depth of ~48 km, while the Aravalliï ½Delhi Fold Belt demonstrates a five-layered crustal configuration with listric faulting and lower crustal velocities up to 7.3 km/s. The Kutch Basin presents Mesozoic rift-related structures, including sub-horizontal reflectors down to ~15 km and domal features within a 33ï ½35 km thick crust. In contrast, the northwestern Himalaya exhibits significant crustal thickening, with the Moho deepening from ~45 km to ~76 km near Nanga Parbat, reflecting intense shortening and uplift. Collectively, CSS investigations highlight that the Indian Shieldï ½s crustal evolution is shaped by cyclic processes of compression, rifting, and crustï ½mantle interactions from the Precambrian to the Cenozoic, offering crucial insights into regional geodynamics and resource potential for minerals.

Keywords: SGT, Dharwar Craton, Aravalli-Delhi Fold Belt, CITZ, Kutch Basin, Northwestern Himalaya, Moho offset, crust-mantle interactions

[ABS-0184]

MAGNETIC MINERAL INVENTORY OF INDIAN OCEAN SEDIMENTS

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Magnetic minerals are ubiquitous in deep-sea sediments originating from large number of potential sources including terrigenous, biogenic, diagenetic, authigenic, volcanic, cosmogenic, and hydrothermal mineralization. This study focusses on developing a magnetic mineral inventory of the deep-sea sediments from the Indian Ocean region using rockmagnetism, granulometry, and electron microscopy to classify all magnetic mineral phases and investigate their regional distribution, origin, transport and depositional conditions.We conducted suites of room-and high temperature rockmagnetic measurements on sediment cores retrieved from different Indian Ocean regions including Arabian Sea, Bay of Bengal, Ninety East Ridge, Southeast Indian Ridge, Southwest Indian Ridge, Chagos-Laccadive Ridge, and Central Indian Ocean Basin to characterize the different magnetic mineral assemblages. Our results indicate that ferrimagnetic- and antiferromagnetic minerals are the dominant magnetic minerals in the studied sediment cores and exhibit broad grain size and coercivity distributions. Magnetic mineral distribution maps were developed based on the spatial variability of magnetic particles interms of their content, mineralogy, and grain size. Specialized magnetic data coupled with electron microscopy data helped to identify different magnetic mineral phases at each studied site and evaluate the relative contribution of each magnetic mineral phase to the bulk magnetic properties. Magnetic mineral inventory of the Indian Ocean sediments established in this study provided important insights on the distribution of magnetic minerals, characteristics of magnetic carriers, their mineralogy, granulometry, and potential sources.

Keywords: Indian Ocean, Magnetic Minerals, Inventory, Source-to-Sink Processes

[ABS-0176]

HEAT MAP-BASED INTERPRETATION OF GRAVITY AND MAGNETIC DATA FOR SUBSURFACE MINERAL EXPLORATION

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Gravity and Magnetic methods are fundamental tools in mineral exploration, owing to their efficiency in detecting subsurface density and magnetic susceptibility variations commonly associated with mineralized bodies. In recent years, the integration of advanced data visualization techniques, particularly the use of heat maps, has significantly improved the interpretation of gravity and magnetic anomaly data. Heat maps provide a powerful means of visualizing spatial variations in geophysical parameters, enabling the clear identification of anomalous zones that may correspond to subsurface mineral deposits. These high-intensity

zones often coincide with geological features such as fault lines and shear zones, which are known pathways for hydrothermal fluid migration and mineralization. Importantly, areas exhibiting steep geophysical gradients on heat maps frequently align with such structural controls, offering valuable insights into the tectonic setting and mineralization processes. This integrated geophysical approach not only enhances the targeting of mineral-rich zones but also reduces exploration risk, especially in geologically complex and poorly understood regions. The present study highlights three case studies from the part of South Rewa Basin, the Bastar Craton, and the Cuddapah Basin in India, where mineralized zones show a strong correlation with high-intensity regions on gravity and magnetic heat maps, affirming the effectiveness of this method in delineating prospective mineral targets.

Keywords: Heat-Map, South Rewa Basin, Bastar Craton, Cuddapah Basin, Mineral exploration

[ABS-0206]

EVIDENCE FOR MULTI-SOURCE HYDROTHERMAL VENTING AT 67.67°E, EASTERN SWIR

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Water column studies conducted along the eastern Southwest Indian Ridge (eSWIR) during scientific cruises MGS26 and MGS36 have identified several hydrothermal plumes. Anomalies in turbidity and temperature across various depths (three) confirm the presence of a hydrothermal field near 67.67°E, 26.61°S. Chemical tracer analyses of these three plumes revealed dissolved methane (CH_4: 1.0 37.8 nmol/kg) and dissolved manganese (DMn: 1.0 68.6 nmol/kg) concentrations. Detailed physico- chemical characterization indicates that Plume Layer 1 represents a transient (event-type) plume, while Layers 2 and 3 are chronic in nature. Plume Layer 2, spanning depths of 3400 to 4100 m, comprises two distinct fields two located south of the axial high and one independent field to the north. Plume Layer 3 originates at depth around 4200m is from a separate hydrothermal source. Despite the differing origins, the geochemical CH_4/DMn ratios predominantly fall below 0.5, with a few approaching 1. These values suggest seawater interaction with mafic rocks and are consistent with hydrothermal systems typical of mid-ocean ridges.

Keywords: Hydrothermal plumes, methane, manganese

[ABS-0083]

HEMATITE MONAZITE RICH BEACH PLACERS ALONG THE LAKE NORSJØ: A SURFACE INDICATOR OF REE MINERALIZATION FROM THE FEN CARBONATITE COMPLEX, NORWAY

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The Fen Carbonatite Complex, located approximately 110 km southwest of Oslo, Norway, is the largest Rare Earth Element (REE) deposit in the Europe. However, limited research exists on the soil and accumulated sediments derived from this complex. We conducted a study of beach placers found along the Lake Norsjø, near Fen using various analytical techniques such as mineral identification under a binocular microscope, SEM, EPMA, XRD to understand its REE potential. Minerals observed under a binocular microscope are calcite, hematite, quartz, pyroxene, apatite, monazite, and strontianite, with several confirmed through XRD and EPMA analyses. The SEM based textural study reveals several features, such as etching and dissolution along the cleavage and reprecipitation of calcite, overgrowth of magnetite on hematite. Based upon the number count on mineral mounts; calcite is the most abundant mineral (35%) followed by hematite-calcite (25%), garnet (12%), hematite (8%), and quartz (7%). Apart from that, monazite which is a REE bearing mineral is found in significant amount (7%). Minerals such as barite, rutile, and apatite are also present in considerable amounts. The preponderance of calcite and hematite suggests its derivation from sövite and rødbergite, respectively. Garnets are of almandine variety (Al63-70Py22-32Sp1-2.3Gr2.4-5.9) indicating its origin from the country rock (Telemark gneiss). Monazite and apatite are linked with the carbonatites. Textural studies and EPMA analyses indicate their simultaneous crystallization. Apatite, monazite, siderite shows high concentration of fluorine indicating the role of hydrothermal fluids in the enrichment of REE. These beach placers are interpreted to have formed through weathering and erosion of carbonatite and associated rocks, followed by transport via ephemeral streams resulting in localized concentrations of REE-rich minerals. This study indicates that the soil and sediments derived from carbonatites contain a significant amount of REE minerals and may represents a potentially important REE deposit.

Keywords: beach placer, hematite, apatite, monazite, rødbergites, sövites,REE bearing minerals, Lake Norsjø, Fen Carbonatite Complex, Norway

BIORESOURCES – FISHERIES, DRUGS FROM THE OCEAN AND MANGROVES

[ABS-0175]

INDIAN SEAWEEDS: EXPLORATION FOR MARINE PHARMACEUTICALS

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Seaweeds are increasingly recognized as valuable sources of nutrients and bioactive compounds with significant pharmaceutical potential. With the rising global incidence of diabetes mellitus and the limitations of current synthetic drugs, particularly their adverse side effects, there is an urgent need to explore safer and more natural therapeutic alternatives. In the present study, Indian seaweed species were examined for their phytochemical composition and antidiabetic potential. Extracts of these seaweeds were assessed for inhibitory activity against the key carbohydrate-hydrolyzing enzymes α-amylase and α-glucosidase. Seaweed extracts demonstrated promising antidiabetic effects. To identify the bioactive metabolites responsible for this activity, LC-MS and LC-MS/MS analyses were conducted, leading to the detection of diverse compounds. Novel metabolites with no prior reports of antidiabetic activity were subsequently selected for in silico molecular docking studies against four critical targets relevant to diabetes management: α-amylase, α-glucosidase, protein tyrosine phosphatase 1B (PTP-1B), and dipeptidyl peptidase-4 (DPP-4). Docking results revealed strong binding affinities, suggesting potential multitarget mechanisms of action. This was followed by formulation development using the seaweed extract exhibiting most promising profile. The prepared formulation was characterized for its physicochemical properties, providing a basis for further in vivo validation. This comprehensive investigation highlights the potential of Indian seaweeds as natural reservoirs of novel antidiabetic agents and supports the development of seaweed-based formulations for safer diabetes management.

Keywords: Seaweed; Antidiabetic potential; Metabolomics; in silico analysis; Formulation

[ABS-0232]

BIO-RESOURCES OF THE INDIAN OCEAN: FISHERIES, DRUGS FROM THE OCEAN, AND MANGROVES AS PILLARS OF A SUSTAINABLE BLUE ECONOMY

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The Indian Ocean sustains millions of livelihoods and represents a reservoir of bio-resources critical to India s Blue Economy vision. This task will focus on three key pillars: sustainable fisheries, marine biotechnology, and mangroves; and outline pathways for their responsible utilization within a science-led framework. The presentation will highlight the role of sustainable fisheries in ensuring food and nutritional security, while also addressing the economic importance of healthy stocks. Advanced stock assessment techniques, digital traceability, cold-chain infrastructure, and diversification into mariculture and seaweed farming

will be explored as innovative approaches to strengthen value chains and integrate small-scale fishers into modern markets, covering the importance of healthy fisheries for global food security and economic stability. In addition to nearshore resources, the untapped potential of deep ocean marine fisheries will be examined, with an emphasis on sustainable harvesting practices and the scientific exploration needed to expand India s fisheries frontier responsibly.

Keywords: Fisheries, drugs from the ocean, Mangroves, Sustainable Blue Economy

[ABS-0032]

INTEGRATED FISHING PRACTICES OF UTTARA KANNADA FOR SUSTAINABLE FISHERIES

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Karnataka has three coastal districts Dakshina Kannada, Udupi and Uttara Kannada. The coastal stretch of Uttara Kannada is around 160 kms which contributes significantly to the marine fisheries. The proliferation of mechanized vessels, such as trawlers and purse seiners, has resulted in intensified fishing pressure, evidenced by a noticeable decline in fish stocks and escalating conflicts between mechanised and traditional fishing communities. In a state where total marine fish production has shown recent declines. The present study outlines a multi-faceted research approach to address these challenges and establish a robust framework for sustainable fishing practices in the region. The proposed strategy integrates technological, governance, and socio-economic solutions. Firstly, it emphasizes the critical role of selective, eco-friendly fishing methods. Research will focus on the adoption and efficacy of Bycatch Reduction Devices(BRDs), including square-mesh nets and Turtle Excluder Devices(TEDs), to minimize the unintentional capture of non-target species. The study will also explore the potential of low-impact fishing gear and the incentives required for their widespread adoption by both small-scale and commercial fishers. Secondly, the research will investigate the strengthening of fisheries governance through enhanced monitoring, control, and surveillance(MCS). Finally, the work highlights the crucial importance of a collaborative and community-based management approach. This research will analyse the socio-economic disparities within the fishing community, particularly focusing on the marginalization of traditional fishers and women in post-harvest activities. The goal is to develop a framework that not only conserves marine resources but also ensures equitable access and improves the livelihoods of all stakeholders. Ultimately, by addressing these ecological, governance, and social challenges in an integrated manner, this research seeks to forge a sustainable pathway for Uttara Kannada's fisheries, ensuring both the long-term health of its marine ecosystems and the socio-economic security of fishing communities of this region.

Keywords: Sustainable fishing practices, Marine fisheries Marine Biology, Uttara Kannada.

[ABS-0004]

SAFEGUARDING MARINE RESOURCES: PROMOTING SUSTAINABLE SHORE SEINE FISHING AT AMANATTANTHERI SHORE, KANNIYAKUMARI, TAMIL NADU

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Shore seine fishing, locally known as karai madi, is a traditional and community-driven fishing practice prevalent at Amanattantheri, Kanniyakumari, Tamil Nadu. This study explores the ecological, economic, and social dimensions of shore seine operations, emphasizing their seasonal variability, targeted species, post-harvest roles of fisherwomen, and evolving market trends. The primary fishing season spans from October to April, with peak catches recorded between December and February. Fish species such as sardines, anchovies, mackerel, and carangids are captured using nets deployed by country boats and manually hauled ashore by coordinated teams. An analysis of catches from December 2024 to March 2025 highlights species diversity and pricing trends, with large carangids fetching higher market values. Transportation modes have shifted from truck-based bulk hauling to flexible auto-rickshaw use, indicating changes in catch composition and market demands. Despite its cultural and economic importance, shore seine fishing faces challenges due to unregulated practices, mechanized fishing pressures, and inconsistent state regulations between Tamil Nadu and Kerala. The study underscores the importance of harmonized policies, particularly enforcing Minimum Legal Size (MLS) norms for pelagic fish. It advocates for sustainable management measures such as mesh size regulation, seasonal fishing bans, bycatch reduction, and community awareness programs. Promoting eco-friendly practices and government-supported co-management can ensure the continuity of this heritage fishery. By integrating traditional knowledge with modern conservation approaches, shore seine fishing can continue to sustain coastal livelihoods while safeguarding marine biodiversity.

Keywords: Shore Seine, Sustainable Fisheries, Coastal Livelihoods, Pelagic Fish, Kanniyakumari.

[ABS-0033]

PRESENT STATUS OF MANGROVE DISTRIBUTION IN KALI AND AGHANASHINI ESTUARIES OF KARNATAKA

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The Uttara Kannada District, divided into five coastal talukas, each contributing to a rich estuarine landscape. Karwar Taluka, the largest of these, spans an impressive 677.72h, followed by Kumta at 207.19h, Honnavar at 129.57h, Ankola at 79.26h, and the smaller Bhatkal Taluka at 25.91h. This unique geographical composition sets the stage for a critical comparative

analysis of its two most prominent mangrove ecosystems, found within the Kali and Aghanashini estuaries. The study reveals a striking contrast in their current status and ecological health. The Kali estuary, for instance, hosts a notable diversity of 14 true mangrove species, including resilient examples such as Avicennia officinalis and Sonneratia caseolaris. However, its mangrove distribution is markedly fragmented, a condition that leaves it vulnerable to natural and anthropogenic pressures. Despite these significant challenges, recent conservation efforts have begun to show promising results, suggesting a potential path to recovery. In contrast, the Aghanashini estuary presents a more pristine and ecologically robust environment. Its status as a free-flowing river has been a key factor in its preservation, leading to its recent and well-deserved designation as a Ramsar Wetland of International Significance. This recognition highlights its unparalleled biodiversity, which includes 12 true mangrove species and an additional 33 mangrove-associated species. The estuary's ecological value extends far beyond its flora; it serves as a critical habitat for a wide array of marine life and supports the livelihoods of over 6,000 local households. Despite its current health and recent international recognition, the Aghanashini is also under threats, particularly from proposed developmental projects and the expansion of commercial aquaculture, which could jeopardize its delicate balance. Ultimately, while both estuaries are crucial to the region's overall ecological integrity, the Aghanashini stands out as a well-preserved wetland in sharp contrast to the fragmented patches of the Kali estuary.

Keywords: Mangrove, Kali, Aghanashini flora, Marine Biology, Karnataka

[ABS-0005]

INTEGRATING SATELLITE DERIVED OCEANOGRAPHIC PARAMETERS WITH SPECIES SPECIFIC CATCH AND FISHING EFFORT (2018- 2023) FOR THE WEST COAST OF INDIA

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The interaction between fish distribution and oceanographic conditions has consistently influenced the fish species present in the waters off the west coast of India, especially during the biologically abundant post-monsoon season. In this study, important pelagic fish (Oil Sardine, Lesser Sardine, Anchovies, Indian Mackerel and Horse Mackerel) and environmental variables from 2018 to 2023 were examined, including upwelling indices, sea surface temperatures (SST), sea surface salinity (SSS), surface currents, and Chlorophyll-a concentrations. Focus was paid to the role of the West India Coastal Current (WICC), which has seasonal reversals and influences nutrient transport, salinity gradients and dispersal of larvae along the coast. To understand the seasonal and inter-annual variations in fish landings for the west coast of Indian states from Gujarat to Kerala, we devised a multi-source dataset framework which included Global Fishing Watch effort maps, fish landing data from CMFRI reports, satellite-derived Chlorophyll from ocean colour datasets, Copernicus ocean reanalysis

for currents magnitude (vectors) and Optimum Interpolation Sea Surface Temperature (OISST) for temperature. This study improves prior knowledge of the distinct and predictable habitat preferences of the species on the fishing ground and the climate impacts on the ecosystem, which in turn facilitates planning for sustainable fisheries. Such results, in turn, augment planning for regional economic development, potential fishing zone (PFZ) optimisation, and sustainable fisheries management.

Keywords: Oil Sardines, Indian Mackerel, sea surface temperature, Potential fishing Zone, West Indian Coastal Current, Optimum Interpolation Sea Surface Temperature, west coast of India.

[ABS-0167]

SUSTAINABLE BLUE ECONOMY STRATEGIES: COMPARATIVE INSIGHTS FROM TROPICAL AND POLAR MARINE SYSTEMS

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The Blue Economy emphasizes the sustainable use of ocean resources to support economic growth, livelihoods, and ecological balance. Within this framework, marine algae, marine-derived drugs, and fisheries are key sectors, yet opportunities differ markedly between tropical and polar regions.In tropical Asia, including India, favourable year-round conditions enable large-scale seaweed farming, mariculture, and aquaculture, supporting food security, exports, and the nutraceutical industry. Marine algae serve as feed, biofuels, and fertilizers, while rich biodiversity fosters bioprospecting for marine-derived drugs. Fisheries in India contribute over 1% of GDP, with the broader Blue Economy accounting for ~4% of GDP, sustaining millions of livelihoods. Expansion prospects exist via integrated multi-trophic aquaculture (IMTA) and mariculture, following successful Asian models such as China and Japan. In contrast, the Polar Regions (Arctic and Antarctic) present unique dynamics. Algae are mainly ice-associated, with highly seasonal productivity, producing novel bioactive compounds like antifreeze proteins and cold-adapted enzymes with pharmaceutical potential. Fisheries are limited to a few regulated species (e.g., Antarctic krill, Arctic cod), and aquaculture is nearly absent. This comparative perspective highlights the need for region-specific strategies that balance economic potential, environmental sustainability, and global collaboration to advance the Blue Economy across diverse ecosystems.

Keywords: Marine Algae, Blue economy, Drugs, Fisheries, Ocean

[ABS-0107]

ASSESSING MANGROVE RESILIENCE AND COASTAL INSTABILITY IN BHITARKANIKA, INDIA: INSIGHTS FROM 20 YEARS OF SATELLITE MONITORING

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Mangroves deliver vital ecosystem services by sustaining coastal biodiversity, sequestering carbon, shielding shorelines from natural hazards, and filtering land-based pollutants. Bhitarkanika, India s second-largest mangrove ecosystem, is increasingly threatened by both natural and anthropogenic pressures. This study evaluates long-term mangrove health and shoreline dynamics using multi-temporal satellite data from 2005-2025. Landsat imagery was atmospherically corrected using Atmospheric Correction for OLI and TIRS (ACCOLITE), and Normalised Difference Vegetation Index (NDVI) values were classified into degraded, stable, and healthy categories. Shoreline change was assessed using the End Point Rate (EPR) method in DSAS. Results indicate stress phases in 2009, 2010, 2011, and 2016, while 2015, 2017, 2019, and 2020 showed relative stability. Peak healthy conditions occurred in 2006, 2007, 2020, and 2022. Mangrove expansion was observed along the outer Mahanandi estuaries and inner Kanikal Island, likely due to regeneration or localized restoration. Degradation was concentrated along the northeastern coast, seaward Kanikal Island, and eastern Mahanandi estuaries. Shoreline erosion strongly correlated with mangrove loss, whereas accretion supported new growth. By integrating NDVI and EPR metrics, this study highlights the link between ecological health and geomorphic change, offering a practical framework for long-term monitoring and evidence-based mangrove management.

Keywords: Mangrove Health, NDVI, ACOLITE, Landsat, Shoreline Change, Landsat

COASTAL AQUIFERS AND SUBMARINE DISCHARGES - COASTAL AQUIFERS, SEAWATER INTRUSION, SUBMARINE GROUNDWATER DISCHARGES

[ABS-0022]

SUBMARINE GROUND WATER DISCHARGE - A REVIEW

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Submarine ground water discharge (SGD) refers to the discharge of fresh ground water from the aquifer to the ocean near the coast and continental shelf, including recirculated seawater through the aquifer. It is lately recognised as an important component of the hydrologic cycle. However, its recognition and usage are as late as the first century A.D., but in the 1990s onwards, only scientific publications surged ahead. SGD mostly occurs in estuarine

environments and high rainfall zones along the coast. Modern investigations reveal that though SGD forms less than annual river discharge to the sea, it transports nutrients several times greater than river transport. Therefore, the coastal ecosystem's environment is substantially affected by the SGD by stimulating algal growth, contributing to eutrophication, and potentially threatening coral reefs, even in thermally tolerant species. It has been found that SGD has become a pathway for microplastics and other pollutants to the sea. Sometimes, SGD can be detected even by the naked eye in the form of seepage from the coastal sands towards the sea. Its quantitative estimation and detection can only be made indirectly by thermal infrared imaging, geophysical techniques, measurements by seepage meter, modelling techniques, and geochemical tracer techniques. Out of all the methods, isotopes of Radon and Radium tracer techniques are the most popular. From mid-2000 onwards, investigations took a quantum jump both in India and abroad, but there are uncertainties over the time and length scales of the SGD with respect to recharging, residence time, and even the volume. However, in recent years, researchers have been distinguishing between fresh SGD (from aquifers) and recirculated SGD (from seawater that has already flowed through sediments) to better understand their respective impacts. Understanding of SGD circulations in a more precise way led to better hydrological models.

Keywords: Submarine ground Water Discharge, Review

[ABS-0143]

DIFFERENTIATING SALINE AQUIFERS VIA AIRBORNE EM AND HYDROCHEMISTRY: SEAWATER INTRUSION VS. MINING EFFLUENTS

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The coastal regions are increasingly susceptible to seawater intrusion (SWI), principally caused by excessive groundwater abstraction, placing significant stress on freshwater reserves. Surat, a rapidly developing urban centre on the Arabian Sea coast, is experiencing increasing reliance on groundwater and surface water from Tapi River for domestic and industrial requisites. Intensive withdrawals, compounded by the region s semi-arid climate, have resulted in declining water levels and deteriorating water quality, accelerating risk of SWI. A dual moment airborne electromagnetic data provided high-resolution resistivity distribution of the near surface from upper a few meter to more than 300 m depth. The study area being located at the Arabian sea coast, it is prone for SWI especially due to heavy pumping. The industrial effluents coming out of the existing mine in the area also can influence the measured resistivity. This is also well-known fact the formation resistivity is cumulative effect of the physicochemical properties of the formation. However, neither there is clear understanding nor any established methodologies how the lithology, presence of water and water quality influence the formation resistivity, which is crucial for translation of resistivity data into lithological and hydrogeological models. The paper presents details analysis of AEM resistivity distribution and hydrochemical data from borewells measured during pre-monsoon and post monsoon period to differential zones influenced by SWI, industrial effluent and lithology. The study

established that the resistivity falling below 3 Ωm in the western sea coast is dominantly influenced by SWI . However, lowering of resistivity in the eastern part of the study area is caused by clay dominance. A small zone in the north east close to mine industry is caused by waste water coming out of mine where Mg+ is found exceptionally high, even during post monsoon season.

Keywords: Sea water intrusion, Dual moment, Resistivity, Seawater intrusion, Groundwater

[ABS-0204]

DELINEATION OF SEAWATER INTRUSION IN THE COASTAL AQUIFER USING 3-DIMENSIONAL GROUNDWATER MODELLING IN THE HARBOUR CITY OF THOOTHUKUDI, TAMIL NADU, INDIA

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Coastal aquifers around the world are under threat by witnessing the wide range of environmental issues especially due to Sea water intrusion. Seawater intrusion affects the quality and sustainability of the groundwater resources in the coastal aquifers. In India, most of the coastal aquifers are affected by seawater intrusion up to 2 km, whereas it has intruded up to 15 km towards inland in the coastal aquifers of Chennai. Recently groundwater salinization has become a major threat in the Thoothukudi regions of Tamil Nadu, due to excessive pumping of groundwater, lack of groundwater recharge and reduced rainfall. The present study was carried out to evaluate the groundwater chemistry of the region and delineate the extent of seawater intrusion. Groundwater samples were collected during October 2023 and January 2024 in 18 locations around the Thoothukudi region. The collected samples were analyzed for Physio Chemical parameters, concentration of major and minor ions. It was found that most part of the coastal regions were highly salinized and high concentration of Na-Cl were observed. The extent of seawater intrusion was demarcated with 3-Dimensional Numerical groundwater modelling using the FEFLOW computer code. Initially, Groundwater model was developed under steady and transient condition. After successful comparison between the Observed and Simulated head, the model was further allowed to carry out density dependent groundwater model to study the extent of seawater intrusion. It was found that the seawater were intruded in the coastal aquifer up to the distance of 3km inland. Thus these seawater intrusion is an evidence of deterioration of groundwater quality in the Thoothukudi region. The study highlighted the threat's to the aquifer of this region. The present study is helpful to formulate the mitigation and remediation measures for sustainable management of groundwater system.

Keywords: Seawater Intrusion, Groundwater modelling, Density dependent model, Thoothukudi

[ABS-0234]

COASTAL GROUNDWATER SALINITY AND SUBMARINE GROUNDWATER DISCHARGE DYNAMICS UNDER THE LAND USE CHANGE AND SEA LEVEL RISE IN THE CASE OF CENTRAL GODAVARI DELTA

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Central Godavari Delta in East Godavari District, Andhra Pradesh, a fertile region with intensive irrigated agriculture and expanding aquaculture. Utilizing an integrated approach combining geophysical surveys, hydrogeochemical analysis, multivariate statistics, and density-driven SEAWAT modeling the study investigates the origin, transport of salinity and submarine groundwater discharge in the alluvial aquifer system. The region supports three annual cropping cycles, predominantly paddy and aquaculture, with consistent canal irrigation. Although surface water is abundant, limited groundwater use has intensified near the Ravva onshore terminal, where continuous pumping since 1991 (600 m^3/hr per well) has led to saline upconing. Groundwater levels are generally shallow (1 12 m bgl), with minimal seasonal fluctuation. ERT surveys delineate thick marine clays (0.5 1.0 ohm-m) underlying sandy clays, indicating in situ salinity, especially around Ravva. Water quality data (2006 2016) reveals increasing Na-Cl and Na-Mg-Cl water types, indicating seawater mixing and evaporite dissolution. Stable isotopes ($\delta^{18}O$) and bromide tracers support mixing processes. Multivariate analysis shows that geology more than agriculture is a key driver of groundwater chemistry. However, expanding aquaculture (noted from 2006 2024 land use data) contributes significantly to surface infiltration of saline water, intensifying shallow groundwater salinity. The SEAWAT model simulates regional groundwater flow and salinity transport, showing flow toward the Bay of Bengal without seawater intrusion but with local upconing at Ravva. Estimated groundwater inputs include 13.4 MCM/yr of recharge and 1.9 MCM/yr lateral inflow, with 5.1 MCM/yr extraction and 5.0 MCM/yr submarine discharge. Overall, this study provides critical insights into recharge mechanisms, aquifer salinization due to both natural and anthropogenic factors, submarine groundwater discharge and the need for sustainable groundwater management. The integrated methodology offers a robust framework for assessing coastal aquifer vulnerability to salinity and guiding future land and water use planning.

Keywords: Godavari Delta, groundwater flow, salinity transport

[ABS-0236]

UNVEILING THE HIDDEN WATER FLOWS: EXPLORING SUBMARINE GROUNDWATER DISCHARGE IN SE COAST OF TAMILNADU

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Submarine Groundwater Discharge (SGD) has gained much attention in recent years, as it plays a crucial role in maintaining the water quality and ecological balance of coastal regions. This

study aims to investigate the SGD in the SE region of Tamilnadu, which is located in the southern part of India. The study aims to understand the quantity and quality of SGD in the region, as well as its potential impact on the surrounding marine ecosystem. The study was conducted using a geochemical tracing techniques, including Radium, Radon and salinity measurements. The region is located in southern India and is a major hub of agriculture and fisheries. The study found that the groundwater discharge into the sea in the region is substantial and significantly affects the water quality of the coastal ecosystem. The results of the study reveal that the SE region of Tamilnadu has a significant SGD that contributes to the freshwater budget of the coastal region. The total SGD flux is estimated to be around 0.04 to 0.12 m3/day in the Punnakyal region. The new method employed in this study, which involves measuring the water flow rate near the shore, proved to be a reliable and efficient technique for estimating submarine groundwater discharge. The study also found that the SGD is influenced by several factors, including tidal fluctuations, rainfall, and groundwater recharge. Overall, this study provides important insights into the SGD in the SE region of Tamilnadu, which can help in better management and conservation of the coastal water resources. The study also identifies potential anthropogenic impacts on SGD, such as land-use changes and groundwater pumping, which may have negative consequences for the region's coastal ecosystem.

Keywords: Submarine Groundwater Discharge, Radon, Radium, Ecosystem, SE of Tamilnadu

[ABS-0053]

APPLICATION OF FUZZY LOGIC TO INTEGRATE HYDROGEOCHEMICAL INDICATORS FOR ASSESSING SEAWATER INTRUSION IN THE COASTAL REGION OF MANGALURU, KARNATAKA, INDIA

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Seawater intrusion is a global issue affecting groundwater quality in coastal aquifers, primarily due to over-extraction of groundwater associated with rapid urban development. This study investigates the potential for seawater intrusion in the coastal region of Mangaluru city, Karnataka, located along India s western coastline. The study area was divided into six zones, extending from the coast inland, and 70 groundwater samples were collected during both pre-monsoon and post-monsoon periods. Seawater intrusion was evaluated using hydrochemical approaches, including ionic ratios, index methods, and graphical analyses. Modified Piper diagrams indicated a dominance of freshwater (Ca-HCO3 type) in inland zones and slight intrusion (Na-Cl type) in areas near the coast. Ionic ratio analyses (Na/Cl, Ca/Mg, Ca/(HCO3 + SO3), and Cl/(HCO3+ CO3)), BEX index results, and graphical methods such as EC v/s Cl plots, hydrochemical facies evaluation diagrams, suggest that salinization from seawater intrusion extends up to 2 km inland. To integrate findings from all methods, a fuzzy logic approach was applied, providing a comprehensive assessment of intrusion patterns. The results offer valuable insights to support decision-making for sustainable coastal groundwater management.

Keywords: seawater intrusion, mangaluru, hydrogeochemical signatures, fuzzy logic, hydrochemical facies evaluation

[ABS-0029]

ASSESSING SEAWATER INTRUSION IN MULTI-LAYERED COASTAL AQUIFER OF THE PENNAR DELTA THROUGH GEOPHYSICAL AND HYDROCHEMICAL INVESTIGATIONS

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Seawater intrusion is a major concern in coastal aquifers, primarily caused by excessive groundwater extraction near the coast. To assess this issue, Vertical Electrical Soundings (VES) were carried out from the coastline to the inland areas of the Pennar delta during June 2025. Groundwater samples from shallow and deep wells were also collected near the VES sites, and hydrochemical data were correlated with resistivity data. The VES results indicate that the Pennar delta hosts a multi-layered aquifer system with three to five geoelectric layers, comprising shallow alluvial aquifers and deeper confined sand/gravel aquifers separated by clay aquitards. In the upper Pennar delta, shallow aquifers show lower resistivity (4.5 9.5 Ωm) extending to depths of nearly 30 m, whereas in the lower delta, high resistivity (8.5 42 Ωm) is restricted to about 10 m, reflecting distinct hydrogeological settings between the southern and northern regions. Very low resistivity (<1 Ωm) observed at some coastal sites corresponds to extremely high TDS (16,000 33,000 mg/L), confirming severe seawater intrusion. Interpolation of 1D resistivity models into 2D cross-sections delineates freshwater saline water boundaries and maps the extent of intrusion. Two major intrusion zones are identified: a southern pocket at Krishnapatnam, and a northern pocket spanning around Pedapalli, Ramathirtham, Varini, Alaganipadu, and Isakapalli. Seawater intrusion is shallow (15 m) at Krishnapatnam and Isakapalli, while in the northern sites it appears at deeper levels (40 m). Seawater intrusion in the region is largely driven by excessive and unregulated groundwater withdrawal for aquaculture near the shoreline, which has severely impacted the aquifer system and facilitated the inland advancement of saline water. Mitigation requires strict regulation of deep groundwater pumping in vulnerable coastal zones. The study demonstrates that VES is an effective tool for accurately mapping the depth and extent of saline intrusion and distinguishing freshwater from saline aquifers.

Keywords: VES, Hydrochemistry, Pennar Delta, Seawater Intrusion

[ABS-0130]

EVALUATION OF REPLENISHABLE AQUIFERS IN CRYSTALLINE HARD ROCKS USING MULTI-DISCIPLINARY APPROACH

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Groundwater availability in crystalline hard rock terrains is highly variable due to heterogeneous nature of fractured and weathered zones and over exploitation has caused declining water levels and deteriorating quality in many areas. Therefore, a comprehensive evaluation of aquifer vulnerability is essential to support judicious management, safeguarding their long-term sustainability and resilience to over use and environmental stresses. This study presents a multi-disciplinary assessment of shallow and deep aquifers in a 368 km2 crystalline hard rock watershed by integrating Analytical Hierarchy Process (AHP), Electrical Resistivity Tomography (ERT), hydrograph analysis of 84 wells across two seasons and hydro chemical assessment to evaluate aquifer heterogeneity and vulnerability. The results indicate that AHP-derived groundwater potential zones (GWPZs) and ERT surveys effectively delineated a three-layer litho structure revealing the heterogeneous nature of crystalline hard rocks. Shallow aquifers (<30 m depth) exhibited pronounced water level fluctuations (up to 5.6 m), reflecting their dynamic behaviour influenced by fractured lithology and seasonal recharge-discharge processes. In contrast, deeper wells (>30m depth) showed minimal fluctuations (R2 =0.82), indicating the relatively static nature of confined aquifers. Further hydrochemical analysis revealed that shallow aquifers subject to frequent surface water interaction are dominated by carbonate weathering whereas deeper aquifers show silicate weathering signatures consistent with longer residence times and limited surface influence. This study presents a comprehensive aquifer vulnerability map and recommends measures to mitigate over extraction supporting sustainable groundwater management and ensuring the long-term viability of replenishable aquifers in crystalline hard rock terrains

Keywords: Replenishable aquifers, Hydro dynamics, Geospatial, Hydrogeophysics, Hydrochemical characterization; Southern India

ENERGY RESOURCES

GAS HYDRATES, OIL & GAS, HYDROTHERMAL, WAVE, TIDE AND WIND ENERGIES.

[ABS-0039]

INTEGRATED AUV-BASED MAPPING AND CHARACTERIZATION OF COLD SEEP SYSTEMS IN THE KRISHNA GODAVARI BASIN: LINKING FAULT-CONTROLLED FLUID FLOW, GAS VENTING, AND CHEMOSYNTHETIC COMMUNITIES

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Autonomous Underwater Vehicles (AUVs) are transforming marine geoscience by enabling detailed, high-resolution mapping of active cold seeps, shallow gas hydrates, and gas venting systems. In December 2023, a collaborative expedition by the National Institute of Ocean Technology (NIOT), CSIR National Institute of Oceanography (NIO), and the National Centre for Polar and Ocean Research (NCPOR) surveyed the Krishna Godavari (KG) Basin, building upon CSIR NIO s 2018 discovery of a major cold seep system. The AUV deployed multibeam bathymetry (MB), water column imaging (WCI), sub-bottom profiling (SBP), synthetic aperture sonar (HiSAS), and high-definition cameras, operating at altitudes of 30 m and 5 m to achieve ~1 m bathymetric resolution and ~25 cm photographic resolution. MB revealed detailed seafloor morphology, including over 100 pockmarks, indicating potential fluid escape pathways, while WCI identified ~303 gas flares, confirming active seepage and highlighting regional variations: the southern SW region and northern sector were actively venting, whereas SE regions with extensive authigenic carbonate beds showed minimal venting and sparse chemosynthetic communities, suggesting relict conditions. SBP revealed numerous subsurface faults that spatially correlate with active pockmarks and gas venting, indicating a fault-fed system. HiSAS data showed high backscatter over active venting sites, chemosynthetic communities, and carbonate beds, with gas flares also detectable, providing complementary evidence of seepage and seafloor heterogeneity. High-definition camera imaging identified chemosynthetic fauna, including Bathymodiolus sp., Calyptogena sp., tube worms, and bacterial mats, concentrated around active vents, while regions with dense carbonates but minimal venting were largely relict. The integrated datasets reveal fault-controlled fluid pathways linking active venting with benthic communities: the northern sector hosts fault-aligned pockmarks with dense fauna, the southern SW region shows active flares and surface hydrates, while the SE carbonate-rich sector reflects relict seepage. This multi-sensor approach offers a comprehensive view of the geological, geochemical, and ecological dynamics of KG Basin cold seeps.

Keywords: Krishna Godavari Basin, AUV survey, Active Gas venting, Pockmarks, Chemosynthetic communities

[ABS-0170]

METHANE COLD SEEPS: SMALL SCALE EXPRESSION OF SUSTAINED LARGE SCALE GEOLOGICAL PROCESS

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Methane cold seeps are reported widely from the marine realms. Methane cold seeps are unique benthic ecosystems sustained by the advective flux of methane-rich fluids from subsurface reservoirs into the overlying sediments and water column. At the sediment water interface, anaerobic oxidation of methane (AOM) coupled with sulfate reduction drives the precipitation of authigenic carbonates and the accumulation of sulfide, creating localized geochemical gradients. These conditions support dense communities of chemosynthetic fauna, including bivalves (e.g., Calyptogena), siboglinid tubeworms (e.g., Lamellibrachia), and diverse microbial consortia. Cold seeps thus function as biogeochemical hotspots, mediating carbon and sulfur cycling while serving as long-term archives of methane seepage history. Their occurrence is closely linked to large-scale geological processes such as hydrocarbon migration, faulting, and gas hydrate dynamics, yet their ecological expression is highly localized. Studying methane cold seeps provides critical insights into carbon fluxes at continental margins, the resilience of chemosynthetic ecosystems, and the role of methane in global climate regulation. Here we present geochemistry of molybdenum and authigenic carbonates from cold seep off Krishna Godavari and Mannar basin. K-G and Mannar basins are characterised by active methane seepage site as well as well developed ecosystem. Sediment cores collected from these methane seep sites show significant content of 13C depleted high magnesian and aragonite carbonates as tell-tale indicator of methane flux and sulfate driven methanotrophy. On the other hand, molybdenum enrichment well above average shale suggest hydrogen flux at the sediment water interface indicating shallow sulfate-methane transition zone (SMTZ) fuelled by enhanced methane flux. The most important outcome of these finding is the long term occurrence (>20 ky) of these geochemical features with pulsating manner clearly indicating sustained flux of deep seated methane (biogenic and/or thermogenic).

