Volume 48 April 2015 Special Issue

JOURNAL OF NEPAL GEOLOGICAL SOCIETY

ABSTRACT VOLUME

SEVENTH NEPAL GEOLOGICAL CONGRESS (NGC-VII)

April 7-9, 2015

Kathmandu, Nepal

EDITORIAL BOARD

SEVENTH NEPAL GEOLOGICAL CONGRESS (NGC-VII)

"Geosciences in Sustainable Development: Challenges and Opportunities"

April 7-9, 2015
Kathmandu, Nepal

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Acknowledgements

Nepal Geological Society (NGS) is pleased to host the Seventh Nepal Geological Congress (NGC - VII) in Kathmandu, Nepal during April 7-9, 2015. The main objectives of the Congress are to exchange expertise, experiences and knowledge for building effective cooperation among the geoscientists from all over the world. As part of its geoscientific activities, the NGS is regularly organizing Nepal Geological Congress or another regional or international scientific event biennially since 1995, in which geoscientists from most of the continents have participated. It has successfully organized six congresses and a number of regional and international symposiums and conferences, including the Himalaya-Karakoram-Tibet (HKT) workshops, Asian Regional Conference on Engineering Geology, International Symposium on Engineering Geology, Hydrogeology and Natural Disaster and International Seminar on Hydrology. Geoscientists from across the world have contributed and have benefited much from each other during such scientific undertakings.

This volume contains 151 abstracts from scientists from 23 different countries comprising Armenia, Australia, Bangladesh, Bhutan, China, France, Germany, India, Indonesia, Iran, Italy, Japan, Morocco, Nepal, Philippines, Pakistan, Poland, Korea, Russia, Singapore, Thailand, the UK and the USA. The abstracts cover a wide range of topics under geosciences, such as regional geology, stratigraphy, tectonics, mineral resources and mining, oil and natural gas, seismology and seismotectonics, hydropower and other infrastructure development, hydrogeology, engineering geology, Quaternary geology, exploration geophysics, geohazards, disaster management, climate change, paleoclimate, geo-heritage and geo-park conservation and development, geosciences education, and remote sensing and GIS. About 190 participants are expected to attend the Congress with 109 oral presentations and 21 posters. We extend our warmest welcome to the delegates of the Congress and look forward to hosting you in Kathmandu, Nepal. We anticipate an exciting week of scientific exchanges, renewing friendships and making new friends. We hope you will find NGC–VII a memorable event and the Abstract Volume a useful collection.

The Nepal Geological Society and the Seventh Nepal Geological Congress Organizing Committee are grateful to the following organizations and individuals for their financial and other necessary supports to organize this scientific event.

Department Analyse Surviellance Environnment (DASE), France
Nanyang Technological University, Earth Observatory, Singapore
International Centre for Integrated Mountain Development (ICIMOD), Nepal
President Chure-Terai-Madhesh Conservation Development Board, Nepal
Poyry Infra AG, Switzerland
Hifab International Ltd., Sweden
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We are grateful to the members of Nepal Geological Society, various organizations and individuals who provided generous support for successful organization of the Congress.

Nepal Geological Society and
Seventh Nepal Geological Congress Organizing Committee

Contents

Tectonics of the Nepal Himalaya: shaping our understandings with new data

B. N. Upreti

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The broad and sketchy picture of the geology and tectonics of the western Himalaya began emerging from early- to mid-twentieth century through the pioneering works of the geologist from the then Geological Survey of India under British rule and by some explorers from Europe (e.g. Heim and Gansser, 1939). On the other hand, Nepal Himalaya remained practically unexplored until 1950, except for a few sketchy reports of the geology by some sporadic visitors from India. Despite this late start, the post 1950 years particularly the last three decades of the twentieth century, were exceptionally very productive period in the geological research in the Nepal Himalaya that led foundation to establish many of the basic geologic framework of the entire Himalayan range, and contributed to a much better understanding of this mountain range.

While the master thrusts of the Himalaya, viz, the Main Boundary Thrust (MBT) and the Main Central Thrust (MCT) were already well established by late 1970s all along the Himalaya, the position, nature and tectonothermal history of the MCT has remained the prime focus of research till today. MCT that carried the package of the Higher Himalayan unit for over a 100 km from north to south played a major role in the evolution of the Himalaya.

The zone in the vicinity of the MCT which is known as the MCT zone is undoubtedly a shear zone with a high thermal imprints and the foot wall of the thrust shows the classically known inverted metamorphism (Le Fort, 1975). This shear zone reaching even to a km or more in thickness has caused difficulty in delineating the discrete position of the fault. The recent works on Nd isotope (ε_{Nd}) values and U-Pb geochronologic data from the detrital zircons of the MCT zone in Nepal have become useful tools to delineate the two rock assemblages of the Higher and the Lesser Himalayan sequences. These methods can delineate the Greater and the Lesser Himalayan rock contact, and thus place the precise location of the MCT

Based on U–Pb detrital zircon age populations, the hanging wall rocks of the MCT are now well established to be of Neoproterozoic age (~1000-500 Ma), and in contrast, the foot wall rocks show maximum depositional age of Paleoproterozic (c. 1900–1850 Ma; DeCelles et al. 2000; Kohn et al. 2010; Martin et al. 2011). The ε_{Nd} values of pelitic rocks from the footwall of the MCT ranges from c. -21.5 to -25.9; whereas, Greater Himalayan rocks have values from c. -12 to -18.5 (Parrish and Hodges, 1996, Robinson et al., 2001; Khanal et al., 2014), a marked contrast to show the difference in the rocks on either side of the MCT.

Today, the multiple competing extrusion models of the Higher (Greater) Himalayan Crystalline Unit and its structural and metamorphic evolution vis-a-vis the MCT and the STDS have caught the focus of research of many Himalayan geoscientists. The improved analytical methods of high precision thermobarometry and much better quality pressure-temperature paths, and accessory mineral geochemistry and geochronology have helped to further constrain the tectonometamorphic evolution of the metamorphic core of the Himalaya (Kohn, 2014).

The Main Frontal Thrust (MFT) which was recognized quite early as a series of discontinuous structures in the southern front of the mountain range took long time to be recognized as a regional structure of great significance in terms of active tectonism in the Himalaya. Now, this youngest structure is well recognized as a major tectonic element of the Himalaya where the present-day Himalayan tectonic activities manifest along this plane.

The Lower Lesser Himalayan rocks which were long considered to be younger than the Greater Himalayan rocks is now well constrained to be the oldest rocks in Nepal Himalaya, and generally it is true beyond its east and west borders. The study on the tectonic setting, paleogeography and sedimentation history of the Lesser Himalayan rocks began only more recently with varying interpretations (Sakai et al., 2013, Kohn et al., 2010). All along the length, this essentially unfossiliferous Lesser Himalayan unit forms a complicated geology due to foldings of multiple generation and presence of a number of longitudinal and transverse faults. A large number of E-W trending thrusts have resulted in the formation of the Lesser Himalayan Duplex structure which forms the backbone of the Lesser Himalayan architecture. This structure has accommodated a significant amount of shortening resulted from the Indo-Asian collision. To reconstruct the deeply eroded duplex

structures is a challenge since the stratigraphy of these largely unfossiliferous rocks has been difficult to establish with confidence. It is only more recently that due to improved techniques for precise and rapid datings to handle larger number of zircon samples at a time, the quartz rich rock horizons in various formations have now helped to better constrain their ages. As a result the stratigraphy of the Lesser Himalayan rocks is now better known than in the past and the tectonics better deciphered.

One of the Lesser Himalayan thrusts, the Ramgarh Thrust (Ramgarh-Munshiari Thrust, Khanal et al., 2014), which brings the older Lesser Himalayan rocks over the younger ones that was first recognized in the Kumaon Himalaya, is now a well established thrust in Nepal and forms an essential and important component in the formation of the Lesser Himalayan duplex structure (Ofori et al., 2005). The stratigraphy and the evolutionary history of the Kathmandu Nappe is also being revisited (Gehrels et al., 2006).

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Mass extinction and global paleoclimate change across Cretaceous-Tertiary boundary in the northern and southern hemispheres

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Well-known sequences of the Cretaceous-Tertiary Boundary from India, Europe and South America have been reviewed from the northern and southern hemispheres. The Um Sohryngkew section of Meghalaya is located in northeastern India, approximately 800–1000 km from the Deccan volcanic province in Central India and represents the most complete KTB marine sequence known from Indian subcontinent. It is correlatable globally with the most complete sequences. The Um Sohryngkew section is well exposed in the Meghalaya, near Therria village, East Khasi Hills District, Shillong Plateau, northeastern India. The KTB in this section is characterized by a thin red clay layer enriched in Ir and other PGE with abundant subangular quartz grains. The Mahadeo Sandstone just below the KTB shows glauconite grains. The US section suggests a shallow marine coastal, estuarine and nearshore tidal flat depositional environment. The conformably overlying Langpar-Lakadong Formations of Paleocene-Eocene age confirm shallow-marine shelf-carbonate ramp sedimentation. The northward movement of the Indian Plate during the Late Cretaceous-Paleogene period, rise of Himalaya and the paleogeography of the southern and northern hemispheres with special reference to the collision of the Indian plate and the Eurasian plate is discussed in the light of the new data.

The KTB sections at Stevns Klint, Gubbio, Neuquén Basin, Salta Basin, Paraíba Basin, Trieste Karst (Padriciano in northeastern Italy), Jhilmili intertrappean sediments in Central India, and Meghalaya (Mahadeo and Langpar formations in Um Sohryngkew River section, Shillong plateau) in northeastern India have been discussed. All these crucial sections have been reviewed and correlated based on high-resolution biostratigraphy and mass extinction, carbon-isotope chemostratigraphy, sedimentary microfacies analysis, paleoclimatic changes and major, trace and platinum group elements geochemistry. The KTB sections from Europe represent complete boundary sequences. In the Southern Hemisphere, Meghalaya in the Shillong Plateau is the only complete sequence which displays a well preserved KTB layer.In South America Bajada del Jagüel displays almost complete KTB layer.Recent results of occurrence of iridium anomaly, strong negative shift of $\delta^{13}C$ values across the KTB, presence of microtektites at the top of a Maastrichtian breccia in an outcrop near Padriciano and Hg isotope from some sections have thrown new light on the cause of mass extinction at the KTB. This section displays strong evidence of mass extinction well preserved KTB layer, stable isotope excursion and sea level change and can be correlated with the El Kef Global Stratotype Section and Point (GSSP) in Tunisia.

Recent landslide disaster in Bangladesh

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Bangladesh lies in the northeastern part of south Asia between 20° 34' and 26° 38' N latitude and 88° 01' and 92° 41' E longitude. It has land area of 147,567 sq. km and a population of 160 million. It is a deltaic landform in the flood plain areas, except the exposed Miocene-Plio-Pleistocene sedimentary rocks of the Chittagong Hill Tracts in southeastern and some parts of Sylhet district, which is located in the northeastern part of the country. The Ganges-Brahmaputra Delta and the Bengal Basin includes part of Indian state of west Bengal in the west and the Tripura in the east. Geological history of Bangladesh is basically related to the uplift of the Himalayan Mountains of outbuilding of the landmass by the major river systems originating in the uplifted Himalayas. The geology is mostly characterized by the rapid subsidence and filling of a basin in which, a huge thickness of deltaic sediments were deposited as a mega delta out build and progressed towards south. The Delta building is still continuing into the present Bay of Bengal and a broad fluvial front of the Ganges-Brahmaputra-Meghna (GBM) River system.

Climatically, Bangladesh is Tropical Monsoon region, precipitation here is rainfall, on average rainfall in Bangladesh is recorded about 2300 mm/a. The highest recorded Rainfall is about 6000 mm/a in the northeastern district of Sylhet. In the southeastern Chittagong hill tracts, the landslide prone area, is recorded rainfall about 3500 mm/a.

In 2012, Flash Flood situation and landslide occurred in Chittagong, Cox's Bazar, Bandarban (southeast Bangladesh) Sylhet and Sunamganj districts (northeastern Bangladesh) due to continu rainfall (an example of Chittagong port is abnormal recorded about 400 mm/a single12 hours) since 24th June 2012, flow of upstream water since 26th and 27th June, 2012. These flood and landslide cause huge damage of assets in the above areas, and also died a total 125 people. Recent Hill cutting and Monsoon rainfalls (more than 200 mm/d), are the main causes to landslides disaster in this area. A comprehensive disaster management on landslides is an effective tool for the reduction of the landslide in Bangladesh.

Paleoseismological studies in the Nepal Himalaya

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To understand the caused and devastating effect of the earthquake and to be able to mitigate the associated destruction, the scientists throughout the world have been monitoring and evaluating the seismic activities by using various equipment and techniques since late forties. This period is not enough to evaluate the impending seismic risk of the region because great and megaquake's return period is far longer than this window. Thus Paleoseismology is a good tool to document pre-historical earthquakes that are large enough to produce significant ground surface ruptures. It is usually most efficient when the regional tectonic context is well understood and the active faults are clearly identified. In Nepal, since the beginning of the 1990's, a continuing effort to improve the mapping of the active faults, to determine the slip rate on them and to install permanent or temporary networks of seismometers and GPS stations has led to a better understanding of the regional tectonic context and has opened doors to more efficient paleoseismological investigations.

In collaboration with EOS Singapore and DASE France we started systematic mapping and sampling of uplifted terrace surfaces and abandoned paleo-channel meanders truncated by the megathrust was based on the interpretation of stereoscopic air photos, high-resolution satellite images, and 1/25,000 topographic maps. Several Total Station (TS) and Terrestrial Lidar Scanner (TLS) surveys provided high-resolution DEMs, Shallow seismic profiles, Electrical Resistivity Tomography to quantify the 3D evolution of the geomorphic landscape and unravel sequential mechanisms of uplift and incision.

Reversing the Chure degradation: analysis of the issues and measures underway for correction

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The Chure, also known as the Churiya or the Siwalik, is the youngest mountain range made up of sandstone, mudstone and conglomerate. On the basis of geological formations, the range is classified into the upper, middle and lower Siwalik. Annual precipitation in the Chure is very high compared to other regions in Nepal. Until 1950s, Chure, its foothills and several miles into the plains in the south were covered by dense forest. This made this region a water recharge zone for the Tarai plains and prevented floods in the lower region. Extraction of timber for export, campaign for malaria eradication and development of the road network along the Chure foothill led to flow of settlers from other regions. Due to increasing settlements and human activity, the forest cover in the Chure region has gone down to below 73 percent. Shifting cultivation is rampant in some very fragile slopes of the hills and improper extraction of natural resources from the region has led to widespread slope failure. This has been the reason for huge flow of sedimentation in the lower plains during rainy season. This has been the reason for floods every year in the lower plains washing away farmland and causing loss of lives and property. Due to low water retention when raining, water table in the lower plains is receding and many settlements now find their conventional water sources dried up. The prognosis, by scientists and the politicians alike, based on the current state of the Chure is that if it is allowed to let go then the Tarai plains will become almost uninhabitable. In order to further prevent the Chure degradation, make corrections and to conserve multi-sectoral and multidimensional approaches are needed. At the same time, there has to be human and cost considerations as well.

Jure rockslide-rock avalanche and Seti glacial disaster in the Nepal Himalaya: an overview of their causes and consequences

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On 14 August 2014, a large rock slide – rock avalanche dammed the Sun Koshi River in central Nepal and claimed about 137 lives. Such events are frequent on the steep slopes of the antecedent Himalayan rivers, such as the Kali Gandaki, Marsyangdi, Tama Koshi, and Karnali. Though they pose a serious threat to the life and property of people, there have been just some preliminary studies. On the other hand, similar disasters in the Alps, Andes, and Caucasus Mountains have been investigated in detail. For example, at Randa, in Switzerland, a rockslide – rock avalanche occurred from a cliff above the town on 18 April 1991. As a result, about 22 million cubic metres of rock fell near the village. The debris cone dammed the Mattervispa River, and created a lake that flooded part of the settlement of Randa. There was a second event on 9 May 1991, when an additional 8 million cubic metres of rock fell down. The second event was well monitored and its time of failure was predicted accurately.

In Nepal, another significant event related to the debris flows and flash floods of 5 May 2012 in the Seti Rivervalley claimed about 72 lives. The last disaster was the consequence of a snow, ice, and rock avalanche originating in high altitudes of the Himalaya. Such events too are neither unique nor isolated. In the past, there have been similar disasters in the Himalaya and elsewhere. Presumably, about 1500 years ago, an analogous but enormous event in the Seti River accumulated in its middle reaches much sediment, dammed many tributaries, and thus created the flat land of Pokhara with several beautiful lakes. Globally, there have also been a number of big glacial disasters in South America, Alaska, the Alps, and the Caucasus Mountains.

Landslide dams and glacier lakes are visible threats. On the other hand, the geological phenomena operating in steep river valleys and the glacial processes acting in high mountains are concealed; yet they may pose a greater risk than the lakes and can bring about devastating consequences.

River morphology and evolution of the Barind Tract, Bangladesh

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The Barind Tract is an elevated Pleistocene Terraces (about 11-48 m amsl) in northwestern Bangladesh. It is widely believed that the tract may have been evolved due to tectonic upliftment and/or exists as an erosional geomorphic feature. Some part of the Barind Tract bears the characteristics of morphological origin but some areas are providing evidences of tectonic upliftment. The present study is an attempt to interpret the morphological characteristics of the rivers in the area and tried to unveiling the processes that are responsible for the evolution of the tract. River morphology are interpreted from satellite images and field mapping and are used to relate neotectonic activities occurred in the area. The river forms U-shaped valleys in floodplain areas whereas these are V-shaped within the Barind Tract. The rivers and valleys on the tract are also comparatively more straight, incised and entrenched, and rivers are tightly meandered, more localized, form paired and unpaired terraces, and antecedent in nature, whereas the rivers in the floodplain are either meandering, braided or anastomosing in nature. Along the boundary between Barind and floodplain the rivers form asymmetric valley with steeping bank along the tract sides. The width/depth (W/D) ratios of these rivers are much lower within or near to the tract than the nearby floodplain. The rivers flowing from the Himalayas change their morphology, trend, nature etc. near and within the tract. Some of the N-S flowing rivers turned towards southeast and southwest directions to maintain slope of the uplifted tract. These are the indication of structural control of these rivers as well as the tectonic origin of the Barind Tract rather than only geomorphic origin. In the recent past few earthquakes in this region also support the same view about structural control and neotectonic activities.

Trend of geological research in the Nepal Himalaya

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Systematic geological investigation in the Nepal Himalaya started only after 1950 though some sporadic geological investigations were made before. The three decade's period after 1950 was period of descriptive geological study, which was based on field observation, mapping and description of observed facts in terms of lithology, stratigraphy and structures. After development of the theory of plate tectonics in late sixties, microstructural, mineralogical and geochemical studies were started in collided range of the Himalaya. These studies were targeted on subducted and collided zones with the aim to investigate mineralization due to stress and heat effects of metamorphism and magmatism. Another three decade's period after 1980 was characterized by intensification and modernization of classical geological survey and application of geology in engineering design and natural hazard assessment. The trend of geological research in last five years is characterized by radiometric dating of rocks (isotope studies) to find out the exhumation rate of the Himalaya and Quaternary geological mapping aided by geophysical investigations in the background of large historic earthquake dates. This paper mainly describes the trend of geological research in last five years in the Nepal Himalaya and their major achievements.

Sea level changes and vulnerability of inhabitants of eastern coastal margin of Bangladesh

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Sedimentological and palynological data indicate that mangrove community developed under transgressive condition in and around Maheskhali and Kutubdia Island areas during Mid Holocene time (7000 to 5500 years BP) leading to the locally widespread deposition of organic-rich sediments. During Holocene time global rise and fall of Eustatic Sea Level played an important role not only in the depositional environment but in creating geomorphic feature in the island. Recurrent occurrence of freshwater and mangrove pollen in Maheskhali and Kutubdia Island area indicate that these area undergone cyclic marine and non-marine influences. The study of accretion and erosion gives the information related to the physiographical evolution of the Kutubdia Island between the periods 1984 to 2010, and the Kutubdia is an erosion island. Since the Last Glacial Maximum (about 20,000 years ago), sea level has risen by over 120 m at locations far from present and former ice sheets, as a result of loss of mass from these ice sheets. There was a rapid rise between 15,000 and 6,000 years ago at an average rate of 10 mm/yr. Based on geological data, global average sea level may have risen at an average rate of about 0.5 mm/yr over the last 6,000 years and at an average rate of 0.1 to 0.2 mm/yr over the last 3,000 years. Vertical land movements are still occurring today as a result of these large transfers of mass from the ice sheets to the ocean. During the last 6,000 years, global average sea level variations on time-scales of a few hundred years and longer are likely to have been less than 0.3 to 0.5 m. Based on tide gauge data, the rate of global average sea level rise during the 20th century is in the range 1.0 to 2.0 mm/yr, with a central value of 1.5 mm/yr (as with other ranges of uncertainty, it is not implied that the central value is the best estimate). Based on the few very long tide gauge records, the average rate of sea level rise has been larger during the 20th century than that during the 19th century. No significant acceleration in the rate of sea level rise during the 20th century has been detected. So it is observed that there is a cylclic occurrence of marine and non marine pollen. First transgression was noticed around 6000-5500 cal BP and then a subsequent regression of the bay had been observed from around 5500 cal BP. This was again followed by another small scale transgression episode occurred around 2500-2000 cal BP. So the palynomorph assemblages from the Holocene sediment samples indicate that Maheskhali and Kutubdia Islands and their surrounding area were an intertidal environment occupied by mangrove community.

3D visualization to depict urban problems a case study of Kuet Campus, Khulna City, Bangladesh

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With rapid population growth and haphazard urbanization, understanding urban problems has been really important to attain sustainable living. More than half of the global population is living in urban areas and this will increase to 70% by 2050. As cities grow in size and population, harmony among the spatial, social and environmental aspects of a city and between their inhabitants becomes of vital importance. Large sealed areas, for example, induce urban heat island effects, higher air pollution or extreme wind regimes, and shortage of green spaces are some of the causes of rapid urbanization. In such cases geospatial technologies have been really helpful to delineate these changes for a long time. But to cope up with the futuristic demands of better urban planning 3D visualization of the portions of the city scales and urban problems are necessary. This will help policy makers for the cities to make better decisions. Thus presentation of an approach to integrate environmental aspects into a two-step urban modeling framework, generating 3D visualizations from GIS-based and procedural modeling is a timely demand. The dynamic nature of this approach provides considerable support for trans-disciplinary communication processes in urban planning. This study visualizes problems using 3D visualization drawing on research on one case study area Khulna University of Engineering and Technology campus in Khulna, Bangladesh. 3D analysis to delineate problems has been accessed using satellite images, shape files and procedural modeling of spatial analysis tools. Then the results of 2D visualization and 3D visualization are compared for understanding the problems. The results show that 3D visualization is more prominent and consistent with allocating precise levels of urban problems. The understanding from this study might be easily replicable at large scale urban issues to delineate urban problems to promote better urban decision making.

1D joint inversion of TEM and MT resistivity data with an application of soundings from the Námafjall high-temperature geothermal area, NE Iceland

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Geophysical methods are most useful in extracting subsurface information. Which geophysical method should be used to characterize a site depends on what information one needs. Resistivity has a direct relationship with the subsurface rock temperature. TEM and MT are very cost effective methods in a subsurface resistivity study. Although the MT method is very efficient at getting information down to the mantle, it suffers a static shift problem. Joint interpretation of TEM and MT data removes the static shift from MT data. Geologically, Námafjall is a very important area in Iceland. Tectonically it is related to Krafla volcano. It was formed in subglacial eruptions during the last glaciation and has undergone cooling. In this study sixteen TEM and MT soundings were used to evaluate the subsurface resistivity. At shallow depth there is a low-resistivity layer having resistivity less than 10 Ωm below Námafjall ridge. On the surface this area coincides with surface geothermal manifestations. It signifies the presence of low-temperature alteration minerals, mainly zeolites and smectite. Resistivity values above this low-resistivity cap indicate the presence of unaltered fresh rock. Below 200 m b.s.l., high resistivity values below the low resistivity signify high-temperature alteration minerals, mostly chlorite and epidote. At about 800 m depth, there is again a low-resistivity layer at the northernmost site, indicative of a fracture zone which might be connected to the Krafla volcano. A low-resistivity zone with resistivity of less than 5 Ωm is also found from 2 km to 10 km b.s.l. This low-resistivity zone signifies a probable heat source for Námafjall area. Electrical strike analysis and Tipper study suggest a conductive zone at less than 1 km depth and the presence of fractures at different depths that are not always parallel to the major geological structures.

Application of geophysical resistivity soundings survey for the exploration of hydrogeological conditions at Chuadanga Pourashava, Chuadanga, Bangladesh

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Since the last few years, water supply from shallow aquifer is limited due to arsenic pollution at Pourashava area of Chuadanga in the central western border of Bangladesh. Most of the shallow tube wells exceeded arsenic level of Bangladesh standard (50 µg/L) and leads to the exploration of alternative sources of sustainable potable groundwater at Pourashava and surroundings areas. To decipher the subsurface lithology distribution and aquifers at different depth level, 15 geoelectric soundings using Schlumberger configuration with spreading AB/2=400 meters have been executed. The analyzed VES results show that the subsurface sequence of the area is broadly divided into two geoelectric units. First, the near surface geoelectric unit of low resistivity (< 20.0 Ωm) termed 'Top Soil' composed of silty clay to clay materials. The thickness of this layer varies from 1m to 3m. The second geoelectric unit represents the sand layer that characterized by a wide range of resistivity (18.0 to 200.0 Ωm). This unit has been subdivided into six sub-units viz. very fine sand with variable thickness of 20 to 314m while resistivity varies from 20.0 to 30.0 Ωm, very fine to fine sand having thickness from 1 to 5 m for shallow depth where geoelectric resistivity value varies from 31.0 to 40.0 Ωm, fine sand with resistivity from 41.0 to 50.0 Ωm showing thickness variation from 20 m to 384 m, fine to medium sand having resistivity from 52.0 to 70.0Ωm, medium sand and medium to coarse sand with resistivity valuesfrom 80.0 to 126.0Ωm and 150.0 to 200.0 Ωm, respectively. The ultimate total thickness of sand unit could not be determined due to limited spread of survey. In the context of groundwater storage, the second geoelectric unit acts as the regional aquifer and is used for groundwater development in the Pourashava area for water supply.

