INDIAN GEOPHYSICAL UNION

57th Annual Convention
on
"Sustainable Geosciences & Blue Economy“
2-4th Feb 2021(Virtual)

Jointly organized by
IGU & CSIR-NIO

CSIR-National Institute of Oceanography (CSIR-NIO)
Dona Paula, Goa.

ABSTRACTS

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57th Annual Convention (Virtual)

on

Sustainable Geosciences & Blue Economy

Venue:
CSIR-National Institute of Oceanography (CSIR-NIO)
Dona Paula, Goa.

February 2021

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Message

The Indian Geophysical Union (IGU) has been organizing annual conventions on various themes at research organizations, universities and academic institutes since its inceptions. IGU has provided a platform for dissemination of knowledge of earth system science through plenary lectures, invited talks, oral/poster presentations, special talks on current topics of interest in the earth sciences having societal relevance. IGU and CSIR-NIO, Goa are jointly organizing the 57th Annual convention on ""Sustainable Geosciences & Blue Economy"" during, February 2-4, 2021. I am sure deliberations of the Annual Convention is likely to fulfil the societal needs of sustainable development. The pattern of economic growth should be such that resource use is balanced by human needs while preserving the environment.

It is gratifying that Prof. Ashutosh Sharma, Secretary; DST has kindly agreed to inaugurate the Annual Convention. A response from more than 200 delegates and participation of dignitaries is a positive stride towards the success of this program. It is indeed an honour to welcome esteemed dignitaries, delegates, speakers and invitees to the 57th convention of IGU and wish an enriching participation. I wish the convention a grand success.

SRNayak

(Shailesh Nayak)

Prof. Sunil Singh,
Director,
CSIR-NIO, Goa

LOC Chairman Message

I welcome all the participants of the 57th Annual Convention (Virtual) of Indian Geophysical Union (IGU) being held at CSIR-NIO, Goa during February 2-4, 2021. Owing to global pandemic situation it is being organised on virtual platform, however, I would have preferred it to be with physical presence . At the outset, I am so glad to see the progress of this Annual Convention both in terms of quality and quantity. Based on the success of earlier conventions, the response of the participants are large and much more scientists and students in the domain of geosciences from all around India showed interest to participate actively in this conference, however, due to pandemic situation we are arranging this conference in quite restricted manner, our apology for the same. As we are aware, the last convention held at Hyderabad was a great success, I trust genuinely that we will stride on a higher pedestal of this convention this year in Goa.

The main theme of this year Annual Convention is “Sustainable Geosciences & Blue Economy" encompassing the entire Earth Sciences. This theme becomes significantly important in view of the just started UN Decade of Ocean Science for Sustainable Development meant to boost the international efforts at the science-policy interface to reverse the cycle of decline in ocean health.

I am very much sure that this three-day convention will provide an excellent platform to all the geoscientists to highlight their excellent researches carried out in different organisations in all the fields of Earth Sciences.

I sincerely thank all those associated with organizing this convention and program committee who are working hard to ensure a successful convention in Goa. I specially thank to the authors who fervently contributed to this convention.

Preface

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

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

IGU is planned to provide a proper forum for presentation of latest works in various disciplines in earth sciences. IGU has taken up the initiative to jointly organize its 57th annual convention at CSIR-NIO during 2-4, February-2021. The disciplines cover Solid Earth Geosciences, Marine Geosciences and Atmospheric, Ocean and Space Sciences. For this year the special theme is "Sustainable Geosciences & Blue Economy". This three day convention (Virtual) covers plenary and invited talks and there would be sessions covering different disciplines of Earth Sciences during the 57th Indian Geophysical Union.

Besides the award lectures and invited talks, more than 70 papers are expected to be present during the three-day convention. We have included 20 of them under poster session. In general, 300 to 350 delegates participate in every year convention. More than 300, delegates expected to participate in the convention as it is on virtual mode. This would help in better interaction between eminent scientists and young researchers and students. On behalf of IGU, we request the delegates to send full papers of their presentations, for publishing the same in the Journal of IGU, after proper reviewing process.

The IGU is congratulate all the medal winners viz., Decennial Award, Krishnan Medal, Anni Talwani Memorial Prize, Prof. K.R. Ramanathan Memorial Lecture, Dr. HN Siddique Memorial lecture award, Anni Talwani

Memorial award for Women Researchers and Prof. Jagdeo Singh and Dr. S. Balakrishna Memorial award for student's participation in the annual convention. IGU - Harinarain Lifetime Achievement award in Geosciences and Prof. D. Lal best paper award, papers published in The Journal of Indian Geophysical Union six issues during 2020.

We place on record our Thanks to the Local Organizing Committee and Dr. Sunil K Singh (LOC- Chairman), Dr. Pawan Dewangan (Convener-LOC) for their committed involvement and help in organizing the 57th Annual Convention. This hope fully, would ensure uninterrupted conduction of various technical sessions and better presence of delegates during the Award talks.

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

Abhey Ram Bansal
ASSSRS Prasad

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SUSTAINABLE GEOSCIENCES AND BLUE ECONOMY

Quantification of transitions matrix of marine fish landings of India as precursor of a potential value chain using a Blue Economy approach

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Abstract

The marine fishery sector in India is an enterprise of high value chain with a significant potential to create huge employment opportunities, remedy the socio-economic backwardness of the nation as well as support sustainable fishing practices. These activities form the core of the Blue economy approach, a strategic framework of ocean-based economic development to achieve developmental benefits from a human-centric perspective. More recently, this approach has also been recognized as imperative for regional-scale sustainable development of both the marine ecosystem as well as the fisheries. According to a recent report of Government of India (GoI), fishes contributed to 12.8 per cent of total animal protein while 16 million people are directly dependent on fishery sector and this number is almost double along the value chain. India had harnessed 3.56 million metric tons (Mt) of marine fishes in 2019 with a 2.1 per cent of annual growth rate while the estimated marine fisheries potential was about 5.31 Mt. During the FY of 2018-19, India exported about 1.39 Mt of seafood worth ₹465.89 billion, was around 20 per cent of the total agricultural export. The National Fisheries Policy 2020 has advocated a systematic approach to develop, harness, manage as well as regulate fisheries scientifically and sustainably.to meet the targets of Sustainable Development Goal 14 (SDG 14) Life Below Water for India. The present study provides a scientific basis to quantify a transitions matrix of the spatio-temporal changes of marine fish landings across nine maritime states and two union territories of India since 1950s. Preliminary analyses of data on the marine fish landings illustrated that marine fish production in India had grown from 0.58 Mt in 1950 to 3.56 Mt in 2019; however, unexpectedly, a decreasing trend is evident in the last decade i.e., 2010-2019. The transitions matrix approach is further extended to quantify

these transformational changes towards data on state-wise landings in the present investigation. The role of technological pathways to support scientific and sustainable fishery management is also examined, providing a useful frame of reference to plan maximum sustainable yields for marine fisheries.
Key words: Marine fisheries, Blue economy, Fish landings, SDG 14, Maximum sustainable yield.

Along-track altimeter sea level data assimilation in a high-resolution Indian Ocean model and impact assessment on simulated surface and sub-surface currents

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Abstract

Estimation and forecast of oceanic flow is very crucial for safer and efficient navigation. Numerical ocean models are generally used to forecast the ocean surface currents for next 24 - 120 hours which are then provided to the users for their operational use. Numerical models suffer from inherent errors which then result in high errors in the model forecast. Initial condition of numerical models is improved by means of data assimilation of various observations (both in situ and satellites) which then result in increase in the accuracy of the model forecast. In this study, altimeter based sea level anomaly (SLA) observations from Jason-3 are assimilated in a high resolution Indian Ocean model and the impact of assimilation is analyzed in the Bay of Bengal region. The study uses a 3-D primitive equation numerical ocean model forced with analysed atmospheric data to generate ocean state for a particular period, in this case for the year 2018. In order to study the impact of SLA assimilation, two set of model outputs are generated, one in which no SLA is assimilated (CNTRL) and the other in which along track SLA from Jason-3 satellite is assimilated (EXP) using Ensemble Optimum Interpolation technique. The impact of assimilation is primarily analyzed on ocean surface currents. For this purpose, satellite derived sea surface currents and buoy based vertical

current profiles are used to evaluate CNTRL and EXP. It is found that there is a profound improvement in ocean current simulation after assimilation of SLA. Mesoscale eddies that were weak and misplaced in CNTRL have now improved in EXP in terms of both strength and position. Sub-surface current simulation from EXP exhibit observed variability in most of the evaluation period, which was absent in the CNTRL. Computed statistics show much improved ocean current simulations in EXP at all the depths. Particle trajectory analysis has been performed and it is seen that assimilated model velocity fields faithfully simulate the observed trajectory of tracers. Power spectra of simulated SLA from both EXP and CNTRL were compared with spectra from satellite SLA and it is found that after assimilation the slopes of the simulated spectra becomes much closer to slope of spectra from the observations indicating that the along track assimilation of SSHA has definitely improved the model simulations and thereby preparing accurate initial conditions for an accurate model forecast.

Gas seepages along the Indian Continental Margins: Role of Seismic Chimney

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Abstract

Methane seeps have been reported from the deepwater regions of Indian continental margins and have received broad attention from researchers working on methane budget, geohazards, gas hydrates, and extreme ecosystems. In general, methane gas is trapped into solid crystalline gas hydrates stable under high pressures and low temperatures. In the present study, we examine various factors that lead to methane migration up to seafloor and facilitate the proliferation of the chemosynthetic community and shallow occurrence of gas hydrate deposits. Seeps are discovered using the water column imaging functionality of the multibeam system, where the

bubbles are observed as gas flares. In addition to water column images, flares are also observed in the high frequency (> 18 KHz) seismic data. The geological sampling of methane seeps by CSIR-NIO in the Krishna-Godavari (KG) offshore basin, Bay of Bengal and the Mannar basin have confirmed the chemosynthetic community and shallow presence of gas hydrate. Shale tectonism in the KG basin governs gas flares' spatial distribution in offshore regions, and toe-thrust and diapiric zones provide an environment conducive for seeps. The compressional forces resulting from shale tectonism causes folding and faulting of overburden sediments. In some cases, the overpressured strata are mobilized as shale diapirs. Faults generated from the movement of shale diapir facilitate the migration of gas from deep-seated reservoirs.

The geophysical data analysis suggests a chimney-like structure in the subsurface beneath the gas flares in both KG and Mannar basins. The clay sediments cannot support vertical migration of gas; therefore, geological structures like faults/fractures, seismic chimneys/pipes, or high permeable strata are required for gas migration. In the KG and Mannar basins, seismic chimneys are responsible for mobilizing deep-seated gas to the seafloor. We analyzed numerous mechanisms to explain gas migration through the gas hydrate stability zone (GHSZ), like thermal perturbation due to warm fluids, salinity increase due to hydrate formation, and pressure drop due to sea-level fall. Our analysis suggests that forming a hydrate shell around the advancing gas front is the most likely mechanism that can limit methane diffusion and allow the migration of methane gas through stability zone. The mechanism can support both the methane seep and seismic chimneys observed in the KG and Mannar basins.

Marine cold seep ecosystem: A close link between benthic life and sediment biogeochemistry

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Two recent (during 2018-2020) discoveries of the cold-seep ecosystems in association with shallow methane hydrates along the east coast of India have put India on the Global cold seep map**.** Marine cold-seep ecosystems are characterized by the buildup and/ or emission of methane across the sediment-water interface and accumulation of very high interstitial hydrogen sulfide concentrations close to the sediment-water interface at cold bottom water temperature conditions. The cold-seep ecosystem occurs as patches of variable shape and size across the ocean floor depending upon the areal extent of hydrocarbon conduits like fractures and faults. The cold-seep biotic community represents a dominantly endemic ecosystem, characterized by chemosynthetic and heterotrophic fauna. A steady flux of methane and hydrogen sulfide gases control the growth and sustenance of cold-seep ecosystems. On the other hand, variability of H_2S and CH_4 fluxes at the sediment-water interface primarily controls the faunal diversity and spatial distribution of such ecosystems.

The first report (Mazumdar et al., 2019, JESS, v-128) of the cold-seep ecosystem was made from the Krisha-Godavari basin (12th January to 6th February 2018 onboard ORV Sindhu Sadhana: SSD045) where the cold-seep ecosystem and shallow methane hydrates (2-3mbsf) are associated with methane gas flares in the water column. The seep-sites are located at water depths of 900-1800 m. Chemosymbiont bearing Bivalves (Vesicomidae, Mytilidae, Thyasiridae, and Solemyidae families); Polychaetes (Siboglinidae family), and Gastropods (Provannidae family) are identified from seep-sites. Carbonate crusts were also reported from these sites. The second discovery of a cold-seep ecosystem was made from the Mannar basin (13th to 22nd February 2020: onboard ORV Sindhu Sadhana: SSD 070). Here, we report (Mazumdar et al., under rev.) for the first time of the genus Lamellibrachia tubeworm and associated chemosynthetic ecosystem from a cold-seep site in the Mannar basin. The chemosymbiont bearing polychaete worm is associated with squat lobsters (Munidposis sp.) and Gastropoda belonging to the family Buccinidae. Relict shells of chemosynthetic Calyptogena clams are ubiquitous at the seep sites. The Lamellibrachia tubes were found to be firmly anchored into the authigenic carbonate crusts. The authigenic carbonate crusts (chemoherm) are packed with large Calyptogena shells (whole shell and fragments). Very high concentrations (3800-12900 μM) of H_2S in the

interstitial waters is responsible for the sustenance of chemosymbiont bearing tubeworms. The posterior end of the tube penetrates downwards into the H_2S-rich zone. The high concentration of H_2S at ~40 cmbsf is attributed to sulfate reduction via anaerobic oxidation of methane (AOM) pathway. Methane hydrate was observed within the faults/fractures in the sediments. The presence of ethane and propane along with methane in the headspace gases and $\delta^{13}C_{CH4}$ values (-28.4 to -79.5 ‰ VPDB) suggest contribution of deep-seated thermogenic methane.

