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March 10-11, 2025

Kathmandu, Nepal

11th Nepal Geological Congress (NGC–XI)

"Geosciences for Climate Change Adaptation, Natural Resources and Geo-hazard Management"

March 10-11, 2025
Kathmandu, NEPAL

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We extend our deepest gratitude to our collaborating institutions for their unwavering support and commitment to advancing geological research and professional development. These include the Department of Mines and Geology (DMG), Department of Water Resources and Irrigation (MoEWRI), Department of Electricity Development (DoED), Central Department of Geology, Ministry of Education, Science and Technology, Central Department of Geology, Tribhuvan University, Tri-Chandra Campus, Ghantaghar, Institute of Engineering, Pulchowk Campus, Lalitpur, Nepal Electricity Authority (NEA) and Nepal Hydrogeological Association. Their collaboration has played a pivotal role in fostering knowledge-sharing and strengthening the scientific community in Nepal.

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10 years after the 2015 Gorkha earthquake, what have we learnt from the study of regional seismicity? A focus on the technical and scientific progress of the DASE-DMG collaboration

***Laurent Bollinger[1], Lok Bijaya Adhikari[2], Blandine Gardonio[1], Marine Laporte[1], Roser Hoste-Colomer[1], Jean Letort[1], Christian Baillard[1], Bharat Koirala[2], Munkunda Bhattarai[2], Chintan Timsina[2], Ratna Mani Gupta[2], Bal Bahadur Tamang[2], Tara Pokharel[2], Shila Bhattarai[2], Nicolas Wendling-Vazquez[1,2], Daria Batteux[1,2], Theo Besson[1,2], Ludovic Desmeuzes[1,2], and the DMG/NEMRC[2] and DASE teams[1]**

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On April 25, 2015, the M 7.8 Gorkha earthquake devastated central Nepal at the toe of the high Himalayan range. The seismic rupture has initiated at depth on the Main Himalayan Thrust, the plate boundary fault between India and the Himalayas, and propagated eastwards on the fault plane for 50 seconds, accommodating a slip of several meters over an area of 140 km by 50 km. This earthquake was followed by tens of thousands of aftershocks, that occurred around the region of the fault activated by the mainshock. These exceptional seismotectonic events happened right below the Nepal national seismological network, the backbone of which was deployed, maintained and updated within a long standing collaboration between DMG and DASE. The aim of this presentation is to illustrate the studies that have been developed as part of the collaboration between CEA/DASE and the DMG over the last 10 years, in order to gain a better understanding of the behavior of the Main Himalayan Thrust in Nepal. These studies have benefited from the work of several PhDs and post-doctoral students, French cooperants and permanent staff at the NEMRC laboratory or their correspondents in DASE, who have constantly helped maintained the network and documented complementary aspects of the seismicity along the thrust.

Emerging studies from this work include:

- Studying the very small earthquakes that preceded the rupture in the earthquake initiation zone, in order to gain a good understanding of the rupture initiation mechanisms
- The study of aftershocks and, in particular, their relationship with the ruptured fault segment, ramps and tear faults that produced earthquakes
- Paleoseismic studies on either side of the ruptured fault segment, to better understand the extension of strong earthquakes in the past and their segmentation along the front of the range
- Studies of seismicity in other regions, including Far Western Nepal, subject to stress build up along locked fault segments, a period inevitably followed by the rupture of future earthquakes.
- Each of these studies set out to reveal/unravel some of the complex relationships between the great Himalayan thrust fault or the faults of its hanging wall and seismicity, and at the same time contribute to a better understanding of seismicity and seismic hazards in Nepal. It is also part of the great human and scientific adventure of a collaboration spanning almost 50 years.

Keywords: Seismic monitoring; Gorkha earthquake; aftershock; Pre-shock; Seismotectonics

Refining Thermometry: Assessing the Accuracy and Reliability of Metamorphic P-T Estimates

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Thermobarometry, the study of pressure-temperature (P-T) conditions in metamorphic rocks, is crucial in understanding metamorphic processes. However, many widely used thermobarometers face several challenges, including calibration issues, excessive sensitivity to P-T changes, reliance on unverified assumptions, and susceptibility to post-metamorphic resetting. This review evaluates the current state of various thermometers, highlighting significant limitations such as inaccuracies in thermodynamic data, issues with compositional extrapolations, and the failure to account for volume corrections related to temperature and pressure. Despite these challenges, it is possible to achieve accurate temperature estimates within ±50°C by carefully selecting and cross-validating multiple thermobarometric methods. The paper discusses several experimentally and empirically calibrated thermometers applicable across different metamorphic facies, ranging from greenschist to granulite. These include pairs such as garnet-biotite, garnet-orthopyroxene, garnet-clinopyroxene, garnet-hornblende, orthopyroxene-clinopyroxene, and garnet-cordierite. The study outlines the P-T conditions across various metamorphic facies in different regions, including the Himalayas, Rajasthan, Antarctica, and the Southern Granulite Terrain, particularly focusing on the garnet-biotite pair. The findings emphasize the need for continuous refinement of thermodynamic models and experimental calibrations to enhance the accuracy and reliability of metamorphic P-T estimates.

Keywords: Thermometry; pressure; temperature; mineral pair; metamorphism

Stratigraphy of Nepal Lesser Himalaya: A critical review

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Much controversy exists among the researchers over the stratigraphic nomenclature of the Lesser Himalayan sedimentary succession. Since most of the unfossiliferous Lesser Himalayan rocks are of Proterozoic age, a lithostratigraphic classification scheme is applied. It has become a matter of convenience to include them in a single carbonate succession (e.g. the Krol or Shali Formation, Lakharpata Formation, Dhading Dolomite, Baitadi Carbonates), a quartzite-predominating unit (e.g. the Nagthat Formation, Kushma Quartzite, Fagfog Quartzite), a predominantly phyllitic sequence (e.g. the Chail nappes, Seti Formation, Kuncha Formation, Ranimatta Formation), and a slate unit (Simla Slates, Benighat Slates, Ramkot Formation, Galyang Formation). Stöcklin and Sakai being two exceptions, many other geologists have considered the lithological similarity the only stratigraphic criterion for defining or correlating various Lesser Himalayan rocks throughout Nepal. Such researchers do not provide information on the contact relationship between the overlying and underlying formations. They do not provide any detailed geological route map or stratigraphic log to justify their lithostratigraphic classification. In many instances, the designated formations are hundreds of kilometres apart, and neither their lower nor upper bound is defined. Stromatolites have been used to correlate various Lesser Himalayan carbonate sequences. However, detailed geological mapping, stratigraphic investigation, and sedimentological studies demonstrate that such correlation based on stromatolite occurrence alone is untenable. Such successions reveal at least four separate stromatolitic successions. The lowest unit is the Dhading Dolomite, Shali Formation, Baitadi Carbonates, or the Lakharpata Formation. The Sorek Formation and Halesi Dolomite occur in an intermediate position, whereas the Chappani-Khoraidi or Hapurkot-Dhorbang Khola Formations appear in the upper part. On the other hand, the Krol, Kerabari, and Ranibas Formation occupy the topmost position in the Proterozoic stratigraphic rung.

Keywords: Stratigraphy; Lesser Himalaya; controversy

Mount Everest: Tectonic Evolution, Uplift, Exhumation, River Capture and Models

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Mount Everest (8850 meters) is the highest mountain along the Himalayan chain and its uplift history is related to processes including tectonic uplift (thrusting, underplating), rock exhumation, glacier and river incision, surface uplift, and isostatic compensation as a result of unloading and erosion. Geochronological constraints define four periods during the thermal history: (1) crustal thickening, regional metamorphism (45-25 Ma), (2) mid-crustal melting, channel flow, rapid cooling (25-15 Ma), (3) relatively slow cooling (15-2 Ma), and (4) glaciation, increased rapid cooling (2-0 Ma). Mount Everest spans the Greater Himalayan Series metamorphic rocks and the base of the unmetamorphosed Tethyan sedimentary rocks in the Nepal-South Tibet Himalaya. Two north-dipping, low-angle normal faults cut the massif, the upper Qomolangma Detachment placing Ordovician sedimentary rocks above Everest Series greenschist – amphibolite facies rocks, and the lower Lhotse Detachment placing Everest Series schists above sillimanite gneisses, migmatites and leucogranites. The two faults merge northwards into one large ductile shear zone (South Tibetan Detachment). Pressure-temperature constraints and structural restoration shows that the fault acted as a passive roof fault during extrusion of the footwall. At least 120 km southward flow of footwall rocks occurred during the Miocene resulting in exhumation of rocks that were buried to 5.5 kbar (~18-22 km depth) below the detachment juxtaposing them against hangingwall rocks that are essentially unmetamorphosed. The low-angle normal faults were operative during north-south convergence and reflect exhumation of a locked passive roof fault, not to any crustal extensional processes. U-(Th)-Pb dating of peraluminous leucogranites exposed on Everest (21–20 Ma), Nuptse (~19–18 Ma) and along the Rongbuk valley (15.6–15.4 Ma) show that ductile extrusion occurred during the Early Miocene, with brittle faulting at <15.4 Ma, during exhumation. River capture (Arun, Sun Kosi) played little or no part in the uplift of Mount Everest.

Keywords: Tectonics; uplift; Tethyan sediments; hanginingwall

NMT for sustainable and environmentally friendly tunneling

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Recent weather pattern in the world indicates that there is a considerable impact on the weather system of the world, which is believed to be due to global warming. The change in weather has started causing serious damages in the Himalayan region and elsewhere in the world. The debate on the minimization of carbon emission through the reduced use of fossil fuel is ongoing for some couple of decades. However, the carbon emission caused by the production of cement and concrete is also considerable, which has been less discussed and highlighted issue around the world. In addition, an unnecessarily excessive use of cement is counterproductive due to increased project costs. Therefore, there is a strong need for the reduction in the use of cementitious products while developing the infrastructure and hydropower projects in Nepal where use of underground space will be considerable in the days to come. Use of Norwegian Method of Tunneling (NMT) could serve as an alternative to this endeavor. This Key-Note lecture will highlight the principals used in Norwegian Tunneling Method (NMT), benefit it gives in the reduced use of concrete which ultimately helps to optimize project costs, protects environment and assists to enhance sustainable development of infrastructure and hydropower energy projects.

Keywords: Environment; tunneling; carbon emission

Special Papers

Cross faults in the Himalaya: their topographic and structural expression

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Recent studies by a variety of researchers have found that in addition to the major range-parallel thrust faults, the Himalaya has a significant number of faults that strike at a high angle to the orogen. These faults have been suggested to possibly play a role in limiting lateral propagation of thrust fault rupture, thus limiting earthquake magnitude, and they likely play a role in increasing the landslide hazard in the numerous ~north-south river drainages. This presentation explores the structural and topographic expression of a selection of cross fault features. The NNE-striking Benkar fault system is well-exposed in the Khumbu region of eastern Nepal as a dip slope of a brittle-ductile fabric where deformation is concentrated on sillimanite-rich planes with a dextral, normal sense of shear. To the south along strike of this structure, the exposures show significant brittle deformation resulting in ~10-meter-wide gouge zones. The Benkar fault system is expressed topographically forming a lineament that has been recognized by previous authors. The Melamchi valley also has an associated topographic lineament quite close to the valley floor in places. Shear fabric is seen on near vertical planes near Nakote. The lineament passes through a large landslide east of Melamchi Gaon, that were re-activated during catastrophic flooding in 2021. South of Kathmandu, around the Kulekhani reservoir there are several lineaments that correspond to NE-striking brittle fault zones. Detailed structural studies along prominent topographic lineaments are limited, but analysis of satellite imagery and topographic data shows many of these lineaments align with major sites of mass wasting such as the Sabche rock avalanche in the Annapurna region or the Khumjung landslide in the Khumbu. We emphasize the need for further field studies along lineaments that are orthogonal to the orogen and that may relate to both the seismic and landslide hazards.

Keywords: Cross faults; lineaments; topography; structural

A decade of discovery: tectonics and geological evolution of Nepal's Lesser Himalaya – the Jugedi-Gorkha corridor of west-central Nepal as a center for academic research

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The Jugedi-Gorkha corridor in west-central Nepal's Lesser Himalaya offers a unique setting to study Himalayan tectonics, stratigraphy, and geomorphology. Its accessibility via major roads and proximity to historically and geotouristically significant sites enhances its importance. Over the past decade, extensive field-based research, including detailed geological mapping (1: 25,000 scale), petrography, illite and graphite crystallinity studies, microstructural analysis, mineral resource assessments, and Quaternary geology, has advanced understanding of the region. The geomorphology, shaped by rivers like the Marshyangdi, Seti, and Trishuli, reflects the interplay of tectonics and geomorphological processes, with features such as deep gorges, wide terraces, and intermontane valleys. Stratigraphic revisions based on mapping highlight key structures, including the Jalbire Syncline, Ghumaune-Ramjakot Synclinorium, Gorkha-Khuncha Anticlinorium, and local-scale folds. The region represents a duplex system, with the Main Boundary Thrust (MBT) as the floor thrust, the Dewachuli Thrust as an imbricate fault, the Bhangeri Thrust as a back thrust, and the Main Central Thrust (MCT) forming the roof thrust. These structures, along with evidence of polydeformation and polymetamorphism, provide critical insights into Himalayan tectonic evolution. The region also contains valuable mineral resources, including stratiform iron deposits, hydrothermal copper mineralization, polymetallic deposits in amphibolites, and semi-precious stones in the MCT zone, along with dimension stones like quartzite, limestone, dolomite, slate, and metasandstones. However, it is prone to natural hazards such as landslides linked to thrusts, faults, shear zones, and fold cores. The epicentre of the 2015 Gorkha Earthquake lies within this corridor, emphasizing its tectonic significance for disaster studies. This research underscores the importance of integrating stratigraphy, structural geology, metamorphism, geomorphology, hydrology, and Quaternary studies to understand Himalayan tectonics and landforms. Collaborative efforts from Tribhuvan University have established the Jugedi-Gorkha corridor as a key academic hub for multidisciplinary research and advancing knowledge of active tectonic processes in the Himalayas.

Keywords: Stratigraphy; duplex structures; back thrust; mineral resources; landslides; earthquake

The Kagbeni flood event (August 13, 2023), Mustang District (Nepal): triggers, sediment cascades, aggravating infrastructures. How to manage the risk equation?

***Monique Fort[1], Narayan Gurung[2], Perrine Yvrard[1], Rainer Bell[3], Katy Burrows[1] and Gilles Arnaud-Fassetta[1]**

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Kagbeni Village was affected by a severe, unusual flash flood on August 13, 2023 evening. It caused significant damage to property and infra-structures (worth about $ 7.4 million), without human losses thanks to early warning from villagers living upstream. Located in the northern Himalayan, rain-shadow zone, Kagbeni (2810 m) normally receives low rainfall (<300mm/yr). However, for several years, the trend is towards increased rainfall, leading to more landslides and flooding. Rainfall data from Jomsom (2720 m) show that rainfall was high, and CHIRPS rainfall data (resolution: 5km) confirmed higher rainfall in the area where the flood originated. Videos taken by locals illustrate the hyper-concentrated, flash flood event triggered by a landslide-lake outburst. No accessible path prevented a visit to the landslide source area, but landslide existence was confirmed by analysis of Sentinel_1 Radar coherence time series (slumps upstream from Chongur gorges). Downstream, the flood spread over the entire valley floor with significant rise in water level, as evidenced by new deposits (thin plaster or debris deposition), bank cuttings reactivating landslides in the Spiti shales, providing additional debris and making downstream flooding even more destructive. The volume of debris transported was estimated at 647,000 m^3, followed by post-flood re-incision (215,000 m^3). By settling on very low terraces or flood plains, encroaching on the local Kagkhola riverbed, the inhabitants of Kagbeni are contributing to disasters. The Upper Mustang Road bridge caused the most damage (bottleneck effect): its concrete deck collapsed, was torn apart, and its zigzag trajectory was very destructive (loss of numerous buildings, shelters, trees and gardens). Given the trend towards global warming, the possibility of future flash floods in Kagbeni remains high, but residents have rebuilt their homes and continue to live on potentially threatened flood plains. We will suggest some measures for controlling this risk.

Keywords: Kagbeni flood; CHIRPS; landslide lake outburst, cascades

Understanding of cascading hazards for risk-informed decision making in the Asian Highland

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Nepal Himalaya is one of the seismically active mountain belts in the world with several kilometers of relief and very prone to catastrophic mass failure. The collision between Indian and Eurasian plates resulted numerous tectonic faults/thrusts and highly deformed rocks, which are responsible for triggering many earthquakes of different scales. High grade of rock weathering and subsequent torrential rainfall are directly related to increase the numerous geo-hazard problems i.e., landslides, debris flow, and floods. The recent events such as Seti Flood (2012), Chamoli flood (2021), Melamchi debris flow (2021), Kagbeni Flood (2021), Sikkim Flood (2021) and Thame GLOF (2024) have shown the scale of devastation in the Nepal Himalaya. The Seti Flood was created due to a large rock slope failure occurred at Sabque Crique, Annapurna range, Nepal. The collapsed material transported the whole material deposited in the upstream of the Seti River creating large scale debris flow. Similarly, the catastrophic debris flow at Melamchi Bazaar killed at least 5 people and damaged major infrastructures including Melamchi Water Supply Project. This debris flow caused wide-spread aggradation along tens of kilometer of Melamchi River corridor, with up to 15 meters of deposition in the town of Melamchi Bazaar. The source of these deposits lies in the upper catchment of the Melamchi River at an elevation of ~3600m, where ~ 100 million m^3 sediments was stored behind a paleo-landslide dam. These cascading events highlight the importance of understanding paleo-landslide dam, glacial moraine, or other geomorphic process in the mountain catchment. These events are responsible for numerous infrastructure damage along the river corridors. The critical infrastructure can be saved by installing community-based early warning systems. Establishing high-altitude hydro-meteorological stations, implementing risk-sensitive land use planning, and monitoring mountain slopes offer a vital opportunity for sustainable risk reduction in the Nepal Himalaya. A resilient Himalayan infrastructure is essential not only for sustainable development but also for safeguarding millions in this disaster-prone region.

Keywords: Landslides; highland; risk reduction; mountain slope

Oral and Posters

Geological study of the graphite mineralization from Holban area of Gulmi District, Lumbini Province, Nepal

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This study explores the graphite mineralization potential within the Holban area of Gulmi District, Lumbini Province, Nepal, with a focus on the Arkhaban Member of the Sirseni Formation. The primary objective of this research was to assess the quality and economic feasibility of the graphite deposits in this region. A comprehensive suite of analytical techniques was employed, including geological mapping, petrographic analysis, X-ray diffraction (XRD), and proximate analysis, to provide a thorough evaluation of the mineralization. Our findings reveal that the carbonaceous schists from the Holban area are characterized by crystalline graphite, with a distinct XRD diffractogram peak at $2\theta = 26.5°$. Petrographic examination highlighted the fine-to-very fine-grained texture of the graphite, while proximate analysis revealed a low fixed carbon content (≤2%) and a notably high ash content (≥90%). These characteristics classify the graphite as "low-crystalline to amorphous graphite," which is typically considered less valuable and commercially less viable for extraction. This study highlights the limited economic potential of the graphite deposits in the Holban area and provides valuable insights into the mineral's commercial limitations, offering guidance for future mining strategies in the region. Additionally, the development of such graphite resources could present an opportunity for future studies on geo-thermometry, and the metamorphism of the region's rocks, potentially contributing to a deeper understanding of the area's geological evolution.

Keywords: Graphite; proximate analysis; XRD analysis; low-fixed carbon

Geological Study of Copper Mineralization in Pyuthan District, Western Nepal, Lesser Himalaya

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A geological study was conducted to investigate copper mineralization in the northeastern part of Pyuthan District, Western Nepal, located in the Lesser Himalayas. The study involved field mapping to produce a mineral prospecting map, thin-section, and polished-section analyses, and XRF analyses to determine the genesis and characteristics of copper mineralization. Qualitative chemical analysis was also performed to assess the grade of the copper deposit. The studied area encompasses the Chaurjhari Formation, Bagliban Granite, and Thabang Formation, featuring crystalline rocks such as garnetiferous schist, metasandstone, carbonaceous schist with granitic intrusions, and impure crystalline marble. The Bagliban Copper Prospect, located at the contact between the Bagliban Granite and the Chaurjhari Formation, hosts copper mineralization in garnet schist and metasandstone. The granodiorite of the Bagliban Granite is identified as the source of the mineralization. Primary sulfide ore minerals include chalcopyrite and bornite, while secondary oxide minerals such as malachite and azurite are also observed. Evidence of chalcopyrite veins in the host rock disseminated chalcopyrite associated with pyrite, and opaque minerals formed through cavity-filling processes, along with the presence of quartz as a gangue mineral, indicates that the Bagliban copper mineralization is of hydrothermal origin. The copper grade, measured at 0.69%, suggests the deposit is economically viable.

Keywords: Copper mineralization; chalcopyrite; hydrothermal deposit; mineral prospecting; economic grade

Earthquake preparedness in Calicut, Kerala: Analysing seismic hazards, built environment vulnerabilities, and risk management

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This study evaluates seismic hazards and loss estimation for Calicut and other major cities in Kerala (9°N–13°N and 75°E–78°E) using the IS 1893-Part 1:2016 guidelines and HAZUS software. It assesses the vulnerability of these cities to earthquake events and their potential impacts on regional infrastructure and populations, emphasizing the need for effective preparedness and mitigation strategies. Calicut, categorized as a seismic zone III area, experiences peak horizontal accelerations (PHA) up to 0.2422g and peak vertical accelerations (PVA) of 0.1460g, with the highest seismic risk attributed to Fault-1 in the Arabian Sea. Similar analyses for Thiruvananthapuram, Kollam, Palakkad, Kochi, and Thrissur reveal varying levels of seismic hazard and vulnerability across the region. An analysis of 75 wards in Calicut highlights potential earthquake-induced losses, with Ward 61 facing significant economic impacts, including \$ 0.14 million in building damage and \$ 0.016 million in content damage. Overall, the projected economic losses for building damage in Calicut amount to \$ 26.77 million, presenting substantial risks relative to the municipal budget. These findings underscore the urgency of strengthening building codes, retrofitting vulnerable structures, and implementing targeted preparedness measures. These recommendations aim to mitigate risks and enhance the region's resilience to earthquake events. Hazus generates contour maps for the study area and then average these ground motion values for each ward (tract) and the total economic loss for the whole study area of Calicut amounts to \$280.46 million in building damage and \$18.47 million in content damage.