Sediment chemistry of Dakshin Sonaichhari estuary, Sitakund upazilla, Chittagong, Bangladesh

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The present work deals with the sediment geochemistry of the Dakshin Sonaichhari estuary, Chittagong coastal area, Bangladesh, where ship breaking industries are being developed at present. Thirteen sediment samples have been studied by XRF for non-clay and XRD analysis for clay sized part. The sediment geochemistry has been studied in order to understand the chemical composition, provenance, and tectonic setting of the study area with special emphasis on the effect of growing ship breaking activities, if any. Harker variation diagrams show positive correlation of K_2O and Na_2O, which increase with increasing SiO_2, whereas CaO, Fe_2O_3 and MgO decrease with increasing SiO_2. Also no recognizable trends are exhibited by some diagrams. Weight % of Al_2O_3 varies from 8.31 to 20.34, that of CaO form 0.79 t0 2.47, of K_2O from 2.34 to 4.58, of total iron from 4.80 to 9.58, of TiO_2 from 0.48 to 1.01, of CaO from 0.60 to 1.92, of MgO 0.62 to 3.34, and of MnO 0.073 to 0.16. The CIA and CIW values suggest intense to moderate weathering in the source area and moderate recycling of the sediments. The tectonic discrimination diagrams indicate that the sediments were deposited in a basin that stretched from passive continental margin as it is now to oceanic island arc through active continental margin and continental island arc in earlier times.

The clay minerals are kaolinite, illite and montmorillonite and non-clay minerals are quartz, albite, muscovite and glauconite. Kaolinite is produced by decomposition of alumino-silicates, especially the feldspars, either by weathering or hydrothermal activity. Montmorillonite is most commonly formed by alternation of beds of volcanic ash. Glauconite is an authogenic mineral of marine sedimentary rocks. Illite is of marine origin. Presence of kaolinite,illite montmorillonite and glauconite indicates warm and humid continental to shallow marine paleoenvironment of deposition of the clay part of the sediments, which corroborates with the present estuarine sediments. Impact of ship breaking activities is not much clear in the sediment chemistry of the study area except the presence of oxides like Cr_2O_3, MnO, NiO and CuO.

Lithofacies and depositional environments of the southeastern fold belt of the Bengal basin, Bangladesh

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Lithofacies analysis of exposed rock sequences from the Mio-Pliocene Surma Group in the southeastern fold belt has been examined to infer their depositional conditions. This succession along the eastern margin of the Bengal Basin range in thickness from ~10 m to more than 3000 m and are dominated by fine to coarse, thin to thick-bedded sandstones with subordinate siltstone and mudstones. A total of seven lithofacies (e.g., massive sandstone facies, cross-laminated sandstone facies, ripple-laminated facies, parallel-laminated facies, interbedded fine sandstone and mudstone facies, siltstone facies and mudstone facies) have been identified in the sequence and these have been grouped into five facies associations (FA1 to FA5), which were formed within two broad distinct depositional systems. Facies association of the lower Surma Group suggests a deposition in deep marine to shallow marine environmental conditions, while in the upper Surma Group was deposited in shallow marine to shoreface conditions.

Holocene and late Last Glacial (43 ka) climate variability and change around the northern Japanese Alps region, central Japan

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To reconstruct the climate for the last 43 ka in central Japan, sediment cores from Lake Aoki were investigated for grain-size, diatoms and total organic carbon (TOC) and total nitrogen contents. TOC flux and diatom abundance are closely positively correlated in both short- and long-term fluctuations throughout the record. An abrupt decrease in sand and clay contents and increase in TOC flux and diatom abundance at 13 ka cal BP is interpreted as the last Glacial/Holocene boundary. Changes in surface water temperature and paleohydrology appear to be the main factor affecting the variability in the proxy records. Glacial cooling, with a series of fluctuations, lasts until 13 ka cal BP. More cooling events are centered at ca. 16, 28, 34, and 39 ka cal BP, which are correlated with Heinrich events H1, H2, H3 and H4, respectively. The Last Glacial Maximum reaches its maximum ca. 22 ka cal BP. Beginning with a rapid warming, the Holocene climate history is characterized by an alternating sequence of seven warm and seven cool phases, with abrupt transitions and lengths lasting from hundreds to thousands of years. Climatic events such as the Little Ice Age (LIA), the Younger and Older Dryas, the Medieval Warm Period, and the Holocene Optimum are evident, and some other warm and cool events not previously well recorded are also apparent. Generally, the Holocene warm phases were as warm as or even warmer than what the world experienced in the twentieth century but cool periods even colder than the LIA are also observed. The magnitude of climate change observed after the LIA was commonplace in the Holocene.

Climatic scenario and establishment of rainfall threshold for landslide hazards of some areas of Chittagong and Chittagong hill tract, Bangladesh

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This research has established the relationship of rainfall pattern with landslide hazard events of some areas of Chittagong and Chittagong hill tracts, Bangladesh. Both antecedent and single day major rainfall pattern can influence on the sliding events. It is also established that monsoonal rainfall can significantly influence on the catastrophic landslide events. From the overall observation, rainfall threshold line is established for the landslide hazard events of Chittagong, Cox's Bazar and Bandarban area, individually. It is clearly observed that a total rainfall of 215 mm (35.83 mm/day), 180 mm (30 mm/day), 280 mm (46.67 mm/day) within a six-day period appears to define the minimum rainfall that has led to shallow landslides in Chittagong, Cox's Bazar and Bandarban, respectively. On the other hand a total rainfall of 450 mm (75 mm/day) and 425 mm (70.83 mm/day) within six-day period appears to define the minimum rainfall that could be a cause of catastrophic landslide in Chittagong and Cox's Bazar, respectively. Finally from the different regions data, two regional rainfall thresholds for Chittagong and CHT areas of Cox's Bazar and Bandarban are established in terms of causalities. It is clearly established that a total rainfall of 180 mm for six consecutive days prior to landslides (equivalent to a sustained 30 mm/day for six days) and a total rainfall of about 440 mm (equivalent to a sustained 73.33 mm/day for six days) is sufficient for shallow landslides and deep seated landslides to take place which causes a huge loss of human lives and property. This research helps to define the precipitation thresholds for landslide trigger, which will enable communities for continuous vigilance and monitoring of slopes in an event of reaching the limits. Finally recommendations for the future work are made in the conclusion

Measurement of braiding indices of the Brahmaputra-Jamuna River: implications and constraints

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This study attempts to measure the braiding index of the Jamuna River Bangladesh and identify the constraints in braiding indcies measurement, and finally tried to establish a relationship with the braiding indices and river morhodynamics. The Brahmaputra-Jamuna is a major braided river system that flows through many unique regions: the Tibetan Plateau, the Himalaya Mountains, the Assam Plains and finally through the deltaic plain of Bangladesh into the Bay of Bengal. The braided bars of the Jamuna River create new opportunities to establish settlement and pursue agricultural activities on them. However, many of the bars are prone to erosion, threatening human as well as agricultural security. Understanding of the river morphodynamics therefore has immense value for a densely populated country like Bangladesh. Secondly, understanding parameter of river morphodynamics, like braiding intensity is useful for establish safe navigation route, which is still widely used as one of the main communication route for trade in Bangladesh. This study is aimed at quantifying the braiding index along the Brahmaputra-Jamuna River based on the Google Earth satellite image employing Germanoski and Schumm's (1993) method. Braiding indices for the measured five reaches are 4.6, 7.68, 5.2, 4.28 and 5.47 respectively. Highest braiding index was found in reach 2 which indicates aggradation and lowest value found in reach 4 which indicates degradation. On the other hand, using the same methodology, the average values of the braiding indices of the previous studies are 3.9 and 12.33. Using the methodology of Howard's the EGIS (1997) study got average value of 6.02 for the year 1996. The main reason of this variation of braiding indices is selection of methodology for different years and bar dynamics and bar morphology.

The constraints of braiding indices measurement are: migration of bars over the period of one or a few years, lacking of available satellite images throughout the year and delineation of bars is not clear in the satellite images, small bars are not included in this calculation and bar length is not covered by the length of reach. In the Jamuna River, a sudden decrease of slope around Gaibandha results in large number of sediment deposition and give rise to the development of prominent braiding pattern as well as an increment of braiding indices. Braid bar reduction as well as decrement of braiding indices was greatest in the steepest channel. Braiding intensities are decreased towards downstream, as channel area becomes narrower. Due to the narrow reach, high gradient and the presence of maximum vegetated bars, the braiding index of the reach 4 of the Jamuna River is lowest and degradation occurs.

Status of potential iron ore deposits and promotion of iron and steel industries in Nepal

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Iron ore occurrences, prospects and few potential deposits are known from 91 localities in 32 districts of Nepal. Only few of them appeared interesting for further detail exploration. The main ores are hematite, magnetite, oolitic ironstone, limonite/goethite and rarely siderite. Existing old workings (pits, adits, tunnels) and scattered slag are the solid proof of very small scale domestic mining activities and smelting of the ore using primitive furnaces. Such operations were based on some of these ore deposits since historic time (>200 years BP) till 1964. In those early days people were fully dependent on indigenous production and Nepal was also exporting iron and copper to Tibet. After 1964 neither old-workings nor new mines are in operation in spite of tremendous increasing demand of iron and steel in the country.

Geological investigations of the known iron ore mineralization and their assessment revealed that there are mainly four types of iron mineralization in Nepal. Out of these, sedimentary hematite and metamorphosed specular hematite±magnetite type ore deposits are the most common. Most of the known prospects/deposits, except Phulchoki, are of slightly lower in grade (40 – 56 % Fe). As a result, they are not feasible for mining at this stage and have remained unexploited. However, some of these ores can be upgraded (up to 62 % Fe) by simple beneficiation technique and then they can be roasted to make sponge iron or produce cast/ pig iron, wrought iron and steel by smelting the ore. Iron and steel industries use these iron to manufacture various products.

Iron being one of the principal metal, extensively used in all types of civil construction works, housing, infrastructure development works like dames, bridges, hydropower plants, irrigation structures and to manufacture heavy machinery equipment, arms, mechanical and agricultural tools, steel frameworks, furniture, utensils, various types of iron and steel products.Hematite and limonite are also used in pigments, red/ yellow ocher and polishing powder. Present annual demand of iron and steels is around 500,000mt and the trend is increasing with an average rate of 15%. Therefore, it is high time to utilize these valuable resources to promote iron and steel industries in Nepal.

Some of the iron ore deposits like Phulchoki (10.67 mln. mt.), Thoshe (15.96 mln. mt.), Labdikhola (7.5 mln. mt.), Jirbang (1 mln. mt.), Dhauwadi – Pokhari - Durlung (>65 mln.mt.), Bhedikhor - Ransing (>15 mln.mt.), Lukurban – Dhiri (>12 mln.mt.) etc. are well explored by Department of Mines and Geology (DMG) and some private sectors and confirmed them as economic/sub-economic deposits. Quite a few other iron prospects are known from Taplejung, Okhaldhunga, Dolakha, Makwanpur, Dhadhing, Tanahu, Chitwan, Palpa, Baglung, Gulmi, Parbat, Myagdi, Rolpa, Rukum, Surkhet, Jajarkot, Achham, Bajhang and Baitadi districts. But all these deposits/prospects still remained unexploited because of poor or no infrastructures, complex geology, contradiction in few clauses of Mines and Mineral Act 2042 BS with Forest Act 2049 BS and Local Governance Act 2055 BS, which makes mining activities more complicated for the lease holders. Exploration of iron ore in the Higher Himalayan region has not yet been performed although chances of finding of some magnetite deposits are high.

Individual Nepalese citizen and national or foreign company formally registered in Nepal and interested in mineral exploration and mining activities can obtain Prospecting/Mining license from DMG under Nepalese Government's existing Rules and Regulations. Few national and foreign companies have shown their interest to invest in iron mine and set up iron and steel industries. As of DMG record, about 40 prospecting licenses and 2 mining licenses for iron have been issued in FY 2013/14. Identification and utilization of own natural resources like iron ore for the benefit of the country will not only generate employment, save foreign currency to import iron required for iron and steel industries and rolling mills in the countrybut also contribute substantially in national GDP. Therefore, Nepal Government must give high priority and invite national and foreign investment to exploit and utilize such valuable natural resources of the country to promote its own iron and steel industries.

This paper is based on author's own field observations, laboratory (chemical and mineralogical) investigations and preliminary beneficiation and metallurgical testing of the ore as well as literature review and personal communications with some previous workers.

The ground temperature measurement for survey and mitigation work of landslide - Introduction of a case study in Japan and consideration of its extension to potential landslide in Bhutan

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Generally, landslides occur after rainfall. In the SAARC countries, there were some big landslides after the heavy rain fall in 2014. Landslide is thought to be a term that refers to mass movement, where there is a distinct zone of weakness that separates the slide soil mass from stable underlying soil or rock. Groundwater is also considered to be a cause of trigger for landslide. The rain seeps into soil and the zone of weakness as groundwater, and consequently, groundwater is worked as pore pressure or up heaving force for the potential slide soil mass to be unstable leading to slide. So, it is important to know how groundwater related to landslide exists or flows in the soil, because it can indicate where to prepare countermeasure for mitigation such as borehole or well to drain groundwater in order to make landslide be more stable. The ground temperature measurement is suitable for grasping the groundwater, and just only requires to dig narrow holes in the ground with a rod by hand and to measure temperature of the bottom of these on the landslide area. Its result can provide information of the groundwater flow easily by analyzing the difference in temperature between water flowing area and the other one on the map. In this paper, we will introduce the method of the measurement first, then will consider a case study of well performed landslide survey and mitigation work in Japan using the survey, and will discuss how to apply the one to potential landslide around Thimphu in Bhutan. As mentioned above, the ground temperature measurement ensures access to affordable, reliable, sustainable and less energy for survey and mitigation work of landslide. It will correspond to the concept of Geosciences in Sustainable Development.

Structural evolution of the Tibetan Plateau, Nepal Himalaya and their foreland basins

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The most spectacular history of the Tibetan Plateau and the youngest Himalayan region was formed over the past 55-50 million years (Ma) as a result of the enter-continent collision (Indo-Asia) in the Tibetan-Himalayan tectonic province, occupying the east-west trending, high-altitude Himalaya ranges in the south and the vast Tibetan Plateau to the north of central Asia. Structural evolution of Tibetan region seems to be began during the late Paleozoic to Cenozoic as the central Himalaya (Nepal Himalaya), evolved in different stages 30 to 50 Ma and are still active and continue to rise in present-day, and the Indian plate moving north at the rate of 5 cm/year. The major structures in the Tibetan Plateau include the three Mesozoic Suture Zone: Kunlun, Jinsa, Bangong Suture, also the Nepal Himalaya as Main Central Thrust (MCT), the Main Boundary Thrust (MBT) and the Main Frontal Thrust (MFT), respectively.

Due to their Structural evolution, forming of foreland Basins in Tibetan Plateau and Nepal Himalaya thinks to be a quite similar in age and the rock types: Eocene–Recent, sedimentary sources, and the sedimentary rocks of them are directly affected by large scale geological structures. The most of compressed structures and unusual uplifted mountains play the key role to formation of foreland basin in both Tibet-Nepal regions. In addition, various techniques, such as petrography, heavy mineral, XRF and single grain dating by Ar–Ar, U–Pb and fission track methodologies (methods), single grain Sm–Nd and Pb isotopic analyses, and seismic reflection profiles have been described.

Tectonic and stratigraphic evolution of the central Nepal Himalaya and their foreland basin

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Before 55-50 million years (Ma), tectonic collision of two continents (Indo-Asia), the east-west trending, approximately 2400 km long, high-altitude of the Himalaya ranges expanded in south Asia. Continued converging rate influences a number of thrust and fault in the Nepal Himalayan region, developed during Early Miocene to Pleistocene. The Nepal Himalaya occupying on the central sector of Himalayan arc and extend is about 800 km. Schematic evolution of the Transhimalaya and the Himalaya regions were clearly observed in the Central Nepal Himalaya section. A complete sequences from South to north are; middle Miocene to early Pleistocene age of Siwalik, Precambrian sequence of Lesser Himalaya (LH), East African orogen (800 to 480 Ma) of Higher Himalaya(HH) and Paleozoic through Eocene sequence of the Tethys Himalaya (TH) exposed in different span. The detrital muscovite $^{40}Ar/^{39}Ar$, paleomagnetic stratigraphy, detailed biostratigraphy and U- Pb detrital zircon ages suggest that the LH Zone of Tansen Group (including foreland Basin) developed during Late Carboniferous to early Miocene, Kaligandaki Super Group(Nawakot Complex) sedimentary rocks derived from Indian Craton during Early to Late Proterozoic, Ortho-Para Gneiss bearing HH zone developed 800Ma and carbonate to fine-grained clastic rocks of the Tethyan sequence developed during 400 to 100 Ma. Tectonic movement of major structure and unusual uplifted mountains supply enormous sediments are the key reason for formation of Miocene- Eocene foreland basin in the Southern region of Central Nepal and almost sediments in foreland basin of Bhainskati and Dumri Formation elucidated the exhumation rate of Himalaya and are the key area for the study of tectonic history of Himalaya.

Sandstone petrography and detrital zircon U-Pb geochronological record of the Siwalik Group of the Nepal Himalaya: implications for provenance analysis

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The Himalayan-Tibetan orogeny is one of the typical continent-continent collision belts on the earth. The foreland basin formed due to collision is a key laboratory in studying tectonic records that arose during the course of mountain building. Prior to the exhumation of the Himalaya, sediments were deposited in the northern margin of the greater India, which ultimately recycled, reworked and deposited in the foreland basin. The coarsening upward fluvial deposit of the Siwalik Group was deposited along the foot hill of the Himalaya during middle Miocene to early Pleistocene that archives the upliftment history of the Himalaya during the Neogene. In this study, three well exposed sections along the Koshi Nadi, Surai Khola and Karnali River were selected for the provenance analysis using the sandstone petrography and detrital zircon U-Pb dating techniques.

The studies on optical petrography of sandstone and resulting QFL plots have shown a "recycled orogeny" field indicating northern lithotectonic units; Tethys Himalaya, Higher Himalaya and Lesser Himalaya as the source zones. The detrital zircon U-Pb geochronological data have clearly revealed the majority of the grains clusters at the ages are younger than ~ 1000 Ma with subordinate peaks at ≥1000 Ma. The obtained age spectrum is similar to the Tethys Himalaya and the upper Lesser Himalaya but the lower Lesser Himalayan rocks were not distinct, which indicates that sediments in the Neogene foreland basin of the Nepal Himalaya were primarily sourced from the Tethys Himalaya and upper Lesser Himalaya. The minor subordinate scattered peaks that roughly correspond to the age of the Higher Himalaya and lower Lesser Himalaya may indicate that a lower proportion of the sediments might have a link with the Higher Himalaya and lower Lesser Himalaya. Since and after the deposition of the middle Siwalik i.e. ~10 Ma, the input of the lower Lesser Himalayan sediments were relatively higher. Therefore, the Siwalik Group in the Nepal Himalaya might have witnessed a mixed type of provenance similar to the northwestern Himalaya.

Well logging interpretation models of ultra-low permeability reservoir based on reservoir characteristics analysis

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Because of special reservoir characteristics, the ultra-low permeability reservoir has complex pore structure and poor fluid seepage ability which can bring some difficulty in well logging and give fine interpretation of ultra-low permeability reservoir. Therefore, the formation mechanism of ultra-low permeability reservoir must be firstly analyzed, and based on analysis the high precision logging interpretation models can be established. The work is basis and premise of effective development for ultra-low permeability reservoir. In this paper, the ultra-low permeability reservoir of Chang 7-1 member of Triassic Yangchang Group in Longdong oil-gas region in southwest area of Ordos basin is selected as research object. Firstly, the pore structure characteristics are analyzed and combined with multiple information which include core observation, cast thin section, scanning electron microscope and mercury injection curves, then the formation mechanism of ultra-low permeability reservoir are determined, and research results show that main reasons are following four aspects such as the secondary enlargement of mineral particles, the distribution of clay minerals, the diagenesis of carbonate minerals and the irregular corrosion of mineral particles.

On the basis of above results, the flow zone indicator FZI which can comprehensively characterize pore structure of ultra-low permeability reservoir is preferred as constraint parameter of reservoir modeling, and according to iterative method a high precision FZI model is established by use of the multiple linear regression method. Then under flow zone indicator constrain the permeability models which could reflect different pore structure are established and their accuracy are greatly improved than non-classification model. In addition, the conductivity experiments with core saturation water confirm that the additional conduction phenomenon of clay minerals is not very obvious in research area, and the influence of whole rock conductivity can be neglected. Therefore, Archie formula has certain applicability for ultra-low permeability reservoir in section Chang 7-1. Finally, the fine logging interpretation models are applied and achieved very good results in the practical application, the relative errors of physical property and oil-saturation are both controlled within 10%. These study results provide corresponding technical support for comprehensive evaluation and reserves calculation of ultra-low permeability reservoir.

Microfabric analysis as tool for investigating history, properties and behavior of crystalline material

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Microfabrics occupy a key position in material analysis. They are formed by various processes and their interaction, depend on material properties, and - vice versa -may affect behaviour and properties of material, such as strength, elasticity, conductivity or reactivity. Consequently, microfabrics also serve as witnesses for material history and may support predictions about material fate. In detail, crystal-plastic deformation fabrics allow estimating deformation temperatures and constructing the deformation-metamorphism history of rocks. Brittle deformation structures help investigating the stress and strain status and history of material. Based on microfabrics of rock-forming minerals, applications in mineralogy, petrology and structural geology will be exemplified. Geothermometers will be presented and their application in various geotectonic and metamorphic environments. Specifically, methods and applications of microfabric quantification - most important quantification of fabric anisotropy and inhomogeneity will be outlined. Last but not least, the potential of microfabric analyses in material engineering will be highlighted.

Revisiting the catastrophic emplacement of the Pokhara Formation

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The Pokhara valley is covered by 40-100 m thick (4-5 km^3) fan deposits that attest to massive aggradation of the Seti Khola, a river draining the Greater Himalaya's Annapurna Massif. Poorly sorted, gravelly fluvial facies intercalated with debris-flow and mud-flow facies known as the Pokhara Formation indicate highly energetic transport conditions during one or several catastrophic mass flows. In May 2012, a destructive debris flow in the Seti Khola rekindled interest in the origin and timing of the Pokhara Formation as it may provide constraints on the magnitude and frequency of similar past events. Previous sedimentological work and radiocarbon dating led to the belief that the Pokhara Formation was catastrophically emplaced only 500 to 1000 years ago, although the exact timing, mechanisms, and triggers of the purported event(s) remain obscure. It remains debated whether the Pokhara Formation was deposited catastrophically, e.g. within less than a year, or whether sedimentation was more protracted over decades to centuries. We present new geomorphological, sedimentological, geochemical, and radiocarbon data and re-assess the potential for catastrophically filling the Pokhara Valley during one or several large debris flows. Support for this scenario comes from continuous long-runout (~50 km) debris-flow deposits topped by large (>10 m) boulders, and a distinctly calcareous lithology diagnostic of a Greater Himalayan source area tens of kilometres upstream. Ages of slackwater deposits in tributaries blocked by the Pokhara Formation are largely consistent with previous reported ones, though pooled ages may well reflect more than one phase of massive deposition before rivers began to re-incise. Geochemical fingerprinting of slackwater deposits reveals a single sediment source in the Seti Khola's glaciated headwaters. This finding is at odds with the sedimentology of the Pokhara Formation that records several phases of deposition during high-energy events. We conclude that our results call for a much more detailed enquiry into the timing and mode of emplacement of the Pokhara Formation in order to avoid gross misestimates of the hazard portfolio of the Pokhara valley.

Balance and deficit of seismic slip in central Nepal: implication for a repeat of the 1344 earthquake in Nepal

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Strikingly, in the 13-14th as well as in the 19-20th centuries, two pairs of large earthquakes devastated Kathmandu 89 and 101 years apart, respectively. Here we test whether these two pairs of earthquakes could be similar or not, expressing, for example persistent rupture termini. For this purpose we first confront, using a Bayesian approach, the stratigraphy and dating of the terraces with the historical earthquakes along the strike of Nepal. We discuss their possible extent along strike. We finally estimate the moment release potency of the great 1833 and 1934 earthquake and show that the 1833 was unable to rupture the MHT to the front releasing the slip deficit a depth. This slip deficit could have been released by aseismic slip on the uppermost part of the MHT, a scenario that appears unlikely. It could also have been released by another large earthquake. 1344 qualifies to be such an event, rupturing the MHT up to the surface at least partially under Kathmandu Klippe. This event occurred 89 years after the great 1255 earthquake, which falls in the same trace as the 1934 earthquake. The slip deficit on the Main Himalayan Thrust may have therefore reached presently, in the vicinity of Kathmandu, a value close to the value attained a few years before the destructive 1344 earthquake.