Geomorphology of the back-arc volcanic system, active fluid/gas seeps, and shallow magma chambers? in the off Nicobar region

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High-resolution multibeam swath bathymetry system along with water column imaging capability was used to survey, twelve submarine volcanic arc seamounts between 6.5°S and 8.2°N in the off Nicobar region to study submarine volcanism. The survey was carried out using RV Sindhu Sadhana. We analyzed the acoustic signals that are detected by the backscattering data within the water column. We observed for the first time around 300 gas flares in the water column image at depths ranging from 340 m to 3500 m in the off Nicobar region over a length of ~114 km. A prominent plume-like signature was also observed over the cratered seamount. The high-resolution bathymetry map shows various premature to well-developed crater seamounts. It displays large scale tectonic and volcanic related features like lava flow, radial dyke intrusions, upthrust faults, regional extensional faults, regional strike strip faulting associated with the extension of the Seulimeum and Andaman Nicobar faults. The observed water column anomalies, and the interpreted fault system in the high-resolution bathymetry maps, are linked

to the frequent earthquake swarms in this region after the 26th December 2004 Andaman – Sumatra Megathrust Tsunamigenic earthquake. The observed gas flares are clustered over various structures like crater seamount, thrust faults, normal faults, strike-slip faults, and regional extensional faults along the submarine volcanic arc system. Gas venting across the various faults provides direct evidence of gas/fluid emanations from the volcanic chain. The frequent earthquake swarms suggest interaction of subsurface magma movement with the sliver fault systems. Shallow subsurface magma chambers in the off Nicobar region may be inducing the emanation of the observed gas/fluid flares along the volcanic arc.

Petrography and geochemistry of gas-hydrate related authigenic carbonates from Krishna-Godavari Basin (Bay of Bengal).

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Abstract

During the first expedition of the Indian National Gas Hydrate Program (NGHP-01), deep drilling core up to 203.8 m, at a water depth of 1040 m. Early diagenetic carbonate precipitates occur at depths between 6 to 197 mbsf as micro-nodules, nodules, tubules, thin crusts, bioturbation casts, cements and exhibit clear vertical zonation with respect to hydrate occurrences. Petrographic thin section studies of methane-derived authigenic carbonate precipitates depict typical micritic texture with dissolution structures, micritic matrix crosscut by veins and fissures and showing well preserved foraminiferal tests filled pyrite framboids. The total rare earth elements (□REE) of carbonate concretions (42.4- 103.7 ppm) are relatively less enriched compared to the host sediments (128.9-187.7 ppm) indicating that REE patterns for bulk carbonate concretions are distinctly different from

the host sediments. The positive Eu anomaly of the REE carbonate patterns suggests that the seep carbonates are most likely formed in reducing conditions where in Eu2+ is incorporated along with Ca2+ due to similar atomic radii. A less pronounced positive Eu anomalies observed in the host sediments could be attributed to the convection of Eu to the sediments via preferential fluid transport from deeper region. The δ13C and δ18O for the HMC nodules range from -52.40 to -43.26 ‰ (avg.-48.27) and 4.12 to 5.26 ‰ (avg.4.57) VPDB respectively, while the Fe-rich carbonates showed the widest range in carbon and oxygen isotopic composition ranging from -6.28 to 10.25 ‰ (avg.5.15) VPDB and 3.80 to 4.91 ‰ (avg.4.23) VPDB respectively.

Keywords: Authigenic carbonates; Gas-hydrates; Krishna-Godavari offshore basin; Bay of Bengal; carbonate petrography; carbonate geochemistry; stable carbon and oxygen isotopes

Assessment Of Submarine Groundwater Discharge Based On Radon And Salinity Variations Along Nagapattinam Coastal Aquifers, Tamilnadu, India.

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Submarine groundwater discharge (SGD) is the direct discharge of groundwater to the ocean along with which it also transfers dissolved nutrients, heavy metals, organic components and inorganic compound carbon from the continents to the ocean. Attempt has been made in the Nagapattinam coastal aquifers to quantify SGD and related fluxes to the sea using radon isotopes and physical parameters like pH, EC, TDS and Salinity. Water samples representing surface water, pore water, groundwater and sea water were collected at specific localities by adopting standard procedures and analysed for the said parameters. Large variations in radon (1.0 to 716.586 Bq/m^3) were observed in view of locations and sample types. Salinity varied between (470 to 37900 ppm). Lower radon was observed in porewater

samples and higher was noted in groundwater samples. Salinity is found to be influenced by depth in view of depth, where lower salinity was confined to groundwater samples. Significant correlation noted between radon and salinity. In locations where radon was found to be higher (716.586 Bq/m^3) salinity was found to be lower (470 ppm) and vice versa. From the study correlation of radon and salinity signifies discharge of fresh groundwater discharge in locations isolated with higher radon and lower salinity and recirculated groundwater discharge in locations where lower radon (1 Bq/m^3) correlated with higher salinity (37900 ppm). The study clearly demarcates location of fresh and recirculated groundwater aided by radon and salinity.

Key words - Radon, Salinity, Submarine Groundwater Discharge.

Assessment of Submarine Groundwater Discharge fluxes from Tamilnadu and Pondicherry coastal aquifers to Bay of Bengal using Radon Mass Balance modeling

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Abstract

Submarine groundwater discharge (SGD) has been perceived as a significant pathway for material transport such as dissolved ions, nutrients, metals, and organic compounds that are more significant for marine geochemical cycles and material pathways to the oceans. Measurement of SGD is more significant due to input of nutrient from SGD is comparably higher than the atmospheric and riverine that might influence the marine ecology and environment. Attempt has been made to quantify the SGD and related flow to the coast along the coastal tracts of Tamilnadu and Pondicherry using radon isotopes. Water samples representing groundwater and pore water were collected at parallel transects to the coast and analyzed for radon isotope. The concentration of ^{222}Rn irrespective of water type higher radon (2643.41 Bq m^{-3}) was confined to groundwater samples and lower (7.43 Bq m^{-3}) recorded in porewater samples. The radon attributed SGD fluxes were attempted by considering the radon mass balance approach that incorporates

various sources and sinks like growth due to ^{226}Ra dissolved in water, tidal dynamics, atmospheric losses, sediment diffusivity and mixing loss due to discharge of water. The radon attributed fluxes range between <1.0 m/d and 28.56m/d. Greater fluxes correlated well with higher radon and lower fluxes vice versa suggesting the role of radon attributed fluxes influencing SGD to the bay.

Keywords:SGD, Radon fluxes, coastal Tamilnadu and Pondicherry, Dissolved ions and Nutrients.

Safe Weather Route using Dijkstra Algorithm

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Abstract

Observations of ocean wave height from satellite altimeters have been assimilated into a nested wave model WAVEWATCH III operating in the Indian waters. These forecasts are routinely available from Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC). This activity is now enriched by estimating the safe weather routes over ocean. Optimum Ship Routing can be defined as “the selection of an optimum track for a transoceanic crossing by the application of Long-range predictions of wind, waves and currents to the knowledge of how the routed vessel reacts to these variables”. The primary goal of ship routing is to reduce a voyage cost in various aspects and keep safe during the period of vessel underway. In this study, the optimum ship routing is attempted using the wind and wave information. This optimal ship routes are based on the user defined information of source and destination locations. The significant wave height and wind fields from model forecasts are used for selecting the most suited route for shipping. The technique on which the routing is based on Dijkstra's algorithm or Dijkstra's Shortest Path First algorithm (SPF algorithm). The algorithm provides solution to single source shortest path problem in graph theory.

SOLID EARTH GEOSCIENCES

3D Fuzzy Constrained Inversion of Gravity Data – A Case Study from Chromite Mineralization

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Abstract

The ultimate problem that geophysical techniques are intended to answer is the actual structure and property of the subsurface under investigation. Despite having good data acquisition, obtaining the three-dimensional subsurface structure is still a challenge. Moreover, there is a lack of a relationship between geophysical inversion results and lithological classification. In the present study, we have developed a fast 3-Dimensional inversion algorithm of gravity field data. First, we have computed the vertical component of the gravitational attraction due to individual rectangular prism at the surface observation point. Further, total gravitational field due to all rectangular prisms have been computed as the summation of the field due to individual prism at the observation points. For the inversion part, the preconditioned conjugate gradient algorithm is implemented. The conjugate gradient algorithm guarantees the convergence to the solution within n-steps for n-dimensional model space. Since the gravity field follows inverse square law, the source body's response decreases as its depth increases, due to the same fact response of the rectangular prisms at considerable depth will be weak and ineffective to some extent. To counteract this effect, we incorporate preconditioning in our inversion scheme in the form of a depth weighting function. Preconditioning provides the depth information of the source body and reduces the number of inversion iterations. For uniting lithological classification and geophysical inversion into a single scheme, a-weighted fuzzy c-means clustering algorithm is implemented. This clustering technique is a part of the objective function. It serves two purposes: in the first place, it incorporates a prior petrophysical value and, furthermore, as an automated means of differentiating between various geological units (i.e., lithological classification). Fuzzy c-means clustering serves as a bridge between inverted

geophysical models and geology interpretations. Thus, no post-inversion steps are required anymore. We illustrate our developed approach using two examples, one synthetic, and one real field data set. As a field case study, the developed algorithm was used to identify the extension of chromite bearing target rock around the Tangarparha, Orissa (India) region.

Keywords: 3D inversion, Gravity, fuzzy c-means clustering, Mineral exploration.

Identification of Localized Controlling Factors of Fluoride Contamination in Groundwater at Watershed Scale

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Abstract
This study was conducted to find out locally dominated factors responsible for fluoride accumulation in groundwaters of Maheshwaram watershed, Rangareddy dist., Telangana. To conduct the study fluoride concentration data and six key parameters were selected. The parameters are soil order, soil chemistry, weathered layer thickness, weathered aquifer layer thickness, vegetation and elevation. First, individual relationship between fluoride concentration and each key parameter was evaluated through Box-plot. Then multiple linear regression was performed to screen the six key parameters. It was found that out of six parameters four parameters (soil order, soil chemistry, weathered aquifer layer thickness and vegetation) were significant and explained 70% of the variation in groundwater fluoride concentration. Significance of this study lies on the following fact that the study has included different controlling parameters for fluoride accumulation than generally followed factors such as hydrochemistry and geology. Moreover, these parameters would be applicable on small as well as large geographical area during modeling or mapping of fluoride contamination.
Keywords: Fluoride, Controlling parameter, Watershed, Groundwater.

Application of Remote Sensing and GIS for the Identification of Ground water potential Zones in Bangra Block, District Jhansi, Uttar Pradesh of India

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Abstract

An integrated hydro-geological investigation has been made to delineate the groundwater-potential zones of the Bangra block, district Jhansi, U.P. has been carried out based upon the scientific investigation of Drainage, Hydro-Geomorphology, Lithology, soil, land use & Land cover, Geo-resistivity data and their inter-relationship. Thematic layers of drainage, canal, surface water body, geomorphology, lithology, lineament, Soil, and Land use & land cover were prepared with the help of satellite images (LISS IV +Cartosat PAN merge data).

The exploration for groundwater in hard rock terrains is a complex task. To overcome this complexity, the integrated approach based on advanced applications of remote sensing and geographical information systems (GIS) lends itself as an efficient and effective result-oriented method for studying the development and management of water resources. Bangra area, comprised of a hard rock terrain, is located in the Jhansi district, Uttar Pradesh of India. Using remote sensing and GIS technology, groundwater potential zones were delineated and classified.

Groundwater is an important resource contributing significantly in total annual supply. However; overexploitation has depleted groundwater availability considerably and also led to land subsidence at some places. Assessing the potential zone of groundwater recharge is extremely important for the protection of water quality and the management of groundwater systems. Groundwater potential zones are demarked with the help of remote sensing and Geographic Information System (GIS) techniques. In this study a standard methodology is proposed to determine groundwater potential

using integration of RS & GIS technique. The composite map is generated using GIS tools.

The Accurate information to obtain the parameters that can be considered for identifying the groundwater potential zone such as geology, slope, drainage density, geomorphic units and lineament density are generated using the satellite data and survey of India (SOI) toposheets of scale 1:50000. It is then integrated with weighted overlay in ArcGIS. Every class in the thematic layers were placed into one of the following categories viz. (i) Moderate and (ii) Poor depending on their level of groundwater potential. Considering their behaviour with respect to groundwater control, the different classes were given suitable values, according to their importance relative to other classes in the same thematic layer.

Results indicated that, for the town of Bangra, 17.0122% of the area was classified to moderate groundwater potential, and 73.4794% of the area was classified as Poor.

Key Words: - Ground Water Potential, Remote Sensing, GIS, Resistivity Data, SRTM Image, DDR-3 Machine, LISS IV +Cartosat PAN merge data.