Keywords: cold seep, methane , AOM, chemosynthetic

[ABS-0021]

OFFSHORE NATURAL HYDROGEN PROSPECTIVITY OF INDIA

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Natural (white) hydrogen forms mainly by (1) serpentinization of ultramafic rocks and (2) radiolysis of water in U Th bearing crystalline rocks, then migrates along fractures into traps. Where degassing coincides with high hydrothermal temperatures, alkaline pH, and negative

redox (ORP) conditions, serpentinization rates can be elevated. Producible accumulations also require effective migration pathways and seals. These conditions are present in the following Indian offshore provinces. Andaman domain: A forearc ophiolite belt with an accretionary prism, mud-volcano fields, and an active back-arc basin offers the strongest potential. Peridotite chromitite assemblages provide olivine-rich substrates; back-arc heat flow and fluid circulation accelerate reactions. Forearc breaks and trench-slope faults focus transport, while the prism supplies vertically repeated conduit seal pairs. Ninetyeast (90°E) Ridge: Fractured basalts and intrusions along ridge highs, flexural margins, and fracture-zone intersections create reservoirs and pathways. Regional drape by the mud-rich Bengal Fan furnishes seals. Though ultramafics are rarer than Andaman, iron-rich basalts can yield limited serpentinization-style H_2 via water rock reaction. Passive-margin basins: Eastern (Krishna Godavari, Mahanadi, Cauvery) and western (Kutch Saurashtra Cambay Mumbai High) sectors combine crystalline-basement highs, segmented margin faults, Deccan-related volcanics, and thick shale evaporite packages creating an architecture conducive to charge, migration, and seal. While Radiolysis in U Th-bearing basement, reactions in mafic dikes/intrusions supply sources and transport, fine-grained covers act as regional caps. Exploration is envisioned in three steps. We start with a regional screen integrating MT and broadband seismic with seabed flux, He H_2 ratios, heat flow, and pore-water chemistry to map active generation and migration corridors. Then we deploy AUV/ROV surveys across spreading centers, ridge-flank faults, and mud-volcano provinces, pairing samples with geomicrobial assays to quantify sinks. Finally, we drill shallow scientific wells to confirm charge, seal, and deliverability.

Keywords: White Hydrogen, Andaman, Passive Margin

[ABS-0040]

THERMAL STRUCTURE OF THE EASTERN CONTINENTAL MARGIN OF INDIA AND BAY OF BENGAL FROM CURIE DEPTH ESTIMATES DERIVED THROUGH BAYESIAN INVERSION OF SHIPBORNE MAGNETIC DATA

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The Eastern Continental Margin of India (ECMI) is a passive continental margin formed during the breakup of Gondwanaland in the Mesozoic. Since rifting, it has experienced thermal subsidence, magmatism, and continued tectonic activity. Although shipborne magnetic surveys provide extensive data coverage, the regional thermal structure of the ECMI and the Bay of Bengal remains poorly constrained. Magnetic methods allow estimation of the Curie depth, which reflects the base of crustal magnetization and serves as a proxy for thermal structure, crustal rheology, and geothermal energy resource potential. In this study, shipborne magnetic data were corrected for cross-over errors and compared with the spectral content of a global magnetic model. Curie depths were estimated using a Bayesian power spectrum inversion that incorporates a fractal source distribution and an a priori sediment thickness constraint for the top of the magnetic layer. Sensitivity tests with varying window sizes and fractal exponents

identified an optimal configuration: a 150 km² window with 85% overlap and fractal exponent of 3. The results indicate Curie depths of 16-28 km, corresponding to surface heat flow values of 48-75 mW/m². Shallower Curie depths and elevated heat flow occur in the Krishna-Godavari (KG) Basin and southern Mahanadi Basin, consistent with rift-related magmatic intrusions and plume activity. In contrast, deeper Curie depths and lower heat flow are found in the Cauvery Basin and central ECMI. The estimated thermal lithosphere thickness ranges from 39 to 74 km, being thinnest beneath the KG and Mahanadi basins and thickest beneath the Cauvery and central sectors. Geotherms indicate temperatures of ~1300 °C at ~39 km depth in the hyperthermal KG and Mahanadi basins. Overall, the ECMI exhibits a north-south gradient in lithospheric thickness, paralleling variations in the Lithosphere Asthenosphere Boundary (LAB), highlighting significant post-rift thermal and tectonic influences.

Keywords: Geothermal energy, Curie depth, Shipborne magnetic data, Fractal, Bayesian inversion, Eastern Continental Margin of India

[ABS-0075]

SEISMIC FACIES IDENTIFICATION USING MACHINE LEARNING IN MAHANADI OFFSHORE BASIN.

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The Mahanadi Offshore Basin, located along the eastern continental margin of India, represents a geologically complex environment where seismic facies interpretation is particularly challenging. Conventional manual approaches often struggle to delineate subtle stratigraphic features, leading to subjective and inconsistent outcomes. This study introduces a novel machine learning (ML) framework aimed at automating seismic facies classification to improve objectivity, reproducibility, and precision in subsurface interpretation. The methodology integrates multi-attribute seismic data including amplitude, frequency, phase, and coherence with well log information to train supervised classifiers such as Support Vector Machines (SVM) and Random Forests. High-quality 2D/3D seismic datasets from the basin are first enhanced through advanced pre-processing techniques, including band-pass filtering, FX deconvolution, and normalization. Seismic attributes are then extracted and optimized using Principal Component Analysis (PCA) for dimensionality reduction and feature selection. To ensure reliable ground-truth constraints, synthetic seismograms generated from well log data and Ricker wavelets are tied to seismic sections through time depth conversion and alignment. Model performance is assessed using metrics such as accuracy, F1-score, and confusion matrices, while predictive uncertainty is quantified via bootstrap resampling and Monte Carlo dropout. The anticipated outcomes include high-resolution seismic facies maps and uncertainty maps, which together provide enhanced insights into depositional settings, reservoir heterogeneity, and potential fluid distributions. This ML-driven approach offers a scalable, data-driven alternative to traditional interpretation techniques. By reducing subjectivity and improving predictive confidence, it holds the potential to significantly enhance

exploration efficiency, mitigate risks, and optimize hydrocarbon exploration strategies in complex offshore basins like the Mahanadi.

Keywords: Seismic Facies, Machine Learning, Mahanadi Offshore Basin, Support Vector Machines, Random Forest, Seismic-Well Integration, Principal Component Analysis, Uncertainty Quantification, Hydrocarbon Exploration.

[ABS-0222]

INTEGRATED SEISMIC ATTRIBUTE APPROACH FOR CHARACTERIZING LOWER EOCENE RESERVOIR SANDS IN THE EAST GODAVARI SUB-BASIN, KRISHNA-GODAVARI BASIN, INDIA

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The East Godavari Sub-basin, located within the Krishna-Godavari (KG) Basin, is a prolific hydrocarbon province shaped by complex deltaic sedimentation and tectonic deformation during the Paleogene-Neogene period. This study employs an integrated seismic attribute approach to evaluate the geometry, facies variation, and continuity of Lower Eocene reservoir sands within a gas-bearing structure. By combining three-dimensional seismic interpretation with well-log correlation, two key pay-sand intervals were delineated with improved structural and stratigraphic clarity. Advanced seismic attributes, notably instantaneous bandwidth and geometric parameters, effectively resolved subaqueous channel systems and identified spatial variations in energy absorption associated with lithological and fluid changes. Areas displaying higher absorption correspond to intervals of greater porosity and fluid content, highlighting potential hydrocarbon-rich zones. Frequent channel migrations driven by variable sediment supply explain the subdued channel-cut signatures in amplitude data. Structural analysis reveals that growth-fault-related roll-over features and shale diapirs provide primary traps, while depositional heterogeneity governs reservoir distribution. This integrated analysis improves understanding of subsurface architecture and reservoir behavior, providing a robust framework for optimizing well placement and guiding hydrocarbon exploration in the East Godavari Sub-basin of the KG Basin.

Keywords: Seismic interpretation, Seismic attributes, Hydrocarbon exploration, East Godavari Sub-basin, Krishna-Godavari (KG) Basin

[ABS-0084]

COUPLED THERMAL HYDROLOGICAL MECHANICAL MODELING OF FRACTURED MEDIA FOR SUSTAINABLE ENERGY RECOVERY

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A coupled flow geomechanics framework has been developed to simulate the complex thermo-hydro-mechanical (THM) behaviour of low-permeability subsurface formations. This approach captures the interactions between fluid flow, heat transport, and rock deformation which are key processes in applications like geothermal energy production, CO_2 sequestration, and nuclear waste disposal. Fluid injections or extractions change pore pressure, influencing the stress field, while temperature variations cause thermal expansion or contraction of the rock matrix. These mechanical changes, in turn, alter porosity and permeability, feeding back into how fluids and heat move through the reservoir. The model integrates governing equations for heat conduction, fluid flow, and solid deformation, incorporating mass and energy conservation, Darcy s law, and mechanical equilibrium. A finite element framework is used to solve the coupled system. To accurately represent reservoir heterogeneity, discrete fractures are explicitly modelled within a dual-porosity approach, allowing for more realistic simulation of flow and stress behaviour. The modelling approach was built incrementally, starting from a simplified hydro-thermal model used for benchmarking pressure, temperature, and Darcy velocity changes over time. Building on this foundation, work is currently ongoing to develop a 2D fully coupled THM prototype that captures feedback mechanisms between fluid pressure, thermal effects, and mechanical stress redistribution. This model is intended to enable more integrated simulations of heat recovery processes once fully established. By combining discrete fracture representation with a fully coupled THM model, this study presents a robust method for analysing fractured, low-permeability geothermal reservoirs. The results highlight the importance of adopting a Multiphysics framework to understand reservoir behaviour and guide the design of sustainable, long-term energy extraction strategies.

Keywords: Coupled THM Modelling, Geomechanics, Dual-Porosity, Fractured Media

[ABS-0086]

FORWARD MODELLING OF ANOMALOUS MAGNETOTELLURIC PHASE DATA IN PANAMIK-CHANGLUNG HOTSPRINGS REGION, LADAKH

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The Panamik geothermal field in Ladakh, one of the most prominent geothermal systems in the Nubra valley, between the Karakoram Fault (KF) and the Shyok Suture Zone (SSZ) in the Trans-Himalayan region of Ladakh. This region has not yet been mapped well with geophysical methods. We acquired Broadband (BBMT) and Long-Period (LMT) measurements at 34

locations covering a 30 km profile, which crosses the Panamik and Changlung hot springs. We analysed the data, and predominantly, a cluster of sites shows anomalous phases along the profile. This anomalous behaviour mainly arises due to current channelling and anisotropy effects of the subsurface formations. Current channeling from near-surface inhomogeneous effects can reverse or distort the direction of electric fields. Additionally, electrical anisotropy in layered materials can create similar distortions. Traditional inversion methods, with this data may give rise to an unrealistic subsurface picture. To address these issues, an anisotropy modeling and current channeling approach is necessary for accurate subsurface conductivity mapping. Hence, we have conceptualized a forward model mimicking the geology and tectonics of this region. Initial modelling studies suggest the possibility of an L-shaped conductor in this region, giving rise to phase out of quadrant behavior. However, we are also studying an alternative possibility of micro anisotropy at the upper crustal depths. We present these scenarios and discuss the genesis of anomalous phases in the Panamik geothermal region. These analysis leads to clearer interpretations and improve the accuracy of subsurface conductivity mapping, strengthening the identification of geothermal targets.

Keywords: Magnetotellurics, Panamik-Changlung Hotsprings, Anomalous Phase, Current channeling, Anisotropy

[ABS-0087]

FLUID SUBSTITUTION MODELLING OF UNCONVENTIONAL SHALE RESERVOIR TO IDENTIFY SHALE RESOURCE POTENTIAL IN THE DAMODAR RIVER VALLEY BASIN, INDIA

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Fluid Substitution Modelling is a powerful tool to assess the sensitivity of elastic properties to pore fluid variations and plays a vital role in evaluating unconventional shale reservoirs. The characterization of such reservoirs requires a robust understanding of rock fluid interactions, as their elastic responses are strongly influenced by pore structure, mineral heterogeneity, and fluid distribution. In this study, Fluid Substitution Modelling was applied to two wells containing prominent shale formation in the Damodar River Valley Basin of India to investigate the shale resource potential. Well log data were used to derive petrophysical properties, including porosity, volume of shale, and water saturation, which formed the input for subsequent rock physics analysis. Fluid substitution was performed using Gassmann, Mavko Gassmann, Soft Porosity Model (SPM) and Single Aspect Ratio (SAR) formulations to simulate elastic responses under varying fluid conditions. The results indicate a clear difference in the sensitivity of different models. SPM revealed the strongest gas effect on compressional velocity (Vp), SAR showed intermediate sensitivity, while Gassmann consistently produced the smallest fluid response.. Shear wave velocity (Vs) remains largely unaffected in all cases, but variations in acoustic impedance and Vp/Vs provide effective discrimination between gas- and brine-saturated zones. Comparative analysis shows that SPM captures fluid sensitivity

more effectively and matches measured log responses more closely than SAR and Gassmann formulations, enabling more reliable elastic characterization of shale intervals. The improved consistency between modelled & measured responses further validates the applicability of SPM for unconventional shale settings. This study demonstrates that fluid substitution, when constrained by petrophysical analysis and calibrated rock physics models, can delineate potential gas-bearing zones in the prominent shale formation with improved confidence.

Keywords: Unconventional Shale; Fluid Substitution Modelling; Rock Physics Analysis; Damodar Basin

[ABS-0095]

ROLE OF GEOLOGICAL PROCESSES IN CONTROLLING METHANE SEEPAGE ALONG THE INDIAN CONTINENTAL MARGIN

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Methane seepages across Indian offshore basins are critical geobiological and geochemical phenomena influencing benthic ecosystems and regional carbon cycling. Investigations in the Bay of Bengal and Andaman Sea reveal dissolved methane concentrations up to ~1500 nmol/L, far above background seawater, confirming widespread active seepage. Geological controls, however, vary significantly between basins. In the Krishna Godavari basin, shallow-water seepages (~200 m; ~172 nmol/L) are linked to recent submarine landslides, whereas deeper-water seepages (~700 1800 m) are associated with compressive structures formed by shale tectonism, which provide favourable conditions for gas hydrate accumulation and cold seep activity. Twenty-two seepage sites have been identified in the deep basin; while a fully developed cold seep ecosystem has been documented at one site, the remaining 21 require detailed ecological assessment. In contrast, shallow-water seepages, despite active methane release, show no evidence of ecosystem development. The Mannar basin hosts gas-bearing sediments underlain by a well-developed bottom-simulating reflector (BSR), with vertical chimneys and fractures acting as conduits for deep-seated gas migration, sustaining seepage activity (~48 nmol/L). In the Andaman Sea, elevated methane concentrations at a submarine seamount (SM-13) may reflect hydrothermal influence, though this remains unconfirmed. The recovery of Bathymodiolus mussels indicates the presence of a potential seep ecosystem at this site, warranting further investigation. Nearby mounds display seepage controlled by compressional tectonics associated with subduction, where BSRs and fault systems provide structural pathways for fluid migration. Collectively, these seepages demonstrate that methane release in the northern Indian Ocean is governed by diverse geological processes, including landslides, shale tectonism, faulting, hydrothermal activity, and subduction. Yet, the extent to which these contrasting geological controls regulate the intensity, persistence, and ecological consequences of seepage remains poorly understood. Resolving these uncertainties is essential for constraining methane cycling and evaluating its role in global carbon dynamics.

Keywords: Methane seepage, Indian continental margin, Krishna Godavari Basin, Mannar Basin, Andaman Sea, Gas hydrate, Shale tectonism, Submarine landslides, Hydrothermal activity

[ABS-0106]

3D MAGNETOTELLURIC MODELLING FOR GEOTHERMAL EXPLORATION: A CASE STUDY OF THE PUGA FIELD

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The Puga geothermal field, located in the Ladakh region of India, is among the most promising high-temperature geothermal systems in the Himalayas. Its tectonically active setting and surface manifestations such as hot springs and fumaroles suggest significant subsurface heat flow and reservoir potential. To evaluate the field s subsurface structure and identify possible reservoir zones, this study employs three-dimensional (3D) magnetotelluric (MT) forward modeling in combination with dimensionality analysis. A synthetic 3D resistivity model of the Puga field was developed using resistivity distributions derived from a previously published two-dimensional (2D) inversion study. Synthetic MT responses were generated from this model, exported in .edi format, and then subjected to 2D inversion to evaluate the capability of simplified inversion approaches to recover 3D resistivity features. The inversion successfully reproduced the primary structural elements, most notably the central low-resistivity anomaly interpreted as a geothermal reservoir, although finer-scale details and subtle conductive pathways were not fully resolved highlighting the inherent limitations of 2D inversion for complex 3D structures. Dimensionality analysis was performed using Swift s and Bahr s skew parameters together with phase tensor analysis. These revealed that the subsurface is predominantly 1D 2D at greater depths but exhibits localized 3D complexity in shallower regions. To explore potential regional connectivity, the resistivity model was extended toward the nearby Chumathang geothermal field. Preliminary modeling results indicate a possible deep conductive linkage between the Puga and Chumathang systems, suggesting that they may share a common deep-seated heat source within the same tectonic regime. This work demonstrates the value of combining 3D forward modeling and 2D inversion to characterize geothermal systems in tectonically active environments. The findings highlight the potential of MT methods for identifying reservoirs, understanding structural controls on fluid flow, and evaluating field connections. The results support future 3D inversion studies and geothermal development in the Himalayan region.

Keywords: Magnetotellurics, 3D forward modeling, Geothermal exploration, Puga geothermal field, Dimensionality analysis

[ABS-0122]

ADVANCE IN SEISMIC IMAGING -HIGH RESOLUTION SUBSURFACE IMAGING USING RTM AND FWI

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Seismic imaging is a powerful method for mapping subsurface structures and properties through the analysis of seismic data. Reverse Time Migration (RTM) and Full Waveform Inversion (FWI) stand out as effective approaches for imaging complex geological features due to its ability to handle two-way wave equation, consisting of multipathing and complex wave phenomena. Further, it accounts for all wave types, including backscattered and turning waves, which makes it more accurate in areas with irregular velocity contrasts, particularly effective in imaging deep targets beneath complex overburden, such as subsalt or thrust-belt structures. Whereas, FWI goes beyond kinematic information and uses the entire seismic waveform (phase and amplitude), extracting much more detail, producing high-resolution velocity models. In this study, we design controlled numerical experiments on synthetic acoustic datasets to investigate the combined application of FWI and RTM. A suite of geological velocity models, from simple to complex are employed to evaluate performance across varying structural complexities. FWI is first applied to recover high-resolution velocity models from shot gathers, capturing fine-scale variations in the acoustic medium. The inverted velocity models are then directly used as the input migration velocity in RTM to generate structural images of the subsurface. This integrated workflow enables assessment of the accuracy and reliability of FWI-derived models for migration purposes, particularly in complex settings where conventional migration velocities are inadequate. The results demonstrate that the FWI-RTM approach improves imaging of steep dips, synclinal closures, and thrust geometries, while also reducing migration artifacts compared to using the initial velocity models. This study highlights the potential of FWI-enhanced RTM for more reliable seismic imaging in both simple and geologically complex scenarios.

Keywords: Seismic Imaging; Full Waveform Inversion (FWI); Reverse Time Migration (RTM); Synthetic Data; Acoustic Wave Equation; Velocity Model; Marmousi; Thrust Model; Syncline; Migration Velocity

[ABS-0153]

GEOTHERMAL RESERVOIR CHARACTERIZATION AND RESOURCE MANAGEMENT USING GEOMECHANICAL MODELLING IN CENTRAL INDIA GEOTHERMAL REGION

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Reservoir geomechanics model is very crucial to provide valuable information associated with multiple applications including the prediction of surface subsidence, pore pressure estimation, observation of in-situ stress variability, wellbore stability and fault reactivation mechanism. This study is mainly focused on the 3D static geomechanical model building towards potential reservoir characterization and resource management in a vital geothermal province situated in Central India. The preliminary step of the workflow is to build 1D geomechanical and petrophysical model by integrating available log data and related mathematical expression. For proper optimization of the model in high temperature and high pressurized geothermal environment seismic data is also applied with the initial 1D model for generating fault polygons and horizon grids. The geomechanical model generated using geostatistical simulation technique consists of the structural and stratigraphy interpretation of the reservoir, 3D grid, well log data, rock strength, fluid-rock interaction in reservoir, elastic property and in-situ stress estimation. Fault stability analysis is done by using Mohr-Coulomb failure criteria to know about the possibility of fault activation under extreme stress conditions. The model indicates a stress regime of maximum horizontal stress around 70-72 MPa and minimum horizontal stress around 37-40 MPa and a strike-slip to normal faulting regime is also identified. This work gives insight into optimizing drilling strategies, reducing geomechanical failure probability and enhancing reservoir management techniques which can ensure sustainability in geothermal energy production. Moreover, this study provides a reliable framework for a safe and efficient geothermal resource management which is supportive to fulfill the agenda of energy transition. This research also contributes to reducing global dependence on fossil fuels by strengthening the role of geothermal system in renewable energy sector by lowering carbon emissions.

Keywords: Geomechanical and Geostatistical Model, Pore Pressure, In-Situ stress, Mohr-Coulomb Failure Criteria, Geothermal Energy

[ABS-0179]

SHALLOW STRUCTURES AND GAS HYDRATE BEARING ZONES IN THE KRISHNA-GODAVARI OFFSHORE USING SEISMIC REFLECTION DATA

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The Krishna-Godavari (KG) offshore basin, located along the eastern continental margin of India, stands as one of the country s most productive and petroliferous regions. Formed through continental rifting and seafloor spreading between the Indian, Antarctic, and Australian plates,

the basin spans nearly 45,000 sq. km across onshore and offshore domains. Continuous sediment influx from the Krishna and Godavari rivers has created exceptional stratigraphic conditions for the accumulation of hydrocarbons and formation of gas-hydrates in this basin. This study investigates the subsurface architecture and gas-hydrate bearing zones in the KG offshore basin using high-resolution multi-channel seismic (MCS) reflection data, acquired by CSIR-NGRI, Hyderabad. The seismic sections were conditioned with dip-steered median filtering (DSMF) to suppress noise and enhance reflector continuity, thereby enabling accurate geological interpretations. The analysis highlights prominent structural and stratigraphic features, including submarine canyons, horst graben systems, channel fills, and seaward-dipping reflectors. A distinct Bottom Simulating Reflector (BSR), the most reliable geophysical marker for gas hydrates, was successfully identified across several sections along the seismic profiles. Beyond hydrate indicators, numerous tectonic and depositional elements such as faults, folds, gullies, chaotic reflections, mini-fill basins, blanking zones, gas chimneys, and mass transport deposits (MTDs) were delineated, revealing the basin s structural complexity and dynamic depositional history. To strengthen the interpretation, seismic observations were integrated with the bathymetric, gravity, and magnetic anomaly datasets, establishing correlations between the surface anomalies and deep-seated structures. The findings provide a refined tectono-stratigraphic framework, reinforce the hydrocarbon and gas-hydrate potential of the KG offshore basin, and underscore its significance as a frontier domain for India s future energy security.

Keywords: Seismic data, Dip Steered Median Filter, Interpretation, Gas-hydrate, BSR, Subsurface structures.

[ABS-0200]

BASIS PURSUIT AIDED SEISMIC SPARSE-LAYER REFLECTIVITY INVERSION: A CASE STUDY FROM KG BASIN, INDIA

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A conventional sparse-spike inversion assumes that seismic trace is represented by a convolution of a sparse series of spikes - representing subsurface reflectivities and a wavelet. In contrast, Basis Pursuit Inversion (BPI) is an approach which assumes that subsurface reflectivities can be decomposed into a series of odd and even pairs of spikes with varying thicknesses. A kernel dictionary matrix is required for the purpose of decomposing the reflectivities. This dictionary matrix consists a set of odd and even pairs of spikes with thicknesses may vary from a minimum of one sample rate to a maximum of a tuning thickness. BPI will then find a minimum combination of odd and even pairs of spikes from the dictionary matrix which can be used to represent the seismic trace. We have investigated the performance of the technique on both synthetic wedge model and real seismic data from Krishna-Godavari (KG) basin. Results show that BPI is superior in resolving thin bed problems than sparse-spike technique. This can be observed from the closed similarity of the obtained reflectivities from the well log data.

Keywords: Sparse-Spike inversion, BPI, dictionary matrix, tuning thickness, wedge model

[ABS-0217]

LONG-DISTANCE MIGRATION OF METHANE AND DEVELOPMENT OF SEDIMENT-WAVE CONDUITS FACILITATING VERTICAL FREE-GAS MIGRATION NEAR THE GAS-HYDRATE STABILITY ZONE OF THE CAUVERY MANNAR BASIN.

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The Cauvery Basin is the southernmost among the Mesozoic rift basins of India. It is located between India and Sri Lanka along the eastern continental margin of India. It is endowed with an active petroleum system. The present study area lies in the Gulf of Mannar Ramnad Palk Bay sub-basin, situated near the recent gas discovery in the deepwater block CY-DWN-2001/2 of the Cauvery Basin. An integrated interpretation of 2D and 3D seismic data reveals the widespread occurrence of a Bottom Simulating Reflector (BSR), indicating the presence of gas hydrates and underlying free gas. The landward limit of the hydrate stability zone, known as the feather edge, is distinctly identified on seismic line CY1-06. Beneath the Base of the Hydrate Stability Zone (BHSZ), a thick free gas zone exhibits lateral migration towards shallower strata near the continental shelf break. Faults act as key conduits, facilitating the migration of methane from deeper hydrocarbon reservoirs to shallower levels, where gas hydrate formation occurs. Moreover, sediment waves near the shelf break appear to channel vertical gas migration, creating a minor slope break visible in seismic line CY1-02 and corroborated by bathymetric data. Correlation with well CY-DW-F-1 provides further evidence of methane gas encountered during drilling. Additionally, gas flares reported in previous studies from the Cauvery Basin provide important evidence of ongoing subsurface fluid migration processes.

Keywords: Free gas migration, sediment waves, gas hydrate stability zone

[ABS-0052]

EFFICACY OF RADON TRANSFORM IN MULTIPLE ATTENUATION

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The seismic multiple attenuation is essential for improving the clarity and interpretability of subsurface images, as multiples can obscure primary reflections and complicate reservoir characterization. The Radon transform, with its ability to separate events based on moveout differences in the time offset domain, is widely used for multiple attenuation in seismic data processing. This study evaluates the efficacy of Radon transform-based multiple attenuation, with a focus on comparing the performance of linear, parabolic, and hyperbolic Radon transforms. Despite their widespread use, Radon methods face challenges such as energy

smearing and the limited availability of systematic comparative studies across transform types. To address these issues, we apply a sparse inversion framework designed to improve the separation of multiples and primaries and enhance energy focusing in the Radon domain. Synthetic seismic gathers with known event types are generated using wavelet modelling to evaluate the transforms, with performance assessed in terms of multiple suppression, primary preservation, and focusing sharpness. Results indicate that the inversion framework achieves enhanced focusing and interpretability, offering a practical solution to common Radon-based limitations and providing a rare systematic comparison of transform types for seismic multiple attenuation.

Keywords: Seismic multiple attenuation; Radon transform; multiple suppression; primary reflections

[ABS-0035]

ESTIMATION OF GAS HYDRATE SATURATION USING MACHINE LEARNING

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Sediments that contain gas hydrates can pose a geohazard, affecting slope stability and climate feedbacks. They also represent a promising energy source. Evaluating gas hydrate saturation (Sh) is crucial for understanding geomechanical risks and resource potential. Conventional estimation methods, such as resistivity, acoustic velocity, and nuclear magnetic resonance (NMR) logging, have notable limitations. For instance, resistivity methods are affected by pore-water salinity and require specific Archie parameters. Acoustic methods depend on accurate elastic models and can be influenced by variations in rock types. NMR measurements are direct but can be expensive and often not available. The accuracy and usefulness of traditional workflows are constrained by these challenges, particularly in data-limited situations. To address the challenges of parameter sensitivity and financial constraints in traditional Methods, this study develops a machine learning (ML) framework to predict gas hydrate saturation more accurately and flexibly. The process begins with detailed well-log interpretation and quality control of NMR, acoustic, and resistivity data from multiple hydrate-bearing sites. Despite their uncertainties, standard resistivity, acoustic, and NMR techniques were initially applied to estimate gas hydrate saturation to create reference labels. After validation on separate datasets lacking one or more complex measurements, a supervised machine learning model was trained using these multi-parameter petrophysical estimates. This model aimed to capture complex, nonlinear relationships between routine logging measurements and gas hydrate saturation (Sh). With about an 80% accuracy rate in replicating benchmark saturation estimates, the ML model surpassed individual physical methods and showed strong performance across various lithologies and depositional environments. The suggested ML approach offers a transferable and affordable tool for accurate gas hydrate saturation prediction in settings where resistivity, acoustic, or NMR data are lacking or economically limited by incorporating multi-log information and discovering hidden relationships beyond the presumptions of physical models.

Keywords: as hydrates; Machine learning; Well log interpretation; Saturation estimation; Petrophysics

[ABS-0018]

INTEGRATED AVA ANALYSIS AND SEISMIC INVERSION METHODS FOR FLUID IDENTIFICATION

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Accurate and efficient characterization of hydrocarbon reservoirs is essential for responsible resource management and sustainable development. Conventional post-stack inverted volumes alone often lacks detailed lithological and fluid-fill information necessary for robust reservoir delineation. Prior studies of the Mississauga sands highlight the need for multi-attribute analysis. This study presents a comprehensive and integrated workflow that combines AVA analysis from 3D PSTM angle gathers, deterministic post-stack band-limited impedance inversion and pre-stack simultaneous inversion using simulated annealing to identify gas bearing sands in Mississauga Formation in the Scotian Basin. The Simulated annealing algorithm iteratively perturbs P- and S-impedance models to minimize the misfit between synthetic and observed data, with constraints provided by low-frequency impedance models derived from logs. The derived elastic parameters are then used to calculate the Vp/Vs ratio, lambda-mu, which are highly sensitive parametres to fluid content providing clear distinction between gas-filled and wet sands. This integrated approach improves fluid indicators and, when combined with multi-attribute analysis, enhances understanding of lateral and vertical fluid distribution enabling more accurate fluid maps and reduced exploration uncertainty, which benefits seismic exploration and interpretation.

Keywords: AVA, Post-Stack Inversion, Pre-Stack Inversion, Simulated Annealing, Fluid Identification

[ABS-0015]

TRANSFORMS APPLICATIONS FOR LITHOSPHERE SUBSURFACE IMAGING

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Lithosphere subsurface imaging is challenging task before geoscientists for extractive industries hydrocarbon, minerals, coal, geothermal energy resources, natural geologic white hydrogen exploration and extraction. Transforms applications geophysical signals are essential for precisise subsurface imaging.Fourier , Wavelet, Stockwell, Hilbert, Hilbert Huang, Radon, ,ParabolicRadon, Hartley, Laplace, Z-transform, Walsh, Mellin, Hough, Weyl,Hit and Miss ,etc are employed for geophysical data analysis. Wavelet transform- Diplet, Ridgelet(Radon & Wavelet), slantlet, Curvelet,shearlet, phaselet, beamlet, contourlet, caplet, Seislet, dreamlet,etc, is used for nonstationary data analysis-seismic spectral decomposition thin bed imaging, deepwater channel detection hydrocarbon exploration, hard rock seismic imaging minerals

exploration, image processing seismic interpretation, etc, spectral leakage smearing signal of wavelet transform is corrected by synchrosqueezed wavelet transform. Hilbert huang transform-nonlinear nonstationary signal EMD Empirical mode decomposition is done.The Weyl transform, a mapping between a signal and its autocorrelation coefficients, can capture multiscale symmetries in texture, making it useful for classifying sediment types from acoustic images.In the context of geophysics, the Laplace transform is used to analyze gravity anomalies by transforming the gravity field from the spatial domain to the frequency domain, which can simplify the interpretation and modeling of subsurface structures. The Hankel transform, a mathematical tool, can be used to analyze and interpret gravity anomalies by transforming gravity data from the spatial domain to the frequency domain, aiding in the identification and characterization of subsurface structures. The Mellin transform can be used for gravity interpretation, particularly for analyzing and understanding gravity anomalies, which are variations in the Earth's gravitational field revealing differences in rock density and crustal structures. Hilbert transform is useful for analytic signal analysis calculating instantaneous attributes of time series especially amplitude and frequency. Harltley transform is employed for gravity and seismicdata analysis.

Keywords: Transform, wavelet transform, lithosphere subsurface imaging, seismic imaging

[ABS-0080]

SUBSURFACE COMPLEXITY ANALYSIS OF THE NEW RIVER GEOTHERMAL RESERVOIR, CALIFORNIA, USING MAGNETOTELLURIC DIMENSIONALITY PARAMETERS

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Characterizing the structural complexity of the New River Geothermal Reservoir in California is critical for resource exploration, as fluid migration is controlled by deep-seated faults and heterogeneous resistivity contrasts within a tectonically active rift system. Magnetotelluric (MT) dimensionality analysis provides a robust framework for delineating these subsurface features prior to computationally intensive MT inversion. This study utilizes a multi-parameter approach integrating Swift and Bahr skew, phase-tensor (PT) attributes, and WAL rotational invariants to systematically evaluate the reservoir's geoelectrical dimensionality. The results indicate that near the surface the rock layers are simple and form a one-dimensional structure for measurement periods between 0.002 s and 10 s. Deeper down the structure becomes more complex and is two-dimensional for periods from 10 s to about 1400 s. By assessing the system's dimensionality, this approach establishes a distinct, empirical basis for choosing the best inversion strategy, leading to a precise and geologically-sound representation of the geothermal reservoir.

Keywords: Magnetotelluric, Swift and Bahr skew, phase-tensor (PT) attributes, WAL rotational invariants

GEO HAZARDS

METEOROLOGICAL EXTREME EVENTS, MARINE AND COASTAL HAZARDS, EARTHQUAKES, LANDSLIDES, POLLUTION, AND RELATED SUBJECTS WITH SPECIAL EMPHASIS ON SPACE-BASED OBSERVATION OF GEOHAZARDS AND IONOSPHERIC SEISMOLOGY

[ABS-0129]

A CASE STUDY OF THE PRE - SEISMIC IONOSPHERIC RESPONSE TO 2021 HAITI EARTHQUAKE USING GROUND AND SPACE-BASED OBSERVATIONS

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The detailed information about ionospheric anomalies associated with earthquakes are possible now due to the advent of various ground and space based ionospheric measurements. A strong Mw = 7.2 earthquake struck Haiti on August 14, 2021 at 12:29 UTC (18.434°N, 73.482°W, depth ~10 km). This earthquake occurred as the consequence of oblique reverse motion along the Enriquillo-Plantain Garden fault zone (EPGFZ). In this study, the plausible pre-seismic variations in the ionosphere due to 2021 Haiti earthquake are examined using ground and space-based instruments. The daytime ionospheric response is analyzed using Vertical Total Electron Content (VTEC) from IGS stations and electron density from Swarm satellite data. Results demonstrate that bandpass filtered VTEC reveals clear, pronounced, pre - seismic oscillations of peak magnitudes of ~ 0.2 TECU on August 5 2021, i.e., 9 days before the earthquake for stations near and just outside the earthquake preparation zone. Similarly, enhanced wave-like oscillations are also evident in the filtered VTEC data near the conjugate stations on the same day. Another unique feature during August 5, 2021 is the anomalous enhancement of northern Equatorial Ionization Anomaly (EIA) crest shown by Swarm electron density data. Such an enhancement is not observed for other days during August. This is also concurrent with the drop in Relative humidity (RH) occurred during the same day near the impending epicenter region. Hence the concomitant anomalies found in various atmospheric and ionospheric parameters suggest that the anomalies found on August 05, 2021 is plausibly related to the Haiti 2021 earthquake. This study also sheds some light into similarities with the Haiti 2010 event which occurred very close to the epicenter of 2021 event, hence emphasizing the need of detailed study of the Earthquake prone regions of Haiti using multiple precursor parameters

Keywords: Haiti 2021 earthquake, GNSS TEC, Swarm satellite, earthquake precursors, ionospheric seismology

[ABS-0133]

POLEWARD PROPAGATION OF IONOSPHERIC ANOMALIES DUE TO VOLCANIC ERUPTIONS, GREAT EARTHQUAKES, AND TSUNAMIS

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The ionosphere, a vital layer of Earth s atmosphere, is highly responsive to large-scale geophysical events such as volcanic eruptions, earthquakes, and tsunamis. In this study, we investigate ionospheric Total Electron Content (TEC) variations associated with the 2022 Hunga Tonga Hunga Ha apai volcanic eruption, two major earthquakes of magnitude greater than 8, and the 2011 Tohoku earthquake-induced tsunamis, with a particular focus on their poleward propagation characteristics. Using GNSS-TEC observations in conjunction with surface pressure data from meteorological sensors co-located with GPS receivers, we compare the intensity, propagation patterns, and underlying mechanisms of the ionospheric anomalies triggered by these events. Our analysis reveals that the Hunga Tonga eruption generated clear ionospheric disturbances, including multiple eruption signatures, which were detected in Antarctica with amplitudes up to 2 TECU. In contrast, no significant ionospheric anomalies were observed in the polar regions for either the great-magnitude earthquakes or the tsunami events, despite their large energy release. These findings suggest that seismo-tectonic events do not produce discernible ionospheric signatures in polar regions, whereas volcanic eruptions can generate strong and detectable disturbances at high latitudes. Furthermore, the long-period (0.28 16.67 mHz) ionospheric oscillations recorded in Antarctica were found to closely follow the surface pressure perturbations, highlighting the strong coupling between atmospheric acoustic-gravity waves and ionospheric responses during volcanic activity.

Keywords: GNSS, TEC

[ABS-0137]

IONOSPHERIC SEISMOLOGY: INSIGHTS INTO CURRENT STATUS AND FUTURE PROSPECTS

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Large seismic events, such as large earthquakes, tsunamis, and explosive volcanic eruptions, generate atmospheric acoustic and gravity waves through the dynamic coupling between the solid Earth and the overlying atmosphere. Upon reaching the ionosphere - a region of the Earth's upper atmosphere extending from approximately 60 km to over 1000 km in altitude - these waves induce fluctuations in the distribution of ionospheric electron density. In recent years, these ionospheric disturbances have garnered significant attention as they offer valuable insights into the source characteristics of the underlying seismic events. Ionospheric seismology, an emerging interdisciplinary field, refers to the investigation of earthquakes and tsunamis - through the analysis of co-seismic/tsunami ionospheric disturbances. The present

paper would discuss the advancements made so far in this field and also highlight the future prospects.