Keywords: Seismic hazards; HAZUS; vulnerability; ground motion

Assessment of the 2021 debris flow and flood related loss and damage in Melamchi watershed of Central Nepal

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This study aims to elucidate the 2021 debris flow and flood-related loss and damage and its impact on local livelihoods in the Melamchi Municipality and Helambu Rural Municipality of Sindhupalchok district. Data were collected through both qualitative and quantitative techniques by using household surveys, FGD, KII and field observations were carried out. The sample size was determined by using the Arkon and Colton formula. Disruption of infrastructure, extensive sediment deposition and damage across affected areas, significant erosion, river widening, landscape transformation, temporary river blockage, changes in river morphology, formation of new river channels, and the destruction of agricultural lands were observed in satellite imagery and aerial photographs and they were verified in the field. The event heavily impacted Melamchi Bazaar, claiming over 25 lives and causing substantial damage to the Melamchi Water Supply Project and settlements nearby. The survey revealed that 56% of the respondents lost their agricultural land, 28% lost non-agricultural income sources, 11% lost their employment, and a few others lost other income sources. The total estimated loss of the event was $ 436 million in Melamchi and $ 62 million in Helambu Rural Municipality, including the loss and damage of houses, land, crops, and livestock. Flood and landslides are common phenomena in the Nepal Himalaya and the 2021 Melamchi event was unprecedented in terms of the loss and damage. The result of this study can help policy makers and managers with better planning to minimize the impacts of loss and damage of the geodisaster in the future.

Keywords: Disaster; flood; landslides; Melamchi Watershed; Sediment

Stratigraphy of Tamghas-Libang Section of Western Nepal

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The stratigraphy of the Tamghas-Libang section in western Nepal has been investigated to establish the region's lithostratigraphic framework. Extensive route mapping and columnar section preparation were conducted to document the vertical and horizontal extensions of the rock units. The research has identified and documented several new stratigraphic units. Carbonate and quartzite strata, previously considered part of the Lesser Himalayan Metasedimentary Sequence, have been reclassified as garnet-grade marble and quartzite. These units are now assigned to the Bastu Formation and Purkotdaha Formation, correlating with the Gwaslung and Musimarang Formations of the Kahun Klippe in west-central Nepal. The Chaurjahari Formation, characterized by garnet schist, correlates with the Raduwa Formation and Shivapur Schist of the Kathmandu Nappe and Kahun Klippe respectively. However, the thick psammitic garnet schist succession observed as the Arkhabang Member of this formation is absent in central Nepal. Gneissic and basic rocks within these units are mappable laterally along the thrust sheet which are not observed in central Nepal. Additionally, the Thabang Formation, over 2 km thick, comprises biotite-garnet-grade marble, quartzite, and schist and is correlated with the Bhainsedovan Marble of central Nepal. The study also reveals that the metasedimentary strata of the autochthonous sequence in the study area correspond to the Birbas Slate, Tamghas Dolomite, and Resunga Formation. These units are equivalent to the Benighat Slate, Malekhu Formation, and Robang Formation of the Nawakot Group in central Nepal. The allochthonous sequence of the Jajarkot Thrust Sheet is mapped into the Bastu Formation, Purkotdaha Formation, Chaurjahari Formation, and Thabang Formation, in ascending order. These formations show a degree of correlation with the Bhimphedi Group of the Kathmandu Nappe and the Tanahun Group of the Kahun Klippe, respectively. The findings underscore the need for a revised stratigraphic framework to enhance the understanding of the geology of this region.

Keywords: Stratigraphy; Jajarkot Thrust Sheet; Lesser Himalaya; western Nepal

Geological hazards and risk mitigation in transmission line projects across the Nepal Himalaya

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The sustainable development and construction of transmission lines in the Nepal Himalayas is critical for harnessing the region's immense hydropower potential and ensuring energy connectivity. However, the area's complex geological conditions present significant challenges due to its rugged terrain, varied geomorphological distribution, high seismic activity, and vulnerability to various natural hazards. This study examines the geological hazards impacting transmission line projects in the Nepal Himalayas, including earthquakes, landslides, rockfalls, soil erosion and weathering, and glacial risks such as glacial lake outburst floods (GLOFs). The paper emphasizes the integration of geological investigations in project planning, focusing on hazard identification and risk assessment. Key mitigation strategies are discussed, including route optimization using advanced remote sensing, seismic-resilient design of structures, slope stabilization measures, and innovative foundation engineering techniques tailored to the unique geological conditions. The use of early warning systems and real-time monitoring for dynamic hazard management is also highlighted. Drawing on case studies from ongoing and completed transmission line projects, the research underscores the importance of interdisciplinary collaboration between geologists, engineers, and policymakers to ensure the safety, sustainability, and efficiency of transmission line infrastructure. This study provides a framework for addressing geological challenges in future transmission line projects, contributing to Nepal's goal of becoming a regional energy hub.

Keywords: Transmission lines; geological hazards; Nepal Himalaya, risk mitigation

Assessment of raw materials used for a ceramics tile body composition and their availability in Nepal Himalaya

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There are various types of tiles available in the Nepalese Market with different prices according to their quality. In Nepal, tiles are used for multiple purposes, deeply ingrained in contemporary and traditional architectural practices. The theme of this research is to list the raw materials used for tile body composition and their availability in the Nepal Himalayas. In other words, investigate the probable formations for the availability of raw material in the Nepal Himalayas. The required raw materials like plastic raw materials, flux raw materials, and inert raw materials were available in the different zones of the Nepal Himalayas. Plastic raw materials are present in the Siwalik, flux raw materials are present in some igneous intrusion form, and inert raw materials are available in the Lesser Himalaya zone of Nepal. Clays and Kaolins are plastic raw materials that help ceramic products shape and give enough cohesion to the body during production. Feldspars, Feldspathic sands, and Feldspathoids are flux raw material that permits glass phase formation and accelerate chemical and physical transformation during the firing process. Silica sand and quartz are inert raw materials that help to reduce body plasticity and help to control shrinkage of the products, during firing together with clays, giving structure to the ceramic body. Talc, Dolomite, and, calcite work as corrective components to reach body-specific characteristics. The material colour, water absorption, shrinkage, loss of ignition, and their chemical compound play an important role in the quality of raw materials. In assessing raw materials for ceramic tile production in the Nepal Himalayas, common constituents like clay, silica, feldspar, and fluxed are essential.

Keywords: Ceramics; raw materials; properties

Recent normal faulting earthquake sequence in Dingri, south Tibet and its stress linkage to the 2015 Gorkha, Nepal earthquake

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South Tibet is characterized by east-west extension along several north-south trending rift systems. While various mechanisms have been proposed to explain this extension, its underlying cause remains debated. Shallow normal faulting earthquakes are a key manifestation of crustal extension in this region. Following the 2015 Mw 7.8 Gorkha earthquake on the Main Himalayan Thrust (MHT), a sequence of earthquakes (Mw>5) ruptured the middle segment of the Xainza-Dinggye rift over the past decade, including the most recent 2025 Mw 7.1 Dingri earthquake. Here, we determine the coseismic slip distributions for these earthquakes using InSAR measurements and investigate the stress changes on modeled fault plane induced by preceding events, as well as by the coseismic and postseismic processes (afterslip and viscoelastic relaxation) following the 2015 Gorkha earthquake. Our results indicate the 2015-2025 earthquake sequence represents a cascading failure triggered by Coulomb stress perturbations. A similar sequence of normal-faulting earthquakes in the rift system of south Tibet followed the 1934 Mw 8.2 Bihar-Nepal earthquake on MHT. We propose that the normal faulting earthquakes in south Tibet are largely triggered by great thrust events along the Himalayan arc. This perspective highlights the role of underthrusting India plate beneath Tibetan Plateau as a critical mechanism for crustal extension, particularly after the synchronous initiation of widespread rift systems.

Keywords: 2015 Gorkha earthquake; faulting; Tibetan plateau; InSAR

Impact of Climate and Land Use/Land Cover changes on the stream flow pattern of Mayurakshi river basin, India

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The study is focused on the impact of climate change and Land Use Land Cover Change (LULC) of the Mayurakshi river basin of India (a major agrarian belt) from 1991 to 2020 on stream flow. The trend and magnitude of climate change was estimated by the modified Mann-Kendall (mMK) statistics and Sen's Slope statistics. The change point statistic of the various climatic parameters during the said time period was evaluated by applying Pettitt Test, Standard Normal Homogeneity Test (SNHT), and Buishand's U test. In general, for the study area, the change point statistics showed that the computed p-value is lower than the significant level = 0.05 which indicated a significant change point in the climatic parameters. The LULC was executed by using the Random Forest (RF) a machine learning algorithm. The accuracy of the classified LULC was validated and accepted with Kappa agreements of greater than 0.85 for the study period. Throughout the study period, a decreasing trend was noticed in the LULC classes of water, vegetation, and bare-land while substantial increase in agriculture and built-up areas were recorded. The impact of climate and LULC on stream flow is evaluated by dividing the whole period into two segments as natural period (1991-2008), and impact period (2009-2020). The model's performance was finally evaluated by R^2 and Nash-Sutcliffe simulation efficiency (NSE) which demonstrated satisfactory performance of more than 0.80. In the natural period the surface runoff was 125.06mm and it decreased in the impact period to 118.33mm. The climatic impact towards decreased runoff of the basin was accounted to 65.35mm. LULC played positive role towards accelerated runoff of the basin (583.80%). It is hoped that this work will help in the proper planning of the river basin which faces regular floods and drought condition.

Keywords: Mayurakshi; rainfall trend; discharge; natural period; climate change

Himalayan lineaments: Implications for earthquake hazard assessment

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Lineaments have long been enigmatic features of the Himalayan orogen, often regarded as potential but poorly understood tectonic structures. The Mw 7.8 25 April 2015 Gorkha earthquake renewed attention to lineaments as two (Judi and Gaurisankar) may have influenced its rupture dynamics. Using ArcGIS and earthquake data since 1990, we tested the hypothesis that Himalayan lineaments are active faults based on their association with seismic activity. Our analysis identifies seven highly active Himalayan lineaments with more than 15 seismic events occurring within 10 km of their mapped extents. These include the Gaurisankar, Thaple, and Arun lineaments in central Nepal, the Martadi lineament in western Nepal, and the Thrizino, Old Brahmaputra, and Bomdila lineaments in northeast India (Assam). Locations are available here: *https://tinyurl.com/HimalayaLineaments.* Notably, the Old Brahmaputra and Bomdila lineaments extend into the Indian craton, indicating potential stress transfer. Two lineaments, the Gaurisankar and Thrizino, pose significant seismic risks due to their association with shallow (< 40 km deep) and high magnitude (M > 6.0) events located within 10 km of their mapped extents. Mapped Himalayan lineaments commonly trend NE-SW or NW-SE, and intersections between them often coincide with deep earthquakes (>50 km), suggesting that these record deep-seated tectonic processes related to the fragmentation of anomalies in the Indian craton. The findings provide a new perspective, emphasizing a network of lineament systems that must be considered when developing models for Himalayan orogenesis and deformation. These insights also have significant implications for regional seismic assessments. The role of lineaments likely extends to climate change adaptation through their influence on slope stability and groundwater resources, as well as natural resource exploration for localizing ore deposits or geothermal energy. Their potential as new geohazards is important to recognize for sustainable development in infrastructure planning, hazard mitigation, and land use management.

Keywords: Earthquake hazard; 2015 Gorkha earthquake; Himalayan orogenesis

Cenozoic structural framework and crustal shortening of the Himachal Tethyan Himalaya, northwestern India: implications regarding conflicting thermobarometry and stratigraphy

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The Tethyan Himalayan sequence (THS) is the structurally-highest lithotectonic unit of Indian affinity within the Cenozoic Himalayan orogen. In Himachal Pradesh, northwestern India, the Neoproterozoic–Cretaceous THS is thought to have relatively modest deformation, which contrasts that of other lithotectonic units closer to the foreland. In addition, burial depths of the Himachal THS estimated from structural reconstructions (~10 km) and basal metamorphic pressures (7–8 kbar, ~28 km lithostatic burial) conflict by nearly threefold. To address these issues, we performed geological mapping, thermochronology, and balanced cross-section restorations across the Himachal THS to better constrain its deformation state and timing, stratigraphic thickness, and burial extent. Along Spiti-Pin valley, the THS is shortened by nine, predominantly northeast-dipping thrusts that are mostly expressed as fault-propagation folds. Along Sutlej Valley to the southeast, the THS is shortened by four, mostly southwest-dipping thrusts. The timing of THS deformation is reflected in $^{40}Ar/^{39}Ar$ dates (ca. 24–18 Ma) from the basal section near the South Tibetan detachment and southwest-younging zircon (U-Th)/He dates (ca. 42–5 Ma) from throughout the section. Structural reconstructions of the THS suggest a stratigraphic thickness of ~12 km measured from the basal Akpa granite and Haimanta Group to the uppermost-exposed Tandi Group. Cross-section restorations along Spiti-Pin and Sutlej valleys yield minimum, horizontal shortening estimates of ~30 km (~22% strain) and ~8 km (~21% strain), respectively. These THS shortening estimates added to those for other Indian rocks in the Himachal Himalaya (Webb, 2013) yields a total minimum estimate of 515–537 km. Our results confirm that the Himachal THS experienced relatively minor Cenozoic shortening that may have been compensated by duplexing of other rocks at depth and/or closer to the foreland. Our findings also confirm the discrepancy in structural versus pressure-derived burial depths, which may be a product of Cenozoic, non-lithostatic pressure.

Keywords: Tethyan Himalaya; stratigraphy; structural; deformation

Two phases of post-onset collision adakitic magmatism in the southern Lhasa subterrane, Tibet: Geodynamic and metallogenetic implications

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Abundant Neogene adakitic magmatism occurred in the southern Lhasa subterrane after the onset of the India–Asia collision while convergence continued. However, the tectonic setting and magmatic evolution of the adakitic rocks and the associated porphyry-Cu mineralization are still under discussion. Two phases of post-onset collision adakitic magmatism have been identified in the southern Lhasa subterrane: an early late Eocene to Oligocene phase at ca. 38–25 Ma and a late Miocene phase at ca. 20–10 Ma. The eastern part of the southern Lhasa subterrane, which is situated to the east of the ~87°E line of longitude, is characterized by adakitic rocks and associated with Mid-Miocene (17-13 Ma) porphyry Cu–Mo deposits with minor potassium-rich volcanic rocks. The western part, which occurs to the west of the ~87° E line of longitude, mainly comprises potassium-rich volcanic rocks with sparse adakitic porphyritic plutons that are mostly barren. Laser ablation–inductively couple plasma–mass spectrometry (LA–ICP–MS) zircon U-Pb dating yielded crystallization ages of ca. 30 Ma for the monzogranite and ca. 15 Ma for the granodiorite. Both rock types have high Sr and extremely low Y and Yb contents and plot in the field of adakitic rocks on the Sr/Y versus Y and $(La/Yb)_N$ versus Yb_N diagrams. Furthermore, systematic variations in zircon trace-element compositions record fractional crystallization of specific minerals (e.g., titanite, magnetite) for the ca. 30 Ma monzogranite and equilibrium crystallization for the ca. 15 Ma granodiorite. Progressively reduced oxygen fugacity conditions during magnetite fractionation in the monzogranitic magmas resulted in sulfide segregation, thereby removing sulfur and chalcophile elements such as Ni and Cu from the melt.

In summary, we propose on the basis of in situ zircon trace-element geochemistry that magnetite fractionation within shallow to mid-continental crust may lead to the low Cu fertility of magmas, forming some of the Cu-poor post-onset collision adakitic rocks in the Gangdese magmatic belt.

Keywords: Magmatism; volcanic rocks; geodynamics

Geochemical Evolution of the Deltaic Sediments in Bangladesh

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Geochemical investigations were performed on the Bengal delta sediments in Bangladesh to evaluate weathering, paleoclimate, and provenance while sediments accumulated in the shelf area. High SiO_2 (up to 91 wt.%) and low Al_2O_3 (up to 17 wt.%) contents with a clear negative correlation (r = -0.98) demonstrate SiO_2 mainly controlled by detrital quartz rather than aluminosilicate. Marked depletion of Na_2O, CaO*, K_2O, Ba, and Sr comparative to the average upper continental crust (UCC) composition indicates progressive chemical weathering of feldspar in the source region. Sediments dominate quartz, feldspar, calcite, magnetite, titanite, and zircon. The index of compositional variability (ICV) and SiO_2/Al_2O_3 ratios vary from 0.79 to 1.83 and 3.47 to 22.69, respectively, implying that the sediments were compositionally early to moderate mature. The chemical index of alteration (CIA, ~67-81), chemical index of weathering (CIW, ~69-91), and plagioclase index of alteration (PIA, ~71-92) proxies suggest that the sediments were experienced in moderate to high chemical weathering under the warm and humid climatic conditions. The V/Cr (0.23-2.56), Ni/V (0.16-0.58), Ni/Co (2.06-4.37), U/Th (0.02-0.24), Cu/Zn (0.22-0.45), and V/V+Ni (0.45-0.75) elemental ratios implied oxic to sub-oxic environments preserving sediments in the shelf zone. Different provenance discriminant diagrams and the ratio values of Th/Sc (0.96-16.06), Zr/Sc (7.69-71.06), La/Sc (2.34-27.58), Cr/V (0.37-4.14), and Co/Th (0.07-1.67) support felsic source compositions such as granodiorite, rhyolite, granite and UCC. The LREE enrichment (La_N/Yb_N, 7.61-14.35), flat HREE (Gd_N/Yb_N, 1.33-2.25), and negative Eu anomalies (Eu/Eu*, 0.24-0.88), indicate the dominance control of the felsic materials. The immobile trace element ratios and REE proxy parameters are comparable all over the vertical section, denoting that felsic source materials were preserved throughout the sediment core.

Keywords: Geochemistry; delta sediments; chemical weathering; provenance; Bangladesh

Field relation and petrography of metabasic rocks from West-Central Nepal, Lesser Himalaya

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The Lesser Himalaya, marked by complex structural configurations including numerous faults and folds, is further complicated by magmatic intrusions across various stratigraphic horizons, depths, and periods. Within the central and western Nepal of the Lesser Himalayas, metabasic bodies have been identified within the Kuncha, Nourpul, and Robang Formations of the Nawakot Group. This study investigates the field relationships, stratigraphic context, and petrographic characteristics of these metabasic rocks to address gaps in their composition, occurrence, and textures. The methodology included detailed field mapping, stratigraphic column preparation, systematic sampling and petrographic analysis. The study covers four key sections: Jugedi, Ghumaune-Mugling, Anbukhaireni, and Malekhu, spanning south to north. Field observations reveal that metabasic rocks exhibit discordant relationships with host rocks in the Ghumaune-Mugling and Anbukhaireni sections, whereas concordant relationships are observed within the Nourpul and Robang Formations in the Jugedi and Malekhu sections respectively. Petrographic analysis shows a mineralogical assemblage comprising plagioclase, hornblende, actinolite, chlorite, quartz, and mica in the samples taken from all the sections. However, the Malekhu section is distinguished by a hornblende-rich composition (hb>45%), while samples from the Anbukhaireni section are dominated by biotite, actinolite, and chlorite, reflecting pronounced foliation and greenschist facies metamorphism. Quartz content across all sections averages 15–25%. Evidence of retrograde metamorphism is apparent, with hornblende breaking down to form chlorite and biotite in the Anbukhaireni region. Additionally, copper and iron ore minerals were identified through both hand specimen examination and reflected light microscopy of polished sections, indicating significant economic mineral potential. An attempt is made to describe the geological evolution of metabasic rocks in Nepal's Lesser Himalayas.

Keywords: Metabasic rocks; field relationship; petrography; retrograde metamorphism; Lesser Himalaya

Stratigraphic Analysis and Correlation of Carbonate Units in the Lesser Himalaya, Central Nepal

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The autochthonous succession of the Lesser Himalaya in central Nepal is characterized by several prominent carbonate bands. These include the upper part of the Nourpul Formation, Dhading Dolomite, Jhiku Carbonate Member of the Benighat Slates, and Malekhu Limestone. In west-central Nepal, carbonate units are stratigraphically identified as the Chhapani Formation, Khoraidi Formation, Saidi Formation, and Kerabari Limestone in ascending order. Additionally, the geological units developed in the Syangja section are identified as the Ripa Member of the Sorek Formation and Dhanpure Limestone. Fossils are notably absent in most of these carbonate units, except for rare occurrences of algal structures. The complex tectonic framework of the Lesser Himalaya, characterized by extensive folding and thrusting, presents significant challenges for precise geological mapping, stratigraphic interpretation, and resource development. To address these challenges, recent investigations focused on the Malekhu and Palpa-Syangja sections to refine the stratigraphic framework of carbonate successions in central Nepal, using these units as marker beds for stratigraphy work. Detailed vertical and horizontal stratigraphic analyses were conducted, supported by the preparation of columnar sections and route maps. Geological contacts of the carbonate successions were mapped, and petrographic studies were carried out to examine mineralogical and biogenic structures. The study identifies four distinct stratigraphic positions for carbonates in central Nepal, characterized by variations in lithology and algal structures. However, more than four carbonate positions are recognized in west-central Nepal, where notable lithological and biogenic differences are observed between the two regions. Efforts were made to correlate the carbonate successions from central to western Nepal, emphasizing regional variations in lithology and algal assemblages. This study significantly enhances our understanding of carbonate stratigraphy in the Lesser Himalayas and lays a solid foundation for future geological mapping, tectonic interpretations, and resource exploration in the region.