Data-Driven Modeling of Hydraulic Parameters using LSTM based on Memristor Cross Bar Array

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Abstract
Reliable estimation of hydraulic parameters from geophysical and/or hydro-geochemical data assumes a special significance for successful management of water resources in hard rock areas. Accurate estimation of hydraulic parameter is challenging due to various hydrogeological complexities. Traditional techniques such as pumping test and tracer studies are invasive and costly in estimating hydraulic parameters. Moreover, these methods do not take care of underlying non-linearity between "data" and " hydraulic

parameters" in various stages of estimation processes. Here we present a novel deep neural network (DNN) approach namely Long Short-Term Memory Network based on Memristor Crossbar Arrays trained by Grey Wolf Optimization (Memristor LSTM-GWO) to estimate and spatially interpolate hydraulic parameters from vertical electrical sounding (VES) data. Our network was trained using data samples generated by physics-based theoretical model for fractured media and was subsequently employed to predict hydraulic parameters from VES data of Sindhudurg district of Maharashtra, India. A comparative study was proposed using Memristor LSTM-Quick prop, Memristor LSTM-SGD models for the reliable estimation of Hydraulic parameters. Our model exhibits high Pearson's correlation coefficient (R) (≥0.9) in prediction. We propose deep learning as an approach to predict and spatially interpolate hydraulic parameters from geophysical data thereby reduce non-uniqueness and uncertainty in hydraulic parameter estimation.

Keywords: Hydraulic conductivity; Transmissivity; Deep Learning; Memristor-LSTM; Memristor LSTM-GWO; Data driven-variogram model

Climate sensitivity of summer runoff from two contrasting high Himalayan catchments

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Abstract

Changing run-off in the glacierised Himalayan rivers may expose a large downstream population to climate risks in the near future. An understanding of the climate sensitivity of the present-day runoff from the high Himalayan catchments may help in predicting the changes accurately. We quantify the climate sensitivities of summer runoff to annual precipitation and mean summer-temperature changes in two upper Himalayan catchments – winter-

snow dominated Chandra (western Himalayan) and summer-rain dominated upper Dudhkoshi (eastern Himalaya). The climate sensitivities are extracted by analysing the interannual variability of runoff during 1980–2018 as simulated by the Variable Infiltration Capacity (VIC) model that is validated against field data. The best-fit linear sensitivities during 1998–2018 explain the interannual variability of summer runoff during 1980–1997 quite well and capture the runoff response to a step change in regional climate post-1992 accurately. The climate sensitivities of the summer runoff generated from the glacierised and non-glaciersied parts of the catchments are used to predict the changes in summer runoff from upper Dudhkoshi catchment by 2050 while taking into account the future glacier loss. The predictions from this simple climate sensitivity based model compare favorably with those derived from sophisticated glacio-hydrological models. In the both the catchments, the summer runoff generated from the glacierised parts are sensitive (insensitive) to temperature (precipitation) changes. In contrast, the summer runoff generated from the nonglacierised parts are sensitive (insensitive) to precipitation (temperature) changes. While the analysis presented here are based on runoff simulated with VIC model, the same protocol can be applied to catchments with long-term runoff data to obtain accurate predictions of the hydrological changes and to benchmark complex hydrological models.

The study of geochemistry and hydrogeochemical evolution of groundwater surrounding dyke using SOM: A case study of Dhanbad district, Jharkhand.

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Abstract

In this study, the hydrochemical evolution and geochemistry of water sample with dyke has been studied in hard rock area of Dhanbad, Jharkhand. By collecting numerous water sample over site it become large dataset. So,the

conventional method of estimation of water quality index (WQI) becomes tedious. So here approach of Self Organising Approach (SOM), unsupervised neural network has been applied. In 30 water sample,out of 12 physico-chemical parameter,7 parameters (EC (53.33%), NO_3^-(53.33%), Ca^{2+}(53.33%), Cl^-(20%),SO_4^{2-}(13.33%), HCO_3^-(10%), TDS(6.67%),) in samples has exceeded the permissible limit (WHO ,2004). By SOM approach, it clearly divides 30 water sample into three clear clusters in which cluster 1 has low mineralization and excellent water types (43.33 % of the total samples (n=13), mean value of EC =493.76, TDS=322.46, NO_3^-=29.53). The dominant hydrogeochemical facies are Ca-Mg-Cl, Ca-Mg-HCO_3, and Ca-Mg-SO_4. There is acidic weathering of primary aluminosilicate minerals such as Ca-plagioclase, amphiboles, pyroxenes, and carbonates from the interaction of water with the dolerite dyke. So, division of water sample into three cluster using SOM approach matched with conventional method of determining Water Quality Index(WQI). Thus, the SOM approach is an efficient, fast, and economical way to classify the groundwater samples.

Recharge estimation in a crystalline hard rock aquifer: comparative analysis of AEM supported LCR and borehole WTF methods

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Abstract:
Groundwater management is one of the most challenging issue in an over-exploited crystalline hard rocks terrain, where groundwater is locked within the sporadically distributed fractures. The limited understanding such complex hydrogeological setting accelerating the groundwater scarcity, currently spread over the large area in India. To improve the understanding, we have attempted to estimate groundwater recharge using lithology constrained rainfall (LCR) and water table fluctuation (WTF) methods in granitic hard rock terrain of Ankasandra watershed, Tumkur district, Karnataka. LCR uses heliborne resistivity data of soil and rainfall to estimate the groundwater recharge at spatial scale. Additionally, the effective porosity

(specific yield; S_y) of the fractured aquifer is also computed for the better understanding of the fracture density. The computed S_y varies from 0.1 % to 2 % with mean value of 0.7 % which is slightly underestimated as compare to the other watershed studies in similar type of aquifers. The lower mean S_y may appear here due to the presence of deeper water level in comparison of different area. The spatial annual recharge from WTF method shows the significant influence of bedrock depth which is supported by LCR based recharge distribution within the watershed. Though the overall amount of recharge estimates is found in almost similar order, the LCR recharge estimates is found well distributed spatially. In contrary, WTF recharge estimated is mostly localized only in a limited area with high range of variation. The corresponding variogram of recharge from WTF is not well structured, showing a moderate spatial dependency, considering the complexity of the aquifer. As a result, the recharge map from WTF method is more significant near the observation wells. Overall estimate of recharge from both methods are in agreement. The paper discusses the advantage and limitation of both methods and also demonstrate the optimum recharge values from the average of both estimates, may reduce the individual biasness.

Keywords: Recharge, crystalline hard rock aquifer, LCR and WTF.

Ground-Water Elemental fluxes and transport using Mass Balance modeling in Shanmughanadhi a hard rock terrain, South India: evidence from Hydrochemical analysis

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Abstract:

The present study aims to characterise and to quantify the export fluxes of (Major, REEs, and Trace Elements) and controlling factors involved. Shanmuganadhi is marked with superior rainfall, oscillating temperature and runoff with litho units encompassing charnockite (CHK) and hornblende biotite gneiss (HBG). Groundwater samples (n=60) collected from aquifers hosted in weathered and fractured crystalline formations and analysed for major and minor chemical constituents. Relative abundance of ions between upstream and downstream samples of study area shows noticeable differences, which suggest multiple sources/processes controlling hydrochemistry, e.g., atmospheric supply, silicate weathering, dissolution and precipitation of solids as well as anthropogenic inputs (domestic and farm/plantation residues). Based on discharge data, discharge-weighted composition and dissolved elemental flux rates (with respect to Ca, Mg, HCO_3, Si, REEs and Trace elements) of the groundwater were estimated. The estimated total elemental flux rates (EFR) for CHK and HBG using major ions were 5.84736×10^{-4} and 4.337204×10^{-3}tons/Km^2/day. The calculated EFR for CHK and HBG was 2.69×10^{-6} and 2.89×10^{-6}tons/day using trace elements. The total REEs flux estimated for CHK and HBG was 3.93×10^{-6} and 8.79×10^{-6}tons/day. The calculated elemental flux rate using major and minor ions is higher in HBG in comparison with CHK. This study suggests that a rock formation, flushing rate, residence time and climate has a significant role in the variability of flux rates in the drainage basin.
Keywords: Fluxes, Hydrochemistry, Sources, Dissolved, Ions, Mineralogy**,** Rate, Variability, Residence time, Flushing

Relocation of earthquakes in Makran show alignment of intermediate-depth events along NE-SW lineaments

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ABSTRACT:

To resolve better the image of seismicity in Makran subduction zone, we relocated 171 intermediate and large events happened during 1960 to present using a multiple event relocation method. The pattern of the relocated seismicity shows that the number of events at all focal depths are larger in the east Makran. The intermediate-depth earthquakes have focal depths in the range of 45 to 75 km but mostly centered around 60 km depth. The shallow depth of the intermediate-depth events is in full agreement with the small thermal parameter of the old, slow and low angle subducting plate. The intermediate-depth earthquakes in the east Makran align themselves mostly along a NE-SW lineament subparallel to the trend of the volcanic chain whereas in the west Makran they do not show any clear trend. The large intermediate-depth events have normal mechanism with fault planes almost parallel to the NE-SW trend. We attribute the alignment of the intermediate-depth events along the NE-SW lineament to the gradual reduction of the slope of subducting plate and also to the possible pre-existing weakness in the subducting plate allowing for initial hydration of the oceanic plate and later intensification of the dehydration embrittlement of the subducting plate.

Teleseismic P-wave tomography beneath the Malani Igneous Province in Rajasthan, Northwestern India

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The Malani Igneous Province (MIP) is a result of the second largest volcanic episode to affect the Indian Subcontinent and is characterised by acid volcanics. It represents an intraplate anorogenic felsic event covering an area of about 50,000 km^2 in northwestern India. The MIP hosts the Barmer and Sanchor rifts in the west, the 850 Ma Erinpura Granites in the east that adjoin the Aravalli mountain belt, and also alkaline rocks of age 68 Ma which pre-date the Deccan volcanism in the center. The present study attempts to provide constraints on the prevalent hypothesis by mapping the three dimensional P-wave velocity perturbations (%) in the crust and upper mantle

beneath the MIP using teleseismic P-wave tomography. During the period 2012 - 2017, a network of 15 broadband seismographs were deployed in phases at 29 locations, with an average operational period of two years per station. They cover an area of 300 x 300 km^2 encompassing the MIP. The dataset consists of 7954 P-phase arrivals, picked from 933 teleseismic events with magnitudes greater than 5.5 within the epicentral range of 30-90 degree. P-wave residual data is prepared with respect to the ak135 theoretical Earth model and inverted using a weighted damped least square method. A multilayer model is obtained that is completely resolved up to a depth of 200 km. Large crustal velocity perturbations of up to -2% are observed over the Barmer and Sanchore rift zones in the western region. This observed low velocity zone extending down to 200 km may possibly reflect the influence of a thermal anomaly beneath the rift systems of northwestern India. This can be attributed to the reworking of the lithosphere during the Deccan episode or a possible compositional imprint of the Proterozoic Malani volcanism.

Imaging of the main Himalayan thrust (MHT) in the Uttarakhand Himalaya, through teleseismic P- receiver function modelling

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Abstract

We image the lateral variations in the main Himalayan thrust (MHT) and Moho across the Uttarakhand Himalaya, through the Differential Evolution waveform modelling of 1500 PRFs from 52 three-component broadband stations. The shear wave velocity (V_s) profiles reveal a laterally varying mid-crustal low-velocity layer between 12 and 25 km depths, representing the MHT, and a sharp increase in V_s (by ~ 0.3-0.5 km/s) at 33-54 km depths, defining the Moho. Our study also detects a high velocity mafic lower crust (with Vs≥4 km/s) at 22-53 km depths below the study region, which is inferred to be composed of garnet granulites. Small to large size earthquakes are noticed to occur in areas with marked up-warping of the MHT, indicating the bending of the Indian plate. The mapped MHT with modelled low frictional coefficient (~0.01-0.08) and low V_s is interpreted as a highly fractured layer

filled with aqueous/metamorphic fluids, which, in concert with the resulting stress field due to the Indian plate bending and continued convergence between the Indian and Eurasian plates, could provide the possible mechanism for generating Himalayan earthquakes. Based on our modelling results, we predict that the zones with marked MHT and Moho up-warping (bending of the Indian plate) below the region near MCT1 could be representing possible nucleation zones for future moderate to large earthquakes in Uttarakhand Himalaya.