Keywords: Ionosphere, Earthquake, Tsunamis

[ABS-0231]

PAST TSUNAMIS IN THE ARABIAN SEA AND FUTURE POSSIBILITIES

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Future source zones of earthquakes that can generate tsunamis in the Indian Ocean are identified based on past seismicity and gap areas. The tectonics and seismicity in these zones are briefly discussed and long-term assessment of future tsunamigenic great / major / moderate earthquakes in these zones is presented. The two subduction zones which can give rise to great earthquakes are Sunda Arc (Sumatra and Java) and Makran coast. The Sunda Arc generates frequent great earthquakes, volcanoes and tsunamis. The Andaman-Nicobar group of islands is also seismically active zone that generates frequent earthquakes. However, northern Sumatra and Andaman-Nicobar regions are assessed to be probably free from great earthquakes for a several decades due to occurrence of 2004 Mw 9.3 and 2005 Mw 8.7 earthquakes. The M8 earthquakes in the southern Sumatra and Java can generate strong tsunamis, however, the directivity will not be towards India. Only in rare case of mega earthquake or mega volcanic eruption, the tsunami could be hazardous for India. For example, the Krakatoa volcano along the Sunda arc between Java and Sumatra caused one of the most catastrophic explosive eruptions in 1883 and largest tsunami in history. Thrust-type earthquakes along the 1200-km-long Makran subduction zone of Iran-Pakistan situated on the northwestern side of the Arabian Sea can generate tsunamis. It had at least five great earthquakes of M 8+ along different ~200-km long rupture zones which generated tsunamis and mud volcanoes in the past: 1483 (Long. 58° - 60°E), 1851 and also 1864 near Gwadar (Long. 61° - 63°E), 1945 (Long. 63° - 65°E) and 1765 (Long. 65° - 67°E) in easternmost Makran. The 28 Nov. 1945 (Mw 8.0) earthquake generated the last major tsunami in the Arabian Sea. More than 4000 people were killed on the Makran coast by both the earthquake and the tsunami. This earthquake occurred in the central part of the Makran zone. Eastern and western parts remain potential zones for great earthquakes. It is also possible that the entire length of Makran subduction zone ruptures in one go in M9+ mega earthquake accompanied by landslide generating mega tsunami like that of 2004 Sumatra-Andaman. It is estimated that waves height could reach ~5 m along the Indian coast and 11 m in Gulf of Kachchh for a tsunami due to M8+ earthquake and much higher for a mega earthquake along the Makran coast. Thrust-type major earthquakes occurring along coastal zones of compressive stress along the Indus delta and Kutch-Saurashtra region have given rise and can again generate moderate tsunamis. Minor tsunamis can be generated due to dip-slip earthquakes along oceanic ridges. A local tsunami with maximum amplitude of 1.5 m was generated due to normal faulting earthquake of Mw 7.7 on November 30, 1983 at Diego Garcia Archipelago.

Keywords: Arabian Sea, Sumatra and Java, Makran coast

[ABS-0147]

MONITORING HIMALAYAN LANDSLIDES WITH TIME SERIES INSAR: A PILOT STUDY TOWARDS A DYNAMIC LANDSLIDE MONITORING FRAMEWORK

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The Himalayan region is experiencing an alarming increase in extreme rainfall events, exacerbated by rapid infrastructure development. These factors are destabilizing fragile mountain slopes and intensifying the frequency of landslides and land subsidence. Uttarakhand has emerged as one of the most vulnerable states in the Himalaya, where active tectonics, weak lithology, and rapid urban expansion interact with climatic extremes to amplify slope hazards. This study presents a pilot analysis of active landslide and subsidence processes in the Chamoli district (~1,000 kmÂ²) using time-series Interferometric Synthetic Aperture Radar (InSAR). Sentinel-1 SAR datasets (2016- 2024) were processed with the Small Baseline Subset (SBAS) technique to extract millimetre-scale deformation rates. Four critical sites were identified: Topovan, Sonla, Gopeshwar, and Longsi. Topovan has experienced catastrophic subsidence since 2021, with some areas near Joshimath exhibiting -20cm/yr., Sonla exhibited persistent creeping movements (-4 cm/yr.) that intensified during monsoon peaks, Gopeshwar showed localized instabilities (-5 cm/yr.) along steep urban slopes, while Longsi, a historically unstable region, recorded continuous deformation (-10cm/yr.) with sharp accelerations following high-intensity rainfall. By linking rainfall anomalies with InSAR-derived deformation, this study highlights the decisive role of extreme precipitation in shaping Himalayan landslide dynamics. The findings underscore the limitations of static landslide hazard zonation, which often fails to capture slow-onset or rainfall-accelerated instabilities. Instead, integrating time series InSAR with rainfall datasets offers a scalable pathway toward dynamic landslide monitoring frameworks. The case studies further demonstrate how hydrological forcing reactivates metastable slopes, with deformation persisting well beyond rainfall episodes. This pilot analysis provides actionable insights for disaster preparedness in Chamoli and establishes the foundation for a state-wide landslide monitoring system across Uttarakhand. Results reveal a strong temporal and spatial coupling between rainfall extremes and slope instability, underscoring the need for continuous monitoring in the Himalayan context.

Keywords: InSAR, Landslide, Extreme rainfall, Slope instability, Geo-hazards

[ABS-0201]

THREE DIMENSIONAL CO-SEISMIC DEFORMATION AND FAULT SLIP MODEL DUE TO THE 28 MARCH 2025, MW 7.7 MANDALAY (MYANMAR) EARTHQUAKE FROM SAR AND OPTICAL IMAGES

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The destructive 28 March 2025, Mandalay earthquake (M w =7.7) is one of the largest earthquakes (hereafter referred as Myanmar earthquake) to have struck Myanmar and neighbouring countries. Sentinel-1 Synthetic Aperture Radar (SAR) images were utilised to estimate azimuth and range displacements using pixel-offset tracking (POT) technique. 3-D co-seismic deformation field due to the 2025 Myanmar earthquake were constrained from ground displacements measured from ascending and descending geometries. Horizontal component of the co-seismic displacements were independently estimated using sub-pixel correlation of optical images from Sentinel-2 satellite. The results suggests that the 2025 Myanmar earthquake ruptured a ~480 km section of the Sagaing fault with a maximum displacement of 4 m in horizontal and 1 m in vertical directions. While the SAR measurements could constrain the 3-D co-seismic deformation field, high-resolution horizontal displacements from optical images could capture the surface rupture along the Sagaing fault. We use the 3-D deformation field and fault trace information to model the co-seismic rupture on the causative fault. We infer average slip 3-5 m on a steeply dipping fault extending for a distance ~430 km toward south and 50 km towards north from the hypocentre. The model suggests maximum slip distribution upto a depth of 12 km. Present results and paleoseismological inferences suggest repeated large earthquakes with significant rupture overlap along Sagaing fault, implying potential future seismic hazard.

Keywords: 28 March 2025, Mw 7.7 Mandalay (Myanmar) earthquake; co-seismic deformation, Synthetic Aperture Radar, fault slip model

[ABS-0174]

MUD VOLCANISM AND OVERPRESSURED SYSTEMS AS DRIVERS OF RECENT SUBMARINE SLOPE FAILURE IN THE KRISHNA-GODAVARI BASIN, BAY OF BENGAL

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CSIR-NIO identified a recent submarine slope failure in the shelfal region of the Krishna-Godavari (KG) Basin, Bay of Bengal, through integrated analysis of geophysical datasets spanning over two decades. The failure scarp reveals erosion of ~160 m of sedimentary strata, displacing an estimated ~11 km³ of sediments and representing one of the largest documented submarine slope failures through time-lapse geophysical surveys. Repeat surveys constrain the event between January 2009 and December 2015, with Cyclone Helen (November 2013), a

Category-1 storm that passed directly over the slump head, emerging as a likely trigger. To investigate preconditioning factors, we analyzed pre-failure 3D seismic data (2004) provided by the Directorate General of Hydrocarbons (DGH). Seismic attributes indicate that the failure surface was controlled by the geomorphology of a paleo-submarine canyon intersected by multiple active faults, forming a zone of pronounced weakness. Subsurface layers below the canyon exhibit enhanced amplitudes with negative polarity, indicative of gas-charged sediments and the layers underneath this horizon show enhanced attenuated with low-frequency shadows. A central mud volcano confirms the presence of an overpressured system in the study area. Post-failure multibeam and water-column surveys aboard RV Sindhu Sankalp (2022, 2025) detected numerous gas flares within the slumped area, consistent with gas release triggered by reduced overburden pressure. We propose that subsurface overpressured system, active faulting, pre-existing canyon geomorphology, and mud volcanism are key pre-conditioning factors that facilitate the slope failure, rendering the region highly susceptible even with low-to-moderate external triggering forces. This study highlights a potential risk associated with submarine slope failure for offshore operations in narrow-shelf basins with gas-charged, paleo-canyon systems and shows the importance of long-term geophysical monitoring, structural mapping, and real-time slope stability assessment of gas charged, hydrocarbon-bearing continental margins.

Keywords: Mud volcanism, slope stability, KG basin, geohazards, overpressured system, slumping/sliding

[ABS-0092]

DEVELOPMENT OF SEARCH AND RESCUE AID TOOL (SARAT)

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Prediction of the probable position of a lost object or a person at sea is inherently challenging due to the chaotic nature of the sea and the complex interaction of the lost object with its environmental forcings. The objects tend to drift away from the lost location. Search and Rescue (SAR) agencies must search for the object over a vast area with limited search facilities. An optimal utilization of resources implies a smaller search area with a high probability of locating the object. Therefore, to aid the Indian SAR agencies in saving valuable human life and lost property at sea, we developed the Search and Rescue Aid Tool (SARAT) based on LEEWAY, a Lagrangian model. SARAT can predict the probable marine drift of various lost objects under the combined influence of forecasted surface currents and winds for up to 5 days ahead, given the type and the last known position and time of the lost object. This study discusses the theoretical details, development, implementation, and operationalization of SARAT. It further discusses a thorough validation of SARAT against observations to show that the final positions of lost objects are well within the ambit of the predicted search areas of high

probability. This operational web application aids SAR operations of India and other Indian Ocean countries, contributing to safer seafaring.

Keywords: Search and Rescue, Marine Drift, Leeway, Indian Ocean

[ABS-0068]

A DECADE OF BOREHOLE SEISMOLOGICAL STUDIES IN THE KOYNA WARNA REGION, INDIA: CHALLENGES AND ACHIEVEMENTS

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The Koyna Warna region of Maharashtra, western India, is the world s most prominent site of reservoir-triggered seismicity (RTS), active since the impoundment of the Koyna Dam in 1962. To advance earthquake research in this natural laboratory, CSIR NGRI, with the support of the Ministry of Earth Sciences (MoES), Government of India, established the country s first borehole seismic network unique in its scale and depth with sensors deployed at 1 1.5 km. Operational for more than a decade, this initiative represents a landmark in Indian seismology. The establishment of the network posed significant challenges. A crucial step was the selection, customization, and configuration of borehole seismometers to suit the drilled borehole conditions and depths of installation. This customization proved vital, as the instruments have remained uninterrupted and fully functional for over a decade. In parallel, indigenous tools and procedures were developed for installation, coupling, and long-term stability at depths exceed

Keywords: RTS, Borehole seismometers, micro seismic activity

[ABS-0210]

FINITE ELEMENT MODELLING OF TECTONIC STRESS AND DEFORMATION OF HIMALAYAN-TIBET TO ZAGROS-IRANIAN REGION

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The Himalayan and Zagros regions are continental-continental collision zones that evolved orogenic belts with both diffuse and localized deformation between the Indian-Arabian and Eurasian plates. This study utilized finite element modeling to assess the stresses causing deformation in the Himalaya-Tibet and Zagros-Iran regions, focusing on gravitational potential energy (GPE) and basal drag from mantle convection with thin sheet approximation. Results indicate that in central and eastern Tibet, variations in GPE from topographic load significantly influence stress and deformation, more so than in the Zagros-Iran region. While mantle contributions are crucial for matching observed deformation in southwestern Tibet and the Pamir-Hindu Kush, the simpler Zagros-Iran region can often be explained by mantle contributions alone. However, uncertainties in the structure of the lithosphere and mantle complicate understanding their relative impacts in the Himalaya-Tibet area.

Keywords: tectonic stress, deformation, GPE, Mantle convection

[ABS-0026]

GEOPHYSICAL INSIGHTS INTO INTRAPLATE SEISMICITY AND GEOTHERMAL ACTIVITY ALONG THE NARMADA-SON LINEAMENT, CENTRAL INDIAN SHIELD

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Abstract Geothermal and Seismotectonic Insights from the Central Indian Shield Traditionally seen as tectonically stable, the Central Indian Shield is now recognized for its seismic and geothermal activity. Events like the 1993 Latur and 1997 Jabalpur earthquakes (Mw 6.0), along with persistent microseismic swarms near Pandhana (Madhya Pradesh), illustrate intraplate seismicity earthquakes occurring away from plate boundaries, often driven by the reactivation of ancient faults or internal stress build-up. These events, coupled with geothermal manifestations along the Narmada-Son Lineament (NSL), highlight a complex interplay of tectonic inheritance, stress localization, and fluid migration in the deep crust. Geologically, the region consists of Archean Proterozoic cratons, greenstone belts, and mobile zones, intersected by crustal-scale faults. The NSL, trending ENE WSW, separates the Bundelkhand and Dharwar cratons and is a major zone of crustal weakness, active from the Precambrian through the Phanerozoic. It continues to influence present-day seismicity, fault-controlled hot springs, and anomalous heat flow. This study integrates gravity, magnetic, resistivity, and magnetotelluric (MT) data to explore the shield s crustal architecture. Potential field methods delineate deep-seated structures, while resistivity and MT imaging detect conductive zones linked to shear zones, fault intersections, and fluid pathways often coinciding with seismic clusters and geothermal anomalies. Findings highlight the NSL as a lithospheric weak zone where ancient tectonic fabrics interact with current stress fields, enabling both seismic reactivation and hydrothermal circulation. The correlation between geophysical anomalies and observed seismicity underscores the role of pre-existing structures in driving deformation within stable continental interiors. This integrated geophysical approach not only advances our understanding of intraplate tectonics but also aids in seismic risk assessment and geothermal energy exploration, offering valuable insights for sustainable development in central India.

Keywords: Intraplate Seismicity, Geothermal Activity, Narmada-Son Lineament, Central India

[ABS-0024]

IMPACT OF BAROTROPIC ROSSBY WAVES ON MONSOON DEPRESSIONS DURING THE 2020 INDIAN SUMMER MONSOON

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India has received above-average rainfall during the 2020 summer monsoon season. Total 12 Low Pressure Areas (LPAs) formed in the north Indian Ocean during summer 2020 (in JJAS

season). The significance of this monsoon season is that August 2020 received the highest all-India rainfall in the past 44 years since 1976. This is accompanied by around 50% of the total seasonal LPAs formed in August 2020, none of which intensified into a monsoon depression (MDs). It is noted that the anomalous warming over the northern parts of the Arabian Sea (NPAS) resulted in increased convection over this region in August 2020, as a result, strong convergence of low-level wind is observed over NPAS region. In addition to this convergence, strong northwesterly winds emanating from central Asia merged with the enhanced cross-equatorial monsoon flow. However, this strong flow over the Arabian Sea sheared/dissociated into two branches: one extending up to northwest (NW) India along the monsoon trough, another one diverging into an anticyclone over the south BOB (SBOB), which reduced the horizontal shear there (Barotropic Instability). The interplay of the barotropic Rossby wave alongside an anticyclone over the WNP accompanied by local conditions caused the above normal rainfall over India in August 2020, even though there are adverse dynamical conditions.

Keywords: summer monsoon rainfall, ow-pressure area, Rossby wave, barotropic instability, stationary, retrogress

[ABS-0023]

MILLENNIAL-SCALE GEOCHEMICAL AND TSUNAMI RECORDS IN THE DEEP SEDIMENTS OF THE JAPAN TRENCH

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The deepest oceanic trenches on Earth, which are less studied than Mars, preserve unique records of tectonic and sedimentary activities. This research examines geochemical signatures and paleoseismicity in the deepest sediment core retrieved worldwide (8,060.74 mbsl; IODP Exp. 386, Japan Trench). A thorough geochemical analysis of 150 samples considered from 18 different basins reveals a felsic continental source, peculiar to the Honshu-Hokkaido region. The provenance is characterized by silica (SiOâ) concentration ranging from 53 to 59 wt.% and alumina (Alâ Oâ) content ranging from 10 to 13 wt.%. The sediments were conveyed through the Nakaminato-Ogawara canyon system and display intermittent contributions from arc volcanic activity, as indicated by elevated concentrations of iron (Fe), magnesium (Mg), and calcium (Ca). Limited mafic input is reflected in the measured Feâ Oâ (3.9â 5.5 wt.%) and MgO content (1.9â 2.3 wt.%), while the potassium and sodium oxides range between 1.6â 2.0 wt.% and 3.7â 4.9 wt.%, respectively, possibly suggesting derivation from weathered granitoid sources. Notably high sedimentation rates, ranging from 1 to 4 meters per thousand years, enable the development of stratigraphic records at the millennial scale. These records identify regionally extensive turbidite deposits, exceeding 120 kilometers in length, which have been correlated through tephrochronological analysis and tsunami event records with megathrust earthquakes of moment magnitude (Mw) 9 or greater, such as the 869 CE Jogan and 1454 CE Kyotoku events. Computed weathering indices (CIA, CIW, PIA) indicate moderate chemical changes. Moreover, irregularities in manganese oxidation detected at the bases of these event

layers indicate the discharge of fluids following seismic events. Such occurrences transpire at intervals ranging from 260 to 880 years and correspond to more than 90% of the global seismic energy released in subduction zones. Our findings indicate that hadal trenches are essential records for interpreting subduction risks, sediment routes, and tectonic drivers.

Keywords: Hadal zone, IODP Expedition 386, Japan Trench, Sediment provenance

[ABS-0192]

SHEAR WAVE STRUCTURE AND STRESS FIELD OF THE LITHOSPHERE BENEATH THE HINDUKUSH-PAMIR REGION: GEODYNAMIC IMPLICATIONS

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Systematically image the salient lithosphere structure and stress regimes beneath the Hindukush and Pamir regions. High-resolution surface wave tomography delineates the fine structure of the Lithosphere, and the stress regime patterns at different depths are elucidated through the inversion of focal mechanisms. Tomography indicates a low-velocity zone within the Lithosphere expressing the undergoing continental crust along with the mantle as the subducting slab. In the Hindukush region, the seismicity is concentrated up to 280 km depth with three distinct depth zones (up to 70, 70-160 and 160-280 km). Deeper earthquakes extend from the southwest in the southern part of the Hindukush to a maximum depth of ~150 km. In the central part of the Hindukush, they plunge to a depth of ~250 km, decreasing towards the central Pamir, and finally, this deeper depth seismicity diminishes towards the northeast beneath eastern Pamir. These intermediate focal depth earthquakes delineate slab plunging down and suggest an isolated stable block beneath the Hindukush, a distinctive nature of tectonic collision. The clockwise rotation of the largest principal stress in the compressive regimes with respect to increasing depth reflects the rotational behaviour of the subducted slab with the increase in depth. Simultaneously, in the Pamir region, anticlockwise rotation of principal stress together with a change in stress regimes with respect to increasing depth has been perceived as a complex collision geometry. An effective conceptual model that highlights the depth-wise regional stress environment is provided by the seismicity and Stress Tensor Inversion results in the Hindukush-Pamir regions. Also, the S-wave velocity tomography investigation indicates a very clear signature of submerging of the lithosphere structure of the Indian and Asian plate beneath the Hindukush-Pamir. The present work and data provide effective information on the India Asia collision, and additional data in the future will strengthen the results.

Keywords: Hindukush-Pamir, Shear wave structure, stress field, Subducted slab, Seismcity

[ABS-0010]

DETECTION OF VLF IONOSPHERIC PRECURSORS AND EARLY PREDICTION ON 05TH JULY 2025 FROM INDIA OF THE JULY-2025 M8.8 KAMCHATKA, RUSSIA EARTHQUAKE SEQUENCE

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On 29th-30th July 2025, the Kamchatka region of Russia experienced a massive M8.8 earthquake. This sequence of earthquakes began on 14th July 2025 with a M6.7 event in Indonesia followed by several M6-M7 quakes in the Northern Pacific region. A VLF Ionospheric Monitoring Station being operated in the state of Maharashtra, in western part of India had detected the early precursors starting overnight on 04th 05th July 2025 and the author had publically released an earthquake alert numbered 19/2025 on 05th July 2025 at 1330Hrs IST (0800Hrs UTC/GMT) and also some important offices in New Delhi were communicated by email about the possibility of M7++ earthquake/s likely during 15th 21st July 2025. The first major event of this sequence occurred on 14th July 2025 with an event in Indonesia and the final major event of magnitude M8.8 took place on 29th 30th July 2025 in the Kamchatka region of Russia. The precursors of Dual-Simultaneous nature were simultaneously detected by two different VLF Ionospheric paths operating on two different frequencies. This paper discusses these precursors and the alert that was released on 05th July 2025 warning for a possible M7++ earthquake more than a week in advance. By looking at the track record of several years of this VLF Ionospheric Monitoring Station in detection and early prediction of many earthquakes of M7+ magnitude, the paper then concludes that the VLF Ionospheric Technique has been proved to be a reliable, consistent and repeatable method in detection of early precursors both for the major earthquakes and volcano eruptions alike.

Keywords: Earthquake Prediction, Volcano Prediction, VLF, Ionosphere, Earthquake Precursors

[ABS-0013]

VELOCITY VARIATIONS ACROSS THE MOHO BENEATH THE NORTHWEST HIMALAYA

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To accurately evaluate seismic risk and comprehend the tectonic activity in the Himalayan region, it is essential to have comprehensive knowledge of the structure of the crust and shear wave velocity contrast across Moho (δβM). Measurements of δβM are conducted using seismological data recorded at 26 BBS located in the Himalayan region. To estimate δβM, a novel technique that utilizes P-to-s converted wave amplitude data was applied. The values of δβM range from 0.7 km/s to 1.3 km/s across the area under investigation. The δβM values beneath the Himalaya region vary from 0.7 to 1.0 km/s, whereas with the presence of

sedimentary layers, it jumps up to 1.3 km/s. This indicates that the presence of sediments influences the δβM values. The Moho depth has been taken from the published results below these stations. The crustal thickness (H) varies in the Himalayan region from 44 to 63 km. In the presence of sediments, H varies from 44 to 54 km below the 5 stations. The scaling relation between δβM and H is positive, which indicates the thick crust associated with a high δβM meaning that the presence of a low-velocity material may be fluid at the lower crust beneath the Himalayan region. It is proposed that the fluid, connected with the weak zone, may have activated pre-existing faults, leading to the generation of earthquakes. It is suggested that the accumulation of strain in the crust-mantle transition zone, which is rich in fluid, might be sufficient to generate seismicity in the lower crust. The identification of such a velocity contrast could allow tracking of temperature-pressure conditions responsible for the genesis of the crust-mantle boundary and their evolution.

Keywords: Crust, Moho, Himalaya, Receiver functions, Shear Wave velocity

[ABS-0025]

INTEGRATING PHYSICS-BASED SIMULATION: A KEY ELEMENT IN EARTHQUAKE HAZARD ASSESSMENT FROM INDIAN TECTONIC PERSPECTIVES

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Accurate seismic hazard assessment is crucial for mitigating the impacts of earthquakes in India, a region characterized by diverse tectonic settings and varying seismic risks. While Ground Motion Prediction Equations (GMPEs) are commonly used to estimate seismic hazards, they have significant shortcomings, including intrinsic assumptions and inadequate constraints in near-source regions. These models often overlook critical factors such as fault dynamics, rupture velocities, and complex rupture histories. To address these uncertainties, physics-based (PB) approaches have emerged as vital tools in seismic hazard estimation. These methods incorporate complex fault geometries, material properties, and heterogeneous rupture characteristics. This study underscores the significance of PB earthquake simulations in understanding seismic mechanics and enhancing hazard preparedness. By employing dynamic rupture processes that integrate frictional laws, we can capture the complexities of earthquake initiation, propagation, and cessation. The advanced simulation techniques enable accurate modeling of seismic wave propagation. The findings emphasize the necessity of integrating these methodologies into routine hazard assessments, particularly in regions with high seismic vulnerability, with specific examples drawn from the Indian context. In conclusion, this study advocates for interdisciplinary collaboration and the adoption of physics-based simulation methods to improve our understanding of earthquake risks in India, ultimately enhancing preparedness for future seismic events.

Keywords: Earthquake rupture, physics-based simulation,Ground-motion estimates, Seismic hazard assessment

[ABS-0027]

OIL SPILL RESPONSE STRATEGY MAPS: A GEOSPATIAL EARLY WARNING AND PREPAREDNESS TOOL FOR MARINE POLLUTION HAZARDS

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Indian National Centre for Ocean Information Services (INCOIS) has been involved in issuing oil spill advisories since 2011. Oil spill advisories issued by INCOIS to the Indian Coast Guard enhance preparedness, response efficiency, and coordination during oil spill incidents. They enable the Coast Guard to respond swiftly, allocate resources effectively, and mitigate the impacts of oil spills on the marine environment and coastal communities. In addition to oil spill advisories, INCOIS started generating Oil Spill Response Strategy (OSRS) maps that contain the details of oil spills and plans to reduce impacts to sensitive natural, cultural, and economic resources. They also set priorities for various spill risks and direct the response until real-time information becomes available. The present paper describes the method of generating OSRS maps for a real oil spill event that occurred off the Mangalore coast during June 2022. The proposed oil spill response strategies were indicated in Geographical Information System platform which is collectively called as an OSRS map. The map contains information such as oil trajectory patterns, geomorphological classes and the location of resource availability, Pollution control vessels, and shore-based facilities near to the spill location. This OSRS map will be communicated to the Regional and District Response Centers established by Indian Coast Guard wherein the centers serve as operational hubs for oil spill response activities in their respective regions. The OSRS map along with oil spill advisories provide critical input to incident commanders, enabling them to assess the situation accurately, monitor the spill's progression, and make informed decisions regarding response strategies, resource allocation, and operational priorities. However, the availability of accurate and real-time information enhances the overall effectiveness of incident management.

Keywords: Response, Strategies, pollution, spills, maps

[ABS-0047]

LINKING EARLY WARNING TO FIELD ACTION IN POLLUTION RESPONSE: LESSONS FROM NURDLE SPILLAGE RESPONSE OFF THE KERALA COAST

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On 24 May 2025, the Indian Coast Guard (ICG) and the Kerala State Disaster Management Authority (KSDMA) reported the capsizing of the Liberian-flagged container ship MSC ELSA 3 enroute from Vizhinjam to Kochi Port, raising concerns of nurdle (plastic resin pellet) spillage along the coasts of Kerala. Nurdles, owing to their persistence and similarity to fish eggs, pose significant risks to marine ecosystems, food webs, and coastal livelihoods. To address this emerging challenge, the Indian National Centre for Ocean Information Services (INCOIS)

employed its spill trajectory prediction system to simulate the drift and dispersion of nurdle particles. These forecasts guided targeted field surveys and enabled dissemination of actionable advisories to stakeholders, facilitating early preparedness and response. The present study demonstrates the novelty and utility of integrating predictive modeling with ground validation for managing unconventional marine pollution events. It also illustrates how forecasting and dissemination frameworks for nurdle spillages is vital, as they can identify the likely zones that are going to be affected. By presenting the simulation of nurdle drift patterns, their validation through observed beaching events, and the subsequent issuance of advisories, this work highlights a replicable framework for proactive response, improved disaster preparedness, and the safeguarding of coastal ecosystems.

Keywords: Pollution, hazards, nurdles, spillage, response, survey

[ABS-0050]

RECEIVER FUNCTION ANALYSIS AND H-K STACKING FOR CRUSTAL STUDIES IN THE DELHI REGION

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The Delhi region is marked by complex tectonics and thick sedimentary cover. The region's limited crustal and Moho study remains debated among the geophysical explorers. Further, the recent earthquake in Delhi and its proximity proved that understanding the crustal structure beneath this area is crucial for both geodynamic models and seismic hazard studies. Receiver function (RF) analysis provides a robust means of probing subsurface discontinuities by utilizing P-to-S converted phases from teleseismic events. Further, use of Hï ½K stacking constrains crustal thickness (H) and the Vp/Vs ratio (Îº), which are key parameters for imaging the Moho and characterizing crustal composition. In this study, broadband teleseismic data from stations in and around Delhi are utilized to generate receiver functions and estimate crustal thickness and Poisson's ratio. Waveforms from events in the 30ï ½ï ½90ï ½ epicentral distance range are used, and weighting strategies are applied to reduce trade-offs between H and Îº. The Hï ½K stackin

Keywords: Receiver Functions; H-K Stacking; Crustal Thickness; Delhi Region Seismotectonics.

[ABS-0056]

SEASONAL AND SPATIAL VARIATIONS IN GEOCHEMICAL FRACTIONATION OF HEAVY METALS (NI, CR, PB, & CU) IN COASTAL SEDIMENTS OF THE CENTRAL AND SOUTH-WEST COAST OF INDIA

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Heavy metals in coastal sediments pose significant ecological risks due to their persistence and potential bioavailability. This study investigates the seasonal and spatial variations in the

distribution and geochemical fractionation of nickel (Ni), chromium (Cr), lead (Pb), and copper (Cu) in sediments from off the coast of Kochi and off the coast of Goa, along the central and southwest coasts of India. Sampling was conducted during the post-southwest monsoon (September 2022), northeast monsoon (December 2022), and spring inter-monsoon (March 2023) seasons. Physicochemical parameters (TC, TIC, TN, pH, salinity, and temperature) and sediment texture (sand, silt, and clay) were evaluated to understand their role in metal enrichment. Sequential extraction followed by ICPMS analysis (recoveries: Ni 105%, Cu 105%, Pb 104%, Cr 97.4%) showed that Ni, Cu, and Cr were predominantly associated with organic matter, whereas Pb was mainly confined to the residual fraction. Seasonal differences were more pronounced in Goa, particularly post southwest monsoon, where metals followed the order (Fraction: Fr) Fr4 > Fr3 > Fr2 > Fr1. Total concentrations at several sites approached or exceeded the Effect Range Median (ERM) values. Correlation analysis revealed strong associations between metals, organic matter, and nitrogen under aerobic conditions. While Ni, Cu, and Pb showed affinity for finer silt and clay fractions, Cr was preferentially linked to sand. These findings highlight the influence of organic matter and sediment texture on metal binding and underscore the need for continuous monitoring to assess long-term impacts.

Keywords: Heavy metals; Fractionation; Seasonal variability; Coastal sediments; Central west; and coast of India

[ABS-0059]

FRACTAL ANALYSIS OF THE DAUKI FAULT

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The Dauki Fault, which defines the southern boundary of the Shillong Plateau in Meghalaya, is one of the most prominent tectonic features in northeast India. Its activity has long been debated, making it an important focus for both understanding regional geodynamics and assessing seismic hazards. In this study, I use fractal analysis to explore the spatial, temporal, and magnitude distribution of earthquakes along the Dauki Fault zone, drawing on data from multiple open-source earthquake catalogues. To examine spatial patterns of seismicity, I applied both the correlation integral and box-counting methods to calculate the fractal dimension (D). The correlation dimension for the study area is about 1.33, suggesting that earthquakes are not randomly dispersed but tend to cluster along linear structures such as the main fault and associated fractures. At the same time, the value indicates some spreading around the primary fault line, reflecting the fault s complex geometry. The magnitude distribution was evaluated using the Gutenberg Richter relation, which produced a b-value of 1.16. Since this is greater than one, it shows that smaller earthquakes occur more frequently than larger ones, pointing to ongoing stress release within the fault system. Such values are typical of moderately active, heterogeneous faults. These results are consistent with earlier studies of similar fault systems, which have linked b-values above one to active deformation and fault complexity. Together, the spatial clustering, magnitude distribution, and temporal

decay reveal that the Dauki Fault is both active and structurally complex. The integrated use of fractal analysis, b-value estimation, and aftershock modeling offers a clearer picture of the fault s dynamic behavior. These findings not only support earlier observations of fault activity but also highlight the Dauki Fault s importance for evaluating seismic hazards in northeast India.

Keywords: Fractal analysis, Dauki fault, fractal dimension, b-value, Correlation integration, Box counting

[ABS-0061]

MACHINE LEARNING BASED LANDSLIDE SUSCEPTIBILITY ASSESSMENT OF WAYANAD PLATEAU IN SOUTHERN PENINSULA, INDIA

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The Western Ghats, a globally recognized biodiversity hotspot, has recently experienced escalating environmental stress due to urban expansion, terrain modifications, and intensifying rainfall variability. The eastern escarpment of Wayanad district in Kerala has emerged as a critical zone, where recurrent landslides between 2018 and 2024 culminated in a catastrophic event in 2024 that triggered a Landslide Lake Outburst Flood (LLOF), causing severe loss of life and property. To address the urgent need for systematic risk evaluation, this study applies a machine-learning framework to generate a detailed landslide susceptibility map for the region. A spatial inventory of over 260 past landslide occurrences was integrated with twelve conditioning factors, including lithology, soil characteristics, topography, hydrological indices, land use/land cover, and proximity to linear features. The Random Forest (RF) algorithm, optimized through grid search and validated with five-fold cross-validation, was employed to capture the complex relationships between landslides and geo-environmental drivers. Model performance was evaluated using multiple statistical indicators, including root mean square error (RMSE), log loss, receiver operating characteristic (ROC) curves, and confusion matrix metrics. The RF model demonstrated strong predictive capability, with an AUC of 0.911 for training and 0.85 for independent validation, though minor overfitting was observed. Importantly, the susceptibility map successfully delineated the recent Wayanad landslide site as a high-risk zone, highlighting the model s practical relevance. These findings underscore the potential of data-driven approaches for guiding hazard preparedness, land-use regulation, and long-term disaster resilience in vulnerable mountain environments.

Keywords: Landslide Susceptibility Assessment, Machine Learning, Wayanad Plateau, Southern Peninsula, India

[ABS-0062]

REGIONAL VARIABILITY OF SEISMIC WAVE ATTENUATION IN THE NORTHWESTERN HIMALAYA: IMPLICATIONS FOR SEISMIC HAZARD

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The North-west (NW) Himalaya, extending west of the Kali River and encompassing Uttarakhand, Himachal Pradesh, and the Kashmir Himalaya, is one of the most seismically active regions of the Indian subcontinent. In this study, attenuation characteristics are quantified for four sectors: (1) Kumaon, (2) Garhwal, (3) Himachal, and (4) Kashmir Himalaya. The coda normalization method is used to calculate frequency-dependent P-wave (Qp(f)) and S-wave (Qs(f)) quality factor. Attenuation parameters are obtained at 28 seismic stations. A consistent dataset and similar methodology applied across all sectors highlight the novelty of this work. The Qp(f) and Qs(f) values obtained at each station are used to determine a regional relationship for each sector of the form Q = Qof n, where Qo and n vary between 34 45 and 0.90 1.16 for P-waves, and between 58 74 and 0.87 1.10 for S-waves, respectively. The low Qo (<200) and high n (>0.8) indicate strong heterogeneity and high seismic activity, consistent with active plate-boundary regions. Regional relations established for each sector are further integrated to obtain regional relations for the NW Himalaya as Qp(f) = (38±1) f (1.03±0.02) and Qs(f) = (65±2) f (1.02±0.01). Among the sectors considered in this work, Kashmir and Kumaon exhibit lower quality factors, implying higher attenuation compared to Himachal and Garhwal, as Q is inversely proportional to the attenuation properties. High attenuation in the Kashmir Himalaya is attributed to the presence of sediments/alluvium within the Kashmir basin, while in Kumaon, it may be due to the presence of partial fluid saturation at shallow depths. In contrast, Himachal and Garhwal are characterized by relatively less attenuating crust, suggesting higher seismic hazard potential than the Kashmir and Kumaon sectors. This study delineates attenuation patterns across the NW Himalaya, providing key inputs for seismic hazard assessment, source parameter estimation, and ground-motion simulation.

Keywords: Himalaya, Earthquake, Attenuation, Quality factor, Seismic Hazard

[ABS-0063]

SOIL PROFILES MEET EXPLAINABLE AI: A CATENA-BASED APPROACH TO IMPROVING LANDSLIDE PREDICTION

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Landslides are influenced by multiple geo-environmental factors, yet most machine-learning based susceptibility models primarily depend on DEM-derived topographic variables, leaving the contribution of depth-wise soil properties underexplored. This study incorporates soil geotechnical and hydrological properties at multiple depths into landslide susceptibility modelling, employing Random Forest (RF) combined with SHAP-based Explainable AI (XAI) to enhance model transparency and interpretability. The research was conducted in the

Muthirapuzha River Basin (MRB), Southern Western Ghats, India, using both grid-based and slope unit (SU)-based mapping units. Findings show that depth-wise soil parameters substantially improve model accuracy and mitigate overestimation compared to models using only surface or topographic variables. Key predictors included Field Capacity (FCY), Chemical Index of Alteration (CIA), Liquid Limit (LLT), and Unsaturated Hydraulic Conductivity, along with topographic factors such as slope angle and Topographic Wetness Index (TWI). SU-based models outperformed grid-based ones in AUROC and offered deeper insights into landslide depth and volume. SHAP values and waterfall plots effectively explained model outputs and provided site-specific insights, demonstrating their utility for landslide risk assessment. The consistent ranking of predictor importance across mapping units further supports the robustness of the selected variables. Overall, this study highlights the significance of incorporating depth-wise soil parameters in landslide susceptibility modelling and advocates for SHAP-based XAI methods to strengthen model transparency and applicability, particularly in tropical mountainous regions.

Keywords: Landslides, Explainable AI, Soil parameters, Western Ghats, Kerala, India

[ABS-0064]

TEMPORAL ANALYSIS OF THERMAL ANOMALY FOR BARREN ISLAND USING THE SPACEBORNE THERMAL INFRARED BANDS OF ASTER (ADVANCED SPACEBORNE THERMAL EMISSION AND REFLECTION RADIOMETER) TIR (THERMAL INFRARED) DATA

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Barren Island, located ~138 km northeast of Port Blair in the Andaman Sea, is the only active volcano in India and provides a natural laboratory for thermal monitoring using remote sensing. This study evaluates its thermal anomalies through Land Surface Temperature (LST) retrieval from ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) TIR (Thermal Infrared) data for the period 2022-2024. LST estimation requires careful consideration of radiometric and atmospheric parameters, and spatial variations are influenced by vegetation cover, lava deposits, and geomorphology. In 2022, LST values ranged from ~18.7°C to 45.7°C across February December, with higher anomalies consistently observed in the northern sector and lower values in vegetated southern areas. A circular anomalous zone was detected in the northeastern part during July. In 2023, LST varied between ~15.7°C and 82.5°C, with unusually high values recorded in February and April, possibly linked to unrecognized triggering events. In 2024, data from January to August indicated temperatures spanning ~4.9°C to 48.9°C, continuing the observed spatial pattern of high anomalies near the eruption center. These results highlight the spatiotemporal variability of thermal activity at Barren Island and its significance for monitoring active volcanic systems. Such thermal anomalies are not only critical for hazard monitoring as they provide early-warning indicators of eruptive phases but also highlight the geothermal potential of the Andaman arc system. The persistent heat signatures suggest a shallow magmatic or hydrothermal source that could be

harnessed for clean energy in the long term, subject to feasibility and environmental considerations.Satellite-based LST analysis offers critical insights where in-situ observations are limited and supports future efforts to investigate subsurface processes controlling eruptions.

Keywords: Land Surface Temperature (LST), Barren Island, Thermal Infrared, Volcanic Monitoring, ASTER

[ABS-0072]

COUPLING GEOSTATISTICS AND MACHINE LEARNING FOR REGIONALIZED CLASSIFICATION OF LAND USE AND ROCK TYPES FROM SOIL GEOCHEMICAL DATA

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This work deals with the regionalized classification of 10 lithological rock types and 10 land use/land cover (LULC) categories from the data of continuous features (concentration of 63 chemical elements and oxides in stream sediments from adjoining districts of Assam and Meghalaya) by means of a supervised ensemble learning algorithm, namely random forest. The novelty of our proposal is the deployment of a complementary set of features (ï ½proxiesï ½) at the sampled data points, calculated ingeniously by means of geostatistical techniques: (1) leave-one-out cross-validation (LOOCV), and (2) ordinary point cokriging with nugget-variance-filtering (for removing the short-scale spatial variation). Kriging or cokriging leverages the spatial correlation structure (variogram) but has limited capacity to incorporate the non-linear effects of environmental covariates (such as land use, lithology, etc.) on soil properties, which restricts high-precision prediction. In contrast, machine learning (ML) captures the quantitative relationship between soil properties and features derived from environmental covariates for predictive modelling, but cannot leverage the variogram, as it considers spatial data to be independent. This work highlights the importance of leveraging the strengths of geostatistical and ML approaches to ensure robust categorical data classification and spatial prediction of soil heavy metal content. We perform the cleaning and preparation of data of 4309 data points, provided by the Geological Survey of India (NGCM program) and accessible in the Bhukosh portal. We also added the LULC categories and the rock types to the data points. Compared to the traditional approach where rock types and LULC types are predicted from only the measured features, the random forest classifier that additionally uses the geostatistical proxies provides better performance scores (accuracy rate and Cohenï ½s kappa for measured features in combination with the geostatistical proxies are 92.61% and 0.9254 respectively, against the accuracy rate = 82.02% and Cohenï ½s kappa = 0.7854 for the traditional approach).