Keywords: Carbonate stratigraphy; stromatolites; petrography; correlation

Assessment of shallow groundwater and river water interactions along Budhi Rapati river in Chitwan, Nepal

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The interconnection between river water and groundwater plays a crucial role in maintaining water quantity and quality within hydrological systems. However, accurately observing and quantifying this interconnection remains challenging, especially in agricultural or urbanized regions. This study examines the interactions between shallow groundwater and the Budhi Rapati river in Chitwan, Nepal, with a focus on flow dynamics, water quality, and seasonal variations. Elevation head measurements, river stage data, and in-situ temperature profiles of groundwater and river water were collected to analyse flow patterns. Groundwater flow patterns in both pre-monsoon and post-monsoon seasons revealed multidirectional flow influenced by topography and seasonal groundwater dynamics. Notably, near the river, groundwater flows towards the river, indicating the river acts as a losing stream during the pre-monsoon period. This finding is supported by temperature data, which shows aligned groundwater and river temperatures, suggesting groundwater discharge into the river. Hydro-chemical analysis further revealed similar ion concentrations in both sources, with bicarbonate ions dominating, highlighting significant chemical exchange. The Piper diagram categorizes both groundwater and river water as mixed water types, underscoring strong hydro-chemical interactions. These results indicate that the Budhi Rapati river plays a significant role in recharging shallow groundwater, with notable seasonal variations influencing these interactions.

Keywords: Groundwater; river water; hydro-chemical; Budhi rapati river

Design and Construction of Mahadevtar Tunnel and challenges during excavation

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The Mahadevtar tunnel is situated in a lithology comprising rock from the Upper Nawakot and Bhimphedi Group. These rock successions are separated by the Mahabharat Thrust (MT). The excavation method employed is the New Austrian Tunneling Method (NATM), resulting in two fully lined tubes. During design and construction, variations in rock composition were encountered. Similarly, the expected support types for detailed design and construction also exhibited some diversity. Challenges during construction included weathered and jointed rock masses, fault and shear zones (main fault is Mahabharat Thurst passing across the tunnel alignment), and groundwater inflow. Pedestrian cross tunnel seems to be shifted 50 m ahead than designed location due to occurrence of MT. Overbreaks and collapses occurred due to weak rock and joint conditions. Addressing these issues involved installing additional ribs, rock bolts, grouting, and replacing sections in the exit left and right tunnels.

Keywords: Tunneling; Mahabharat Thrust; excavation

Revised Lithostratigraphy and Paleo-Lakes of the Pokhara Valley: A Scientific Perspective

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Pokhara, nestled within the intermontane basin of the Lesser Himalaya in Nepal, showcases a dynamic geological landscape defined by its significant terraced topography. Spanning approximately 50 Km from its upper to lower reaches, the valley presents a rich stratigraphic record of Quaternary sediments. A contemporary lithostratigraphic framework for the Pokhara Valley has been meticulously developed, incorporating diverse geological and geomorphic factors. The framework integrates key characteristics such as the geomorphic features of the deposits, the relative elevation of terraces above the riverbed, and sedimentary attributes including composition, structure, and texture. Complementary geological cross-sections and columnar sections were systematically prepared to illustrate these stratigraphic units. This effort has culminated in the classification of Pokhara Valley sediments into eleven distinct lithostratigraphic units: Begnas, Siswa, Tallakot, Phurse, Ghachok, Pokhara, Gagangauda, Mardi Khola, Tal Khola, Rupakot, Phewa, and Chankhapur Formations. These formations collectively represent sedimentary deposits from the Quaternary period. The development of a detailed geological map at a 1:25,000 scale, complemented by geological cross-sections, has provided a spatial understanding of the valley's stratigraphy. A particularly striking feature of the Pokhara Valley's sediments is the fine-grained deposits associated with paleo-lake environments and river damming events, which are evident in certain tributary regions. These deposits suggest that the valley experienced several phases of lacustrine activity, river damming, and glacial washout damming during its geological history. To elucidate these findings, several conceptual models are proposed to explain the origins and evolution of these paleo-lakes.

Keywords: Quaternary stratigraphy; paleo-lakes; geomorphic features; Pokhara Valley

Geological Mapping and Facies Analysis of the Southwest Kathmandu Basin: Emphasizing Stratigraphic Framework and Settings

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The Kathmandu Valley, nestled in the heart of the Lesser Himalaya, is a unique intermontane basin surrounded by Shivpuri Lekh to the north, Nagarkot to the east, Chandragiri to the southwest, and Phulchouki to the south. This basin holds a treasure trove of geological features, including lignite deposits, Pleistocene fossil assemblages, and diverse lacustrine as well as fluvial sediments. Drained by the Bagmati River and its tributaries in a striking centripetal drainage pattern, the valley's geology remains underexplored, especially in terms of its unified stratigraphy and facies. This study addresses the gaps by defining stratigraphic units, identifying facies associations, and producing a detailed geological map at a 1: 25,000 scale. Rigorous fieldwork, including the preparation of vertical columnar sections and detailed exposure analysis, led to the identification of five distinct stratigraphic units. The oldest, the Tarebhir Conglomerate, is composed of coarse-grained sediments. This is followed by the Lukundol Formation with silty clay and lignite beds, the Sunakothi Formation dominated by silt, the arkosic sand-rich Thimi Formation, and the clay-dominated Kalimati Formation. The study also identified eleven lithofacies, unravelling three major depositional environments: fluvial, lacustrine, and a mixed fluvial-lacustrine setting. These findings highlight multiple sedimentary events that shaped the basin's dynamic history.

Keywords: Kathmandu basin; stratigraphy; depositional environment; facies analysis

Assessment of blasting vibration and adverse impact on the underground support system and surrounding structure

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The drilling and blasting method (DBM) of excavation is still economical and efficient where various underground openings are required. DBM is highly preferred in the Himalayan geology where variation in rock mass is very common. It is also estimated that 7-25% of energy utilized for fracture and removal of rock fragments, remaining amount of energy released in the form of ground vibrations, heat, light, noise and fly rock. The escaped energy in the form of wave energy which is measured in Peak particle velocity (PPV). Blast-induced ground vibrations can impact the underground support systems, causing damage and compromising structural integrity. The effects of these vibrations are complex and depend on various factors, including rock mass characteristics, blast design, and support system properties. Several studies have investigated the relationship between blast-induced vibrations and tunnel damage. PPV is commonly used as a measure of vibration intensity, with site-specific attenuation models developed to predict PPV based on scaled distance. Interestingly, blasting cycles can result in damage at lower vibration levels than the critical PPV. Additionally, the frequency content of the vibrations plays a crucial role in determining the potential for damage, with low-frequency waves contributing to far-field damage and the vibration effects surrounding building and other civil structures. A comprehensive approach to assessing and mitigating blast-induced damage to nearby underground support systems should consider multiple factors, including PPV, frequency content, rock mass properties, and cumulative effects of repeated blasting. Site-specific studies can provide more accurate predictions of blast-induced vibrations and their potential impacts on underground and surrounding structures. One of the controlling mechanism of the controlling ground vibration is blast design optimization by adjusting blast patterns, charge weights, and delay design. In this study, some approaches to study the PPV and its effects on support system and surrounding structures are given.

Keywords: Blasting; Peak particle velocity; Structure damage

Numerical Modeling and Simulation of the Large-scale Landslide Dynamics

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Numerical modeling provides valuable insights into the failure mechanisms and post-failure dynamics of large-scale landslides. The occurrence of many large landslides in central Nepal Himalaya signifies the importance of the numerical approach in this region. This study deals with the application of the particle finite element method (PFEM), a Lagrangian-based numerical approach to examine the post-failure behavior of the Jure Landslide in Sindhupalchok. The analysis is based on field-acquired data that helped to estimate the failure surface. The friction angles of the failure and runoff planes were calibrated using iterative computations of model simulations to execute the model outputs. The results highlighted the significant influence of geotechnical, geological, and structural variables linked to slope geometry during landslide initiation and evolution processes. The PFEM simulation demonstrated that the friction angle of the failure and runoff planes played a critical role in determining the volume of debris deposited in the river channel. Material characteristics were also identified as key factors affecting failure dynamics and debris impact. Furthermore, river water dynamics amplified the impact of landslide debris within the affected area, highlighting the intricate interplay between geological and hydrological processes in landslide behavior. This approach effectively simulated the post-failure dynamics, providing detailed insights into debris trajectories and deposition patterns. The innovative application of PFEM to the large-scale landslide has confirmed its potential as a robust tool for advancing the understanding of complex landslide processes in the Himalaya. These findings will contribute to improving hazard assessment, disaster mitigation strategies, and infrastructure planning in landslide-prone regions.

Keywords: Numerical modeling; large-scale landslide; PFEM; simulation; post-failure dynamic

Geological Investigation of the Thabang-Jaljala Section in Western Nepal

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The Jaljala thrust sheet in western Nepal remains relatively understudied. This research focuses on its geology, emphasizing stratigraphy, geological structures, deformation, and metamorphism. The primary objective is to produce a detailed geological map at a 1:25,000 scale and prepare cross-sections to understand the structural framework of the region. Field investigations along the Lukum Bazar–Mahatgau–Thabang–Jaljala section involved detailed columnar section preparation, geological mapping, systematic sample collection, and database development for microfossil and petrographic studies. The study area exhibits a distinct geological framework, where low-grade metasedimentary rocks of the Nawakot Group (autochthonous succession) are overlain by medium-grade crystalline rocks of the Jajarkot thrust sheet (allochthonous succession), separated by the Mahabharat Thrust (MT). Additionally, unmetamorphosed fossiliferous sedimentary rocks of the Jaljala Group overlie the crystalline units. The autochthonous sequence resembles with the rocks of the Benighat Slates, characterized by laminated calcareous slate, dolomite, and quartzite. The allochthonous succession includes three crystalline units: the Lukum Formation, consisting of quartzite interbedded with pelitic and psammitic schist and fine-grained garnet-bearing schist; the Chaurjahari Formation, containing medium- to coarse-grained garnet-bearing schist and quartzite; and the Thabang Formation, comprising garnet- to biotite-grade schist and marble interbedded with thin quartzite layers. Transitional boundaries are observed within these units. The Jaljala Group's sedimentary rocks include limestone interbedded with phyllite and sandstone, containing conodont fragments in the lower part and laminated sandstone with crinoid and trilobite fragments in the upper part, indicating a Paleozoic age. Metamorphic intensity decreases toward younger sedimentary strata, disappearing entirely in the Jaljala Group. Based on field relationships, petrographic characteristics, and fossil assemblages, these strata can be correlated with the rocks of the Kathmandu Nappe and the Kahun Klippe in central and west-central Nepal respectively. Detailed investigations of microstructures and microfossils are currently underway.

Keywords: Jaljala Group; stratigraphy; microstructures, conodonts

Railway network plan in Nepal

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Nepal's railway network, historically limited to colonial-era lines built by the British in the 1920s–1930s, is undergoing transformative expansion to enhance regional connectivity and economic growth. The government's ambitious Railway Network Plan prioritizes six strategic projects. The flagship East-West Railway (945 km), detailed project report prepared by India's Konkan Railway Corporation Limited, will parallel the Mahendra Highway, linking key Terai cities like Biratnagar and Nepalgunj to boost domestic trade and cross-border ties with India. Urban mobility is addressed by the Kathmandu Metrorail (27 km), a proposed high-capacity transit system connecting critical nodes such as Tribhuvan Airport and Kalanki, backed by South Korea's KOICA for feasibility studies. Cross-border connectivity is central to two major initiatives: the Kerung–Kathmandu Railway (170 km), part of China's Belt and Road Initiative, aims to traverse the Himalayas, reducing Nepal's trade dependency on India and unlocking tourism potential. Meanwhile, the Raxaul–Kathmandu Railway (136 km), still in draft stages, seeks to streamline Indo-Nepal trade. Additionally, upgrades to the historic Jayanagar–Bijalpura line and the new Bathnaha–Biratnagar route emphasize India-Nepal economic integration. These projects face challenges, including rugged terrain, funding constraints, and geopolitical coordination. However, they promise to revolutionize Nepal's transport sector by slashing logistics costs, easing road congestion, and positioning the country as a transit hub between India and China. Nepal's railway expansion signifies a strategic leap toward economic modernization and regional integration. By leveraging partnerships with India and China, the nation aims to overcome geographic barriers, stimulate trade, and foster sustainable development, marking a critical shift from road-dependent transport to a diversified, efficient rail network.

Keywords: Railway network expansion; economic Integration; challenges

From Rocks to Records: Geology and Stratigraphy of Barhabise-Tatopani, Central Nepal

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Geological mapping was conducted along the Barhabise-Tatopani section of central Nepal, covering a significant portion of the Lesser Himalayas. The study aimed to investigate the geology and lithostratigraphy of the area to address unresolved issues related to stratigraphy and depositional environment. Field observations included bed-by-bed analysis of rock types, mineralogy, and depositional features, along with mapping the vertical and lateral continuity of geological units. Columnar sections were prepared from multiple traverses, and petrographic analyses were performed on representative samples. The study area comprises crystalline rocks of the Higher Himalayas and meta-sedimentary sequences of the Lesser Himalayas, differentiated by lithological, stratigraphic, and tectonic characteristics. Six lithological units were identified in the Lesser Himalaya, in ascending order: Barhabise Formation, Chaku Metasandstone, Daklang Schist, Narayanthan Formation, Ghumthang Dolomite, and Tatopani Schist. The Barhabise Formation dominates the area, consisting of schist and metasandstone with subordinate quartzite and marble near the stratigraphic top. Calcareous metasandstone occurs within the Chaku Metasandstone. The Daklang Schist and Narayanthan Formation, with limited exposures, comprise schist, metasandstone, and quartzite. The Ghumthang Dolomite is mainly siliceous dolomite with poorly developed stromatolites, while the Tatopani Schist includes carbonaceous garnet schist and dolomite-marble interbedded with schist, classified as Larcha Carbonate. The Main Central Thrust (MCT) places Higher Himalayan crystalline rocks over Lesser Himalayan units in the Tatopani area. The Higher Himalaya consists of banded gneiss, schist, and quartzite in various proportions. The Sunkoshi Anticline, a regional fold, influences the stratigraphy, while the upper Barhabise Formation and Chaku Quartzite exhibit calcareous characteristics.

Keywords: Stratigraphy; depositional environment; MCT; Lesser Himalaya

Structural control on the landscape evolution and avulsive behavior of the Kosi River in eastern Nepal Himalaya

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The Kosi River flows from the eastern Nepal Himalaya into Bihar (India) and has experienced frequent avulsions, causing extensive flood-related damage. The avulsion of 2008 was the most catastrophic avulsion event recorded for the Kosi and has been attributed primarily to hydrological and sedimentological processes that formed a super-elevated river channel and caused avulsion. Detailed topographic analysis of the region near the Kosi exit from the Himalayas, using mean-corrected and resampled 1-arc, Shuttle Radar Topography Mission (SRTM) and Real Time Kinematic Global Positioning System (RTK-GPS) datasets, reveals that the Kosi channel is super-elevated only relative to its eastern floodplain. The western floodplain elevation is similar to or higher than the Kosi channel in the region between the Kosi River exit from the main east Nepal Himalaya and the Kosi barrage at the Indo-Nepal border. Structurally, the Kosi exits the Himalaya in the transition zone between the closed Trijuga dun to the west and the Dharan salient to the east. The Trijuga dun is closed by the Main Frontal thrust (MFT)-related frontal topography or the Outer Churia Hills. The eastern slopes of these hills induce west-to-east topographic slope in the channel, such that topographic avulsion indices are highest only in the Outer Churia Hills affected parts of the Kosi Channel and the 2008 avulsion region. Therefore, our preferred model for the primary control on the channel's asymmetric, metastable, super-elevation is the influence of the tectonically controlled MFT-related Outer Churia Hills on the Kosi River channel. Geomorphological processes have operated in the Kosi channel in this backdrop. This study emphasizes that detailed structural and topographic analysis of river exits from mountain belts like the Himalayas can provide better insights into river channel metastability and avulsion worldwide.

Keywords: Koshi river; hydrology; sedimentology; avulsion

Secular change of metamorphic features in the Himalayan orogen during the Cenozoic and its tectonic implications

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The Himalayan orogen is an archetype of collisional orogens built by the continental collision between India and Asia in the Cenozoic, and it has been a natural laboratory for studying the tectonic evolution of continental collision zones. Various tectonic models interpret its formation and evolution, often based on localized structural and petrological observations that sometimes conflict. Metamorphic rocks, with their pressure-temperature (*P–T*) records, are key to reconstructing the tectonic evolution history of the orogen. Here we review the metamorphic evolution of crustal rocks across the Western, Central, and Eastern Himalayas, identifying spatial and temporal trends in *P–T* paths and *T/P* ratios. The evolution is divided into three periods: (1) Pre-collisional period (Early Jurassic–Paleocene): Characterized by low *T/P* Alpine-type metamorphism, forming high-pressure (HP) blue-schists in the Western and Central Himalayas. (2) Syn-collisional period (Paleocene–Eocene): Early stages (Paleocene–early Eocene) involved deep subduction at low *T/P* ratios, producing HP to ultrahigh-pressure (UHP) eclogites in the Western Himalayas. Late stages (early–late Eocene) witnessed hard collision at moderate *T/P* ratios, forming Barrovian-type amphibolite and granulite in the Central and Eastern Himalayas. (3) Post-collisional period (Oligocene–Pliocene): Initially marked by moderate *T/P* metamorphism, transitioning to high *T/P* conditions in the Miocene, resulting in Buchan-type HT to UHT rocks and extensive anatexis in the Central and Eastern Himalayas. The spatiotemporal variation in metamorphic *T/P* ratios reflects transitions from oceanic subduction to continental collision and post-collisional extension. This secular change reveals shifting geothermal gradients and tectonic regimes, supporting the orogenic wedge model. Failed continental rifting is proposed as a viable mechanism for high *T/P* metamorphism and granitic magmatism in the intracontinental orogen.

Keywords: Orogen; metamorphic; anatexis; tectonic

Geological Mapping and Facies Categorization of Quaternary Sediments in Southeastern Kathmandu Valley

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The study focuses on the lithostratigraphy and sedimentary facies analysis of the southeastern part of Kathmandu Valley to develop a unified stratigraphic framework and interpret the paleo-depositional environment. Extensive fieldwork, combined with borehole data, facilitated the creation of detailed columnar sections and a geological map at a 1: 25,000 scale, along with cross-sections illustrating sedimentary structures and depositional patterns. The southeastern Kathmandu Valley, the intermontane basin of the Lesser Himalaya, contains up to 650 meters of Quaternary fluvio-lacustrine deposits. Stratigraphic units in the study area include the Tarebhir Conglomerate, Lukundol Formation, Sunakothi Formation, Kalimati Formation, and occasionally the Thimi Formation. These units exhibit a transition from fluvial sedimentation in the south to lacustrine deposits in the north. The Lukundol Formation represents swampy fluvial deposits, the Sunakothi Formation consists of fluvial-lacustrine sediments, and the Kalimati Formation is dominated by black lacustrine clay. Additionally, thick alluvial and colluvial deposits are present near the southern hillslopes. Some coal beds and fossiliferous horizons are also traced out in this study. However, the identification and interpretation of those fossils are under study. Facies analysis identified eleven sedimentary facies, which were grouped into three facies associations: fluvial (FA1), fluvial-lacustrine (FA2), and lacustrine (FA3). These facies associations reflect the dynamic depositional environments and processes that shaped the southeastern Kathmandu Basin.

Keywords: Sediments; Quaternary stratigraphy; facies analysis; depositional environment

Geological Mapping and Structural Analysis of the Kathmandu Nappe and Nawakot Group Interface, North-West of Kathmandu, Central Nepal

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A geological study along the Pasang Lahmu Highway, from Kathmandu to Battar Bazaar, investigated the lithological, metamorphic, and structural characteristics of the Lesser Himalayan autochthonous unit (Nawakot Group) and the Kathmandu Nappe. The study aimed to produce detailed geological mapping at a 1:25,000 scale to clarify the geological setting, stratigraphy, petrography, and microstructural and metamorphic features of the region. The area comprises both autochthonous and allochthonous rock successions, separated by the Mahabharat Thrust (MT). The Lesser Himalayan rocks, including the Benighat Slates, and Robang Formation, exhibit inverted metamorphism at the footwall of the Kathmandu Nappe, transitioning from the biotite zone in the Benighat Slates to the garnet zone in the Robang Formation. Similarly, the Kathmandu Nappe rocks such as Kalitar Formation, Gneiss Zone, Tistung Formation, Sopyang Formation and Chandragiri Limestone -shows inverted metamorphism north of Kakani, where the garnet zone is overlain by the sillimanite zone. In contrast, the southern region exhibits normal metamorphic zonation, with the biotite zone above the chlorite zone. Petrographic and microstructural analyses revealed evidence of polyphase deformation (D1–D5) involving both Pre-Himalayan and Syn-Himalayan phases. Features such as folds, mineral fish, and boudinage structures indicate a southward shear sense. The Mahabharat Thrust plays a significant role in controlling deformation and metamorphism in this region. Inverted metamorphism in the hanging wall is linked to high-temperature contact metamorphism from pegmatite intrusions. The study has revised the region's stratigraphy, tectonic history, and metamorphic processes, highlighting poly-deformation and polymetamorphism as key characteristics.

Keywords: Mahabharat Thrust; metamorphis; microstructures; deformation; inverted zonation

Geological Prospection of Talc and Magnesite in the Bhotekoshi River Section

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High-grade talc and magnesite mineralization has been identified in the Listi, Karthali, and Phulpingkatti regions along the Bhotekoshi River section in Sindhupalchok. These deposits are hosted within the dolomitic marble of the Lesser Himalayan rock sequence. The study aimed to understand the mineralization and its geological context through geological field mapping at a 1:25,000 scale, combined with columnar sections to examine field relations with host rocks. Petrographic studies under thin and polished sections, geochemical analysis, and X-ray Diffraction (XRD) analysis were used to analyze the concentration, texture, structure, and mineral associations. Magnesite occurs as bedded deposits ranging in thickness from 15 to 30 meters, situated at the upper boundary of dolomitic marble and the lower boundary of garnet mica schist. It exhibits prismatic and bladed textures and emits a fetid odor when hammered. Talc is present as lenticular milky white deposits associated with magnesite in the form of lenses and pockets, with an average thickness of 50 centimeters. Geochemical analysis revealed MgO concentrations in magnesite ranging from 36% to 43%. XRD analysis of talc indicated a monoclinic crystal structure with clinochlore and a composition primarily of aluminum, silica, oxygen, and gadolinium. XRD analysis of magnesite showed peaks corresponding to a trigonal crystal system and hexagonal axes. Petrographic analysis revealed coarse crystalline magnesite with rhombohedral cleavage, along with inclusions of chlorite and quartz. The mineralization shows a concordant relationship with the host dolomite, suggesting a synsedimentary origin for magnesite, while talc is interpreted to have formed through metamorphic replacement. These findings highlight the geological significance of talc and magnesite deposits in this region and their potential economic value.