Past, present and perspectives of the Franco-Nepalese collaboration in seismology

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The Franco-Nepalese cooperation in seismology is now more than 35-year old. This poster sums up the main phases of the collaboration, including the early history of the network. It also reviews the principal scientific results which emerged from the research projects conducted, thanks to the good quality of the local earthquakes catalogues processed at both Regional and National Seismic Centers (RSC and NSC). It also provides information about what is presently planned within a major upgrade of the seismic networks. Indeed, in 2014, the RSC network was upgraded, from analogous to digital. In 2015 and 2016, the NSC will be similarly rejuvenated. During that period, a 17-stations temporary seismic network, deployed in December 2014 on top of the midcrustal seismic clusters of far-western Nepal will help constrain the geometry of the fault system and its segmentation. The main objectives and future perspectives in term of scientific research are finally reported.

Monitoring the lateral variations of the seismicity in far-western Nepal with a temporary seismological network

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The Main Himalayan Thrust (MHT) absorbs 20 mm/yr from the 40 mm/yr of the convergence between the Indian Plate and stable Eurasia. This mega-thrust is fully locked from the surface to approximately 80-100 km northwards where it becomes a ductile shear zone. This superficial segment remains locked during the interseismic period and breaks episodically into large earthquakes (M>8). A significant microseismic cluster is localized by the Regional and National Seismological Center networks nearby the downdip end of the interseimically locked segment at depths of about 10-20 km. However, the microseismicity rate as well as the clusters shape varies along Nepal Himalayas. Temporary seismological networks have been deployed in central and eastern Nepal in order to better understand the interseismic seismicity and its relation with the MHT. In Western Nepal, the last very big earthquake occurred in 1505. The microseismicity rate within the suspected trace of this event is higher than elsewhere along the Himalayan range in Nepal, the microseismicity being also more distributed. In order to better understand there the relations between the MHT and the midcrustal seismicity, temporary broadband seismic stations have been deployed in November-December 2014 by NSC and DASE seismologists. The emplacement of the sites where chosen according to the distribution of the local midcrustal seismicity. The stations where installed in five districts of western Nepal including Bajhang (6 stations), Bajura (1 station), Dailekh (4 stations), Jumla (2 stations) and Mugu (1 station). The network will benefit from three other stations that will be deployed in Humla (2 stations) and Mugu (1 station) and will cover an area of about 200X130 km. These temporary stations will complement for two years the RSC network, the permanent regional seismological network upgraded in November 2014 within the framework of the DASE-DMG collaboration. Indeed, the temporary stations are located above the seismicity belt while the permanent ones are located further south. Records from both networks will improve the accuracy of the microseismic epicenters and their depths. A better comprehension of the localization of the seismicity, will then help improving our understanding of the seismotectonics of western Nepal.

Geological assessment of Sibundong hydropower project, Tapnauli, Sumatra, Indonesia

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The general geological feature of Indonesia is characterized by the presence of basement formation of metamorphic rocks with intrusion of some plutons. They are overlain by Mesozoic, Cenozoic and recent volcanic and quaternary deposits. The oldest rocks of Sumatra Island are gneiss, schist and quartzite and the schist often contains gold. They probably belong to several geological periods but all were folded and denuded before Carboniferous beds were deposited. They form the backbone of the island and crop out on the surface at interval along mountain chain which runs parallel to the west coast of Sumatra. The Sibundong hydropower project area is covered within physiographic region of Western Barisan ridges. It is located west of Axial Barisan Zone - where the volcanic chain of Sumatera and the core of Barisan ridges bounded by Sumatera Fault System exist - and east of the narrow strip Sibolga Coastal Plain. Western Barisan is mainly composed of the pre-Tertiary Meta-Sediments, the Sibolga Granite Complex and the Quaternary Toba Tuff. The terrain is characterized mostly by the rugged relief which is controlled by the deep seated structures and gave rise to the pre-Tertiary metasediment exposed on the ground surface, deeply incised rivers. Less consolidated volcanic ash/loose to very weakly cemented Younger Toba Tuff set on top of stratigraphic sequences unconformably underneath the alluvial deposit, whereas the metasediments set as the lowermost stratigraphic sequence intruded by the Sibolga Granite. Typically, the welded tuff spreads over the river banks and to build long-high wall, and the hummocky along the toe of upstanding ridges. The granite unit consists of a series of intrusions of granite to granodiorite exhibiting large phenocryst of orthoclase and plagioclase, interlocked within a ground mass of quartz crystal and mafic minerals. At some places the granite unit experienced high deformation by showing shear features. Inaccessible project area covered by dense rain forest, steep escarpment, and narrow steep sided longitudinal ridges makes the investigation and surface geological mapping extremely difficult. Thus, the study is based on the limited geotechnical investigation data and surface geological mapping. Despite the difficulties, an effort was made to define Q and RMR of the waterway as an input for determining tunnel lining types.

Tsunami disaster management due to the local wisdom

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Tsunami is one of the biggest natural disasters due to the number of victims affected from it. To reduce the tsunami victims, it is necessary to manage the tsunami disaster. There are many methods of tsunami disaster managements. Usually, the method was developed due to normal condition, it means all requirement to manage the tsunami disaster are available. The availability of structures and infrastructures to manage the tsunami disaster are very important. Local wisdom in the nature of structures are building, road, and coastal conditions. The infrastructures should be taken account in the tsunami disaster management are land use, communication system, government hierarchical system, and social condition. The tsunami disaster management due to the local wisdom was developed in one of vulnerability tsunami area in east Java province in Indonesia, namely Pacitan city. The model was developed into three steps. The first step is numerical model to estimate the inundation area due to the runup elevation. The second model is evacuation route network due to the road network, buildings conditions along road network, location of evacuation area, and land use conditions. The last model or third model is communication model, which is developed due to the local social communication system, government hierarchical process, and the availability of communication equipments. From the research results, it can be concluded that the tsunami runup elevation are depend on the history of earthquake (magnitude and location), bathymetry and topographic conditions, and shoreline belt condition. The evacuation route can be decided due to the location of evacuation area, road network, building condition along road network, and land use condition especially the dwelling area. The data needs from the road network are road alignment and road geometry. The data from the buildings condition along road network use in the analysis are the building material, number of floors, building size, and accessibility from the road. The purpose of the analysis is to find the number and location of existing building can be used as shelter during evacuation process. The data need for developing the last model are social communication and government hierarchical communication process conditions. Finally, the communication through the mosque is very important to inform the tsunami occurrence to the local citizen.

The killer landslide of 6th September 2014 at Saddal, Udhampur district Jammu and Kashmir, India

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The outer Himalayan Tertiary strata in Jammu and Kashmir, India is prone to landslides and slope failures particularly during incessant rains. On 6th September 2014 a devastating slope failure occurred that wiped out the entire Saddal Village comprising of 45 houses, killing 50 people and 500 domestic animals. The slope failures occurred within the slope debris accumulated on the Tertiary bed rocks comprising of the semi-consolidated to well indurated sandstones, mudstones and pebble conglomerates of Murree Formation. These strata are marked by local thrusts and faults which make these more vulnerable. The present paper evaluates the role of these tectonic features and incessant rains for 5 days that triggered the slope failure.

Hydrocarbon source rocks palynology and rock eval of the Tertiary successions of Manipur region, India

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The sedimentary successions are well exposed in Manipur region ranging from Late Mesozoic to Cenozoic and bounded with the states of Assam, Nagaland, Mizoram and the international border of Myanmar in the east. Geological information of this region is made up of the metamorphic rocks, ophiolite suite, Disang Group, Barail Group, Surma Group and Tipam Group. The present investigation is confined to the Disang and Surma groups of Manipur for reconstructing their depositional environments and source rock potential for hydrocarbons. The organic matter of the Disang shale is predominantly of Type III and Type IV. Rock-Eval and TOC analysis of the Disang shale suggest that all the rocks have poor organic richness (TOC < 0.5 %) and poor hydrocarbon generation potential (S2 <0.5 mgHC/g rock). A shallow marine environment of deposition for the Disang Formation is also implied on the basis of dinoflagellate cysts in association. On the other hand, Rock-Eval and TOC analysis of the Surma shale suggest that most of the samples of this succession have poor organic richness (TOC < 0.5 %) and poor hydrocarbon generation potential (S2 <0.5 mgHC/g rock). A plot of HI versus T_{max} for Surma shale suggests that the source rocks are predominantly of kerogen type III and type IV. Most of samples are mature, several are immature and a few are overmatured. The kerogen type III or IV fits with the predominance of gaseous hydrocarbon. On the basis of palynological assemblages the Surma rocks have deposited under swampy (freshwater) condition and confined by tropical and subtropical conditions.

A record of shift in climate and orogenic events in the Tethys Himalaya: evidence from geochemistry and petrography of sandstones from the Spiti area, Himachal Pradesh, India

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Through a multidisciplinary approach, including petrology and geochemistry, the sedimentary provenance and paleoweathering of the Permo-Carboniferous Spiti sandstones of Tethys Himalaya is investigated. The Spiti region consists of texturally immature to mature sandstones composed of unsorted to sorted and subangular to subrounded clastic grains dominated by variable amounts of quartz and feldspar accompanied by lithic fragments (mostly metasedimentary, sedimentary and plutonic grains). They are characterized by moderate to high SiO_2 contents, moderate K_2O/Na_2O ratios but relatively low mafic contents. Uniform REE patterns similar to UCC with LREE enrichment (LaN /SmN= 3.91), flat HREE (GdN/YbN=1.21-2.5) and negative Eu anomalies with variable amounts of REE and Eu anomalies (0.4-0.8) suggest that hydraulic sorting played a significant role. The striking similarities of the multi-elemental spider diagrams of the Spiti sandstones and the Himalayan granitoids indicate that sediments are sourced from the Proterozoic and Cambro-Ordovician orogenic belts of the Himalayan region. The nature of the feldspar observed in thin sections from most altered to euhedral pristine minerals corresponding to Carboniferous to lower Permian sandstones strongly indicate a change in climate from most favorable conditions for rapid feldspar alteration (humid) to conditions where negligible alteration is possible (arid and glacial). It is found that the CIA values of these sandstones accorded with inferences based on CIX and Ca values, sedimentologic and paleontological evidence, discriminating well between warm-humid (indicated by high CIA values) and arid- glacial (representing low CIA) conditions in the Spiti basin. Thus these results document a complete record of glacial and interglacial phases in the Permocarboniferous Spiti sandstones and the interpretations are consistent with other such studies on the Phanerozoic glaciation events on Gondwana supercontinent.

VSP borehole geophysical signal analysis

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Borehole seismic geophysics - Vertical Seismic Profile (VSP) is a technique of seismic measurements used for correlation with surface seismic data. The VSP survey is being carried out in open or cased borehole and data can be processed to reveal formations ahead of the bit, identifying overpressure or deeper target zones; distinguishes upgoing and downgoing wavefields that help identify primary and multiple events; reveals the location of fault planes, reefs, and pinchouts; can determine reflector dip; calculates amplitude versus offset and anisotropy values; has higher frequency content than surface seismic for targeted imaging in 2D and 3D .The VSP survey provides a true depth calibration to the surface seismic data and is the best way to create a well tie . The defining characteristic of a VSP is that either the energy source, or the detectors (or sometimes both) are in a borehole. VSPs include the zero-offset VSP, walkaway VSP, salt-proximity VSP, 3D VSP and seismic-while-drilling VSP, etc. When seismic wave propagating in the low pass filter heterogeneous and anisotropic Earth, seismic wave will be attenuated and the resolution of recorded seismic signal will be lowered. Usually the seismic attenuation can be quantified by quality factor Q and the estimation of Q is an important procedure in seismic processing and interpretation. Not only can the estimated Q be used in inverse- Q filtering to improve seismic resolution, but also it contributes to lithological classification and gas reservoir characterization. Seismic quality factor Q estimation and Vertical Seismic Profile (VSP) data is analyzed by using Continuous Wavelet Transform (CWT). The Q estimation formula with impulse source can be considered as its specific case that the standard deviation of source approaches the infinity. IODP International Ocean Discovery Program VSP data is analysed by SEISMIC UNIX and MATLAB toolboxes (DSISoft).

The geometry of the Beas River basin: a manifestation of structural geometry and active tectonics

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The Beas River originates south of the Rohtang pass and flows across the Himalayan ranges onto the Indo-Gangetic plains where it ultimately merges with the Sutlej River. The initial course of the river is mainly in the S-SE direction till it takes an abrupt bend towards the SW at Aut. Further downstream, it again changes direction towards NW at Pandoh and again SW at Mandi. There on the river flows into the Sub-Himalayan fold-thrust belt (FTB) of the Kangra re-entrant. In the FTB, the river displays subtle to abrupt bends of various sizes ranging from several hundred meters to several kilometres, either parallel or normal to the NW-SE striking ranges. The Beas basin within the Himalayan ranges is highly asymmetric. The main channel of the Beas River exhibits a clear shift towards SE. Such anomalies as reported here, present over large areas are mainly controlled by the tectonic adjustments along major geological structures. More specifically, the trace of the Main Boundary Thrust (MBT) is curved in this part forming the Kangra re-entrant. The river flows almost parallel to this curvature, especially from Kullu to Aut. Preliminary investigations (much wider from Manali to Kullu and sudden narrowness from Kullu to Aut) suggest that the curvature in the MBT exerts a strong control on the geometry of the Beas River in this area. Further south in the Sub-Himalaya, it is largely controlled by the series of internal thrusts which run almost parallel to each other in the NW-SE direction. This direction is in conformity to the flow of the Beas River till it takes a large bend of several kilometres across the outermost range.

New insights in shear wave velocity estimates through combined use of passive techniques in a tectonically active area

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The study area, which is located in Shillong, Northeast India, falls in seismic Zone V. It has experienced large number of earthquakes of magnitudes greater than 5 in recent past. To get an insight of shear wave velocity profile of this tectonically active area, we carried out array recordings at five sites in by incorporating three passive methods viz. SPAC, Frequency Wavenumber and Ellipticity inversion of H/V ratio. The estimated shear wave velocities out of these three methods are found to be quite consistent with each other. We observed a good convergence in the estimates by all these techniques whose methodologies differ from each other. The computed Vs values up to depth of 30m are observed to be in the range of 275 m/s to 375 m/s, indicating a low velocity region in most of the sites. This has been found to be in good agreement with local geology. Additionally, the profiles exhibit a rising tendency of VP and VS values with increase in depth.

Green building in contaminated soil

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Bamboo is used for making low cost housing in hilly regions. However, wall and roof elements made of simple bamboo mat do not last long due to their poor strength against static as well as impact loads and durability. A present project suggests use of cement-sand mortar panels with bamboo as reinforcing material. Three types of dwelling units with varying plan area are proposed using locally available material in contaminated soil. Cost estimate of these units are also presented for comparison. Bamboo mat panels, generally used as wall and roof elements in housing in hilly regions, are not able to bear heavy stresses under static or impact loads caused due to soil and boulders falling down the slopes of hills. However, if bamboo mat or bamboo mesh is used as reinforcing material in panels made of cement-sand mortar, it can withstand sufficiently large values of both static as well as impact loads. Therefore, it is recommended to use bamboo based cement-sand mortar panels.

This mini project investigation deals with the prediction of settlements of shallow foundations of different sizes and shapes supported on arsenic content granular soil of different grades indicated by different ranges of SPT values. The data needed were collected from literature and investigation will be carried out to predict the settlements by different methods. The soil parameters will be computed and the errors in prediction of settlement will be compared from the actually measured settlements. Some of the existing methods will be modified for satisfactory prediction of settlements in contaminated soil. The analysis of the field data is continuing since last 1-2 years. The computation of settlements by different methods has almost been completed for data, but still to be completed for other field data taken from the literature. The mini research project proposal is submitted to modify the certain methods of low cost housing through bamboo, which are not made for contaminated soil to achieve the satisfactory prediction in the structures, because in nature every soil is contaminated with some toxic and non-toxic chemicals.

Earthquake Safety Measures Through Snakes and Ladders Game

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Every year, India and its surrounding countries face various natural disasters like earthquake, landslide, tsunami etc. Earthquake destroys buildings which in turn causes the loss of lives. Adults come to know of the safety measures that need to be taken in the wake of an Earthquake through various means like media, social networking etc. But, school going kids don't come across this information in their day to day lives. Earthquake safety may be taught as a subject in schools, but children will learn more through interactive ways rather than reading textbooks. Keeping this in mind, we came up with an idea of a simple game which will not only tell the players about the Earthquake safety measures, but will also engage every age group of our society. Due to its simplicity and popularity worldwide, we have chosen snakes and ladders board game for this purpose. As we know, in a snakes and ladder game a player's progression up the board represents his life journey dotted with its virtues (ladders) and vices (snakes). In much the same way, our snakes and ladders board provides all the information about the ladders and snakes when it comes to earthquake safety measures. In this paper all the information regarding the above has been explained.

Mineral Chemistry and nomenclature of amphiboles from Gyangarh Bhilwara Rajasthan, India

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Amphiboles are frequently observed in the medium to high grade metamorphic rocks of garnet bearing amphibolite, metanorite and basic granulites from Gyangarh. The present work discusses the mineral chemistry and nomenclature of amphiboles. On the basis of mineral chemistry, the amphibole from garnet bearing amphibolite are normally varies from Hastingsite and Ferropargasite to Tschermakite variety, while amphibole from metanorite are Tschermakite and amphiboles from basic granulite varies from Magnesiohastingsite to Cannilloite variety.

E-content: teaching through web

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In the world of globalization, World Wide Web has emerged as a useful tool to gain knowledge about the changing scenarios. Educational systems around the world are under increasing pressure to use the new information and communication technologies (ICTs) to teach students the knowledge and skills; they need in the 21st century. The inclusion of e-content in learning is now inevitable, and the MHRD-UGC-CEC initiative is designed to meet the new challenges, and to help India take the lead in this newly emerging field. For the upcoming generation, we need to create a digital learning culture and environment. E-Learning serves this purpose in its various forms such as web-based learning; computer based learning, virtual classrooms etc. UGC-CEC e-content scheme aims to develop high quality e-content as well as expertise for generating such content over the long term. The e-content development and associated web based leaning does not seek to replace traditional teaching and learning, but is expected to supplement them. The Department of Applied Geology, Sagar University is involved in the process of e-content development, wherein, audio, video, graphics, animation and text are used to involve learners and make them a part of the exotic voyage of discovery, wonder and enquiry. This is Government of India planning and curriculums mainly based on UGC syllabus and Choice Based Credit System (CBCS). The ultimate aim of e-content development is to create an information rich society where everyone, irrespective of gender, region, caste and religion etc are empowered to create, receive, share and utilize information and knowledge for the educational upliftment and development. In the process of e-learning structure and validated e-content can serve as an effective virtual teacher.

Petrogeochemistry of charnockite/enderbite from the NW part of Bhilwara Rajasthan, India

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The granulites in NW part of Bhilwara district, Rajasthan, are part of the granodiorite–charnockite/ enderbite suite of Gyangarh-Asind acidic rocks. The charnockite/enderbite is mostly consisting of pyroxenes, plagioclase, garnet, hornblende and biotite etc. The SiO_2 and Al_2O_3 content varies from 52.81 to 55.46 % and from 13.14 to 15.61 %, respectively. The average K_2O/Na_2O ratio of these rocks is 1.08.

The REE values show a slightly steeper light rare earth elements (LREE) pattern and a relatively flat to slightly enriched heavy rare earth element (HREE) pattern. These rocks show negative Eu anomaly. The geochemical data reveals that they are similar to those of modern volcanic rocks. The Zr/Y and Zr/Nb ratios of these rocks suggest that the parent magma for these rocks has evolved. The negative Nb anomaly and a low Th/La ratio of these granulites indicate an asthenospheric or primitive mantle source. The nature of the parent magma is evolved as indicated by Zr/Y and Zr/Nb ratios of these rocks.

Petrogeochemistry of Mylliem granitoids from Meghalaya Plateau northeast India

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Petrogeochemistry of Mylliem granitoids suggest the source of evolution of Mylliem granitoids. Petrographically, the essential minerals are quartz, alkali feldspar and plagioclase while biotite, muscovite, and opaque's occur as accessory minerals. Geochemically, Mylliem Granitoids contains SiO_2 (61.06 to 68.38 %), CaO (1.09 to 3.77 %), Al_2O_3 (12.10 to 15.11 %), MgO (0.53 to 3.64 %,), TiO_2 0.13 to 0.53 %), MnO (0.02 to 0.07 %) and P_2O_5 (0.04 to 0.27 %). K_2O varies between 3.87 to 7.32 % and is higher than Na_2O, which ranges from 1.71 to 3.04 %.

The total alkali content (Na_2O+K_2O) ranges from 6.00 to 9.22 % and K_2O/Na_2O ratio ranges from 1.37 to 3.85 depicting the potash-rich character of Mylliem granitoids. It is characterized by slightly steep to almost flatten light rare earth element (LREE) pattern with average La/Eu ratio 8.429, relatively flat to slightly enrich heavy rare earth element (HREE) pattern with average Eu/Lu ratio 8.991 and slightly negative Eu anomaly with an average concentration of 2.255 ppm. Geochemical parameters (MALI, ASI and Fe) suggests its magnesian, peraluminous and calc-alkalic to alkali-calcic character. Critical correlation between petrography and geochemistry indicates that Mylliem granitoids have S-type characteristics.

Study of geological complexities of Rawana landslide, Sirmaur district Himachal Pradesh, India

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The Rawana Landslide is unique as it is dynamic in nature and associated with emission of hot water vapors (Temp 450 to 600 C) bringing changes in raw qualities and rock types. The active landslide area is increasing in its aerial extent as observed from LISS III, the present dimension shows length as 420 m and variable width from 190 m-270 m. Thus the landslide is in geologically complex area where lithology, structural features, seepage from springs etc are contributing to the recurring of the landslide activity. This activity is associated with the NW-SE trending linear Giri Thrust, and is marked by a prominent fault trending NNW-SSE. The other prominent structural feature are the presence of a NE-SW trending planar lineament, orthogonal to the Giri Thrust, which dissects the landslide mass on its SE extreme and rendering the western portion to go down compared with the eastern part. This has resulted in the formation of a prominent scarp on the western side facilitating the slide. The landslide area has a close network of drainage pattern and presence of two springs which continuously drain through the landslide, producing exothermic reaction converting seepage water into acidic with low pH (2.4) and high salinity with EC 6320 mhos. These chemical reactions have altered the basic composition of rock producing new mineral assemblages. Based on the study of various parameter for Landslide Hazard Evaluation Factor (LHEF) rating, the total estimated hazard value is 7.75 which shows the landslide falls under Zone IV of the Hazards Zone i.e. High Hazard Zone.

Recent advances in the stability assessment of natural and engineered rock slopes - CSIRO research focus

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The understanding of the mechanisms of failures of large natural and engineered slopes has been improved considerably over the last 15 years. There has been significant improvement in the development of innovative data acquisition methods through field measurement and monitoring and in the development of sophisticated numerical modeling techniques. Over the past decade, the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia has directed considerable resources in rock slope stability research and developed a number of novel techniques to facilitate efficient assessment of stability of rock slopes, such as Sirovision (for rock mass structural mapping), Siromodel (for discrete fracture network (DFN) generation, polyhedral (rock block) modeling and kinematic analysis), CSIRO-SPH, CSIRO-DEM and CSIRO-COSFLOW for large scale rock mass stress deformation analysis. Sirovision is a geology/geotechnical mapping and analysis system that generates accurate, scaled 3D images of rock faces from stereo photographs of exposed rock surfaces allowing for rapid rock mass structural mapping. Siromodel is a polyhedral modeling system that reads the Sirovision data and generates DFN and performs polyhedral (rock block) modeling and a first pass stability analysis. CSIRO numerical stress analysis codes (CSIRO-SPH, CSIRO-DEM and CSIRO_COSFLOW) are used for detailed stress-deformation analysis of rock slopes. Though all these codes can perform stress deformation analysis, each code has some specific advantage over others depending on the nature of problems at hand. CSIRO-SPH is suited for large deformation problems and its advantage lies in the ability to simulate large scale fluid flow problems; an example of modeling the breakage of dam will be presented. CSIRO-DEM can be used for large scale rock slope failure analysis and assessment of runout distance of debris generated; an example of slope failure analysis will be presented. CSIRO-COSFLOW is designed specifically for conducting efficient and accurate stress-deformation analysis of sedimentary rocks where failures along the preexisting bedding planes and along the intact rock layers take simultaneously; an example of modeling flexural toppling failure of rock slopes will be presented.

Development of Tethys Sea in northeastern India and India-Asia collision

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Indian Ocean and Neotethys Ocean developed during the Cretaceous Period after the breakup of the Eastern Gondwana Supercontinent (India, Antarctica and Australia). The anticlockwise northward movement of India continued and the new intracratonic basins and shelves developed. The largest Mesozoic-Tertiary sedimentary basins of the Northeastern India includes the Assam-Arakan region, covering northeastern states of Assam, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram, Surma valley, South Cachar and Mikir hills as well as in subsurface sections of upper Assam. The thick sedimentary pile was deposited in Late Mesozoic to Cenozoic in shallow shelf, inner and outer ramps to basinal facies. These early foreland basins formed the floor for the Tertiary basins in the Indian subcontinent including Himalaya. Early foreland basin evolution during Late Cretaceous-Paleogene in the South Shillong Plateau, Meghalaya is of global significance. The rifting initiated with extrusion of widespread basaltic traps (Sylhet Traps) and the development of new basin (Neotethys Ocean) took place (Tewari et al. 2010, 2011). The basin architecture and evolution of the Shillong shelf has suggested that Lower Cretaceous sediments are not deposited in the Shillong shelf. The Middle and Late Cretaceous (Campanian-Maastrichtian) sediments (Jadukata Formation and the Mahadek/Mahadeo Formation) directly overlie the Sylhet Traps in the Um Sohryngkew River section in East Khasi Hills of the Shillong Plateau.