Abyssal peridotites from the Vema and Vityaz fracture zones of Central Indian Ridge: Insights on melt percolation, mantle refertilization, a geodynamic transition

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The geochemical and petrogenetic attributes of abyssal peridotites have yielded conspicuous evidence for compositional diversity of sub-oceanic lithospheric mantle at divergent settings. Reactive percolation of enriched asthenospheric melts and pervasive melt-rock interactions are the principal proponents for this upper mantle heterogeneity. This study presents new petrological, mineralogical and geochemical data for the abyssal peridotites exposed along the Vema and Vityaz Fracture Zones of the northern portion (between 5-10° S) of Central Indian Ridge (CIR) located in the Indian Ocean to address factors contributing to the chemical heterogeneity of CIR mantle. The CIR peridotites are mineralogically composed of olivine, orthopyroxene, serpentine, chromium spinel, magnetite along with primary and secondary opaque, overprinting the pristine mantle-derived mineralogy of the rock. Most of the olivine grains are forsteritic (avg. Fo~90) and the Cr-spinel chemistry reflects the restitic nature of the peridotites. Cr# of the spinels varies from 0.37 to 0.60, suggesting a metasomatic fluid infiltration. Orthopyroxene

chemistry (Wo4.7En86.3Fs9) indicates an equilibration temperature of ~1000-1400°C depicting peritectic reactions of Cr-spinels to form orthopyroxenes started at a high temperature regime, probably at lower crust-upper mantle conditions. Cr-spinel chemistry corroborates a transitional depleted MORB-type to enriched, SSZ-related arc-type magma composition. LILE, HFSE and REE geochemistry reflects a deviation from typical, depleted N-MORB composition to an enriched intraoceanic fore-arc mantle which further substantiates refertilization of the upper mantle peridotite by boninitic melt percolation. Higher values of Zr/Hf (avg: 45.16) and Zr/Sm (avg: 73.78) in addition to lower Nb/Ta (avg: 4.75) with respect to primitive mantle compositions (Zr/Hf: 36.25, Zr/Sm: 25.23, Nb/Ta: 17.39) conform to a metasomatized, enriched mantle signature. Lower Nb/U (avg: 0.19) values with higher Ba/Th (avg: 213.16) and Ba/Nb (avg: 316.27), compared to OIB (Nb/U: 47.06, Ba/Th: 87.5 Ba/Nb: 7.29) and N-MORB (Nb/U: 49.57, Ba/Th: 52.5, Ba/Nb: 2.7) attest to contributions from subduction-derived fluids. The mineral, chemical and trace element signatures of the CIR peridotites envisage i) replenishment of depleted sub-ridge upper mantle by enriched subduction-derived melts and fluids indicates role of a recycled arc mantle component or a tectonic transition from mid-oceanic ridge-rift to an embryonic supra-subduction zone ii) boninitic melt percolation underpins incipient stage of oceanic subduction and iii) network of sub-marine transform faults and fractures zones along slow-spreading CIR owing to their weakness and mechanical instability develop favorable conditions to serve as potential precursors for initiation of spontaneous subduction.

Slab-mantle interaction in active subduction zone magmatism: constraints from geochemistry of submarine felsic volcanics of Andaman arc

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Petrochemical studies on the ocean floor volcanic rocks dredged from the Andaman subduction zone yield insights into the melt generation processes, oceanic crust emplacement and tectonomagmatic evolution of the Andaman arc-back arc system. New petrological and geochemical studies of the ocean floor volcanic rocks dredged from the volcanic arc region reflect wide range of compositions from mafic basalts to felsic rhyolites with presence of intermediate andesite and dacite varieties depicting BADR trend of magmatic differentiation. Dacites are most dominant lithologies recovered from the Andaman arc volcanoes. Petrographic studies of the dacites shows that these rocks are porphyritic in nature and composed of intermediate to low Ca-plagioclase, K-feldspar and quartz phenocrysts with subordinate biotite and chloritized amphibole embedded in a siliceous, microcrystalline, felsic groundmass of quartz, K-feldspar, volcanic glasses. Rhyolites from Andaman arc are also porphyritic in nature predominantly composed of K-feldspar, quartz and albite phenocrysts embedded in a silica rich microcrystalline groundmass of quartz, K-feldspar, biotite, opaque and acidic glass. The studied differentiated felsic rocks are mostly medium-K calc-alkaline in composition with higher SiO_2 (63.25-72.77%) and total alkali (3.68-10.02 %). The studied felsic rocks exhibit depleted HFSE (Nb–Ta, Zr–Hf), pronounced LREE and LILE enrichments suggesting contribution from subduction-related components during their genesis. Th and U enrichment over Nb–Ta indicates influx of fluids dehydrated from subducted oceanic lithosphere. Lower Dy/Yb and variable La/Yb ratios suggest their generation at shallower depth within spinel peridotite stability field. The Zr/Hf (27–60), Zr/Sm (16-50), Ba/Nb (71-605) and Ba /Th (34-104) ratios suggest a depleted to enriched mantle source with variable influx of subduction- derived fluids and sediments. Elevated abundances of Ba, Nd, Sr, La with high Ba/La (14-80), and Ba/Nb (71-605) ratios for the dacites-rhyolites from Andaman arc suggest variable contributions from both subducted slab sediments and aqueous fluids released by slab dehydration. Further, Ba/Nb in the studied

rocks substantiate variable magnitudes of shallow subduction input and presence of hydrous minerals in the source region. The significant control of residual amphibole in the source possibly from the down going slab is supported decreasing Dy/Dy* against Dy/Yb.

Key words: volcanic arc region; enriched mantle source; subduction derived fluids; slab dehydration; residual amphibole

Preliminary analysis of Probabilistic Seismic Hazard Assessment for Nuclear Power Plant Site in Nigeria.

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ABSTRACT

Preliminary assessments of a suitable site for nuclear power plants and industrial constructions devoid of seismic shock and earthquake disaster in Nigeria have been carried out. We emphasized that the current tremor experienced across Nigeria is an indicator to an occurrence of large magnitude earthquake with possibilities of casualties and destructions of properties. This is in tandem with the seismicity of the west African region as experienced by some of the neighboring countries: Ghana, (18th December, 1636 M_s = 5.7; 1862 M_L ~ 6.5 and $M_s \geq 6.5$; 11th February, 1907 and 22nd of June, 1939 M_s ~ 6.5 and m_b ~ 6.4) and 22nd December, 1983 (M_w ~ 6.3) in Guinea and volcanic eruption of mount Cameroun on August 21st, 1986 Fomine (2011) led to the death of 1,700 people. However, Ghana, Guinea, Cameroun and Nigeria are located in seismotectonic zone 1 of the African zonation map (IGCP, 2015). Nigeria is considered as one of the gap areas where possible large magnitude earthquake is next to occurring. The study entails the use of Geographic Information System (GIS) and Probabilistic Seismic Hazard Analysis (PSHA). Peak ground acceleration (PGA) values were exclusively

determined for two suitable zones of the GIS based site suitability studies, which were found to be useful for construction of nuclear power plants, where seismic and other related hazard are considered to the bearest minimum. Pertaining to site of study, during a large magnitude earthquake occurrence, the hazard is found to occur between the structural periods of 0.00 sec and 0.5 sec, therefore the engineering design of structure (building) must put in place a measure of resistance parameters to withstand the intensity of ground vibration up to 4 sec. This will ensure the safety of structure or structures in case of large magnitude earthquake occurrence.

Seismic Coda Attenuation Analysis in the Gauribidanur Seismic Array (GBA) Region, Southern India

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Abstract

Seismic coda wave attenuation (Q_c^{-1}) characteristics in Gauribidanur seismic array region of southern India is studied using vertical component seismic observations from local events of hypocentral distance less than 250 km and magnitude range 0.3 to 3.7. Coda-wave attenuation is estimated using single isotropic scattering method at central frequencies 1.5, 3, 5, and 8 Hz at different lapse times (*LT*) (from S-wave on set) and coda window lengths (*WL*), from 10 to 60 seconds at an interval of 10 seconds. The results show that the Q_c^{-1} values are frequency dependent in the considered frequency range, and fit the power law $Q_c^{-1}(f)=Q_0^{-1}f^{-n}$ using least square. The Q_0 (Q_c at 1 Hz) value ranges from about 50 (Q_0^{-1} =20.143x10^{-3}) for lapse time of 10 sec and window length 20 sec combination to about 361 (Q_0^{-1} =2.769x10^{-3}) for *LT* of 60 sec and *WL* 60 sec combination. The exponent of the frequency dependence law, *n* ranges from 1.45 to 0.92; however, it is greater than 1.0 in general, indicating that the region is seismically and tectonically active with high heterogeneities. The attenuation in this region is less as compared to other tectonic and seismic active regions of the world, however, comparable to other

regions of India. The variation of coda attenuation has been estimated for different lapse time and window length combinations to observe the effect with depth and it indicates that the upper lithosphere is more active seismically as compared to the lower lithosphere and the heterogeneity decreases with increasing depth.

Crustal structure of Aravalli-Delhi Fold Belt: Precambrian accretion of Bundelkhand-Marwar cratons and uplift in north-western India

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Abstract

The region encompassing the Aravalli-Delhi Fold Belt (ADFB), sandwiched between the Marwar-Bundelkhand cratons, preserves the multiple Precambrian tectono-magmatic records of north-western India. Imaging in-depth crustal signatures as an imprint of tectono-magmatic events taken under distinct tectonic settings have been challenging. This study modelled the 2D crustal density structure along two W-E profiles using gravity data extracted at an average interval of 2 km and geological and geophysical constraints available from previous studies. We found the maximum lithological variation in the upper crust of thickness 8-10 km along both the profiles. The crust is found to be normal beneath the Marwar craton, varying from 33 to 40 km. About 6-8 km thick high-density (2.78 g/cm^3) sills emplaced in upper crust down to ~9 km depth and 10-15 km thick high-density (3.05 g/cm^3) body at the Moho indicates the possible presence of mafic mantle material beneath the Malani Igneous Suite (MIS). In contrast, the high relief ADFB is characterized by an anomalous crust of thickness ~45 km, having a 12-13 km thick high-density (3.05 g/cm^3) body at its base. The trap covered ~9 km thick upper crust characterizes the Vindhyan basin with normal Moho laying at a depth of 40-42 km. With available signatures of the Proterozoic subduction and collision processes, we believe that the orogenic reworking may be the reason for the 'modification' of the ADFB crust. Whereas

the post-tectonic mantle plume responsible for the MIS propelled crustal modification in the Marwar Craton.

Evidential layers derivation using aster vnir-swir data for gold-sulphide mineralization in parts of gadag schist belt, Karnataka,India

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Abstract

Gadag schist beltisknown for sulphide-gold mineralization. The sulphide-gold mineralization is controlled structurally and lithologically. In this context, Advanced Space Borne Thermal Emission and Reflection Radiometer (ASTER) Visible Near InfraRed (VNIR) - Shortwave Infrared (SWIR) bands were utilized to derive alteration zones and structures present in the study area. Lithology also have been updated using ASTER VNIR-SWIR bands derived image enhancement products i.e. principal component analysis (PCI) and False Colour Composite (FCC). Further, image spectra of alteration zones (Hydrous mineral etc.) derived from ASTER calibrated VNIR-SWIR bands were compared with the standard corresponding reference library spectra. Structures were demarcated using high pass (HP) filtered image and FCC. Low pass (LP) filter image and PCA image composite were utilized to update the lithological boundaries in the study area. These are very important evidential layers which can be further integrated using different integration techniques (fuzzy logic, weight of evidence etc.) to identify potential zones of gold-sulphide mineralization in the present study area. For similar kind of gold-sulphide mineralization, ASTER data can to utilized to derive the important evidential layers in any part of the world which is very important to find the potential zones of gold sulphide mineralization.

Keywords: ASTER, VNIR-SWIR, alteration, PCA, FCC.

Delayed Aftershocks in Koyna and Bhuj

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Upper crustal earthquakes in Peninsular India in general and some lower crustal earthquakes have long aftershock sequences due to presence of network of faults and fluids in stressed zones. Presence of fluids is inferred from the detection of low velocity layers/pockets. The earthquake sequences in Himalaya (though mostly occurring at 10-20 km depth along the ramp) and Narmada-Son rift zone (NSZ) are short-lived. One of the reason for it may be absence of network of small faults. Examples of such NSZ earthquakes are the 1997 M_w 5.8 Jabalpur earthquake at Moho depth and 1970 Mw 5.4 Broach earthquake at 10-15 km focal depth. Many regions in peninsular India of ancient rocks are heterogeneous with network of faults around major faults resulting into long aftershock sequences. In such scenarios the aftershock zones have wide areas. The Koyna and Bhuj earthquakes are prime examples where up to M4 seismicity is still continuing. Even some small earthquakes have also had many aftershocks in wide areas. Around an old reservoir named Osmansagar near Hyderabad an M 3.5 January 14, 1982 shock had 200 microearthquakes for 5 weeks. Near a new Sriramsagar reservoir, some 200 km north of Hyderabad on Godavari river, 570 miicroearthquakes followed M 3.2 shock for 3 months in 1984.

The sequence of Koyna 1967 Mw 6.3 earthquake includes 17 earthquakes of $M \geq 5$, over 150 earthquakes of $M \geq 4$ and hundred thousand smaller events. The seismicity had shown a southward migration during 1967-2001. Until 1980, seismicity was mainly confined to about 20 km long zone south of Koyna reservoir. During 1982-87, seismicity showed a subdued behaviour. With the impoundment of another reservoir, Warna, about 30 km south of Koyna, which was filled to a height of 60 m in 1993, seismicity began to migrate further south as anticipated by Rastogi et al. The burst of seismicity during March-September 2000 had occurred in a region southwest of Warna reservoir. Earthquakes of $M \geq 5$ have mostly occurred until 2000AD.

Detailed field observations and interpretation of detailed aeromagnetic, geophysical and geological mapping of the area revealed that three fault systems mainly characterize the seismic zone namely the steeply west dipping Koyna River Fault Zone (KRFZ) in the west comprising of North Koyna fault (NKF) and south Koyna fault (SKF), NE-SW trending Patan Fault and another parallel fault (P1) in the east and a number of NW-SE trending fractures (i.e. L1, L2, L3 and L4) extending to hypocentral depths in the area between KRFZ and Patan Fault. In addition to above-mentioned faults, the NNE-SSW trending Donichiwada Fault (D) is found slightly east of KRFZ, which is NNE striking and dipping 60^{o} towards WNW. KRFZ, Patan Fault, P1, L1, L2, L3 and L4 form steep boundaries of crustal blocks and provide access for fluids to flow to hypocentral depths.