Keywords: Magnesite; talc; petrography; XRD analysis; geochemical analysis

Rock durability and abrasion characteristics: a case study of the Nawakot Group in Bagmati Province

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Rocks' durability and abrasion character play a pivotal role in their selection for engineering applications, ensuring stability and longevity in construction. The slake durability test evaluates the resistance of rocks to disintegration through wetting and drying cycles, while the LAA test assesses their resistance to abrasion and wear under impact and shear forces. The samples for the present study were collected from the Lesser Himalaya region of central Nepal, specifically from quartzite and gneiss units located within 3-4 km of the Main Central Thrust (MCT) zone. The objective of this study is to establish a correlation between the slake durability index (Id_2) and the Los Angeles Abrasion (LAA) loss for these rock types, aiming to propose empirical equations for estimating one property based on the other. The methodology involved testing ten oriented rock samples (five quartzite and five gneiss) collected from natural, unweathered exposures at depths of about 1 meter inside from the exposed surface. The samples, uniformly sized at 45–55 mm in diameter, totaled 10–12 and weighed approximately 450–500 grams. The slake durability test was conducted using a slake durability drum (conforming to ASTM D4644), and the LAA test employed a Los Angeles abrasive machine with a 5000-gram sample and charge of steel spheres, following ASTM C131 specifications. Both tests utilized the metric measurement system for accuracy. The LAA values for quartzite range from 24.75 to 31.63, while those for gneiss range from 42.3 to 51.7. Correspondingly, the slake durability index (Id_2) varies from 97.33 to 98.64 for quartzite and from 95.38 to 97.24 for gneiss. Empirical formulas were derived: for quartzite, $Id_2 = 102.36 - 0.16 \times LAA$ ($R^2 = 0.85$), and gneiss, $Id_2 = 104.75 - 0.18 \times LAA$ ($R^2 = 0.53$). This relationship has high practical insights into material evaluation for engineering purposes.

Keywords: Slake Durability Index; Los Angeles Abrasion, engineering properties, quartzite, gneiss

Revealing landscape dynamics in the Terai Arc: combining paleoecology and geomorphology to study human impact

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The Terai Arc landscape is home to a unique ecosystem, as well as a high human population density. Because of this, conservation methods are being revisited, especially in and around national parks, to support a good balance between people and wildlife. Studying the interactions between humans and the environmental context through combining paleoecology with geomorphology can help to inform effective landscape conservation policies. Current knowledge on the Terai landscape of the past, is largely informed by modern landscape observations combined with linguistical studies of human migration and some archeological findings, giving an approximation of Tharu arrival in the Terai. Quantitative data to support the findings and the resulting landscape changes is however largely lacking. To generate this data, we collected two lake sediment cores from the Bardia district. By extracting and analyzing pollen, phytoliths and sedimentary ancient DNA from these cores, we use a multiproxy approach to reconstruct the past vegetation, animals and land use. Preliminary findings appear to support a transition in the ecosystem around 1.000 cal. yr. BP. To further support the interpretation of the data, we opted to collect data on past river channel patterns by identifying and dating past paleochannels corresponding with our lake sites. Through Optically Stimulated Luminescence dating, the age of activity of these channels will be identified. This will help identify if ecosystem transitions were human- or geomorphologically induced. Overall, this study can support uncovering the settlement of people in this landscape, and show what impact their land use had on the system. This in turn, supports decisions on modern landscape management, as it can be better predicted which outcomes will come from possible interventions.

Keywords: Landscape; pollen; geomorphology

Investigating crustal structure and implications for faulting near the Main Himalayan Thrust in Nepal using local earthquakes

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In response to the devastating April 25, 2015 M7.8 Gorkha earthquake on the Main Himalayan Thrust in Nepal, we deployed a rapid response seismic network known as NAMASTE (Nepal Array Measuring Aftershock Seismicity Trailing Earthquake) for ~11 months beginning ~7 weeks after the main shock. The network consisted of 41 broadband and short-period seismometers and 14 strong motion sensors at 46 sites across eastern and central Nepal. The network spanned a region approximately 210-km along-strike by 110-km across strike. The region covers the earthquake rupture area from east to west and extends from south of the Main Frontal Thrust to the northern edge of the rupture from south to north, with a station spacing of ~20 km. Using the data from this network, we relocate thousands of aftershocks, calculate their magnitudes, and determine the focal mechanisms for the larger events. We used Boulder Real Time Technologies Antelope seismic analysis tools and the HypoDD double-difference earthquake location algorithm to obtain locations. Relocations of aftershocks from the NAMASTE network appear to illuminate the Main Himalayan Thrust at depth as well as several other possibly related fault structures, including strike-slip faults. Using P- and S-wave arrival time picks from several thousand aftershocks, we invert for P and S-wave velocity models of the lithosphere beneath the Nepalese Himalayas using a regional-scale double difference tomography. We examine complex structural changes along the India-Eurasian plate boundary and discuss implications for future earthquake hazards in this region.

Keywords: Earthquake; seismic tools; tomography; structural

The Early Jurassic *Lithiotis*-type Bivalves buildups along Tethyan margin of Pangea – Albanian-Nepal connections

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The large bivalves of so-called "Lithiotis" facies (*Lithiotis*, *Cochlearites*, *Lithioperna*, *Mytiloperna*, *Gervileioperna*) are most significant representatives of buildup-maker of shallow marine/lagoonal bivalve mounds/biostromes („reefs") in various locations around the Pangea during Pleinsbachian-Early Toarcian time. In Europe they are known from Alpine Spain, Italy, Slovenia, Croatia, Albania, Greece, where they constitute part of the Early Jurassic Alpine-Dinaridic-Hellenidic carbonate platforms with different kind of shallow carbonate environments, including peritidal to subtidal sedimentation regimes. The spectacular continuous section with limestone rich in these bivalves is located in north-western part of the Albanian Alps. Taphonomic and autecological analysis of bivalves-rich horizons based on semi-quantitative observation of orientation of shells and density of their occurrence indicate dominance of parauthochthonous associations with a few places with record of shells in life position. Plant roots were recognized close to bivalve accumulations. Some lithiotid beds have oblique, lens-shape character and correspond to "biostrome" nature in origin. Bivalve-rich limestones/marls are intercalated by oolitic/oncolitic leyers which indicate occasional shifts to higher-energy shallow-water (subtidal?) carbonate environments. Simultaneously, *Lithiotis*-type bivalves biostromes, which have recently been discovered in three sections along Kali Gandaki valley (Thakkhola region of northern central Nepal), are characteristic also for other parts of the Himalayan-Karakorum area. Palaeogeographicaly, these deposits located several thousand kilometers from their European counterparts but along the same southern margin of the Tethys Ocean, and belong to the so-called Kioto Carbonate Platform, which is represented by extremely shallow-marine palaeoenvironments, i.e. alternating intertidal clastic-rich layers, bivalves-bearing biostromes and oolitic/oncolitic limestones. Association indicates restricted palaeoenvironment probably either closed lagoons or transitional regions between nearshore and open marine conditions. The widespread occurrences of *Lithiotis*-facies bivalves along the peri-Gondwanan margin of Pangea, constitute of an extensive relatively continues carbonate platforms system with shoreline sometime occupied by coastal vegetation, possibly mangrove-like plants (Albania) and/or emersion features (both in Albania and Nepal).

Keywords: Bivalve; Tethys; biostrome; Thakkhola region

Oxidising the mantle wedge: on carbon and sulfur interplay in subduction zone fluids

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CO_2 and SO_2 degassing at volcanic arcs are thought to require oxidised sulfur and carbon dissolved in subduction-zone aqueous fluids to increase the mantle wedge redox state, enabling arc magma genesis. However, how sulfur is mobilized and transferred by fluids at subarc depths remains unclear. Via electrolytic fluid thermodynamic modelling at subarc depths and at varying redox conditions, we explore the nature of dissolved sulfur and carbon derived from deeply subducted and dissolving meta-carbonate sediments. Modelling shows that pyrite, the most common sulfur mineral in subduction zones, dissolves into sulfate, sulfite and sulfide ionic species, while carbonate minerals dissolve into ionic carbonate and bicarbonate species. This behaviour is modelled to also occur in serpentinites and eclogites, suggesting its general relevance in the downgoing slab. Evaluation of sulfur and carbon redox impact onto the subarc mantle reveals that at first, carbon and sulfur act as mantle oxidants; however, once carbonate minerals are stabilised into the mantle wedge, only sulfur can increase the mantle's redox state. Finally, a global mass balance of oxidised COHS slab fluids shows how combining dissolved oxidised carbon and – chiefly – sulfur leads to full mantle wedge oxidation within a few million years of subduction initiation. These results show how sulfur mobilisation at convergent margins can impact and facilitate lithosphere scale processes like magma genesis below volcanic arcs and release geogenic climate-forcing gasses like CO_2 and SO_2.

Keywords: Subduction zone; thermodynamics; modelling

Tectono-metamorphic evolution of the Gyeonggi Massif in the Seoul area, Korea: An ancient analog of the Himalayan orogen

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The geology of the Seoul metropolitan area and adjacent areas in west-central Korea consists primarily of Paleoproterozoic (ca. 1.85 Ga) basement gneisses and schists intruded by Mesozoic granites of ca. 230 and 170 Ma, respectively. These rocks often form mountainous hills around Seoul, which have served as popular hiking trails for foreign tourists. In this study, a complex evolutionary history of tectono-metamorphism in the basement gneisses of Mt. Cheonggye (618 m), located south of Seoul has been carried out. Major lithology includes biotite gneisses, K-feldspar megacrystic orthogneisses, and metapelitic gneisses, which are migmatized and deformed to varying degrees. Mineral assemblages and reaction textures of the gneisses were used to define a composite pressure-temperature path given by two clockwise trajectories, M1 and M2. Pseudosection modeling constrains peak metamorphic conditions for M1 as ~10.5 kbar and 840-860 °C, followed by M2 recrystallization at 4.5-5.5 kbar and 720-770 °C. Both M1 and M2 events were well dated using a sensitive high-resolution ion microprobe (SHRIMP). The U-Pb ages of zircon and monazite define the M1 event as ca. 1.86-1.85 Ga. In contrast, some monazite grains yielded U-Pb ages of 235-231 Ma, suggesting a strong thermal overprint associated with the Triassic continental collision between the North China and South China cratons. Finally, a post-kinematic leucogranitic dyke intruded at 226 ± 5 Ma, suggesting the end of the crustal thickening event. The Triassic collisional orogeny is prominent throughout the East Asia, including the Gyeonggi Massif, and can be explained by the Qinling-Gyeonggi microcontinent model, where the accretionary tectonics of arc-related rocks over basement rocks is prolonged and widespread. Such juxtaposition of different lithologies in the Gyeonggi Massif eventually produced tectonic mixtures with affinities close to either the North China or South China cratons.

Keywords: Mesozoic granites; lithology; Himalayan orogeny

Tracking flood events including glacial lake outburst floods in a warming climate using seismology

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Glacial lake outburst floods (GLOFs) are a significant natural hazard in high mountain regions as they are intensified by climate change through faster glacier retreat. Since 1990, the world's glacial lakes have grown in size, number, and volume by over 50%, putting downstream people at greater risk of catastrophic floods. Our research uses geophysical methods to better understand these risks, with a special focus on the evolving hazards in Bhutan's high-altitude lakes. Ninety million people in thirty countries live in areas vulnerable to GLOFs, with High Mountain Asia facing the highest risks. In Bhutan, changes in the Lunana glaciers endanger downstream communities, in spite of an established early warning system consisting of manual and fully automatic based. To improve risk assessment, we will use seismic and radar analyses to study glacier movement and lake stability. So far, we've created 3D models of Thorthomi Tsho in QGIS, mapped Bhutan's seismic stations, and analyzed seismic data from the Wangdue station to detect potential flood and landslide activity. We've also developed a 3D flyover video of Thorthomi Tsho from Thanza village, offering a new way to visualize potential hazards. Recently, we received hands-on training in using Kinemetric Q8 digitizers and Nanometrics Trillium Compact Horizon seismometers and learned how to deploy them in the field. Looking ahead, we are preparing for a field expedition to Bhutan in March, where we will install several seismic stations near Punakha and the Pho Chu River as part of our new NSF-funded project. These stations will help us monitor GLOFs, track river dynamics, and study sediment transport, all while contributing to better early warning systems. By strengthening disaster resilience in mountain communities, our work supports Sustainable Development Goal and highlights the urgent need for proactive solutions as climate change continues to reshape high-altitude landscapes.

Keywords: Flood; climate; GIS; kinematric

Implementation of TBM Tunneling Project in Nepal, Himalaya

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Geologically, Nepal is broadly divided into five major tectonic zones which include Terai, Siwalik, Lesser Himalaya, Higher Himalaya and Trans-Himalayan zones from south to north respectively. Each geological division has their own inherent general characteristic both mechanically and geologically. At the same time these divisions also possess some unexpected characteristic to offer for the development projects in there. So far, tunneling of two multipurpose projects (BBDMP and SMDMP) having more than 12 Km and 13 Km length have been completed in Nepal. The rugged topographical terrain put forward the opportunity of challenge and when combined with the former surprising characteristics, the threat to construction of tunnel through such regions becomes intensively enough forcing the development agency to re think on the decision to use tunnel boring machine. The design aspect of the project shall consider all geological, geotechnical/mechanical, hydrogeological aspect of the geological units along the alignment of the tunnel so that the proper types of the machine with necessary ancillary facilities are designed. The tender document shall clearly state the risk sharing mechanism of the ground conditions likely to encounter in addition to the pre excavation site investigation programs which otherwise was impossible because of the cost incurred and terrain difficulties. During construction the adoption of the pre anticipated corrective and excavation measures has to be followed and the risk sharing mechanisms has to be applied. Each party shall be made obliged for their respective duties, performance and nonperformance of such duties in terms of general and special conditions of contract and technical specifications/employers requirement. It will be very helpful to complete the tunneling contract within stipulated time and cost. Therefore, proper understanding of geotechnical condition along the tunnel alignment, the careful and conscious design of the tunnel boring machines with adequate facilities, logical, rational distribution and sharing of risks is key to the success of TBM tunneling in Nepal.

Keywords: Geology; tunneling; GIS; tender; construction

Geological Characteristics of Ulleri Augen Gneiss in the Birethanti-Ghodepani Area, Western Nepal

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The Ulleri Augen Gneiss, located in the Lesser Himalaya from the Birethanti-Ghodepani area of western Nepal, was studied to map its geological distribution, field relations with adjacent rocks, and petrographic characteristics. This research focuses on understanding its mineralogy, microstructures, and stratigraphic position. Fieldwork involved preparing columnar sections, route maps, and recording deformation-related structures, alongside systematic sampling from various stratigraphic levels. The study area transitions from low- to medium-grade metamorphic rocks of the Nawakot Group in the south to mylonitic lithologies near the Main Central Thrust (MCT) in the north. The Kuncha Formation, a key lithological unit, predominantly consists of phyllite, schist, metasandstone, and metabasic rocks, with the Fagfog Quartzite forming a prominent younger succession displaying sedimentological features modified by tectonism. The Ulleri Augen Gneiss, a metaacidic orthogneiss, is stratigraphically positioned within the Kuncha Formation, bounded by garnetiferous schist and metabasic lithologies. Its field relationships reveal both concordant and discordant contacts with host rocks, with xenoliths of country rocks embedded within the gneiss. Petrographic analysis shows pressure shadows, S-C foliation, and mineral lineations, highlighting ductile deformation associated with Himalayan orogenesis. The presence of plagioclase confirms its ortho-gneissic nature. Polyphase metamorphism, evident from chlorite, biotite, and garnet zones, indicates both regional and contact metamorphism. The Ulleri Augen Gneiss evolved through magmatic intrusion, tectonic deformation, and interaction with adjacent lithologies, reflecting a multi-phase geological history.

Keywords: Ulleri Augen Gneiss; orthogneiss; xenoliths, ductile deformation; polymetamorphism

Petrogenesis of Granites from the Palung area Central Nepal with its Deformational History

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Orogenic events are imprinted in the medium to coarse crystalline leucocratic granite in the Palung area of Central Nepal which defines its genesis. The granite has intruded the metamorphic rock like Schist and quartzite of Precambrian age. The coarse crystalline granite lies at the edge of the granite body. Petrographic observations of the granite reveal a mineral assemblage dominated by quartz, potassium feldspar, plagioclase, muscovite, and biotite, with accessory minerals such as tourmaline, garnet, and zircon. The microscopic view of the different minerals in granite shows that the granite is formed in a syn-tectonic environment and has record of the post tectonic activity. New mineral formation in the boundary of existing mineral with destruction of its shape reflects the metasomatic activity. The feldspar and mica in the western part of granite has developed the kaolin clay in the facility of tectonic stress (effect of Mahabharat Thrust) and hydrothermal activity. The kaolin formation in the Palung-Kulekhani area mostly belongs to hydrothermal alteration and supergene weathering. The metasomatism are leading to irregular boundaries in biotite and other minerals along its boundaries. The low grade metamorphism in feldspar causes the Carlsbad twining. The metasedimentary rocks mostly garnetiferous schist with aluminous rich minerals are main marker of the xenolith in granite. The cross cut in the country rock and deformational structures in xenoliths are assigned as younger age of the granite than the rock of Bhimphedi Group. Such aluminous minerals like muscovite, garnet with almost absence of hornblende shows the S-type granite associated with continental collision zones (in orogenic belt).

Keywords: Leucocratic granite; Lesser Himalayan Granite; Deformation history

Backthrusting and Fault Propagation Folding in The Lesser Himalaya of Far West Nepal

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Two large overlapping thrust sheets occupy Far West Nepal's Dadeldhura, Baitadi, and Darchula districts in the Inner Lesser Himalaya. The Greater Himalayan thrust sheet, representing the hanging wall of the Main Central Thrust, includes a few klippen that rest over the Lesser Himalayan thrust sheet characterised by inverted metamorphism and Palaeozoic Dadeldhura Granite intrusion. The upper part of the Dadeldhura Granite is transformed to augen gneiss, presumably during the southward propagation of the Greater Himalayan thrust sheet. Though most of the Lesser Himalayan Sequence is of Proterozoic age, a few Palaeocene–Miocene sedimentary slices having fossils of foraminifera and bivalves in limestone, shale and sandstone also occur. These youngest sediments facilitated the movement of the Lesser Himalayan thrust sheet. As a result, the incompetent dolomite, limestone, shale, sandstone quartzite, and slate succession of the inner belt was intensely folded and faulted. The south-dipping Malikarjun Backthrust has developed several fault-propagation folds in its hanging wall. On the other hand, the propagation of the Lesser Himalayan thrust sheet towards the south created a large overturned succession sandwiched between the Lesser Himalayan (roof) thrust sheet and the Main Himalayan (floor) Thrust. In this process, the slates and quartzites underwent superposed folding and transposed foliation, especially in the region between Dhung Gad, Ganjari, Khodpe, Patan, Melauli, and Pancheshwar of Baitadi district.

Keywords: Thrustsheet; sediment; fold and faults; Lesser Himalaya

Lithostratigraphy and facies classification of sediments in the northeast Kathmandu basin

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The present study has focused on the Quaternary geological mapping of the northeast section of the Kathmandu Valley with the aim to carry out the stratigraphy and depositional sedimentary environment of the sediments. This region lacks comprehensive studies on lithostratigraphy and facies categorization, creating significant research gaps. The study aims to address these gaps by detailing lithostratigraphy, categorizing facies, and preparing geological maps at a 1:25,000 scale, including columnar sections. Fieldwork involved creating vertical litho-logs, identifying lithofacies, and interpreting data using manual techniques. The mapping identified four stratigraphic units: the Sankhu Formation (gravelly fluvial sediments), the Gokarna Formation (coarse brown sand and black clay with prominent sedimentary structures), the Thimi Formation (fine sand and silt with small-scale structures), and the Kalimati Formation (massive silty clay with fine sand partings). These units indicate fluvial deposition for the Sankhu Formation, deltaic origins for the Gokarna and Thimi Formations, and lacustrine deposition for the Kalimati Formation. Sixteen facies were grouped into four facies associations: proximal fan delta (FA1), delta plain (FA2), delta front (FA3), and pro-delta (FA4), representing depositional environments ranging from flooding channels and swampy zones to lacustrine and marshy settings. This study has proposed a revised stratigraphy along with the facies classification in the region.

Keywords: lithostratigraphy; facies association; deltaic deposition; lacustrine environment

Assessing the lateral groundwater contamination resulting from the severely degraded Bagmati River, Kathmandu Valley, Nepal

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The Bagmati River, once a vital lifeline for the Kathmandu Valley, held immense economic and spiritual significance. However, in recent decade, the river has suffered from severe pollution as a result it may have significantly contributed to polluting the groundwater in the peripheral areas. The study aims to explore the lateral transportation of contaminants into the groundwater resulting from polluted surface water of the Bagmati River system. To achieve objective, environmental geophysics was employed along with hydro chemical analyses of both groundwater and river water at six key locations from Uttabahini to Chobhar. The survey was conducted for both pre-monsoon and post-monsoon seasons. The electrical resistivity survey shows that there are significant changes in resistivity from pre-monsoon to post-monsoon period across the bank of the Bagmati River indicating changes in groundwater pollution level. The results of the water chemistry analysis suggest that the overall water quality degrades significantly on moving downstream from the source and the effect of the river pollution is reflected in the groundwater directly. Microbial contamination was detected in all the river and groundwater samples. During pre-monsoon, the level of arsenic exceeds the national drinking water limit in all the samples but attains a safety level during post-monsoon due to dilution. Meanwhile, the BOD and COD show an almost 10 times higher average value during pre-monsoon with the highest values 417.33mg/L (BOD) and 834.67 mg/L (COD) observed at Uttarbahini. The anions and cations in general showcase a decreasing trend in concentration in the groundwater sample as we move further from the river indicating the migration of contaminants from the river.