The fluvial boulder beds and the pebbly sandstone of the Jadukata Formation are the oldest sediments in the area which is overlain by the marine glauconitic sandstone of the Mahadek (Mahadeo) Formation of Late Maastrichtian age (Tewari et al. 2010a, b). The overlying Langpar Formation of Paleocene age is a coastal marine sequence of thinly bedded shales, marl and limestone with planktonic foraminifera. The Cretaceous-Tertiary Boundary lies within this section. In this K/T boundary succession, several fossiliferous beds of the gastropods, ammonoids, echinoids and foraminifera-algal limestone have been recorded. The fish remains are found associated with the shallow marine benthic foraminifera of Paleocene age from Mawsmai. The Komorrah Limestone Mine in the Um Sohrynkew River section, represent shallow marine sedimentation in the south Shillong shelf during Paleocene to Late Eocene in which Langpar, Therria, Lakadong, Umlatdoh, Narpuh, Prang and Kopilii Formations in ascending order were deposited without any sedimenological break as strongly supported by transitional sedimentary facies variations and occurrence of larger planktonic foraminifera and algae (Tewari eta al., 2010; Lokho and Tewari, 2011).

However, in the West Khasi Hills, near Dirang village along the road from Ranikaur, rich dinosaurian bones occur in the gritty, pebbly sandstone of continental environment. The bones are associated with grey, purple, gritty sandstone and possibly represent sauropod dinosaurs (Tewari et al. 2010b). In general, the Cretaceous sediments in the Indian subcontinent are fluvial, lacustrine and shallow marine in nature and the conditions were not favourable for carbonate sedimentation. The entire Shillong Plateau witnessed the Paleocene marine transgression in which the carbonate facies was dominant.

The shallow marine Lakadong Limestone of Paleocene age was deposited around Mawmluh Quarry near Cherrapunji (Sohra) in Shillong shelf, where the foraminiferal-algal limestone indicate a carbonate ramp geometry. The Lakadong Limestone consists predominantly of low magnesium calcite. Geochemical data on whole rock samples show that they have high $CaCO_3$ (79 to 98 wt.%) content and the carbon isotope ratios of the Lakadong Limestone also show variation from- 2 to + 2 ‰ (V-PDB) indicative of marine conditions Tewari et al., 2010a).

Therefore, it is interpreted that the Cretaceous-Paleogene sedimentary basin in the Um Sohryngkew River section of the south Shillong Plateau developed on the extruded floor of the Sylhet flood basalt. Similarly, the other Cretaceous-Tertiary intracratonic rift basins must have developed along the southern margin of the Himalaya. The Late Maastrichtian is represented by rich shallow marine fauna in the Mahadek (Mahadeo) Formation in Meghalaya and indicates a marine regression event. The Cretaceous-Tertiary boundary is a regressive phase in the Shillong shelf. The Paleocene-Late Eocene sediments of the basin were deposited in the shallow marine (carbonate ramp) environment on Shillong shelf. However in the Tethyan Himalaya, the deepening of the shelf has been recorded (Lokho and Tewari, 2013).

The calcareous-algal foraminiferal assemblage of the western Tethyan realm in Mediterranean region (Adriatic platform in Italy and Slovenia, Tewari et al.

2007) is correlated with the eastern part of the Neotethys in Meghalaya. The sedimentary facies and calcareous algae of the Lakadong Limestone indicate slow rate of sedimentation and their growth on shallow water environment in carbonate ramp. The symbiosis relationship between coralline algae and foraminifera has been observed in the microfacies analysis. The Lakadong Limestone is characterized by the presence of Standard Micro Facies belonging to mainly algal biosparite (Tewari etal. 2010a, b). The sedimentary facies suggest a post Cretaceous-Paleogene (K/Pg) boundary sedimentation and Paleocene transgression in the Lakadong Limestone (Tewari et al., 2010a, b). It was a shallow eastern Neotethys sea extended in the Himalaya as evidenced by the algal-foraminiferal biota, sedimentary structures, facies and inorganic and organic carbon isotope excursions from the Lakadong Limestone**.** The similar paleobiological assemblages from the Mediterranean region of Europe, Afro-Arabian-Central Asian and Himalayan regions suggest that Indian Plate was very close to the Eurasian Plate during Paleocene-Eocene times before India-Asia collision. The collision might have taken place in Middle Eocene (50 Ma). The subsequent paleoclimatic changes followed the collision and uplift of the Himalaya.

A global correlation of the Cretaceous-Paleogene (K/Pg) boundary stratigraphy at 65 million years ago has strongly suggested that an asteroid impact was responsible for the extreme paleoclimatic changes and mass extinction on Earth. The highly depleted negative carbon isotope value just below the Cretaceous-Paleogene boundary in many sections indicates global cooling. Recent evidences from the Chicxulub crater in Yucatan Peninsula, Mexico and Um Sohryngkew River section, South Shillong Plateau, Meghalaya, NE India has further supported the mass extinction at Cretaceous-Paleogene boundary due to large extraterrestrial impact. A number of land and marine animals like dinosaurs, reptiles, ammonites, calcareous nonnofossils, foraminifera disappeared across the K/Pg boundary and new species of foraminifera and fish appeared after the boundary in Paleocene. A global comparison of the carbon isotopic events, geochemical, changes sedimentological facies variations, palaeontological and astrobiological implications of the asteroid impact has been discussed (Tewari et al. 2007; 2010b). The K/Pg boundary catastrophic asteroid impact also must have triggered Deccan flood basalt on western margin. The K/Pg transition is marked by a boundary clay layer that globally contains iridium anomaly, however recent studies have shown that there is a variation in the thickness and amount of concentration in iridium from Mexico to other regions of the world, depending upon the distance from Chicxulub crater.

Deeper marine deposits are found in some parts of Dishang and Bhuban formations. In the Mizoram hills.two distinct shelf and basin sedimentation has been recognized (Lokho and Tewari 2011, 2013). The sediments of the inner and outer shelf are well developed in the Garo , Khasi and Jaintia hills of the Shillong Plateau, Meghalaya. The paleogeography and the paleoclimatic changes in the northeastern region during Late Mesozoic to Tertiary period has been discussed with special reference to basin architecture , depositional facies, foraminifera- algae records , organic and inorganic carbon isotope ratios and thermal events (hydrocarbon potential) of these basins (Lokho and Tewari, 2011; 2012, 2013). Stable isotope data of the limestones from the exotic blocks of the Manipur Ophiolitic belt has been analysed and interpreted. The carbon isotope from Ukhrul, Mova cave and Kankhui shows $\delta^{13}C$ values range from +0.44 ‰ (V-PDB) in Ukhrul to + 2.08 ‰ (V-PDB) in Kankhui. $\delta^{18}O$ values range between -47 ‰ (V-PDB) to – 10.23 ‰ (V- PDB) indicating shallow marine environment. A Lower Maastrichtian age is suggested by the foraminiferal assemblage *Globotruncana linneiana, Pseudotextularia excolata, P. elegans, Heterohelix globulosa* and *Rugoglobigerina hexacamerata?*

In the northern Manipur Ophiolite Complex the ultramafics are closely associated with mafic volcanics-intrusives, oceanic pelagic sediments, radiolarian- foram bearing limestone and chromitites (Tewari et al., 2011; Singh et al., 2013). The ophiolite complex is haphazardly juxtaposed along faults or they consist of lensoid slices interbedded with Disang Group of rocks. The Lower Disang sediments were intermixed with pelagic cherts and limestone. The flyschoid Disang Formation gradually merges into the post-orogenic mollassic Barail Group of rocks towards the west of the study area. The mélange zone is characterized by the occurrence of exotic blocks of varying size (a meter to hundreds of meters) fossiliferous limestone, marl sandstone, mafic rocks and conglomerate embedded in matrix of flyschoid rocks (Singh, 1992). On the basis of faunal assemblages (radiolarian, planktonic foraminefera) in the olistolithic blocks of pelagic limestone and cherts, the Naga-Manipur ophiolites has been assigned to range in age from Upper Cretaceous to Eocene (Tewari et al. 2011 and the references therein). The planktonic foraminifera of Late Cretaceous age is found associated with the pelagic limestone.

Recent carbon and oxygen isotopic study from the post Cretaceous-Palaeogene (K/Pg) boundary Santa Elena borehole from the Chicxulub impact crater (Urrutia and Cruz , 2008) has shown that $\delta^{13}C$ values vary from 1.2 to 3.5 ‰ (PDB) and $\delta^{18}O$ values from -1.4 to -4.8 ‰ (PDB). The Paleocene marine carbonate cores from the North Pacific Ocean also show similar carbon and oxygen isotope ratios. Palaeocene stable carbon and oxygen isotope variation from Lakadong Limestone, South Shillong Plateau, Meghalaya shows similar environment and isotope chemostratigraphy (Tewari, 2004; Tewari et al, 2004, 2007, 2010a, b). The

Palaeocene Beds of the Liburnia Formation, NW Adriatic-Dinaric platform, Slovenia are open shelf subtidal marine limestone (Ogorelec et al., 2001) and the $\delta^{13}C$ values range from 2.3 to 0.1 ‰ (PDB). The oxygen isotope ratios of the Lakadong Limestone from Meghalaya are more negative when compared with the Chicxulub crater and may be related to local paleogeographic conditions (Tewari et al. 2010). The $\delta^{18}O$ values from Santa Elena core are more or less similar to the DSDP hole in the North Pacific Ocean (Urrutia and Cruz, 2008). Tewari et al (2007) and Ogorelec et al. (2001) have shown that the Cretaceous-Paleogene (K/Pg) boundary marine carbonates from the Padriciano section in the North Adriatic platform are highly depleted in $\delta^{13}C$ values (-3.62 to-10.01 ‰ PDB) and $\delta^{18}O$ values range from -3.85 to -5.47 ‰ (V-PDB).

The Indo-Myanmar Orogenic Belt (IMOB) is interpreted as representing the eastern suture of Indian plate and it was formed due to the collision of the Indian plate with the Myanmar plate (Mitchell, 1981; Acharyya *et al*. 1989; Tewari et al. 2011; Singh et al.2013). The ophiolite sequence in this region is highly tectonised, dismembered and shows three phases of deformational events broadly comparable to the Himalayan orogeny and sea floor spreading of the Indian Ocean.. The ophiolites were generated during the beginning of spreading of ocean basin, which escaped re-equilibration and significant fractionation developed at the edge of ocean basin adjacent to continental margins. These ophiolites are represented by dismembered mafic and ultramafic rocks with closely associated oceanic pelagic sediments.

The possible role of Alpine-Himalayan orogeny and syn and post India- Asia collision scenario has also been discussed in the light of global paleogeographic reconstruction.

Potential of geopark development in the Sikkim Himalaya, India: some suggestions

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The Sikkim Himalaya in the NE India has vast potential of Geo Park Development along the Teesta and Rangeet river valleys. The geology, structure, stratigraphy and the geomorphology of the Sub, Lesser and the Higher Himalaya is very fascinating and significant geological features must be preserved and these sites must be developed as Geological and Fossil Parks. Some very important and geologically significant sites in the South Sikkim Lesser Himalaya needs to be preserved immediately and developed as Fossil Parks since these are located very close to the ongoing and proposed new hydropower projects, road constructions and other developmental civil constructions. The Meso-Neoproterozoic stromatolites are very well preserved in the Buxa Dolomite Formation in the Rangeet river valley near Tatapani, along the road from Tatapani to Reshi and Namchi town to Mamley village. Highly diversified assemblage of characteristic taxa Colonella columnaris, Conophyton garganicus, Kussiella kussiensis, Baicalia sp., Jurusania sp., Minjaria sp., Gymnosolen sp., Kalpanaella new form Tewari , Stratifera sp., Colleniella sp., Tangussia sp., and Nucliella sp. etc. are well preserved in the eastern Himalaya (Tewari, 2004, 2009, 2011). The chert bands associated with the stromatolites have yielded the organic walled microfossils Siphonophycus sp., Eomycetopsis sp., Obruchevella sp., Myxococcoides sp. and Oscillatoriopsis sp., (Tewari, 2011; Schopf et al., 2008).The Laser Raman Spectroscopic and Confocal Laser Scanning Microscopy has shown that these bacteria are biogenic and can also be useful in search for the extraterrestrial life on Mars and other planets (Schopf et al. 2008; Tewari, 2011). Recent astrobiological studies have shown that stromatolites or microbially induced sedimentary structures and bacterial microorganisms may be found on Martian surface.

Therefore, the stromatolite fossil park may be urgently developed at Tatapani and Mamley to preserve these rare evidence of early life and its evolution on planet earth from the eastern Himalaya in the South Sikkim. The other equally important evidence of Permian glaciation is also well preserved at Tatapani where large Gondwana Ranjeet Boulder Beds (glacial diamictites) indicate strong past evidence of glacial cool climate on this part of the Earth in the eastern Himalaya. This outcrop also needs to be protected and developed as Geopark depicting extreme past climate change of global significance. South Sikkim Gondwana Deposits are also characterised by the excellent development and preservation of plant fossils like Glossopteris sp, Gangamopteris sp., Vertebraria sp. and other plant groups found in the coal beds near Namchi town and Jorethang – Legship road section. There are well developed cave deposits or Speleothems in the South Sikkim. They are used for the paleoclimate and paleomonsoon determination. We can also understand the climate change and monsoon during last few thousand years in the eastern Himalaya and the intensity of the Indian Summer Monsoon also.

Therefore, there is great potential to protect these important fossil localities in situ where they are found and also a larger Fossil and Geo Park may be developed near Namchi town (preferably near Mamley village) where all these fossils and geological features may be kept in a museum. The entire park may be planned in such a way to depict different themes from geological past oldest (Meso-Neoproterozoic) to youngest (Holocene/Recent) covering the aspects of the (1) Origin and Evolution of Proterozoic Life and Astrobiology, (2) Paleozoic Life and Paleoclimate, (3) Mesozoic-Tertiary Life and Mass Extinction, (4) Holocene-Recent Climate Change, Monsoon and Himalayan Glaciers from the Sikkim. There could be a research laboratory also to develop this park on par with the international Geoparks and Museums. This park may be developed as a unique park in India to educate the local students and people of Sikkim to understand the importance of the geology and also to attract the tourist from all over the world by the Sikkim government.

Landslide hazard zonation of Tehri reservoir rim area using fuzzy logic technique

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Tehri reservoir (67 KM long) has developed due to construction of a 260.5 m high dam at the confluence of Bhagirathi and Bhilangana River. The reservoir is situated in the rugged Lesser Himalayan. The area is represented by different types of phyllite rocks, river borne materials, debris, weathered quartzites and carbonate rocks. A number of villages are situated at the side slopes of the valley which are at risk of landslide hazard due to reservoir water fluctuation. In order to assess the stability condition of the reservoir side slopes, landslide hazard zonation (LHZ) mapping of the reservoir rim was performed using fuzzy logic technique. Ten landslide causal factors namely, lithology, land use/land cover, soil cover, lineaments, slope angle, aspect, relative relief, drainage buffer, road buffer and reservoir buffer were subjectively assigned the fuzzy membership values. Further, fuzzy gamma integration (using five different gamma values) was performed to compute landslide hazard index (LHI) value for each mapping grid. Natural break classification was performed on the LHI map to delineate five relative hazard zones namely, very low, low, moderate, high and very high hazard zones. Prediction capability of the LHZ map was carried out by using successes rate curve. Peak prediction accuracy of 84 % was achieved for the fuzzy integration using gamma value of 0.92.

Final LHZ map adequately reflected landslide probable zones present in the area along with the relationship of causal factor with the landslides. Lower hazard zones were observed in terraces, build-up areas, terrains supporting thick vegetation cover and relatively flatter talus slopes. Most of the settlement areas were reflected as moderate hazard zone in the LHZ map. High and very high landslide hazard zones were found along the side slopes adjoining the reservoir, road network, lesser proximity to drainage, lesser proximity to photo-lineament, steeper slopes and ridges.

Late Quaternary paleoceanographic changes in the southern South China Sea (ODP Site 1143): the benthic foraminiferal record

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Deep-sea benthic foraminiferal assemblages from Ocean Drilling Program (ODP) Site 1143 located in the southern South China Sea (SCS) were investigated to evaluate the relationship between faunal composition patterns and paleoceanographic changes during the late quaternary.The South China Sea (SCS) located on the edge of the Western Pacific Warm Pool is one of the largest marginal seas in the western Pacific that exchanges water with the western Pacific. The South China Sea is influenced by East Asian monsoon. In the present work benthic foraminifera were analyzed from the well-dated cores of ODP site 1143 recovered from the southern South China Sea to evaluate deep sea environment during the last about 50,000 years. We used quantitative and factor analysis of benthic foraminiferal assemblages which suggest that the distribution patterns of dominant deep-sea benthic foraminiferal species are primarily controlled by organic carbon flux to the sea floor in the southern South China Sea. The *favocassidulina favus* a typical component of Pacific Bottom Water (PBW) is present before LGM (~ 18 ka) and absent during LGM from the SCS, suggesting that the PBW is unable to flow over the Bashi strait over the SCS due to lowering of sea level. In the last glacial stage, surface water in the southern South China Sea was covered by cold, nutrient-rich, and less-saline water because circulation through shallower straits was probably restricted due to the eustatic sea level lowering as revealed by absence of *favocassidulina favus* in the South China Sea. Low salinity water was stratified in the water column, preventing deep ventilation in the sea and leading to anoxic bottom conditions.

Petrological, mineralogical and geochemical characteristics of granitoids from Narnaul area of Delhi Super Group rocks, Mahenderagarh district southern Haryana, India

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Southern part of Haryana (28˚2'-28˚7 N', 76˚3'- 76˚7' E) mainly consists of metasedimentary rocks of Delhi Supergroup (900-1600 Ma) are exposed in the Aravalli Mountain range. The metasedimentary rocks are mainly quartzite with lesser amount of schist, granitic gneiss, basic rocks, calc rocks, phyllite, slate, granite, pegmatite and veins of quartz. Most of the Granitoids of the study area intruded into the quartzite. Granitoids occur as irregular masses, dyke swarms, branching dykes, criss-cross veins and elongated lenses. They strike in NNE direction with low dip angle. Their dimensions are variable (0.5 m-250 m length and 0.5-00 m width).

Narnaul granitoids are medium to coarse, coarse to very coarse grained and consist of quartz (smoky, milky, yellowish brown, buff), orthoclase, albite, biotite, muscovite, tourmaline as essentials minerals and calcite, beryl, garnet, hornblende, ilmenite and natrolite as minor phases. Pegmatitic, hypidiomorphic, equigranular, graphic and granophyric textures are observed in them. Model analyses data of the granitoids is plotted mainly in the field of granite, also in alkali granite and quartz rich granitoid fields of QAP diagram (Streckeisen, 1973). Also plotted in the fields (Lameyre and Bowden, 1982) of calc-alkaline-granodiorite series & granitoid generated by crustal fusion process. Geochemically the granitoids are high in SiO_2, Al_2O_3, K_2O, Rb, Zr, Cs, Ta, Pb, P and Y and low in CaO, K, U, Th, Ti, Ba, Sr, Nb and Nd. These characters attest them as peraluminous and formed in postorogenic tectonic settings**.**

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Earthquake induced landslide hazard zonation of Nainital region

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Landslide is a very common problem in the Himalayan region. Nainital's geographic site (29°2'-29°37' N, 78°51'-79°59' E) and condition allows for landslides to occur much more often than in any other regions of the Himalaya. Being the youngest mountain system of the world, it constitutes a fragile network of unstable slopes with a major geohazard of landslides. Three major tectonic features (MCT, MBT and MFT) running all along the whole Himalayan belt capable of generating major to large earthquakes in the regions. Each type of earthquake-induced landslide occurs in a particular suite of geologic environments. In addition to various static factors responsible for instability of slopes, earthquakes are to be considered a major triggering factor for the occurrence of landslides in this region. To assess the potential landslide hazard distribution in the region, we have taken topographic map of the region as base map for delineation of the whole Nainital region into smaller areas (facets) and other based on the certain tectonic and geologic environments. An empirical method, which pays landslide hazard evaluation factor (LHEF) rating scheme have been applied in each facet. The calculated total estimated hazard (TEHD) facet-wise by adding ratings of all causative factors, landslide hazard zonation (LHZ) map is prepared. On the basis of TEHD, the LHZ map is divided into 5 categories, namely, very low hazard (VLH), low hazard (LH), moderate hazard (MH), high hazard (HH) and very high hazard (VHH) and presented in the final map.

Permian carbonate platform palaeozoogeography of Iran

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Geographical extension of Permian rocks in Iran is widespread and it is believed that due to Hercynian events during late Carboniferous and early Permian downward movements of earth surface provide widespread transgression of sea. This transgression helps to provide post-ecosystems within the north of Azerbaijan, central Iran, Sanandaj-Sirjan zone and in Zagros.

Some descriptive papers have been published on Permian corals from several localities in Iran and adjacent regions (e. g., Abich, 1878; Douglas, 1936, 1950; Heritsch, 1937; Hudson, 1958; Iljina, 1962, 1965a; Flugel, 1964, 1972; Graf, 1964; Kropatcheva, 1983). Among them, Iljina's works are the most remarkable and they greatly contributed to knowledge of the faunal characteristics of the Middle to Upper Permian corals. Iljina's phylogenetic hypothesis of the Rugosa and the Scleractinia (e. g., Iljina, 1965a) is based on specimens from the Upper Permian of the Transcaucasia, and her direct descendant theory has greatly influenced thinking about a possible relation between these two groups.

Ezaki (1989, 1991) indicated that no transitional and derived characters are to be recognized in the Upper Permian corals (plerophyllids). Rugose corals became completely extinct, leaving no descendants. Therefore, the faunal characteristics of the rugose corals from the Upper Permian reveal a terminal phylogenetic history of the group.

In this study the results from Iranian Permian corals were compared with the Permian corals from other part of the world based on similarities and the position of each province with respect to the Iranian platform. The Permian corals were studied and up to 22 genera of rugosa and tabulata corals have been distinguished. They are: *Ufimia*, *Pentaphyllum*, *Waagenophyllum, Ipciphyllum*, *Lophocarinophyllum, Miyagiella*, *Wentzelell, Polithecalis*, *Lonsdaleiastraea*, *Iranophyllum*, *Lonsdaleia*, *Actinocyathus*, *Ivanovia*, *Parawentzelella*, *Ruteha*, *Sinopora*, *Yatsengia*, *Calophyllum*, *Asserculinia*, *Praetachylasma*, *Protomichelinia* and *Polythecalis*.

The corals assemblages of the Iran have the most important and most similarity with 16 rugosa and tabulata with the North-Asiatic part of the Ex USSR and China Provinces. The similarity with the provinces of North America is with 15 rugosa and with East Asia province with 13 rugosa and 1 tabulata corals, Eastern Europe with 10 rugosa and 1 tabulata and West Europa with 9 rugosa. The Iranian basin shows lesser similarity with provinces of Australia with 7, North Africa with 3 and Alaska with 2 genera of rugosa corals. The similarity of the Iranian corals assemblage with North-Asiatic part of the Ex USSR and China basins is accountable because of being near both of two areas to each other, in paleogeography, because these basins with being relative near in south of equatorial ocean have been in a Permian Tethys.

Alborz mountain limstone formations effects on characteristics of highly calcareous Quaternary soils of Miyaneh county, Azerbaijan

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This study focuses on Alaborz mountains limestone formations and its effects on calcareous Quaternary alluvial deposites of Miyaneh county. These calcareous formations have been outcropped tectonically within this area and sourse of calcareous soils. By the weathering of these rocks and interflow of rain water they might transmit their carbonates to soils and waters. The Alaborz thrust zone consist of fourteen folded formations. Most of the formations in the Alaborz mountains contain different amounts of carbonate compounds. From theanalysis of these compound it shows limestone rock or other calcareous sedimentary rocks of marine origin.These soils are either limestone-rich parent materials (about 30 % of the pilot area) or from calcium-rich sedimentary rocks which may belongs to different geological eras. These carbonatic rocks have various ages, origins and different composition and characteristics, which outlined and surveyed by many scientists in Iran. Fourteen formations of the Miyaneh region proposed by previous authors is redefinded into six formations by us which are: Rutehand and Dorud Formation, Mila Formation, Barut Formation, Soltanieh Dolomite (Infracambrian) and Bayandor Formation (Infracambrian).

The climate of the Alborz mountains is arid to semi arid with high potential evapo-transpiration (ET_o) which diminish the deep-perculation of rain water and caused carbonate accumulation in the topsoil profile. In the most of the established Quaternary surface depositions, the soil profiles had more than 50 percentage $CaCO_3$ equivalent. There are some perennial rivers in the studied area with south-north directions which most of them are rich of carbonate deposits. Most of the soils ranked as Calcisols by FAO and USDA classifications (Ttable 1).

Table. 1. Physical and chemical characteristics of soil samples collected in the Miyaneh Basin.