Keywords: Geostatistics, Machine Learning, Regionalized Data, LandUse/LandCover, Kriging

[ABS-0074]

W- PHASE CENTROID MOMENT TENSOR INVERSION OF THE 29th JULY 2025 KAMCHATKA EARTHQUAKE: CONSTRAINTS FROM VERY-LONG PERIOD WAVES

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The W-phase provides a very-long-period (100 1000 s) window for rapid, stable source characterization of great earthquakes. We analyze the 29 July 2025 Kamchatka megathrust event, where the Pacific Plate subducts obliquely beneath the Okhotsk Plate along the Kuril Kamchatka margin. We perform a manually supervised W-phase centroid moment tensor inversion of three-component teleseismic records from 12 long-period FDSN stations, filtered to 0.001 0.005 Hz. Synthetics are generated from a Pyrocko Green s-function store using a spherical-Earth normal-mode approach with the ak135-f velocity model. Source-time functions are half-sinusoids with duration treated as a parameter searched from 50 to 600 s. The best-fitting W-phase solution indicates a great (Mw 8.82) oblique-reverse, near double couple source on the plate interface, with seismic moment $M_0 \approx 2.2 \times 10^{22}$ N·m, a shallow centroid at 19 km depth, a 113 s centroid-time delay relative to origin time, and a total effective source-time duration of 155 s; the Mw is consistent with the USGS estimate. The centroid is at about 19 km depth and located approximately 244 km to the SSW (azimuth 211°) of the hypocenter broadly trench-parallel indicating a predominantly along-strike bias in moment release inferred from the W-phase CMT. Coherent very-long-period fits across the network with ensemble behavior showing tight well-constrained Mw and no required non-DC component. This study provides results with robust constraints for subsequent finite-fault and first-order tsunami modeling.

Keywords: cmt,w-phase,kamchatka,earthquake

[ABS-0076]

DECIPHERING METASOMATISM AND SEISMIC QUIESCENCE: IMPLICATIONS FOR INTRAPLATE EARTHQUAKES IN THE DHARWAR CRATON

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The Dharwar Craton in southern India, one of the oldest Archean continental blocks, has long been viewed as geologically stable. Yet, seismic observations from the region reveal alternating phases of quiet intervals and bursts of intraplate earthquakes. These patterns of seismic quiescence and reactivation point toward a more dynamic lithosphere than previously assumed. One mechanism that may explain this behavior is lithospheric metasomatism, where fluids or melts infiltrate the mantle root, altering its composition and reducing its mechanical strength. This study explores the relationship between metasomatic modification of the lithosphere and the occurrence of seismic quiescence in the Dharwar Craton. Seismological techniques

including receiver function analysis, shear-wave splitting, and tomography are applied to characterize crustal and mantle structures. In parallel, isotopic and trace-element data from xenoliths and volcanic rocks are evaluated to detect metasomatic signatures. Comparative results suggest that the Western Dharwar Craton maintains a thick and rigid lithosphere, sustaining long periods of quiescence, while the Eastern Dharwar Craton is underlain by thinner, chemically modified lithosphere that experiences episodic quiet phases interrupted by localized earthquake clusters. By integrating seismic imaging with geochemical evidence, this work highlights how metasomatism contributes to weakening cratonic lithosphere and influences cycles of quiescence and intraplate seismicity. The findings provide new insights into stress accumulation and release in continental interiors, with implications for seismic hazard assessment in regions traditionally considered stable.

Keywords: Seismology Seismotectonics Intraplate seismicity Archean cratons Dharwar Craton Seismic quiescence Lithospheric metasomatism Earthquake hazard assessment

[ABS-00P2]

LANDSLIDE SUSCEPTIBILITY ANALYSIS ALONG THE NATIONAL HIGHWAY (NH)-2 IN THE WOKHA-MOKOKCHUNG REGION, NAGALAND: AN AI-ENHANCED GEOSPATIAL APPROACH

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The Wokha-Mokokchung region along the National Highway (NH)-2 in Nagaland is highly prone to landslides due to its complex geology, rugged topography, and intense monsoonal rainfall. The area lies within Seismic Zone V and comes under the Disang Formation, comprising highly weathered shales, siltstones, and sandstones. Structural weaknesses, represented by extensive thrusts and faults, aggravate slope instability in this region. Combined with steep gradients and annual precipitation of ~2000 4000 mm, these factors result in recurrent slope failures that disrupt regional connectivity and pose significant hazards. The study introduces an AI-enhanced geospatial framework that integrates machine learning with traditional parameters such as topography, hydrology, geology, environment, rainfall intensity, and anthropogenic influences. The Random Forest (RF) algorithm, known for its ability to process high-dimensional geospatial data, demonstrates superior predictive accuracy compared to conventional statistical methods. This study presents an AI (Random Forest)-enhanced geospatial framework for landslide susceptibility mapping along NH-2, which combines traditional conditioning parameters with the superior predictive performance and interpretability of this ensemble learning algorithm. The proposed framework generates high-resolution landslide susceptibility maps, which are rigorously validated through statistical measures including ROC AUC analysis, precision recall curves, and field verification during accessible seasons. Beyond methodological advancement, the study highlights the practical way of combining conventional geoscientific knowledge with modern AI techniques for systematic landslide risk assessment. The outcomes have direct relevance for hazard mitigation and regional planning in the northeastern Himalaya.

Keywords: Landslide, Wokha-Mokokchung, Random Forest

[ABS-0094]

THE PROCESSING AND ANALYSIS OF MAGNETOTELLURIC DATA BENEATH THE TECTONICALLY ACTIVE SHILLONG PLATEAU, INDIA

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The Shillong plateau, also known as the Meghalaya plateau, is one of the highly seismically active regions, spanning an area of approximately 25,000 km^2. It is composed of Archean gneissic basement rocks, indicated by a high Bouguer anomaly. The structure lies between the Himalayan collision zone to the north and the Indo-Burmese subduction zone to the east. As a result, it experiences significant tectonic forces from both directions, which have contributed to its uplift since the Tertiary period. Tectonically, it is bounded by the Dauki fault to the south, the Brahmaputra fault system to the north, the Kopili fault to the East, and the Dhubri fault to the west. The geoelectrical properties of this region were investigated using the magnetotelluric method (MT), where broadband data were acquired at 16 stations and long-period data at 7 stations. The profile crossed two faults, namely the Dudhnoi Fault and the Oldham Fault, with the epicentre of the 1897 Shillong earthquake, which had elevated the plateau by approximately 10 meters. Most seismic activities in the region are confined to depths of 35 km, extending to 45-50 km. The processing of the MT data was performed using MAPROS and SigMT for Broadband and Geomag for the LMT data, as well as with Russian PRC_MTMV and EPI-Kit software. The sounding curves showed lower resistivity values (between 10 - 1 ohm-m) on some stations along the profiles. Thus, the need to analyse the dimensionality and directionality became crucial for the interpretation. The swift skew was somewhat effective for interpretation, but the Bahr skew showed predominantly a 3D nature, with some 1D and 2D behaviours (mostly in higher frequencies). The phase tensor skew value is abnormally high ($\hat{I}^2$=10) at stations near or beneath the Oldham fault and Dudhnoi fault, suggesting their presence. The strike directions also vary near the faults and at some other stations, indicating the complexity of the region, and would require further modelling to examine them.

Keywords: Shillong plateau, Oldham fault, Magnetotelluric method, Dimensionality and directionality

[ABS-0098]

SITE AMPLIFICATION STUDY USING THE INDIAN STRONG MOTION NETWORK FROM THE EARTHQUAKE OCCURRED IN HIMALAYAN REGION

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This study investigates site amplification phenomena across the northern India using strong motion recordings from the National Centre of Seismology (NCS) Strong Motion Network, with a particular focus on seismic events in the western and eastern Himalayan regions. Earthquakes used in the present study ranges from moderate events of M > 5 to large Himalayan shocks of M ~ 6-7.5 including Nepal and Manipur events and important regional earthquakes. We have utilized horizontal-to-vertical spectral ratio (HVSR) method to analyse data from multiple stations spread across Indian subcontinent deployed on soft and hard geological formations spanning the foothills of the Himalayas-including sites in Indo-Gangetic and Brahmaputra plains, cratonic region of central India and Deccan traps of south-western India. The findings demonstrate a strong connection between subsurface geology, dominant frequency and amplification of seismic waves particularly influenced by sediment thickness, lithology and impedance contrasts. Thick alluvial deposits such as those near the Indo-Gangetic plains, predominantly amplify low-frequency ground motions while stiff hard rock formations including sites like SMLA (Simla), SHL (Shillong) and KOHI (Kohima) resonate at higher frequencies. Analyses of both far field events and near field events states that soft soil sites like Bhopal, Hyderabad, Jorhat, Itanagar, Tezpur, Goa and Bhuj amplify low to mid frequencies as compared to hard rock stations deployed at Himalaya foothills. Integrating these empirically derived site amplification functions into ground motion prediction models enhances seismic hazard assessments and strengthens earthquake resilience strategies across India s diverse geological settings.

Keywords: Site amplification, Predominant Frequency, Strong Motion Network (NCS), Subsurface Geology, HVSR.

[ABS-0099]

ESTIMATION OF EARTHQUAKE MAGNITUDES FROM IONOSPHERIC PERTURBATIONS USING EMPIRICAL METHOD

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Co-seismic ionospheric perturbations (CIP), observed near the earthquake epicenter, provide insights into the underlying earthquake source processes. The amplitude of these near-field CIPs (within ~500-600 km of the epicenter) is mainly controlled by seismic parameters, such as earthquake magnitude and depth. Nevertheless, non-seismic factors including the geomagnetic field, background ionospheric electron density, and satellite-receiver geometry

also significantly influence the manifestation of CIP at ionospheric altitudes. Using GNSS-derived Total Electron Content (TEC) data, we identified the CIP for 75 global earthquakes (Mw >6.4, depth < 110 km) that occurred between 2000 and 2024. The present study aims to systematically investigate the individual and combined effects of both seismic and non-seismic parameters in controlling CIP amplitudes. To achieve this, we developed an empirical relationship that combines both seismic and non-seismic parameters to reconstruct CIP amplitudes using an iterative least-squares curve-fitting approach. This formulation allows for a quantitative assessment of the relative contributions of each factor to CIP generation. Our analysis reveals that earthquake magnitude, satellite geometry, background ionospheric electron density, and geomagnetic field exert a positive influence on CIP amplitudes, enhancing their strength, whereas focal depth and ionospheric pierce point (IPP) distance act as limiting factors, reducing the observed perturbation. Leveraging this relationship, we demonstrate the capability to estimate earthquake magnitude (Mw) directly from observed CIP amplitudes. The method provides magnitude estimates with an uncertainty of 0.3, reflecting robust predictive accuracy. Validation against five independent earthquakes, spanning different magnitudes and tectonic settings, confirmed that the estimates consistently fell within this uncertainty range. Overall, the study highlights the potential of ionospheric measurements for earthquake monitoring. The ability to estimate earthquake magnitudes from ionospheric data represents a step forward in ionospheric seismology, opening new opportunities for integrating space-based observations into earthquake science.

Keywords: Empirical model, reconstructed CIP, earthquake, Ionospheric perturbation, Magnitude estimation, GNSS-TEC

[ABS-0102]

SPATIO-TEMPORAL ASSESSMENT OF SEISMIC ACTIVITY IN NW HIMALAYA J&K BASED ON B-VALUE ,P-VALUE AND Z-VALUE ANALYSIS

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The research focuses on understanding earthquake behavior in the northwestern Himalaya, covering Jammu & Kashmir, Zanskar, and Kishtwar between 33Â°â 37Â° N and 72Â°â 80Â° E. Using data from NCSâ MoES, USGS, ISC, and GCMT between 1900â 2024, about 9700 earthquakes (M â ¥ 1.5) were analyzed. The b-value was used to study the frequencyâ magnitude relation, and the area was grouped into three segmentsâ Block A (Kashmir), Block B (Zanskar), and Block C (Kishtwar). The 2005 Kashmir, 2013 Jangalwar, and 2023 Doda earthquakes were examined to calculate aftershock decay (p-value) and seismicity rate change (z-value). Results show b-values between 0.62 and 0.93, indicating differences in stress and tectonic activity. The Kashmir and Kishtwar blocks, with lower b-values, show higher stress build-up and the potential for future strong earthquakes. Seismic activity is mainly controlled by the interaction between the Karakoram, Pir Panjal, and Shivalik ranges, and deep-seated fault systems. The observations highlight that this region behaves as a tectonically active

foreland zone near a convergent margin, where varying b-values reflect complex stress accumulation and crustal deformation processes.

Keywords: Seismicity, spatiotemporal, p value, b value and z value

[ABS-0104]

IDENTIFICATION OF LANDSLIDE-GENERATED SEISMIC SIGNALS: CASE STUDIES FROM ARUNACHAL PRADESH, NORTHEAST INDIA

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Landslides are identified as one of the world s most dangerous natural hazards due to their potential to cause immense threat to life and infrastructure. Spatio-temporal information of mass flow processes like landslides, rockslides, avalanches, etc is of utmost importance for disaster management and mitigation. Prediction of such events are not possible, however, an early-warning may be generated for downslope regions of an imminent threat. The rapid analysis and assessment of the event is critical for generating early warning. However, traditional methods like optical imagery and field investigations are time-consuming and do not provide the necessary temporal resolution to generate warning. Recent studies show that seismological signals from dense seismic networks is a plausible option in this regard. Although, seismic signals provide high temporal resolution, it is not straightforward to identify seismic signals of landslides because of the lack of sharp onset and absence of body-wave arrivals in their records as compared to events like earthquakes. In this study, we attempt to identify seismic signals of a few landslides using a local network of broadband seismological stations. This type of analysis is novel and is being carried out for the first time in Arunachal Pradesh. In 2022, CSIR-NGRI established a network of broadband seismic network in Itanagar with inter-station spacing of ~3 km. We utilized this data to analyze and identify seismic signals of landslides in the vicinity of the network during 2022-2023. By analyzing continuous time-series and spectrogram analysis, the landslides signals could be identified. In general, landslide energy appear as spindle-shaped in the spectrogram, compared to triangular-shaped for earthquakes. The landslides are located by a noise-correlation based source migration method. The analysis shows that the density of seismic stations is very critical for accurate location of the landslides.

Keywords: landslides, spectrogram, location

[ABS-0110]

HIGH-FREQUENCY DECAY PARAMETER (κ) ACROSS DELHI NCR REGIONÏ ½ ROLE OF LOCAL GEOLOGY AND SOIL CONDITIONS.

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This study investigates the influence of kappa (κ) for Delhi and its surrounding regions. Path, as well as site dependent components of κ, are calculated from the available strong motion database. The estimated κ value using the NS component (κ_N) ranges from 0.007 to 0.087s (±0.0001 to 0.029), while the EW component (κ_E) ranges from 0.013 to 0.099s (±0.001 to 0.058). The κ_{Avg} and κ_o values for the study region are in the range of 0.015 to 0.093s (±0.0005-0.003) and 0.002 to 0.040s (± 0.0001-0.0002) respectively. The estimated κ values varied across sites and within sites in the study region highlighting the level of lateral crustal heterogeneities. No significant statistical relationship of κ with earthquake source was observed whereas the epicentral or hypocentral distances does not significantly affect the κ_o calculation for the study region. We also examined the seismic stations for V_{s30} and f_o of HVSR as these metrics provided insights into the soil properties at the seismic stations. κ exhibits inverse correlation with V_{s30} and f_o emphasizing the significant influence of the soil properties, bedrock depth, and sub-surface geology. The results indicate that hard sites (Class B) situated on Proterozoic meta-sedimentary rocks exhibit lower κ_o values than soft sites (Class D and E) located on Quaternary alluvial deposits. High values of κ_o also observed for the stations lie near the Yamuna River due to the presence of soft sediment deposits. These soft sediments exhibit higher levels of damping and energy dissipation at high frequency during the earthquake. The hard sites close to different tectonic features show comparatively high κ_o that may be attributed to the existence of micro-fracture and degree of erosion. This study represents the first comprehensive investigation into site-specific κ values in this region, focusing on how seismotectonic and geological structures influence kappa across an extensive region. By analysing these factors, the research aims to enhance our understanding of κ variability and its implications for regional seismic assessments, and the development of ground motion models for the study region.

Keywords: Kappa(Îº), Fundamental frequency(fo), Delhi and surrounding region, Site amplification.

[ABS-0112]

INTENSITY PREDICTION IN THE HIMALAYAN REGION USING STATISTICAL AND ARTIFICIAL NEURAL NETWORK TECHNIQUE

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A limited intensity information of the pre-instrumental and early instrumental era earthquakes is a hindrance to understand the effect of these earthquakes on construction elements/buildings and precise assessment of their magnitudes. An effort has been made to predict intensity using

hypocentral distance and magnitude of the pre-instrumental and early instrumental era earthquakes utilising 24 earthquakes of magnitude 6.1 to 8.2, hypocentral distance 10 km to 2128 km having sample strength of 2183 recent earthquake intensity data. The study has been conducted on NW Himalayas, NE Himalayas and Central Himalayan region using Multi Variate Linear Regression technique by validating almost 75% (1743 samples) of the datasets with the 25% (440 samples) unused data. In the present study, the relation has been derived to predict the intensity based on magnitudes at different hypocentral distances using the multi-variate linear regression technique. The multi-layer perceptron (ANN) technique has been used on the derived prediction equation to verify the authenticity of the prediction equation for the intensity. The ANN technique established the verification of the prediction equation with R2 value of 0.67 (for Central Himalayan region), 0.58 (for NW Himalayan region) and 0.69 (for NE Himalayan region). The validation process strengthens the results and assurance as well as robustness of the developed equation for predicting the intensity of the pre-instrumental and early instrumental era earthquakes with root mean square error of 0.9 (for NW Himalayan region), 1.19 (for NE Himalayan region) and 0.7 (for Central Himalayan region).

Keywords: Intensity, MLR, Magnitude, Hypocentral distance, ANN

[ABS-0118]

HOMOGENIZING EARTHQUAKE CATALOGUES WITH EVALUATION OF SEISMIC TRENDS FOR ENHANCED SEISMIC HAZARD EVALUATION IN THE EASTERN HIMALAYAN SYNTAXIS

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Earthquake magnitude conversions are crucial for creating homogeneous catalogues to assess seismic hazard in the Eastern Himalaya Syntaxis (EHS), a seismically active region marked by the catastrophic 1950 Great Assam earthquake (MW 8.6). However, magnitude scales (Mb, MS, ML, MW) remain inconsistent across different reporting agencies, necessitating standardized conversion relationships among different magnitude scales. This study develops magnitude conversion equations for the Eastern Himalayan Syntaxis using seismic data from the International Seismological Centre (ISC, 1906 2025), United States Geological Survey (USGS, 1929 2025), and Global Centroid Moment Tensor catalogue (GCMT, 1985 2024). Various regression techniques, such as Standard Least Squares (SLS), Inverse Least Squares (ILS), Standard Orthogonal Regression (SOR), and General Orthogonal Regression (GOR), are evaluated to determine the best conversion relationships. A notable methodological advancement is presented here with the application of singular value decomposition (SVD) for general orthogonal regression, moving away from the traditional analytical method. Key findings demonstrate robust correlation e.g., for 312 ISC-USGS events, Mb,USGS=0.82*Mb,ISC+0.87 (GOR: λ=0.8, R2= 0.80, σ=0.17) and for 48 events Mw,USGS=0.79*Ms,ISC+1.359 (GOR: λ=0.9, R2= 0.91, σ=0.16). Despite challenges from data limitations and regional tectonic variability, these equations provide a vital tool for seismic studies. When this study emphasizes on homogenization of the seismic events, we also

concentrate to identify the seismic potential zones for hazard estimation by measuring the Gutenberg-Richter relationship throughout the EHS. Our preliminary b-value analyses reveal spatial variations throughout the EHS, suggesting western EHS more potential for hazard scenario compared to the eastern part. This study continues to refine magnitude conversions and b-value estimates, significantly enhancing the precision of seismic hazard assessments in the Eastern Himalayan Syntaxis.

Keywords: Eastern Himalayan Syntaxis, General Orthogonal Regression, Gutenberg-Richter Relationship, Seismicity, Magnitude Homogenization

[ABS-0119]

GEOCHEMICAL CHARACTERIZATION OF IRON-RICH GROUNDWATER OF DHEMAJI DISTRICT, ASSAM: IMPLICATIONS FOR WATER QUALITY AND PUBLIC HEALTH

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Groundwater is a vital resource for domestic and agricultural use in Dhemaji district, Assam, yet its quality is often influenced by underlying geochemical processes. This study presents a geochemical assessment of 16 groundwater samples, with a focusing on iron enrichment and its implications for water quality and public health. Samples were analyzed for pH, temperature, total dissolved solids (TDS), major anions (Cl^-, NO_3^-, SO_4^{2-}), major cations (Ca^{2+}, Mg^{2+}), total hardness and iron (Fe) content. Results show that pH values range from 6.43 to 7.62 and TDS from 16.3 to 434 mg/L, indicating spatial variability in groundwater mineralization. Iron concentrations exhibited significant variation (0.15-69.36 mg/L), indicating localized geogenic enrichment. Total hardness ranged from 50 to 655 mg/L, classifying soft to very hard water. Elevated iron in several areas poses potential health risks, including concerns from long-term exposure liver and heart damage, diabetes, and joint pain. Spatial patterns suggest that groundwater quality is controlled by both natural geochemistry and local hydrogeological settings as Quaternary alluvial sediments and piedmont deposits. These findings provide a baseline for sustainable water resource management, highlighting the need for targeted monitoring, mitigation strategies and public awareness initiatives. The study underscores the importance of integrating geochemical insights into water quality management and public health planning, especially in iron-affected regions of Assam.

Keywords: Groundwater, iron contamination, geochemical assessment, water quality, Dhemaji District, Assam

[ABS-0124]

GEODETIC SIGNATURE OF POST- SEISMIC DEFORMATION OF THE 2004 SUMATRA- ANDAMAN MEGATHRUST

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The 2004 Sumatra-Andaman megathrust Mw 9.2 has ruptured a very long segment (~1400 km) of subduction zone and generated a tsunami with a very high tsunami wave that caused numerous casualties and devastated the region. The earthquake has released a tremendous amount of strain energy that is accumulated over centuries along the India- Eurasian subduction plate boundary. The sudden energy release perturbed the deep-seated ductile zone of the upper mantle, causing a prolonged phase of post-seismic deformation in the region. INCOIS has been operating more than 30 GNSS networks in the Andaman-Nicobar Islands for the improvement of early warnings for tsunamis for the past decade. Using GAMIT-GLOBK software we have processed and analysed the GNSS data and observed a significant post-seismic deformation in most of the stations. Even after two decades, the motion at stations has not reached the interseismic plate motion rates. To quantify the present day plate motion rates we estimated the exponential decay parameter for all three components of surface displacement, which is strongly influenced by the viscosity of the upper mantle, using an analytical approach. For this, a constant interseismic motion, reported at Port Blair by Jade (2004) before the occurrence of megathrust, has been assumed at all stations located in the Andaman-Nicobar Islands. A least-square approach was used for a range of characteristic timescales that varied from 0.1 to 100 years to calculate the best-fit parameter value. Our analysis suggests that the value of the characteristic timescale of the decay varies from 4 to 20 years. The smaller value of the decay timescale better explains the early phase of post-seismic deformation, and the larger value of it provides a better fit to explain the later phase of post-seismic deformation.

Keywords: Plate motion, 2004 Sumatra - Andaman earthquake, postseismic deformation

[ABS-0125]

SEISMIC STRUCTURE OF MYANMAR: IMPLICATIONS FOR CRUSTAL STRUCTURE AND TSUNAMI HAZARDS

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On 28 March 2025, a Mw 7.7 earthquake, followed by a Mw 6.7 aftershock, struck the tectonically complex Indo-Burma subduction zone at a shallow depth of 10 km. Surface wave tomography (SWT) based on Rayleigh wave dispersion (RWD) was applied to earthquake events (≥ M5.5) recorded by 46 IRIS broadband stations (2000-2025) to image the crustal structure of the Myanmar region. Shear-wave velocity (Vs) models reveal a low-velocity zone

at 40-45 km depth, indicating significant heterogeneity. In eastern and central Myanmar, Moho depths (~20-30 km) suggest thinner crust and reduced subduction influence, whereas in western Myanmar (Indo-Burma Ranges), a deeper Moho (~30 km) near the Indian-Burma plate interface points to strong seismic coupling. Such locked segments are capable of generating large megathrust earthquakes, as reflected in the recent sequence that significantly impacted the Sagaing and Mandalay regions. Hydrated LVZs in these zones appear to control earthquake size, location, and depth along the Indo-Burma Arc, which also governs tsunami generation. Overall, the tomography results provide critical structural insights for identifying high-risk rupture zones, thereby contributing to improved seismic and tsunami hazard assessment in the region.

Keywords: Rayleigh wave tomography, Myanmar, Seismogenic zones, Tsunami hazard, Shear-wave velocity.

[ABS-0126]

IDENTIFYING POLLUTION HOTSPOTS USING MAGNETIC SCREENING AS A PROXY: A CASE STUDY OF KUMBH MELA 2025 IN PRAYAGRAJ, UTTAR PRADESH, INDIA

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Urbanization and increasing vehicular emissions have led to a marked deterioration in air quality, particularly in rapidly developing Indian cities. This study investigates anthropogenic pollution in the eastern region of Prayagraj, Uttar Pradesh, by integrating magnetic susceptibility measurements with scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS) analysis. Road dust, leaf dust, and soil samples were examined to identify magnetic mineral pollutants. A total of 62 samples were collected in two phases: pre-Kumbh (June-July, 2024) and Kumbh (January-February, 2025) from major traffic junctions across Prayagraj. A comparative study was conducted to assess the impact of Kumbh Mela 2025, using pre-Kumbh data as reference. The results reveal distinct temporal variations in pollution characteristics. Pre-Kumbh samples contained fine-grained, anthropogenic magnetic particles, typically associated with urban emissions. In contrast, during Kumbh Mela 2025, magnetic susceptibility values increased markedly at major junctions, while frequency-dependent susceptibility (FD%) dropped below 2%, indicating a greater proportion of coarse-grained particles linked to heavy traffic, construction, and ground disturbances. Such pollutants pose dual threats, with direct adverse impacts on respiratory health and indirect risks through entry into the food chain. Thus, the assessment of magnetic pollutants is very important for targeted urban planning measures, stricter vehicle emission controls, and enhanced public awareness to mitigate the environmental and health impacts of large-scale urban gatherings.

Keywords: Environmental magnetism, Magnetic susceptibility, Urban pollution, Road dust, SEM-EDS analysis, Prayagraj, India

[ABS-0127]

AN ANALYTICAL STUDY OF EXTREME PRECIPITATION EVENTS OVER THE HIGHER REACHES OF THE NORTHWEST HIMALAYAS DURING 1978-2023

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The Himalayas plays vital role for Indian weather & climate. It controls the Western Disturbances (WDs) in winter months and easterly winds associated with summer monsoon. In the present study, a detailed analysis is carried out to understand the various meteorological features associated with it. In the present study, daily precipitation data of 08 meteorological stations located in northwest Himalayas (highest of the station > 1.5 Km) for the period 1978-2023 during summer monsoon. The extreme precipitation is considered, when a meteorological station reports daily precipitation more than 99.9 percentile in past 24 hours (which is 140 mm). There are total nine events of extreme precipitation over the northwest Himalayas i.e. (1) 09 September 1992, (2) 10 July 1993, (3) 04 September1995, (4) 22 August 1996, (5) 27 August 1997, (6) 06 July 2005, (7) 01 September 2006, (8) 04 September 2014 and (9) 22 September 2015. In general, it is observed in all the cases that there is a Low Pressure area over northwest India & neighbourhood embedded in Monsoon Trough that drags huge amount of moisture incursion over northwest India from Arabian Sea as well as from Bay of Bengal. In addition, there was an active western disturbance as a cyclonic circulation or as a deep trough in mid-tropospheric westerlies over Jammu & Kashmir. Both the synoptic scale systems interact with each over northwest Himalayas. Also, the position of Tibetan high, presence of another low pressure area/Cyclonic Circulation over northwest Bay of Bengal & adjoining Indian coastal area or/and over Arabian Sea plays very important role for enhancement of extreme precipitation activity over the northwest Himalayas.

Keywords: Western Disturbances,

[ABS-0131]

POSTSEISMIC RELAXATION IN ANDAMAN FOLLOWING THE 2004 SUMATRA ANDAMAN MEGATHRUST EARTHQUAKE

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The Sumatra Andaman subduction zone is one of the most seismically active plate boundaries, where the Indo-Australian Plate subducts obliquely beneath the Sunda Plate. This complex convergence produced the 2004 Sumatra Andaman megathrust earthquake (Mw 9.1), which ruptured ~1500 km of the Sunda Trench over ~10 minutes, generating a catastrophic tsunami that caused more than 200,000 fatalities. Owing to its large magnitude, this earthquake triggered long-lasting postseismic deformation across a broad region. Previous studies have modeled this deformation as afterslip, viscoelastic relaxation, or a combination of both. Far-field sites are generally well explained by viscoelastic relaxation, with afterslip dominating

during the initial postseismic years, whereas near-field sites remain less well understood. In this study, we model the postseismic deformation at near-field sites in the Andaman and Nicobar Islands using VISCO1D, which incorporates a spherical, layered, compressible, self-gravitating, viscoelastic Earth model. We adopt a PREM-based Earth structure with a 62 km elastic lithosphere, underlain by a biviscous (Burgers body) asthenosphere and a Maxwell viscoelastic upper mantle. The coseismic rupture source is constructed using STATIC1D, incorporating both the 2004 (Mw 9.1) Sumatra Andaman and the 2005 (Mw 8.7) Nias earthquakes. We use continuous GPS measurements from sites on the Andaman and Nicobar islands. The model produces very good results for far field sites, consistent with the previous models, however the near field sites are not adequately explained, with the exception of Campbell Bay (CBAY) in the Nicobar Islands. The result enforces the fact that for a complex subduction zone such as Sumatra Andaman, lateral heterogeneity is required in the earth model to produce consistently good results in both near and far field sites.

Keywords: Postseismic, Viscoelastic, Sumatra-Andaman, Megathrust

[ABS-0136]

A STUDY ON THE SEVERITY OF NATURAL DISASTERS THAT HAVE BEEN ESCALATING IN RECENT TIMES, THE LOSSES CAUSED, AND THE POLICIES TO BE FOLLOWED.

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It has been recognized by everyone that the damage caused by the recent worsening weather conditions will be at the same level. At the same time, it is a fact that the need for quality early warnings has also increased. The design to be followed in the necessary measures to control the natural disasters that are causing sudden heavy rainfall, floods, and many other problems and disrupting the lives of people is of utmost importance. Why is there a lack of control over the factors that contribute to the rapid occurrence of climate change? It is a fact that only the most effective policies have the full potential to make the future world safe. Has it ever been recognized that the way of life followed by people in the present era leads to severe climate change? Why do we fail to achieve satisfactory results despite the implementation of policies focusing on many aspects as part of extreme weather mitigation measures over the years? How dangerous is the growing pollution problem pushing the world into? To what extent are industrial pollution control measures being implemented properly? How much of the natural resources are being polluted? There is a great need to design environmentally friendly and sustainable ways to achieve a safe future. We need to focus on the opportunities available to control adverse weather conditions with full commitment. In recent times, not only has public awareness of environmental protection increased to a high level, but governments have also significantly increased the pace of pollution control measures. As people become more aware, social responsibility towards the environment increases and lifestyles are being shaped accordingly. It is a very auspicious development that people are adapting and changing their lifestyles in line with the developments taking place.

Keywords: Pollution, Climate change, Environment, Health, Extreme weather and Life.

[ABS-0139]

COSEISMIC LIQUEFACTION DURING M6.0 2021-ASSAM EARTHQUAKE AND PALEOLIQUEFACTION FEATURES IN THE BRAHMAPUTRA PLAIN, INDIA: IMPLICATIONS ON BOUNDARY CONDITIONS AND PALEOSEISMICITY

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Extensive coseismic liquefaction features, such as sand dykes and vents, ephemeral sand-water springs, and lateral spreadings, have developed along the river banks in the mesoseimic area of the M6.0 (April 28, 2021) earthquake in the northern Kopili Fault Zone (Brahmaputra Plain, Himalayan Piedmont zone). In order to explore their stratigraphic and structural expressions, we mapped and excavated shallow trenches across the coseismic liquefaction features in the sediment profile of the point-bar deposits. The paleoliquefaction features, suggesting the occurrence of a past event, were also observed in the sediment profile. The subsurface architecture of sand boils/blows, feeder-dykes, soft-sediment deformation (SSD) structures, depth of liquified sand bed, thickness of confining cover bed, and depth of water table helped establishing the boundary conditions for the SSD. We dated the sediment profile using the OSL dating technique to constrain the age of the present and paleoliquefied sediments. The analysis of results suggests the 1714-Bhutan paleoseismic trigger event was responsible for the observed SSD structures. The study also highlights the significance of favorable boundary conditions for the occurrence of liquefaction features at moderate magnitude events and the importance even of a shallow sediment profile as a paleoseismic repository.

Keywords: Liquefaction, Soft sediment deformation (SSD), Trigger mechanism, Boundary conditions, OSL dating; Kopili Fault Zone

[ABS-0144]

PROCESS BASED PROBABILISTIC MODELING OF SHALLOW LANDSLIDES USING SATELLITE DERIVED INPUTS AND GEOTECHNICAL PARAMETERS IN HIMALAYAN MOUNTAIN ENVIRONMENT: A CASE STUDY FOR LAHAUL-SPITI VALLEY

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Shallow landslides represent a significant geohazard in mountainous terrains where intense rainfall, steep slopes, and variable soil-vegetation conditions interact to reduce slope stability. The proposed study involves a process-based probabilistic model for shallow landslide initiation in the Lahaul-Spiti district, Himachal Pradesh, using Landlab in Python. The model couples the infinite-slope stability equation with steady-state subsurface hydrogeology under varying groundwater recharge conditions. Spatially distributed raster datasets representing topography, soils, and vegetation properties were used to parameterize model inputs. The model computes grid-cell scale factor of safety from the Mohr-Coulomb law, balancing friction

and cohesion against gravity accounting for pore-water pressure. Slope and specific contributing area were computed using Copernicus DEM, with thresholds of 170 slope and ≤1 km2 upslope area used to delineate potential slope failure regions. Geotechnical parameters such as root cohesion was derived using vegetation cover from LISS-3 data. Internal friction angle, soil density, and saturated hydraulic conductivity were estimated from downloaded gridded soil texture datasets. Transmissivity was calculated by combining soil depth (obtained from Bhuvan portal) with saturated hydraulic conductivity. Recharge forcing was introduced using downloaded (from CHRS portal) global rainfall data. In the study region, estimated geotechnical parameters varied within the ranges as root cohesion (12.1-24.9 kPa), internal friction angle (220-380), soil density (1015-1854 kg/m³), saturated hydraulic conductivity (0.77-12 m/day), and soil depth (0.25-1.48 m). Uniform recharge scenarios with minimum and maximum rainfall values (0.44-3.25 mm/day) were tested for the study region. Using these topographical, geotechnical and hydrogeological parameters slope failure probability map was generated. The relatively low mean probability but non-zero unstable fraction highlights that the landslide hazard is localized rather than widespread. The model generates spatial probabilities of shallow landslides, highlighting the role of topography, vegetation, soil, and rainfall patterns and provides process-based susceptibility maps for geohazard assessment and risk reduction in the Himalayan region.

Keywords: Shallow Landslides, Geohazard, Landlab, Digital Elevation Model, Groundwater Recharge, Geotechnical Parameters, LISS-3.

[ABS-0150]

TRANSIENT LANDSCAPE PROCESSES IN THE WESTERN GHATS OF PENINSULAR INDIA; A MULTI-PROXY ASSESSMENT OF STREAM CAPTURE AND ESCARPMENT EVOLUTION

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The Western Ghats of Peninsular India represent one of the most prominent passive margin escarpments globally, forming a steep, west-facing slope along the western continental margin of the Indian plate. Despite the long-term tectonic quiescence, its morphology shows geomorphic disequilibrium. The study is on the transition zone between the Cretaceous - Paleogene Deccan volcanic province and the Archean Dharwar Craton, focusing on ten west-flowing basins adjacent to the lower Krishna basin to evaluate the influence of erosional processes on ongoing transient landscape. High-resolution SRTM 30 m DEM data were used to extract morphometric parameters for calculating the modified Index of Active Tectonics (IAT). The analyzed parameters include the Stream Lengthâ Gradient (SL) index, channel steepness (Ksn), hypsometric integral (HI), basin asymmetry (AF), and sinuosity index. The published apatite fission-track (AFT) and (Uâ Thâ Sm)/He thermochronological data (Mandal et al, 2015; Gunnell et al, 1998) are used to estimate long-term landscape evolution. Results

shows High HI and corresponding High Ksn and SL values in Gangavali, Sharavathi, Kali, Anghnashini rivers which denote youthful, actively incising zones controlled by localization of the escarpment. The trend consistently links high stream power and relief retention to active geomorphic expressions with landscape growth related to diachronous cooling at (~65 - 35 Ma) along the escarpment. These outcomes suggest that drainage divide migration and stream capture are controlled by lithological contrasts and long-term erosional retreat that dominates landscape evolutional processes in Western Ghats.

Keywords: Western Ghats, IAT, Drainage Divide Migration, Stream Capture.

[ABS-0152]

GEOCHEMICAL CHARACTERIZATION, SOURCE OF FLUORIDE ENRICHMENT, AND GROUNDWATER VULNERABILITY IN THE CRYSTALLINE GRANITIC TERRAIN

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Groundwater in the Maheshwaram watershed, South India, is chronically affected by elevated fluoride (Fâ□») levels; However, the mechanisms of releasing it, its controlling mineral sources, and the spatial vulnerability remain poorly characterized. This study integrates multiple approaches, such as hydrochemical analysis, mineralogical characterisations, and GIS-based DRASTIC modelling, to reveal the geogenic factors driving Fâ□» enrichment in a crystalline granitic aquifer. A total of 46 pre-monsoon and 47 post-monsoon groundwater samples were analyzed for physico-chemical parameters, while representative rock samples were examined to link F-bearing minerals with groundwater chemistry. Fâ□» concentrations ranged from 0.89 to 3.50 mg/L (pre-monsoon) and 0.83 to 3.72 mg/L (post-monsoon), with 32% and 30% of samples surpassing the WHO threshold of 1.5 mg/L. The hydrochemistry is primarily influenced by rock-water interactions and ion exchange mechanisms, resulting in alkaline conditions that promote Fâ□» mobilization. PHREEQC modeling showed that groundwater is undersaturated in fluorite and oversaturated in calcite, a state that facilitates the release of Fâ□» via calcite precipitation. Principal Component Analysis (PCA) and Cluster Analysis (CA) found silicate weathering and ion exchange as the principal factors for Fâ□» enrichment. Mineralogical studies (Microscopic, Model and Electron Probe Microanalysis) confirmed the presence of F-bearing minerals such as biotite, epidote, apatite, sphene, and allanite. The alteration of these minerals, particularly the chloritization of biotite, is recognized as a principal release mechanism. The DRASTIC model delineated 'high' to 'very high' vulnerability zones covering 57% of the watershed, demonstrating a good correlation with reported high-Fâ□» regions. These areas are defined by shallow water tables and the existence of Fâ□»-rich lithologies. By integrating hydrochemical, mineralogical, and aquifer risk mapping, this research provides a comprehensive framework for understanding fluoride mobilization and offers guidance for targeted management and sustainable use of groundwater in fluoride-affected crystalline regions.