Keywords: Water pollution; Electric Resistivity Tomography; Water Chemistry Analysis; Bagmati River

Petrography, depositional setting and provenance of the Gondwana Sequence in eastern Nepal Lesser Himalaya

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The Extra-Peninsular Gondwana sequence exposed in the Barahakshetra-Ranitar area of eastern Nepal consists of the Upper Carboniferous-Lower Permian Kokaha Diamictite, Permian Tamrang Formation, and Late Cretaceous to Paleocene Sapt Koshi Formation. Systematic petrographic study was carried out in the area to understand the lithological characteristics, depositional setting and provenance of the Gondwana sequence in the Barahakshetra-Ranitar area. Petrographic study was carried out in 20 samples of different lithologies. Quantitative modal compositional analysis was done to classify sandstones and interpret depositional environments and provenance. The Kokaha Diamictite, dominated by quartzarenite, subarkose, and feldspathic litharenite, records craton interior and recycled orogenic sources, deposited under cold, semi-humid glacial to glaciolacustrine conditions during Permo-Carboniferous glaciation. The Tamrang Formation, with quartzarenite, sublitharenite, subarkose, and litharenite represents fluvial sedimentation of Permian when glacial environment shifted to relatively warm and humid fluvial environment. The Sapt Koshi Formation, comprising quartzarenite and sublitharenite, reflects its deposition in northern shelf of the Indian continent after it got separated with Australia-Antarctica in early Cretaceous

Keywords: Gondwana sequences, petrography, modal composition, provenance analysis, Permo-Carboniferous glaciation.

Lithostratigraphy and age of the Gondwana sequence in eastern Nepal: Lithological, paleontological and paleoflow constraints

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Gondwana sediments have been reported from two localities, Barahakshetra and Takure area, in east Nepal Himalaya as a narrow linear belt at the hanging wall of the Main Boundary Thrust. The lithostratigraphy and depositional age of the Godwana sequence in those areas have been always matter of discussion among various researchers. In the present study, we have tried to clarify the lithostratigraphy of the Gondwana sequence based on detailed lithological study both in outcrop and thin sections, investigation of floral and faunal fossil prints and measurement of plaeoflow direction. The study shows that Kokaha Diamictite is the oldest unit (Upper Carboniferous-Lower Permian) in the area. It is followed by the Permian Tamrang Formation. The Upper Permian Kali Khola Formation and Late Jurassic to Cretaceous Sehera Khola Formation are exposed only at the Takure section. The youngest unit in the area is the Sapt Koshi Formation probably of Late Cretaceous to Paleocene time. The Baraha Volcanics previously placed within the Kokaha Diamictitie actually lie within the Tamrang Formation.

Keywords: Gondwana sequence, floral and faunal fossils, diamictite, volcanics, eastern Nepal, Lesser Himalaya

Young's modulus Anisotropy of foliated Metamorphic rocks of Nepal Himalaya

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Young's modulus, a fundamental property of materials, measures their resistance to elastic deformation under stress. It serves as a critical factor in engineering, aiding in material selection, structural analysis, and mechanical applications. Anisotropy is a defining characteristic change in elastic or strength variation according to the angle of foliation in foliated rocks which is produced because of change in mineral alignment and/or textural changes during orogenic process. This anisotropy highly affects mechanical properties. Therefore, understanding their anisotropic behavior is crucial for geotechnical stability and designing of engineering structures in the highly active Nepal Himalaya. Several researchers have carried out the measurement of the strength anisotropy for different rocks. Wenk et al. (1997) explored the mechanical properties of gneiss, showing how mineral banding affects its elasticity and fracture toughness. Similarly, Jaeger et al. (2007) provided a comprehensive analysis of anisotropic elastic constants. Dimitris et al. (2021) has compared the static and dynamic young's modulus of meta-basic rocks, reported young's modulus determined by dynamic method of various metamorphic rocks illustrating the need for directional testing. This paper discusses its theoretical foundation, measurement methods utilizing the most widely used laboratory tests for foliated rocks deformability according to ASTM. (2017) D7012-14e1 standard where measured secant, average and tangential Young's modulus of metamorphic rocks, particularly fine-grained slate, medium-grained metasandstone, and coarse-grained banded gneiss of Lesser Himalaya, Nepal. About 180 specimens having a height to diameter ratio of 2 to 2.5 at different orientation angles β (0˚, to 90˚ with the interval of 10˚) were cored from rock blocks and tested. The results showed that the maximum Young's modulus was found at 0 and 90 ˚ and the minimum was in the 30˚ with major anisotropic foliation angle with loading.

Keywords: Young's modulus; anisotropy; deformability

Comparison of springs water quality in carbonate and associated rocks of Lesser Himalaya in Seti Khola Watershed, Nepal

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Springs are a concentrated natural flow of groundwater at the Earth's surface in different geological settings. They are essential freshwater sources in the mid-hill region of the Nepal Himalaya. Spring water quality is also an important parameter, because it contains both geogenic and anthropogenic concentrations. The present study area is in the Seti Khola Watershed with 115 sq km, which is located in western Nepal where 175 springs were studied. This study aimed to investigate the water quality of selected springs emerging from carbonates and associated rocks in the study area by collecting samples from 66 springs. Physicochemical parameters included pH, EC, TDS, turbidity, major ions, nutrients (nitrate, sulfate, and phosphate), and potential contaminants (iron, manganese, and ammonium). The mean trends for all cations and anions were $Ca^{2+}>Mg^{2+}>Fe^{2+}>Mn^{2+}$ and $HCO_3^{-}>Cl^{-}>SO_4^{2-}>PO_4^{3-}>OH^{-}>NO_3^{-}$. However, the geogenic and anthropogenic concentrations of cations and anions in the carbonate lithology were higher than those in the non-carbonate lithology, except for chlorine, sulfate, and phosphate. Nitrate levels were observed in three carbonate and six non-carbonate springs with highest value in Naudada Quartzite and least in Nayagaun Formation ranging from 0.1 to 3.2 mg/L, Ammonium was detected in four sources at most in non-carbonate rocks with 0.002 mg/L. Higher concentrations of iron (>0.17 mg/L) were noted in 10 springs, three in carbonate rocks, and seven in non-carbonate rocks, with a maximum of concentration 0.68 mg/L. Mangenese was not detected in any of the samples, indicating the absence of this chemical element in the host rock. The hydrogeochemical characteristics of spring water are influenced by the interaction of water with the underlying carbonate and associated rocks, potentially leading to elevated levels of certain ions.

Keywords: Carbonate rock; Lesser Himalaya; hydrogeochemitry; iron concentration

Geological study of northern part of the Pokhara valley with emphasis to geological structures and metamorphism

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The geological mapping was carried out to investigate tectono-stratigraphy of the Northern part of the Pokhara which includes a major thrust zone in between the Lesser Himalaya and the Higher Himalaya. This contact zone has been described in various ways by geoscientists where rocks fabric was altered due to the deep-seated thrust which is the MCT. This study has done regionally with well tectono-stratigraphic division: the Nawakot Group, the Bhimphedi Group, and the Higher Himalaya. They are divided by the large-scale thrusts, namely from south to north, the Mahabharat Thrust (MT), and the Main Central Thrust (MCT). These units extend roughly NNW-NNE. A southerly unit is built by meta-sedimentary rocks of the Nawakot Group; the Kuncha Formation, the Fagfog Quartzite, and the Dandagaon Phyllite. The central zone consists of the Lesser Himalayan Crystallines (Bhimphedi Group), lithostratigrpahycally, it consists of thin succession of the Raduwa Formation and the Bhainsedobhan Marble, followed by the Kalitar Formation in the upper part. About 400m thick succession of the Bhimphedi Group exposed in the Seti River section; highly metamorphosed argilo-areanceous with calcareous deposits are diversely exposed in this zone of the study area. The MCT is based on the first appearance of kyanite-bearing gneiss at the Karuwa village in the Seti River section. And the MT marked on the basis of breakage of inverse metamorphism of the footwall (Nawakot Group) rocks, crenulation cleavage, ptygmatic fold, slickenside, small scale fold, shear zones, weak mylonitization, S-C fabric, lithostratigraphical diversity. In general, metamorphism increases in the south of the Mahabharat Thrust, showing inverse metamorphism (M2) in the Nawakot Group; however, in hanging wall there is regional metamorphism, which is decreased from the Garnet zone to the biotite zone in the Bhimphedi Group, and the Kyanite zone appeared in the foot of the Higher Himalaya separated by the MCT.

Keywords: Lithostratigraphy; metamorphism; Mahabharat Thrust

Integrated Numerical Simulation Approach (LEM, FEM and PFEM) for Cut Slope Stability Assessment in Lesser Himalayan Zone of Nepal

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The Lesser Himalaya Zone of Nepal comprising low-grade metamorphic rocks with steep slopes and thick soil cover exhibits significant challenges for slope stability during the rainstorms of monsoon season. This study has evaluated the Kokhe slope failure along the Gorkha-Arughat Road section in Gorkha District (28°01'36"N, 84°40'13"E) using the Limit Equilibrium Method (LEM), the Finite Element Method (FEM) and the Particle Finite Element Method (PFEM). LEM analysis determined a factor of safety (FoS) of 1.853 during the dry season showing a slope stable. Under 150 mm of rainfall in 24 hours, the transient analysis projected the FoS to be 0.761 thereby showing the instability of this slope. FEM analysis identified the maximum shear strain at the soil-bedrock interface, with a stress reduction factor (SRF) of 1.1, indicating marginal stability. PFEM combines a Lagrangian Finite Element Method (FEM) with an efficient and fast remeshing procedure when a mesh is too distorted. The PFEM simulation incorporating continuous remeshing during the slope failure showcased post-failure dynamics, revealing a maximum runout distance of 405 m, peak sediment deposition of 26.2 m, and a maximum velocity of 19.6 m/s. These findings highlight the complementary aspects of LEM, FEM, and PFEM in assessing the slope stability in Lesser Himalayan terrain in terms of pre-failure and post-failure behavior. The integration of these three methods has provided a comprehensive framework for understanding and mitigating unstable slopes in tectonically active and monsoon-affected regions and/or similar geo-environmental settings.

Keywords: Cut-slopes; LEM; FE; PFEM; numerical modelling; slope stability

Geological study along the Khutti Khola watershed, Siraha district, eastern Nepal

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The Khutti Khola watershed area located in the Lahan Municipality and Dhangadhimai Municipality of the Siraha district is divided into the Sub-Himalaya and the Terai Plain, separated by the Main Boundary Thrust (MBT) to the north and the Main Frontal Thrust (MFT) to the south. This study presents a detailed geological mapping at a 1:25,000 scale, aiming to delineate geologically sensitive areas of the Khutti Khola watershed. Through a comprehensive methodology involving literature review, fieldwork, and data analysis, the study establishes the stratigraphy and geological structures of the area. The rock sequence of the Sub-Himalaya is divided into the Lower Siwalik, Middle Siwalik, and Upper Siwalik. The Middle Siwalik is further subdivided into the Middle Siwalik 1 and the Middle Siwalik 2. The Terai Plain is subdivided into the Bhabar Zone and the Middle Terai. The Bhabar Zone is observed immediately south of the MFT. The appearance of northward inclined beds, slickenside on sandstone, landslides, fault breccias, and sudden topographic breakages are evidence of the MFT. The Lower Siwalik and Middle Siwalik units are categorized as Feldspathic Wacke due to their composition of quartz, feldspar, and lithic fragments, along with a matrix content exceeding 15%. Conversely, the Upper Siwalik unit is categorized as Lithic Arenite because it contains less than 15% matrix. These findings provide invaluable clarity on the stratigraphy of the study area, enabling informed decision-making for engineering projects, environmental studies, and site selection for development initiatives.

Keywords: Khutti Khola; mapping; Sub-Himalaya; Terai Plain

A thick quartzite succession in the Lesser Himalaya of Pokhara–Baglung area: implications for the Stratigraphy of Kuncha Formation

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A thick quartzite succession occurs between Pokhara, Syangja, Phalebas, Kushma, and Baglung in West Nepal. It belongs to the lower part of the Kuncha Formation. Previously, the quartzite band was mapped as the Lower Quartzite, Birethanti Quartzite, Naudanda Quartzite, or the Kushma Quartzite. Instead of a single unit, the investigators have depicted many bands and separated them by thrusts and overturned sequences. The geological interpretation was complicated by the assumption that such quartzite bands must be equivalent to the Fagfog Quartzite that overlies the Kuncha Formation. The quartzite succession varies in thickness from a few hundred metres to more than a kilometre. The ripple marks, cross-lamination, and graded bedding indicate primarily a right-way-up succession with a few large-scale folds and some minor folds with overturned limbs. This study implies that this thick quartzite sequence differs from the Fagfog Quartzite, and hence can be used to subdivide the Kuncha Formation into various lithostratigraphic units.

Keywords: Stratigraphy; mapping; sedimentary structures; interpretation

Recognizing Deep-seated Gravitational Slope Deformations around the Dam and Reservoir Rim surrounding area of Budhigandaki River Basin Central Nepal Himalaya

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Deep-seated Gravitational Slope Deformations (DGSDs) are widespread yet often overlooked by geological features in the high-relief, seismically active Himalayas. Their recognition is crucial for understanding long-term landscape evolution and assessing slope stability, especially in regions undergoing major infrastructure development. This study focuses on the identification and recognition of DGSDs in the Budhigandaki High Dam Reservoir area, located in Gorkha and Dhading districts Central Nepal. The proposed 283m high Budhigandaki Dam and its extensive reservoir are expected to alter the hydrogeological conditions of the region, potentially influencing DGSD activity. To systematically recognize DGSDs, we employ a multi-disciplinary approach combining geomorphic mapping, remote sensing (DInSAR, LiDAR, and high-resolution satellite imagery), and field investigations. Key indicators such as ridge-top depressions, antiscarps, double ridges, uphill-facing scarps, and disrupted drainage networks are used to delineate DGSD features. Structural and lithological controls are analyzed to understand their role in deformation processes, while numerical modeling is applied to assess the response of DGSDs to future reservoir impoundment. Preliminary results indicate the presence of multiple DGSDs within the reservoir rim area, many of which show evidence of slow, ongoing movement. These deformations, influenced by tectonic activity, river incision, and lithological weaknesses, pose potential hazards to reservoir stability and nearby infrastructure. Our study highlights the necessity for continuous monitoring and adaptive engineering strategies to mitigate risks associated with DGSDs. The findings contribute to the broader understanding of DGSD recognition in the Himalayas and provide essential insights for sustainable hydropower development in high-mountain environments.

Keywords: Deep-seated gravitational slope deformation; Budhigandaki Dam; reservoir; geomorphic mapping; remote sensing, slope stability

Lithostratigraphy and Geological Setting of Tamghas-Dhurkot Area of Gulmi District, Lesser Himalaya

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The study area lies in the Lesser Himalaya of Gulmi and Arghakanchi districts, bounded by the Main Boundary Thrust (MBT) to the south and the Main Central Thrust (MCT) to the north. This research focuses on the lithostratigraphic framework and structural architecture of the region to enhance understanding of Lesser Himalayan geology. A significant research gap exists due to limited detailed geological mapping and stratigraphic studies in this area. The primary objective was to prepare a detailed geological map at a scale of 1:25,000 and establish the lithostratigraphy and structural framework through field investigations and petrographic analysis. The study identified low-grade metamorphic rocks of the Nawakot Group as the autochthonous unit, overlain by garnet-grade metamorphic crystalline rocks of the allochthonous unit, separated by the Chhaldi Thrust. The autochthonous sequence includes, from older to younger, the Benighat Slates, Malekhu Limestone, and Robang Formation. The Benighat Slates are characterized by dark grey to yellow slates interbedded with metasandstone and carbonate beds, sharply overlain by dolomite beds of the Malekhu Limestone, which transition into the Robang Formation, comprising phyllite and quartzite. The allochthonous sequence includes the Bastu Marble, Darlamchaur Quartzite, and Arje Schist. The Bastu Marble consists of marble interbedded with schist, transitioning into quartzite and schist in the Darlamchaur Quartzite and garnet-bearing schist in the Arje Schist. These findings provide a comprehensive lithostratigraphic framework and structural interpretation of the region. An attempt is made to correlate these successions with the most adopted stratigraphy in central Nepal.

Keywords: Stratigraphy; Chhaldi Thrust; Arje Schist; Darlamchaur Quartzite; Bastu Marble

Petromagnetic characteristics of purple sandstone laminae within the Middle Siwaliks of Amlekhganj area, Nepal

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Petrological (mineral composition) and magnetic characteristics (magnetic mineralogy, remanent magnetization, low-field magnetic susceptibility (k) and magnetic fabric) of sandstone-dominated sediments within a middle Siwaliks outcrop, situated north of Amlekhganj town in south central Nepal, have been described. Emphasis is given to understand the nature and significance of garnet-opaques-rich purple laminae (up to 3 mm thick). Magnetic susceptibility contrasts and trends enable effective field screening to discriminate sediment intervals of differing scales: millimetric laminae, a few meters thick beds with different grain size classes (e.g., sand, silt or clay), and several meters thick alternating sediment sequences or cycles (e.g., upward fining sand to clay packages). The upper half of the section and the thin laminae within it suggest a foredeep depositional setting resulting from a tectonic scenario that involved an accelerated exhumation of the source area occupied by Mahabharat Crystalline in the immediate north of the area and episodic denudation of the crushed shear zone formed at the high-grade metamorphics at the base (Bhimphedi Group), respectively. Deposition of each lamina likely owes to episodic reactivation of the Mahabharat Thrust forming the shear zone as a source of garnet and heavy minerals sometimes during 9–8 Ma. Magnetic fabric is a composite of (i) bedding-parallel magnetic foliation of sedimentary compactional origin, and (ii) W-E trending and sub-horizontal magnetic lineation (i.e. transverse to N-S compression) of tectonic origin, as in other parts of Sub-Himalaya in Nepal.

Keywords: Sub-Himalaya; Middle Siwaliks; Magnetic Susceptibility; Garnet; Magnetite

Geological and Structural Framework of the Khairenitar Area, Southern Pokhara, Nepal

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A detailed geological mapping was conducted in the Khairenitar area, covering parts of Tanahun, Kaski, and Syangja districts, to establish the lithostratigraphy and structural framework of the Lesser Himalayan rocks and Quaternary sediments surrounding Pokhara Valley. This region, lacking comprehensive studies and petrographic data, was selected to address the research gap in stratigraphy, micro-tectonics, and geological structures. The study involved field mapping at a 1:25,000 scale, supported by laboratory analysis and computer-based data interpretation. The lithostratigraphic succession of the basement hard rock consists of six geological units: The Kunchha Formation, the Fagfog Quartzite, the Dandagaon Phyllite, the Nourpul Formation with Purenbesi Quartzite, the Dhading Dolomite, and the Benighat Slates, from bottom to top. Quaternary sediments are categorized into the Siswa Formation, the Ghachok Formation, the Pokhara Formation, and Recent Deposits. Sedimentary structures such as ripple marks, graded bedding, and laminations were observed. Structurally, the area is dominated by the SE-NW trending Khoradi Syncline, along with plunging non-cylindrical to recumbent meso-scale folds of similar orientation. Secondary structures include foliations, joints, crenulations, quartz boudinages, and ptygmatic folds. Petrographic analysis reveals chlorite- and biotite-grade metamorphism, highlighting microstructures such as grain boundary migration, core and mantle structures, polygonized grains, and deformed or folded veins. These microstructures indicate top-to-south shearing, low-temperature dynamic deformation, and poly-deformation processes. The observed small-scale folds and folded veins align with the major syncline trends. This study provides critical insights into the structural and micro-tectonic evolution of the Lesser Himalaya in the southern Pokhara region.

Keywords: lithostratigraphy; geological structure; Pokhara valley sediments; Lesser Himalaya

A hill slope failure analysis: A case study of Hupsekot landslide, Nawalpur, Nepal

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The Siwalik region, characterized by heterogeneous lithology and highly permeable Quaternary sequences, is one of the most landslide-prone zones in Nepal. Geological weak zones such as active fault regions, shear zones, fold axes, and unfavorable lithological settings contribute significantly to slope instability. The Hupsekot landslide, located in Pipaldada village of Hupsekot-6, Nawalpur district, serves as a notable case study of the interplay between geological factors and landslide dynamics. This research aims to assess the causes of the Hupsekot landslide, focusing on petrography and geotechnical characteristics of the affected materials. Petrographic analysis of sandstone samples from the landslide area revealed irregular grain boundaries, recrystallized groundmass, and deformation lamina in quartz grains, indicating the influence of two major thrusts—the Main Boundary Thrust (MBT) and the Central Churia Thrust (CCT)—located within a kilometre of the landslide. Additionally, the swelling properties of clay, the cohesiveness of silt, and toe cutting by Daaun Khola further exacerbate the instability. These findings suggest that geological factors, particularly structural weaknesses and soil behavior, are the primary causes of the Hupsekot landslide. To mitigate the risk and expansion of the landslide, proper drainage management is recommended to lower the water table and reduce hydrostatic pressure. Bio-engineering techniques such as grass planting, mulching, jute netting, and bush layering should be implemented, alongside engineering consultations for effective slope stabilization. This study highlights the importance of understanding geological and geotechnical factors in landslide-prone regions and provides actionable recommendations for mitigating similar hazards in the Siwalik region.

Keywords: Landslide, deformation, MBT, CCT, Siwalik

Fractal analysis of seismicity across the Central Himalaya and nearby regions

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The Central Himalaya remains a high-risk seismic region, as evidenced by the 2015 Gorkha earthquake (Mw = 7.6), followed by a 7.0 aftershock near Dolakha-Sindhupalchowk. Another moderate-magnitude earthquake (Mw = 5.6) occurred in Doti in 2022, reinforcing concerns about ongoing stress accumulation and release. We evaluated the b-value of earthquakes, which represents the stress heterogeneity of a region, from the Gutenberg-Richter seismic relation. Since earthquake faults and clusters exhibit fractal characteristics, we also analyzed the spatiotemporal variation of the fractal correlation dimension (Dc) of earthquake epicenter distributions within the region 80–89°E and 26–31°N. The study divided the seismic region into three sub-regions: western, central, and eastern Nepal and their vicinity to investigate regional differences in seismicity. The obtained Dc values and b-values were (1.89 ± 0.02 and 0.68 ± 0.03), (1.76 ± 0.01 and 0.60 ± 0.05), and (1.85 ± 0.02 and 0.63 ± 0.03) for the respective regions. Additionally, the spatiotemporal distribution of *b*-values along five major fault zones was analyzed using 10,500 seismic events (Mc = 2.0 ML). Notably, significantly low b-values were observed in the Judi Fault (0.45 ± 0.02), Thaple Fault (0.48 ± 0.02), and Motihari-Everest Fault (0.55 ± 0.04), indicating potential stress accumulation, which could be associated with future seismic hazards. Furthermore, during the active period of the Doti earthquake in the western Nepal Himalaya, we observed low b-values of 0.68 ± 0.03 and high Dc values of 1.81 ± 0.02, suggesting an increase in seismic activity and stress release. Our findings provide critical insights into the heterogeneous stress distribution and seismic potential of the Central Himalaya, helping to better understand of earthquake hazards in the region.