No.	Name and depth of horizon (cm)	pH 1:1	EC ($mS.cm^{-1}$)	$CaCO_3$ (%)	OC (%)	Sand %	Silt %	Clay %	Texture Class
1	(A) 0-20	7.7	2.5	23.0	1.1	40.0	40.0	20.0	L*
	(B) 20-65	7.9	1.2	37.0	0.0	-	-	-	-
2	(A) 0-15	8.1	1.1	50.4	0.9	33.0	32.0	35.0	CL**
	(B) 15-85	7.8	3.5	66.2	0.8	-	-	-	-
3	(A) 0-20	7.9	2.5	34.0	0.8	38.0	38.0	24.0	L
	(B) 20-90	7.5	2.2	40.0	0.5	-	-	-	-
4	(A) 0-15	8.2	2.1	32.5	0.3	28.0	46.0	26.0	SiL***
	(B) 15-150	8.2	1.7	40.0	0.3	-	-	-	-
5	(A) 0-20	7.4	2.1	45.0	0.5	36.0	39.0	25.0	L
	(B) 20-70	7.8	3.1	53.0	0.3	-	-	-	-
6	(A) 0-20	7.9	1.5	40.0	0.6	30.0	40.0	30.0	L
	(B) 20-120	8.1	2.1	47.0	0.2	-	-	-	-
7	(A) 0-10	8.1	0.7	28.0	0.8	38.0	38.0	24.0	L
	(B) 10-90	8.5	1.6	34.0	0.4	-	-	-	-

Soil texture class symbol: *L=loam; **CL=Clay Loam;***SiL=Silty-Loam

A comparative study of strong ground motion records from 30 August 2013 south Tibet earthquake on the rock and soil sites of Kathmandu valley

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The present study is based upon strong ground motion records from 4 seismic stations established by Hokkaido University in the Kathmandu valley at Kirtipur height, Tribhuvan University, Patan and Thimi. The stations, one right above the bed-rock and others over the lake sediment of the valley have been continuously recording for over 2 years. We considered the rock-site station in Kirtipur height as the reference site to quantify the amplification of other sites on the lake sediments. The *Mb*=4.9 Southern Tibet Earthquake of 30 August 2013 was analysed to understand the site response of the sites. The horizontal maximum velocity of the strong ground motion is 0.84 cm/s in the site at Thimi in contrast to 0.23 cm/s in the rock site of Kirtipur height and these PGVs follow the attenuation law of Si and Midorikawa (1999). The Fourier spectra of the horizontal components show marked difference between that of the rock site and the soil sites. The highest spectral amplitude is observed at the Tribhuvan University site at 0.5 Hz. Analysis of the S-wave part indicates a spectral ratio of 2-10 in the 1-2 Hz band in the sediment sites. Surface waves in the records of three sites continue for quite a long time when compared to that of the rock-site. Even though the difference in azimuth and epicentre distance of the sites is not significant, it is observed that the initial motion at the Kirtipur height site is a quarter of second earlier than expected. This implies the difference in the underground body wave velocity structure of the sites. But the lack of accurate underground structure of the valley necessitates further study. We will try to discuss the basin underground structure with these strong ground motion data including *Mb*=4.4 Gorkha Earthquake of 25 November 2014 and *Mb*=5.0 Solukhumbu Earthquake of 18 December 2014.

The analyses of debris flow disasters by heavy rainfall in western Shimane and eastern Yamaguchi on July 28, 2013

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On July 28, 2013, an unprecedented torrential rainfall occurred in west Shimane and east Yamaguchi, Japan. For restoration purpose, these sites were investigated about one year after the disaster. These investigations were carried out on April 19 and May 15, 2014 in Shimane and Yamaguchi, respectively. The meteorological stations of Shimane and Yamaguchi were able to record the data of heavy rainfall from both prefectures. The detail information of the check dams destroyed by the disasters in both prefectures was also collected. In Shimane most of the check dams protected the houses and human lives though a young person was killed. Every collapsed slope is shallow plane failure. The samples of soil were collected from the collapsed slopes to investigate the two kind of physical soil properties in the fields. In this study, the analyses of debris flow using three dimensional GUI were carried out for the restoration at that time. As the result, it was evaluated that the check dams could protect the people's life in the district from such kind of extreme rainfall. However, the check dams in Yamaguchi were not useful for almost the similar disaster. The different phenomena were considered by the results of the debris flow analyses developed in this study.

Shallow underground structure of strong ground motion observation sites in the Kathmandu valley

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The Kathmandu valley, formed with lake similar to Mexico City, consists of thick soft sediment below the center of city. As a result, the Kathmandu city has been damaged not only by near field earthquakes but also far field earthquakes in the past. Three people were killed by a collapsing wall during the 18th September 2011 Sikkim earthquake that occurred over 400 km away from Kathmandu. It is most important to know the strong ground motion character of the Kathmandu valley to plan earthquake disaster counter measures. We installed strong motion seismometers in 4 stations to grasp characteristics of strong ground motion in the Kathmandu valley on September 2011. One of them is on the rock site in Kirtipur (KTP) and Tribhuvan University (TVU), Patan (PTN) and Thimi (THM) are on sedimentary basin. The instruments of strong motion observation are Mitsutoyo JEP-6A3-2 accelerometers and Hakusan LS-7000XT, LS-8800 data logger with GPS time calibration.

We explored shallow underground structure of our 4 sites by surface wave method. Surface wave method was carried out with 24-channel Geode Seismic Recorder (Geometrics Co.). Surface waves were generated by striking the ground using a large wooden hammer. We inverted shear wave velocity from observed surface wave phase velocity. The detected shear wave velocity of rock site KTP is 500-700 m/s. On the other hand, velocity of other sedimentary basin sites are 100-200 m/s. We observed some earthquake records from all stations and found site response of each site clearly. The recorded strong ground motions are being presented by Bijukchhen et al. on this conference. We will discuss recorded strong ground motion data with our explored shallow underground structure and deep underground structure in further study. Our ultimate purpose is prediction of strong ground motion for the Kathmandu valley using these results.

GIS-based landslide hazard analysis for road network discontinuity assessment during earthquakes - a state-defining parametric approach

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Recurrence of existing large-scale landslides is inevitable during earthquakes, and it is all important to assess road network discontinuity due to roadside slopes failures and recurred landslides. However, in absence of identified landslide inventory data, it is often difficult to assess the hazard. In this study, we prepare a GIS-based roadside landslide database in Shikoku region of Japan, where a big earthquake is anticipated in next 30-50 years and include the landslide state-defining parameters, such as area, slope, amount of displacement, distance from road, stage of occurrence, etc. for each individual landslide, and make use of the database to assess landslide hazard for the road network functionality during the earthquake. Unlike landslide causal factor-based parametric analysis, in this study we adopt a new approach of individual landslide parameter-based analysis together with the peak ground acceleration estimated for the region during the anticipated earthquake. Individual hazard level is determined for each landslide on the basis of its relative position in between minimum and maximum values of each considered parameter. The results obtained are then verified with the high hazard risk road locations designated by the road authorities. Although it is relative, it has proved to be a numerically simple and reliable landslide hazard assessment method for road network discontinuity during earthquakes.

Environmental changes of the Nepal Himalaya in terms of GLOF phenomena

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Due to the present global warming, many glaciers are receding, glacial lakes are expanding and the Glacial Lake Outburst Floods (GLOF) have been occurring in the Nepal Himalaya. For example, Mingbo GLOF of 1977, Lagmoche GLOF of 1985 and Saboi GLOF of 1998 were occurred in the Khumbu region. All of the reported GLOFs were smaller glacial lakes with area less than 1 km^2, and no larger glacial lakes showed any GLOFs. The Tulagi glacial lake is located at the upper part of the Dana Khola in the west of Mt. Manaslu. The water level of Tulagi glacial lake has been lowered due to the outlet erosion at the end moraine since the 16th century glacial advance that indicates low GLOF risk. At the same time, the lake level continuously lowers in recent years since 1990s. The end moraine structure of a large glacial lake is strong enough to prevent the occurrence of the GLOF that is completely different from a small glacial lake with steep cliff at the upper part of the lake producing avalanches directly dropping into the lake causing TSUNAMI to destroy the fragile ice-cored moraine. We must be very careful about the small glacial lakes developing in the Hong Khola around Mt. Chamlang which have steep cliff in the upper part of their accumulation area, so they must be taken to mitigate against GLOF. However, the large glacial lakes such as the Tulagi and the Imja are safe against the GLOF, as the ICIMOD (2011) reported as the Imja Tso has less likelihood of outburst than Tulagi lake.

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Critical slope angle inducing landslides on dip slope by each geological type in central western part of the lower Nepal Himalaya

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One of the most important causative factors of landslide is slope angle; however, it varies with geology. Lithological property of rock affects the degree of vulnerability to landslide. The author, by using landslide inventory map and aerial photographs (1:50000) of central western part of Lower Nepal Himalayas, tried to clarify critical slope angle on dip slope at which landslides are prone to occur. The inventory map is superimposed on the topographic map generated from GDEM and geological map of Department of Mines and Geology, Nepal. And then measurement of topographic features of each landslide such as width, relative heights and gradients of source area of the landslide by each geological type in Tansen area was implemented. This area also covers Siwalik Hills, Mahabharat Ranges and Lower Himalaya. Total number of landslides used for this study is 512.

Mean slope gradient of landslide source area is different by each geological type. And the critical gradient at which the number of landslide abruptly increases varies by each geological type. It means that each rock property affects the degree of vulnerability for landslide. Gradients of the secondary landslides decrease compared with those of the primary ones due to advanced fracture of rock masses. The most hazardous rocks in this region are the Lower Siwalik unconsolidated mudstone or Swat Formation of carbonaceous shale that easily slide at lowest angle. Those slope angles of source areas are less than 20 degrees. However, limestone or dolomite with slope angle about 30 degrees indicate high rigidity and resistance to landslide.

Assessment of rainfall-triggered shallow landsliding using hydro-geotechnical model of hill slope stability

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The concern for climate change has increased worldwide. Localized rain storms with high intensity and short duration have been observed in Asia. Korea is also experiencing changes in climate parameters, including annual precipitation. Landslide susceptibility maps are important for risk management and land-use planning in mountainous countries such as Korea. Many of the slopes of the mountainous areas of Korea are composed of residual soils that originate from weathering of bedrock. A series of debris flow events occurred around 8:00 to 8:50 a.m. on July 27, 2011 in the Umyeon Mountain area located in central Seoul, Korea. Due to the debris flows with runout distances ranging from 300 m to 1,000 m, 16 people were killed and more than 150 houses had been damaged in the area. In this research, a physically based slope stability model for shallow landslide is presented. A model for the prediction of both topographic and climatic control on shallow landslide initiation processes in hilly mountainous terrain is proposed. A fundamental study was carried out on the cause and mechanism of landslide/debris flow. An analytical method is developed for determining the failure mechanism of unsaturated soil slopes under extreme-rainfall, the effect of groundwater flow; the downward velocity of wetting front, and the upward velocity of groundwater level. Based on this, we propose the conceptual methodology of landslide design based on experimental tests and numerical analyses which consider the important mechanism of the combined effects of both groundwater flow and rainfall infiltration into the slope.

The western tip of the Alpine belt: hyper-extended margins, oblique convergence, slab retreat and the birth of the Gibraltar Arc

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The Gibraltar Arc constitutes the western tip of the Alpine Belt pinched between the African and Iberian (European) plates. We review the origin of this enigmatic westward closure of the Alpine Belt in the light of the latest structural achievements in the area. The Gibraltar Arc formed together with the other West Mediterranean belts at the expense of a NE-trending orogen extending along the European margin in the continuation of the Alps. This early belt formed above the southeastward subducting European plate during the Late Cretaceous-Eocene closure of the Alpine-Ligurian-Maghrebian (ALM) Tethys. During the Jurassic-Early Cretaceous, the latter domain was not a true oceanic domain but looked like the juxtaposition of hyper-extended margins depending of the adjacent, European and African (Nubian) plates.The ALM Tethys connected westward with the Central Atlantic through a narrow (ca. 400 km-wide) dextral transform zone whereas it was wider in the east, next tothe Africa-dependent Adriatic plate.Oligocene collision of the latter plate against Europe caused a subduction flip, so as the ALM lithosphere began subducting northwestward, which in turn caused back-arc extension to occur northwest of the early orogen. Slab retreat resulted in the progressive curvature and boudinage of the Alpine orogen whose fragments (Kabylias and Alboran terranes) collided with the adjacent continents during the late Oligocene-Miocene. Three suture zones can be distinguished in the Alboran terrane.The HP-LT Mulhacen suture extends within the Sierra Nevada in the eastern Betic Cordilleras. The MaghrebianFlyschsuture underlines the Gibraltar Arc (western Betics and Moroccan Rif) and can be followed eastward up to southern Italy (Calabrian Arc). The newly described Mesorifsutureseparates a distal continental allochthon from the proximal African margin.Final building of the Gibraltar Arc occurred through oblique collision of the Alboran terrane with the adjacent plates, block rotations and back-arc extension.

From the West African Craton to the Atlantic Ocean: a recommended geoheritage trail in southern Sahara of Morocco

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The remote regions of Southern Morocco are rich in outstanding geological landscapes and outcrops not well known by the general public. In this work, we propose a200 km long, southeast-trending geotrail starting from the Dakhla sea-resort and ending at Awsard inside the Sahara Desert, with a total of ten geosites of particular interest for geotourists as well as for geologists. The geotrail gives the opportunity to observe the oldest rocks (Archaean) of Morocco, belonging to the West African Craton (WAC) nucleus, with splendid outcrops of migmatites and nepheline syenite. Upper Ordovician periglacial sandstones overlie directlythe WAC rocks, followed upward by thin Silurian shales and Devonian limestones. The trail also presents a section across the Mauritanides nappes (Neoproterozoic quartzites, Archaean orthogneisses and metagabbros) thrust over the WAC during the Appalachian-Variscan collision.This tectonic setting is exceptional in Morocco but extends widely in the south (Mauritania, Senegal). The trail includes finally four geosites in the Cretaceous-Cenozoic deposits of the Coastal Basin, belonging to the Atlantic margin deposits onshore. The Early Cretaceous red beds record the major, Upper Jurassic uplift event of NW Africa. These reddish sandstones show frequent Neolithic engraving. They constitutethe main water table of the area and continue westward in the form of a thick sandy prism offshore (a potential oil and gas reservoir). The Eocene deposits of the shoreline south of Dakhla offer abundant vertebrate remnants (whale bones, shark teeth). The Dakhla-Awsardcross-section contrasts with the classical section 700 km in the north between the Tarfaya Basin and the Variscan Anti-Atlas Mountainswhere the Palaeozoic series are much thicker and show a quite different structure. The adjustment and promotion of the Dakhla-Awsard geotrail will increase the attractiveness of the wild Nature in the Saharan regions of Morocco.

Hydropower and other infrastructure development: a case study from Tamakoshi River basin, central Nepal

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Hydropower is the path of leading other infrastructure development in Tamakoshi River Basin (TRB) of Nepal. Originally, the basin was accessible only through foot and animal porter and even the district headquarter was accessible only through foot till 1980. Various infrastructure development activities (bridge, hydropower, road..etc) dropped out in the river basin after introduction of Jiri Multipurpose Development Project with initiation of Swiss cooperation. The first infrastructure of road was Lamosangu Jiri Road linking the basin with Kathmandu in 1981. Later, the basin was joined with Kirne due to Khimit hydropower (60MW), Charikot Singati Road (1997-1999), Nayapol Manthali road- 1999. Other motor able roads are Maghe Deaurali Road Melung Doranmba Road, Mainapokhjari Jhugu Road, Singati Chapaleti Road, Bhadaure Patagaon Road, Marbu Chhetrapa Road, Khawana Chaaudi road , Jiri-Planti Road , Rasanalu Plaanti Road, Khimt bensi- Siwalaya road etc.. Moreover, different types of infrastructure are being developed along major river courses- Tamakoshi, Khimti, Khare etc. The river basin is connected with almost all parts of the country. The northern part is connected up to Lamabagar while southern part up to Tribeni and Manthali, which are accessible year round with vehicles. All infrastructure development in the basin is due to hydropower production. The under construction of upper Tamakoshi Hydropower (456 MW) and Khimti hydropower made difference in development of infrastructure. The present paper tries to conceptualized the study of relationship between hydropower and infrastructure development in Nepal with special reference to Tamakosh River Basin Key word: Infrastructure , river basin, Hydropower

Challenges of pressure shaft excavation in the Nepal Himalaya: case studies from hydroelectric projects

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The excavation of the long blind pressure shaft is one of the most difficult and risky job in the Nepal Himalaya for hydropower development. Excavation of the shaft greater than 200 m length is a challenge due to vertical or inclined orientation, limited space, available technology and changing geological conditions in the Nepal Himalaya. Amongst Alimak raise climber, shaft sinking and raise boring excavation methods, Alimak raise climber is most commonly used in Nepal. Selection of excavation method depends on geological conditions, size and length of shaft, access and of course the cost. Pressure shaft of Jhimruk, Khimti I, Chilime, Kaligandagi, Kulekhani, Khani Khola, Upper Tamakoshi and the like. Hydroelectric projects were excavated with the help of conventional Alimak raise climber method. Severe overbreak problems were faced in Khimti I hydropower project during construction of upper inclined pressure shaft, whereas 214 m vertical pressure shaft of Upper Tamakoshi and 280 m vertical pressure shaft of Khani Khola hydroelectric projects in Dolakha have recently constructed successfully with minor problem. Raise boring method was first tried in Upper Tamakoshi Project but could not succeed due to deviation of pilot hole and hence shaft sinking and Alimak raise climber have used. This paper describes challenges, excavation methods and difficulties during construction of the pressure shaft with reference of case studies.

Investigation of ground response of the Kathmandu sedimentary basin using ground acceleration data from small size earthquakes

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Kathmandu Valley is anintermountain sedimentary basin composed of gravel, sand, silt and clay. Especially, the subsurface of the central part of the valley is dominated by the presence of thick clay. When seismic waves enter into sediments from rocks, certain frequencies of the wave are amplified and certain frequencies are de-amplifieddepending on the presence and thickness of clay layers.

Variable experience of ground shaking during earthquakes in the Kathmandu Valley has been reported occasionally. The destruction in the Kathmandu Valley, especially during the 1934 Bihar-Nepal Great Earthquake, suggests unconsolidated quaternary sediment played a major role in the amplification of ground motion. Such a variation arises from the response of the Kathmandu Valley sediments to seismic motion.

We have analyzedground acceleration data recorded at Kirtipur Municipality Office (rock site), Central Department of Geology, Tribhuvan University, Kirtipur (soil site), Pulchowk Engineering Campus, Lalitpur (soil site), University Grant Commission, Sano Thimi, Bhaktapur (soil site) and Department of Mines and Geology, Lainchaur, Kathmandu, Nepal (soil site). The ground acceleration data comes from the record of six small size earthquakes (M<5.5) recorded at five sites, which occurred at varying distance from the Kathmandu Valley. Analysis of the ground acceleration data recorded at four soil sites reveals that the amplification is not uniform for different earthquakesrelative to the reference (rock) site. Result of theinvestigation demands a more detailed investigation using ground acceleration data from homogeneously distributed, different size earthquakes, around the Kathmandu Valley and recorded by a network of densely distributed accelerometers so that the amplification characteristics of the Kathmandu Valley could be better understood in order to help to minimize losses from future earthquakes.

Landslide hazard mapping in the Indrawati basin, sub-basin of Koshi watershed, Nepal

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Indrawati basin, sub-basin of Koshi basin, lies in the Sindhupalchowk district of central Nepal. The watershed covers an area of 1240 $km^{2,}$ and has large numbers of landslides. It has fragile topography with steep to moderate slopes. Each year landslides cause losses of human lives and properties and incur additional damage to agricultural lands, crops, human settlements. In order to identify the numbers of landslides and to perform landslide hazard mapping of the Indrawati basin, Geographic Information System (GIS) was used.

Different parameters considered for the study are slope, geology, distance from river, road, and geological discontinuities, rainfall, slope curvature, soil thickness and land cover. The soil thickness map was prepared based on the field visit and interpolating the obtained data. An isohyets map was prepared based on the rainfall data of nine meteorological stations of the study area. Other thematic maps were obtained from different departments such as Survey Department, DMG and DOLIDAR. Weightages are based on the heuristic judgment, and higher value of 5 was assigned for high probability of landslide susceptibility and lower value of 1 to less probable areas.

Based on the landslide hazard mapping the area is classified in three zones, namely, highly susceptible zone (27.29 %), moderately susceptible zone (54.02 %) and low susceptible zone (18.69 %). The southern part of the watershed is high hazard zone for being located in weak rock and human encroachment area. There are 158 settlements living in high hazard zone, 303 in moderate hazard zone and 307 in low hazard zone. The settlements in high hazard zones need to be moved or need mitigation action. Any construction on high hazard area must be approved only after detail study is performed.

Climate change impacts and adaptation practices in water resources management in Salyantar, central Nepal

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The impacts of climate change are being felt in all sectors but the most critical are likely to be the impacts in water resources. Present study has attempted to understand and assess the extent of climate change impacts on water resources and explore the adaptation strategies of local communities in Salyantar village in Dhading district of central Nepal. Impact assessment was performed through the analysis of hydro-meteorological data, landsat images, laboratory soil sample analysis, water level measurement, people's perception on climate changes and adaptation strategies relative to water resources. Mann-Kendall statistical trend test was used to assign statistical significance to the trend. The changes in forest, water and agricultural area coverage in last three decades are estimated using landsat images whereas temperature vegetation dryness index and lab analysis of soil samples was used to identify soil moisture. People's perception was studied through generalized questionnaire survey and Participatory Rural Appraisal. The study showed the increase in temperature and decrease in precipitation. The maximum temperature was increasing at the rate of 0.039 ^{o}C per year with statistically significant trend, and there was a steady increase in minimum temperature with the rate of 0.006 ^{o}C per year. Similarly, the rate of decrease of precipitation is 22.99 mm per year which is statistically significant. The study showed that wet periods were getting hotter and dry periods were exposed to increased intensity of drought and a tendency of future shift toward extreme conditions. The perception was fully justified by the analysis of landsat images, discharge of Haping River, soil moisture calculation, and other scientific and field assessments. Similarly, the drinking water was identified as a very sensitive sector to impacts and hence community had identified new sources and other adaptation measures to cope with it. During the assessment of adaptive capacity, water and irrigation sector were identified to have the least capacity further exaggerating the problems.

Geology and quality assessment of cement grade limestone from the Bhutuke limestone prospect of Kerabari Formation, Palpa, western Nepal

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The Bhutuke limestone prospect lies on the early Paleozoic carbonate unit of Kaligandaki Super Group. It is located on the northern side of Main Boundary Thrust (MBT) (Sakai, 1983) in western Nepal. The Formation is lithostratigraphycally divided into four parts (Sakai, 1983), as the lowest part is about 100 m thick monotonous sequence of dark- grey to black, platy bedded, argillaceous limestone, which is correlated with Malekhu Limestone of the central Nepal. The lower part is platy bedded dolomite. The Middle part is 5 cm to1m thick evenly laminated or sheeted, grey stromatolitic dolomite with frequent intercalation of thin band and lenses of chert and the upper part is comprised of few to 3 m thick beds of grey dolomite.

Field investigation was concentrated on the lowest part of monotonous sequences of grey to black, platy bedded, and argillaceous limestone to find out the cement grade limestone from the Butuki area of Kerabari Formation. For this purpose, 60 grab samples were taken during preliminary survey and 81 chips, 55 channel samples were taken during detail exploration along the dip direction at three different sections, which have about 750 m strike length and about 100 m thickness. The major constituents of cement grade limestone CaO and MgO and other constituents Na_2O, K_2O, SiO_2, TiO_2, P_2O_5, Cl, LOI, LSF, SM and AM of the samples were analyzed by using XRF techniques.

Among the 60 grab samples 49 were cement grade and remaining 11 shows below cement grade quality. Similarly, among 81 chip samples 73 were cement grade and 8 shows below cement grade and among 55 channel samples 48 were cement grade and 7 were below cement grade. In average, the deposit containing CaO of 50.29 %, MgO 2.34 % and SiO_2 5.095 % in the chip and channel samples are of cement grade, according to Nepal standard.

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Reinterpretation of the fluvial systems from the Siwalik Group, Karnali River section, the Nepal Himalaya, and their comparison with other proxies records from the Himalayan region: implication for tectonics and paleoclimate

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Fluvial sediments of the Siwalik successions in the Himalayan Foreland Basin are one of the most important continental archives for the history of Himalayan tectonics and climate change during the Miocene period. This study reanalyzes the fluvial facies of the Siwalik Group along the Karnali River, where the large paleo-Karnali River system is presumed to have flowed. The reinterpreted fluvial system comprises fine-grained meandering river (FA1), flood-flow dominated meandering river with intermittent appearance of braided rivers (FA2), deep and shallow sandy braided rivers (FA3, FA4) to gravelly braided river (FA5) and finally debris flow dominated braided river (FA6) facies associations, in ascending order. Previouswork identified sandy flood-flow dominated meandering and anastomosed systems, but this study reinterprets these systems as a flood-flow dominated meandering river system with intermittent appearanceof braided rivers, and a shallow sandy braided system, respectively.

Comparison of the fluvial systems from different sections of the Siwalik Group shows that a facies change from the FA1 to FA2 is important indicator of the climate change. The flood-flow dominated meandering facies (FA2) resulted by increase in flood in river channels due to increase in precipitation related to climate change. The timing of such facies change ranges from 13.5 to 9.5 Ma along the Siwalik Group in Nepal Himalaya. The earlier appearance of this facies at about 13.5 Ma in the Karnali River section may have been due to the larger catchment size of the Paleo-Karnali River. The large catchment system is quite consistent with the εNd isotopes values and ^{40}Ar-^{39}Ar mica age values from the Karnali section. The newly discovered climate shift at about 13.5 Ma in the Siwalik Group along Karnali area is interpreted to be related to intensification of the 'Indian Summer Monsoon'.

This intensification of the Monsoon is consistent with increased exhumation rate of the Higher Himalaya as well as paleosols and isotopic data from several Siwalik sections, uplift of the Himalaya and Tibetan plaetau, increased weathering and sedimentation records, and aridity in western China.