Keywords: Fluoride, PHREEQC, PCA, Groundwater-rock interaction, Weathering and alteration, Ion Chemistry

[ABS-0154]

ASSIMILATION OF DOPPLER WEATHER RADAR DATA USING WRF 3DVAR FOR TROPICAL CYCLONE FENGAL PREDICTION

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This study investigates the impact of assimilating C-band Doppler Weather Radar (DWR) observations using the three-dimensional variational (3DVAR) data assimilation technique in the Weather Research and Forecasting (WRF) model for improving the prediction of Tropical Cyclone Fengal, which formed over the southeast Bay of Bengal. The system originated as a low-pressure on 23 November 2024, intensified into a cyclonic storm by 0900 UTC on 29 November, and made landfall near Puducherry along the north Tamil Nadu and Puducherry coast between 1700 and 1800 UTC on 30 November. Numerical experiments were carried out using the Advanced Research WRF (ARW) model version 4.3. The model was initialized at 12 UTC on 28 November 2024 and integrated up to 12 UTC on 2 December 2024. The National Centres for Environmental Prediction (NCEP) Global Forecast System (GFS) 0.25Â° x 0.25Â° analysis data were used to provide the initial and lateral boundary conditions. Two experiments were conducted: a control run (CNTRL) without data assimilation and a 3DVAR experiment that assimilated DWR radial velocity and reflectivity data from the C-band radar at Kalpakkam, along with conventional upper-air and surface observational data. The performance of the simulations was evaluated against observations from the India Meteorological Department (IMD) best track. The 3DVAR experiment showed improvement in the prediction of the tropical cyclone Fengal track, intensity and rainfall distribution. Assimilation of radar data helped capture the cyclonic vortex more accurately. The simulated hydrometeor reflectivity from the 3DVAR run showed closer agreement with radar observations at Kalpakkam than the control run. Overall, assimilating radar and conventional observations through the 3DVAR technique significantly enhanced the simulation of the cyclone structure and evolution. The study emphasizes the importance of assimilating radar data in numerical weather prediction models to improve the forecasting of tropical cyclones and to support timely disaster preparedness and management along coastal regions.

Keywords: 3DVAR, Tropical Cyclone, Reflectivity, Radial Velocity

[ABS-0157]

SEISMOTECTONICS OF THE KOPILI FAULT ZONE, NORTHEAST INDIA: INSIGHTS FROM A 3D SEISMIC BODY-WAVE VELOCITY MODEL AND STRESS FIELD ANALYSIS

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The Kopili Fault Zone (KFZ) is a seismically active intra-continental fault system located at the juncture of the Himalayan Arc and Indo-Burman Ranges, playing a crucial role in regional tectonics and seismic hazard. Despite several documented moderate to large earthquakes, understanding of the fault's subsurface structure and stress regime remains limited due to crustal heterogeneities. This study integrates local earthquake tomography and focal mechanism-based stress field analysis to elucidate the 3D seismotectonic framework of the KFZ. Using seismic data from the Indian Institute of Geomagnetism (IIG) and the National Centre for Seismology (NCS), we jointly inverted P- and S-wave arrival times to generate crustal velocity models (Vp and Vs), revealing significant lateral and vertical variations. A prominent near-vertical, NW-SE trending low-velocity anomaly extends to 30 km depth and is interpreted as a damaged fault core. Earthquake hypocenters cluster along its margins, suggesting strain localization at the interface between this weak fault core and the surrounding rigid crustal blocks, highlighting fault zone heterogeneity as a key control on seismicity. Additionally, stress-field analysis derived from focal mechanisms indicates a predominantly compressional regime with the maximum horizontal stress (SHmax) oriented NNE-SSW, consistent with Indian plate convergence. Faulting is mainly strike-slip with a significant thrust component, aligned with observed moment tensors. Localized rotations of principal stress axes near the fault imply complex stress partitioning influenced by crustal anisotropies and fluid presence. These results support a unified seismotectonic model wherein KFZ seismicity is driven by interactions between a fluid-modified weak fault core and regional compressive stresses, advancing understanding of fault mechanics and seismic hazard in this densely populated, tectonically complex region of Northeast India.

Keywords: Kopili Fault Zone, North-East India; Seismotectonics, Velocity Tomography, Focal Mechanism Solutions, Seismic Hazard

[ABS-0159]

CHRONICLE OF DESTRUCTION: GEOMORPHIC MECHANISMS BEHIND THE WAYANAD LANDSLIDE OF JULY 30, 2024

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This study presents a comprehensive investigation of the 2024 Wayanad landslide, integrating field observations, satellite image analysis, numerical modeling, geotechnical testing, and aerial surveys to reconstruct the failure mechanisms and assess the catastrophic downstream

impacts. Our results indicate that the landslide was primarily triggered by a pre-existing crack in the source area, first observed in 2020, within a geologically complex terrain characterized by sheared rocks and structural discontinuities. These inherent weaknesses, compounded by extreme rainfall, played a decisive role in slope failure. Intense water infiltration through cracks and joint sets in the gneissic complex accelerated weathering and erosion, while soil mantling exceeding 30 m further heightened slope susceptibility. Numerical simulations suggest that the debris flow was initiated around 01:00 hrs and peaked at approximately 04:00 hrs on 30 July 2024, reaching maximum velocities of up to 28 m/s. The event mobilized an estimated 5.17×10^6 to 5.72×10^6 m^3 of material, ranking it among the largest documented debris flows in India. In the transitional deposition-dominant zone, the debris run-up height reached ~32 m, amplified by repeated damming, entrainment, and topographic factors such as cascades and river sinuosity. These processes collectively caused devastating impacts on downstream infrastructure and settlements. Given the inherent fragility of the terrain and its history of recurrent mass-wasting events, the Wayanad region demands urgent attention, including the establishment of real-time monitoring and early-warning systems to mitigate future risks.

Keywords: Wayanad Landslide, Western Ghats, Climate Change, Early Warning, Debris Flow.

[ABS-0161]

CHARACTERIZATION OF HIGH-ALTITUDE RIVER VALLEYS PRONE TO DEBRIS FLOW: A CASE STUDY OF DHARALI DEBRIS FLOW ON AUGUST 5, 2025

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The high-altitude valleys of the NW Himalaya are increasingly experiencing extreme events such as flash floods and debris flows, driven by changing climatic patterns and erosional dynamics. On 5th August 2025, flash floods and debris flow occurred in the tributary valleys to the Bhagirathi River at Dharali and Harsil villages of Uttarakhand. The kheer-gad valley of Dharali experienced 6 surges of flash floods in the span of 5 hours, while the adjacent Tel-gad valley of Harsil suffered a single event of debris flow depositing a huge volume of debris, ranging from silt to boulders, and expansion of the fan by about 140% in the former. The geomorphic characterisation and modelling of the debris flows along the major river valleys and mapping of the debris fan using GPR survey at Dharali helped in estimating the freshly deposited debris volume. The complex interaction of glacial and fluvio-glacial processes in the valley is analysed to understand the mass wasting process related to the long-term climatic pattern in the area, as it is not related to any extreme precipitation. The enhanced surface-air temperature from June to August 2025, compared to the previous five-year averages, caused enhanced snowmelt, which disturbed the terrestrial water storage in the glacial moraine and other regolith bodies in the upper catchment, making them metastable and vulnerable to mass movements. The combined effect of oversaturated glacial and slope debris on the oversteepened slopes under the influence of changing climatic patterns led to the cascading

events of debris flows. The results are discussed in comparison to the other similar mass wasting phenomena observed in the western Himalaya during the period.

Keywords: NW Himalaya, GPR, Debris fan, Flash flood, Climate change, Glaciers, Bhagirathi river

[ABS-0163]

CHARACTERIZATION OF THE RAYLEIGH SURFACE WA CHARACTERIZATION OF THE RAYLEIGH SURFACE WAVES FROM IONOSPHERIC OBSERVATIONS DURING THE MW 9.1 TOHOKU-OKI EARTHQUAKEVES FROM IONOSPHERIC OBSERVATIONS DURING THE MW 9.1 TOHOKU-OKI EARTHQUAKE

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This study utilized the total electron content measured by nearly 1200 GEONET GPS receivers across Japan to examine ionospheric perturbations mainly generated by Rayleigh-induced acoustic waves (RAWs) following the Tohoku-Oki earthquake (2011). Earthquakes release wide range of seismic energy, which propagates as seismic waves through the Earth's surface and interior. During these events, vertical surface movements caused by propagating Rayleigh surface waves (RSWs) induce acoustic waves that travel into the atmosphere through dynamic coupling. Their amplitudes increase with altitude due to decreasing atmospheric neutral density. When these waves reach the ionosphere, they alter the plasma density, resulting in co-seismic ionospheric perturbations (Perevalova et al., 2014). We analyzed data from various GPS satellites to estimate the propagation velocity and amplitudes of these perturbations. Subsequently, we examined seismic waveforms recorded by 64 seismic stations of the NIED F-net system across Japan to determine the period-dependent group velocities of RSWs using their energy dispersion curves and their amplitudes. While correlating the ionospheric response with ground observations, we found that RSWs with periods, 10-50 s effectively manifested at the ionospheric heights, as their mean propagation velocity correlates with that of ionospheric perturbations, and their amplitudes correspond fairly well (Sunil et al., 2025, under review). Furthermore, we extended this analysis to large earthquakes worldwide, aiming to identify a more specific period range of RSWs that predominantly manifest in the ionosphere. Major events, such as the Tokachi-Oki earthquake, 2003 (Japan), Illapel earthquake, 2015 (Chile), and Iquique earthquake, 2014 (Chile), were selected for detailed analysis, as they exhibited notable perturbations caused by RAWs. This extended work further confirms our earlier conclusion that RSWs with periods, 10-50 s are most prominent at ionospheric heights. Therefore, it is emphasized that the low-frequency RSWs could be characterized from the ionospheric observations, as they manifest effectively in the ionosphere. Reference: Perevalova, N. P., Sankov, V. A., Astafyeva, E. I., & Zhupityaeva, A. S. (2014). Threshold magnitude for Ionospheric TEC response to earthquakes. Journal of Atmospheric and Solar-Terrestrial Physics, 108, 77â 90. https://doi.org/https://doi.org/10.1016/j.jastp.2013.12.014.

Keywords: Comparative assessment between Rayleigh wave-generated ionospheric perturbations and Rayleigh waves was performed for Tohoku-Oki Earthquake, Rayleigh waves with periods of 10-50 s predominantly manifested in the ionosphere during the Tohoku-Oki Earthquake

[ABS-0166]

CRUSTAL IMAGING OF MARS FROM INSIGHT SEIS

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Mars shares geological similarities with Earth despite lacking active plate tectonics, and seismic activity is expressed through marsquakes. NASA s InSight mission deployed the SEIS instrument, comprising Very Broadband (VBB) and Short Period (SP) seismometers in UVW coordinates, which recorded 1,319 events (Lognonné et al., 2023). High signal-to-noise events were analyzed for the P Receiver Function (P-RF) method in which out of 26 events, in 15 events glitch is identified and removed for further analysis to constrain the martian crustal structure. In the P-Receiver Function (P-RF) approach, three-component seismic data (UVW) are first rotated into ZRT components (vertical, radial, transverse). A time-domain iterative deconvolution with a Gaussian width of 2 is then applied to remove source and path effects and isolate the receiver-side response. This enhance the quality of P-to-S converted phases, which are used to estimate crustal structure beneath the station. Further enhance the quality of the P-RFs, we applied Principal Component Analysis (PCA) for noise reduction and waveform consistency. Additionally, to improve inversion performance at depth, we computed apparent shear-wave velocity and carried out a joint inversion of P-RFs and apparent shear velocity. The results provide new insights into the upper-crustal structure of Mars beneath the InSight SEIS station, and detailed inversion outcomes will be presented.

Keywords: Mars, Marsquake, Insight SEIS, P Receiver Function, Inversion

[ABS-0171]

EXTREME PRECIPITATION VARIABILITY AND LANDSLIDE SUSCEPTIBILITY MODELLING USING MACHINE LEARNING IN THE UPPER GANGA BASIN, INDIA

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Extreme Precipitation Events (EPEs) and landslides pose significant challenges to society and the environment, particularly in high-altitude regions like the Himalayas. This study analyses the spatiotemporal variability and trends of nine key extreme precipitation indices in the Upper Ganga Basin, India, revealing a general increase in most of these indices, particularly in the western region. We also found increasing episodes of flood events based on the Standardized

Precipitation Index, mostly after 2010. Increasing trend of EPEs significantly affects landslide occurrences given the steep slopes and rugged terrain of the region. Therefore, to evaluate landslide susceptibility in the region, we applied advanced machine learning techniques (Random Forest, XGBoost, and Support Vector Machine) to develop Landslide Susceptibility Maps using fifteen key conditioning factors. Results indicate that about 37.39% to 58.94% of the region is classified as having very low susceptibility, 16.78% to 29.15% as low, 7.11% to 12.01% as high, and 5.54% to 9.12% as very high susceptibility to landslides. Model performance evaluation shows that Random Forest recorded the maximum Area Under Curve (AUC) of 0.96 and an accuracy of 0.901 and is closely followed by the XG Boost with an AUC of 0.946 and an accuracy of 0.887. In contrast, the Support Vector Machine demonstrated relatively lower AUC (0.845) and accuracy (0.765). Additionally, our findings show that regions susceptible to landslides strongly correspond to regions experiencing the highest frequencies of EPEs, underscoring the need for targeted risk mitigation strategies.

Keywords: Extreme Precipitation, Landslide, Machine Learning, Upper Ganga Basin.

[ABS-0173]

ARE THE INDIAN SUBCONTINENTAL COASTS HAZARDOUS DUE TO TSUNAMIGENIC EARTQUAKES LIKE SUMATRA (MW 9.3) OF 26 DECEMBER 2004?

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Tsunamis are characterized and generated by subduction zone megthrust earthquakes. The horizontal length of the locked slab and thin layer of sediments are playing an important role for maximum strain accumulation in megthrust faults in the subducting zones. It is being loaded with cyclic stresses due to oblque Indo-Australian Plate subduction under Sunda Arc region. The maximum slip due to the earthquake of 26 December, 2004 , Mw 9.3 ,focal depth of 36 km is about 30m that displaces a mass of sea water from equilibrium position to vertical displacement of 10-15m from the source of this mega thrust earthquake at mantle wedge at a adistance of 160km from the mouth of the subduction zone. An another large earthquake occurred on 28, Nov, 1945 in Makran coast Mw 8.1 is less effective on the Indian coasts because of slow slipping rate which in turn had generated tsunami waves, is less affected western Indian coast. The physics of the earthquake process maybe explained.

Keywords: Tsunami, Megathrust ,subduction , sedimentation

[ABS-0178]

APPLICATION OF MULTICHANNEL ANALYSIS OF SURFACE WAVE TECHNIQUE- A GEOTECHNICAL/ GEOPHYSICAL TOOL.

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Multichannel analysis of surface waves (MASW) is one of the popular geotechnical/ geophysical tools that can be utilised to evaluate the subsurface layers in terms of shear wave

velocity. Currently, this technique is widely applied in the field of civil engineering. The MASW method effectively maps the fractures, lineaments, contacts, faults, subsidence, weak zones, voids, weathered zones, and shallow basement up to the depth of <50m in terms of shear wave velocity. The present study emphasises the importance of this technique during the implementation of various major civil engineering projects and earthquake resilience studies.

Keywords: MASW, fractures, shear wave velocity, lineament. Fault and earthquake

[ABS-0181]

SWOT IMAGING OF THE TSUNAMI CAUSED BY THE 29 JULY 2025, MW=8.8 KAMCHATKA EARTHQUAKE

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The 29 July 2025, Mw 8.8 Kamchatka (Russia) earthquake caused a major tsunami in the east Pacific Ocean. We use the sea surface height measurements from the recently launched wide-swath satellite altimeter, Surface Water and Ocean Topography (SWOT) mission, to extract the tsunami signal. The ascending pass (P0267) of the SWOT mission captured the perturbation on the ocean surface in two-dimensions after about 70 min. The tsunami signal sampled by SWOT has a peak amplitude of 0.7 m spread across a horizontal distance of ~250 km. We compare the tsunami signal extracted from SWOT with the wave fields simulated using seafloor deformation computed from uniform and distributed co-seismic slip models. SWOT observations could capture major features of the simulated wave field correspnding to the distributed slip model with a correlation coefficient of r = 0.81. Whereas, the tsunami waves simulated using uniform slip model could not explain well the SWOT observations (r=0.65). Our results suggest that tsunami observations from SWOT could be useful for modeling the earthquake source charecterstics. In addition, the wide-swath measurements from SWOT provided the two-dimensional details of the tsunami wave field that could contribute in the detection and mitigation of tsunami-related hazards.

Keywords: SWOT mission, wide-swath measurements, tsunami events

[ABS-0186]

DEVELOPING A HYDRO-GEO-SYN MODEL FOR HYDROLOGICAL DROUGHT ANALYSIS IN THE CHITRAVATHI RIVER BASIN, INDIA

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The primary objective of this study is to develop and implement an innovative Hydro-Geo-Syn model for assessing hydrological drought in the Chitravathi River Basin (CRB), India. The model integrates hydro-climatic parameters - rainfall, NDVI, NDSI, NDTI, and land surface temperature (LST) - with geo-environmental variables such as geology, geomorphology, soil

type, stream orders, drainage density (DD), lineaments, and land-use/land-cover (LULC). Syn refers to the synthesis of these datasets for a comprehensive drought analysis. Remote sensing, GIS techniques, and field data were employed to derive the Hydrological Drought Index (HDI), categorizing the basin into six drought severity zones: extreme, severe, moderate, mild, no drought, and waterbody zones. The findings indicate that 12.51% of the CRB is under extreme drought, predominantly in the southern and southwestern parts, while 19.90% is under severe drought. Moderate drought zones (24.56%) show potential for recovery with immediate conservation measures. Directional analysis of the Hydro-Geo-Syn model reveals spatial variability, with the southern and eastern regions more vulnerable to drought, whereas the north and northwest show better hydrological conditions. Model validation using ground-truth data yielded high classification accuracy: user accuracy (81 92%), producer accuracy (78 89%), and an AUC-ROC score of 0.869. The Hydro-Geo-Syn model demonstrates robust predictive capability and offers a reliable framework for hydrological drought assessment. Its application supports informed decision-making for sustainable water resource management and adaptive land-use strategies in semi-arid regions.

Keywords: Hydro-Geo-Syn, Drought, Hydrology, HDI, CRB.

[ABS-0187]

ANALYSIS OF HYDROMETEORS AND ATMOSPHERIC CONDITIONS DURING THE CLOUDBURST EVENT OF AUGUST 8, 2025 NEAR KULLU, HIMACHAL PRADESH

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Cloudbursts in the Himalayan region, which are followed by heavy rain in small areas, make it very hard to predict and stop disasters. Understanding the atmospheric and meteorological conditions that lead to cloudburst formation is crucial for improving early warning systems and enhancing climate resilience. This study analyzed the atmospheric and hydrometeorological aspects of a cloudburst occurrence near Kullu, Himachal Pradesh (31.9°N, 77.18°E) on August 8, 2025 around 17:35 IST, utilizing ERA-5 reanalysis data across pressure ranges ranging from 1000 to 50 hPa. According to the India Meteorological Department, a Western Disturbance as a cyclonic circulation lay over north Punjab and its neighborhood in the middle tropospheric levels, with a trough aloft in the middle and upper tropospheric levels. We analyzed vertical cross-sections of potential vorticity, specific humidity, and specific water contents (cloud liquid, cloud ice, rain, and snow) from 10-13 UTC. This was at the diurnal convective peak. High specific humidity (0.012-0.015 kg kg^{-1}) in the lower troposphere (1000-700 hPa) indicates a wet monsoon environment, which is good for forming clouds. In the 1000 500 hPa layer, specific cloud liquid water content (clwc, ~0.001 kg kg^{-1}) was more common than cloud ice (ciwc), rain (crwc), or snow (cswc). This was because to mild temperatures (>0°C), orographic lifting, and convective activity in the Himalayas. Potential vorticity patterns indicate dynamic instability that promotes convection. In addition, vertical velocity (w) and

meridional wind (v) analysis at 850, 750, and 650 hPa indicates intense upward motion (negative w, reaching -0.8 Pa/s) and meridional variable winds, with southerly flows (negative v) prevailing at lower levels, which favors moisture transport and triggering convection. These findings highlight the interaction of monsoon moisture, meridional wind patterns, and orographic effects in triggering cloudburst events, offering insights for improved forecasting of extreme rainfall in susceptible mountainous regions.

Keywords: Cloudburst, Hydrometeros, vertical velocity, potential vorticity, monsoon dynamics, orographic convection

[ABS-0189]

CORNER FREQUENCY AND STRESS DROP OF THE 2023 JAJARKOT EARTHQUAKE (MW 5.7) NEPAL

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On 3 November 2023, an earthquake of Mw 5.7 (ML 6.4) struck in Jajarkot, western Nepal. The present study analyzed the broadband waveforms from three far-field (>100 km) stations, applying Bruneâ s source model to displacement spectra to estimate seismic moment (Mâ), corner frequency (fc), rupture radius, and stress drop (Î Ï). Corner frequencies ranged from 0.11 to 0.48 Hz (mean 0.26 Â± 0.05 Hz) and stress drops from 2.31 to 32.93 MPa (mean 10.93 Â± 3.83 MPa). Mâ and fc followed an inverse trend (i.e. slope = â 1.41), while Î Ï scaled as square of fc indicates slow rupture mechanism. Station ST02 recorded higher and more variable Î Ï . It is obtained that the spectral plateau levels varied from station to station, indicating strong site and path effects. In general, the spectral plateau remains consistent across most stations . Higher Î©â values suggest the influence of local geological conditions, especially in sediment-filled valleys and basins. These site effects can amplify ground motion, similar to patterns observed in other Himalayan valleys. Such amplification is important for seismic hazard analysis because it can locally increase shaking intensity even during moderate earthquakes. This may lead to variations in stress drop estimates and ground-motion predictions. These findings are broadly in line with previous studies on moderate Himalayan earthquakes except upper bound for stress drops in Mw 5â 6 events . The results improve our understanding of earthquake source physics in the Himalayan collision zone and provide valuable input for refining seismic hazard models in tectonically active regions. The study also provides the important clues about rupture characteristics in western Himalayan country Nepal .

Keywords: Fault , Himalaya belt ,Bruneï ½s model , Spectral analysis , Ground motion

[ABS-0190]

REACTIVATION POTENTIAL OF FAULTS AND SEISMIC HAZARD IN AND AROUND THE DELHI-NCR.

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The Delhi-National Capital Region (Delhi-NCR), located within the central Indian plate, experiences notable intraplate seismicity, characterised by shallow, non-repeating earthquakes distributed across the region. Localised stress variations and fault geometries increasingly influence the episodic reactivation of ancient faults, causing these seismic events. The tectonic framework of Delhi-NCR, despite its high population density and urban sensitivity, has not received enough attention in terms of its potential for reactivation. The current study presents the first integrated assessment of fault reactivation likelihood in the region, utilising a hybrid approach that combines fault slips with mapped fault traces to compute slip tendencies, dilatation tendencies, and fracture susceptibility. These parameters offer a multidimensional perspective on the mechanical readiness of faults to slip under current stress regimes. The results reveal marked contrasts in fault behaviour between the northern and southern sectors of Delhi (NCR). In the northern region, NE-SW-oriented faults tend to be well-situated for reactivation; however, in the southern region, NW-SE-trending faults, in conjunction with dominant NE-SW-oriented faults, confound this theory. In the eastern part of the northern sector, low fracture susceptibility coincides with high slip and dilatation tendencies, suggesting localised stress accommodations. Meanwhile, the southern region shows geometric irregularities that could amplify stress perturbations through pore pressure variations. This structural complexity highlights the role of fault geometry in modulating stress transfer and influencing seismic potential. Overall, the findings emphasise the heterogeneous nature of the regional stress field and fault architecture, highlighting their significance in understanding earthquake generation processes and improving seismic hazard models for this densely inhabited and tectonically active region.

Keywords: Delhi-NCR; Reactivation potential; Slip Tendency; Fault geometry

[ABS-0191]

SPATIAL CLUSTERING AND STRESS INVERSION OF FOCAL MECHANISMS OF CENTRAL HIMALAYAN SEISMICITY (1980-2025): EVIDENCE FOR PARTITIONED DEFORMATION AND NW-SE COMPRESSION

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The ongoing continental collision between India and Eurasia renders the Nepal Himalaya one of the most seismically active regions on Earth. However, the spatial partitioning of

deformation and the state of stress within this complex orogen remain incompletely resolved. This study employs an integrated machine learning and mechanical analysis workflow to delineate seismogenic zones and quantify their stress regimes using the Global Centroid Moment Tensor (GCMT) catalog. From 131 events (Mw≥4.0) between 1980-2025, we first classified earthquakes into thrust (n=38), normal (n=40), strike-slip (n=22), and oblique (n=31) types. K-means clustering analysis revealed 10 spatially distinct seismogenic clusters. Formal stress inversion was performed on each cluster to determine the principal stress orientations and the stress ratio (R). Our results reveal a dominant NW-SE compressive stress field (σ_1 azimuth: 299-316°) driving thrust and strike-slip faulting in the orogen, challenging the simplistic view of pure N-S compression. Normal faulting clusters in Tibet confirm E-W extension but show complex, variable extension directions (σ_3 azimuth: 92-255°). Strike-slip faulting exhibits a uniform NW-SE compression. Oblique faulting clusters represent a critical transition zone between these regimes. The stress inversion misfits were low (11-30°), confirming robust solutions. This analysis provides a quantitatively refined, mechanics-based model of Himalayan tectonics, revealing a highly partitioned and complex deformation field that must be incorporated into future seismic hazard assessments.

Keywords: Nepal Himalaya, Seismotectonics, GCMT Catalog, K-means Clustering, Stress Inversion, Himalayan-Tibetan Orogeny

[ABS-0193]

SUBDUCTION ZONE MW 8.8 2025 GREAT KAMCHATKA EARTHQUAKE TECTONIC IMPLICATIONS

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This study presents an analysis of Global Centroid Moment Tensor (CMT) parameters of 551 events occurred between 1977 and 2025 in the area lying between latitude 50.5°N and 55.5°N and longitude 155.5°E and 164.5°E of the Kamchatka Peninsula. A central component of this research is the reconstruction of a comprehensive seismotectonic map using GMT scripting, which visualizes the spatial distribution of earthquakes, demarcating the major tectonic boundaries and slab geometry. In addition, a trench-orthogonal Benioff Zone was identified along the subduction zone, highlighting seismicity clustering at different depth-levels. Stress inversion was performed using MATLAB using rigorous statistical analysis and multiple noise realizations to resolve principal stress orientations, integrating focal mechanism data, iterative randomization, and parameter sensitivity analysis for robust uncertainty quantification and stability of stress solutions. Results reveal distinct spatial and depth-dependent trends in the ambient stress field, closely associated with tectonic segmentation and slab-mantle coupling in the Kamchatka subduction zone. The seismotectonic map successfully illustrates the linkage between clusters of seismicity, magnitude occurrences, and underlying plate boundaries, while the depth section provides insights into changes in earthquake distribution with increasing depth and proximity to the subduction zone flexing. Stress inversion outputs including detailed

plots of shape ratios, stress orientations, and Mohr circles illuminate variability in stress regimes across different depths and lithospheric sections. These findings substantiate the dynamic interplay between tectonic configuration and ambient stress, shaping both the seismic hazard landscape and the ongoing tectonic evolution of Kamchatka region. The analysis shows that the bending portion of the subducting plate was the nodal domain for stress accumulation and triggering great earthquakes. The study can also be extended for basin modelling along the subduction margin globally.

Keywords: Kamchatka, subduction zone, focal mechanism, stress inversion, seismicity map, depth section, ambient stress, tectonic structure.

[ABS-0194]

APPRAISAL OF ELECTRICAL RESISTIVITY TOMOGRAPHY AND HYDRO-GEOCHEMISTRY FOR UNDERSTANDING THE BEHAVIOUR OF CHROMIUM MOBILIZATION IN FRACTURED MEDIA OF HARD ROCK

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Bangalore City, one of India's major industrial hubs, groundwater and soil contamination have become a pressing issue due to industrial discharges. These activities alter the chemical composition of groundwater, compromising its potability and posing significant risks to public health and environmental sustainability. To address this, a multi-disciplinary approach combining Electrical Resistivity Tomography (ERT) with hydro-geochemical analysis offers valuable insights. This integrated method enhances the understanding of chromium mobilization and transport within porous and fractured media, enabling more effective identification of contamination zones and guiding remediation strategies. The influence of groundwater regimes associated with industrial activities can be assessed quickly through the ERT inverse pseudo-section model. Results revealed that integrating geochemical (water and soil) and resistivity studies in identifying the contaminated zones and understanding subsurface hydrogeological conditions for mobilization of ions/metals. TDS varied from 580-3300 mg/l during July 2016, 340-6700 mg/l during January 2017, and 380-5660 mg/l during August 2017 in groundwater samples. The variation in the TDS values is due to precipitation occurring during rainy and dry periods. The Cr+3 concentration in groundwater ranges from 0.0011-33.9 mg/l (July 2016), 0.0040-15.05 mg/l (January 2017) and 0.00012-26.12 mg/l (August 2017), and Cr+6 ranges from 0.0005-0.076 mg/l (July 2016), 0.09-14.3 mg/l (January 2017) and resistivity for the contaminated site ranges from 0.738 to 8.70 Ohm-m in the industrial area. Outside the industrial area, quite a normal range of resistivity ranged from 31.7 to 47.7 Ohm-m was observed, indicating the groundwater regime was not affected by industrial effluents. Tracking variations helps evaluate natural attenuation and remediation strategies. Integrated studies identify contamination sources for sustainability, ecology, and environmental health, protecting groundwater resources for human survival.

Keywords: Electrical Resistivity Tomography (ERT), contaminated zone, Soil and groundwater chemistry

[ABS-0196]

HYDROGEOPHYSICAL INVESTIGATION USING ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT) FOR AQUIFER CHARACTERIZATION AND GROUNDWATER QUALITY EVALUATION: A CASE STUDY FROM GRANITIC TERRAIN

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Electrical Resistivity Tomography (ERT) is a reliable geophysical tool for investigating subsurface hydrogeological conditions, offering high-resolution imaging of lithological variations, aquifer geometry, and contamination. In this study, ERT surveys were conducted in a granitic terrain to evaluate groundwater resources and to delineate contamination zones. The objectives were: (i) groundwater exploration, through mapping of potential aquifer horizons, and (ii) contamination assessment, by identifying very low-resistivity signatures associated with polluted zones. The study employed a multi-electrode resistivity system with a Wenner-Schlumberger configuration, enabling both vertical and lateral resolution of subsurface resistivity, which provided cross-sections up to a depth of ~45 m. The results revealed significant spatial variability in resistivity values, reflecting the heterogeneous nature of the fractured granitic aquifer system. Zones of moderate resistivity (50 - 400 Ωm) were interpreted as water-bearing fractured horizons, while very low resistivity anomalies (<10 Ωm) indicated possible contamination. Correlation with the hydrochemical analysis confirmed that areas showing lower resistivity were consistent with higher concentrations of Total Dissolved Solids (TDS) map of the study area, validating the capability of ERT in detecting contaminated zones. Furthermore, resistivity contrasts highlighted the presence of structurally controlled fracture networks, which play an important role in groundwater movement and storage in hard rock terrains. The study demonstrates that ERT is an effective non-invasive method for groundwater exploration and also a powerful tool for contamination mapping when integrated with geochemical data. Such integrated hydrogeophysical approaches are crucial for developing sustainable groundwater management strategies in regions affected by contamination and limited water availability.

Keywords: Hydrogeophysics, Groundwater Exploration, Gorundwater Contamination, Aquifer Characterization

[ABS-0208]

SEISMIC B-VALUE ANALYSIS OF THE SUBDUCTING LITHOSPHERE IN KAMCHATKA REGION

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This study presents a detailed analysis of b-value at different depth-levels within the subducting lithosphere beneath the Kamchatka region, covering between 50.5°N and 55.5°N and 155.5°E

and 164.5°E. A total of 5353 earthquake event data were compiled from the USGS catalog for the period July 01, 1976 to July 29, 2025. After applying a depth error filter with 10 km and less, this is reduced to 2613 event data. Only the events with magnitudes Mw ≥ 3.0 were considered to maintain its uniformity. Using the Generic Mapping Tools (GMT), the spatial distribution of earthquakes was mapped, followed by the construction of a trench-perpendicular cross-section with a 100 km swath width to visualize the depth distribution of seismicity. Five distinct clusters were identified based on depth and spatial concentration patterns. For seismic b-value calculation, the Gutenberg-Richter frequency-magnitude relationship was used, and the standard error of the b-value was calculated based on the model of Shi and Bolt. The b-values across clusters range from 1.19, 0.99, 1.43, 0.992, 1.17 from shallower to deeper level) with corresponding error of 0.13, 0.02, 0.09, 0.07, 0.09 and the corresponding Mc values are 4.2, 4.2, 4.4, 4.3, 4.1, respectively. High b-values in certain clusters indicate lower stress or higher heterogeneity, whereas the little lower b-values correspond to high-stress accumulation regions. The overall results highlight the complex stress distribution within the Kamchatka subduction system, showing distinct variations in the seismogenic layer s behavior. We will now carry out the analysis of time-varying distribution of seismic b-values along the region, which might unravel the causes of triggering the 2025 Mw 8.8 great Kamchatka earthquake.

Keywords: Seismic b-value, Gutenberg-Richter frequency-magnitude relation, Seismic Hazard, Kamchatka subduction margin, Stress.

[ABS-0209]

SEISMIC HAZARD EVALUATION IN NORTHEAST INDIA

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The North East (NE) India region is one of the six seismically active regions in the world that lies in the zone V of the seismic zoning map of India. The rapid development of the region in the recent past has made it highly vulnerable to seismic risk. The present study provides an updated probabilistic seismic hazard analysis (PSHA) of the NE India region spanning over 22Â° - 29Â° N and 89Â° - 98Â° E. It employs a comprehensive and updated earthquake catalog for 260 years from 1762 to 2024. Three different seismic source models, linear, areal and smoothed gridded seismicity models were used to compute seismic hazard of the study area. Based on the seismotectonics of the region the study area was spatially divided into six seismogenic source zones. Suitable region specific ground motion prediction equations (GMPEs) and GMPEs developed for similar tectonic regions worldwide were used in the hazard analysis. To account for epistemic uncertainties due to the varied inputs used for the seismic hazard analysis the logic tree method is adopted assigning equal weightage to all the three source models. The ground motion parameters in the form of Peak Ground Acceleration (PGA) and Spectral acceleration (Sa) values at bedrock levels were estimated for the entire region by dividing the area into grids of size 0.1Â° * 0.1Â°, for probability exceedance (PE) of 2% and 10% in 50 years corresponding to return period of 2475 and 475 years. The results

indicate high level of seismic hazard in the range between 0.4 and 0.55g for 10% PE in 50 years for the Indo-Burma ranges, Mishmi Block and some parts of the Eastern Himalaya. The results of the study may provide basis for the seismic microzonation of the area, earthquake engineering purposes and input to seismic risk assessment.

Keywords: Peak Ground Acceleration, Spectral Acceleration, Seismic hazard, Microzonation

[ABS-0211]

SEISMIC B-VALUE ANALYSIS OF THE SUBDUCTING LITHOSPHERE ALONG THE MYANMAR MARGIN

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This study mainly focuses on seismic b-value vis-à-vis ambient stress field analysis at different depth-levels along the Myanmar subduction margin. Initially, we have collected 3243 earthquake event data of magnitude ≥ 3.0 from the United States Geological Survey (USGS), occurring between 17°N and 28°N latitude and 91°E and 99°E longitude, covering the period of January 01, 1905 to March 27, 2025. After a thorough scrutiny, we found most reliable 456 event data with depth error ≤ 10 km, which further constrain our depth-domains. The study area was divided into three zones paralleling the subduction margin. The first, second and third zones lie between 17°N and 22°N, 22°N and 25°N and 25°N and 28°N, respectively. For each zone, we found clustering of events at different depth-levels. Seismic b-value is computed using Gutenberg-Richter frequency-magnitude relationship and the corresponding errors have been calculated based on the model of Shi and Bolt. The analysis shows that the shallow cluster has higher b-value (0.95) as compared to that of deeper cluster (b=0.68). For the second region, deeper cluster show lower b-value (0.69) while the shallow-cluster record 1.48. In the third region, shallow part records a low b-value (0.61) while the deeper part show a higher b - value of 1.22. The error for the entire analysis ranges between 0.04 and 0.15. The higher b-values at the deeper level in zones one and two might be accounting higher stress-level and low heterogeneity and vice-versa. While the lower b-value at the shallow depth in zone three, towards north, might be accommodating higher stress caused by the mutual interaction between the north-eastward moving Indian plate and northward moving Myanmar plates near the Himalayan syntaxis.

Keywords: Seismic b-value, Gutenberg-Richter frequency-magnitude relation, Seismic Hazard, Myanmar subduction margin, Stress.

[ABS-0212]

PRELIMINARY CHARACTERIZATION OF NOISE CONDITIONS AND VARIABLE SITE EFFECTS IN UTTARA KANNADA, KARNATAKA, USING AMBIENT NOISE ANALYSIS

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Accurate assessment of local seismic site conditions is often constrained in regions with limited earthquake activity and insufficient ground motion data. In such cases, ambient noise analysis offers an effective alternative for understanding shallow subsurface characteristics and potential amplification behaviour. Among available techniques, Power Spectral Density (PSD) and Horizontal-to-Vertical Spectral Ratio (HVSR) methods are widely used to evaluate background noise and site response characteristics. Together, these methods provide a comprehensive understanding of seismic tomography and hazard evaluation. This study examined noise conditions and site effects across Uttara Kannada District, Karnataka. Continuous seismic data from six microseismic stations operated by CSIR-NGRI were used. PSD quantified the amplitude and frequency content of background noise, while HVSR determined the fundamental resonance frequency (f0) and amplification factor (A0), reflecting impedance contrast between shallow layers and bedrock. Continuous waveform data recorded between October 2024 and August 2025 were pre-processed to remove instrumental effects, with each component (Z, N, E) tapered using a cosine function. Data were divided into overlapping segments, and PSD was computed using the Welch method. HVSR was computed as the ratio of horizontal to vertical spectral amplitudes. PSD and HVSR results were compiled for each station, and summary statistics generated to assess spatial variations in noise conditions and local site response. Preliminary results provide insights into ambient noise and site response across the district. PSD shows significant spatial variation in background noise, distinguishing sites based on installation and location. HVSR analysis indicates f0 varies between 0.1 Hz and 19.7 Hz, while A0 varies from 5.0 to 14.0, suggesting heterogeneous subsurface conditions. Temporal analysis reveals seasonal variations in both A0 and f0, with a spike in amplification during monsoon onset, likely due to soil moisture and near-surface velocity contrasts.