In Maharashtra close to west coast and in the Deccan Basalt region, several other reservoir triggered earthquakes had long sequences. Bhatsa reservoir at 90 km NE of Mumbai or 200 km north of Koyna had Mw 4.9 earthquake on 15 September 1983 followed by thousands of shocks for a decade. Dhamni reservoir 100 km north of Mumbai had M3.5 tremor followed by about 2000 shocks for 6 months. However, the 1993 M_w 6.2 Latur earthquake along a NW-SE trending south-dipping reverse fault at 7 km depth had only about a year-long sequence. The site, though in Deccan basalts is a few hundred km inland and only one fault could be inferred in the area.

The 2001 MW 7.7 Bhuj earthquake, having focal depth 22 km, in the Kachchh rift zone had two-decades long sequence that includes over 18,000 shocks of M1-2.9, 2,891 shocks of Mw 3-3.9, 382 shocks of Mw 4-4.9, 20 shocks of Mw ≥5.0 and 7 of M≥6 during 2001-2019. Mw ≥5 shocks have continued until 2006. Some 2 to 4 shocks of Mw 4-4.9 and 40 to70 shocks of Mw 3-3.9 are annually occurring since 2009. The Kachchh region has several major E-W trending listric or step faults going to Moho depth. These faults have formed half grabens. The major faults have some subsidiary faults too. Presence of fluids is inferred from the presence of low velocity layers/pockets. In this scenario the aftershock sequence has continued for two decades. Most of the earthquakes indicate reverse faulting along south dipping faults. Some earthquakes were associated with strike-slip faulting, for example the 7 March 2006 Gedi earthquake of Mw 5.5. Geological formations include

mostly hard Mesozoic/Jurassic sediments, partly covered by 1-2 km of Tertiary sediments. Deccan basalts lie in the southern part.

Rock magnetism and Anisotropy of magnetic susceptibility studies on Nagercoil charnockites from Southern Granulite Terrain, India: Implications to the magma flow direction

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Abstract

New rock magnetism, and anisotropy of magnetic susceptibility (AMS) results are presented on Nagercoil block (~2.0 Ga), Madurai block (~1.75) and Achankovil shear zone (~0.9 Ga) charnockites in the Southern Granulite Terrane (SGT), south India. 70 oriented block samples from 14 sites have been studied. The rock magnetic properties indicate ratio of remanence (Mrs/Ms) ranging from 0.04 to 0.53 and the Coercivity ratio (Bcr/Bc) between 1.18 to 5.19, with respect to charnockite blocks. The saturation of magnetization is at 250-300 mT, and the coercive force range from 24 to 41mT for all the samples. Thermoremanent analysis indicate that the Curie Temperatures vary between 570-590°C. Overall rock magnetic results indicate that magnetite (Fe_3O_4) is the dominant magnetic carrier and predominantly show multi-domain (MD) nature.

The observed principal AMS axes show mainly two types of magnetic fabrics. First one is the minimum susceptibility axes, horizontal to sub-horizontal and maximum susceptibility axes plot near the horizontal. The second fabric shows the minimum susceptibility axes is intermediate to vertical and maximum susceptibility axes plot near the horizontal to sub-horizontal. The AMS results reveal that magma flow was sub-horizontal to horizontal upward and magnetic fabrics of Nagercoil block and Madurai block grains are triaxial to prolate shape whereas Achankovil shear zone show oblate to prolate. The present study suggests that charnockite propagation in

the southern granulite terrane is a multiple magma flow-induced fabric during the Proterozoic period.

Key words: Rock magnetism, AMS, Charnockites, Proterozoic, and southern India.

Contrasting lower crust of Kohistan and Ladakh arcs inferred from surface wave analysis

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Kohistan-Ladakh Terrane (KLT) sandwiched between the Karakoram and the Indus suture is part of a chain of island arcs that were obducted onto the Indian plate during the India-Asia collision. The Kohistan block, an intra-oceanic arc, preserves the exposure of a complete arc crust with mafic to ultramafic lower crust signature in the south to volcanic upper and middle crust in the north and is an ideal laboratory to study how a young island arc is transformed into a juvenile continental crust. The Ladakh batholith holds key to a linkage between the Kohistan and the Gangdese batholith and contains components of both an island arc (like Kohistan) and an Andean-type arc (like southern Tibet). The current understanding of the crustal structure of the KLT is largely based on geological/petrological studies along with limited geophysical studies from eastern Ladakh. We present a crustal shear wave velocity (Vs) model obtained from inverting fundamental mode Rayleigh wave dispersion (from 5-60 s) computed from ambient noise and earthquake data recorded over seismological stations from the western Tibet-Himalaya, Ladakh, Pamir and the surrounding area. In Kohistan block our results show a uniform upper and middle crustal structure with average Vs ~ 3.5 km/s up to 30 km depth, sharply increasing to 4 km/s at 40 km and gradually increasing to 4.3 km/s at a depth of 65 km representing Moho. The lowermost 25 km of the Kohistan crust is a high velocity layer (Vs > 4.0 km/s, Vp > 7.0 km/s) commonly known as an underplated layer representing ultramafic rocks. In contrast, Ladakh and Nanga Parbat crust with Moho depth of 65-70 km, is characterized by a mid-crustal low velocity zone (Vs <

3.4 km/s) between the depth of 15 to 40 km and absence of a ~25 km thick high velocity lower crust. Our observation of dense lower crust under Kohistan is consistent with the previous geological studies showing the presence of high density lower crust representing mafic garnet granulite lithology which undergoes density sorting and episodic delamination resulting in a continental crust of intermediate composition and ~ 40 km thickness. The study also shows a gradational change in input from the lowermost continental crust as we move from an island-arc environment in the west to an Andean-type margin in the east.

Geo-electrical imaging of over-exploited fractured aquifer system in Tumkur district, Karnataka

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ABSTRACT

Systematic characterization of water saturated fractured zone is a vital input for aquifer delineation and management. The excessive groundwater exploitation towards growing demand has led continued depletion of aquifer. As a result, the principal aquifer which is mainly controlled by weathered layer is mostly dry and groundwater is confined to the underlying fissured hard rock, controlled by fractures. The sporadic distribution of fractures increases the hydrogeological complexity by many folds.

A continuous depth wise measurement of the resistivity distributions through multiple electrode arrangement has been carried out in Tumkur district, Karnataka to delineate the saturated fracture zones for groundwater prospecting. Seven 2D Electrical resistivity tomography (ERT) surveys using the Schlumberger array with 10 m electrode spacing have been carried out. Observed resistivity revealed moderate resistivity contrast between the weathered and fissured layers and significant contrast between weathered

layer and compact basement. Paper presents a demonstrative exercise to identify the fissured aquifer supported and validated by borehole litholog and video camera logging. The water oozing from the fractures specially at interface of weathered and fissured layer validates the finding.

Keywords: Electrical resistivity tomography, weathered, fissured, groundwater, hard rock.

Earthquake Swarms in the Off Nicobar Region of Andaman Sea: Volcano - Tectonic Implications.

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Off Nicobar region in the Andaman Sea has experienced number of significant earthquake swarms particularly after the 26 December 2004 megathrust event, as a result of complex tectonics arising from oblique subduction, active volcanic arc and sliver fault systems. One of the most energetic offshore earthquake swarms occurred in this region in January 2005, following the 26th December 2004 (9.1 M_w) Sumatra megathrust event. After a brief quiescence this region experienced series of earthquake swarms in March 2014, October 2014, November 2015, and in April 2019. We observed for the first time hybrid very long-period earthquakes with prominent hydro-acoustic phase during the March 2014 earthquake swarm; these were documented by passive Ocean Bottom Seismometer experiment. The observed swarm roughly aligns in the northwest–southeast direction along the trends of submarine volcanic arc and Seulimeum strand of the Great Sumatra fault. The occurrence of low-frequency earthquakes and prominent hydro-acoustic phase are suggestive of sub-surface tectonic and magmatic influence. We also analysed the temporal and spatial variation of b-value of these swarms using the global network data and the Ocean Bottom Seismometer data to

understand their genesis. Temporal variation of b-value suggests that b-values are larger than unity for earthquake swarms, indicating volcanic origin. Bimodal distribution of frequency-magnitude relation suggests that the earthquake swarms have occurred due to complex seismic process controlled by both tectonic and volcanic activities. We propose that a combination of magmatic pulsation in the arc volcanism in response to 2004 and 2005 megathrust events and the 6.5 M_w magnitude 21st March 2014 event, and the reactivation of sliver fault systems, are the dominant mechanisms for the observed frequent earthquake swarms in the off Nicobar region.

Investigation of site characteristic for seismic hazard analysis in Gorakhpur city, Uttar Pradesh using Microtremor measurements

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Abstract:

Gorakhpur city is situated on river fluvial system in the vast Indo-Gangetic plain. The city is more vulnerable experiences high intensity of tremor because of seismic activity in the Himalayan region. The younger sediment easily traps seismic energy which can create disaster for manmade structures. It is primarily analyse the dynamic property of soil of urban areas to prevent loss of life and property damage.The ambient noise is an efficient and cost effective method for seismic hazard analysis of virgin area without knowledge of subsurface geology. Microtremor measurement of ground shaking sites effect conducted at 150 sites around Gorakhpur city. The analysis of data were estimate resonance frequency and peak amplitude at each site using horizontal to vertical spectral ratio (HVSR) method or Nakamura technique.The most of site response have predominant frequency range 0.45 to 0.47Hz with mean of 0.46±0.01Hz. High predominant frequencies in the range of 1.4 to 1.45Hz were observed in the west part of

Ramgarhtaal in Taramandal area. The resonance frequency in north part toward the Himalayan region shows low frequency, indicate thick sediment deposits while as move south goes higher. It shows the frequency varies inversely with depth and vice versa. 1D shear wave profile estimated using Microtremor array measurement and evaluated phase velocities of microtremors in the frequency range from about 0.5 to 3.0 Hz using the high resolution f-k spectrum and special autocorrelation (SPAC) methods to obtain the S-wave velocity structures. From an array measurement, at depth of 35 to 40m the shear velocities range 280 to 320m/s with mean of 300±20m/s. From phase velocity structure the study area is associated with class D as per National Earthquake Hazards Reduction Program (NEHRP) site classification.

Keywords: Seismic Hazard analysis, H/V spectral ratio, resonance frequency, amplification, phase velocity

Study of site characteristics for seismic hazard analysis in BHU region using Microtremor measurements

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Abstract:

In this study Microtremor measurements is applied for detailed seismic hazard mapping of the BHU in the vicinity of Varanasi city. In addition, borehole data is used to calibrate our results of the shallow subsurface structure. This was done by carrying out 31 single station and 2 array seismic surface wave tests using Microtremor measurements. Microtremor data (ambient vibration), have been analysed to determine the site amplification parameters. The geological time period has a significant effect on the resonant frequencies of sites associated with different layer of depositions. In this study H/V spectral ratio confirms that the sites have an average predominant frequency around 0.532Hz and average amplitude 7.94, which refers that the

average thickness of sediments in BHU region is around 30-40 meters. These resonant frequencies are related to the thickness of the sediments, which conforms to other geological interpretations in this region. Based on the available details, shallow and deeper cross-sections through BHU are presented. Results are correlated with deeper boreholes depth (150 m) for better understanding of deeper subsoil stratification. These reports show the presence of clay up to a depth of 40 meter mix with sand and kankar at some locations, followed by layers of sand, and clay with kankar upto 200 m. Our findings are also well collaborated with inverted shear wave velocity profiles. Thus, the inverted 1-D velocity models clearly show low shear wave velocity having sediment thickness about 30 to 40 meters. Fundamental frequency and amplitude maps also are prepared of the study area. Subsequently, computed response spectra are very useful tool for engineers to quantify the intensity of earthquake ground motion which can provide great help to determine the capacity of buildings to resist earthquakes.
Keywords: Site characteristics, Microtremor, resonant frequency, shear wave velocity.

MARINE GEOSCIENCES

Evidence of climatic and tectonic control on the Bengal fan sedimentation: A 6 Ma record

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Abstract

Strontium and Nd isotope ratios of the lithogenic fractions of the sediment core IODP-353-U1445A collected from the deep-water end of the Mahanadi basin (western Bay of Bengal) was carried out to evaluate the sediment sources as well as to understand the link between the temporal variations in the Sr-Nd isotope ratios and climatic and tectonic forcings during the last 6 Ma. The Sr-Nd isotopic compositions along with Fe/Al ratios and clay mineralogy show tell-tale signature of Ganga-Brahmaputra sedimentation (Bengal fan) in the deep water end of the Mahanadi basin. The significant temporal fluctuations observed in the Sr-Nd isotopic compositions suggest variation in the relative sediment contribution by the Ganga and Brahmaputra river systems, which in turn are controlled by climatic factors such as monsoon intensity variations coupled with orographic effect, glaciation, and multiple tectonic activities. The results show the marked influence of glacial-interglacials on the relative sediment contribution by Ganga and Brahmaputra rivers during 0-1.8 Ma, while the sedimentation during the 1.8-6 Ma time window was likely influenced by both climatic and tectonic forcings such as uplift of the Shillong plateau, eastern syntaxis development of Indo-Burma wedge, reorganization of Brahmaputra river system. The work establishes the dominant control of Ganga-Brahmaputra sedimentation along the deep waters of the Indian east coast. The study has also brought to light multiple isotope fluctuations linked to climatic and tectonic forcings for the last 6 Ma from the Bengal fan.