Geology of Katari - Patana Bhanjyang area, eastern Nepal, with special reference to Pre-Siwalik rocks

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Though, conventionally, the Siwaliks have been defined to be delimited to the north by the Main Boundary Thrust (MBT), this definition does not hold true in case of eastern Nepal. In the Katari – Patana Bhanjyang area, the rock succession older than Siwaliks (pre-Siwaliks) is exposed alternately in the form of imbricate slices within a band of 1.2 km thick zone. These imbricate slices of Pre-Siwalik succession are concentrated between the Baseri Thrust in the north and Sikre Thrust in the south. The Benighat Slates of the Upper Nawakot Group are distributed north of the Baseri Thrust and the Siwaliks are confined mainly to the south of the Sikre Thrust. The Kamala-Tawa Thrust also brings some dolomites of the Pre-Siwalik succession over the Upper Siwaliks in the southern part of the study area. The Pre-Siwalik succession assembles the rocks of the Proterozoic and Gondawana sequences. The Proterozoic carbonate rocks are very fine-grained and contain dominantly micrite with a minor amount of spar. They are mostly wackestones containing abundant clay deposited in a marine environment.

Similarly, pink orthoquartzites and sandstones of the same succession posses well rounded, matured and recrystallised quartz grains with undeformed cement and matrix. Replacement features are very common but recrystallisation is at its initial stage. The mineral grains are slightly altered but the foliation is totally absent. Mud-cracks and ripple marks are well preserved in pink orthoquartzites and red-purple shales of the same succession, indicating a near-shore environment of deposition. The Gondawana sequence consists of black, carbonaceous, quartzose sandstones with a few coal seams. This sequence is unconformably followed by the Siwaliks with a basal conglomerate horizon. The marine or near-shore origin and absence of metamorphism suggest that these rocks were deposited prior to the Himalayan orogeny, and hence they are older than the Siwaliks. Further, intense deformation in the exposure and presence of crush breccias suggest that these Pre-Siwalik rocks were brought to the surface by imbricate slices during post-Miocene deformation.

Landslide hazard zonation of Sunkoshi-2 hydropower project area using quantitative GIS methods

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Landslides are one of the critical geological processes which cause not only enormous damage to civil engineering structures like road, bridges, dams and houses but also lead to loss of lives. The construction of hydropower projects involves disturbance to the natural slop making them vulnerable to slide. Hence, there is a need for land slide hazard zonation so that hazardous area could be stabilized before it escalates major disaster. The present study attempts to develop a landslide model by using multi-criteria decision analysis in GIS and remote sensing techniques.

Sunkoshi-2 Hydropower Project area was selected for the model implementation. Digital topographical data, regional geological maps, remote sensing image and field data were used as an input to the study. The data layers represent the soil, land use, geology (geological faults and existing landslide), slope, aspects and elevation. A numerical rating scheme for the factors was developed for spatial data analysis in GIS. The resulting landslide hazard zonation map delineates the area into different zones of three relative classes: High, Medium and Low. The present study shows that the implementation of Sunkoshi-2 Hydropower Project would make the areas at the reservoir water level more vulnerable to landside.

Study of hard rock aquifers in hill and mountainous area of central Nepal

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The importance of groundwater in mountain area cannot be undermined since people residing in this area are dependent in this resource for the drinking and other domestic purposes. It has been reported in many places of the mountainous areas that the trend of springs and seepages which are principally fed by the groundwater has been drying in the recent time and few villages have been displaced due to water shortage. Such problem is expected to be much more severe in view of climate change condition in coming days. In this regards, it is important to establish a methodology to explore groundwater in the mountainous terrain for better planning to avoid water deficiency problem in these areas in the coming days. With the objective to establish methodology to demarcate groundwater potential zones in the mountainous terrain with the help of remote sensing and Geographic Information System (GIS) techniques and as a pilot project, Ground Water Resources Development Board has carried out a study entitled "Study of Hard Rock Aquifers in Hill and Mountainous Area of Central Nepal". This paper is based on this report which can be envisaged as one of the milestone for GWRDB to formulate an approach to work in the mountainous terrain from the groundwater exploration and exploitation perspectives. The study was carried in the Indrawati Sub-Basin area. The Indrawati Sub-Basin has an area of 1194 Km^2 lying in Sindhupalchowk and Kavrepalanchowk districts in Central Nepal.

The parameters considered for identifying the groundwater potential zone are geology, slope, drainage density, geomorphic units and lineament density which were generated by using the satellite imageries and topographic map (1:25000). In addition, land use and precipitation were also considered. The generated information was analyzed in GIS to identify the groundwater potential zones in the study area. All the thematic layers were then assigned weights according to their relative importance in groundwater occurrence. The outcome of the study is the model which divides the watershed area into three groups with respect to the groundwater potential. These three groups of the area are assigned as the area having low, moderate and high groundwater potential. The result shows that about 51% area belongs to the low potential area while 44% lies within moderately potential area and remaining 5% occupies high potential area. The moderate to high groundwater potential areas are mostly distributed in the southern, central and northwestern part of the watershed. The field investigation revealed that most of the existing springs occur within moderate to high groundwater potential zone, suggesting that the obtained model well represents the field condition. Thus, the present adopted method can be replicated in other parts of the country for preliminary assessment of the groundwater occurrence in the mountainous region, especially in hard rock aquifers.

Landslide inventory mapping of Jharlang area, Dhading district, central Nepal

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Landslides are second most lethal disasters causing huge loss of lives and properties in Nepal. Landslides on hill slopes of river bank create landslide dammed lakes leading to flash floods. Jharlang area that lies in Dhading district of central Nepal is a hilly region, well known for large landslides. The study is focused to prepare landslide inventory map of Jharlang VDC, which help for hazard and vulnerability mapping. The map is prepared with the help of satellite images and field visit. All landslides are found on east facing gentle slope. West facing slope is steep but has no landslides because the bed rock is stronger. Highly foliated and weathered schists and phyllites are the major rock types of the landslide occurrence zone. The east facing slope is highly unstable comprising of materials of past landslides as well. Downpours during monsoon make the mass saturated and causes mass movements. There is no detailed technical investigation till date to find out the root cause of landslides. No land conservation has been applied but plants like *Alnusnepalensis*, which grow easily on deposits and scar of landslides, seem to give little cover to the slope. Farming activities on unstable slope has weakened the landmass accelerating landslides. There is need of detailed geological study to explore the root cause of recurrent landslides. Since the area is still not connected to roadnetwork, future constructions should take care of the landslides in the area, otherwise it may aggravate the problem.

Multi-temporal mapping of the Montaguto earth flow in southern Italy for kinematic interpretation

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Periodic movement of the Montaguto earth flow (southern Italy) on a discrete basal surface produces modifications of the topographic surface, creates faults and folds, and influences the locations of springs, ponds, and streams. The geometry of the basal-slip surface is responsible for differential deformation and kinematic segmentation of the landslide body. We used photo interpretive and GPS field mapping methods to map structures on the surface of the Montaguto earth flow. Our maps show the distribution and evolution of normal faults, thrust faults, strike-slip faults, flank ridges, and hydrological features at nine different dates between 1954 and 2010. Within the earth flow we recognized several kinematic elements and associated structures. Within each kinematic element, the flow velocity was highest in the middle, and lowest in the upper and lower parts. As the velocity of movement initiated and increased, stretching of the earth flow body induced the formation of normal faults. Conversely, decreasing velocity and shortening of the earth flow induced the formation of thrust faults. A zone with relatively few structures, bounded by strike-slip faults, was located between stretching and shortening areas. These kinematic elements indicate that the overall earth flow was actually composed of numerous linked internal earth flows having a distinct pattern of structures representative of stretching and shortening. These observations indicated that the spatial variation in movement velocity associated with each internal earth flow, mimicked the pattern of movement for the overall earth flow. That is, the earth flow displayed a self-similar pattern at different scales. Furthermore, the presence of other structures such as back-tilted surfaces, flank-ridges, and hydrological elements provide specific information about the shape of the basal topographic surface. Our multi-temporal maps provided a basis for interpretation of the long-term kinematic evolution of the earth flow.

Geological, engineering geological and geotechnical study of the Bheri-Babai diversion project, Surkhet, midwestern, Nepal

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The Bheri - Babai diversion project is a 47.85 MW hydroelectric project with the design discharge of 40 m^3/s and design net head of 133.75 m. It is located at Ramghat, Lekhparsa and Chhinchu VDCs in Surkhet district, mid-western Development Region of Nepal. The study area lies within 28° 20' - 28° 27' N latitude and 81° 42' 30" - 81° 48' 30'' E longitude. The study is concerned with geological, engineering geological and geotechnical investigations of the Bheri - Babai diversion project. Geologically, the study area consists of the rocks of the Siwaliks Group. The Siwaliks rocks are sub-divided into five formations, namely Lower Siwaliks, Middle Siwaliks, Middle Siwaliks, Upper Siwaliks (Mudstone) and Upper Siwaliks (Conglomerate). The Lower Siwaliks consists of very thick alternating beds of red-purple, yellow, brown and grey-green mudstone, calcareous mudstone and shale with siltstone and medium- to -fine-grained, grey and green-grey sandstone intercalations. The Middle Siwaliks consists of medium- to -coarse-grained, grey coloured, micaceous sandstone and red-purple mudstone with pseudoconglomerate intercalations. The Middle Siwaliks comprises very coarse grained peeper-&-salt coloured sandstone. The Upper Siwaliks (Mudstone) consists predominate mudstone. The Upper Siwaliks (Conglomerate) is characterized by thick to very thick loosely to well cemented cobble and pebble-conglomerate and mudstone. The reservoir area of the project is a good site with large storage capacity.

The headworks site is fairly suitable for the dam structures. Approach canal, desander basin and inlet portal are located on flat alluvial terraces on the left bank of the Bheri River. The headrace tunnel, 4.20 m diameter, is 12006 m long and horse-shoe shaped with NE-SW orientation. Common rock type along the headrace tunnel is mudstone, sandstone and conglomerate. There are two regional thrusts, namely the Bheri Thrust and Babai Thrust in the middle and southern part of the study area. The headrace tunnel crosses only the Bheri Thrust. Generally bedding is oblique to the proposed tunnel axis with dip against drive, which is fair for excavation. In some places, alignment is unfavorable with respect to the rock orientation. Adjusted RMR and Q range from 31 to 54 and from 1.38 to 7.5, respectively. Generally rocks belong to poor to fair class. The headrace tunnel outlet portal and surge shaft lie on the hill slope characterized by colluvial deposits. The penstock alignment passes through the highly weathered conglomerates and mudstone of the Upper Siwaliks covered by alluvium terraces. The area is moderately steep to gentle. The surface power house lies on the lower alluvial terrace and flood plain overlying the pebbly sandstone and conglomerate beds of the Upper Siwaliks. The tailrace canal runs through the recent flood plain deposits. Geotechnical studies included preliminary stress analysis and rock excavation support design along the headrace tunnel. Average in-situ deformation modulus ranges between 3.42 and 17.23. Vertical and horizontal stress as well as horizontal to vertical stress ratio ranges from 1.12 MPa to 15.50 MPa, 2.03 MPa to 8.05 MPa and 0.39 MPa to 2.47 MPa, respectively. Unconfined compressive strength of the rock along the headrace tunnel ranges from 13.89 MPa to 48.33 MPa. Damage index along the headrace tunnel ranges from 0.07 to 0.23. Support design for construction of the tunnel based on RMR and Q systems suggest the combination of the systematic bolting and reinforced shotcrete as per requirement. Wedge analysis along the headrace tunnel shows one potential wedges at the roof of the tunnel which may fall due to gravity loading and it can be control or stabilized by installing the rock bolt of length of 2.5 - 4 m.

Soil fertility status and soil quality index in Tibrekot community forest, western Nepal

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Physiochemical attributes of soil under *Schima-Castanopsis* forest managed by the local community as Community Forest user's group in the Lesser Himalayan meta-sedimentary zone in Hemja VDC of Kaski district, western Nepal was estimated to evaluate the soil fertility status and soil quality Index. Soil organic carbon was varied from 0.62 to 3.73 per cent and soil organic matter 1.06 to 6.41 per cent in different layers in the soils at different altitudes. The mean soil pH of all soil layers was moderately acidic (4.90 to 5.50). The soil acidity showed decreasing trend with increasing depths. The bulk density was increases with increasing soil depths. The BD was varied from 0.78 to 1.22 g/cm^3 in all soil layers. In different depths, total nitrogen varied from 0.11 percent in lowest layer (90-120 cm) to 0.40 in top layer (0-15 cm) at different elevation. The available phosphorus in different soil layers varied from 1.48 to14.90 mg kg^{-1}. The layer wise mean value of available phosphorus was observed maximum in lowest soil depth 90-120 cm (11.76 mg kg^{-1}) followed by 0-15 cm layer (10.13 mg kg^{-1}). Exchangeable potassium content under in all soil depths varied from 29.40 mg kg^{-1} to 72.85 mg kg^{-1}. The layer wise exchangeable potassium content was observed maximum in 90-120 cm depth (64.17 mg kg^{-1}) and 60-90 cm (64.05 mg kg^{-1}) followed by 0-15 cm soil depth (58.23 mg kg^{-1}). Differences were tested through one way ANOVA of the studied soil parameters in different altitudes and observed that they were statistically significant at 0.05 level ($p = <0.05$). Pearson correlation analysis among the different soil parameters in TCF were showed statistically significant at the 0.01 level (2 – tailed) and 0.05 levels (2 - tailed). The SQI in surface layer at all altitudes revealed higher that was varied from 0.62 to 0.76 (fair to good) qualities as compared to subsurface layer that was ranged from 0.54 to 0.56 (fair) qualities. The SQI was decreased with increasing soil depths. An average SQI in TCF was found 0.61 (fair) up to 120 cm depths.

Late Quaternary vegetation and climate from Phaidhoka Section (Thimi Formation), Bhaktapur

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The Kathmandu Basin is one the most interesting geological setting that represents late Quaternary fluvio-lacustrine depositional environment. Thimi Formation, constituting the upper part of basin fill sediments, is found to be rich in micro and macrofossils. It is characterized by alternation of fine- to medium-grained sand, silt, silty clay and clay deposited by a distal fluvial system in the Late Pleistocene. Thimi Formation is exposed at several locations and with high speed of urbanization and quarrying, fresh exposure are seen at many locations. Palynological investigation was carried out in one of the part of Thimi Formation, generally known as Phaidhoka Section. Microfossils like pollens and spores were extracted and processed further to reconstruct vegetation,climate and depositional environment during the Late Quaternary Period. Palynostratigraphy were based on 44 samples collected from 25.5m thick sequence from Phaidhoka Section. 22 samples were rich in pollen and spores. The analysis of those samples indicated 3 major pollen assemblages. 74 genera belonging to 40 families were identified to the genus, species and family. Among angiosperms 41 genera were identified as Dicotyledons and 6 genera were identified as Monocotyledons. The upper and middle part of the pollen assemblage shows the dominance of cold climate vegetation like Pinus, Picea, Alnus, Betula ,Poaecae and other herbaceous grass. So the climate during the deposition of upper and middle part of the section can be termed as cool. However, lower part of the section comprises of warm to warm temperate vegetation like Quercus, Alnus and Betula. The dominance of such taxa clearly suggests the climate of lower section to be subtropical to warm temperate. Phaidhoka section was also found to be rich in macro fossils. Gastropods operculum (Bithyniidae) of species Digoniostoma sp. or Gabbia sp. were discovered from the upper section of the sequence. The presence of operculum above lignite layer shows swampy, moist or humid condtions. Similarly vertrebrae Bovid molars (Bos) were found to be preserved in middle part of the sections

Morphology and dynamics of the Malekhu river, Dhading district, central Nepal

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Rivers have always been an indispensible part of the human civilization. They play a vital role in daily life purposes to big engineering constructions such as dams, reservoirs or hydropower projects. It is mandatory to understand the morphology and dynamics of the river before initiating any projects for easier planning and to prevent possible damage to structures. The Malekhu River area is one of the potential areas for urbanization and has already been undergoing development of settlement and other infrastructures. This study emphasizes on the morphology and dynamics of the Malekhu River to classify and characterize the river's behavior and competency. The Malekhu River is a sixth order river having its total length of 24.83 km, watershed area of 101.28 km^2 and the average gradient of 0.041 m/m. Different morphological parameters were measured with the aid of topomaps, aerial photographs and Geographic Information System (GIS). The hydraulic parameters, channel sediment and slopes were measured at 10 different transect sites through field surveys. The river was classified using the Rosgen's Level II criteria. The river reaches have been classified as A4-, B4- and C4-type streams. A4- and B4-type streams are moderate-gradient gravelly and low sinuosity rivers whereas C4-type streams are low-gradient gravelly meandering river. The Malekhu River gradually changes from A4- to B4-type streams up to 12 km downstream, and then to C4-type stream further downstream, but B4-type streams reappear within the distance of 15 km to 19 km from the origin. This study presents temporal changes in river channel, and flow competence and aggrading/degrading potential evaluation of the Malekhu river.

A balanced cross-section across of the Siwalik of Kohalpur-Surkhet mid-western Nepal

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The Sub-Himalayan zone constitutes a tectonic wedge of synorogenic sediments along the southern edge of the Himalayan Belt. Sediments are incorporated into the prism from the foreland Indo-Gangetic plain, which undergo a tectonic cycle within it, and eventually are eroded. The structural sketch map exhibits westward-plunging arcuate structures on the foremost location of the Outer Belt. A balanced cross-section has been constructed across the Sub-Himalayan Siwalik Hills of the Kohalpur-Surkhet region of mid-western Nepal in order to determine the structural geometry of the region and to calculate tectonic shortening. The mid-western Nepal Sub-Himalaya is underlain by a basal detachment fault, the Main Detachment Fault (MDF) which lies at a depth of about 5 km beneath the Sub- Himalaya. The Main Boundary Thrust (MBT), the Bheri Thrust, the Babai Thrust and the Main Frontal Thrust (MFT) are all splay thrusts off of the MDF which ramp up-section through the 5 km thick Siwalik sedimentary prism with no major intervening thrust fiats; the central Nepal Sub-Himalaya thus has an emergent imbricate- fan geometry. North-south shortening across the Kohalpur-Surkhet Sub-Himalaya has been approximately 29 km, or 55% shortening.

Landslide susceptibility analysis around the Dhading bazaar Dhading district Nepal

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This study considers landslide susceptibility mapping by means of frequency ratio approach using geographic information system (GIS) techniques as a basic analysis tool. The selected study area was that of the part of Dhading district, Central Nepal. GIS was used for the management and manipulation of spatial data. Landslide locations were identified from field survey and aerial photographic interpretation was used for location of lineaments. Ten factors in total are related to the occurrence of landslides. Based on the same set of factors, landslide susceptibility maps were produced from frequency ratio method, and was then compared and evaluated. The weights of each factor were determined using one to one comparison of each factor with the existing landslides. Landslide susceptibility map produced from frequency ratio and then compared by means of their checking. The landslide location data were used for checking the results with the landslide susceptibility maps. The accuracy of the landslide susceptibility maps produced is 72.45%.

Correlation between microfabrics and index properties of rocks from Dhading district, central Nepal Lesser Himalaya

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The study of the microfabrics and index properties of rocks is important for characterizing construction aggregates which are potentially used in various engineering infrastructural development projects. The study area comprises wide varieties of metamorphic and metasedimentry rocks of the Central Nepal Lesser Himalaya, and is accessible for sampling of these rocks within a few kilometers covering the Lower Nawakot Group, the Upper Nawakot Groups and the Bhimphedi Group. Rock microfabrics were analysed in thin sections using petrological microscope and petrographic image analysis (PIA) to determine grain size distribution, shape and angle factor of elongated grains, and modal composition. Some quantitative parameters such as micropetrographic quality index (K), angle factor (AF), aspect ratio (AR), shape factor (SFo), texture coefficient (TC), index of interlocking and grain size homogeneity (t) were also determined. Study of index properties included porosity, dry density and point load strength index. The micropetrographic quality index (K) is high in Silica rich rock Group, SRRG (Quartzite, metasandstone, gneiss, etc) and low in Carbonate rich rock Group, CRRG (limestine, dolomite, marble, etc.). Grain size homogeneity (t) is highly affected by the presence of porphryoblast and the number of grains considered. CRRG has the greatest interlocking. Texture coefficient (TC) is highly influenced by angle factor (AF1) and aspect ratio (AR). The dry density ranges from 2309 to 3224 kg/m^3 and is high in CRRG compared to silica rich rock group and foliated rock group, FRG (Slate, phyllite, schist, etc.) except for few cases. Similarly, porosity ranges from 0.04 to 8.91%. SRRGs are found to be stronger than CRRG and FRG. The point load strength index varies from 0.26 MPa (for slate) to 13.13 MPa (for psammitic schist), and is often higher (around 6 MPa) in SRRG compared to the other rock group categories. Bivariate correlation analysis was carried out between microfabric and index properties of varied rock types. The correlations considering overall rock categories were found poorer compared to those in which individual rock group category was considered separately. Correlations were even better for CRRG. The nature and degree of correlations between variables of microfabric and index properties were discussed.

Geotechnical and geomechanical characteristics of the rocks along the tunnel of Kulekhani III Hydroelectric project, Nepal

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Geotechnical and geomechanical properties differ according to rock types. Therefore, tunnel passing through different rock types have diverse geotechnical and geomechanical characteristics of rocks in different sections. The tunnel alignment of Kulekhani III hydroelectric project crosses five stratigraphic formations which comprises eight lithological units. Geologically the tunnel alignment lies partly in the Lesser Himalaya Zone and partly in the Higher Himalaya Zone of the Nepal Himalaya of the Kathmandu Complex and the Nawakot Complex of Central Nepal. Beside the rock type diversity, the tunnel alignment also has overburden diversity which is in wavy topography.

The rocks of the area have dominantly three sets of joints in which foliation set is prominent. The strike values of the foliation plane lies between 100° to 110° and dip values lies between 50° to 60°. Similarly, other two sets have diversity than foliation set where strike values lies between 125° to 145° and 350° to 40° and dip values lies between 60° to 80° and 40° to 55° respectively.

Geo-technical properties of intact rock and rock mass were determined. In intact rock and rock mass properties uniaxial compressive strength (UCS), tensile strength, young's modulus, poisson's ratio, friction angle and cohesion were determined where unit weight of intact rock was also included. In intact properties, quartzite of Robang Formation has highest average mean of UCS 190 MPa, tensile strength 23.2 MPa, young's modulus 33 GPa, cohesion 60 MPa, and friction angle 41° and phyllite of Robang Formation has lowest poisson's ratio 0.26 where garnetifereous schist of Raduwa Formation has lowest average mean of UCS 78 MPa, Benighat slate has lowest average mean of tensile strength 6.4 MPa and young's modulus 1.5 GPa and cohesion 31°, phyllite of Roban Formation has lowest value of cohesion 26 MPa and garnetiferous schist of Raduwa Foarmation and phyllite of Roban Formation have lowest angle of friction 27°. Similarly, in rock mass properties, quartzite of Robang Formation has highest mean of UCS 33 MPa and Bhainsedovan Marble has highest average mean of tensile strength 0.3 MPa, young's modulus 37.56 GPa, cohesion 0.9 MPa and friction angle 56° where Benighat Slate has lowest mean value of UCS 0.3 MPa, young's modulus 0.02 GPa, and cohesion 0.6 MPa, quartzite of Robang Formation has lowest average mean of tensile strength of 0.07 MPa and phyllite of Robang Formation has lowest value of friction angle 41°.

RMR, Q and GSI were used for geo-mechanical classification. The Bhaisedhovan Marble has highest average mean of RMR 48.8 and dolomite of Malekhu Limestone has lowest average mean of RMR 41.9. The Bhaisedhovan Marble has highest average mean of Q 2.76 and dolomite of Malekhu Limestone has lowest average mean of Q 0.79. Similarly, phyllite of Robang Formation has highest GSI 46 and dolomite of Malekhu Limestone has lowest average mean of GSI 35.

Technological characterization of the roofing slate deposits in Nepal

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Roofing slate is a group of natural stones which can be split into thin, large and regular tiles. The World's slate market is the third in importance for natural stone, just after granite and marble. Most of the World's production of roofing slate is concentrated in Spain, but there are new emerging countries (Brazil, China, India and Nepal) with huge resources. However, many of these resources are not yet well studied. Nepalese slate industry is still incipient, with most of the quarries located in the Sindhupalchock, Tanahun, Dhading and Baglung Districts. From a geological point of view, the productive formations are the Benighat Slate and Nourpul Formation, but other formations are likely to be potential slate outcrops. Previous studies have shown an important estimated reserve of slate which deserves a closer research. Petrography and mineralogy of Nepalese slates are similar to the rest of the World's roofing slate. Regarding to technical characterization, tests results give values according to the acceptance thresholds for roofing slates. This work offers a comparative study of Nepalese slates with other roofing slates of the World. Roofing slate industry from Nepal is promising, but still there are many points to improve.

An integrated hydrogeological and geophysical approach to groundwater productivity potential mapping of hard-rock aquifers in Nepal: lessons learned

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Globally, the volume of groundwater contained in hard-rock aquifers is not well constrained and has often been considered negligible from a water resource perspective. Groundwater flow in hard-rock aquifer is strongly controlled by the characteristics and distribution of structural heterogeneity. Little research has been conducted on the distribution of groundwater productivity potential (GPP) in Nepal, and the analysis methods have not yet been systematically formulated. A methodology based on integration of complementary, multi-scale hydrogeological, geological and geophysical, approach together with geographic information system (GIS) has been applied for GPP mapping in areas underlain by metamorphic rocks. This approach was applied to four areas with contrasting geological and hydrogeological settings in the outskirts of Kathmandu city. For the GPP mapping, development of multi-scale, GIS based hydrogeological map was commenced followed by surface geophysical methods. Geologic mapping and surface geophysical methods conducted for hydrogeological investigation confirm that the regional structural trends and lithological compartmentalization of bed rock exerts strong control on groundwater flow and occurrence. Regionally, the distribution of springs is the manifestation of the complex folding, faulting, and intrusions in the region. Observed groundwater flow direction reflects these multi-scale structures. The proposed integrated approach is directly applicable to identify key dominant structures for controlling groundwater flow, characterizing the origin of spring water resources for each hydrogeological setting and resolving the spatial distribution of relevant aquifer units.