Keywords: Seismic; 2015 Gorkha earthquake; prediction; hazard

Modification of dam abutment – A case of Upper Tamakoshi Hydroelectric Project, Nepal

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Hydropower projects often face unforeseen geological challenges due to inadequate investigation campaigns, budget constraints, and cost-saving approaches prior to the construction stage. Such constraints can lead to significant time and cost overruns during execution. This paper presents a case study related to the Left Abutment of the Upper Tamakoshi Hydroelectric Project, in Nepal, where geological uncertainties necessitated an alternative intervention. Core samples and data retrieved from in-situ tests which conducted in boreholes at the Left Bank of the Tamakoshi River, during the feasibility and the detailed design phases raised concerns about the suitability of the area as dam abutment. However, due to similar characteristics in comparison to the adjacent bedrock and a limited scope of study, a clear distinction between autochthonous rock mass and a massive heterochthonous boulder could not be made in advance. Adopting a detailed engineering geological investigation during the construction phase, the exposed material was confirmed to be a heterochthonous massive boulder rather than competent bedrock. Given the fact that construction was already underway, a conventional strategy of blasting the boulder and extending the dam structure to the competent rock was not feasible, due to significant financial and scheduling impact. In this regard, several alternatives were assessed and a consolidation grouting strategy was adopted. In addition, the extension of the jet-grout columns to the upstream sound rock, construction of a face slab over the jet-grout columns, and conduction of contact grouting at the rock-concrete interface were implemented. This case study highlights the importance of adaptive engineering approaches when complex geological challenges inherent in the Himalayan rock masses need to be addressed. The experience gained and the lessons learned offer valuable insights for future hydropower projects in similar geologic regimes.

Keywords: Dam; Tamakoshi; engineering geology, hydropower

Texture and Maturity Status of Fluvial Sands in the Karnali River Basin: A Study of Downstream Sediment Variation

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This study aims to investigate the textural characteristics of sands within the Karnali River Basin (KRB), focusing on variations in grain size, shape and maturity along its downstream course, from the high-altitude Tibetan Plateau through the mountainous and hilly midstream regions to the Indo-Gangetic Plain. The results show that the sands are mainly fine to medium-grained with some mud content. The inclusive graphic standard deviation(σ_I), which reflects sorting, varies from the upstream to the downstream stretches. In the upstream reaches, particularly from samples KR1 to KR5, sorting values range from 1 and 2 phi(φ), indicating poor sorting. However, as the river moves downstream, sorting improves, most samples from the mid and lower stretches of the river, fall within the moderately well-sorted to moderately sorted range. Skewness trends also shift downstream; in the upper reaches, the sands exhibit a coarse skew, reflecting a dominance of coarser particles. From sample KR6 onward, skewness becomes nearly symmetrical, suggesting a more balanced mix of coarse and fine grains. Despite this trend, certain locations (KR8, KR37, and KR45) show a reappearance of coarse-dominant sediments, while KR43 stands out with a fine-dominant composition, indicating localized variations in sediment transport and deposition processes. Grain roundness remains within subangular to angular throughout the river course, suggesting ongoing transport and abrasion. The sphericity of the grains is mostly medium, ranging from 0.70 to 0.80, indicating moderately spherical shapes. The proportion of fines is generally low (<5%) across the basin, except at specific locations such as KR7, KR14, KR15, KR18, KR36, KR37, KR38, KR45, KR46, and KR48, where fines exceed 5%. Overall, the sands in the KRB do not exhibit a consistent trend of increasing maturity along the downstream course. Instead, the maturity status of the sediments remains mostly submature throughout the river's course, immature characteristics at some places indicates incomplete transport or local sediment contributions.

Keywords: Himalayan river system, Karnali River, Fluvial environment, Sediment texture, Textural maturity

Slope stability analysis using continuous slope mass rating along the Kanti Rajpath from Tinpane Bhanjyang to Khor Bhanjyang

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The fragile and steep slopes along the Kanti Rajpath have high risk of slope instability, cause the damage of the engineering structures and property, lifeline and human life loss. The failure of the slopes is controlled by the slope and its geometry, discontinuities parameter, dynamic parameters and the lithology itself. Continuous slope mass rating and kinematic analysis are followed for the stability analysis of slope after focusing the aim of study by calculating the continuous slope mass rating (CSMR) based on the Bieniawski's rock mass rating (RMR) system and kinematic analysis based on Markland's test described by Hoek and Bray respectively. The selected exposures were studied from the Tinpane Bhanjyang to Khor Bhanjyang and the result showed, CSMR values ranging from class IV and bad quality of rock to class II and good quality of rock and the probability of failure. The kinematic analysis shows the three modes of failure; plane, wedge and toppling failure. The comparison of the results from two approaches is seventy percent concordantly similar. The required slope cut angle and the support system were suggested which refers to the toe ditch or fence netting, systematic to spot bolting/anchors, systematic to spot shotcrete, to wall/dental concrete, re-excavation and drainage management. The support is not essentially required for all slope, however depends upon the nature of slope and discontinuities. The results of analysis are presented such that they can be very useful for the slope stability and design for extension of Kanti Rajpath.

Keywords: SMR; CSMR; RMR; Kinematic analysis; Slope stability; Markland's test

Geological mapping and petrographic study of the Jyamire Gneiss, eastern Nepal

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Granitic rocks are present within different tectonic units in the Nepal Himalaya. The outer Lesser Himalaya of eastern Nepal, around Bhojpur-Dhankuta districts, consists body of augen gneiss, the Jyamire Gneiss, which has not been studied in terms of its extent, field relationship, petrographic characteristics, and the emplacement-evolution history. In order to address these gaps, detailed geological mapping was carried out around the area, and systematic sampling was performed for petrographic and microstructural study of the gneiss. The Jyamire Gneiss overlies the Okhre Formation and is overlain by the Belhara Formation, all of which lie within the Phongsawa Group of the Chimra Thrust Sheet. Both the enclosing units comprise of schist in contact with the gneiss. It is a mylonitic to protomylonitic augen gneiss, over 28 km long and 1.5 km thick, composed of alkali feldspar, quartz, plagioclase, muscovite, biotite and tourmaline. The gneiss falls within the granite field in QAP triangular plot. It shows discordant relationship with the underlying Okhre Formation, with the contact varying from sharp to transitional, and shows concordant relationship with overlying Belhara Formation, where the contact is transitional. S-C mylonitic fabrics and other kinematic structures indicate top-to-the-south sense of shear. Based on the textural resemblance, petrography and tectonostratigraphic positioning, the Jyamire Gneiss can be correlated with the Ulleri augen gneiss of central Nepal. The morphology, field relationship, grain size of gneiss indicates intrusive origin of the protolith, which may be of multiple events. The gneiss has undergone a single phase of Pre-Himalayan and three phases of Himalayan deformation.

Keywords: Jyamire Gneiss; Ulleri; augen gneiss; granite

Variation of iron in groundwater and its impact on human health in Dhangadhi area, Far-Western Nepal

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In April 2024, a study was conducted to assess the distribution of iron in the different types of groundwater resources in the Dhangadhi area. A total of 50 samples were collected, including 29 from shallow sources and 21 from deep sources. Iron was detected in 24 shallow and 8 deep sources. In shallow sources, iron concentrations ranged from 0.17 to 9.68 mg/l, with a mean of 2.46 mg/l and a standard deviation of 2.14 mg/l, while in deep sources, concentrations ranged from 0.17 to 7.14 mg/l, with a mean of 1.30 mg/l and a standard deviation of 2.24 mg/l. Except for samples SS5, SS7, DS10, and DS15 all other samples exceeded the permissible iron limit of 0.3 mg/l set by NDWQS 2022. The Water Quality Index (WQI), without considering iron, ranged from 2.10 to 122.22, classifying groundwater as 52% excellent, 34% good, 6% very poor, and 8% unfit for human consumption. When iron was included, the WQI ranged from 1.985 to 446.70, categorizing groundwater as 38% excellent, 20% good, 6% poor, 6% very poor, and 30% unfit for human consumption, highlighting iron as the primary factor degrading water quality. The highest concentration was found in sample SS2 in the northern part of the area, with industrial and agricultural activities contributing to elevated levels. The reliance on shallow sources with high iron concentrations has led to public health issues, including liver and kidney diseases. Effective management and stringent quality control measures are essential to protect this critical water resource.

Keywords: Groundwater; Iron; Shallow sources; Deep sources; Water quality; Drinking water

Optimization of landslide conditioning factors for susceptibility zonation mapping in Lunglei district, Northeast India

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Landslide is a major geological hazard in the northeastern part of India. The study aimed to identify significant landslide conditioning factors and uncertainty during landslide susceptibility modelling for the Lunglei district of Mizoram. In the first, 17 different landslide conditioning factors are selected after multi-collinearity test. A landslide inventory of 234 landslide points classified into training set (70%) and testing set (30%), randomly. A bivariate technique namely Index of Entropy (IOE) is used to calculated the weightage of conditioning factors. Based on the weightages, conditioning factors are classified into two categories as group-1 (significant weightages) and group-2 (All weightages). As per result, elevation, slope, aspect, curvature, normalized difference vegetation index, geomorphology, distance to road, distance to lineament, and distance to river. On the other hand, factors such as land use land cover, stream power index, terrain ruggedness index, terrain roughness, topographic wetness index, annual rainfall, topographic position index, and geology had negligible weightage. Lastly, two landslide susceptibility zones map are prepared based on group #1 and 2 respectively. To assess the accuracy of the models, a receiver operating characteristic (ROC) curve and quality sum ratio method was performed using 30% of the testing landslide data and an equal number of non-landslide data points. The area under the curve (AUC) for group-1 and 2 are 0.947 and 0.922, respectively, indicating higher efficiency for group-1. The findings indicate that group1's LSZ mapping is suitable for policymakers to manage landslide risk reduction and land use planning.

Keywords: Landslide susceptibility; Index of Entropy; Optimization; Jhum cultivation

Tunneling in weak rock: A case study of Kathmandu University Research Tunnel

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The Lower Himalayas, a relatively young and seismically active mountain range, present considerable difficulties for tunnel construction due to diverse and unstable geological features. Factors such as weathering, shear and thrust zones, rock folding and interbedded layers, rock overburden, seepage from rainfall, and seismic activity collectively contribute to the complexity and risk of tunnel excavation in this region. These conditions lead to frequent tunnel instability issues like rock bursts, squeezing, and failures in sheared zones and heavily weathered rock masses. In the present study, Kathmandu University Research Tunnel located at lesser Himalaya, is reviewed with a focus on the problems encountered during the tunneling and their possible causes and remedies. Frequent challenges included rock falls, block detachment and soil overflow, especially at highly weathered and clayey zones that were widespread throughout the tunnel, particularly in the crown area. Numerous weak zones with complex features, highly jointed rock mass with low RQD value belonging to Tistung formation including closely spaced shear bands and disintegrated rock mass created mixed-face conditions that weakened structural stability and compromised worker safety. This paper presents the major geological challenges and the remedies applied during tunneling and is expected to be of value in other tunneling projects in highly weathered and geologically complex regions like the Himalayas.

Keywords: Tunneling; RQD; excavation; research tunnel

The influence of Geomechanical Structure and variable Rock Mass Parameters in slope stability study

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Slope Stability of rockmass is influenced by a complex interplay of geological factors like rock type and properties, discontinuities, fault and fold in addition to others factors like geometry of hillslope, groundwater condition and seismicity of the area. This research aims to investigate the geological factor including fault zones, folding, and jointing along with the rockmass type and properties in the headworks area of Dudhkoshi Storage hydroelectric project. Given the complexities of the Himalayan terrain, the rock mass parameters, such as strength, cohesion, and friction angle, exhibit considerable spatial variation, making accurate predictions of slope behavior challenging. The study involves the geological survey, field data acquisition and assessment of geotechnical investigation like laboratory tests, borehole drilling and geophysical survey in headworks area of the project. The study utilizes both deterministic and probabilistic approaches to assess slope stability, incorporating geological mapping, field observations, and laboratory testing to quantify rock mass properties. The findings reveal that geological structures such as active fault zones and shear zones significantly weaken the rock mass, exacerbating slope instability. Additionally, the uncertainty in rock mass parameters, including variations in material strength and heterogeneity, introduces significant risks in predicting potential slope failure. The results emphasize the importance of incorporating both geological context and the inherent variability of rock properties when evaluating slope stability in the Nepal Himalayas. This research provides valuable insights for risk assessment and the design of mitigation strategies for landslides and other mass wasting events in the region.

Keywords: Slope Stability; Geomechanical Structures; Rock Mass Parameters; Probabilistic Methods; Deterministic Methods

Assessing Geothermometer suitability: insights on garnet-clinopyroxene thermometer from Himalaya

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Garnet-clinopyroxene mineral assemblages from the Himalayas play a significant role in understanding high-pressure metamorphism and the tectono-metamorphic evolution of the region. These assemblages are commonly found in eclogites, high-pressure granulites, and mafic garnet-bearing gneisses, providing valuable insights into the burial and exhumation history of the Himalayan orogeny. The garnet-clinopyroxene thermometer is frequently used to estimate the equilibration temperature of these rocks in the Himalayas. Given the existence of several calibrations for this thermometer, the authors conducted a study to determine the most suitable model for this mineral pair. They collected 31 sample data sets of garnet-clinopyroxene pairs from the Himalayan region, drawing from published literature that assesses eleven geothermometer models proposed since 1970. The collated data were processed using Gt-Cpx.Exe software, and the results indicated that the model by Raheim and Green (1974) yields the best regression values with minimal scattering. This was followed by the models from Mysen and Heier (1972), Jun Lui (1998), Ganguly and Saxena (1987), and Ganguly (1979).

Keywords: Garnet; Clinopyroxene; Exchange reaction; Granulite; Comparative study

Geochemistry and petrogenesis of tonalite trondhjemite granodiorite gneisses of Babina area, District Jhansi, Uttar Pradesh

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The Archean crust of the Bundelkhand Craton is characterized by tonalite-trondhjemite-granodiorite (TTG) gneisses, which are associated with the central greenstone belt. This study focuses on the geochemistry and petrogenesis of the TTG gneisses found in the Babina area of District Jhansi. The TTGs in this region exhibit alternating banding patterns, consisting of lighter felsic bands made up of quartz and plagioclase feldspar (with an An% range of 7.02 to 27.83%), and darker mafic bands composed of biotite and hornblende. Accessory minerals present include epidote, apatite, allanite, zircon, and Fe-Ti oxides. The chloritization observed in biotite and hornblende indicates the influence of hydrothermal activity. Geochemical analyses of the TTG gneisses were conducted and compared with published data. The results indicate that these TTGs have a high silica content, ranging from 58.17 to 72.26 wt%, along with low levels of K_2O (0.99 to 3.33 wt%) and Na_2O (1.29 to 0.93 wt%). A negative correlation was observed for CaO, Al_2O_3, TiO_2, K_2O, P_2O_5, and MgO, suggesting that magma generation was followed by the fractionation of plagioclase and biotite, along with the removal of accessory minerals such as epidote, apatite, allanite, and Fe-Ti oxides. The geochemical evidence indicates that the TTG gneisses are meta-peraluminous and are believed to have originated from melts generated by the hydrous partial melting of low potassium mafic rocks in a pre-to-post collision tectonic setting.

Keywords: Geochemistry; Petrogenesis; TTG-Gneisses; Tectonic Setting

Quantifying Aluminum: Analytical Approaches to Assessing Exposure and Impact on Human Health and Well Being

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Aluminum (Al), constituting the elemental framework with an atomic number of 13 and symbol Al, pervades various environmental compartments and consumer products, thus presenting potential health hazards to human populations. This synthesis encapsulates insights garnered from diverse scholarly inquiries to elucidate the manifold pathways of aluminum exposure and its repercussions on human physiology. From adulterated aquifers, mining to leaching phenomena from culinary utensils, individuals are subjected to aluminum ingress through ingestion, inhalation, and dermal absorption routes. Prolonged exposure to aluminum, encompassing its isotopic variants such as ^{27}Al and ^{26}Al, has been associated with an array of health ramifications, including neurological impairments, respiratory afflictions, and systemic inflammatory responses. Regulatory initiatives, comprising restrictions on aluminum content in consumer goods, underscore ongoing endeavors to mitigate associated risks. However, the intricate chemistry of aluminum, alongside its isotopic composition, mandates persistent scholarly investigations aimed at refining risk assessment methodologies and informing evidence-based policy formulations. This discourse underscores the interdisciplinary nature of addressing aluminum exposure and underscores the imperative of sustained scholarly endeavors to safeguard public health.

Keywords: Aluminum; neurology; exposure; alzheimer; pulmonary; interdisciplinary; miner

Regional scale landslide susceptibility mapping of Lumbini Province using Frequency Ratio method

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This study presents a comprehensive assessment of landslide susceptibility across twelve districts in the hilly regions of Lumbini Province of Nepal, where frequent landslides pose significant threats to communities and infrastructure. The research analyzes approximately 100 landslide events using an integrated approach combining Geographic Information System (GIS) and statistical methods to assess susceptibility levels in the region. The methodology incorporates multiple causative factors, including slope gradient, geology, land use patterns, proximity to roads and rivers, and rainfall distribution. By using the Frequency Ratio (FR) method, the study integrates these various causative factors and quantifies their individual contributions to landslide occurrences. By calculating the frequency ratio for each factor class, this method highlights the relative influence of each factor in triggering landslides. By employing such a multi-criteria evaluation technique, the study quantifies the relative influence of each factor on landslide occurrence, enabling the identification of high-risk zones with greater precision. The integration of field surveys, historical data, and remote sensing techniques enhances the reliability of the susceptibility assessment. The findings reveal that areas characterized by steep slopes, unplanned construction of roads and dense road networks, and unplanned settlements exhibit the highest susceptibility to landslides, with recent events predominantly linked to human activities. This research has significant implications for regional planning and disaster management, providing a scientific basis for implementing targeted mitigation strategies. The developed susceptibility map serves as a valuable tool for decision-making in land-use planning and infrastructure development, and it also highlights the areas requiring immediate intervention for risk reduction. The study also highlights the critical need for regulated construction practices and continuous monitoring in this geologically complex region.

Keywords: Landslide Susceptibility; Frequency Ratio; GIS; Lumbini Province

Plant Fossils from the Siwalik Succession of Nepal Himalaya

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The Siwalik flora of the Himalayan Foreland Basin is important in understanding the vegetation shift and the orogeny of the Himalaya vis-à-vis climate change. The ancient river that meandered to braided between the Lesser Himalaya in the north and the Indo-Gangetic Plain in the south is responsible for depositing these Siwalik sediments. These sediments accumulated all along the length of the Himalayan Foreland Basin in a coarsening upward succession known as the Siwalik Group. This group is divided into three sub-groups, named as the Lower, Middle, and Upper Siwalik. In the Lower and Middle Siwalik sediments of western Nepal, abundant plant fossils have been discovered in the form of leaves, wood, fruits, seeds and pollen. However, there are few floral records from the Siwalik sediments of central and eastern Nepal. Here, we report in total of 30 species comprising of 26 genera to 15 families of pteridophytes and angiosperms including leaves and fruit wings that are identified from the Lower to Upper Siwalik of the central and eastern Nepal. The overall qualitative analysis of present and previous records of the fossil assemblage of the studied area indicates tropical to subtropical evergreen to deciduous taxa in the Lower to Upper Siwalik succession.

Keywords: Megafossils; Siwalik; fossils; qualitative analysis

Plant Fossils from the Siwalik Group of West Nepal and their Climatic Significance

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The Middle Miocene-Early Pleistocene sediments of the Siwalik Group in the Himalayan belt host an excellent archive to analyze paleofloristic and paleoclimate conditions of the region. However, there are few floral records from the Siwalik sediments of the Daldale area, west Nepal. In present communication, we report that 10 species of plant fossils from seven families were identified to their specific level. They are *Amesoneuron* sp. of the family Arecaceae, *Clinogyne ovatus* Awasthi and Prasad of the family Marantaceae, *Bambusa siwalika* Awasthi and Prasad of the family Poaceae, *Mangifera someshwarica* Lakhanpal and Awasthi, *Shorea* of the Dipterocarpaceae family *Cynometra siwalika* Awasthi and Prasad, *Leguminocarpon* sp. 1 and *Leguminocarpon* sp. 2 of the Fabaceae family, *Daphnogene makumensis* Mehrotra et al. and *Cinnamomum palaeotamala* Lakhanpal and Awasthi of the Lauraceae family. The floristic analysis of the plant fossil assemblage of the Siwalik succession enjoyed evergreen to deciduous forests of sub-tropical to tropical climate with warm and humid conditions during the deposition period of the Siwalik sediments.

Keywords: Plant Fossils; Siwalik Group; Miocene; Daldale area; west Nepal

Past and present of the franco-nepalese collaboration in seismology

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The Franco-Nepal collaboration in seismology, between the Government of Nepal (Department of Mines and Geology) and France (Département d'Analyse et de Surveillance de l'Environnement), represents over 45 years of enduring international partnership in scientific research. Initiated in 1978 with a single station, this collaboration marked the beginning of Nepal's national seismic monitoring network, which expanded to five analog stations by 1985. Today, it has evolved into a fully digital network comprising 23 seismic stations, 5 accelerometric stations, and 3 GPS stations. These are managed through two distinct branches with corresponding recording centers: the National Earthquake Monitoring and Research Center (NEMRC) in Kathmandu and the Seismological Centre (SC) in Surkhet. A recent state-of-the-art upgrade has enabled these recording centers to function independently while serving as mutual backups, ensuring data integrity and continuous monitoring. This study presents the key phases and evolution of the collaborative work between Nepalese and French researchers over the years. It also features the operation of the seismic stations and recording centers during critical periods, as in the 2015 Gorkha earthquake crisis, which resulted in the recording of the mainshock and thousands of aftershocks. Moreover, it portrays the quick response of the collaborative team in deploying temporary stations after major seismic events, such as the recent Jajarkot earthquake, enabling the collection of vital data and facilitating in-depth studies of these seismic crises.