Keywords: Bengal fan, Himalayas, provenance, monsoon intensity, glacial-interglacial time periods.

Principal Component Analysis for Seismic Image Enhancement

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ABSTRACT

In exploration seismology, the main aim is to enhance the image of the subsurface in terms of geological features by suppressing the noise. Seismic images are obtained after careful and systematic processing of the acquired seismic data and common midpoint (CMP) stacking results in generating the subsurface image. Stacking is considered as the simplest way of improving the signal-to-noise ratio (SNR) and is accomplished by summing the seismic traces from different shot records that have a common reflection point form a single trace. Weighted stacking gives the prominent result in stacking approach. We have several methods to calculate weights for weighted stack and weights calculated based on similarities is found to be superior among all. The weights of each trace are obtained by calculating the local similarity between each trace and the reference trace and soft thresholding of these similarities. However, in complicated situations like misaligned traces, erratic and non- gaussian random noise, the reference trace too gets affected and, in such circumstances, the Principal Component Analysis (PCA) based weighted stack produces reasonably good images. PCA is a statistical procedure that uses an orthogonal transformation in such a way that the first PC has the largest possible variance, and each succeeding component has the highest variance possible and is orthogonal to the preceding components. In the PCA based weighted stack, the Principal Components (PCs) of seismic data are extracted to approximate a highly accurate zero-offset trace and then a reference trace calculated. This reference trace was used to calculate similarity based weighted stack. The resulting seismic image shows improved seismic reflectors, migration pathways and enhanced reflections compare to traditional seismic stacking methods.

Keywords: Seismic, Signal Processing, Principal Component Analysis, Weighted stacking.

Relict Fe-rich olivine grains in cosmic spherules and their links to carbonaceous and ordinary chondrites

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Abstract
Extraterrestrial dust entering the Earth's atmosphere has shown to represent diverse type of samples produced from asteroid complexes and cometary bodies from the solar system. A substantial amount of this dust the Earth receives is believed to have been lost due to frictional heating with air molecules. Cosmic spherules that are melted extraterrestrial particles have survived this catastrophic entry process and are some of the widely recognized micrometeorites; however their primordial characteristics are altered by atmospheric heating from their precursors making it difficult to identify the precursors. Relict grains are some of the preserved and least altered grains found within cosmic spherules are common as refractory forsteritic olivine in chemical composition. Here we report uncommon relict olivine grains with Fa >10 mol% within cosmic spherules. The cosmic spherules under investigation were recovered from the deep-sea sediments of the Central Indian Ocean and the Antarctica blue ice that has been segregated using magnetic separation method, mounted in epoxy and examined in SEM and analysed under electron microprobe for their chemical composition. Survival of relict olivine grains with Fa >10 mol% in cosmic spherule with chemical composition that is Fe rich is complicated as they are more susceptible to be altered by the heat and can readily equilibrate with the surrounding melt during atmospheric heating. Olivine with Fa >10 mol% are

common in ordinary chondrites which forms a main component in Type IIA chondrules, however they are insignificant in carbonaceous chondrites. Relict olivine grains with Fa >10 mol% from cosmic spherules are compared with olivine from carbonaceous and ordinary chondrites for their major and minor elemental distribution to assert the nature of parent bodies that contribute to relict grains in micrometeorites.

In-situ horizontal stress mapping using neural network for gas hydrate bearing sediment in offshore Mahanadi basin, India

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Abstract

The estimation of in-situ stresses are important parameters for stress distribution analysis around vertical and horizontal borehole. We have estimated the magnitude of minimum (S_h) and maximum (S_H) horizontal stresses for understanding the geomechanical behaviour of gas hydrate bearing sediments in offshore Mahanadi basin. The basin is located in the Eastern Passive Continental Margin (EPCM) of Indian sub-continent. Gas hydrate mainly occur in clay/silt fracture filling sediments of Pleistocene age below the seafloor. Firstly, the in-situ stresses (S_h and S_H) estimated from well site at NGHP-01-19 are considered as target log for multi-layer feed forward neural network (MLFN). 2D multi-channel seismic line MH-10A trending SW-NE direction is used to estimate inverted P- impedance (Zp), P-wave velocity (Vp) and density (Dn) using post-stack seismic inversion. The seismic inverted sections are used as input parameters to create two separate training networks for prediction of S_h and S_H. The training and validation error are kept minimized as possibly less such as 9%. The trained networks are applied on the seismic data to obtain mapping of magnitude of S_h and S_H respectively. The values of S_h and S_H are ranging from 15.07 to 18.07MPa having average value of 16.55 MPa and 15.20 to 18.47 having an average

value of 16.65 in the depth interval of 1493 to 1690 respectively for NGHP-01-19. This analysis will further guide to make a geomechnical simulation for understanding the behavior of sediments deformation with the changes from solid gas hydrate into free methane gas during the production of the gas hydrate and hence to understand well bore stability in the study area.

Simulation of seismic wave propagation in porous media: Application to monitoring of CO_2 storage in reservoir

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Abstract

The theory of wave propagation in porous media that describes the attenuation of wave due to the present of fluid was given by Biot (1956, 1962). We have developed a MATLAB algorithm to generate synthetic data using the Biot's equations. The staggered grid finite difference method, which presents greater stability and avoids the differentiation of material parameters, was used in solving the Biot's equations. Fourth order finite difference method was applied to discretize the spatial derivative and second order was applied to discretize the temporal derivative of the poroelastic equations. Our developed algorithm was tested on a 2-layer cake model in which CO_2 replaced brine in the formation. The top layer consists of CO_2 and bottom layer consist of brine. We observed that the amplitudes of the events increases with the increase in CO2 saturation in the top layer and it is in accordance with the Biot's theory.

Permeability simulation using well log data: Gas hydrate reserve in the Krishna- Godavari basin of India

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Abstract

Permeability study is an important aspect to be considered before applying the field exploration method so that the production-related risks in a gas hydrate reservoir can be avoided. Currently, researchers are looking for feasible and cost-effective methods to exploit the gas hydrates from the reserves with less or without any impairment, and permeability measurement from well log data is one of them. The present study focuses on the computation of the permeability in the Krishna-Godavari (KG) basin using sonic log data from the drill site, NGHP-02-16B by numerical simulation. The reservoir properties such as the hydrate saturation, absolute permeability, and effective permeability were determined from log data and the obtained results are corroborating with the results obtained using the pressure-cores. The permeability of the hydrate-bearing sediments as a function of hydrate saturation is obtained using various theoretical models. Among the different models, the obtained permeability results show that the Masuda model with exponent N=4 agrees well with the core-derived permeability. Also, the hydrate saturations calculated from P-wave velocities of well log data with the estimations from the resistivity log, and the results of both are in good agreement. The absolute permeability and effective water permeability of the hydrate reservoir in the depth interval of 273-288 mbsf for the study site were estimated in the range 0.1-100 and 0.01-10 mD respectively. The hydrate morphology is also a critical aspect, and results suggest hydrates are forming in the pore centers of sediment grains as pore filling, but also as a sediment load bearing. The average gas hydrate saturation obtained in the present study is 68% for the combined morphology of pore filling and loadbearing using the effective medium model. From the obtained results, we infer that the Masuda model is the most accurate and can be used for the permeability computation in gas hydrate-bearing sediments of the KG basin in the absence of core data.

Keywords: Effective permeability, Hydrate Morphology, Hydrate saturation, Masuda model, NGHP-02-16, K-G basin

Diagenesis of magnetic minerals at newly discovered active methane seep in Bay of Bengal.

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Abstract

We conducted rockmagnetic measurements combined with SEM-EDS and mineralogical analysis on the six sediment spade cores retrieved from a newly discovered active methane seep site in Krishna-Godavari basin (Dewangan et al., 2020; Mazumdar et al., 2019). The aim of this study was to establish a magnetic mineral inventory for the methanic sediments and understand the methane related diagenetic processes. Presence of abundant living chemosynthetic communities including Bathymodiolus sp, Acharax sp. and Decapod crustaceans (squat lobsters) provided evidences on the active methane seepage at this site. Multi-proxy data revealed that sediment magnetism mainly comprised of detrital titanomagnetite, authigenic pyrite and greigite, in various proportions. Down-core changes in the rockmagnetic parameters of all the studied spade cores helped to demarcate two sediment magnetic property zones (Z-I, Z-II). A distinct minima in magnetic susceptibility (x_{lf}) is observed at the end of Z-I of all the studies spade cores, probably formed as a result of methane-induced diagenetic reactions and indicate the possible depth of present-day sulfate methane transition zone (SMTZ) in the studied cores. The depth of x_{lf} minima varies between 5 cmbsf and 13 cmbsf indicative of variability in SMTZ fronts which can be reconciled to the differential rate of diagenesis constrained by fluctuations in intensities of vertical methane fluxes at each sediment spade core.

ATMOSPHERIC, OCEAN AND SPACE SCIENCES

Remote Sensing of Drought: An analysis based on Satellite Earth Observations and Ground observations

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Abstract

Drought is a complex and recurring extreme climatic event that directly impact the agriculture sector and bring water shortages, economic losses, and adverse social reverberations. Spatial-temporal variation and severity of drought can be assessed using the satellite and ground-based observations. Traditionally, drought monitoring has assessed through climatic indices such as Standard Precipitation Index (SPI) and Palmer Drought Severity Index (PDSI) which derived from the rainfall data and not able to represent the ground level actual agricultural drought conditions. In this study, the spatial-temporal pattern of drought and its response to vegetation were analyzed from 2002 to 2020. Based on the long-term daily meteorological data set, the SPI was computed to identify the meteorological drought while time series Normalized Difference Vegetation Index (NDVI) and its derivative indices (Vegetation Condition Index (VCI), Temperature Condition Index (TCI), Vegetation Health Index (VHI)) have been analyzed to identify the agricultural drought. The result and findings of the study shows that the frequency and spatial extent of droughts over India has increased significantly during 2002 to 2020. The increase in drought frequency and its severity is observed mainly over the central parts of India, including Indo-Gangetic plains. Drought frequency trend is prominent over central part of India during South-West (SW) monsoon and southern peninsula part of India during North-East (NE) monsoon. Each remote sensing index has its own benefits and limitations

where TCI is more sensitive in dry regions or in summer months while VCI is more sensitive in wet seasons than TCI and VHI. Comparatively VHI gives better drought assessment and occurrence as it is combination of TCI and VCI.

Keywords: Drought, Satellite, Remote Sensing, South-West Monsoon, North-East Monsoon, Vegetation Indices

Neutral Induced Low Frequency Electrostatic Waves in Magnetized Dusty Plasma

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ABSTRACT :

The role of neutral in a partially ionized collisional dusty plasma for the ionosphere has been analyzed. The dispersion relation for the electrostatic wave using electron, ions, dust particles, and neutrals has been derived, in the presence of strong collision among these constituents. The continuity and momentum equation has been solved by assuming that the perturbed electron and ion density varies almost similar to the perturbed plasma potential. The dust perturbation has been obtained by considering the charge neutrality of first order. These perturb quantities are the input for the dispersion relation. The instability condition is found to be depending upon the neutral scale length. The Electrostatic wave propagates almost perpendicular to the neutral wind direction. The simulated frequency is depend upon the thermal velocity of the neutrals, gyrofrequency of ions, collision frequency between dust and ions, and collision frequency between dust and neutrals. The real as well as imaginary part of the wave frequency is depending upon the neutral scale length which also set the condition for the instability to occur at ionospheric altitude.

POSTERS

Predominant periods corresponding to response spectra for the various site conditions of NE, India

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North East India region (NER) is situated in seismic prone zone V according to BIS(2002). The predominant period indicates the period of vibration corresponding to the maximum value of the amplitude of the spectrum. Average predominant periods are estimated for sites situated on three kinds of geology; Quaternary, Tertiary, and Precambrian for NER, India. For estimation of predominant periods, accelerograms of 26 numbers of earthquake events originated in the NE region and its vicinity during the period 2009 to 2016 are collected. These earthquake events used for this study are recorded by 30 numbers stations situated on different kinds of geology in NE, India. Most of the sites are present on Quaternary formations. First of all, Normalised Response spectra are calculated for horizontal components of all accelerograms. The Periods corresponding to the peak value of response spectra is determined. The estimated average predominant period for quaternary, Tertiary, and Precambrian sites is found to be equal to 0.25 s, 0.22 s, and 0.17 s for horizontal components respectively. This study depicts that local site conditions play a significant role in the modification of the response spectrum as well as the predominant period. It is observed that the predominant period increases as site composition changes from older to younger rocks. It can be also conferred that Precambrian rocks have peaks at lower periods or higher frequencies. Quaternary and tertiary formations have peaks at higher periods or lower frequencies as compared to Precambrian rocks. Comparing the present analysis with the spectrum provided in the Indian code(BIS 2002) shows that the average predominant period of the acceleration response spectrum follows the Indian code(BIS 2002) considered for the whole country. While the predominant period provides some

information regarding the frequency content, it is easy to see that motions with radically different frequency contents can have the same predominant period. During the construction of the structures at a particular site, the predominant period should be considered with great importance to avoid the resonance effect. These estimates of the predominant period will be prime input to the seismic hazard assessment of the aforementioned region in NER, India.