Minerals variation within the deltaic and offshore ancient lake environments Kathmandu basin, central Nepal

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The amount and their variation of minerals in the different stratigraphic units are useful indicators for depositional environmental change within the depositional basin. I investigated the mineralogical composition of three different stratigraphic units of the Kathmandu Basin-fill sediments. On the basis of geological mapping and field investigation, these three stratigraphic units represent proper lake and Lake Margin lithostratigraphic units. Non-clay and clay minerals were identified by XRD methods. Outcrop of the Sunakothi, Thimi and Kalimati Formations of the Kathmandu Basin, were collected for the XRD experiments. The sample was dried for 24 hours at 50Â° C in air bath and then weighed. The dry sample was divided into two fractions, clay (less than 2ïm) and non-clay part (greater than 2ïm) by the gravity sedimentation methods. Non-clay part of the samples was dried for 24 hour at 50Â° C on the hot plate and then weighed. This sample was then made powder in the agate mortar. Finally, 10 wt. % of zincite (ZnO) was added as an internal standard into this powder samples. Zincite is suitable for the internal standard for XRD quantitative analysis because it provides stronger and more conveniently located reflection (Srodon et al 2001, Kuwahara,Y 2001). Each clay fraction of the sample was collected by the MilliporeÂ® filter (0.45 Âµm pore, 47 mm diameter) transfer method to provide an optimal orientation (Moore and Reynolds, 1989). Both air-dried (AD) and ethylene glycol solvated (EG) preparations were done for each sample. XRD measurement were done by the Rigaku X-ray Diffractometer RINT 2100V, using CuKï¡ radiation monochromatized by a curve graphite crystal in a step of 0.02Â°with a step-counting time of 2 second. The profile-fitting obtained XRD patterns was performed with an Apple Power Macintosh computer and a scientific graphical analysis program XRD MacDiff (Petschik 2000). The result of the individual mineral obtained from the profile-fitting method was used for quantitative analysis. Relative amounts of minerals of the different stratigraphic units in the Kathmandu Valley were determined by calibration curve obtained from integrated intensity ratio of the standard mineral to internal standard zincite. Mixture of 10 wt % internal standard zincite and a known percentage of each standard mineral was analyzed by XRD under the same condition describe above. The integrated intensity of each mineral was estimated from XRD data using a program XRD MacDiff (Petschik 2000). To determine the individual amount of the minerals we used the standard equations obtained by the calibration curves. On the basis of the variation of the non-clay and clay fraction, here I interpret the paleoenvironmental and paleoclimatic condition during the deposition from the lacustrine facies of the Kalimati to lacustrine deltaic facies of the Sunakothi Formation and probable cause of these changes. Both Kalimati and Sunakothi sediments contain same mineral composition while Thimi sediments did not contain carbonate (calcite) minerals and amount of mica is higher than the Sunakothi and Kalimati sediments. Higher amount of smectite within the clay fraction and presence of calcite within both clay and non-clay fraction in the basal part of the Sunakothi Formation indicates seasonal and prolong dry climatic condition was occurred during the deposition of the Kalimati to Sunakothi Formation. On the other hand, lower amount of kaolinite/smectite ratio and excess amount of carbonate mineral within the basal part of the Sunakothi Formation shows depositional environmental changes from deep to shallow, and lake water became more alkaline. Gradually lacustrine condition changes into the fluvio-lacustrine condition (Lake Delta). On the other hand, higher ratio of the kaolinite/smectite within the Kalimati Formation to lower ratio of the kaolinite/smectite within the basal part of the Sunakothi sediments indicates climatic condition was more seasonal and cold/ dry than the Kalimati Formation. Both kaolinite/smectite and smectite/illite value indicates paleoprecipitation of the Kathmandu valley was higher during the proper lake phase than the lake delta phase.

Establishing a reference rock site for the site effect study in and around the Kathmandu valley, Nepal

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We proposed a reliable reference site for the site effect study of earthquake in and around the Kathmandu valley, which is the location of the capital of Nepal. The data used was accelerograms recorded at two sites, DMG and KKA, and velocity seismograms co-recorded at station PKIN during nine shallow local and regional earthquakes of magnitude equal to, or greater than 5.0. The DMG site is located on the thick fluvio-lacustrine sediments of the Kathmandu valley, whereas the others are rock sites. KKA is located on the granite and gneisses of the Shivapuri Lekh about 10 km to the north-west of the capital and PKIN is in the tunnel of an old iron mine on the southern slope of Phulchwoki Hill about 15 km away toward the southeast. The spectral ratio of the ground motions of DMG compared to those of PKIN, for all earthquakes considered, confirmed that DMG has amplification ranging from 1 to 10 in the frequency range of 0.5 to 4 Hz, and the spectral ratios of KKA compared to PKIN showed that KKA has significant amplification in the frequency range of 4 to 10Hz and its peak value is at most 10. Therefore the site amplification in and around the Kathmandu valley would be significantly underestimated in the frequency range from 4 to 10 Hz if the spectral ratios of DMG to KKA were used as a proxy for input ground motions.

Based on the above analysis, it is proposed that PKIN shouldbe considered as a reliable reference site for the estimation of seismic hazards in and around the Kathmandu valley.

Groundwater flow pattern and water level fluctuation in western parts of the Chitwan valley

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Study of flow pattern and water level fluctuation of western parts of the Chitwan Dun Valley was carried out in 274.48 km^2 area. The study area consists of alluvial deposits of the Narayani and the Rapti River of Pleistocene to recent age. Aquifers in the study area are unconfined and semi confined to confined types. Based on static water level, Jagatpur, Sukranagar and Gunjanagar are deep tube well zone and Shivanagar, Parbatipur, Patihani, Gitanagar are shallow tube well zone. The western half area discharges groundwater to the Narayani River and southern half discharges to the Rapti River rather than getting recharged throughout the year. Average water level fluctuation is 2.34 m with high fluctuation of 4.88 m at Sukranagar and low of 0.49 m at Dibyanagar VDC. This fluctuation is directly related to rainfall.

Recent Seismic Activities in Nepal

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Due to the stress build up in the collision zone of the Indian Plate and the Tibetan plateau, earthquakes occur in this region. Nepal, situated in the central part of the active Himalaya has high seismicity. National Seismological Center (NSC), Nepal has been continuously monitoring earthquakes in and around Nepal since last 36 years. About 4-5 earthquakes recorded everyday by NSC have epicenters on the territory of Nepal. This study summarizes the seismic activity in Nepal and surrounding areas during the last two years (2013-2014AD). During this period, more than 2,661 earthquakes were added in the seismic catalogue of Nepal. Among these earthquakes, 2,625 small events, remaining unnoticed by the local population were associated a magnitude greater than 2.5, while more than 36 events with magnitudes greater than 4 were felt in Nepal. Most of these events were detected and located at midcrustal depths in a narrow zone to the South of the high topography, in the vicinity of the down dip end of the locked fault zone that produced the very large historical earthquakes. The largest event recorded during this period was Solukhumbu earthquake (Lat 27.73 Lon 86.52) of Magnitude ML 5.9 in 2014/12/18, an event felt in the Kathmandu Valley, about 110 km from the mainshock. This earthquake was followed by more than 20 events of magnitude greater than ML 2. A few weeks after, an earthquake with ML 5.5 in 2015/01/31 was located Lat 28.29 Lon 83.73 in Kaski. This study will describe those recent earthquakes as well as present the background seismicity characteristics recorded by NSC.

Geology and metamorphism in Kahun Klippe of central Nepal Lesser Himalaya

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The Kahun Klippe located in the Tanahu district of central Nepal is one of the poorly studied metamorphic crystalline thrust sheets in the Lesser Himalaya of Nepal. In the present study geological mapping was carried out in 1:25,000 scale to unravel the stratigraphy, structural setting and metamorphism of the Klippe. The rocks of the Kahun Klippe are mapped under the Tanahun Group which is thrusted over the rocks of the Nawakot Group. The klippe occupies the core of the Jalbire-Ramjakot Synclinorium. The rocks of the Klippe can be divided into three units: the Gwaslung Formation, the Musimarang Formation and the Shivapur Schist from bottom to top, respectively. The Gwaslung Formation sharply overlies the Benighat Slate along the thrust contact- the Dubung Thrust. The formation is dominated by metamorphic calcareous rocks. This is followed up section transitionally by the Musimarang Formation. It is the succession of intercalation of quartzite and schist in about equal proportion. It is followed stratigraphically up section by the Shivapur Schist with conformable and transitional contact. This formation dominantly consists of garnet-schist with rare occurrences of quartzite and metasandstone.

An attempt was made for lithostratigraphic comparison of the rocks of the Kahun Klippe with other adjacent klippes. The Shivapur Schist is comparable with the Raduwa Formation of the Kathmandu Nappe and the two formations older than the Shivapur Schist are considered the older units than the Raduwa Formation. Based on the illite/graphite and Raman Spectroscopic study, it is found that there is inverted grade of metamorphism in the foot wall of the Kahun Klippe as in the case of root zone area. The garnet porphyroblasts in the rocks of the Kahun Klippe are sheared and asymmetric pressure shadow is developed around the grains. It has been considered as the Eohimalayan metamorphic event occurring after the collision and prior to the MCT.

K-Ar dating of white mica from the Lesser Himalaya, Tansen-Pokhara section, central Nepal: Implications for the timing of metamorphism

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The Lesser Himalaya in central Nepal comprises low- to medium-grade metasedimentary rocks. Metamorphic studies show that they have experienced at least two metamorphic events (M_1 and M_2). However, exact timing of metamorphism is still controversial. In the present study K-Ar dating of white micas in shales, slates, phyllites, schists and gneisses from the Tansen-Pokhara section was carried out to understand the timing of metamorphism. The muscovite in gneiss from the MCT zone shows an age of about 1255 Ma representing the age of crystallization of parent granite. Detrital mica from the Bhainskati Formation gives an age of about 2441 Ma. Probably this is the age of crystallization of muscovite in its provenance. The recrystallized white micas from slate and phyllite show older ages (Early Paleozoic) in the southern part (279 to 458 Ma). Most probably this represents the timing of M_1. Age become gradually younger towards the north due to the mixing of older (M_1 related) and younger (M_2 related) white micas. Youngest age (10 Ma) was measured from the sample just below the Upper MCT. This age may be related to the M_2 which was due to the Late Miocene-Pleistocene reactivation of the Upper MCT.

Topo-stress based shallow landslide susceptibility mapping in the Nepal Himalaya

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In the field of engineering geology and slope stability science, determining the state of stress and the relation between driving force and resisting force are the fundamental deterministic steps. Generally, in slopes, two dimensional stresses are responsible for the distribution of rock fissures and fractures in directions parallel to the slopes. Among the various states of stress in nature, the gravitational stress is the major state of stress that has a direct effect on slope stability. Gravitational stresses affect geologic processes and engineering operations in slopes. In a general sense, gravitational stress is caused by topographic setting of the slope. Considering this well-accepted fact, a concept of topo-stress evaluation is developed in this research and used to produce a shallow landslide susceptibility zonation map of a model area. In this work, topo-stress refers to the shear stress on planes parallel to the ground surface induced by gravity. In other words, topo-stress is referred to as the stress on slopes due to topographical setting. Topo-stress is always existent in slopes to induce landslides. It is basically controlled by two fundamental parameters; weight of slope material and friction angle of jointed rock mass. Considering topo-stress as a main factor for initiating shallow landslides, a GIS-based probabilistic model is developed for shallow landslide susceptibility zonation. An ideal terrain in central Nepal is selected as the study area for this purpose. Two event-based shallow landslide inventories are used to predict accuracy of the model, which is found to be more than 78% for the first event-landslides and more than 76% for the second event-landslides. It is evident from these prediction rates that the probabilistic topo-stress model proposed in this work is quite acceptable when regional scale shallow landslide susceptibility mapping is practiced in the Himalayan rocky slopes.

"Rockbergs" in the Kathmandu valley lake sediment

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The Kathmandu Valley is a lake till 11 kyr B.P. and it filled up in recent geological times by the sediments derived from rapid erosion of the surrounding hills and mountains. The lake sediments are up to 550 m thick in the central part and 350 m in the southern part and they consist mainly of soft and weak organic silts and clays. The valley is roughly circular in shape with about 25 km diameter. Few works have done to understand the geology and basement topography of the Kathmandu valley. Various research findings reveal that the Kathmandu valley is a bowl shaped valley filled with lake sediment. Although all researchers believed as bowl shaped valley, reason behind rock exposures in Pashupati area, Balkhu area, Pulchowk area, and Swambhu area is not well answered. Those rock exposures are believed to be parts of crested or undulated topography of the bowl shaped Kathmandu Valley.

A research work have been started to revisit the basement topography of Kathmandu targeting the causes of rock exposures in the valley. Field investigations of such rock exposures have been done and the geomorphological, geological and geotechnical investigations were performed. The preliminary investigation results revealed that the most of the rock exposures in the valley are not exactly basement rock but they are submerged rock mass on the lake sediments similar to a massive floating body of ice in sea. Thus, these rock exposures are named as "Rockbergs" meaning floating rock mass on lacustrine sediments of Kathmandu valley. Most of these Rockbergs are found to be partly covered by lake sediments and in few places (such as in Pulchowk and Dharmasthali) these Rockbergs are covered by thin lake sediments. These rock masses are believed to be detached from surrounding hills. Joints in the Rockbergs are filled with lake sediments and joint distribution pattern in Rockbergs are different than its basement rock of surrounding hills.

Distribution of large-scale landslides in the Lesser Himalaya of central Nepal

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Landslides are regarded as a natural phenomenon of slope modification processes in the Nepalese mountains. Landslide in Nepal varies from huge whole valley slopes creeping to minor slope failures. So, a proper classification system to investigate them separately is very necessary. Broadly, these landslides can be divided into two categories 1) small-scale landslides (debris flows, debris slides, rock falls, rock slides) and 2) large-scale landslides (deep seated mountain slope creeping). This research describes the preliminary efforts focusing on the understanding of large-scale landslides, their processes and mechanisms that contribute to instability and catastrophic failure. This research also reports the physical characteristics of landslides and the statistical correlations between landslide frequency and terrain variables in the Lesser Himalayan Zone of central Nepal along with large-scale landslide distribution. To this end, large-scale landslide database covering a regional area of Lesser Himalayan Zone is prepared and discussed in terms of their geological controls, morphometric characteristics and distribution probability. Most of the large-scale landslides are occurring in the range of 20-40 degree slope. About 70 % of the large-scale landslides were found to be in phyllite and slate only. Similarly, metasandstone, conglomerates, limestone and dolomite are also suffered from large-scale landslides. 70% of the large-scale landslides posses a slope angle of 20 to 40 degrees which also indicates the steepness of the terrain. Thus, large-scale landslides in central Nepal are occurred in slightly steeper slope terrains.

Site suitability analysis for urban development using spatial multi-criterion techniques the mountainous region: a case study from Bajura district, Nepal

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The scattered and isolated houses and settlements development in the mountainous region, particularly on the unstable mountain slopes, hazard prone area and remote locations are the major hindrances in managing the basic development needs in Nepal. Growing population demands new settlement areas and ultimately expanding at rural areas haphazardly in the mountainous region away from the access of lifeline facilities provided by the government. The life becomes more challenging for the people living at remote areas. To cope with this new settlement area need to develop by a proper investigation and management. Hence, the spatial multi criterion method was applied to identify the suitable location for urban development in the Bajura district, Far-western region of Nepal. For this five major parameters slope, land cover, elevation, drainage and geology were used for the evaluation. The maps of these parameters were standardized and weightage of each parameter were generated by using pairwise comparison matrix known as analytical hierarchy process (AHP). The final output map was categorized into 4 classes high suitable (HS), moderately suitable (MS), low suitable (LS) and not suitable (NS). Here the MS covers highest area of 1135 km^2 (49 %) of total district area. The HS, LS and NS cover 22.5 %, 26.4 % and 1.6 %, respectively. From HS area (518 km^2), 19 most suitable sites were identified by excluding active landslide area and 20 m buffer zone of drainages.

Assessment of disaster risk reduction knowledge of members of constitutional assembly in Nepal

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Nepal is highly vulnerable to natural disasters. A high proportion of the national GDP is lost every year in landslides, floods, and many other forms of disasters. A high number of human casualties and loss of public and private property in Nepal due to natural disasters may be attributed to inadequate public awareness, lack of disaster preparedness, weak governance and lack of coordination among the concerned government agencies, inadequate financial resources, and inadequate technical knowledge for mitigating the natural disasters. In this scenario, quite a few awareness and training programs for disaster risk reduction (DRR) have already been initiated in Nepal and their impact assessments are also already documented. Many political leaders are also stared to involve in the disaster risk management works both in local and regional level. But, effectiveness of the various implemented DRR programs is not yet evaluated through an independent study. The work in this paper was aimed at exploring political leaders' knowledge on disaster risk reduction (DRR). Altogether, 120 members from constitutional assembly (CA) representing various political parties were randomly selected and they were interviewed focusing on various questions on disaster information, disaster knowledge, disaster readiness, disaster awareness, disaster adaptation, and disaster risk perception. The collected response data were statistically analyzed to examine the DRR knowledge of political leaders. The statistical analyses conducted were histogram analysis, distribution analysis, and independent sample t-tests. Findings of this independent research confirmed that the level of DRR knowledge in political leaders is encouraging but initiatives implemented are not enough. These findings will encourage the Government of Nepal and line agencies working in DRR issues in Nepal to modify their programs targeted for the political leaders and local communities.

Locating wells in hard rock aquifer in Lekhnath municipality, Kaski, Nepal

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Nepal is a mountainous country having 224.7 billion cubic meter fresh water flowing annually through its rivers (Himalayan, Midland and Siwalik origin) and springs to the south and finally to India. In Tarai, maximum of 11.5 billion cubic meters groundwater is estimated as annual dynamic reserve. Despite that people in hills and mountains still are distressed due to lack of having potable drinking water and likely to walk more than a mile to fetch a bucket of water. Current data showed that, peoples living in urban cities would be 24 % of the total population. Water management in urban areas would be a critical problem throughout the country in the coming decades. Taking into account, water demand in hills can be fulfilled by adopting jointly the appropriate geo-scientific methods and the available technology. In order to produce sustainable yield proper well sitting in hills can be achieved by the analysis of geological discontinuities, secondary porosity, aspect slopes, hill slopes, drainage density, groundwater flow direction etc. Based on the fact that the likely position for water well drilling proposed at Lekhnath municipality ward no 5. Similarly, in the valley proximity at Kandeni (Lekhnath municipality ward no 4) proposed the well location and drilling was completed at last summer. Geological syncline with weathered phyllitic rock exists to the depth beyond the overlying river sediments-did produce substantial well yield as high as 30 l/s. Geo-scientific investigation before planning the drilling program could help to optimize well yield and assure to minimize the construction cost.

Landslide susceptibility mapping and hazard assessment in the western part of Koshi basin

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The present study focuses on the preparation of landslide susceptibility map of the western part of Koshi basin, mainly the Indrawati River sub-basin area which is located in the mid-hill of the central region of Nepal in the Bagmati zone using Geographic Information System (GIS). Landslide locations were identified from topographic map, Google Earth map and field visit. The parameters considered for the study are land use, geology, altitude, curvature, slope, slope aspect, distance from drainage and drainage density. These parameters were used to produce landslide susceptibility map using Bivariate Analysis in GIS. Thus obtained landslide susceptibility map has been classified into high, medium and low susceptibility classes. It is obtained that 27.41 % of the total basin area falls on the high susceptibility zone, 41.46 % on the medium susceptibility zone and 31.13 % on the low susceptibility zone. 70 % of the total observed landslides were used to produce the landslide susceptibility map and 30 % landslides were used for validation purpose. 77.53 % of the validation data set falls on the high susceptibility zone which exhibits satisfactory performance. The landslide susceptibility map was overlain on settlement, land use, slope and road network parameter map for the hazard assessment. Most of the area of barren land and area covered with shrub/bush were found to be in high susceptibility zone where as most of the part of forest area lies in low susceptibility zone. Slope area >30° shows favorable conditions for land sliding. Almost all the road network in the sub-basin area lies in low and moderate susceptibility zones except that of Chabahil, Sankhu, Jhule, Chautara road network.

Preventive measures for water induced landslide risk reduction:a case study from Kerunge Khola watershed, Nawalparasi district, Nepal

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Nepal is a mountainous country with about 77 % area covered by mountains and hills. Most of those areas are prone to sediment related water induced disasters. The sources of sediments are principally from slope failure, debris flow and landslide which are triggered due to torrential rainfall during the monsoon rainy season, and that causes the loss of lives and properties and environmental degradation each year. The annual rainfall ranges from 2000 to 3000 mm in the Central Region of Nepal. The natural disasters can not be prevented completely but efforts can be made for mitigating the impact of disaster. Among the mitigation measures of Landslide disasters, the Sabo dam and bio-engineering works are the most effective measures. The landslide disaster prone Kerunge khola watershed area covers Ramche and Dhauwadi VDCs and Kawasoti Municipality with East-West Highway to the South in Nawalparasi District of Nepal. Thorough assessment of water induced disaster in the source area as well as in downstream was carried out and site specific required mitigation measures were proposed to reduce the disaster risk and possible losses to lives and properties. The applied mitigation measures based on the adequate assessment has resulted an effective achievement. The disaster risk to the people has been drastically reduced in the Kerunge watershed area, both at the upper watershed area (source area) and at the lower watershed areas. Likewise, the settlement and agriculture land adjacent to the river bank are better protected against flood and the road users are safer. Recommendation has been made to replicate the method of disaster assessment and mitigation measures also in other places of the country. The program was supported by the Nepal Government.

Hydrogeological characteristics of shallow groundwater system of Patan, Lalitpur Submetropolis, Nepal

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Continuous decrease in water table in shallow groundwater sources of Patan has been characterized by decrease in discharges and drying up of perennial stone spouts and shallow dug wells. Adequate hydrogeological understanding of the shallow water system is therefore a requisite for the adoption of appropriate shallow water augmentation technologies and curb water scarcity in the study area. In this study an attempt has been done to understand the general hydrogeological features of shallow groundwater system especially shallow ground lithology, shallow groundwater flow, shallow water recharge and discharge zones and shallow water chemistry. Borehole logs were obtained from auger hole method; central tendency, dispersion and correlation statistics were used for shallow water table response over precipitation and ArcGIS was used to map flow direction and delineate recharge and discharge zones. Similarly, SOPs were followed to analyze water quality from shallow groundwater sources. The study found that shallow ground lithology of Patan varies from place to place with non-uniformly distributed strata of gravel, sand, silt and clay. Shallow groundwater flow direction was from southern Patan towards northern/ northeast Patan with east-west and west-east distortions in eastern and western regions respectively. Shallow groundwater was flowing in peak saturated conditions and groundwater pools were observed during peak dry season. Overall, high elevated terrains were observed as recharge areas and low elevated terrains as possible discharge areas for shallow groundwater of Patan. Apart from the local geochemical effect, organic pollution, preferably of faecal origin, was found as major problem in shallow groundwater sources of Patan. Keywords: Discharge, Hydrogeology, Lithology, Recharge, Shallow groundwater

Landslide susceptibility mapping along Tulsipur-Kapurkot road section and its surrounding region using bivariate statistical model

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The main purpose of this study is to prepare landslide susceptibility map of Tulsipur-Kapurkot road section and its surrounding regions that has been affected by different types of landslides. Geologically, most part of the road section falls within the Lesser Himalaya and Quaternary deposits; while very small portion lies within the Siwaliks. Several large and small scale thrusts and faults are scattered throughout the region making it prone to several instabilities. In this regard, we have used bivariate (frequency ratio) statistical model for developing the susceptibility map of the area. For this, landslide inventory map was generated from satellite image interpretation as well as from detailed field survey using GPS. We were able to identify and map more than 187 different types of landslide in the area. Out of which, 150 (about 80 %) landslides were used for model training and the remaining 37 (about 20 %) landslides were used for validation purpose. Nine different landslide causative factors considered for this study are slope, aspect, elevation, curvature, geology, land use, distance from fault, distance from river and distance from major road sections. Finally, landslide susceptibility map of the region was obtained and it was validated using area under curve (AUC). From the analysis, the success rate of the model is found to be 85.18 % and predictive accuracy is 78.76 %.The resultant susceptibility maps can be useful for general land use planning of the region.

Flood hazard assessment of Dhobi Khola, Kathmandu based on GIS and hydrological models

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Natural disasters are very common in Nepal making it one of the most vulnerable countries in the world. Flood is one of the major disasters in terms of fatality and economic loss. Problems related to flooding have greatly increased in recent years that justify the necessity of effective modeling to help mitigate the effects of flood disasters. Flood inundation models are the tools to provide predictions of flood extent and depth that are used in the development of spatially accurate hazard maps. Ungauged basins with potential flood risks to floodplain infrastructure and settlements are not studied to the level to predict and mitigate the flood disasters. This study is designed to assess the flood vulnerable sites of Dhobikhola Basin and mapping of disaster prone areas using hydrological models and GIS. In this study, the HEC-HMS model is first calibrated and validated in similar characteristic gauged river then transposed to ungauged basin. Slope area method is used to validate the model outcome for Dhobikhola using field data. Model outcomes are used to predict the floods for different year return period flood (YRPF), using HEC-RAS and HEC-GeoRAS flood inundation maps were generated. This study finds the maximum flood depth which may reach to 5.24m in 100 (YRPF) in Dhobikhola basin. The result shows that sites 1, 3, 5, 7 will get inundated during 5, 10, 20, 50 and100 YRPF, respectively. For exposure analysis levee height was used. With inundation depth and bank height flood hazard analysis was done; this shows that site 5 and 6 lie in very very high hazard category to floods. Site 23 lies in low vulnerable category but flood inundation occur there due to low levee height.