Keywords: Seismic noise tomography, Power Spectral Density, Amplification, Fundamental frequency

[ABS-0214]

EMPIRICAL TRANSFER FUNCTIONS FOR ENHANCED SEISMIC HAZARD MODELLING IN THE NORTHEAST HIMALAYA

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The Northeast Himalayan region of India is one of the most seismically active and tectonically complex areas globally, but the scarcity of recorded strong ground motions poses challenges for reliable seismic hazard assessments. This study introduces a refined site correction methodology based on the Empirical Transfer Function (ETF) to improve the accuracy of synthetic ground motion simulations in data-deficient environments. The ETF was estimated for 48 sites across the Northeast Himalaya using 447 accelerograms from 28 earthquakes (Mw 3.9 5.9). Incorporating the ETF into the stochastic simulation process significantly improved the agreement between synthetic and recorded time histories, particularly in the high-frequency range, compared to conventional horizontal-to-vertical ratio-based corrections. The spatial distribution of dominant frequencies derived from the ETF provides new insights into local amplification characteristics. Quantitative error metrics validate the approach, with time-domain and frequency-domain errors reduced from 1.72 to 0.3 and 0.588 to 0.065, respectively. The ETF-based methodology enhances the realism of synthetic accelerograms, strengthens regional seismic hazard evaluations, and contributes to resilient infrastructure planning in the Northeast Himalaya. This scalable framework can be extended to other tectonically active regions with similar geological complexities.

Keywords: Empirical Transfer function (ETF), Stochastic Modelling, High Frequency, Kappa, Site Effects, HVSR, Northeast Himalaya

[ABS-0220]

INSAR-BASED ASSESSMENT OF EXTREME PRECIPITATION INDUCED LANDSLIDES IN THE WESTERN GHATS, INDIA

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A portion of the Western Ghats in Wayanad, including the Vavulmala and Vellarimala hills in Kerala, is highly susceptible to recurring landslides and debris flows during the monsoon season. The extreme climatic event on 8th August 2019 induced a flash flood in Puthumala (Site-1, 5 pm) and massive landslide in Kavalappara (Site-2, 8 pm), followed by landslides and flash floods triggered by extreme rainfall event on 30th July 2024, at Chooralmala (Site-3, 2:17 am), south of Site-1, impacting the villages of Mundakkai and Vellarimala. These precipitation-driven mass wasting events caused substantial loss of life and property. We used time-series InSAR and precipitation data to detect precursory ground movement around the affected zones. Precipitation records show that Sites-1 and 2 received their maximum daily rainfall in 24 years

on 8th August 2019. Longer-term trends indicate rising cumulative annual rainfall and increasing maximum daily precipitation at all sites, reflecting a gradual intensification of extreme rainfall events. Time series InSAR analysis reveals average LOS movements of -25 cm/yr, -6 cm/yr, and -17 cm/yr at Sites-1, 2, and 3, respectively. Notably, InSAR also captures localized uplift at Site-1 (+10 cm/yr), Site-2 (+40 cm/yr), and at Site-3 (+18 cm/yr), indicating hydrological loading and slope destabilization prior to failure. Extreme rainfall was the primary trigger at all three sites. Flash floods followed landslides at Sites-1 and 3 due to their riverine locations, while at Site-2, anthropogenic activities such as agriculture on steep, concave slopes worsened landslide severity. These findings highlight the urgent need for continuous monitoring of the metastable slopes as precursory study to plan slope stabilization, land-use regulation, and early-warning systems. In addition to ground-based monitoring, meteorological data and time-series InSAR can provide actionable intelligence, enabling authorities to proactively manage and mitigate landslide hazards across the Western Ghats regions.

Keywords: Landslides, InSAR, Wayanad, Slope stability, Extreme precipitation

[ABS-0223]

SURFACE MODIFIED ZIRCONIUM OXIDE-MAGNETIC NANOCOMPOSITES INFUSED ALGINATE BEADS FOR THE RECOVERY OF Y AND SC FROM RED MUD LEACHATES IN GROUNDWATER

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The transition towards clean energy is leading to an increased dependence on secondary sources for critical metal production, particularly from waste streams. Globally, red mud poses a significant environmental challenge in the alumina industry, but also represents an interesting source for critical metals such as yttrium (Y) (60-150 mg/kg) and scandium (Sc) (60-120 mg/kg). In the present study, varying compositions of surface modified zirconium oxide and magnetic nanoparticles infused porous alginate beads, and their recovery efficiency towards Y and Sc were studied in batch and column mode. The prepared nanoparticles and beads were characterized using suitable techniques like X-ray diffraction (XRD), field emission scanning electron microscope (FESEM), high-resolution transmission electron microscopy (HRTEM), and scanning electron microscopy (SEM). Y and Sc adsorptions onto beads were confirmed using an inductively coupled plasma-optical emission spectrophotometer (ICP-OES) and X-ray photoelectron spectrophotometer (XPS). From the batch experiments, the effect of pH, time, adsorbent and adsorbate dosage, along with the maximum adsorption capacity (Q0) was calculated. The experimental data have been fitted well with the pseudo second order kinetic and the Freundlich isotherm models. Further, the BDST model was applied to calculate the adsorption capacity (N0) of the fixed-bed column. The selectivity and interference study was carried out on the red mud leachate sample, and the results revealed that the beads showed high selectivity towards Y (43.2%) and Sc (35.17%), respectively. This adsorption study revealed that the developed alginate beads are promising materials that are cost-effective, non-toxic,

biodegradable, eco-friendly, and highly efficient towards the recovery of Y and Sc from red mud.

Keywords: red mud, yttrium, scandium, porous alginate bead, selective adsorption.

[ABS-0226]

CRUST AND UPPER MANTLE LOVE WAVE GROUP VELOCITY MAPS OF NE INDIA

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In the present study, fundamental mode Love waves with periods ranging from 6 to 60 s are used to obtain group velocity maps in Northeast India. A total of 880 ray paths are obtained using 228 local and regional earthquakes (5 â ¤ Mw â ¤ 7.9) recorded by 26 seismic stations. Contrasts in group velocity tomography images at different periods mirror significantly different crustal structures. In periods < 16 s, BB, IBR, EHS, the upper part of BRV, Assam syntaxis, and part of Tibet display low velocities, significantly lower than those of the Shillong Plateau, Mikir Hills, and the Eastern Himalayan Ranges (EHR). Low-velocity zones in BB and IBR systematically shift eastward toward the southern part of the IBR for 16 to 42s, and with increasing period, group velocity increases. Observed low-velocities in the upper part of BRV and within the BB, IBR, and Assam syntaxis indicate the presence of sedimentary layers in the uppermost crust. However, low velocities observed in the higher periods in the BB and IBR indicate thicker sedimentary deposits in these regions. The western part of the BB exhibits higher group velocities compared to the BB in the east, indicating an increasing basement depth from west to east. With increasing periods up to 60s, the area of highest velocity is observed in the SP, Rajmahal trap, and Singhbhum craton due to a thin crust or shield materials. Thickness of the crust increases toward the Indo-Burmese subduction in the east and the India-Asia collision in the north. At periods >50s, lower velocity is observed in the Tibetan plateau, indicating the presence of a thicker crust. The low velocity from ~27 s to 50 s in the Tibetan Plateau is an indication of partial melts in the middle-to-lower crust, which is also reported in several studies.

Keywords: Love wave, Dispersion curve, Tomography images, Crustal structure.

[ABS-0235]

PRELIMINARY ANALYSIS OF EPISODES OF FLOODING IN SINA RIVER, IN 2025, IN PARTS OF SOLAPUR DISTRICT, MAHARASHTRA STATE

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Solapur District is a district in Maharashtra state of India, with Solapur city as its headquarters. It's located on the southeast edge of the state and lies entirely in the Bhima and Sina river

basins. Solapur district is located in a monsoonal rain shadow area of Maharashtra and has an average annual rainfall of approximately 584.3 mm. However in 2025 September, it received about 70-to 100 mm in a day at different places. Simultaneously in the upstream basin?s recharge area, the rain spells were abnormally heavy and sudden. The medium irrigation projects on main 3-4 tributaries overflowed and discharged water, into Sina River haphazardly. Rainfall data analysis for Solapur district in 2025 monsoonal period indicates periods of extremely heavy cyclonic rains, especially in last week of September 2025, that resulted in serial flooding, crop damage, and high water discharge from medium and major dams in both the river basins. In recent decades the ephemeral Sina River was converted into perennial link canal, through Bhima ? Sina link canal project, with aim to distribute water from Ujani Dam to drought prone region around Sina basin- which is actually part of major Bhima basin. This has effected and affected the land use and geohydrological properties around, in the Sina River basin area. The Sina River joins Bhima River, nearly in right angle, at the state boundary of Maharashtra and Karnataka. Bhima was flowing beyond its extreme capacity and acted as bund for Sina excess water mixing at the confluence, resulting in backwater voluminous historic floods, in the broader flood plain areas of Sina River. Attempts have been made to analyze holistically, through detail studies of the various geological, geomorphological, geohydrological and man imposed activities in the total Sina River basin, to investigate the causes and further proposing suggestions to mitigate the problem solution for minimizing the flood hazards in future.

Keywords: Sina River floods, Solapur District, 2025 rainfall data analysis, Bhīma River

RECENT ADVANCES IN GEOSCIENCE & TECHNOLOGY

AI/ML, NEW OBSERVATION TECHNOLOGIES, MODELLING, EARLY WARNING SYSTEMS, MINING

[ABS-0044]

ROCK PHYSICS GUIDED VARIATIONAL BAYESIAN NEURAL NETWORK FOR ELASTIC LOG PREDICTION

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Variational Bayesian Neural Networks (VBNNs) have emerged as a powerful class of models that provide a principled way of integrating prior domain knowledge with data-driven learning, thereby enabling robust predictions with predictive uncertainty. This helps to address the non-uniqueness of geophysical problems and the limited availability of labelled data. Reliable estimation of elastic properties such as P-wave (Vp) and S-wave (Vs) velocities is fundamental for seismic reservoir characterization. However, obtaining high-quality elastic logs is often constrained by acquisition cost, measurement noise, and sparse sampling. To address these challenges, we present a VBNN augmented with a rock physics workflow (RPW-VBNN). The idea is to embed meaningful constraints into deep learning by supplementing limited training data with synthetic elastic logs generated using effective medium models. These synthetic logs capture plausible velocity trends under varying lithological and petrophysical conditions, thereby guiding the learning process toward geologically consistent solutions. The resulting workflow is designed to provide accurate predictions, quantify uncertainty, and respect the underlying physics of the subsurface. Our approach is trained on petrophysical well logs from the Theia 1 well and validated on an independent blind well from China. The results clearly demonstrate the advantages of incorporating rock physics priors. Compared to a standard VBNN, the RPW-VBNN reduces mean absolute error by 73.1% for Vp and 61.9% for Vs. Furthermore, the CC significantly improved from 0.905 to 0.948 for Vp and from 0.896 to 0.963 for Vs. These highlights both the proposed method's predictive accuracy and enhanced reliability. The key contribution of this study is the demonstration that coupling rock physics knowledge with Bayesian deep learning leads to more trustworthy elastic property estimation, particularly in data-sparse or noisy environments. The RPW-VBNN framework provides a pathway toward more interpretable and geologically sound predictions by effectively bridging data-driven inference with physical modeling.

Keywords: Bayesian Neural Network, Deep Learning, Rock Physics, Elastic Logs, Reservoir Characterization

[ABS-0079]

HIGH-RESOLUTION DOWNSCALING OF DAILY MINIMUM TEMPERATURE IN INDIA USING ADVANCED DEEP LEARNING ALGORITHMS

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The Statistical Downscaling method serves as a robust technique for the downscaling of GCMs data to evaluate climate change at a regional level. An unprecedented increase in minimum

temperature (Tmin) has been observed globally, leading to significant impacts that are particularly evident at the local level. High-resolution climate data at the local level is essential for various applications and impact assessments in agriculture, public health, environmental studies, and livelihoods. This study introduces an advanced deep learning approach: The Bidirectional Long Short-Term Memory network (BiLSTM) and the Gated Recurrent Unit (GRU) to downscale the CMIP6 GCMs models (with a coarse resolution of 1.25°) to daily minimum temperature (Tmin) data at a regional scale of 0.5° spatial high resolution for the period from 1951 to 2010 across India. The findings indicate that both methods perform exceptionally well in downscaling across all GCM model datasets; however, the BiLSTM method demonstrates slightly superior performance compared to the GRU method when evaluated against observed minimum temperatures, as well as in terms of RMSE, MAE, correlation, and spatiotemporal variability. Furthermore, the study also analyzes the future changes in Tmin over India under various future scenarios. In conclusion, the study asserts that the BiLSTM approach is a highly effective tool for downscaling (outperforming GRU) daily Tmin over India with optimal parameter tuning. Therefore, we recommend employing the BiLSTM method for downscaling GCMs datasets at a high resolution across India.

Keywords: CMIP6, Diurnal Temperature Range, Deep learning, Downscaling

[ABS-0134]

DECODING THE ANISOTROPIC LITHOSPHERE OF NORTHEASTERN INDIA THROUGH AMBIENT NOISE AND RECEIVER FUNCTION TECHNIQUES

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Northeastern India represents a geodynamically complex zone shaped by the interaction and evolution of multiple tectonic regimes. The region has long been at the centre of debate concerning its past and present tectonic configuration. Bounded by the Eastern Himalaya in the north, the subducting Indian plate toward the east, the uplifted Shillong Plateau in the centre, and an intricate network of faults and lineaments, it provides a natural laboratory to probe lithospheric processes. In this study, we utilize cross-correlation of continuous ambient noise seismic data recorded between 2015 and 2020 to extract empirical Green s functions representing interstation impulse responses. Dispersion measurements from these Green s functions are inverted to construct Rayleigh wave group velocity tomograms in the 7 25 s period range, enabling imaging of lithospheric structure at varying depths. Additionally, receiver functions obtained through Multi-Taper Correlation are subjected to harmonic decomposition to investigate major crustal and lithospheric interfaces beneath stations distributed across the region using data from 2011-2020.Results from ambient noise tomography highlight prominent physiographic and geological contrasts at shorter periods (≤10 s). At longer periods, the Dauki Fault emerges as a north-dipping structure with a near-constant dip to ~20 km depth (period ~16 s), steepening further at greater depths. The tomograms also

provide evidence of oblique subduction of the Indian plate beneath the Burmese plate near ~25°N, reflected by variations in crustal thickness and velocity gradients. Complementary receiver function harmonic analysis reveals tectonic support for the Shillong Plateau, strain heterogeneity near the Kopili Fault and Indo-Burma Ranges. The coexistence of a shallower Moho, and stress-oriented perpendicular to the anisotropic tilt direction observed on Shillong Plateau, validates the hypothesis of a tectonically uplifted plateau. The results imply a crust upper mantle interaction that generates 2D entrained flow along the subduction system, coexisting with the 3D toroidal flow beneath the Burmese arc.

Keywords: Ambient Noise Tomography, Cross-Correlation, Receiver Function, Harmonic Decomposition, Northeast-India, Dispersion

[ABS-0043]

MACHINE LEARNING AIDED ESTIMATION OF MINERALOGICAL ELEMENTS FROM DOWNHOLE NMR DATA FOR CHARACTERISATION OF GAS HYDRATE RESERVOIR

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Downhole nuclear magnetic resonance (NMR) data are useful for detecting and quantifying mineralogical constituents in sediments by analysing grain size distribution. However, because of the variety of hydrate occurrence patterns within the subsurface lithology, its application to gas hydrate reservoir classification remains difficult. The NMR instrument is unable to detect solid gas hydrates in pores and has a low amplitude in the NMR T2 distribution, which can lead to inaccurate subsurface lithology estimation. Therefore, based on grain size, we assess the precise amount of different lithologies in terms of clay, silt, and sand and propose a technique to recover NMR T2 distributions signals without gas hydrates from measured NMR signals (with gas hydrate). The site NGHP-02-05 was selected from Area C of the Indian National Gas Hydrate Program's second expedition (NGHP-02) in the KG offshore Basin. We estimate the volumetric percentages of sediment constituents using the supervised probabilistic automatic relevance determination (probabilistic-ARD) technique and employ the cumulative trapezoidal method to preserve NMR T2 distribution signals free of gas hydrates. When comparing medium (silt) to large (sand) grains to fine (clay) grains, the results reveal a considerable difference in the amplitude distribution, suggesting that the gas is mainly distributed in larger pores. The findings also indicate that silt and sand predominate over clay in the lithology.

Keywords: Krishna-Godavari Basin; NMR T2 distribution; lithology quantification; gas hydrate.

[ABS-0197]

AMPLITUDE COMPENSATED LAPLACIAN FILTERING FOR SUPPRESSION OF THE LOW-FREQUENCY ARTIFACTS IN RTM IMAGING

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Reverse time migration (RTM) with zero lag cross-correlation imaging is commonly employed for subsurface reflector imaging, however it frequently produces low-frequency artifacts due to direct arrivals, backscattering, and diving waves, reducing image clarity and interpretability. To reduce these artifacts, we use a Laplacian filter, a second-order derivative operator that is good for edge enhancement and low-frequency suppression. However, direct application of Laplacian filtering may affect reflection amplitudes and wavelet integrity. As a result, we use an amplitude-compensated Laplacian filtering approach that first normalizes the migrated image with a source-derived compensation factor. Our proposed workflow includes three important steps: 1. Create the initial RTM image using zero lag cross correlation of the source and receiver wave fields. 2. Create a compensation map based on the source illumination energy with wavelet amplitude. 3. Apply the Laplacian operator to the corrected image. This method effectively reduces low-wavenumber noise while maintaining reflection fidelity. We test the strategy using both benchmark synthetic models and field seismic data. The results show clearer reflector delineation, fewer artifacts, and better preservation of amplitude characteristics, beating both unfiltered RTM and naive Laplacian filtering. The suggested technique improves image resolution and interpretability in difficult geological contexts while incurring little additional computing costs.

Keywords: reverse time migration, cross correlation imaging, Laplacian filter, amplitude compensation, low frequency artifact suppression, seismic imaging.

[ABS-0069]

A BAYESIAN INVERSION APPROACH TO CRUSTAL IMAGING FROM VERTICAL TELESEISMIC AUTOCORRELATION

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The structure of Earth s crust provides critical insights into the planet s internal properties and dynamic processes. One effective method to infer these properties involves analysing teleseismic P- or S-waves from distant earthquakes, which propagate as plane waves through stratified media beneath the receiver. Autocorrelation of these waves yields the reflection response of the medium they have traversed, enabling insight into subsurface layering. Inverting these autocorrelograms allows for characterization of the stratified structure; however, such inversions are inherently affected by non-uniqueness. In this study, we address this challenge using a Bayesian probabilistic inversion framework to jointly estimate P-wave

velocity (Vp) and crustal thickness (H). This method offers a robust estimate of model parameters along with their associated uncertainties. The direct inversion of Vp is particularly valuable, as accurate velocity models enhance earthquake location accuracy, travel-time predictions, source characterisation, and seismic hazard assessments. Unlike conventional travel-time inversion, our Bayesian approach incorporates waveform-based misfit evaluation by comparing observed and synthetic autocorrelation stacks. We apply this methodology to the Garhwal Kumaon region of the central Himalaya, an area identified as a potential site for a future large-magnitude earthquake. Seismic data from this region are used to investigate crustal structure, including the depth of the Main Himalayan Thrust (MHT), the major decollement along which the Indian plate underthrusts the Himalayas. Our findings offer enhanced constraints on crustal structure, contributing to a more comprehensive understanding of lithospheric architecture and tectonic evolution in this seismically active region.

Keywords: Bayesian inversion, Autocorrelation, Uncertainty quantification, probabilistic inversion

[ABS-0070]

COUPLING AUV-BASED GEOPHYSICAL MAPPING AND IMAGE CLASSIFICATION TO CHARACTERIZE COLD SEEPS AND DEEP-SEA ECOSYSTEMS IN THE KRISHNA GODAVARI BASIN

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Autonomous Underwater Vehicles (AUVs) enhance deep-sea exploration by enabling high-resolution mapping of cold seeps, gas hydrates, and vents. In December 2023, NIOT, CSIR NIO, and NCPOR jointly surveyed the Krishna Godavari Basin, following CSIR NIO s 2018 discovery of an active cold seep. The AUV, equipped with multibeam bathymetry, water column imaging, synthetic aperture sonar, sub-bottom profiler, and HD cameras, operated at 30 m and 5 m altitudes, achieving ~1 m bathymetric and ~25 cm photographic resolution. Over a 500 × 180 m area, it mapped 100+ pockmarks and ~303 gas flares from WCI data, revealing seabed morphology and fluid escape features. These align with active seepage zones linked to carbonate deposits, shallow gas hydrates, and widespread chemosynthetic communities. The survey revealed extensive faunal distributions in areas with strong gas venting seen in MB and WCI data. To better understand these communities, pixel-based image classification was done using ilastik, a toolkit usually used for microscopic images but adapted here for deep-sea photographs. This pixel-level segmentation enabled systematic classification of seafloor habitats and biota, leading to the identification of nearly ten distinct features. These include Bathymodiolus sp., goose barnacles (Neolepas) attached to Bathymodiolus sp., bacterial mats, sea spiders, dead Bathymodiolus specimens, Calyptogena sp. clams, tube worms, faunal burrows, Siboglinidae tubes, and backscatter gas bubbles. The ability to identify both live and relict chemosynthetic communities highlights the potential of combining AUV imaging with advanced computational classification for ecological assessments in deep-sea environments. This study shows the effectiveness of AUV-based surveys in detailed characterization of cold

seep ecosystems. By integrating geophysical data, water column measurements, and high-resolution imagery with advanced image processing, this study establishes a framework for seep studies. The results offer essential baseline data for environmental monitoring, resource assessment, and understanding fluid dynamics, biogeochemical cycles, and benthic ecosystems in deep-sea settings.

Keywords: AUV, Gas Hydrate, Cold Seep, Chemosynthetic Communities, Image Classification

[ABS-0073]

COMBINING MACHINE LEARNING AND GEOSTATISTICS FOR SUPERVISED CLASSIFICATION OF REGIONALIZED DATA

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The task of predicting the correct class label of a categorical response in a spatial context arises in many disciplines of the natural sciences, social sciences, and engineering. State-of-the-art techniques to typify and quantify hydrothermal alteration include the application of mineralogical (e.g., alteration indices that use normative minerals) and chemical (e.g., mass balance calculations) approaches, which have their inherent disadvantages such as sensitivity to the composition of the precursors, difficulty of reconciling with mineralogical observations, and a component of subjectivity. Another pathway is to use supervised classification via Machine Learning (ML) based on geochemical analyses of drill cores. However, such a classification task faces specific difficulties as ML classification is often designed for independent observations, while geochemical analyses are spatially autocorrelated. In this study, we incorporate geostatistics and machine learning for supervised classification of multivariate regionalized data, with an application to hydrothermal alteration mapping in a porphyry Cu-Au deposit (Mongolia). Among the many directions in the literature, we follow the approach by Dutta and Emery (2024), where geostatistics is used to replace the "noisy" feature variables by "denoised proxies", as an input for machine learning classification. The novelty is the application of geostatistical simulation instead of kriging to create the proxies and the fact that the proxies are processed differently than Adeli and Guartan (2021), who train as many classifiers as realizations. In a nutshell, we demonstrate two things in this study: the first is how geostatistics enriches machine learning to achieve higher predictive performance and to handle incomplete and noisy datasets in a spatial setting. Secondly, it establishes that a better prediction accuracy can be achieved than in previous studies where alteration types were predicted from geochemical data alone.

Keywords: Geostatistics, Machine Learning, Regionalized Data, Hydrothermal Alteration, Simulation, Mining

[ABS-0078]

MODELLING THE THERMO-HYDRO-MECHANICAL BEHAVIOUR OF ROCKS: A CONTINUUM AND PORE-SCALE APPROACH

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Understanding coupled thermo-hydro-mechanical (THM) processes is essential for predicting the behaviour of geological formations under thermal, hydraulic, and mechanical loads. These processes are crucial in applications such as geothermal energy extraction, carbon capture and storage, and overall subsurface reservoir management. This study applies numerical modelling at both continuum and pore scales to investigate the THM response of saturated porous media. At the continuum scale, the Finite Element Method (FEM) simulated displacement-controlled triaxial tests on cylindrical rock samples under drained and undrained THM conditions, where drained conditions allowed pore fluid escape resulting in negligible pore pressure and higher deviatoric stress at failure, while undrained conditions caused progressive pore pressure buildup, reducing effective stress and triggering earlier yielding, followed by post-yield dilation that reduced pore pressure and generated strain hardening. At the pore scale, the Discrete Element Method (DEM) coupled with a finite volume scheme captured grain-scale THM interactions between solid particles and pore fluids under no-flow (conductive) and constant-flow (conductive and advective) scenarios, revealing localized heat transfer, fluid-thermal interactions, and mechanical responses within the pore network. By combining FEM and DEM results, this approach provides a comprehensive multi-scale evaluation of THM behaviour in thermal reservoirs, supporting improved design and sustainable management of geothermal energy systems.

Keywords: Thermo-hydro-mechanical (THM) coupling, Discrete element modelling, Finite element modelling, Displacement controlled triaxial test

[ABS-0081]

AEROMAGNETIC CHARACTERISTICS OF FELSIC AND MAFIC-ULTRA MAFIC PLUTONS AND THEIR STRUCTURAL FEATURES IN PRAKASAM IGNEOUS PROVINCE, NELLORE SCHIST BELT, SOUTHEASTERN INDIAN MARGIN

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The Prakasam Igneous Province (PIP), located along the southeastern Indian margin within the Nellore schist belt (NSB), exhibits evidence of significant felsic-mafic magmatic activity. The PIP geological domain encompasses both felsic and mafic-ultramafic intrusive bodies as plutons, besides alkali plutons. The felsic magmatism contributes to hydrothermal mineralization, while the mafic and ultramafic magmatism hosts the base and precious metals. An attempt has been made to demonstrate how best the high-resolution aeromagnetic studies

can be used in the interpretation of magnetic structural patterns and structural controls within the PIP. Notably, high aeromagnetic signatures (data source: https://geodataindia.gov.in) are observed along the Boggulakonda, Purimetla, Pasupugallu, Chimakurti, and Kanigiri plutons, whereas Ravipadu and Pedda Cherlo Palle plutons show moderate magnetic responses. These aeromagnetic anomalies effectively delineate the structural framework and lithological contacts of the studied plutons, which are in well agreement with the lithological units. First vertical derivative (FVD), Tilt derivative (TDR), and Amplitude of Analytic Signal (AAS) analysis identify magnetic linear/curvilinear structures trending in N-S, E-W, and NE-SW directions. In this study, most of the plutons exhibit linear magnetic characteristics, such as faults and shear zones, which impart elongation and alignment to the intrusive bodies and their magnetic mineral fabrics, whereas the Chimakurti pluton shows a distinctive circular anomaly pattern. The FVD enhanced shallow magnetic sources and revealed that felsic plutons produced negative values due to low magnetic susceptibility, while mafic plutons showed higher magnetic anomalies due to magnetite content in the rock. The TDR and AAS enhanced the source boundaries. The present study provides an insight into structural control and the mineral resource potential of mafic-ultramafic plutonic complexes.

Keywords: Prakasam Igneous Province, felsic-mafic-ultra mafic Plutons, Aeromagnetic anomalies, Magnetic source, Nellore schist belt (NSB).

[ABS-0085]

GRAVITY INVERSION OF BASEMENT RELIEF USING PARTICLE SWARM OPTIMISATION WITH PHYSICS-INFORMED GRAVITY RESPONSE CALCULATION, DATA-DRIVEN FOURIER COEFFICIENT SELECTION, AND ADAPTIVE PARAMETER TUNING

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Gravity inversion is a central technique in applied geophysics for estimating basement relief in heterogeneous sedimentary basins, with applications in hydrocarbon, groundwater, and mineral exploration. Conventional approaches combine Particle Swarm Optimization (PSO) with Fourier series to reduce model dimensionality. However, these methods suffer from resource-intensive gravity response calculations, fixed PSO parameters, and heuristic Fourier coefficient selection, which often limit performance in noisy or geologically complex settings. To address these challenges, we propose an enhanced PSO-based inversion framework with three innovations. First, the iterative calculation of gravity anomalies from PSO-proposed basement relief models is accelerated using a physics-consistent neural network. Second, PSO control parameters are tuned adaptively during the optimization process by a reinforcement learning agent, improving convergence stability and reducing the risk of trapping in local minima. Third, the number of Fourier coefficients is estimated automatically from observed gravity data using a one-dimensional Convolutional Neural Network, offering a robust, data-driven alternative to heuristic selection. The framework is validated on synthetic datasets contaminated with white

Gaussian noise and on field gravity profiles from the Godavari Basin, India, and the Sayula Basin, Mexico. Performance is assessed in terms of computational efficiency, inversion accuracy, robustness to noise, and uncertainty quantification. Results show marked improvements over conventional PSO-Fourier methods, establishing a fully automated, scalable, and reliable approach for basement relief inversion. More broadly, this methodology provides a modular blueprint for integrating Artificial intelligence with physics-based models across diverse geophysical inverse problems.

Keywords: Gravity Inversion, Basement Relief, Particle Swarm Optimization (PSO), Physics-Informed Neural Networks (PINN), Reinforcement Learning (RL), Convolutional Neural Networks (CNN), Fourier Series, Adaptive Parameter Tuning, Geophysical Inverse Problems, Sedimentary Basins.

[ABS-0088]

EXPLAINABLE AI-DRIVEN MODELING AND RISK MAPPING OF GROUNDWATER FLUORIDE CONTAMINATION: A CASE STUDY FROM JHARKHAND, INDIA

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Groundwater is the primary source of drinking water in rural Jharkhand, but it is often contaminated with geogenic fluoride. High fluoride levels cause dental and skeletal fluorosis, which remains a major environmental pollution and public health challenge. Conventional hydrogeochemical studies are useful, yet they are limited in providing reliable prediction of contamination patterns across larger regions. This highlights the need for new technologies that can combine hydrochemistry with artificial intelligence and machine learning (AI/ML) for better groundwater risk assessment. In this study, hydrochemistry data including pH, bicarbonate, calcium, magnesium and other ions were used to build AI/ML models for predicting groundwater fluoride contamination in Jharkhand. The models classified water samples into safe and unsafe categories. To improve transparency, SHAP (SHapley Additive exPlanations) prediction was applied, which helped identify the most important hydrochemical parameters influencing fluoride. The results showed that bicarbonate and calcium play a strong role in controlling fluoride levels, which agrees with hydrogeochemical understanding. The AI/ML models performed better than traditional statistical methods and generated risk maps that highlight contamination hotspots. These maps can guide decision-makers in identifying unsafe zones and planning safe water supply. The use of SHAP-based interpretation makes the framework more reliable, as it explains why certain areas are at higher risk. This work shows that even with limited hydrochemistry data, explainable AI/ML can support early warning systems for groundwater quality. The approach is transparent, reproducible and scalable, offering a practical solution for sustainable water management in Jharkhand and beyond.

Keywords: Hydrochemistry, Explainable AI/ML, SHAP Prediction, Groundwater Fluoride, Environmental Pollution, Risk Mapping, Early Warning System, New Technologies, Jharkhand

[ABS-0089]

NEUROMORPHIC LSTM-RESUNET HYBRID FOR ENHANCED DENOISING AND INVERSION OF GRAVITY GRADIOMETRY DATA

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Gravity gradiometry provides high-resolution measurements of subsurface density variations, supporting applications in mineral exploration, hydrocarbon prospecting, and tectonic studies. However, the inversion of gravity gradiometry data is hindered by measurement noise, spatial correlations, and the ill-posed nature of the problem. Recent advances in deep learning, particularly LSTM and U-Net architectures, opens possibility for better denoising and structural inversion, yet their implementation on conventional von Neumann architectures faces significant inefficiencies. LSTMs require sequential gate computations with repeated access to large weight matrices and hidden states, creating frequent memoryï ½processor transfers. This bottleneck reduces throughput and increases energy demand, especially for high-dimensional or real-time datasets. We propose a neuromorphic-aware hybrid framework that integrates an LSTMï ½ResUNet architecture with memristor-based in-memory computing simulation. The novelty lies in explicitly modeling memristor device-level non-idealities nonlinearity, stochasticity, drift, and quantization while exploiting in-memory computing to bypass the von Neumann bottleneck. This design reduces memory traffic, enables parallelized gate computations, and improves energy efficiency, allowing joint evaluation of inversion quality and system performance. In conclusion, by combining hardware-enhanced in-memory computing with deep learning, the proposed approach provides accurate, energy-efficient, and scalable solutions for gravity gradiometry processing.

Keywords: Gravity Gradiometry, LSTM, Memristor Computing, Neuromorphic computing, Residual U-Net

[ABS-0097]

SUBSURFACE FAULT INTERPRETATION USING CONVOLUTIONAL NETWORKS IN THE UPPER ASSAM FORELAND BASIN, NORTHEAST INDIA

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Understanding subsurface faults is vital for studying reservoir heterogeneity, locating hydrocarbons, tracking basin changes, maintaining reservoir stability, and evaluating seismic risks. Traditional seismic interpretation workflows can be time-consuming and may be influenced by interpreter bias. In this study, we use high-quality 3D seismic reflection data from the Upper Assam foreland basin to automatically find and map subsurface faults and fractures. We developed a machine learning framework trained on real, labeled seismic data. The convolutional neural network (CNN) learns spatial features that show fault shapes, such as breaks, angles, and ends. The objective is to enhance the accuracy and efficiency of fault

detection, minimize interpreter bias, and promote more consistent and scalable subsurface fault modeling. In the present study, utilizing the fault mask by Edge preserving smoother filter (EPS) and thin faults likelihood (TFL) to demonstrate the fault networks, outperforming traditional edge detection and attribute-based methods in both accuracy and speed. The fault networks divided the Oligocene-Miocene period into several structural sections. Thus, the method allows for fast, consistent, and scalable fault detection, which could improve automated seismic interpretation in geoscience and petroleum work.

Keywords: EPS, TFL, CNN, Upper Assam Basin

[ABS-0105]

GREEN SPACE DYNAMICS AND URBAN HEAT REGULATION IN BENGALURU: A DECADAL PERSPECTIVE

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Rapid urbanization has significantly altered land use patterns, leading to fragmented vegetation and intensified urban heat island (UHI) effects. Bengaluru, one of South Asia s fastest-growing metropolitan regions, faces increasing thermal stress as dense construction expands and vegetation cover declines. This study examines the spatiotemporal dynamics between urban green space patterns and thermal regulation over the decade 2014 2024. To capture these changes, multi-source satellite datasets, including Landsat 8 OLI/TIRS, Resourcesat-2 LISS-IV, and high-resolution Google Earth imagery, were analyzed to map variations in green space distribution, impervious surface expansion, and land surface temperature (LST). The Coupling Coordination Degree Model (CCDM) was employed to evaluate the synergy between ecological infrastructure and its thermal mitigation functions. The results show a distinct rising trend in LST together with a consistent drop in vegetation indices like NDVI, indicating persistent ecological stress brought on by rapid urbanisation. Although vegetation maintained a cooling influence, the coordination between green spaces and surface temperature weakened during the latter half of the decade, particularly in densely built-up areas. Spatial clustering patterns further indicate that poorly connected vegetation patches correspond with thermal hotspots, while built-up intensity shows a negative association with thermal coordination. Methodologically, the study advances urban climate analysis by combining manually digitized high-resolution green space data with remote sensing indices, landscape metrics, and CCDM. The results underscore the importance of spatially connected and strategically planned green infrastructure in mitigating heat stress. Targeted interventions, including micro-scale greening and vertical solutions, are critical for enhancing resilience in dense urban environments.

Keywords: Urban Green Space, LST, Coupling Coordination Degree Model (CCDM), NDVI, Urban Heat Island

[ABS-0109]

DEVELOPMENT OF MAGNITUDE-BASED EARTHQUAKE EARLY WARNING RELATIONS FOR THE HIMACHAL PRADESH REGION USING OBSERVED AND SIMULATED DATASETS (M4.0-8.0)

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Himachal Pradesh lies in one of the most seismically active zones of the Himalayas and is located within the central seismic gap. This region is considered highly prone to future large earthquakes. The history of past large events underlines the urgent requirement for a reliable Earthquake Early Warning (EEW) system. In this study, we developed conventional EEW magnitude-based relations using two parameters average period (τc) and peak displacement amplitude (Pd) which are utilized for regional warnings. The largest instrumentally recorded earthquake in this area reached a magnitude of 5.1. Robust EEW relations require data from larger earthquakes. To address this limitation, we employed a modified semi-empirical technique (MSET) to generate synthetic strong-motion P-wave records. Using this method, we simulated 25 scenario earthquakes covering a magnitude range from M 5.0 to 8.0. Further, estimated the EEW parameters τc and Pd from both observed and simulated data and developed corresponding magnitude regression relations. These relations are further validated using simulated datasets from 12 independent earthquakes. Validation of the τc M and Pd M relations for these 12 events yielded low relative percentage errors ranging from 0.13% to 8.0%. The consistently low errors along with a high Pearson correlation coefficient demonstrate the robustness of these relations across a broad range of magnitudes. Thus, the developed relations offer accurate magnitude estimates for regional EEW systems, significantly strengthening early warning capability and enhancing disaster preparedness in this highly vulnerable Himalayan belt.

Keywords: Earthquake Early Warning, Average Period, peak displacement amplitude, Simulation

ABS-0115]

REGIONALIZATION OF WATER MASSES OVER THE INDIAN OCEAN FOR OPTIMAL DEPLOYMENT OF OCEAN OBSERVATION PLATFORMS

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The Indian Ocean exhibits strong spatial heterogeneity in sea surface temperature (SST), salinity due to freshwater stratification, monsoon forcing, and mesoscale eddies, complicating water mass classification and observing system design. A long-standing need is to partition the water masses optimally based on statistical criteria rather than subjective expert judgment. We are focusing on regionalizing SST data from 1950 to 2024, subgrouping into contiguous

clusters, and understanding the spatial patterns. A graph-based clustering framework has been utilized to regionalize the water masses with iterations leading to an ensemble cluster. Clustering produces different results primarily due to randomness, especially in partitional clustering algorithms. To minimize these errors, the iterative ensemble is one of the easiest solutions, although there are limitations to this approach. Then, the Jaccard coefficient measures pairwise similarity between the water masses. The resulting Jaccard coefficient partitions reveal distinct water masses, e.g.. like those freshwater masses primarily from the riverine flows, and those water masses influenced by monsoons and other large-scale climate drivers. Iterative ensemble sampling yields stable regional boundaries and resolves temporal shifts linked to decadal climate variability. The partitioning of the water masses is particularly useful in planning the deployment of buoys, Argo floats, and other ocean observation platforms that rely on the characteristics of the water masses for optimal operations. For future studies and applications, different ocean parameters, such as salinity, chlorophyll, etc, can also be studied to understand the ocean better.