Earthquake precursory research with Overhauser Magnetometer at Multiparametric Geophysical Observatory, Tezpur, Assam.

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Abstract:
The Magnetic field intensity change is an important parameter for correlating a seismic event. The Magnetic field changes at Multiparametric Geophysical Observatory (MPGO), Ouguri hills, Tezpur is continuously monitored and Overhauser data is studied to find the relationship of magnetic anomalies with the earthquakes in and around Kopili fault. The time series plot of magnetic changes is co-related with the earthquake events recorded with Broadband Seismometer and Strong Motion Accelerograph at the MPGO occurring within the distance of 150 km from MPGO. The study has been carried by the magnetic instrument Overhauser manufactured by GEM Systems and data is collected using GEM LINK software. The changes due to solar flux are correlated by the Kp index with magnetic field intensity to find out the unusual magnetic value. The existing study sum up the influence of the magnetic changes to detect the precursory nature of the earthquake in and around Kopili fault.
Keywords: Precursory, magnetic field intensity, Overhauser

Magnetic field study for the Earthquake precursory research at Multiparametric Geophysical Observatory (MPGO), Tezpur, Assam

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Abstract

The variation of various geophysical parameters has been observed during seismic event. The Magnetic field is considered here for the earthquake precursory studies. It is continuously monitored at Multiparametric Geophysical Observatory (MPGO), Ouguri hills, Tezpur. The fluxgate and Ultra low frequency magnetic data is studied to establish the correlation with magnetic anomalies and earthquake events recorded with BBS and SMA at MPGO within the radius of 150 km. The KMS-820 instrument with Lemi coils has been used for data acquisition. The Kp index due to geomagnetic storm has been considered to ensure the anomaly in magnetic field during events. It is observed from FG and ULF data, the magnetic field is increased prior to the earthquake. The increased magnetic field is prominently observed along the horizontal magnetic channel rather than vertical channel.
Keywords: Magnetic field, Precursory, ULF, FG

Challenges for High-Resolution Seismic Surveys in Gondwana Basins of East India

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Abstract

The coal-bearing Gondwana basins of India are much complex with surface topography, deep-seated faulting, and folding, and with several intrusive

bodies like dykes, sills and other structural discontinuities due to its active tectonic evolution history. The Geological Survey of India (GSI) had been the pioneer organization for coal exploration and provided vast information on the prospects in the Gondwana basins of India by using geological mapping and drilling. However, to establish precise coal, shale gas and CBM reserves, much detailed seismic imaging by employing High-Resolution Seismic (HRS) survey is required. HRS survey is known to be conducive for exquisite interpretation and reservoir prediction. The geological complexities pose severe problems in the acquisition and processing of high-quality seismic data. The presence of coal layers and the abundance of a convoluted network of high-velocity sills/dykes result in the attenuation of seismic energy and generate short period multiples that interfere with the primary reflections, which bring significant challenges to seismic data processing and generation of a high precision seismic image due to the low S/N ratio in the data. Further, the CBM reservoirs are deeper targets for the conventional HRS method. Here, we briefly discuss these challenges for the Gondwana sub-basins in east India, which is being explored using the HRS method. HRS survey is a challenging task contrast to routine earlier exploration by regional drilling and borehole geophysical logging, but it is less expensive, and it also images the subsurface structure for CBM mining and development planning.

Keywords: High-resolution seismic, Coal Bed Methane, Gondwana basin, India.

Source-to-sink magnetic properties of shelf sediments, Bay of Bengal

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Abstract

We employed rockmagnetic and granulometry method on the continental shelf sediments to magnetically fingerprint the provenance and depositional proceses off Krishna, Godavari and Mahanadi rivers, Bay of Bengal. Titanomagnetite (fine and coarse-size) grains of detrital origin govern the bulk sediment magnetism in all studied sediment cores as evident in rockmagnetic, SEM-EDS and XRD data. Higher magnetite enrichments were found in the off Krishna and Godavari shelf sediments compared to off Mahanadi. Alongshore decline in magnetite content through off Krishna, Godavari and Mahanadi shelf can be attributed to the shift in sediment provenance (mafic to felsic) and changing depositional processes which is clearly evident in scattered magnetic plots. Ferrimagnetic minerals preferentially reside as discrete magnetites in the silt and clay size fractions in contrast to fine single domain (SD) type magnetic inclusions in sand fraction. Magnetogranulometric ratios (ARM/IRM_{1T}) positively correlate with magnetic mineral content in the sense that larger magnetic particles are associated with higher magnetic enrichment. Granulometry data revealed that the relationship between magnetite crystal size and clastic grain size reverses above 40 μm. This is due to the presence of fine magnetic particles occurring as magnetic inclusions in large silicate grains in sand fractions.

The saga of the two spectacular ridges in the Bay of Bengal

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The 85°E and Ninetyeast ridges are two prominent features in the Bay of Bengal. They run nearly longitudinal along the meridians appearing in their names. They also depict differing geophysical signatures indicating that they have contrasting evolution mechanisms. It is remarkable that within a range of about 550 km, two distinct features were developing over time.

Drill sites over the Ninetyeast Ridge have provided the basement ages and ascertained its origin to the Kerguelen hotspot. But the northward continuation of this ridge to the Rajmahal-Sylhet Traps, products of the same hotspot, has not been established. Due to lack of any drill information on the 85°E Ridge, indirect methods have been applied to infer the timing and source of its emplacement. So till date, there are several hypotheses for the origin of the 85°E Ridge.

The latest theory for the origin of the 85°E Ridge is that it is a fracture zone, over which volcanic emplacement has occurred subsequently. Further this fracture zone is proposed to have two segments. The northern segment is a transform fault along which the eastern part of the Early Cretaceous spreading center jumped north to the Rajmahal-Sylhet line of opening around M0 time, under the influence of the Kerguelen hotspot. The southern segment is the northern continuation of the 86°E fracture zone. This theory is convincing except that the width of the ridge is fairly large for a fracture zone.

A latitudinal comparison of the morphology and burial characteristics of the 85°E and Ninetyeast Ridges using seismic records, suggests that the 85°E Ridge is older to the Ninetyeast Ridge. The present study indicates that the Ninetyeast Ridge indeed turns northwest to meet the Rajmahal-Sylhet Traps. This study also proposes that the unusual width of the fracture zone segments underlying the 85°E Ridge can be attributed to the change in seafloor spreading direction during the Middle Cretaceous. Further, the intersection of the two fracture zone segments lies at 13°N latitude. New deep seismic reflection and refraction data are needed to investigate these features in light of the tectonic evolution of the Bay of Bengal.

Assessment of the relationship between extreme weather events and agricultural productivity

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Abstract

There has been unprecedented increase in global population. Consequently, it has increased demand in the context of food supply. However, it needs to be considered that there is significant change in the landscape pattern. Significant decrease in agricultural land and land degradation are affecting the agricultural productivity. Furthermore, it has been affected by the climate change and extreme weather events. Therefore, this is necessary to analyse factors which may affect the agricultural productivity using earth system science principles.

Hence, this is now indispensable to use geospatial technology for construing earth system science complexities. Different factors affect, and shape earth system characteristics. Most importantly, spatial-temporal complexities are associated with earth system components. Therefore, this becomes an absolute necessity to look at the issues with a multi-dimensional approach. In addition, factors which may affect various earth system science events are from different disciplines. Hence, characteristics of factors vary significantly from each other. Hence, this becomes absolutely important to have a platform which can aid in construing the dynamics of earth system events more effectively.

This study aims to demonstrate the utility of geospatial technology for assessing the impact of landscape changes along with extreme weather events

on agricultural productivity. In addition, a framework has been developed using intelligent agent-based framework to assess the link among the aforementioned aspects. Results and findings of the study proves that there is a significant impact of random changes of landscape pattern on food production and is significantly affected by weather events. Moreover, the utility and efficacy of geospatial technology is demonstrated for deciphering the complexities of agricultural science.

Keywords: Agricultural Science, Geospatial Technology, Food Production, System Science, Extreme Weather Events.

SUSTAINABLE GEOSCIENCES AND BLUE ECONOMY

Estimation of water saturation using rock physics modeling in unconsolidated sedimentary rock formations

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Abstract

The seismic properties, reservoir properties and rock modulus properties are interconnected by rock physics algorithm to address various models for evaluation of a hydrocarbon reservoir. Water saturation is an important parameter for rock physical analysis of a reservoir, as it describes the fraction of pore space occupied by the water and gives an idea about fractional volume of the hydrocarbons present in the pore space. Moduli of a dry rock is affected by its mineralogical constituents and their respective volume fractions, and microstructure of the rock especially, texture of the rock grain. We have applied Hashin-Shtrikman lower bound to estimate effective elastic moduli for a loose sedimentary mixture of quartz and clay. Here, we have assumed rock matrix theoretically as mixture of quartz and clay and fluid as a mixture of brine water and methane gas hydrates with their standard density, bulk and shear moduli. This assumption is practically applied in the highly porous marine sediments at NGHP-01 sites for gas hydrate assessment in eastern

offshore basin of India. Dry rock bulk and shear moduli are estimated using Modified Hashin-Shtirkman bounds found to be ranging from 0.7GPa to 14GPa and 2.3GPa to 8.2GPa respectively for the porosity ranges 44% to 87%. The effect of pore fluid in a saturated rock is seen only on bulk modulus of the rock but not on the shear modulus of the rock because, fluid do not possess shear strain at all and hence shear wave can travel through rock frame only in a saturated rock. Hence shear modulus of the dry rock and saturated rock will be equal. By using sonic P-wave and S-wave velocities, bulk density of saturated rock, porosity log data and dry rock bulk modulus of rock in Gassmann's equation for saturated bulk modulus of the rock and Wood's equation for fluid the water and gas hydrate saturations are determined. Another method called Wood's method is also used here to determine water and gas hydrate saturation estimation. The P-wave velocity in the rock matrix required in Wood's equation is determined by using Hashin-Shtrikeman lower bound for loose mixture of quartz and clay which are found to be ranging from 3.4 Km/s to 6.04 Km/s for well under observation. According to Batzle and Wang (1992), fluid bulk moduli and densities are affected by temperature, pressure, and salinity of brine. Here those effects will be not be taken into account. The estimated water saturation from P-velocity data using rock physics models (modified Hashin-Shtikeman bounds and Wood's model) has been compared with the water saturation computed from resistivity log data at NGHP-01 sites.

Study of gas hydrates and free gas systems in the Mannar Basin, India using velocity modeling and seismic attribute analysis

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Abstract

Gas hydrates are a crystalline ice-like solid substance that forms when lighter hydrocarbon gases (mostly methane) come in contact with water under suitable pressures and temperature conditions. Methane molecules get trapped within the cavity formed by water molecules. Gas hydrates are found within marine sediments along the continental margin of India. They are stable at water depths exceeding 500-700 m, where temperature and pressure conditions are favorable for the formation of gas hydrates. Gas hydrates are considered to be a future energy source due to their enormous capacity to trap lower hydrocarbon gases within their cavity. One volume of gas hydrates releases 164 volumes of methane and 0.8 volumes of fresh water at standard temperature and pressure. In Indian offshore, gas hydrates are discovered in the Krishna- Godavari, Mahanadi, Mannar basins, and the Andaman Sea.

The Mannar basin is a passive continental margin rift basin along the east coast of India and is located between 75°27' to 79°54' E longitudes and 10° 9' to 13°30' N latitudes. The Mannar basin is poorly explored for hydrocarbon as compared to other petroliferous basins in the Indian offshore. 2D multi-channel seismic data was acquired onboard R/V Samudra Ratnakar for gas hydrate exploration. Bottom simulating reflectors (BSR) and several pull-down structures are observed in different seismic lines, which indicate the possible presence of gas hydrates. An automated version of migration velocity analysis was used to estimate interval velocities for selected seismic profiles. High interval velocities are observed above the BSR, confirming the gas hydrate deposits, and low velocities below the BSR show free gas. Instantaneous amplitude and frequency attributes are also used to map gas hydrate and free gas regions. Several chimney-like structures are observed in the seismic data, and a deep low-velocity horizon is identified from which the chimney originates. On the amplitude section, chimneys appear as vertical zones of reduced amplitude. The gas-bearing sediments below the BSR are characterized as high amplitude regions, while in the frequency section, it appears as a low-frequency region due to high seismic attenuation. In the present study, we propose that the chimneys and small fractures provide conducive pathways for deep-seated gases to migrate to shallow depth and form hydrate deposits in the Mannar basin.