Keywords: Seismic; collaboration; 2015 Gorkha earthquake

Study the Instability of Tunnel Portal: A case study of Siddhababa Road Tunnel, Lumbini Province, Nepal

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The Construction of tunnel portal in the Himalaya involves instability problem. The Siddhababa Road Tunnel Project is located in Siwalik Zone. It comprises thick bedded mudstone and sandstone with a high hazards of block fall and rockfall area. This research work is focused in the back analysis of the failure slope of portal area. The back analysis is done by the finite element method. The slope instabilities are carried out before and after tunnel excavation. The input data used in the numerical analysis were obtained from field mapping and performed laboratory tests. The rock mass properties and engineering geological parameters required for stability analysis of the Portal area were carefully evaluated. The north portal slope consisted of four types of materials; i.e., colluvium soil, fine-medium grained sandstone, interbedding of siltstone and mudstone, interbedding of sandstone and mudstone. The output of numerical analysis showed that the natural slope at the north portal was stable, i.e., critical SRF value was 1.46, under static load. The SRF value at first, second and third stage excavations reduced to 0.8, 0.76 and 0.75 respectively. These values indicate the stability decreases after different stages of excavation. The strength parameters like cohesion, friction angle, unit weight, modulus of elasticity, Poisson's ratio, UCS, GSI of different layers were calculated and modelled on RS2.

Keywords: Portal; Instability; RS2; SRF; Numerical modeling

10 years of Gorkha earthquake aftershocks

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The Gorkha earthquake (Mw=7.9) struck Nepal on April 25, 2015, devastating the central region and the Kathmandu Valley. Due to postseismic relaxation, an earthquake of this magnitude is expected to generate tens of thousands of aftershocks over decades, spreading anxiety among the population. Thanks to the 21 historical seismic stations deployed in the framework of the DMG-DASE collaboration and still contributing significantly to the Nepal national seismic network, it has been possible to study the spatial distribution of these aftershocks and the evolution of their occurrence over time. The analysis of five years of aftershocks revealed that the seismicity rate in the region in 2020 was still about five times higher than the interseismic rate. In this presentation, we rely on an additional five years of data to provide an overview of nearly ten years of aftershocks, using the same seismological stations. Our results show a decrease in the magnitude of completeness over time, reflecting an improved ability to detect smaller earthquakes. We present seismicity maps that show an aftershock distribution consistent with previous studies. Finally, we show that the seismicity rate between 2020 and 2025 is about twice the interseismic rate. The instruments monitoring the Gorkha crisis, as well as the excellent phase picking work done at the DMG by the analysts make the Gorkha earthquake and its aftershocks the best instrumented Himalayan seismic sequence in history. The spatio-temporal monitoring of aftershocks from this major event not only enhances our understanding of the structural geology of the Himalayas but also provides valuable information to authorities regarding the current state of seismicity in the region affected by the aftershocks.

Keywords: Gorkha earthquake; Aftershock; Seismicity rate; Hypo71; Seismic hazard assessment; Nepal seismic network

Background noise analysis of Kakani Seismic Station

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The Kakani Seismic Station, located in Kakani, Nuwakot, is a facility for monitoring seismic activity, which is established through a collaboration between the Department of Mines and Geology (DMG) and Departement d'Analyse et Surveillance de l'Environnement (DASE), France. This station is one of the important stations valuable in detecting earthquakes, aftershocks, and background noise, which contributes to the study of seismotectonics and seismological activities, earthquake dynamics, etc. of the Nepal Himalaya. Data recorded by the station has been open and freely available from EarthScope Data Center (IRISDMC) with the network code 'NP' and station ID 'KKN' since 2016. This article presents an overview of analysis of the anthropogenic noise at the Kakani seismic station over the past five years. A broadband Guralp 3T seismometer is used at the Kakani station, which is very sensitive to seismic activities and also environment noises. Further, Power Spectral Density Probability Density Function (PSD PDF) curves are plotted for more than five years to see the background noise level in different frequency bands. We also computed the average displacement recorded by the seismometer and observed the diurnal variation of the background noises. The site is quiet enough to record microseismicity, and unusually noisy data is often observed mainly during the daytime, possibly because of the people's activity at the proximity of the station. Similar noise levels and pattern is expected at all of the seismic stations installed by National Earthquake Monitoring and Research Centre (NEMRC) since installation and setup have the same configuration.

Keywords: Kakani Seismic Station; Background noise; PSD PD

Recent Seismicity of Western Nepal

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Geographically the Himalaya range lies between Namche Barwa in eastern syntaxis and Naga Parbat in western syntaxis. Nepal Himalaya occupies nearly one-third of the 2500 km long Himalaya range. Geographically Nepal Himalaya is differentiated into five stratigraphy, based on the four major tectonic structures i.e. Main Frontal Thrust (MFT), Main Boundary Thrust (MBT), Main Central Thrust (MCT) and South Tibetan Detachment System (STDS) from South to North. Western Nepal seismicity is controlled by the mid-crustal ramp in the hanging wall of the flat-ramp-flat geometry of the Main Himalayan Thrust (MHT), in contrary to the double-ramp geometry in eastern Nepal. This paper reports the seismic activity in western Nepal, the seismic network, and the earthquake catalogue from 2022 to 2024. Seismic data was acquired under the National Earthquake Monitoring and Research Center (NEMRC). Western Nepal has a seismic gap of approximately 520 years. Recently, the region has experienced four significant earthquakes: the Doti earthquake (2022-11-08, ML 6.6), the Bajura earthquake (2023-01-24, ML 5.9), the Bajhang earthquake (2023-10-03, ML 6.3), and the Jajarkot earthquake (2023-11-03, ML 6.4). Over 3,600 seismic events were recorded during this period, with a magnitude of completeness (Mc) 2.3 and a b-value 0.75 ± 0.02.

Keywords: Seismicity; Tectonic Structures; Earthquakes; Epicenter; b-value

Geology of hot springs in Nepal: an overview

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The Himalayan Frontal Thrust (HFT), Main Boundary Thrust (MBT), Main Central Thrust (MCT), and South Tibetan Detachment (STD) divide Nepal from south to north, forming the five prominent tectonic units of the Terai, Siwalik, Lesser Himalayan, Higher Himalayan, and Tibetan-Tethys Himalayan zones. From east to west, the Main Central Thrust Zone of the Nepal Himalaya is the place to existing several hot springs. Nonetheless, a significant number of hot spring locations have been documented from this region in the central, western and far-western Nepal Himalaya than in the eastern region of Nepal. Few hot springs are seen discharging from sandstones and gravel deposits in the Siwalik zone, while hot spring is rare in the Terai plain area. On the other hand, the Higher and Lesser Himalayan regions are showing a significant number of hot springs. The rocks found in the Lesser Himalayan hot springs' outlet area are meta-sandstones and quartzites, whereas the hot springs that are encased in the Higher Himalayan zones are issuing from schists, quartzites and gneisses. The purpose of this study is to present an overview of Nepal's hot spring distributions in terms of geology and large-scale tectonic structures, with an emphasis on the hot springs' physical and geochemical properties.

Keywords: Hot springs; Nepal Himalaya; tectonic structures

Analyzing predicted rock mass classes with actual rock mass classes in pressurized headrace tunnel of Mewa Khola Hydroelectric Project

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This study involves analysing actual rock mass classes of pressurized headrace tunnel with predicted rock mass classes in design stage of Mewa Khola Hydroelectric Project. The adopted rock mass classifications were Q-system, at the time of design phase as well as for classify rock mass during excavation of headrace tunnel in the construction stage. The lithology of the study area consists of gneiss, schist. The total length of headrace tunnel is 4801 m. The excavation procedure was drilled and blast method. Variation in the rock class and support during the design and construction were analysed deeply. The consequence that has generated due to its effect has been analysed. It was found that the predicted classes do not exactly matches with the actual rock masses as a results effecting in construction time, generating variation in proposed cost and economy of the project.

Keywords: Comparison; Geology; Actual rock mass; Predicted rock mass; headrace tunnel

Aftershocks of Gorkha Earthquake and the Seismo-geological Segmentation of the Main Himalayan Thrust (MHT)

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The Mw 7.9 2015 April 25 Gorkha earthquake is the latest of a series of large devastating earthquakes that have occurred in the Himalaya. For the first time ever in Himalaya, a local seismic network above the fault ruptured recorded the large mainshock as well as its aftershocks. More than 55000 aftershocks were recorded by the network and located within the ruptured area during the 10 years that followed the event. Several bursts of earthquakes, sometimes organized in large clusters, have been observed from a few days to several years after the main shock. Most of the clusters occurred in the regions producing seismicity during the interseismic period of the seismic cycle but some new seismic clusters were also recorded elsewhere, to the North (e.g. the Himalchuli cluster) or to the South (e.g. under Kathmandu valley). This presentation will be focused on the principal postseismic clusters that will be confronted to the geological structures at depth. The seismicity projects mainly along the downdip end of the inter-mediate flat section of the Main Himalayan Thrust, near steps or tear faults affecting the main midcrustal ramp. The Kathmandu seismicity occurs in the vicinity of a secondary ramp which separates the upper and intermediate flats of a double-decked structure. All the structural heterogeneities aforementioned contribute to a persistent segmentation of the seismicity along strike. These clusters therefore reveal the seismo-geological segmentation that influences both the coseismic rupture and the post-seismic relaxation.

Keywords: Gorkha earthquake; Aftershock; Seismicity; Main Himalayan Thrust

Environmental Seismic Noise Monitoring in Kathmandu Valley

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Earthquakes are primarily studied through the analysis of seismic data. However, in urban areas, the evaluation of background seismicity is made challenging due to the substantial presence of anthropogenic seismic noise, which is produced by human activities and everyday life. As a result, analyzing seismic data from large cities allows us to determine the main contributors to this noise and consider measures to improve the monitoring conditions in such environments. Kathmandu Valley in Nepal is highly susceptible to seismic hazards due to its geological setting and rapid urbanization. To study the background environmental noise at different sites in Kathmandu Valley, we have used seismic stations already installed by universities, NGOs, or individuals within the framework of Raspberry Shake, one of the largest citizen science seismic networks. We have analyzed seismic data recorded by Raspberry Shake 4D and 1D seismometer and studied the noise level at each site. Based on the Power Spectral Density (PSD) plots, most of the sites in the Kathmandu Valley are noisy, possibly because of the high traffic, human activities at the closer distance, and other activities caused by the people. We also computed daily displacement occurred in each site and found that the background noise varies not only day and night but also in different seasons.

Keywords: Seismic Noise Analysis; Background Noise; PSD; Seismometer

Geospatial distribution of landslides in the Lumbini Province

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Lumbini Province, located in western Nepal, is known for its diverse geography, ranging from the lowland Terai to the rugged hills of the Chure and Mahabharat ranges. The Main Boundary Thrust passes through the region, which makes the geology more complicated due to tectonic movements. This study aims to analyze the geospatial distribution of Landslides in Lumbini province as well as the causes and triggering factors in different areas in the province. First, a preliminary literature review is done on Landslides and its possible triggering factors. The data for this project are retrieved from the Bipad Portal (2012-2024), rainfall records from DHM, seismic and geological maps from the Department of Mines and Geology, and road infrastructure details from the Department of Roads. The data is analyzed by statistical methods to understand the triggering factors (rainfall, tectonic activity, toe-cutting, and road construction) and how these factors influence landslides over the years from 2012-2024. The study shows that the areas most affected by landslides are Rolpa and Eastern Rukum, which are located in the region influenced by the tectonic activity along the MBT. The meteorological station in Baldyanggadi, Palpa, also showed a significant increase in rainfall from 90.4mm to 252.0mm on September 28, 2024, which resulted in several landslides. The weak Geology of Chure helps in triggering landslides as major cities are located in and around Chure in this province with a larger population density, rather a small size of the landslide could be huge in terms of monitory value. Important infrastructures and historical and ecological complex ecosystems in this region can be harmed by landslides in the future. Therefore, the findings suggest that small technical and financial steps in the field can reduce the risk of Landslides in the Lumbini province by a high percentage.

Keywords: Landslides; geospatial analysis; rainfall

Analysis of the main Himalayan thrust fault system based on the 2015 Gorkha and 2023 Jajarkot earthquakes

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Many scientific questions remain about the Himalayan formation, including MHT's geometry and the structural causes of earthquake rupture segmentation. Nepal has experienced two catastrophic earthquakes in this decade: the 2015 Mw 7.8 Gorkha earthquake and the 2023 Mw 5.7 Jajarkot earthquake. These earthquakes occurred in the vicinity of the MHT, providing constraints on the features of this megathrust fault. On 25 April 2015, a Mw 7.8 earthquake occurred in Gorkha district. To understand the seismogenic structure and aftershock behaviour, we extracted aftershocks from continuous seismic waveforms recorded at stations in the source rupture area. The relocation results show a complex pattern due to MHT's geometry, with the mainshock occurred on the MHT and aftershocks above it. Cross-sections show lateral variations, with a lesser Himalayan ramp in the west and a flatter and deeper section in the east of the aftershock zone. On 3 November 2023, a Mw 5.7 earthquake hit Jajarkot district in western Nepal, which hasn't experienced a major earthquake since 1505. We used local seismic stations, deployed by our team in Nepal and southern China, as well as teleseismic stations with depth phase records, to perform the earthquake relocation and study the source rupture process. The fault plane solution indicates a north-dipping thrust fault with an angle of 20°, which is steeper than the average MHT geometry. The rupture propagated to shallower depths, which is the main reason for the severe damage. The study of these two earthquake sequences indicates that the near-horizontal MHT and steeper dipping faults form the thrust faulting system. This region beneath the Lesser Himalaya is the most seismically active and accommodates significant elastic strain accumulation, offering new constraints on the local geometry of the MHT, particularly in central and western Nepal.

Keywords: Main Himalayan Thrust; The 2015 Mw7.8 Gorkha earthquake; The 2023 Mw5.7 Jajarkot earthquake; Seismic observations

A decade of GPS monitoring in Nepal by Nepal Academy of Science and Technology

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Over the past decade, the Nepal Academy of Science and Technology (NAST) has played a crucial role in the 2015 Gorkha earthquake through a GPS network in the ~85E-83E region. As Nepal is located in a seismically active region, continuous GPS monitoring is essential for understanding geodetic movements, land deformation, and seismic hazards. NAST has established and maintained 11 GPS stations for more than a decade at key sites, including Khumaltar, Kirtipur, Hetauda, Birgunj, Betalari (Nawalparasi), Kawasoti, Bhairahawa, Syangja, Damauli, Besishahar, and North of Besishahar, Ghermu. This study provides an insight into a site selection, installation, maintenance, monitoring, and data collection in every six months which is crucial for securing high-quality data. One of our GPS station has recorded the 2015 Gorkha earthquake movements and it is widely cited and recognized in scientific community. We have also installed 4 temporary GPS stations in Kathmandu Valley for the purpose of recording big seismic events; we are collecting ~72 hours data in a regular manner from these temporary stations. More recently, we are aiming to upgrade some of GPS stations with high end latest receivers and the technology with the support of California Institute of Technology. We are also planning to install more GPS stations through south-to-north profile in different section in Nepal. The processed geodetic data are available through the EarthScope platform.

Keywords: NAST; GPS station; monitoring; seismic hazards

The 2024 GLOF disaster in Thame valley: causes, impacts and pathways for future risk reduction

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Glacial Lake Outburst Floods (GLOFs) are among the most destructive natural hazards in high-mountain regions, capable of releasing millions of cubic meters of water and debris within hours, resulting in catastrophic downstream damage. On August 16, 2024, Thame Valley was struck by a severe GLOF, causing widespread devastation. The disaster displaced people from their homes and triggered panic among downstream communities. This study incorporates remote sensing data, field-based geological and geomorphological analyses, along with Uncrewed Aerial Vehicle (UAV) and Differential Global Positioning System (DGPS) surveys to investigate the event's causes and impacts and inform future risk. Our findings indicate that the disaster was caused by the sequential breaching of two glacial lakes, while the valley's unique geological and geomorphological characteristics exacerbated the impacts. The initial breach of the Upper Ngole Cho (Upper Lake) was triggered by a rock avalanche on the left flank, which displaced massive volumes of water causing the lake to overflow and erode 20.7m length and 4.6m depth of the moraine deposits over a bedrock dam. This led to a subsequent larger breach of about 51m length and 21.6m depth of end-moraine of the Lower Ngole Cho (Lower Lake). This cascade of events generated a hyper-concentrated debris flow down the Thame River, leading to extensive erosion and sediment deposition along the river valley. The severe damage in Thame Village can be attributed to the valley's geological and geomorphological settings, which amplified the destructive power of the flood. The upper Ngole Cho remains at risk to similar events of overflow due to rock avalanches, landslides, debris flow and ice avalanches. Additionally, Rindi Cho and Homey Cho, two of the other glacial lakes in the valley, pose moderate to high risk, necessitating further geophysical assessment. The event underscores the urgent need for proactive risk management in the valley, including infrastructure protection, sediment control, river channelization, and monitoring systems. Immediate measures, such as managing flow and erosion, installing hydro-meteorological monitoring and warning systems, and using hazard maps to guide land use decisions, are crucial to reducing future flood risks. However, implementing structural interventions in this high-altitude, harsh environment presents significant financial and logistical challenges. A comprehensive long-term risk mitigation strategy that integrates socio-economic factors is essential for Thame Village's safety and resilience. The event also stresses the need for the government action to monitor high-risk GLOF areas in the country in coordination with relevant agencies and enhance preparedness and communication strategies.

Keywords: GLOF; avalanches; risk management; warning systems

Seismic Performance of foundation with GEOGRID

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This study investigates seismic performance analysis of geogrid stabilized foundations under numerical modeling using a Geotechnical Engineering Software, PLAXIS 2D. The research focuses on consecutive acceleration differences between floors to assess the effectiveness of geogrid in improving structural stability. The results of the study show that geogrid is effective in mitigating sudden change in acceleration from a floor to another, which leads to a homogeneous seismic response. Without geogrid, differences between consecutive floors were 0.049g (Basement–1st), 0.059g (1st–2nd), 0.032g (2nd–3rd), -0.023g (3rd–4th), and 0.053g (4th–5th). But with the addition of geogrid (1.8B 2 case), corresponding differences were 0.017g, 0.025g, 0.034g, -0.007g, and 0.087g, respectively. The results indicate that the foundation stabilized by the geogrid experiences less abrupt change in acceleration floor to floor and thus performs less abrupt jumps that tend to cause more structural damage. For example, the basement-first-floor difference reduced by 65.3% and first-second-floor difference reduced by 57.6%, which is more smoothed seismic response. The study shows the benefits of inter-floor acceleration difference reduction, and general foundation stability enhancement by geogrid reinforcement. The study highlights the importance of geogrid-reinforced foundations in seismically active areas, and its findings helps in future structural design.

Keywords: Seismic response; Geogrid; slope stabilization; PLAXIS

Groundwater Resources Exploitation in Nepal: Challenges, Opportunities, and Technological Interventions

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In Nepal,overall groundwater potential is high, particularly in Terai. There is tremendous scope for expanding groundwater use in river valleys belonging to the hills and mountains. Artificial groundwater rechargeis yet to be carried out within the country. If initiated, it could help replenish depleting groundwater which, in turn would aid in the sustainable development of these precious resources. Recent innovations in groundwater extraction technologies accelerated resource utilization. Yet,we face many challenges inharnessing this precious resource. Some of the major challenges include unregulated extraction, lack of a regulating governing authority, overlapping institutional responsibilities, and the adverse effects of climate change. Recent government higher investment and support provide a path forward to overcoming these challenges. This paper highlights the challenges, opportunities, and technological interventions required for sustainable groundwater management in Nepal.

Keywords: Groundwater; artificial recharge; potential; challenges; technical innovations

Impact of Landfill Leachate on Geotechnical Properties of Soil: A Study from Banchare Dada and Sisdole Landfill Sites, Nepal

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The rapid growth of population and urbanization has resulted in large amounts of municipal solid waste (MSW) being produced worldwide. This increase in waste generation poses significant environmental and geotechnical challenges. Improper waste disposal practices result in soil contamination, altering its engineering properties and posing risks to environmental sustainability. The infiltration of leachate from MSW induces complex physicochemical interactions within the soil matrix, affecting its stability and mechanical behavior. This study investigates the influence of landfill leachate on the geotechnical properties of soil by analyzing 12 samples collected from four locations at varying depths (0.25m, 0.50m, and 0.75m). Two contaminated landfill sites (Sisdole and Banchare) in the Kakani rural municipality of the Nuwakot district were chosen, along with two nearby uncontaminated control sites, for comparison. Laboratory experiments, including pH measurement, electrical conductivity, specific gravity, organic content, Atterberg limit test, sieve analysis, and direct shear tests, were conducted to evaluate the impact of leachate contamination on soil behavior. Results indicate that contaminated soils exhibit increased moisture content, plasticity index, and organic matter accumulation while demonstrating lower specific gravity, dry density, and shear strength. The decomposition of organic material enhances the presence of clay-sized particles, increasing soil plasticity while reducing its load-bearing capacity. Furthermore, the alteration of soil structure leads to a decline in the angle of internal friction, increasing cohesion and further influencing soil shear strength. These findings highlight the necessity of proper waste management strategies to mitigate geotechnical deterioration and ensure the safe application of contaminated land for engineering purposes.