Keywords: Regionalizaton, Clustering, Jaccard Similarity Matrix, Hierarchical Clustering, Graph-based Clustering

[ABS-0116]

INTEGRATING MACHINE LEARNING AND GOOGLE EARTH ENGINE FOR FLOOD MANAGEMENT IN THE LOWER MANAIR RIVER BASIN, TELANGANA

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Floods are recurring natural hazards in the lower Manair River Basin, Telangana, posing significant threats to agriculture, infrastructure and local livelihoods. This study presents an integrated flood monitoring and management framework using Google Earth Engine (GEE), a cloud-based geospatial analysis platform. Multi-temporal datasets from Sentinel-1 SAR (10 m), Sentinel-2 MSI (10 30 m) and MODIS (250 m) were utilized to detect, map and analyze flood dynamics across spatial and temporal scales. Flood inundation was delineated using SAR-based thresholding, while the Normalized Difference Water Index (NDWI), derived from optical imagery enhanced the accuracy of water body classification. A decadal assessment (2012-2022), combined with rainfall records and reservoir release data, identified recurring flood hotspots in low-lying agricultural regions of Karimnagar district. Peak inundation depths reached 1.5-2 m during intense monsoon events, notably in September 2019, when late-monsoon depressions lead to extreme rainfall and widespread flooding. Annual flood-affected areas ranged from 45 to 120 km², with downstream flooding strongly linked to rainfall events ≥120 mm/day and high-volume reservoir discharges. Hydrological modeling within the GEE environment enabled near real-time flood mapping, significantly reducing processing time from several hours in traditional desktop systems to under 20 minutes. Accuracy assessment indicated reliable performance, with mapping range from 88 to92%. The study demonstrates potential of GEE-driven flood assessment as rapid, scalable and cost-effective tool to support

disaster risk reduction, early warning systems and timely interventions, ultimately contributing to enhancing resilience in flood-prone communities of Telangana.

Keywords: Google Earth Engine, Machine Learning, Lower Manair River Basin, flood assessment, SAR, NDWI, Sentinel-2

[ABS-0117]

RECENT ADVANCES IN SPACE GEODETIC OBSERVATIONS FOR TERRESTRIAL WATER STORAGE ASSESSMENT IN MAJOR INDIAN RIVER BASINS

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Recent advancements in space geodesy and remote sensing have enabled unprecedented insights into Earth s dynamic processes. Among these, the Gravity Recovery and Climate Experiment (GRACE) and its successor, GRACE Follow-On (GRACE-FO), have revolutionized monitoring of terrestrial water storage (TWS) variations by observing Earth s time-variable gravity field. These missions provide unique opportunities to track water mass exchanges across land, ocean, and ice. However, challenges remain in down-scaling coarse satellite products, integrating diverse datasets, and translating gravity signals into hydrologic variables of interest. This study investigates groundwater variability in the Ganga Basin, which has undergone significant depletion over the past two decades due to over-extraction, climate variability, and rising demand. In contrast, the Godavari, Krishna, and Mahanadi basins show relatively stable groundwater conditions. TWS changes from 2002 2025 were derived using GRACE/GRACE-FO Level-2 Monthly Geo potential Spherical Harmonics (RL06.3) solutions of JPL, CSR, and GFZ and Degree-1 geocentric corrections, and GIA corrections (ICE6G-D) were applied. To reduce correlated errors and de striping, a 300 km Gaussian filter were applied, along with a 0.25° land grid mask. Our results were compiled with other hydrological datasets, including GLDAS, rainfall records, and groundwater well observations. Findings show persistent depletion in the Ganga Basin, especially in northwestern and central regions, strongly linked to rainfall decline and irrigation demand. In contrast, the other basins exhibit negligible loss. The improved sensitivity of GRACE-FO enhances detection of hydrological extremes and mass fluxes. Integrating gravimetry with modeling and ground observations demonstrates strong potential for early warning systems and future AI/ML-driven down-scaling to support sustainable groundwater governance in the Ganga Basin and beyond.

Keywords: GRACE, GRACE-FO, Ganga Basin, Groundwater depletion, Terrestrial water storage.

[ABS-0123]

TRANSLATION OF AEM RESISTIVITY INTO LITHOLOGICAL MODEL USING RANDOM FOREST CLASSIFIER

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There is an increasing trend of integrated airborne electromagnetic (AEM) surveys for high resolution aquifer mapping worldwide, including India over the past few decades. Translation of AEM resistivity data into lithological and hydrogeological parameters is an essential part of aquifer mapping, which is mostly carried out manually by comparing AEM resistivity with borehole data. The AEM surveys provide large scale resistivity data, whereas borehole data provide precise lithological details but at a point scale in a discrete manner. Besides the large size of the AEM data, the inherent issue of non-unique resistivity inversion and complex resistivityï ½lithology relationship, translation of resistivity into meaningful lithological and hydrogeological models is a challenging task. These difficulties can be addressed by a machine learning approach. In this study, we use machine learning techniques for translating AEM resistivity data into lithological and hydrogeological models. The approach involves pre-processing and statistical analysis of AEM resistivity data, followed by correlation with borehole lithology and finally supervised machine learning (Random Forest Classifier) based classification of lithology in terms of sand and clay probabilities. The term hydrofacies is used to represent strata having uniform hydrogeological properties. The Aquifer which has fine, medium, coarse sands and gravel comes under sand hydrofacies class, whereas clay and silt are considered as clay hydrofacies class. This study provides reliable hydrofacies prediction as Sand and Clay Probabilities even in data-sparse regions. Application of this methodology in the alluvial formation of the Middle Ganga Plain in Ganga-Yamuna Doab region, demonstrates its capability to delineate permeable and impermeable layers, aquifer boundaries, and provide vertical and lateral heterogeneities with higher accuracy than the conventional interpretation methods. This study highlights the role of machine learning techniques in providing an automated and accurate translation between geophysical measurements and hydrogeological parameters through practical case studies.

Keywords: Electromagnetic, Resistivity, lithology, Hydrofacies, Supervised machine Learning, Random Forest Classifier

[ABS-0132]

LITHOSPHERIC DEFORMATION AND DEPTH LOCALIZATION OF SEISMIC ANISOTROPY BENEATH THE SIKKIM HIMALAYA

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Seismic anisotropy serves as a powerful tool for deciphering the strength, direction, and depth of deformation within the crust, lithosphere, and sub lithospheric mantle. This study integrates

shear wave splitting (SWS) analyses and spatial coherency methods to unravel the crustal mantle deformation patterns and source localization of anisotropy beneath the Sikkim Himalaya. Using the core refracted (SKS/SKKS/PKS) and crustal (Direct-S) seismic phases, this work presents novel shear wave splitting (SWS) observations from the Sikkim Himalaya region to understand the deformation patterns at the mantle and crustal scales, respectively. Indo-Eurasian collisional tectonics dominates the deformation patterns beneath Sikkim, as evidenced by significant time delays (δt) and consistent NW-SE orientated fast polarisation directions (ϕ) at all seismic station locations. The Sikkim Himalayan region has a similar crustal deformation pattern (NE-SW), driven by the alignment of maximum shear stress, indicating that the correlated crust-mantle dynamics are influenced by the massive collisional tectonic force. Spatial coherency analysis of splitting parameters based on the Fresnel zone concept was used to further constrain the source and depth of anisotropy. The findings point to a central anisotropic layer at a depth of around 120 km, which is indicative of deformation in the intricate lithospheric mass beneath Sikkim. This work collectively signifies that the lithospheric deformation beneath the Sikkim Himalaya is governed by large-scale collisional tectonics, manifested through the interaction of crust mantle anisotropy and deep-seated heterogeneities that reflect active geodynamic processes along the eastern Himalayan orogenic belt.

Keywords: Sikkim Himalaya, Seismic Anisotropy, Shear Wave Splitting, Lithospheric Deformation, Convergence tectonics, Indo-Eurasia collision

[ABS-0135]

60 YEARS OF HYB OBSERVATORY PRESERVING HERITAGE, ADVANCING PRECISION

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The Hyderabad Geomagnetic Observatory, operated by CSIR-NGRI, has maintained an almost uninterrupted series of geomagnetic measurements since its inception in 1965. As a key low-latitude observatory, it has consistently contributed high-quality data and definitive data and its products to the global scientific community, supporting foundational research in geomagnetism. Over the decades, the observatory has undergone significant upgrades in instrumentation, data acquisition protocols, and technical expertise to meet the evolving needs of researchers. Today, it stands as a pivotal geomagnetic observatory in the Asian continent. This work presents a historical overview and a critical assessment of the improvements in observational capabilities, instrumentation, and scientific skillsets that have sustained its legacy and enhanced its role in geomagnetic research.

Keywords: Key words: Geomagnetic observatory, variometer data quality, baselines

[ABS-0142]

CONSTRAINING THE DIFFERENTIAL TECTONIC UPLIFT IN THE EASTERN HIMALAYAN WEDGE USING THE RIVER INCISION MODEL

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The Himalayan range has evolved as a wedge system due to the underthrusting of the Indian plate into the Eurasian plate. Tectonic and erosional processes have shaped the Himalayan wedge through the evolution of the drainage system. The differential strain partitioning along the Himalayan Arc causes different uplift-erosion regimes, resulting in a transient landscape. A Major knickpoint set (> 3064m) observed on the eastern Himalayan transient basin: Kosi, Teesta, Torsa, Raidak, Sankosh, and Manas, demarcating a significant change in the tectonic-erosion setting in the region. Another set of knickpoints was identified at lower elevations (<2631 m) in the easternmost basins, indicating a second phase of tectonic-erosion change. We have used geomorphic indices like chi profile, Normalised Steepness Index (ksn), paleochannel reconstruction to evaluate erosion and uplift rates, and knickpoints modelling for spatial and temporal constraints. The ksn values of the upper segment of the rivers have < 190 m0.9, termed as the upper relict reach, while the lower segments have >190 m0.9. The two sets of knickpoints are related to the two or multiple phases of tectonic regimes shift, and the relict reach preserves the previous signature of the older uplift-erosion phase. Thus, the reconstructed paleochannel from the relict reach estimates the degree of surface uplift since the drainage perturbation. The upper transient reach gives the estimated surface uplift ranging from 1600 m to ~4000 m, while the lower relict reach gives an uplift of ~800-1700 m. The second phase of uplift was observed only in the basins east of the Dubri/ Jamuna Fault, where, in the Brahmaputra basin, a plateau has grown since 5 Ma, known as the Shillong plateau. We speculate that the second phase of the transient signal must have developed due to differential strain partitioning, possibly coeval with the Shillong plate growth in the south.

Keywords: Himalayan wedge, Transient knickpoints, relict reach, Ksn

[ABS-0145]

3D MAGNETIC INVERSION FOR DEEP SUBSURFACE STRUCTURE NEAR THE CONFLUENCE POINT OF THE GANGA & YAMUNA RIVERS

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In this study, we focused on 3D magnetic inversion to investigate the deep subsurface structures in the Ganga-Yamuna Doab region, with the objectives of understanding aquifer heterogeneities and groundwater dynamics. As transient time domain electromagnetic data (TEM) is sensitive to shallow depth ranges and can map water-bearing sediments effectively, whereas magnetic data is more suitable for imaging deeper causative magnetic sources such as

basement, fault, contacts and joints, etc. Airborne magnetic data were acquired with varied line spacings (500-1500 m) over the Ganga Yamuna Doab region. For 3D magnetic Inversion, we used SimPEG, an open-source platform, to generate 3D susceptibility models from unfiltered data as well as high-pass filtered datasets with cutoff wavelengths of 50 km and 20 km. The model obtained with data filtered with a 20 km cut-off wavelength was selected because it emphasised the response from causative sources at the target depth of 5 km. To interpret the inversion, we made magnetic susceptibility slices at different depths (1 km, 2 km and 5 km) and cross-sections along the flight directions, using the Pyvista and Paraview software. To delineate the lineaments, deep faults, geological contacts, etc, the total horizontal gradient for the susceptibility model has been computed at different depths. The peaks of total horizontal gradient are picked up to highlight the trend for zones of maximum contrast. Based on trend lines, we have identified the lineaments, deep faults and geological contacts in the study area. Such structural features are significant because they allow deep percolation and storage of groundwater and provide potential pathways to understand hydrodynamics on a regional scale. The final 3D susceptibility model may be integrated with TEM to provide a hydrogeological model (with both shallow and deep geological/structural controls) to better understand the deep aquifer systems in the Ganga Yamuna Doab region.

Keywords: Airborne Magnetics, 3D inversion, susceptibility, deep structure, confluence.

[ABS-0146]

APPLICATION OF FULL WAVEFORM INVERSION (FWI) FOR IMAGING SYNTHETIC SEISMIC DATA

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Full Waveform Inversion (FWI) is a high-resolution seismic imaging technique that goes beyond conventional approaches by exploiting the entire seismic waveform rather than relying solely on kinematic information. Conventional methods, such as travel-time tomography and migration, are based on ray theory approximations and often provide insufficient resolution for imaging complex subsurface structures. In contrast, FWI incorporates the full wavefield, enabling more accurate characterization even in geologically challenging environments.In this study, we applied FWI to suite of synthetic seismic data to investigate both shallow and deep subsurface features. Forward modelling generated shot gathers that served as input for the inversion, which was carried out under an elastic approximation. The inversion workflow employed an iterative local optimization scheme, where synthetic data were updated progressively to minimize the misfit with observed data. A multiscale strategy was adopted, beginning with low-frequency components to mitigate cycle skipping, followed by higher frequencies to sharpen structural details.Our results highlight the computational demands of the process, requiring high-performance parallel computing resources. Nonetheless, the synthetic case studies demonstrate that FWI effectively bridges the resolution gap between

conventional tomography and reflection imaging, offering a unified framework for detailed subsurface characterization.

Keywords: Full Waveform Inversion, Seismic Imaging, Forward modelling, Synthetic seismic data, Cycle Skipping, Parallel computation.

[ABS-0151]

QUANTUM INSPIRED AI FOR TIME LAPSE INVERSION OF SEISMIC DATA FOR SIMULATION OF CO2 INJECTION SCENARIOS

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Seismic full-waveform inversion (FWI) effectively reconstructs subsurface velocity models, but its high computational cost limits practical use.Here a new strategy such as a quantum-inspired artificial intelligence framework is presented for time-lapse seismic full-waveform inversion (FWI), aimed at reconstructing subsurface velocity models that characterize changes due to CO_2 injection in earth s subsurface. The Kimberlina-CO_2 synthetic dataset, based on a potential CO_2 reservoir at the Kimberlina site in the southern San Joaquin Basin, serves as the benchmark. This dataset captures the spatial and temporal evolution of a supercritical CO_2 plume over a 200-year period, providing realistic subsurface scenarios for monitoring and detection of CO_2 leakage in deep subsurface reservoirs is vital for safe carbon storage and effective climate management. The proposed hybrid inversion model integrates a convolutional neural network encoder with a PennyLane-based quantum layer wrapped as a TorchLayer, bridging classical and quantum-inspired machine learning to efficiently map seismic inputs to velocity reconstructions. This architecture improves computational efficiency and reduces memory requirements, while maintaining high fidelity in detecting subtle velocity changes induced by the migrating CO_2 plume. Standard error and similarity evaluation metrics such as mean absolute error , root mean squared error and structural similarity index are used to quantitatively benchmark the model s performance against traditional inversion methods. Results demonstrate that the quantum-inspired hybrid model produces realistic and accurate subsurface velocity images under challenging conditions involving weak seismic signals and limited observations, underscoring its potential to accelerate seismic inversion workflows and enhance reliability in CO_2 storage monitoring. This work makes a substantive contribution to the emerging field of quantum-inspired geophysical inversion and advances the tools available for environmental management and climate change mitigation.

Keywords: CO_2 storage monitoring, time-lapse seismic data, full-waveform inversion, quantum neural network

[ABS-0155]

PYGIMLI-BASED INVERSION OF RESISTIVITY DATA FOR GROUNDWATER ASSESSMENT: A COMPARATIVE ANALYSIS WITH RES2DINV

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ERT is a common geophysical tool used to map variations in subsurface resistivity and to evaluate groundwater potential in complex geological settings. The reliability of interpretations depends on the inversion method. In this study, ERT data were processed and inverted using the Python-based open-source PyGIMLi framework to assess groundwater conditions in a semi-arid region experiencing long-term water scarcity. Four 2D profiles were acquired in the Wenner Schlumberger configuration to balance depth penetration and lateral resolution. Data preprocessing included data quality control through variance checks, outlier removal, and median smoothing to stabilize the inversion. In PyGIMLi, the inversion was carried out using a Gauss Newton least-squares approach with regularization term controlled by λ, balancing smoothness (L2 norm) and robustness (L1 norm). The inversion was run in multiple iterations, with adjustments to damping and mesh, until we reached a stable solution. We observed that all four profiles show models with RMS and χ^2 errors below 5%, which suggests the data quality and fit were quite good. On the other hand, Res2DInv employs a grid-based finite-difference mesh and a more constrained inversion routine, optimized for computational efficiency and user accessibility. From our comparison, PyGIMLi gave us more control over inversion settings and error handling. This made the results look more reliable for hydrogeological interpretation. Its open-source design can also be easily combined with other geophysical and hydrological datasets for joint inversion. Res2DInv is fast and easy to use, but it offers limited flexibility for detailed error evaluation and model customization. This study highlights the importance of the chosen inversion method in deriving robust resistivity models for groundwater assessment. A comparative analysis of the inversion routines shows that the PyGIMLi approach achieved better resolution and lower error.

Keywords: Electrical Resistivity Tomography (ERT), PyGIMLi, Gauss Newton least-squares approach, regularization term, L1 & L2 norm

[ABS-0156]

VELOCITY PREDICTION USING INTEGRATED ROCK PHYSICS MODELING OF FRACTURE NETWORKS

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The increasing urgency for sustainable and clean energy resources has bolstered interest in Hot Dry Rock (HDR) geothermal systems, which are characterized by low-porosity crystalline rocks where reservoir performance relies heavily on fracture networks. Conventional reservoir

characterization approaches have limited capability in directly quantifying fracture density, orientation, and complex connectivity, especially in deep-seated, fluid-deficient HDR systems. This study aims to enhance the prediction of velocities in HDR geothermal reservoirs by integrating well log with advanced rock physics modeling frameworks that explicitly account for mineral composition, pore structure, and fracture-induced anisotropy. The modeling workflow employs a combination of the differential Kuster-Toksz theory and the Differential Effective Medium (DEM) approach to simulate the elastic moduli of mixed mineral hosts with vugs, interparticle pores, and varied pore aspect ratios. For anisotropic effects caused by fracture alignment and orientation, Hudson s crack model and Thomsen s anisotropy theory are used to predict the directional dependence of P- and S-wave velocities by incorporating fracture dip, aspect ratio, and volume fraction as independent parameters. Fluid substitution effects on elastic velocities under in situ reservoir conditions are modeled using the anisotropic extension of Gassmann s equation. Simulation results demonstrate that pore aspect ratio and porosity are primary controls on elastic velocities, with low aspect ratio (crack-like) pores exerting a pronounced impact. Fracture porosity and dip emerge as key factors, particularly above threshold values, dictating the anisotropic response of P- and S-wave velocities, and accurately reproducing observed log data and seismic signatures in fractured HDR systems. This integrative rock physics modeling methodology provides a robust and quantitative means to estimate subsurface velocity fields, consequently facilitating improved fracture characterization, fluid detection, and reservoir evaluation, thereby reducing exploration risk and supporting the advancement of geothermal energy extraction from Hot Dry Rocks.

Keywords: Velocity Prediction, Rock Physics Modeling, Differential Kuster-Toksz Model, Differential Effective Medium (DEM)

[ABS-0158]

NOVEL P-WAVE BASED PARAMETERS FOR EARTHQUAKE MAGNITUDE PREDICTION USING MACHINE LEARNING IN THE UTTARAKHAND HIMALAYA

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Accurate and rapid estimation of earthquake magnitude is a critical component of earthquake early warning systems. In this study, seismic waveform data from the Uttarakhand Himalaya were utilized, with event records obtained from the P-Alert network. A set of novel parameters were introduced in addition to source receiver distance. These parameters are extracted from the initial 3 seconds P-wave window. These parameters were specifically designed to capture both spectral and temporal characteristics of early-arriving p phase, providing new insights into their relation with earthquake magnitude. The features were then employed to train and evaluate regression models. On the initial phase of this work three approaches were tested: multiple linear regression, Random Forest regression, and Gradient Boosting regression. Model performance was assessed using root mean square error (RMSE) and coefficient of

determination (R^2). Results demonstrated that nonlinear machine learning models, particularly Random Forest and Gradient Boosting, achieved higher predictive accuracy compared to linear regression, and feature importance analysis revealed the significant contributions of the proposed parameters to magnitude estimation. This study establishes the effectiveness of incorporating novel P-wave based parameters from the P-Alert network in the Uttarakhand Himalaya, offering a robust data-driven framework to improve rapid earthquake magnitude prediction and strengthen early warning capabilities in the region.

Keywords: EEWS, Machine Learning, P-alert, Himalaya

[ABS-0162]

MAPPING OF GROUNDWATER, FLOOD, AND DROUGHT POTENTIAL ZONES IN CHOUTUPPAL WATERSHED, TELANGANA, INDIA USING GIS AND REMOTE SENSING

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The essentiality of water extends beyond sustaining life to assisting agricultural, domestic, and industrial needs. Climate variability, population growth, and land use transitions have intensified pressure on groundwater resources. The fall in water levels and disappearance of weathered zones in semi-arid regions such as the Choutuppal watershed, Telangana, India are an outcome of persistent droughts and exhaustive groundwater exploitation. In spite of the need, integrated spatial analysis identifying areas vulnerable to groundwater depletion, flooding, and drought are limited. This study seeks to map groundwater potential zones along with flood and drought vulnerability using geospatial techniques. Remote sensing and GIS-based technologies were employed in this study. The data was combined with information on drainage density, precipitation, slope, elevation, soil type, and land use or landcover layers and weighted overlay analysis was carried out to map groundwater potential zones. This was followed by an analysis utilizing SCS-CN method for flood risk and standardized precipitation Index (SPI) analysis of 72 years of rainfall data to evaluate drought variations highlighting the importance of mapping flood and drought patterns. Results indicate groundwater potential zones as very poor (0.0045 kmï ½), poor (13.75 kmï ½), moderate (52.99 kmï ½), good (26.90 kmï ½), and very high (0.07 kmï ½). Flood risk zones were categorized as very low (0.99 kmï ½), low (17.79 kmï ½), moderate (48.95 kmï ½), high (25.87 kmï ½), and very high (0.11 kmï ½). Drought-prone zones were mapped as very low (4.07 kmï ½), low (33.66 kmï ½), moderate (56.23 kmï ½), and high (4.38 kmï ½). Consolidating these results offers implementable strategies and insights for sustainable groundwater management, flood mitigation, and drought preparedness, strengthening informed decision-making for regional water resource planning.

Keywords: Choutuppal watershed; groundwater potential; flood risk; drought susceptibility; GIS; remote sensing; weighted overlay analysis

[ABS-0165]

DIGITAL SOIL MAPPING OF SOIL ORGANIC CARBON STOCKS IN WEST BENGAL: A CLIMATE CHANGE PERSPECTIVE

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Digital soil mapping of Soil Organic Carbon stocks in West Bengal: A Climate Change Perspective Progya Mukherjee1* and R.K Mall 1 1 DST Mahamana Centre of Excellence in Climate Change Research, Institute of Environment & Sustainable development, Banaras Hindu University, Varanasi, UP-221005 India * email- mukherjeeprogya@gmail.com, rkmall@bhu.ac.in ABSTRACT Soil organic Carbon (SOC) is an indicator of soil health and contributes significantly towards improving the soil fertility and plays a crucial role in carbon sequestration that might otherwise contribute to the global warming leading to climate change consequences.Therefore, the knowledge of the changing Carbon dynamics is essential for framing of adaptation strategies and agricultural practices for increasing yield. In the present study we have used ISRIC SoilGrids data in a Digital Soil Mapping framework to predict future SOC stocks in West Bengal. We have used multiple linear regression (MLR), random forest (RF) and Support Vector Regression (SVR) method for training the dataset. Based on the model evaluation matrix, SVR was found to be the best performing model. Further, we projected the SOC stocks for the mid-future (2040-2069) and far-future (2070-2099) under two Shared Socio-economic Pathways (SSPs) scenarios SSP2-4.5 (intermediate emission) and SSP5-8.5 (very high emission) based on global climate models (GCMs) from the Coupled Model Inter-comparison Project Phase 6 (CMIP6) using SVR. Further the change from the baseline time period (1980-2009) was calculated. The results show a percentage decrease in most regions under all the scenarios. However, the maximum decrease of about 5% was observed mainly in the central and southern parts of the study area, in SSP5-8.5 scenario during the far-future. The findings can be used to support decision-making in land management and climate change mitigation strategies in West Bengal.

Keywords: SOC, GCM, Climate Change, MLR, RF, SVR, CMIP6, Digital Soil Mapping

[ABS-0177]

MACHINE LEARNING APPROACHES FOR PREDICTING ALGAL BLOOMS: A CASE STUDY FROM THE INDIAN COAST

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Harmful algal blooms (HABs) are increasingly frequent along the Indian coast, creating significant ecological, economic, and public health challenges. This study integrates multi-sensor satellite datasets, in-situ observations, reanalysis model data and machine learning

models to analyze spatio-temporal trends of HABs and improve predictive capabilities. Ocean colour data from OCCI, were processed to generate time series datasets of chlorophyll-a, Kd490, and turbidity from 2003 to 2024, enabling long-term trend assessments using the Mann-Kendall test and Sen s slope estimator. Similarly, sea surface temperature, and wind speed for the region was obtained from Copernicus CMEMS, and ERA-5 datasets respectively, and processed to derive time series for 2003 to 2024. Using percentile analysis, chlorophyll-based threshold for algal bloom was identified for the coastal and offshore waters. The analysis of the threshold-filtered chlorophyll data revealed a statistically significant increase in bloom frequency along the southwest coast during post-monsoon months, particularly in Kerala and GoM, Mumbai, Gujarat, Odisha, Andhra Pradesh and west Bengal coast, where nutrient enrichment and coastal upwelling intensify bloom formation. Machine learning models, including Random Forest and XGBoost, were trained on historical satellite and environmental data and validated against in-situ field measurements, achieving an average predictive accuracy of around 87%. Chlorophyll-a, SST anomalies, wind and proxies for nutrient input emerged as the most influential variables in predicting bloom events. This integrated approach demonstrates that satellite-based monitoring combined with robust modeling frameworks can provide reliable, near-real-time forecasting of HAB occurrences. The findings highlight the importance of developing operational early warning systems to support fisheries, coastal ecosystem management, and public health advisories. Scaling these predictive tools through cloud-based platforms and integrating them with decision-support systems can significantly enhance the capacity of coastal stakeholders to mitigate the adverse impacts of HAB events under a rapidly changing climate.

Keywords: algal blooms, Noctiluca, Northern Indian ocean, machine learning, Random forest, support vector machine

[ABS-0180]

HYBRID ML & DL APPROACHES FOR ESTIMATING PETROPHYSICAL PROPERTIES FROM INVERTED VOLUMES AND SEISMIC ATTRIBUTES

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Accurate Prediction of petrophysical properties from seismic data is a key step in reservoir characterization, but it remains challenging due to the non-uniqueness of inversion and uncertainties in linking seismic to petrophysical parameters. Traditionally, petrophysical properties such as porosity, water saturation, and volume of shale are estimated from inverted seismic volumes (Acoustic Impedance and Vp/Vs) using rock physics inversion. In this work, an alternative data-driven approach is proposed where machine learning and deep learning algorithms are used in place of rock physics inversion. The methodology begins with pre-stack seismic inversion to obtain acoustic impedance and Vp/Vs volumes. In addition to these inverted volumes, seismic attributes (e.g., sweetness, coherence, etc.) are extracted at well locations by considering the traces around the well path to build a comprehensive input dataset.

Wireline-log derived petrophysical properties are used as output variables for model training and validation. A range of supervised machine learning models and deep neural networks are trained and tested for predicting porosity, water saturation, and volume of shale. Model validation is carried out using a blind well to evaluate generalization of prediction performance. Uncertainty quantification is also incorporated to provide probabilistic estimates (confidence) of the predicted petrophysical properties, which helps in assessing prediction reliability. Application of the proposed workflow to a field dataset shows that integrating pre-stack inversion with seismic attributes under a machine learning framework provides reliable petrophysical predictions. This approach demonstrates the potential of replacing inverse rock physics modelling with data-driven methods for more reliable and effective reservoir characterization.

Keywords: Pre-stack Inversion; Petrophysical Inversion; Machine Learning; Uncertainty Quantification

[ABS-0185]

EXPLORING THE ROLE OF ROCK STRENGTH VIS-À-VIS LONG-TERM TECTONIC-CLIMATIC FEEDBACK ON THE LANDSCAPE EVOLUTION OF THE INDO-BURMESE RANGE (IBR)

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The topographic expression of a landscape is considered an outcome of the long-term interplay between tectonic uplift and erosion processes by the fluvial regime, with minor contribution of hillslope processes, often ignoring the physical properties of lithologies. Indo-Burmese Range (IBR) is a north-south-trending exhumed accretionary range developed due to the hyper-oblique convergence of the Indian plate beneath the Burmese plate. We integrated the SRTM DEM-based stream power proxies, such as normalised steepness index (ksn), relief, Hypsometry Integral (HI), with the TRMM precipitation pattern and measured rock strength of different geologic units to explore the interplay of controlling factors in the landscape growth of IBR. The rebound hammer is used to measure the rock strength of diverse lithological units of different geological formations. The uniaxial compressive strength (UCS) values for different geological groups are measured, and they range for different geological units as follows: Tipam Group 16 ± 7.74 MPa, Surma Group 27.33 ± 12.82 MPa, Barail Group 40.84 ± 18.33 MPa, Disang Group 33.86 ± 17.11 MPa, and Ophiolite sequence 54.33 ± 18.82 MPa. The corresponding stream power proxy (Ksn) ranges for different geological units are Tipam Group 10.71 ± 6.01 $m^{0.9}$, Surma Group 22.56 ± 11.32 $m^{0.9}$, Barail Group 55.84 ± 25.78 $m^{0.9}$, Disang Group 62.06 ± 21.24 $m^{0.9}$, and Ophiolite sequence 46.66 ± 6.65 $m^{0.9}$.We estimated normalised rock erodibility (K) of lithological units from the average ksn and rock strength, which show a strong positive correlation, except in shear zones and thinly bedded rocks, where structures have influenced the rock strength. The results are also analysed for spatial variation in the catchment area exchange proxies, which defines the competing headward growth of the catchments vis-à-vis tectonic forcing. The role of rock strength is included in the discussion on

tectonic-climate coupling, which otherwise dominates the discourse of regional landscape growth.

Keywords: Indo-Burmese Range, fluvial geomorphology

[ABS-0199]

COMPREHENSIVE REVIEW OF ELECTRICAL SYSTEM FOR DEEP SEA MINING

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The increasing demand for critical minerals and metals in high-tech and renewable energy sectors has spiked significant interest in the exploration of deep-sea mineral resources such as polymetallic nodules (PMN), polymetallic sulphides (PMS), and cobalt-rich ferromanganese crusts (CFC) are now seen as promising alternatives to declining terrestrial metal reserves. Deep-sea mining offers a viable solution for securing essential materials like nickel, cobalt, and manganese. However, extracting these resources from ocean depthsï ½often several thousand meters below the surfaceï ½poses substantial technical challenges, particularly in the design and deployment of reliable electrical systems. This review presents a comprehensive evaluation of the electrical infrastructure essential for deep-sea mining operations. It includes power generation, high-voltage subsea power transmission, and localized distribution systems that support critical equipment such as seafloor mining tools, riser systems, and remotely operated vehicles. Core components including high-voltage umbilical cables, subsea transformers, variable frequency drives, and pressure-tolerant motors. There are AC and DC system for deep sea mining operations. HVDC is an emerging source of power in deep sea mining systems showing an efficient alternative to commonly used AC systems. As per the advancement of electrical systems it is crucial in enabling efficient, resilient, and environmentally responsible seabed resource extraction.

Keywords: Deep Sea Mining, AC power distribution, DC power distribution, HVDC, Subsea mining machine, AC motors, subsea vehicles.

[ABS-0215]

PYTHON-DRIVEN MULTIVARIATE STATISTICAL APPROACH TOWARDS WATER CONTAMINATION AROUND THE GHAZIPUR LANDFILL SITE, DELHI, INDIA.

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The Ghazipur landfill in Delhi, one of the largest and most overburdened waste disposal sites in India, represents a major environmental concern due to leachate migration into surrounding hydrological systems. This study investigates groundwater and surface water quality around

the landfill, with the primary objective of identifying hydrogeochemical signatures of leachate contamination across seasonal regimes. A total of 24 water samples were collected during the pre-monsoon season and 72 during the monsoon, comprising both groundwater and surface water sources. A Python-based analytical framework was utilized, allowing for reproducibility, automation, and seamless integration of multivariate statistical tools with classical hydrogeochemical techniques. Geostatistical methods were applied to examine spatial variability, while correlation matrix analysis revealed interrelationships among major ions. Multivariate approaches, Principal Component Analysis (PCA), Hierarchical Cluster Analysis (HCA), and Discriminant Analysis (DA), were employed to distinguish natural hydrogeochemical processes from anthropogenic influences. Hydrogeochemical indices, including molar ratios and Chloro-Alkaline Indices (CAI), were calculated to evaluate ion exchange. Classical hydrochemical diagrams, such as Piper and Gibbs plots, along with the Hydrochemical Facies Evolution Diagram (HFED), were used to classify water types and infer governing mechanisms. Preliminary results indicate clear seasonal variability in hydrochemical signatures, with observable patterns consistent with the influence of landfill leachate during the monsoon. Variations in multivariate patterns and hydrochemical indices suggest changes in ionic composition across seasons, pointing to dynamic interactions between natural geochemical processes and anthropogenic inputs.

Keywords: Python, Ghazipur Landfill, Leachate, Multivariate Statistical Analysis, Contamination

[ABS-0216]

3-C WIDE-ANGLE CRUSTAL SEISMIC IMAGING OF THE SOUTH REWA BASIN, CENTRAL INDIA.

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A 2D-3C crustal velocity structure is derived by travel-time inversion of the first arrival seismic refraction and wide-angle reflection data along the N-S trending Hardi-Samatpur seismic profile shot across the South Rewa rift basin, located within the Son-Mahanadi rift system of Central India. Inversion of seismic data along this profile reveals an undulated granitic-gneissic basement apart from fault-bounded horst and graben features. The Vp and Vs models explain that the basin is filled with 2-3 km thick sequences of Gondwana sediments as identified by first arrival traveltime delay, which is overlain by high velocity Deccan volcanics. We also delineated a thick (6.0 km) mid-crustal low-velocity zone at a depth of 13-17 km, which would indicate fluid entrapment during its rifting episode. The high velocity mafic underplating is also seen at a depth of 28-30 km at the base of the lower crust. The Moho is delineated at a depth of 37-44 km, indicating Moho upwarping below the Narmada-Son lineament. Subsequent tectonic activities have reactivated the pre-existing faults, resulting in a complex crustal structure underneath. The evolutionary nature of the basin suggests the interplay of extensional rifting, sedimentation, magmatic activity, and later tectonic reactivation along

major structural lineaments, like the Narmada-Son rift zone. The present study has offered a valuable insight into the broader geodynamic framework of Central India.

Keywords: 3-C; basement; mafic underplating; Moho

[ABS-0219]

MULTISCALE MAGNETIC MODEL OVER THE EASTERN INDIAN SHIELD: INSIGHTS INTO THE DEEP AND SHALLOW CRUSTAL STRUCTURE

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The Precambrian terranes of the Eastern Indian Shield comprise the Singhbhum Craton, the Singhbhum Mobile Belt, the Chhotanagpur Gneissic Complex, and the Eastern Ghats Mobile Belt. Traditionally, studies of potential field data in the Eastern Indian Shield relied on a single scale of observation, corresponding to the altitude at which the measurements were acquired. In the present study, we adopted a multiscale approach, involving the examination of the source properties of the field at various altitudes, to interpret the deep and shallow magnetic sources beneath the Eastern Indian Shield. The key advantage of this multiscale approach is that it allows the behaviors of the field to be explored not only in the horizontal plane but also in the vertical dimensions, leading to a comprehensive understanding of the nature and distribution of the subsurface sources. Here, we employed the multiscale approach to aeromagnetic data at upward continuation from 4 to 100 km altitude. The multi-ridge geometrical method is particularly well-suited for this analysis, as it effectively deciphers the complex features of both shallow and deep crustal interfaces. To estimate the deepest source depths in the Eastern Indian Shield region, we applied the multiridge method on a large scale (50 100 km altitude), obtaining a set of singular points at depths ranging from 25 to 40 km. The results reveal three distinct magnetic source levels: shallow sources at depths of ~5 10 km, intermediate sources at around 20 km, and deep sources ranging from ~35 to 39 km.

Keywords: Multiscale, Aeromagnetic data, Upward Continuation

[ABS-0221]

GRAVITY MODELING FOR CRUSTAL STRUCTURE IN THE KUMAUN HIMALAYA: IMPLICATIONS FOR SEISMOGENESIS

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A detailed gravity survey was carried out along a ~212 km transect extending from the Indo-Gangetic Plain (IGP) to the Main Central Thrust (MCT) zone across the Kumaun Himalaya, India. This tectonically complex and seismically active region hosts several interacting fault systems. To understand underlying crustal architecture and tectonic framework, gravity data were collected at an average station spacing of about 1.5 km and subsequently modeled. Model

is constrained by incorporating results from geophysical and geological studies, power spectrum analysis, gravity separation techniques, wavelet analysis, 2D forward modeling and inversion for crustal configuration in the study area. Subject to geological complexity, spectral analysis is performed separately for the IGP and the Himalayan segments. In the Indo-Gangetic Plain (IGP), two major subsurface interfaces were interpreted at approximate depths of 5 km and 39 km, interpreted as the Indo-Cratonic Basement and the Moho discontinuity, respectively. In contrast, analysis of the Himalayan sector indicated the Moho at around 46 km depth and the Main Himalayan Thrust (MHT) near 10 km. A gravity separation approach was applied using wavelet analysis, PSO-based inversion, and regional modeling, integrated with available geological and geophysical constraints, to isolate distinct gravity components associated with the Himalayan tectonic framework. This approach successfully delineated the gravity effects from the upper crustal region, including major fault and thrust zones. The computed residual gravity anomaly highlighted major tectonic structures. Inversion of the residual gravity anomaly imaged the subsurface configuration of major faults and thrust zones. The results suggest a northward-dipping Moho, varying in depth from approximately 39 km to 46 km and the modeled Main Himalayan Thrust (MHT) exhibits a ramp geometry. The developed density model successfully outlines the crustal architecture across the Kumaun Himalaya and provides valuable insights into upper-crustal fault systems, contributing to improved understanding of seismogenesis evaluation in the region.

Keywords: Gravity, Power Spectrum, Forward Modeling, Inversion

[ABS-0227]

LITHOLOGICAL BOUNDARY IDENTIFICATION FROM WELL LOG DATA USING WAVELET TRANSFORM

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We can get various petrophysical information of the subsurface from geophysical log data which used to provide us an advantage in geological interpretation like lithological succession, sedimentary deposition pattern etc, at drilling location. The process of lithological boundary identification becomes more difficult due to several factors like washout, caving, abnormal mud cake, bad borehole conditions, and discontinuity in borehole data. Previously, Walsh Transform, Discrete Fourier Transform, Fast Fourier Transform have been used by many scientists as a mathematical tool and have identified bed-boundaries from well log data. In this study my goal is to develop a practical system or workflow for lithological boundary detection with a comparatively higher resolution by using Wavelet Transform for signal processing and multi log integration for boundary picking. A suitable level of decomposition and appropriate mother wavelet has to be selected for Wavelet Transform through an error evaluation as this will help us to reduce the noise while preserving the geological information. The abrupt changes in the decomposed signal will be detected via a weighted picking algorithm by assigning separate weightage to each decomposed log data. Basic logs like as gamma ray (GR),

bulk density (ρb), neutron porosity (NΦ), resistivity (Rt), and photoelectric factor (PEF) will be used for this purpose. Final boundaries will be selected by correlating the previously picked abrupt changes and available stratigraphic information from the core completion report. Lithological boundary detection has several applications in reservoir estimation, well to well correlation, resource estimation and mining etc. This approach is expected to be more efficient in boundary identification than the manual picking and single log methods, and can be used in both academic research and industry purpose.