Holocene variations in nature of sediments within the oxygen minimum zone of the eastern Arabian Sea

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Abstract

The Arabian Sea has experienced significant variations in intensity of the oxygen minimum zone (OMZ) during the Holocene. Marine sediments from the Indian continental margin in contact with waters of the OMZ have witnessed considerable changes and are archives of OMZ variability. In order to understand the geochemical variations within sediments of the OMZ, we analyzed a gravity core BP3-GCR3, retrieved from a water depth of 500 m from within the core of OMZ. Variation in the intensity of the OMZ and the influence of OMZ on sediments has been studied using leached particulate Fe-Mn oxyhydroxides, bulk Mn (carbon free basis, cfb)%, Mn/Fe ratios, along with organic carbon (OC), and $CaCO_3$ in sediments. The results suggest that bottom waters were comparatively oxygenated during the Early-Holocene (EH), with a gradual intensification of OMZ during the Mid-Holocene (MH) and a strong and intensified OMZ during the Late-Holocene (LH). Inter-elemental associations between detrital silicates (DS) and biogenic component (BC) suggests that, sediments deposited within oxic and suboxic bottom waters have undergone alterations such as, dilution of $CaCO_3$ due to high terrigenous input during EH, better preservation of OC and dissolution of $CaCO_3$ during the LH, and high organic matter (OM) decay in the water column during MH and LH.

Keywords: Oxygen minimum zone, eastern Arabian Sea, manganese, ventilation, Holocene, Indian summer monsoon

Swarm Impact of Tibet

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Abstract

An unusual finding of ultrahigh-pressure (UHP) nitrides like cubic boron nitride, osbornite in association with micro-diamond with Os, Ir inclusion, coesite and stishovite, boron carbide along with other complex alloys, have been reported in the past from Luobusa ophiolite of southern Tibet. These minerals were found at shallow depths in the placer deposits of the YarlungZangbo region. For the formation of these UHP minerals, pressure in the range of 4-10Gpa and temperature in the range of 700 ^{0} c to 1300 ^{0} c is required. Thus these minerals have been extruded from the deep upper mantle, or they have an impact origin. Dobrzhinetskaya [1] an earlier study by Wen-JiBai [2] have favored the mantle origin because they did not find any evidence of impact. In the event of mantle origin, its hard to justify perfect preservation of coesite crystals, low oxygen fugacity (fO2), and it also faces the challenges concerning the source of nitrogen and boron in the deep mantle. Hence it is critical to re-examine the possibility of an impact. In the event of placer deposits, source craters can generally be traced many kilometers away from the findings. Hence for placer deposits of Yarlung Zangbo suture zone, it is critical to consider a series of lakes in the region (82˚30'E, 29˚N and 90˚30'E, 33˚N). These lakes are connected to the YarlungZangbo river by multiple streams and small rivers. These lakes are unusually closely aligned and have a steep slope facing circular features. These lakes are interconnected by network of fractures and faults, hinting towards a series of impact craters. These lakes have diameter from 1 Km to 65 Km and are linearly aligned. The unusual shapes of these lakes, and spread over such a large area is possibly an outcome of a swarm impact by a comet at an extremely low impact angle. The low density coupled with low angle of impact will result in to the formation of “large flat-floored oblique craters”. Muong Nong and Indochinites reported from various parts of Asia, strongly support the oblique impact of comet on Indochina border. Our study suggests that the ultra-high pressure nitrides, micro diamonds, stishovite,

boron carbide and other UHP minerals reported from Yarlung Zangbo suture zone are the result of oblique impact by comet in the Tibetan region between the latitudes of 82˚30'Eand 90˚30'E and 29˚N and 33˚N.

Earthquake precursory studies at active Kopili fault, Shillong plateau, Northeast India with Radon concentration as a parameter

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Abstract

The soil-gas radon (Rn-222) concentrations have generally been observed to be abundantly high along active faults in many parts of the world. The radon emanation from soil gas at Multiparametric Geophysical Observatory (MPGO), Ouguri hills, Tezpur is continuously monitored and radon data is studied to find the correlation of radon anomalies with the earthquakes near Kopili fault and its adjacent areas. The radon anomalies are co-related with the earthquake events recorded on BBS at the MPGO which occurred within the distance of 150 km from MPGO. The radon monitoring in the soil was carried out by using barasol probe manufactured by Algade BMC2. The effect of meteorological parameter such as temperature and pressure on radon emission has been studied. The average standard derivation of radon in soil is calculated to find the radon anomaly to minimize the effect of meteorological parameter on radon emission. In the present study the radon concentration and anomalies before two earthquakes on 06/12/2020 and 09/12/2020 are considered to deduce the precursory nature of the earthquakes in the region.

Keywords: Soil-gas radon, Shillong plateau, Kopili fault, Precursory 6/12/2020 and 9/12/2020

Rayleigh Wave Group Velocity Analysis for the Crust and Upper Mantle Structure of the Western Indian Ocean.

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Abstract
We obtain the crust and the upper-mantle structure of the Western Indian Ocean using fundamental mode Rayleigh wave group velocities of the period from 12 to 120 sec. 1945 earthquakes located along the Mid-Oceanic ridge and well recorded at stations distributed along the East African Rift used in this study. The epicentral distances of these events are between 2270 and 3300 km. The source-receiver wave paths are divided into five clusters (W1-W5), nearly along E-W between 15^{o}N and 45^{o}S. The observed group velocities of each cluster are then inverted in order to obtain the 1-D shear velocity structure of the crust and the upper mantle. The observed group velocities are consistent with the Global Dispersion Model of the study region. The estimated thickness between the W1 and W5 of the crust, lithosphere, and asthenosphere are 15.5-21 km, 58.2-99 km, and 74.8-106 km respectively. The shear velocity and the crustal thickness indicates the quasi-continental type of crust between the region W2 and W5. The high and low shear velocity variations in the lithosphere and asthenosphere of the study region, reveal that much of the deformation is contained within the upper mantle of the Western Indian Ocean.

ANNI TALWANI MEMORIAL GRANT FOR WOMEN RESEARCHERS

Artificial Neural Network for Estimating theIncomplete Well Log Data

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ABSTRACT

Well logs provide valuable information about the sub surface geological formations. Due to some problems in data recording, like, instrument malfunction, borehole conditions, incomplete logging, etc creates an information gap that can be very crucial to the geophysical interpretations. However, for economic reasons, the re-acquisition of log data is not recommended in most of the situations. Artificial Neural Network (ANN) is an effective way to reconstruct the missing well log data and this method tested on two different geologies i.e., hard rock terrain and in the sedimentary environment for estimating Sonic, LLS, and Gamma logs respectively. The ANN models were developed based on feed forward and backpropagation algorithm. The accuracy of the results from ANN is assessed using mean square error and correlation values. From the present study it is inferred that the successful performance of the network (log prediction) are mainly dependent on the activation function, rather than the network architecture itself.

Keywords: Well log, Artificial Neural Network, Feed forward, Backpropagation.

Subsurface modeling of porosity and saturation in 3D seismic data using acoustic impedance model: A case study of Upper Assam Basin, India.

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Abstract

Quantitative estimation of Porosity and fluid saturation are important for drilling decisions, production planning, and economic assessment of a reservoir. In the case study, 3D seismic volume and well log (namely KM) from the upper Assam basin, are used to create an acoustic impedance model (AI). Based on the inversion results of 3D seismic volume, the porosity and the fluid saturation are estimated at locations away from the well. The 3-D seismic data covers 34 sq km of the Block located within Latitude $26^0$14'N to $26^0$22'N and Longitude $93^0$56'E to $94^0$2'E and bounded by Mikir hills in the west and NE-SW trending Naga Schuppen belt. The major reservoir rocks in the block are expected in the fractured granitic basement rock, Tura sandstones underlying Sylhet Limestone and, intra-formational argillaceous sandstones in Kopili formation. Sandstones within Cretaceous and Gondwana sequences and basal sandstone overlying the basement would also form prospective reservoir rocks. The porosity log and saturation log from the well KM are introduced into the post-stack 3D seismic volume to create porosity and saturation model for the whole seismic volume. The final subsurface porosity model and subsurface saturation model greatly improves the understanding of the distribution of porosity and saturation in the low impedance sand present in the Barail formation, Kopili formation and, Sylhet formation, showing the variation of porosity and saturation both vertically and laterally. The porosity and saturation volumes estimated in the inverted low acoustic impedance zone are used to identify potential hydrocarbon reservoir sands such as Tura sand of Paleocene age within Sylhet formation, interbedded sand of Eocene age within limestone dominated Kopili formation and sand within fractured granite Basement.

Keywords: Porosity, Saturation, Seismic Inversion.

Role of Gas Hydrate and its Migration Pathways in Submarine Slope Failures

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Abstract

Gas hydrate dissociation in the continental margin setting is one of the primary factors that can potentially trigger submarine slope failures. The present study is carried out to investigate such a scenario in the Krishna Godavari basin. We interpret that a fault is generated below the bottom simulating reflector as a result of free gas overpressure in the shale deposits. Gas column height calculated for the KG basin is 51 m and shows that the gas zone is critically over pressured and any further increase in the gas column can potentially trigger slope failure.

Keywords: Gas hydrates, Slope failures, migration pathways.

Use of site amplification for the estimation of earthquake source parameters in the Kinnaur Northwest Himalaya

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Abstract: The Kinnaur Himalaya comprising Lesser Himalaya, Higher Himalaya Crystalline and Tethys Himalaya, which lies in the highly mountain terrain of North-West Himalaya. The region having unique high localized seismicity mainly of micro and low magnitude earthquakes. This region has experienced strongest earthquake of magnitude 6.5 occurred in 1975. The local seismicity of Kinnaur region is recorded by a seismic network of 10 broadband network installed in 2008 in this highly mountain terrain of altitude range from 1369 m to 4141 m. A total of 96 local distance events ($1.6<M_w<4.5$) recorded at ten stations are analyzed to compute various earthquake source parameters. All the stations installed on surface at concrete pillars may have the influence of local site effects depending on geological condition. It is important to identify and remove the site effect for proper estimation of earthquake source parameters. The site effect is evaluated in term of site amplification curves by using the Horizontal to Vertical Spectral ratio method (HVSR) proposed by Nakamura (1989) and modified by Lermo and Chavez (1993). Number of events are considered at each recording station to evaluate the site amplification curves. The average of these events

provide the final site amplification curve, which is further used to correct the spectra. In this work, the S-phase of the earthquake record is utilized and spectrum of S-phase is corrected for the obtained site amplification terms. The obtained source spectrum corrected for site amplification term is compared with the theoretical source spectrum computed at each recording station based on Brune (1970) circular source model. The root mean square error (RMSE) is computed between the observed and theoretical spectrum by implementing iterative forward modeling. The various source parameters of 96 events are estimated on the basis of minimum RMSE, which provide the average estimate of seismic moment 8.13 x 10^{10} to 5.27 x 10^{14} Nm, stress drop 1 bar to 50 bar, source radius 0.1 km to 0.9 km and radiated energy 2.01 x 10^{02} to 1.23 x 10^{08} for the earthquake moment magnitude range of 1.6 to 4.5.

Keywords: Kinnaur Himalaya, Site amplification, Spectrum, Source parameters

Late Quaternary climate variability in Central Ganga Basin (India) - impact on fluvio-lacustrine systems.

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The Indus-Ganga (Indo-Gangetic) plain is one of the thickest Quaternary sediments characterised with highly fertile land and monsoon governed economy landscape of the Indian Subcontinent. The region witnessed the formation of several lake basins during the early-middle Holocene (~8 to 5 ka), due to changes in the course of major river channels. These lakes in the region preserve Holocene climate history and channel shifts in the form of sedimentary deposits. Therefore, to understand the history of lake formation in Ganga plains with the influence of climate on the livelihood of the region, we present a multi-proxy record from 13714 to 3073 cal yr BP using grain size and stable isotope of carbon from the Lilaur Lake, Bareilly (Uttar Pradesh). The chronology of the lake core is constrained using the 14C AMS and the Optically Stimulated Luminescence

(OSL) dating method. The record suggests transition phase from fluvial to lacustrine system from 5800 to 5189 cal yr BP which is also supported by the reduced precipitation condition due to weakening of Indian summer monsoon. This fluvial to lacustrine transition culminated in a severe arid phase during 4250 to 4050 cal yr BP (4.2 ka event), corresponding to enhanced El Niño activity, a southward shift of the Inter-Tropical Convergence Zone and aridification in India when the Indian summer monsoon was weak.

Crustal thickness and composition from receiver functions beneath Malani Igneous Province, Rajasthan, India

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The Neoproterozoic (~750 Ma) age of Malani Igneous Province is the largest alkaline complex, located at the western part of Aravali Delhi fold belt (ADFB) in northwestern India. The pre-Deccan volcanic alkaline signatures found at Sarnu-Dandali and Mundwara regions which are surrounding the NNW-SSE trending Barmer- Sachor rift, passing through the centre of the study area. The variations in crustal thickness and composition beneath MIP is investigated through receiver function (RF) analysis. For this purpose, the teleseismic data within the range of 30º to 90º epicentral distance and magnitude > 5.5 are extracted from continuous data of 23 broadband seismic stations, operated in three phases from 2011 to 2017. A total of 3900 waveforms were selected with the signal to noise ratio is > 5 for further analysis. The crustal thickness and Poisson's ratio is estimated by H-k grid search method, and the standard deviation is determined from the bootstrap method. Results show variation in crustal thickness from ~36 km near the rift region to ~40 km in the Erinpura granites adjoining to ADFB with a total average value of 38± 2 km. The Poisson's ratio varies from 0.26 to 0.29 in the region with the average value of 0.27±0.01, indicating intermediate to mafic crustal composition. The mean value is within 2σ distribution, giving a 95% confidence interval. The variation in results indicates significant heterogeneity in the crust beneath MIP corresponding to several tectonic episodes' imprints.