Keywords: Geotechnical Properties; Landfill site; Leachate; Municipal Solid Waste; Soil Contamination

Analysis of the aftershock activity of the 2023 Western Nepal earthquakes

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Western Nepal experienced two moderate earthquakes at the end of 2023. The first, measuring magnitude ML 6.3, struck Bajhang District on October 3rd, followed by a second earthquake of ML 6.4 in Jajarkot District on November 3rd. This area has been under scrutiny by scientists, who have been anticipating a major earthquake, as the most recent great earthquake occurred over 500 years ago in 1505 AD with a magnitude exceeding MW 8.5. Both recent earthquakes were widely felt in Kathmandu and Delhi, India. Despite being classified as moderate, these earthquakes caused more than 158 fatalities along with considerable destruction in houses and local infrastructure. After the occurrence of the mainshocks, we deployed temporary seismic stations to ensure prompt monitoring of the aftershocks in the affected area. This deployment began three days after the mainshocks and continued for three months. In total, nine Raspberry Shake seismometers were installed, providing continuous recordings of seismic activity throughout this timeframe near the epicentral areas. In this study, we have used seismic data from the nine temporarily deployed seismic stations in conjunction with permanent stations from the Nepal School Seismic Network to analyze the aftershock sequences following the 2023 earthquakes in western Nepal. The automatic detection and localization of earthquakes were conducted using SeisComP software, with each event undergoing manual verification. The detection workflow comprised the identification of P phase arrival times through scautopick with the *STA/LTA* technique, the association of phase triggers with origins using *scautoloc*, and the location determination via *LOCSAT*. After the initial automatic location, we manually reevaluated all earthquakes with the *HYPO71* software, using the local velocity model from the Nepal Earthquake Monitoring and Research Centre (NEMRC). Our results indicate that low-cost instrumentation can be a valuable tool for studying significant seismic events in active regions, requiring less field effort than conventional broadband stations.

Keywords: Aftershock; earthquakes; detection

Landslide Inventory mapping in Bhutan

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The Kingdom of Bhutan, situated in the eastern Himalayas, faces heightened vulnerability to climate change-induced landslides due to its active tectonic setting, fragile geology, and steep terrain. These disasters pose significant risks to infrastructure, livelihoods, and ecosystems. To address this, a comprehensive landslide inventory (2014–2024) was developed using a framework adapted from Oregon (2008), integrating remote sensing, field surveys, historical records, and GIS tools. The study documented 1,144 landslides, classifying 21% (239) as critical and 79% (905) as non-critical. Spatial analysis revealed pronounced regional disparities: the southern region accounted for 79.3% of landslides, followed by the east (11.3%), west (8.8%), and north (0.6%). This distribution correlates with geological and climatic gradients, particularly in the landslide-prone south, where steep slopes, unstable lithology, and extreme rainfall—exceeding 7,220 mm annually (e.g., 2020)—drive recurrent slope failures. Natural triggers (fragile lithology, intense rainfall, seismic activity, river erosion) contributed to 70% of landslides, while anthropogenic factors (road construction, poor drainage, deforestation, unplanned development) accounted for 30%. The southern hotspots underscore the compounding effects of geophysical susceptibility and climate extremes, with heavy monsoon rains amplifying instability. These findings underscore the imperative for region-specific risk mitigation strategies that integrate geotechnical interventions, robust land-use planning, and climate adaptation measures. This landslide inventory provides a critical foundation for policymakers, including the National Land Commission Secretariat, Department of Surface Transport, Department of Human Settlement and Department of Local Government, to prioritize resilience in high-risk zones. This aligns with Bhutan's sustainable development goals, particularly crucial amidst escalating climate challenges. By offering valuable insights into high-risk zones and vulnerable areas, this inventory serves as an indispensable resource for enhancing disaster risk reduction and optimizing land-use planning.

Keywords: Landslide; classification; spatial analysis; monsoon

Identification of river-groundwater interaction and assessing its suitability for drinking and irrigational purposes in the Punyamata river, Kavrepalanchwok, central Nepal

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The Interaction of river and groundwater indicates the exchange of water and nutrients or contaminants within these water systems. The present study was conducted along the Punyamata River to identify river-groundwater interaction using hydro-chemical parameters and water suitability for drinking and irrigation purposes. For this study, eight sampling sites were selected. Each site collected one river water sample and at least two groundwater samples from different distances for chemical analysis. Topographic surveys and water level measurements were also conducted to compare the water levels of dug wells and river channels. The losing and gaining conditions are simultaneously observed along the river. Ca-Mg-HCO3 and mixed type are the dominant river and groundwater types. The Water Quality Index (WQI) and Sodium Adsorption Ratio (SAR) assessments classify most water into excellent to good quality however certain locations were found unsuitable for drinking purposes due to elevated levels of iron, ammonia, potassium, manganese, alkalinity, hardness, and traces of arsenic. The Gibbs plot highlighted the influence of hydrogeological and anthropogenic factors on water chemistry. Groundwater wells closer to the river exhibited higher chemical concentrations than those farther away. Anthropogenic factors, such as unmanaged urbanization, agricultural runoff, septic leaks, and direct sewage discharge, were major contributors to water contamination.

Keywords: Groundwater, physio-chemical, WQI; SAR

Geomorphological and Tectonic Insights from River Terraces in the Kushma Area, Gandaki Province, Western Nepal: Implications for Landscape Evolution and Uplift

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The study investigates river terraces formed by the Kaligandaki River and Modi Khola in the Kushma area, focusing on their geomorphological and tectonic significance. The terraces are categorized into five distinct levels (T0–T5), with elevations ranging from 753.73 to 1403.02 m. Paired terraces in the southwestern and southeastern sections, as well as in the northeastern section, suggest relatively uniform uplift, while the unpaired relationship between the southeastern and southwestern terraces indicates differential tectonic activity. These terraces provide insights into the evolution of the regional landscape, influenced by river incision, uplift, and erosion processes. The deposits in the terraces primarily consist of carbonate-rich lithologies, including marble, limestone, gneiss, granite, schist, phyllite, and quartzite, with sediment sizes varying from clay to boulders. The study identifies a total of 649.29 m of thick river terrace deposits, with 353.08 m being particularly significant. The findings contribute to a better understanding of the tectonic history and river dynamics of the region.

Keywords: River terraces; tectonic uplift; geomorphology, landscape

Need of Integrated National Landslide Risk Management Strategy for Reducing Landslide Risk in Nepal

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National Disaster Risk Reduction and Management Authority (NDRRMA) is the principal body having the authority to act as the central resource body for disaster risk reduction and management as per Section 10 of the Disaster Risk Reduction and Management Act, 2074 BS. Landslide ranks as the second most lethal disaster which cause significant destruction in terms of loss of lives and property. As per the statistics, between 2011 and 2020, landslide density in Nepal has increased from 0.85- 3.34 events per 1,000 km^2 to 3.34 events per 1,000 km^2, indicating a significant rise in the frequency. These statistics suggests the critical need for comprehensive disaster risk reduction strategies in Nepal, focusing on sustainable development, early warning systems, and community preparedness to mitigate the adverse effects of landslides. Identifying the importance and severity of the situation, NDRRMA formulated National Landslide Risk Management Strategy to adopt a holistic approach for mainstreaming landslide risk reduction, besides strengthening of the State machinery and providing all necessary technical to address the landslide problem in a sustainable manner. Different organizations, such as NDRRMA, DMG, ICIMOD, academia, use varied datasets during their study leading to discrepancies in landslide frequency, location and extent. Discrepancies between research outputs and government planning result in conflicting recommendations for land-use planning, disaster response and infrastructure development. Some studies prioritize rainfall as the main trigger, while others emphasize earthquakes, road construction, or deforestation. All these variation has led to several issues during enforcement of the risk management strategy. This paper discusses the need of an integrated landslide disaster risk management strategy incorporating all the institutions working on the related field.

Keywords: Landslides; risk management; sustainable development; disaster

The Empirical Relationship between Soil Resistivity and Soil Strength Parameters as an Alternative to Soil Investigation

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The present study involves the correlation of field electrical resistivity with strength properties of soil along Sunwal to Lamahi section of New Butwal 400kv transmission line alignment. Geologically the area is located in Quaternary deposit of Terai plain and Siwalik. The objective of this study is to find correlation and empirical relationship between field electrical resistivity with strength properties of soil such as Cohesion (*c*), Internal Angle of Friction (*ø*), Moisture Content (*w*), Bulk Density (*d*) and Fine Content (*fc*). To obtain the results undisturbed sample from thirty-six number of test pits up to 3.0m depth and five number of boreholes up to 10.0m depth were extracted by using split-spoon sampler. These samples were tested in the laboratory and soil strength parameters were calculated. The field resistivity values were computed by using Wenner Alpha arrangement. The resistivity values up to 10.0 m depth for boreholes and up to 3.0m depth of test pits were taken for the analysis. The results obtained were compared and correlated with soil strength properties obtained from boreholes and test pits. Results from both the laboratory tests and field electrical resistivity tests indicate that there is consistent in the correlation between the resistivity and soil strength properties. The regression plots of the electrical resistivity (*ρ*) values against each of the determined strength parameters shows an empirical relationship

$ø = 25.143e^{-0.005\rho}$, $c = 2.2167\ln(\rho) + 19.671$, $w = 131.52\rho^{-0.499}$, $d = 0.0009\rho + 1.1697$ and $fc = 83.256e^{-0.004\rho}$ with Internal Angle of Friction, Cohesion, Moisture Content, Bulk Density and Fine Content respectively.

Keywords: Correlation; strength properties; geotechnical; electrical resistivity

Geology of the Inner Lesser Himalaya between Kalikot and Humla, West Nepal

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The research was carried out in the part of the Galwa Tectonic window, Lesser Himalayan Nappe and Karnali Klippe in West Nepal, along the Karnali River from the northern part of Karnali Nappe to Humla, focusing on lithostratigraphy and geological structures. The rocks of the area are divided into the Lesser Himalayan Sedimentary Sequence, Lesser Himalayan Metamorphic Sequence, and Higher Himalayan Crystalline, which are separated by regional thrusts. The Lesser Himalayan sequence comprises of (?) Early to middle Proterozoic low-medium grade metasedimentary rocks, which can be mapped into Grey-green Phyllite and Metasandstone Unit (more than 1000 m thick), Pale Yellow Quartzite Unit (900 m), Grey Dolomite and Slate Unit (more than 4000 m thick), and Black Slate Unit (more than 300 m thick). An anticline is observed in the area in which the axis passes from the Paima area with other small synformal and antiformal local structures. The Phyllite and Metasandstone Unit is thrusted over Grey Dolomite and Slate along the Kawadi Thrust. Similarly, the Lesser Himalayan Metamorphic sequence, comprised of (?) Paleo Proterozoic, medium- to high-grade metamorphic rocks, is sandwiched between the MCT in the South and the Parajul (Baddigad) Thrust in the North. The rocks can be subdivided into Light Grey to White Quartzite Unit (1900 m), Garnet Schist and Quartzite Unit (more than 4000 m), and Calcareous Quartzite and Marble Unit (100 m). Multiple foldings are observed in these sequences. The banded gneiss, augen gneiss, and amphibolite can be observed in various structural levels. Furthermore, the Higher Himalayan Crystalline is found in the south of the MCT, comprising Paleo Proterozoic high-grade metamorphic rocks such as banded gneiss, calcareous gneiss, and augen gneiss.

Keywords: Structures; Taplejung window; lithostratigraphy; MCT

Role of geological structures in groundwater occurrence in the watershed of Chitwan Dun valley from Narayani to Lothar Khola, Central Nepal

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With increased withdrawal of groundwater, the quality of groundwater has been continuously deteriorating. The study was mainly focused on role of structure in ground water heterogeneity. A groundwater potential map is created by integrating thematic layers such as geology, geomorphology, land use, aspect, slope, rock/soil, lineament density and drainage density differentiating into low, moderate and high groundwater potential zone. The maximum number of springs has been found in Main Boundary thrust zone as the distance increase toward the Siwalik zone, the number springs tends to decrease. The linear relation between MBT and springs occurrence rate has been found as r = - 0.677. respectively, showing the inverse relationship between the perpendicular distance to the thrusts and the abundance of springs. This show that the number of springs decrease with increase with distance from MBT. Similarly, the discharge rate between MBT and distance has been found as r = 0.0632, like nearly no correlation. The lower Siwalik have maximum discharge rate whereas as Upper Siwalik have minimum discharge rate. In the study area lineament as MBT, CCT, KT plays a maximum role for groundwater occurrence. Similarly, the majority of joints have NW- SE trending and act as supportive features in recharging the area. Hence the fault, lineament, and geomorphology have an important role in groundwater occurrence in the study area.

Keywords: Spring; Thrust; Lineament; Groundwater

Road cut slope stability assessment along Galchhi –Trishuli section of Pasang Lhamu highway, Central Nepal

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The primary concern in highway construction in the Lesser Himalaya and Higher Himalaya is slope instability. Heavy rainfall is a major factor leading to the instability of cut slopes due to activities such as cutting, filling, excavation, and blasting in road construction and maintenance. Slope stability analysis involves evaluating the factor of safety for both human-made and natural slopes through various activities. This research focuses on an engineering geological study of the study area and analysis of the stability of natural slopes affected by excavation for road development along the Pasang Lhamu Highway, specifically the section between Galchi to Tadi Khola. To assess slope stability, the SEEP/W and SLOPE/W software from Geo-Studio 2022.2v were used for analyzing seepage and stability of cut slopes. Slope simulations were carried out in the high and medium landslide-prone zones, identified by a landslide susceptibility map prepared using the weight overlay method. Various causative factors were integrated while preparing the zonation map. The data for slope stability analysis were gathered from both field surveys and laboratory tests conducted on slope samples collected from the site. A Factor of Safety (FoS) was calculated for the cut slope under various expected conditions. Additionally, kinematic analysis was done to evaluate the stability of rock slopes. The results of the kinematic analysis reveal that wedge failure and toppling failure are the most commonly observed modes of failure in the study area. The findings suggest that the stability of the cut slope decreases as the rainfall duration and intensity, unit weight, material cohesion, and friction angle decreases. Furthermore, an increase in groundwater level during rainfall affects the FoS of the slope.

Keywords: Landslide; weight overlay; kinematic analysis; SEEP/W; Slope/W; factor of safety

Identification of fractured cross structure zone in Chandragiri-Markhu area, Lesser Himalaya, Central Nepal

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The Himalaya Mountain chain is dominated by a number of laterally continuous, range-parallel thrust faults formed by the ongoing continent-continent collision. However, several transverse topographic lineaments are oriented across the strike of the folded and thrusted Himalayan belt and have been confirmed in the field to be faults. In the Chandragiri-Markhu area, Lesser Himalaya, central Nepal we find these faults can also be identified using band ratio techniques on ASTER-SWIR images. Our work combines the remote sensing analysis with geological mapping, field observation and microstructural analysis of samples from the identified linear structure. Topographic analysis of Chandragiri-Markhu area together with field observations shows structurally controlled N-S drainages, river valleys and fractured ridges. Likewise, SWIR band rationing of a (7/6, 6/5, 6/4) combination in RGB shows an array of en-echelon NNE-SSW striking linear structures suggesting that this cross structure is actually a zone of faults. The geological mapping surrounding the fault zone reveals several offsets in geological contacts between the Kulikhani Formation, Markhu Formation and Tistung Formation. Field observation includes, N-S striking beds, valley parallel faults and shear zones. Microstructural analysis of samples shows the localized higher amount of strain along the cross structures with dynamically recrystallized deformed quartz grains experiencing sub-grain rotation (SGR), grain boundary migration (GBM) and grain boundary area reduction (GBAR).

Keywords: Remote sensing; mapping; structure; fault zone

Plant Fossils from the Siwalik Group of Binai Khola section, West Nepal and Their Significance on Paleoclimate

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The uplift of the Himalaya resulted in the accumulation of an enormous quantity of molasse sediments (~6000 m thick) along the length of the Himalayan Foreland Basin covering a longitudinal distance of ~2,400 km. This foreland basin is known as Siwalik (Churia) Group, which lies between the Main Boundary Thrust (MBT) to its north and the Main Frontal Thrust (MFT) to its south. In the foreland basin, the sediments were deposited between the middle Miocene–lower Pleistocene. The group has been classified into four sub-groups named, the Arung Khola Formation, Binai Khola Formation, Chitwan Formation, and Deorali Formation, which shows a succession of fluvial sediments in a coarsening upward sequence. Abundant plant fossils, in the form of leaves, wood, fruits, seeds, and pollen, have been recovered from the Siwalik sediments. However, floral records from the Siwalik sediments of the Binai Khola section are still scarce. Here we report 13 new fossil leaves *Clinogyne ovatus* of family Marantaceae, *Mangifera someshwarica* from family Anacardiaceae, *Calophyllum suraikholaensis* of family Calophyllaceae, *Dipterocarpus* sp., *Shorea siwalika, Shorea* sp. from family Dipterocarpaceae, *Phyllanthus koilabasensis* of family Euphorbiaceae, *Albizia siwalica, Baunihia sp., Cynometra palaoiripa* and *Leguminocarpum* sp. of the family Fabaceae, *Daphnogene makumensis* of family Lauraceae, *Grewia sp.* of family Malvaceae and *Syzygium paleocumini* of family Myrtaceae. The analysis of the present-day distribution of the modern comparable species of these fossils revealed the evergreen to mixed deciduous forest in tropical to subtropical climate during middle to late Miocene.

Keywords: Plant Fossils; Siwalik Group; Miocene; west Nepal

Field relation, fabric and cooling history of Ipa Granite, Lesser Himalayan Granitoids, Central Nepal

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The Lesser Himalayan Granitic Belt (LHGB) in Central Nepal Himalaya, includes six irregular granitoid bodies of varying dimension namely, Simchar, Palung, Ipa, Timaldanda, Narayanthan and, Sindhuli Garhi from west to east respectively within the Bhimphedi Group, Kathmandu Complex. In Kulikhani -Ipa Panchakanya area, a lenticular shaped Ipa Granite intrudes the country rocks of the Kulikhani Formation and the Markhu Formation. Based on field observation and petrographic analysis, the Ipa granite is peraluminous in nature (A/CNK >1) with a silicic composition (SiO_2>65%) mineral assemblage of Qz + K-fs + Pl + Bt ± Ms ± Tur ± Crd. Field relation reveals a multiphase veined-type intrusion with gradational contacts, emplacing at shallow to intermediate crustal depths. Kulikhani Formation's schist enclaves within the granite suggest partial displacement of country rocks during emplacement. A fabric-based classification of Ipa Granite distinguishes centrally distributed isotropic fabric i.e. porphyritic and coarse grained equigranular granites from marginal anisotropic fabric of medium grained granite gneiss. The presence of dynamically crystallized grains, deformation twins, and myrmekite intergrowths in marginal samples indicates post-magmatic deformation, likely associated with the southward tectonic transport of the Kathmandu Nappe, evidenced by augen gneiss with top-to-the-south shearing. Fission track dating of three samples from the Palung and Ipa Granites suggests slow cooling from 180ºC to 120ºC occurred between 26 Ma and 2 Ma, followed by a sudden, abrupt decrease in temperature from 2 Ma to present, likely driven by the formation of the Main Boundary Thrust (MBT), the uplift of the Lesser Himalaya and subsequent erosion.

Geological Mapping at the Western Section of the Jhimruk Khola with Emphasis on Deformation Structures and Micro-tectonics

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A detailed geological investigation was conducted in the Machchhi-Shyauliban area of the Jajarkot Nappe, Pyuthan district, with the aim to analyze the microstructures and tectonic framework. The objectives included mapping at 1:25,000 scale, analyzing structures, identifying shear sense indicators, and studying microstructures for tectonic insights. Geological mapping was conducted at a 1:25,000 scale, supplemented by structural analysis, thin-section microstructural studies, and tectonic interpretation. The study area comprises both autochthonous and allochthonous units. The autochthonous Nawakot Group consists of dark gray slates and phyllites transitioning to creamy white siliceous dolomitic marble with phyllitic partings. The allochthonous unit includes the Chaurjhari and Thabang Formations. The Chaurjhari Formation is composed of pelitic and psammitic mica-garnet schist interbedded with gray micaceous quartzite, whereas the Thabang Formation consists of gray to brown marble with biotite-quartz schists. These units are separated by the Jhimruk Khola Thrust, a significant tectonic boundary. Structural analysis identified two major folds: the Adheri Khola Anticline (NW-SE, 149/11) and the Simalchaur Syncline (SE-NW, 301/18), indicating compressional tectonics and nappe stacking. Microstructural analysis revealed grain boundary migration (GBM) and grain boundary area reduction (GBAR) recrystallization, suggesting deformation temperatures of 300–400°C and 500–700°C (Stipp et al., 2002). Strain shadows around porphyroblasts reveal multiple garnet growth stages, providing insights into deformation history. Shear sense indicators, such as asymmetric quartz boudinage and rotated garnets, suggest dominant top-to-the-south shearing. These findings highlight the Jhimruk Khola Thrust's role in shaping the Jajarkot Nappe and its prolonged deformation within the Nepal Himalaya.

Keywords: Jajarkot Nappe; thrust sheet; microstructures; shear sense indicators

A GIS-based land suitability assessment for agriculture, surface and lift irrigation in Sudurpaschim Province, Nepal

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Land is essential for agriculture, but urban sprawl and population growth threaten farmlands, necessitating identification of suitable agricultural and irrigation zones. This study was carried out to identify the available land resources suitable for agriculture, surface irrigation and lift irrigation in the Sudurpaschim province in Nepal, covering 19552 km^2 area. Land Suitability Assessment (LSA) for agriculture and surface irrigation considered factors like elevation, slope, soil properties, water proximity, and land cover. Weights were assigned using the Analytical Hierarchical Process (AHP), and a suitability map was created in GIS. Lift irrigation suitability depended on water proximity and elevation differences. Subsequently, the land was classified representing different levels of suitability for agriculture, surface, and lift irrigation. The results showed that 6.77% of the land was found to be Highly Suitable, 9.83% of the area was Moderately Suitable, 2.36% Marginally Suitable, and 81.04% Unsuitable for agricultural uses. A total of 3709 km^2 area was found suitable for agriculture, which was close to the agricultural area reported in the Sudurpaschim province Agricultural Diary. The suitability map for surface irrigation showed that 4.72% of the land was found to be Highly Suitable, 4.39% was Moderately Suitable, 0.10% marginally Suitable, and 90.8% of the land was found Unsuitable. A total of 1799 km^2 area was found suitable for surface irrigation. LSA for lift irrigation showed that 1656 km^2 of agricultural land is suitable for lift irrigation, which is 8.47 % of the total province area. The suitability maps could be useful for policymakers, developers, and individuals who work in the field of agriculture and irrigation in Sudurpaschim province. The results could help in preventing the conversion of suitable farmland to other land uses, forecasting agricultural production, and developing irrigation infrastructure.

Keywords: GIS; lift irrigation; suitability; agriculture

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