Keywords: Wavelet Transform, Borehole Geophysics, Logging Techniques, Lithological Boundary Detection

[ABS-0229]

A REVIEW OF REGIONAL AND INTERNATIONAL METEOROLOGICAL NETWORKS OFFERING SOIL MOISTURE SENSORS AND A REVIEW OF THE ANALYTICAL METHODOLOGY.

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Soil moisture is a significant factor in Earth s hydrological cycles that influences weather, drought, climate, and water resources on land and in water bodies. However, throughout most of the 20th century, soil moisture received less attention and was not included in many hydrological studies. Then, in 1978, J. W. Deardorff with the United States National Center for Atmospheric Research started to demonstrate the relationship between soil moisture and meteorologic conditions and, two years later, in 1980 G. C. Topp at the University of Toronto developed the Topp Equation - the first empirical calibration for soil moisture using Time Domain Reflectometry. Additionally, that same year, M. T. van Genuchten published the van Genuchten Equation, which established a numerical relationship between soil moisture and unsaturated hydrologic head. Starting in the 1990s, the United States Department of Agriculture began using impedance-based soil moisture sensor technology to equip SNOTEL sites for watershed scale water supply forecasts. Since then, numerous large-scale regional meteorological networks have emerged worldwide, incorporating soil moisture sensors, often referred to as Mesonets . Currently in the United States there are about 27 major regional meteorological networks that have soil moisture sensors. There are a total of 1,880 stations with over 7,300 soil moisture depths between the 27 networks. 60 to 70 percent of the 7,300 soil sensors are a coaxial impedance reflectometry technology called the HydraProbe manufactured by Stevens Water Monitoring Systems, Inc. based in Portland, Oregon USA.

Keywords: Soil Moisture, Hydrology, Mesonets, SNOTEL, Hydraprobe, Stevens Water Monitoring, Topp Equation, Van Genuchten Equation

[ABS-0051]

SUBSURFACE RESISTIVITY MODELING OF THE SAN EMIDIO GEOTHERMAL FIELD.

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Geothermal energy is an essential unconventional resource in the worldwide transition towards decarbonization, offering reliable, low-carbon baseload power. It demands advanced geophysical techniques to unlock its potentialï ½especially in hidden systems within structurally complex geology regions like the Basin and Range province. Among all physical parameters, subsurface resistivity is especially important for geothermal characterization, as it is sensitive to hydrothermal alteration, fluid content, and temperature-dependent mineralogical changes directly associated with reservoir properties. Magnetotellurics (MT) is a powerful geophysical technique due to its high sensitivity to variations in the resistivity of the subsurface, allowing for the imaging of geothermal systems. MT facilitates the identification of conductive clay caps, conductive reservoir zones, and fluid pathways controlled by faults. Therefore, in the present study, an attempt has been made to characterize the San Emidio Geothermal System using open-source MT data. The dimensionality analysis of the MT data shows a predominant 1D structure in the frequency range 1-1000 Hz for several sites. Therefore, a 1D MT inversion is carried out for the frequency range of 1ï ½10ï ½ Hz. The algorithm used for 1D inversion is based on the minimization of a Tikhonov-style objective function. A one-dimensional inversion framework, which incorporates smoothness-constrained regularization, is solved using an inexact Gaussï ½Newton optimization. Forward modeling is carried out at each step, allowing the model to be progressively updated so that the predicted responses align more closely with the observed data.The 1D resistivity models obtained after inversion highlight the clay cap, reservoir, and deeper resistive zones. This underscores the crucial role of resistivity imaging in promoting reliable and sustainable geothermal resource development.

Keywords: Keywords: Geothermal; Magnetotelluric; Unconventional energy; resistivity modelling; Inversion ; Forward Modelling; 1D inversion

[ABS-0048]

CO_2 PLUME MIGRATION

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Carbon capture, utilization, and storage (CCUS) requires efficient and reliable monitoring approaches to assess the safety of long-term storage. Although active seismic techniques are effective, they are costly and only capture snapshots of subsurface conditions which may not be sufficient for monitoring land energy resources (LER). This study looks to develop a continuous monitoring process for CO_2 plume migration using passive seismic applications.

The process employs dense ocean-bottom or terrestrial seismic arrays to implement Ambient Noise Tomography (ANT), which utilizes existing seismic signals to image temporal variations in the subsurface. New approaches enhance traditional one-dimensional signal processing workflows with machine-learning techniques and multi-component data to improve processing with greater sample density and applications in near real-time. The new workflow includes site specific reservoir rock physics models that relate seismic velocity change to constituent properties within reservoirs, such as porosity and permeability. The enhanced passive seismic workflow will enable automated monitoring of ambient seismic vibration noise and provide advanced warning of possible plume migration. In combination with valuable existing monitoring methods such as 4D seismic, well data and others, passive seismic interpretations become contextualized into multicontrol monitoring observations to reduce overall monitoring costs, improve the safety of long-term CO_2 storage and ultimately serves as a solution for assessing planned (and potentially less costly options) scaling up of CCUS operations.

Keywords: Carbon Capture, Utilisation and Storage (CCUS)

[ABS-0042]

NEELANETRA: FISHERIES INTELLIGENCE IN THE INDIAN EEZ

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India's fisheries sector sustains over 28 million livelihoods and contributes nearly 8% of global fish production, making it a critical driver of the nations Blue Economy. However, the rise of Illegal, Unreported, and Unregulated (IUU) fishing threatens resource sustainability, undermines governance, and poses risks to maritime security. Traditional monitoring systems struggle to integrate diverse vessel and environmental data, limiting effective detection and policy support.This work presents NeelaNetra, an AI-powered framework that leverages Global Fishing Watch AIS data for fisheries intelligence within Indiaï ½s Exclusive Economic Zone (EEZ). The system integrates XGBoost for vessel and gear-type classification, ResNet for AIS trajectory analysis, and bathymetric shapefile visualization to estimate fishing effort and detect unauthorized activity. By fusing heterogeneous datasets, NeelaNetra enables real-time monitoring, and would help in enforcement, and will guide in evidence-based policymaking. The frame work can help strengthen marine governance and support long-term sustainability in the Blue Economy through data-driven fisheries management.

Keywords: Fisheries governance, Blue Economy, IUU fishing, AIS data, XGBoost, ResNet, Vessel classification, Trajectory analysis, Bathymetric visualization, Fishing effort estimation, Maritime security, Data-driven decision-making.

[ABS-0037]

DEEP WATER SEDIMENTARY MODELLING BASED ON GEOPHYSICAL DATA INTERPRETATION FOR PROSPECTIVITY ANALYSIS TOWARDS HYDROGEN EXPLORATION IN ANDAMAN BASIN

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The Andaman basin, which is a part of Sunda Arc System, associated with convergence of west Burmese plate and subducting eastern Indian plate. The basin represents a prospect for unconventional energy resources, particularly White Hydrogen, which is very famous globally for its sustainability in the perspective of Energy Transition. This study mainly focuses on the deep marine environment of Andaman basin in the North-North west region of the western flank of main island. Only a few no. of seismic lines are available in the study area for interpretation. In absence of well log data, a comprehensive lithological idea, structural and stratigraphic concepts from literature survey is implemented for marker selection and horizon mapping. The detailed attribute analysis driven extraction of geological structure and sequence stratigraphic interpretation are also done based on the available data set and related ideas from previous works. The seismic interpretation reveals key deep water depositional features like submarine canyon, fan lobes, channel-levee complex, also with some turbidite sequences. Additionally slope apron systems and accretionary prism sedimentation are identified in the northern part of the basin. The integration of this information with published tectono-stratigraphic environment gives an insight into sediments dispersal patterns and potential entrapment mechanisms relevant to natural accumulation of hydrogen in northern Andaman. The presence of mud volcanoes in the area, give a further support in likelihood of deep-seated fluid or gas migration pathways, which may include molecular hydrogen generated by Serpentinization and Radiolysis. Owing to limited data availability, certain assumptions and insights from previously published works were incorporated, which introduces a degree of uncertainty. Although the lack of data constrains in more accurate characterization of reservoir, the sedimentary model gives a overall framework of deep water depositional set up towards prospectivity analysis for natural hydrogen exploration in such a underexplored basin like Andaman.

Keywords: Seismic Interpretation, Stratigraphy, Sedimentary Modelling, Deep Marine Environment, Serpentinization, Natural Hydrogen

[ABS-0034]

INSIGHTS ON SEISMICITY OF TALALA REGION, GUJARAT FROM DEEP LEARNING BASED EARTHQUAKES DETECTION

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The application of deep learning to seismology holds significant potential for advancing our understanding of seismic processes. In the present study, we utilized the state-of-the-art EQTransformer model to analyse one year (2021) of continuous three-component seismograms from Talala, Saurashtra, a region with a history of earthquake swarms. By automating signal detection, phase picking, and common phase association at 5 stations using EQTransformer, we obtained a catalog that has three times more earthquakes of low magnitude compared to the manual catalog. Further, these phases associated with a minimum of 5 stations were located using the traditional location algorithm HYPOINVERSE. We utilized all the available (3) existing velocity models as a priori structure to locate the earthquakes. The root mean square errors (RMS) are 0.11 s, 0.05 s, and 0.05 s for each velocity model respectively. The mean error in epicentral location and depth are 2.53 km, 2.85 km, and 2.93 km & 2.42 km, 3.30 km, and 2.83 km respectively. The preliminary analysis of these located earthquakes with time clearly shows a cyclic occurrence pattern with an increase in seismic activity before the major earthquake of M 4.5 (16-05-2021), followed by 10 weeks of quiescence, and then a steady increase in seismicity again. The increase in earthquakes directly translates to a significant reduction in the magnitude of completeness, enabling us to observe and analyze smaller-magnitude events that are crucial for understanding the regional stress scenario. It may also aid in the identification of subtle seismological features like hidden/unnamed/unidentified faults, and in studying nucleation patterns of earthquakes with time, which could provide insights into the mechanism of induced seismicity in the region.

Keywords: Deep Learning, Earthquakes, Gujarat, Seismicity

[ABS-0030]

QUANTUM-BEHAVED PARTICLE SWARM OPTIMIZATION FOR GRAVITY INVERSION OVER SEDIMENTARY BASINS

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Sedimentary basins are critical geological formations that host hydrocarbons, groundwater, and mineral resources. Accurate mapping of their basement depth and geometry is essential for understanding tectonic history and assessing resource potential. Gravity data provides an economical approach for investigating these structures, but its inversion is inherently ill-posed and non-unique, as multiple subsurface configurations can explain similar gravity anomalies. Traditional inversion methods, including advanced PSO variants, often rely on prior geological

assumptions, require initial guesses, and are prone to slow convergence or entrapment in local minima. In this study, Quantum-behaved Particle Swarm Optimisation (QPSO) is applied for residual gravity data inversion of a sedimentary basin. Inspired by quantum mechanics, QPSO replaces classical velocity-based updates with probabilistic position updates, enabling more effective exploration of the solution space. The algorithm operates with a single control parameter and requires no prior geological information or initial model. Its probabilistic search mechanism ensures robust global exploration, fast and stable convergence, and avoidance of local traps that can limit conventional approaches. A comparative evaluation with advanced PSO algorithms demonstrates that QPSO consistently achieves lower RMSE errors, faster convergence, and more reliable inversion results. It also performs better in complex geological settings, reconstructing basement geometry with reduced uncertainty and higher accuracy. These results highlight QPSOï ½s robustness and efficiency as a modern geophysical inversion tool. In summary, QPSO provides a simple yet powerful framework for modelling sedimentary basins and basement structures. Its combination of reliability, efficiency, and global search capability makes it a significant advancement in geophysical inversion, particularly for applications where accurate subsurface mapping and uncertainty reduction are critical.

Keywords: Sedimentary Basins, Gravity Inversion, QPSO, Basement Modeling

[ABS-0230]

SOIL WATER RETENTION CURVE USING A DIELECTRIC PERMITTIVITY REGRESSION

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The understanding of the movement of water through soil has many applications. The Richards Equation has become one of the most common ways to describe and quantify the transient movement of water in unsaturated porous media which uses the unsaturated hydraulic conductivity. The unsaturated hydraulic conductivity is important for both physical and statistical models. Hydraulic conductivity is determined from a water retention curve which is a plot of soil moisture verses unsaturated hydraulic head. The water retention curve, however, is often difficult to obtain in the laboratory and difficult to apply to soil moisture data in the field. A fixture called The Travel Assembly has been developed to hold a soil sensor in a soil sample during the laboratory development of a soil water retention curve. The Travel Assembly is a fixture that holds the soil sample with a HydraProbe, so that it can be pressurized up to 15 bar. The resulting soil water retention curve can then be correlated with the HydraProbe. Upon completion of the soil water retention curve, HydraProbes in the field in the same soil tested are able to measure soil moisture very accurately with a custom calibration, and unsaturated hydraulic head. With this information and the unsaturated hydraulic conductivity can then be calculated using the van Genuchten equation. Six soil samples were placed in the Travel Assembly and evaluated at saturation and 10 pressures ranging from 0.01 to 5 Bar. The technique was perfected to generate a soil water retention curve with minimal error.

Keywords: Hydraprobe, Van Genuchten equation, Unsaturated Hydraulic head, Water retention curve, Travel assembly.

[ABS-0016]

QUANTUM SENSING GEOPHYSICAL DATA ACQUISITION

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Quantum sensing is evolving as a game changer for the oil and gas industry, advancing it to the next level with highly sensitive and precision measurement technologies. Quantum sensing seismic applications include highly sensitive detection of underground movements, improved earthquake early warning systems, and enhanced seismic risk assessment by analyzing seismic data with quantum algorithms and quantum-enhanced sensors like gravimeters and magnetometers. Quantum systems, particularly those involving quantum cryptography networks, can act as sensors to detect subtle vibrations from earthquakes, providing valuable data for real-time monitoring and risk analysis. Quantum sensing uses the principles of quantum mechanics to perform highly precise and sensitive measurements of physical quantities like magnetic fields, gravity, and seismology acceleration that are often beyond the capabilities of conventional sensors. This allows for more precise geophysical surveys in mineral prospecting, seismology, and infrastructure monitoring, even in challenging or GPS-denied environments. Applications include underground infrastructure mapping, detecting gravitational anomalies for resource exploration, and improving inertial navigation systems for subsurface operations. Key Geophysical Applications Mineral Prospecting- Quantum gravity sensors can map tiny variations in the Earth's gravitational field, revealing subsurface density changes that may indicate mineral deposits. Compressed sensing applies to quantum sensing by enabling the reconstruction of sparse quantum signals from fewer measurements than traditionally required, using the principle that many quantum signals have a sparse representation in a specific basis. This is particularly useful in applications like quantum process tomography and magnetic sensing for faster, more accurate measurements of low-signal, high-dynamic-range, or sparse phenomena. By leveraging sparsity, the method can achieve the same or better accuracy with significantly reduced data acquisition, leading to more efficient and powerful quantum sensing systems.

Keywords: Quantum sensing, compressed sensing, sparse data , seismic imaging

[ABS-0017]

PHYSICS INFORMED MACHINE LEARNING FOR CO2 PLUME MONITORING

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Monitoring CO_2 storage requires mapping time-lapse seismic changes to subsurface saturation. This work uses time-lapse seismic differences paired with reservoir simulations from the

Sleipner benchmark to train a two-stage model: a supervised 3D U-Net teacher that learns from reservoir fields (Vp, Vs, density, porosity) and a student that takes only seismic difference fields and porosity. In this framework, the student model is trained not only to replicate the teacher s predictions via knowledge distillation but also to satisfy physics-based constraints. Penalty terms enforcing mass conservation and flow continuity are included in the loss function, ensuring predictions remain consistent with reservoir flow behavior. This integration balances data-driven learning with physical realism, leading to reliable outputs for CO_2 storage monitoring. On the study dataset the student recovers the main plume shape and the injected mass with low voxelwise error; visual slices comparing ground truth, teacher, student, and absolute error show good agreement in the plume core and larger differences at the edges. Remaining uncertainty is largest where seismic contrast is low, porosity or registration errors exist, or seismic noise is high; adding physics constraints reduces these errors but does not remove them entirely. Overall, the approach turns time-lapse seismic signals into fast, physically guided 3D plume estimates suitable for routine monitoring and assessment.

Keywords: Keywords: CO_2 sequestration, plume monitoring, physics-informed neural network (PINN), teacher student knowledge distillation.

YOUNG SCIENTIST CONCLAVE

[ABS-0003]

MARINE FISHERY RESOURCES OF KANNIYAKUMARI, TAMIL NADU

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The marine fisheries of Kanyakumari District, located in Tamil Nadu, are an essential component of the local economy and the livelihoods of the fishing community. The district has a 72 km coastline, home to 42 fishing villages and 45 fish landing sites. Key harbors, including Thengapattanam, Chinnamuttom, Colachel, and Jeppiar, act as vital centers for fish landing, auctioning, and associated activities. These harbors are crucial for the economic activity of the local population engaged in fisheries. Fishing in Kanyakumari is diverse, with both traditional and mechanized methods being employed. The community harvests a wide variety of fish, including commercially important pelagic species like sardines and mackerels, seer fish, Tuna, as well as demersal fish such as Elasmobranches, grouper, snapper, pomfret. These species are of high commercial value and contribute significantly to the regional fishery economy. In addition to nearshore fisheries, the district¿s deep-sea fisheries, especially in Thothoor, target valuable species such as tuna. Specialized techniques, including the use of long-line fishing methods for tuna, form an important part of the fishing practices in this area. These methods support high-value fish production, further boosting the local economy. Sustainable fishing practices are of utmost importance in Kanyakumari's fisheries. The hook-and-line method, used primarily for shark fishing in Thoothoor, serves as an example of an eco-friendly technique that maintains ecological balance while ensuring the community's continued livelihood. Such practices, coupled with effective resource management, are vital for the sustainability of marine resources and improving the socio-economic status of the fishing community. This paper outlines the diverse marine fisheries resources of Kanyakumari, highlighting the fishing methods, species caught, challenges faced by the community, and the importance of sustainable fisheries management for the future of the district¿s marine economy.

Keywords: Marine Fisheries, Kanyakumari District, Fishing Methods, Sustainable Fisheries and Economic Impact.

[ABS-0138]

INVISIBLE PATHWAYS AT THE EDGE: MAPPING AND MODELING SUBMARINE GROUNDWATER DISCHARGE FOR INDIA'S WATER FUTURE

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India is at a critical juncture in water resource management, with climate change and rapid urbanization driving unprecedented water scarcity. Declining quantity and deteriorating quality threaten the sustainability of groundwaterâ¿¿the nation's lifeline. This underscores the need to consider all components of the hydrological cycle, including the often-overlooked Submarine

Groundwater Discharge (SGD). As groundwater flows from aquifers to the ocean through the seabed, SGD forms a hidden link between land and sea, shaping coastal water quality, nutrient fluxes, and biogeochemical cycles, yet it remains underrepresented in water management frameworks. Recognizing its significance, the National Centre for Earth Science Studies (NCESS) has launched a national flagship program on SGD, coordinating 14 institutes through a multi-proxy, interdisciplinary initiative to identify, quantify, and characterize SGD along India's coastline. Phase 1, involving nine working groups, identified ~1,200 km (22%) of the 5,400 km mainland coastline as potential perennial SGD zones, establishing a baseline for systematic study. Building on this foundation, Phase 2 emphasizes comprehensive mapping, modeling, and flux quantification along the southwest coast. Nine critical SGD hotspots spanning ~106 km of shoreline have been identified through hydrochemical, isotopic, and geophysical surveys. Water balance studies across 33 coastal catchments, supported by 3D numerical modeling, indicate that 4.3% to 6.4% of annual rainfall is lost via SGD, underscoring its hydrological and environmental significance. Pilot studies along the southwest coast are advancing standardized protocols for pathway tracing, isotopic characterization, aquifer modeling, and SGD flux measurement with potential replication across other coastal zones. A major initiative is the proposed Coastal Critical Zone SGD Observatory at Varkala, designed to monitor SGD and coupled hydrologicalâ¿¿biogeochemical processes. By unveiling this hidden component of the water cycle, NCESS's SGD research is reshaping India's understanding of coastal groundwater and providing vital insights for sustainable groundwater management in an era of escalating water stress.

Keywords: Submarine Groundwater Discharge, Coastal Hydrology, Groundwater, Hydrogeology, Hydrochemistry, Geophysics, Isotopes, Biogeochemistry, Flux Quantification, Sustainable Groundwater Management

[ABS-0195]

HYBRID QUANTUM-DEEP LEARNING FRAMEWORK FOR FIRST-ARRIVAL PICKING IN LOCAL SEISMIC DATA

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Accurate picking of seismic first arrivals is fundamental for earthquake monitoring, source characterization, crustal structure estimation and subsurface imaging, yet remains challenging under noisy conditions. In this study, we present a hybrid quantum-deep learning framework that integrates time-frequency mapping, unsupervised feature extraction, and quantum clustering for automated first-arrival picking from local earthquake data.The raw seismograms are first transformed using the Generalized S-Transform to capture spectral-temporal patterns, followed by a convolutional autoencoder that extracts noise-resilient encoded features without the need for labeled data. Then these encoded features are combined with statistical metrics from the original waveforms to form an enriched feature space. Subsequently, quantum clustering, implemented in the simulated quantum environment, is applied to isolate signal-bearing segments and enable reliable first-arrival picking.The effectiveness of the proposed

approach is first validated on a suite of synthetic datasets contaminated with various levels and types of noise, and subsequently applied to observed data from the STEAD global database and seismic stations in the Jammu and Kashmir Himalaya. The method demonstrates stable first-arrival picking performance under noisy conditions when compared with STA/LTA, AIC Picker, and unsupervised deep learning using classic K-Means. It also exhibits a broadly similar trend to state-of-the-art supervised models such as PhaseNet and EQTransformer, while maintaining computational efficiency even in low signal-to-noise ratio environments.

Keywords: Computational Seismology, Quantum Clustering, Unsupervised deep learning, Signal detection, First-arrival picking

[ABS-0046]

SITE SUITABILITY MODEL ON CORAL RECRUIT RESILIENCE IN THE PALK BAY REGION USING GEOINFORMATICS TOOLS: AN APPLICATION TO CORAL RESTORATION

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Coral restoration is one of the necessary conservation tools for coral recovery from current Anthropocene climate change. The present study carried out a site suitability model on coral recruit resilience in the coral region of Palk Bay using geospatial machine learning model including coral geomorphology, biological, environmental and anthropogenic indicators. Coral geomorphology of Palk Bay revealed that total reef area of Palk Bay was 2.52 km² using LISS-IV maximum likelihood classification. Steel quadrate (0.25m2) was used to assess recruitment density and Line Intercept Transect (LIT) was used to assess the biological indicators, which consisted the live and healthy coral cover (LHC), live coral with macroalgal cover (LCMC), crustose coralline algae (CCA), animal interaction (AI), and herbivorous fish intensity (HB). Environmental indicators were estimated using the standard protocol, which including the PAR, summer season SST climatology, turbidity, Kd(490), total alkalinity (TA), and eutrophication index (EI). Furthermore, Anthropogenic indicators were selected including fishing pressure and anthropogenic physical damage to corals. The lowest prediction error (0.28%) of the hierarchical regression model in the Palk Bay revealed that LC, CCA, HB, and TA have positively supported to the coral recruit resilience in Palk Bay. Whereas, LCMC, turbidity, and Kd(490) were contributed to declining the coral resilience. The selected suitable model algorithm and coral geomorphology of the Palk Bay were applied to the ArcGIS Model Builder. The final suitability map of the Palk Bay classified the higher values as very high suitability that noticed at Vadakdu and Olaikuda reef sites. Meanwhile, low and very low suitability were noticed at the Mandapam, Ariyangundu, Pamban and Thangachimadam reef sites. These results have suggested that the regulation of macroalgal proliferation and herbivorous fishing are necessary actions to enhance coral recruit resilience in coral ecosystems of the Palk Bay.

Keywords: Site suitability model, Maximum likelihood classification, Hierarchical regression model, Coral resilience, Coral restoration, Palk Bay

[ABS-0149]

INFLUENCE OF TRANS-YAMUNA FAULT SYSTEM ON THE ACTIVE TECTONICS AND LANDSCAPE EVOLUTION IN THE NW SUB HIMALAYA

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Assessment of erosion proneness and active structural features is critical in tectonically dynamic regions, which can be effectively evaluated through morphotectonic analysis. The geomorphic indices capture the interaction between uplift and erosion that governs drainage basin dynamics and fluvial landscape. We investigate the influence of the tectonically active Trans-Yamuna Fault System (TYFS) on the NW Sub Himalayan. Unlike major intra-crustal structures such as the Himalayan Frontal Thrust (HFT) and Main Boundary Thrust (MBT), the TYFS affect the Lower Tertiary and pre-Tertiary sequence across the Main Boundary fault (MBF) and MBT, making it a structurally distinct tectonic unit. To quantify tectonic activity, geomorphic indices such as hypsometric integral (HI), stream-length gradient (SL), and basin asymmetry factor (AF), were derived from 30 m SRTM DEMs using ArcMap and MATLAB. Analysis of 20 sub-watersheds shows widespread evidence of uplift and erosion, with anomalous index values reflecting localized structural control. These results were integrated into an Index of Relative Active Tectonics (IRAT), allowing spatial assessment of deformation intensity. We used high-resolution remote sensing data (Cartosat, Google Earth), geomorphic expressions, including sag ponds, deflected streams, and steepened river profiles, aided by field observations reveal a dominant strike-slip deformation along TYFS. The TYFS was mapped by Ground Penetrating Radar (GPR) to a depth of 20-30 m, confirming the predominantly vertical geometry. Chronological constraints on the dislocated fluvial sequence were established through Optically Stimulated Luminescence (OSL) dating, which indicate fluvial aggradation and deformation during the Late Quaternary to Holocene. The integration of geomorphic indices, remote sensing, geophysical imaging, and geochronology provides a robust framework for identifying zones of active deformation in NW Sub Himalaya and role of neotectonics in shaping landscapes, which is important for seismic hazard assessment of the region.

Keywords: Trans-Yamuna Fault System, Neotectonics, Geomorphic Indices, Ground Penetrating Radar, OSL dating

[ABS-0168]

ATMOSPHERIC-IONOSPHERIC RESPONSES TO LARGE VOLCANIC ERUPTIONS: INSIGHTS FROM MULTI-INSTRUMENT OBSERVATIONS

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Large volcanic eruptions inject enormous amounts of energy and momentum into the atmosphere, generating acoustic and gravity waves that propagate upward through the atmosphere and reaches ionosphere. Despite the growing recognition of lithosphere-atmosphere-ionosphere (LAI) coupling, the atmospheric and ionospheric consequences of major eruptions remain less explored compared to other natural hazards. In this work, we investigate the atmospheric-ionospheric responses to several large eruptions using a combination of ground-based and satellite-based observations. GNSS-derived Total Electron Content (TEC) was analysed to identify Co-Volcanic Ionospheric Disturbances (CVIDs), while satellite datasets (Aqua, Suomi-NPP, Aura, GOES, and TIMED/SABER) were employed to trace gravity wave activity across different atmospheric layers. Results show that large eruptions excite both gravity waves, which typically reach the ionosphere within 30-45 minutes, and acoustic waves, which produce rapid ionospheric signatures within 10-15 minutes. Two categories of CVIDs are recognised: long-lasting oscillatory perturbations linked to acoustic resonance modes, and short-lived N-shaped impulses associated with shock-type acoustic waves. Case studies, including the 2003 Soufriere Hills, 2014 Kelud, and 2022 Hunga Tonga-Hunga Ha'apai eruptions, highlight clear vertical coupling from the lithosphere to the upper atmosphere. Additionally, evidence of Earth's free oscillations excited during the most energetic events suggests a strong acoustic resonance between the atmosphere and solid Earth. These findings provide stronger evidence for lithosphere-atmosphere-ionosphere (LAI) coupling, offering new insights into the atmospheric and ionospheric impacts of large volcanic eruptions. The results not only contribute to understanding the underlying wave-driven coupling mechanisms but also hold potential for improving volcanic hazard monitoring through multi-instrument observations.

Keywords: Lithosphere-Atmosphere-Ionosphere (LAI) coupling, Acoustic and gravity waves, Co-Volcanic ionospheric disturbances, GNSS-derived Total Electron Content (TEC), Multi-instrument observations

[ABS-0100]

ASSESSING CLIMATE CHANGE IMPACTS ON SORGHUM YIELD¿WUE DYNAMICS ACROSS TELANGANA AGROCLIMATIC ZONES-

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Sorghum (Sorghum bicolor L. Moench), a key cereal crop in the semi-arid landscapes of Telangana, plays a vital role in food, fodder, and livelihood security for millions of smallholder farmers. Predominantly cultivated under rainfed conditions during the kharif season, sorghum is increasingly vulnerable to climate change, marked by rising temperatures, erratic monsoons, and recurring droughts. These changes threaten both grain yield and water-use efficiency (WUE), two critical indicators of crop performance in water-limited systems. This study employs the DSSAT¿CERES-Sorghum model to evaluate the potential impacts of climate change on sorghum across Telangana¿s agroclimatic conditions. Historical daily weather data from the India Meteorological Department (1980¿2009) and bias-corrected projections from CMIP6 Global Climate Models under SSP2-4.5 (moderate emissions) and SSP5-8.5 (high emissions) provide the climatic basis for simulations. The methodology integrates site-specific datasets on soils, crop management, and genotype parameters, enabling calibration and validation of sorghum cultivars under rainfed conditions. Simulations will be conducted for baseline (1980¿2009), mid-century (2040¿2069), and end-century (2070¿2099) periods to quantify shifts in yield and WUE. Climate stress regimes (hot/dry, cool/wet, warm/wet) will be classified using percentile-based thresholds to capture variability and extremes. The study is expected to highlight future vulnerabilities by linking projected heat events (Tmax > 35°C) and rainfall irregularities with yield¿WUE performance, particularly under rainfed systems where climate risk is most pronounced. By identifying critical climate stressors, vulnerable regions, and projected performance trends, the research will provide a foundation for designing targeted adaptation strategies such as optimized sowing windows, adoption of heat- and drought-tolerant cultivars, and improved soil and water management practices. The findings aim to bridge knowledge gaps in yield¿WUE¿climate linkages for Telangana, where comprehensive assessments remain limited despite sorghum¿s agricultural significance.

Keywords: Keywords: CERES Model, CMIP6, Elevated temperature, CO2, Climate Change

HGS – SOWAR

The Sowar-HGS Group spans over 40 years in providing Geophysical products and solutions to the exploration industry in India & overseas.

Sowar (P) Ltd, (SPL) formed in 1980, focused on providing exploration equipment and services primarily to the Indian industry. To strengthen its position, it formed a joint venture with Sensor Nederland in 1986, namely Geosource India Ltd (now known as HGS (India) Ltd) to manufacture geophones, strings, seismic cables and connectors.

HGS (India) Ltd has grown into a world-renowned geophysical equipment supplier, having subsumed the technology, equipment and manpower of Sensor Nederland by opening its 100% subsidiary HGS Products b.v. in Holland to house the R & D and European marketing office.

Together the Group supplies world class equipment such as Gravity Meters, Geophones from 2Hz to 50Hz, Seismographs from 3 channels to 48 channels, Overhauser PPM & Caesium Magnetometers, Seismometers & Accelerographs, and Accelerated Weight Drop Systems of 50Kg & 500Kg.


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Ministry of Earth Sciences
Government of India

What is INCOIS?

The Indian National Centre for Ocean Information Services is an autonomous body under the Ministry of Earth Sciences. It is mandated to provide the best possible ocean information and advisory services through ocean observations and systematic and improved research.

Our Services

Ecosystem Services

Potential Fishing Zones (PFZ) Advisories provide information on the location of fish aggregation in the ocean.

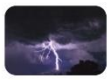
Coral Bleaching Alerts System (CBAS) assesses the thermal stress accumulated in the coral environs and provides early signs of the intensity and extents of coral bleaching.

Algal Bloom Information Services (ABIS) detects and monitors the blooms in the Indian Ocean and provides near real time information on spatio-temporal existence and spread of bloom over North Indian Ocean.

Multi-hazard Early Warning Services

Tsunami Early Warning System detects earthquakes in less than 10 minutes and provides warnings on tsunamis, if any occur, also within 10 minutes of a tsunamigenic earthquakes. The centre operates round the clock to provide services to the coastal population, disaster management agencies and 25 Indian Ocean rim countries.

Storm Surge Early Warning System provides the extent of surge during cyclones and extreme events.



Ocean State Forecasts (OSFs) provide information on winds, waves, ocean currents, water temperature, etc. at every 3/6 hours on a daily basis for next five days.

High Wave Alerts/warnings are provided during extreme / rough weather conditions in the ocean. The service provides details about the coast that may be impacted and duration of high waves, ocean currents, etc.

Online Oil Spill Advisory Service predicts the trajectory of oil spill during any event of oil spilled in the ocean. This information in advance helps the relevant stakeholders to take up the clean-up and control measures.

Small Vessel Advisory and forecast services system issues timely advisories to small vessels operating in the Indian coastal waters to reduce the number of accidents.

Marine Heat Wave Advisory Service provides maps of Marine Heat Wave intensity and different severity categories on a daily basis.

User-customised Service Products

Search And Rescue Aided Tool (SARAT) helps in finding out the most probable Search Area for missing persons/objects at Sea. Users will be able to select 60 types of missing objects such as person in water, life raft, fishing boat, aviation, surf boat, sailboat etc.

Forecast along ship routes provides daily Ocean State Forecast updates along with meteorological data and warnings, on waypoints, for standard routes like Chennai-Port Blair and Kolkata-Port Blair.

Inland Vessel Limits

Our demarcation of Inland Vessel Limits for various coastal states and island territories of India greatly benefits the coastal shipping/ inland navigation sectors.

Ocean Observations

To understand the oceanic processes several instruments such as floats, buoys, gliders, etc are deployed as round-the-clock watchers of the ocean and provide real /near real time data for operational and forecast services.

Climate Services

El Niño-Southern Oscillation (ENSO) is an atmosphere-ocean phenomenon of the tropical Pacific. In the positive phase, also known as El Niño, the eastern Pacific warms, and the western Pacific cools. During El Niño, the Indian Ocean becomes warmer than normal and causes prolonged marine heat waves. It can also weaken the Indian summer monsoon.

Indian Ocean Dipole (IOD) is an El Niño like oceanic phenomenon in the Tropical Indian Ocean. During its positive phase, the eastern Indian Ocean cools and the western Arabian Sea warms.

INCOIS provides global and regional climate outlooks on its portal by regularly updating prevailing El Niño & La Niña (the two phases of ENSO) and IOD conditions.

Information, Communication & Technology Services

State-of-the-art facilities including high performance computing and communications facilities are adopted to provide round-the-clock services to the nation.

Ocean Data & Information Services

Heterogeneous data from various in-situ and satellite platforms as well as numerical modeling are made available at the fingertips of the researchers, students, and industry.

International Training Centre for Operational Oceanography (ITCOOcean)

A Category-II Training Centre, recognised by IOC-UNESCO, provides advanced training in operational oceanography that would help the trainees in translating the results and findings in ocean science to real-time use by end users.

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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 four scientific groups, viz.,

Solid Earth Research Group (SERG) primarily focuses on the geodynamic evolution of Archean cratons, Proterozoic mobile belts, the Western Ghats, and active subduction zones. It also addresses dynamic processes taking place at or near-surface conditions in the Earth's crust, hydrocarbon movements in sedimentary layers, and landslides.

Environmental Hydrology Group (EHG) focuses on research in hydrology and water resources, with a specific emphasis on the Earth's Critical Zone. It also focuses on the evolution of springs, biogeochemistry, solute dynamics, water quality monitoring, pollution assessment, and mitigation.

Marine Science Group (MSG) focuses on understanding waves, currents, sediment transport, and their effects on beaches and nearshore areas. Additionally, it is involved in the national network project on Submarine Groundwater Discharge, which aims to quantify the amount of groundwater discharge through coastal aquifers.

Atmospheric Science Group (ASG) is engaged in research on atmospheric clouds, thunderstorms, lightning, atmospheric electricity, and regional climate over the 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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NCPOR, Goa, under the aegis of the Ministry of Earth Sciences, Govt. of India is a nodal agency for India's expeditions to polar regions such as Antarctica, the Arctic, and the Southern Ocean.

The institute also operates four stations throughout the year- Maitri and Bharati in Antarctica, Himadri in the Arctic, and Himansh in the Himalaya. NCPOR in Goa conducts R&D activities in key areas such as climate variability, oceanography, and cryospheric sciences. The institute is also involved in strategic marine geoscientific projects such as the Deep Ocean Mission, surveys of the Exclusive Economic Zone, the legal continental shelf, and the exploration of hydrothermal sulphide mineral deposits in the Indian Ocean.

- **44** Indian Scientific Expeditions to Antarctica
- **15** Indian Scientific Expedition to Arctic
- **12** Indian Southern Ocean Expedition
- **2010** Indian Expedition to the South Pole
- **2022** Indian Scientist Reached North Pole Indian Antarctic Act, 2022
- **2005** India's *Only Ice- Core Laboratory* established at NCPOR, Goa

Thrust Areas

- **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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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.

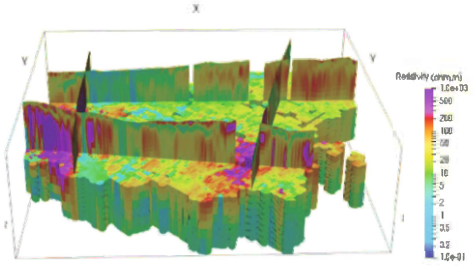
Significant Achievements

- 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

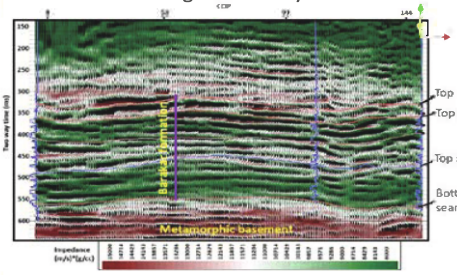
Future R&D

- ✓ Geological Hazard Assessment – Early Warning System
- ✓ Water Security – Sustainable Groundwater Resources Management
- ✓ Energy Security- Hydrocarbon, Uranium, Geothermal
- ✓ Minerals – Lithium and REEs
- ✓ AI/ML for Geosciences

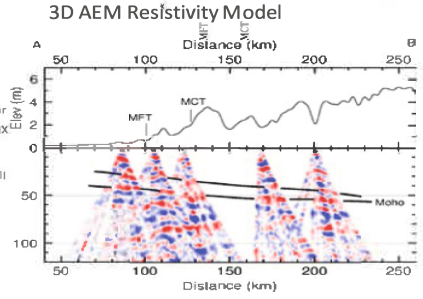
Drone based Magnetic Survey in Ladakh



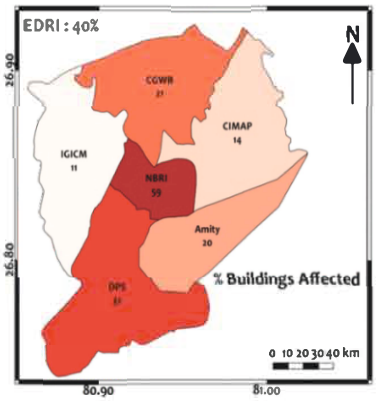
3D AEM Resistivity Model



3D Seismic Data for CBM Exploration



Seismic image of the Moho in Kashmir Himalaya



Earthquake Risk Map – Lucknow

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