Seismic hazard and liquefaction potential analysis of the Tribhuvan International Airport, Nepal

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Tribhuvan International Airport (TIA), being only international airport in Nepal has pivotal importance in case of future earthquake events. As response, relief and rescue would be deployed from this airport and national as well as international efforts would be dependent in this airport; seismic site effects and liquefaction risk would mar the functionality in greater extent. TIA is ideally situated in relatively younger deposit of fluvio-lacustrine facies of Gokarna Formation which has faced severe earthquake impact during past earthquakes. This paper attempts to identify site specific ground response and liquefaction potential based upon equivalent linear site response analysis (EERA). Liquefaction risk has been presented in terms of liquefaction potential index (LPI) and associated level of risk has been formulated accordingly.

Ground response analysis in the maximum scaled acceleration of 0.3 g and 0.5 g has been computed and the results are interpreted in terms of maximum amplification, peak spectral acceleration, peak ground acceleration and predominant period. The maximum amplification is found to be in between 4.5 to 6.7 for 0.3 g scaling and 4.07 to 5.23 for 0.5 g scaling. While accounting the peak spectral acceleration, it has been found to be varying between 0.93 g to 1.67 g for 0.3 g scaling and 1.30 g to 2.48 g for 0.5 g scaling. The peak ground acceleration is depicted to be varying between 0.30 g to 0.51 g for 0.3 g scaling and for 0.5 g scaling the value varies between 0.39 and 0.72 g. Notably, the higher values of maximum amplification, peak spectral acceleration and peak ground acceleration are found to be concentrated on the runway and taxiway of the TIA. Due to the close difference between the values, overall TIA area is likely to be suffered from severe impacts of earthquakes, particularly the ground amplification and shaking. The soil fundamental period has been obtained in the range of 0.38 s to 0.58 s for 0.3 g scaling and 0.32 s to 0.68 s for 0.5 g scaling.

The liquefaction risk has been presented on the basis of calculated LPI values and qualitative designation has been provided. Majority of analyzed boreholes have shown low liquefaction potential, however few boreholes have shown such potential from high to very high as well. The range of LPI has been obtained from 0 to 19.90 for the studied twenty one boreholes within the TIA. However, liquefaction possibility may exist in case of water table fluctuation and earthquakes occurring during rainy days as well. Combined effects of ground amplification, shaking and liquefaction would lead to damage and mal-functionality of airport as well.

Climate change impact on meteorological parameters for future projection in Koshi basin, Nepal

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This study aims to gather information about the impact of climate change on meteorological parameters for future projection in Koshi basin. Spatial and temporal variation of the climatic parameters during observed period along with their long term trends has been analyzed for this purpose. In this study, predicted and observed climatic data has been used from Department of Hydrology and Meteorology (DHM). Currently, DHM has 60 operating precipitation and 22 temperature stations in the Koshi basin but there are only few meteorological stations in High Himalaya region. The projected precipitation and temperature data has been bias corrected and observed meteorological parameters available from DHM are used for consistency check and homogeneity test. The observed data has been analyzed from 1981 to 2011 (30 years) and used as a baseline for assessing comparative change in climatic parameters for future projection. Seasonal precipitations in the meteorological stations within each sub-basin observed that, the Indrawati and Sunkoshi sub-basins receive higher amount of annual precipitation than from the entire Koshi basin. Similarly, the result of average annual temperature for baseline period in the Koshi basin varies from 1.4 °C in the High Himalaya region to 24.3 °C in the Terai region. The annual trends for maximum and minimum temperature are calculated and both increasing trend are seen in stations at Dhankuta, Phatepur, Udaypur, Terhathum while stations in Chainpur and Rajbiraj shows decreasing trend. The warming seems to be more pronounced in the higher altitude than in the Terai and the Siwalik region.

Bank erosion and lateral instability hazard status of the Kodku River, southeast Kathmandu, central Nepal

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The northward flowing fifth order Kodku River confluences with the Manahara River in the southeast of Kathmandu, and has about 16.49 km stretch with 35.67 sq. km watershed area. Many large civil engineering structures such as irrigation cannels, bridges, highways and roads are under construction, and are located along and around the river in the urbanizing Kodku River Valley. Some sections of the river can be of high erosion potential due to various reasons. Many human activities together with natural processes have led to haphazard bank erosion and channel shifting of the Kodku River. Thus, study of the river bank erosion and lateral instability is of great concern as unstable segments of the river may pose threat on civil engineering structures and adjacent agricultural lands. The river bank hazard potential and its variations were assessed in terms of its bank erosion and lateral instability (BELI) hazard indices by considering four parameters namely; bank erosion hazard index (BEHI), near bank stress index (NBSI), lateral instability hazard index (LIHI), and anthropogenic disturbance factors (ADF). For this, thirty nine locations were surveyed throughout the river and achieved the BELI hazard levels. This paper evaluates the BELI hazard levels and channel shifting condition of the Kodku River.

Structural setting of gas and petroleum seeps in the Lesser Himalaya of Dailekh and Dullu, west Nepal

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Gas and petroleum seeps have been recorded from the Dailekh and Dullu region of west Nepal at least since the time of Emperor Akbar in India, i.e. for more than 450 years. The seeps lie along a NW–SE trending straight line of about 20 km length. They seem to be confined to the core of an east-plunging antiform. The gas and oil seeps are located within about 4-5 km thick succession of gently-folded phyllite and metasandstone, containing blue quartz. Coarse augen gneisses and granitoids appear in the Lohore Khola, where the rocks dip essentially due east. Presumably, these gneisses are thrust over the grey-green phyllites along the Lohore Thrust. The augen gneisses are made up of large deformed microcline phenocrysts. Many pegmatite veins penetrate the phyllites. Around the town of Dailekh are distributed black graphitic schists, white quartzites, and some grey garnet schists, sporadically alternating with thin, grey marble bands.

Owing to imbricate faulting, the Tertiary succession to the north of the gas and oil field is repeated for several times in the Baitadi, Darchula, and Bajhang districts. These rocks belong to the Surkhet Group, beginning with white, grey, green, thick-bedded quartz arenites or quartzose sandstones in shale intercalations (Melpani Formation). This primarily medium- to coarse-grained arenaceous succession is followed up-section by 150–170 m thick fissile fossiliferous shales of Palaeocene-Eocene age (Swat or Subathu Formation). Above the fossiliferous horizon are thick-bedded, medium-grained, compact, grey-green sandstones, regularly alternating with silty and micaceous purple shales or shaly sandstones (Suntar or Dagshai Formation). It is inferred that the Swat Formation is the main source rock of gas and oil seeps. The Proterozoic phyllites, quartzites, and augen gneisses constitute the roof (seal) of a duplex (antiformal stack) and the folded horses below the roof thrust, contain the source rock. It is inferred that gas and petroleum migrated upwards and was trapped in the core of the antiform.

Integration of parametric and non-parametric information for characterization of surface and subsurface geology through Bayesian approach

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The surface and subsurface lithological distributions are heterogeneous because of compositional and structural variations. The characterization of subsurface heterogeneity is subject to the amount and quality of field data. In a stochastic prediction, the inference about an unknown location is performed by conditioning on the available relevant information within the domain. The limited field data may lead to increase the amount of uncertainties in the characterization of heterogeneity. Because of various circumstances such as cost, time and accessibility of the site, in the real field, there is often difficult to collect more direct observed information on lithology or soil type especially beneath the surface. If the directly observed information (i.e., primary data) is limited, information from the secondary data sources can be integrated for the predictions of surface as well as subsurface geology with reduction of uncertainties. In the present study, a transition probability based Markovian stochastic model is developed to predict a non-parametric attribute by integrating parametric and non-parametric information. The information about an unknown categorical attribute, e.g., rock or soil type at a certain location can be informed conditioning on either directly observed categorical information available in neighbor or by the supportive and indirectly related secondary information, e.g., physical or chemical properties of that geological unit. Bayesian approach is very essential in updating and improving the prediction of primary attribute by adding secondary information. The present method uses a Bayesian updating rule to construct a posterior probability distribution of each lithology class at each location point. For this, a local prior probability is represented by the Markovian transition probability based model to predict unknown data point conditioning only on directly observed data. A function representing the observed physical, chemical, or physiochemical information at that particular point represents likelihood of the different lithological classes. The posterior distribution combines a local prior and likelihood function at point for each lithological unit. The local posterior probability distributions are constructed at all points in the space to build all alternative, equally probable lithologic prediction models.

Application of remote sensing and GIS on study of river channel shifting in Karnali megafan

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The action of river is dynamic in nature and exhibits morphological changes over time. Shifting of river which is often linked up with vulnerability and risk to life and property is a common phenomenon of nature. Several reasons would be there behind such behavior but mostly happened due to weak geology with unprecedented hydrological discharge added by changes in land cover due to anthropogenic uses. The people living in Karnali Megafan has experienced major shifting of river channel and bank erosions in past decades. This study made an attempt to understand the changing morphology of Karnali River below Chisapani to Nepal-India border and examined the trend and rate of bank shift in last 30 years. GIS and Remote Sensing techniques have been applied to analyze the temporal changes in Karnali River section of the study area. A series of decadal historic data on river course of past 30 years has been captured from Landsat ETM+, TM, and MSS image of 1977, 1990, 2000, 2010 and 2013. Deviation of river bank was measured at an interval of 2 km downstream from Chisapani. An imaginary Tangent line was drawn approximately along the centerline of the river of 1970s, which is later bisected at every 2 km by a straight line crossing the banks of river of all decades. Location of bank line of the year 1977 was considered as base of bank line to calculate its migration over the subsequent year. Arc GIS Platform has been used to extract the topographic features and bank line. Layer overlay and intersection methods were applied to establish the location of bank at different period of times and shift from base year location was measured in distance. High resolution satellite image available in Google Earth is used to extract the imprints of Paleo Rivers, geomorphological units and anthropogenic interventions along the river channels. An attempt has been made to understand the local geological and geomorphologic condition to link up the possibilities and relations with river channel migration.

Bank stability and toe erosion model of the Kodku River bank, southeast Kathmandu basin, central Nepal

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The Kodku River has been used for drinking, irrigation and recreational purposes from prehistoric time. The river is suffering from stream bank instability causing great threat to the infrastructures, agricultural land and settlement areas. In this concern, assessment of Bank Stability and Toe Erosion Model (BSTEM) of the Kodku River was undertaken for eight different sites using the BSTEM version 5.4 that calculates a Factor of Safety (Fs) for multilayer stream bank, based on limit equilibrium-method. Stream banks of the uppermost reach around the Badikhel area is stable, where Fs exceeds 1.3 and average boundary shear stress (τo) is 86.47 Pa with 0.299 sq. m of the total eroded area of the bank toe. Canopy and understorey cover with consolidated bank materials are the causes of stable banks. Stream banks of the Arubot and the Thaiba area are unstable as Fs ranges from 0.45 to 0.75, and the τo is 7.87–37.89 Pa with the total eroded bank toe area of 0.025–0.87 sq. m.There, the failure width and volume of the bank toe are 0.20–0.35 m and 45–113 cu. m, respectively.The sediment load from the particular bank-toe ranges from 89.67–223.40 tons. Major cause of instability are the presence of unconsolidated bank material,high scouring,and sparse riparian vegetation. Within Harisiddhi and Imadol, the river stretches are encroachment by human. Where the Fs are low and banks are disturbed by encroachment, suitable bioengineering measures can be implemented to mitigate excessive bank toe erosion and failure.

Gender perspective in flood risk management: a case study in Dodhara-Chandani areas of Kanchanpur district, far western Nepal

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Nepal is among the most vulnerable countries in terms of climate induced-disasters. It is ranked in 30th among 198 countries in flood hazard. Climate change associated vulnerability is contextual and gender specific as it impacts men and women differently. It magnifies the socially constructed inequalities between men and women where women are always the worst victim for their gender differentiated roles and lack of access and control over resources. This study has been carried out to assess gender perspective on climate induced disaster, its impact and adaptation in Dodhara-Chandani VDCs of Kanchanpur district.

The study is based on both primary and secondary sources of data. The primary information was collected using structured questionnaire from 96 households, key informant interviews and focus group discussions in both VDCs along Mahakali River of Kanchanpur district of Nepal. This study showed that current illiteracy rate of respondents was only 12 % male and 41 % female in Dodhara while in Chandani 21 % male and 56 % female respondents were illiterate. Majority of the people were farmers in both VDCs as most of them were engaged in agriculture (52 % in Dodhara and 58 % in Chandani) while most of youths were far for earnings in both VDCs. The meteorological data (30 years) particularly rainfall and temperature were analyzed to see the rainfall pattern and temperature trends. Analysis of temperature data revealed increment of mean annual temperature by 0.02^0C per year, which verified the increase in number of warmer days in the study area. The analysis of rainfall data confirmed that the rainfall trend was declining by 1.66 mm per year in monsoon. The average monsoon rainfall of the Mahendranagar station was 413.4 mm (1984-2013). However, people experience heavy rainfall in monsoon recently.

The respondents faced the different problems like water logging in agricultural land and settlements, pollution of water resources, loss of assets, etc. during flood. Majority of respondents i.e. 38 % male and 40 % female in Dodhara and 46 % male and 63 % female in Chandani identified that women are vulnerable than others due to their physical strength, responsibility towards family as well as social boundaries. Women were found dependent on men during disaster period. Although people were not practicing any scientific adaptive measures, few people have knowledge regarding the disaster preparedness in both VDCs. Environmental impacts after flood period was also observed.

Appropriate methods of remediation for lead contaminated site at Klity village Kanchanaburi province, Thailand

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Whenever the Bo Ngam lead mine industry founded around 60 years ago at Klity village of Thailand left the waste material in the ground haphazardly, the whole area became contaminated causing negative effect to the biodiversity. People and animals living around fell in sick due to lead contamination in their food chains. Therefore, recently these lead contaminated sites were investigated through detail field observation to analyze the most appropriate methods of remediation. The concentration of lead in surface soil, sub-surface soil and creek sediments were determined via atomic absorption spectrometry. It was found that lead content in surface soil is extremely high i.e. 114,000 mg/Kg however, in the sub-surface soil it is 36000 mg/Kg. Apart from this, the creek sediments near the forest have relatively low concentrations, 13,650 mg/Kg, though the area lies close to the past mining plant site. This result supports that in the forest areas, the plants and organisms are up taking or absorbing the lead from the sediment and hence can reduce the concentration in sediments through bioremediation. The concentration analysis and land use pattern in these areas suggest that degree of risk is different at different locations. Hence, the three methods; Dredging for creek sediments, Excavation for soil at Upper Klity and Lower Klity villages, and Monitored Natural Recovery (MNR) at the non residential and forest sites seem most appropriate methods for remediation. But the precautions in each method need to be followed strictly. These methods can be combined with some additional approaches such as institutional control, environmental monitoring, and engineering practices. Beyond these technical approaches, public participation of the local people should also be considered as far as possible.

Empirical relations between geotechnical properties and P-wave velocity for the colluvial soil from Thankot, Nepal

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Direct soil sampling and testing either in-situ or in laboratory is expensive, time consuming and sometimes difficult. It is utmost difficult to precisely and continuously map geotechnical characteristics of soil throughout the given area based only on a few selected direct sampling. This work focuses on the estimation of the geotechnical parameters, especially where direct soil sampling is difficult to conduct, by correlating the results from geotechnical investigations and seismic refraction survey. For this purpose, colluvial soil of a part of the Nepal Himalaya i.e. Kathmandu Fun Park Project (KFPP) located in the southern flank of the Chandragiri hill, Thankot, Kathmandu is considered. In this study, P-wave velocities of the soil are obtained from the seismic refraction survey. The obtained P-wave values are then compared with the geotechnical parameters such as Unconfined Compressive Strength (UCS), moisture content, friction angle and porosity. UCS is obtained by in-situ Direct Cone Penetration Test (DCPT) while remaining geotechnical tests are performed in the laboratory. Present study shows the following empirical relations between P-wave velocity (V_p) and UCS, friction angle (φ), moisture content (w) and porosity (η). $UCS = 0.0229e^{0.0024V_p}$, $\varphi = 0.0149V_p + 10.36$, $w = -0.0324V_p + 42.56$ and $\eta = 132.58e^{-0.003V_p}$. While calculating porosity we modeled the equation given by Wyllie et al. (1958) at fluid velocity 1450 m/s and found that the material (colluvial soil) velocity in the study area to be 1560 m/s. To conclude, this work presents the development of possible empirical relations between geotechnical parameters and P-wave velocity for the colluvial soil and also helps in cost-effective investigations of the subsurface soil properties.

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Integrated geophysical approach to locate a karst conduit in the cane run - royal spring basin, Kentucky

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Groundwater flow in karst terrains is difficult to map because it can be concentrated through conduits that do not necessarily coincide with the surface features. Electrical resistivity (ER) and self-potential (SP) techniques were applied at three different sites to locate an inferred trunk conduit feeding a major spring, the Royal Spring, in the Inner Bluegrass region of Kentucky. Royal Spring is the primary water supply for the city of Georgetown; the upper part of its basin coincides with the Cane Run watershed. Survey sites were selected based on sink-hole locations and results of dye tracing. ER and SP profiles were perpendicular to the inferred trunk conduit orientation. ER profiles (972 m total length) were measured using a dipole–dipole electrode configuration with 2- to 3-m spacing. SP measurements were taken along those ER lines and an additional test profile (230 m) using one stationary reference electrode and another roving electrode at a fixed interval.

The SP technique has been used by many researchers to detect the electrokinetic potential (streaming potential) generated by groundwater flow. The low resistivity water-filled conduit, as compared to the high background resistivity limestone bedrock, is the ER exploration target for this study. A negative SP anomaly corresponds to a low ER anomaly for most of the profiles, but a few are not comparable. Although SP data collected over multiple days along the test profile differ significantly, they show similar trends. Five of seven SP profiles measured over a period of several months were found to be reproducible. Field drift in SP data is highly sensitive to temperature changes during the time of measurement. Although the overall trends of the final SP profiles for different dates were similar, the SP magnitudes varied with the amount of precipitation and the average soil temperature. The low-resistivity anomalies in the 2D inverted sections and corresponding negative SP anomalies could be water-filled conduits, although mud-filled voids encountered during drilling suggest that these may be tributary conduits rather than the trunk conduit.

Tunneling in the Siwalik: a case study of Mai hydropower project

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This paper explains about the tunneling in the Siwalik of the Nepal Himalaya during construction of about 2.2 km long headrace tunnel of Mai hydropower project located at Chisapani and Danabari VDCs of Ilam district, eastern Nepal with total installed capacity of 22 MW.

Geologically, the project area lies at lower part of the Middle Siwalik comprising jointed inter-bedding of medium to strong sandstone, strong pebbly-sandstone and weak to medium strong siltstone. The proportion of siltstone is higher. The Main Boundary Thrust (MBT) is at about 1.5 km north of the tunnel inlet portal. The shearing effect of the regional thrust was frequently encountered during tunneling.

On the basis of detailed engineering geological study along with analysis of various surface and sub-surface investigation and laboratory test results, rock mass properties were characterized. The combination of different established support systems were used to design rock support and their modifications were done during earlier phase of excavation for defining initial (temporary) support. The Rock Tunneling Quality Index Q-value was adopted for rating rock mass during tunneling and compared with other established support system. The inter-bedding of sandstone and siltstone with frequent clay bands were the major lithology encountered during tunneling. Being the youngest rock of Nepal Himalaya, the Middle Siwalik has its own advantages and disadvantages. Despite different underground problems, the excavation of the headrace tunnel was completed successfully within time. Detailed analyses were carried out to decide final (permanent) support. The applied rock supports were tested by water filling and draw-done.

Rainfall-induced flood disaster prediction in Nepal by using satellite-based resources

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Nepal gets over 3000 mm annual average rainfall. Nearly 80 percent of annual rainfall occurs during the four monsoon months (June to September). Sporadic cloudburst, spatial variation over the areas and variable intensity within the very short duration are some of the climatic phenomena appeared in the country. It is evident that every year Nepal has a huge number of lives and property loss due to water-induced disaster, in which rainfall is the main cause. Because of difficult topographic conditions, human efficiency dependent on station-based recording system, conventional data-flow and transformation systems from rain-gauge to processing center are some of the commonly noticeable reasons behind the time lagging of rainfall data and prediction and forecast of event occurrences and even the accuracy level. Due to these reasons several early warning systems established in the downstream basins for the flood disaster management are also getting problem and they are not able to predict the real-time prediction. In such circumstances rainfall-induced disaster management is becoming a challenge for the disaster management. Individual, institutional and country efforts have been limited to rescue and rehabilitation operation and not been able to attain preparedness and prevention.

The reliable and real-time information about circulation system and its phenomena at the lower atmospheric level in a regional scale, spatial characteristics and surface topography, rainfall and precipitation intensity over the ground are some of the basic requirements for the scientific understanding about the rainfall-induced disaster prediction. In this paper an exercise on searching scientific alternative for the rainfall-induced disaster prediction systems based on satellite resources have been made. Digital Elevation Models (DEMs) derived by the remotely sensed Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data, and rainfall intensity data derived from Tropical Rainfall Measuring Mission (TRMM) have been used in the analysis. A Google Earth image of the study area has been used as input for determining properties and areas under the potential flood event and subsequently generating flood inundation maps.

Landslide susceptibility mapping in eastern hills of Rara Lake western Nepal

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The study area represents eastern hills of Rara Lake located in about 2990 m from sea level. It lies in Mugu district, western Nepal and occupies area of about 40 Km^2. Within this area, two Village Development Committees: Karkibada and Shreenagar VDCs are located which constitute of about 1400 houses. The main objective of the study was to assess the tendency of occurrences of slope failures through mapping process. Ground survey and remote sensing were the methods used in the process. Bivariate statistical index method was used to obtain susceptibility of landslides. Geographic Information System (GIS) was used for preparing the database maps and also for carrying out the spatial modeling of landslide susceptibility. Factors used in this mapping process were slope gradient, aspect, elevation, geology, soil, land use/cover, road buffers and stream buffers. A landslide inventory map was prepared with the use of Google Earth. The weighted values were obtained as the ratio of landslide densities of each individual factor classes to that of whole area. Maps having weighted values were overlaid in GIS to obtain a map with Landslide Susceptibility Index (LSI). Landslide inventory identified 96 slope failures. LSI ranged from -7.12 to 5.45. This index range was organized into five classes from very low to very high susceptibility classes. East and South facing slopes, gradients of $<30^o$, elevation of 2000-2800 m, buffers closer to road and streams, grassland and cultivation lands, and lithology of pelitic metamorphic rocks were major contributors for susceptibility in the region. Landslide density was 4.76 and 8.12 per Km^2 respectively in high and very high susceptible classes. Thirty-five landslides were identified from field survey which was used to make success rate curve for validation. It showed 0.76 portion of area under the curve which means 76 % overall success rate. Higher susceptibility class was observed mainly in cultivated areas and grasslands where most of the houses are found. Thus, knowing the susceptible areas, necessary preparedness should be done to reduce future occurrences of slope failures.

River morphology and flood hazard: a study of the Pathariya Khola far western Nepal

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Pathariya Khola is originated from the southern flank of the Siwalik range in the Kailali district. It has been transporting large amount of sediments from hilly areas. Bank erosion, flooding and inundation, and sedimentation are the major problems in the plain area of the Kailali district along the corridor of the Pathariya Khola. This study aims to understand the causes of bank failure and assess flood hazard along the river corridor in the plain area. Field data were analyzed using HEC-RAS and GIS tools for data interpretation. Riverbank failures were mostly triggered by groundwater seepage particularly in the fine-grained river bank area. Major mechanism of bank failure belongs to rotational mass movements. Remarkable sedimentation in the overbank area of the Terai plain is found during monsoon. Such areas lies in the very high flood hazard area that result has been attested by field evidences.

Projection of impacts of climate change in the hydrology of the Koshi Basin

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Climate change is a major global issue which has received a serious concern at national and international levels. It is unambiguous that the earth is getting warmer over the recent period and there has been change in precipitation patterns (spatial and temporal variations) along with increase in intensity and frequency of extreme events. Climate change projection in the Koshi basin using the output of PRECIS (Providing Regional climate for Impact Studies) for A1B scenario shows that annual average precipitation in the Koshi basin would change by -3 %, +2 % and +5 % in 2030-2039, 2040-2049, 2050-2059 periods, respectively, compared to 1981-2010 period. Though there is not much change in annual precipitation volume, seasonal changes are significant. Winter precipitation is projected to decrease in future period while summer and autumn precipitation would increase. Similarly, magnitude and frequency of extreme precipitation has been also projected to increase in the future periods, especially in high mountain and middle mountain regions. This projected change in precipitation will have implication in the basin hydrology. This study has attempted to quantify the impacts of climate change in the hydrology of the Koshi basin. HEC-HMS model has been used to simulate discharge under climate change scenario. Arun sub-basin has significant catchment area that lies in the high altitude of China and the discharge from this upper catchment at Uwagaon outlet is also fed by glacier melt. So HBV model has been used to simulate discharge from catchment up to Uwagaon. The study shows that annual average discharge at Chatara will increase by about 9% in 2050-2059 period compared to 1981-2010. During the same period, winter average discharge will decrease about 9% while, spring, summer and autumn discharge would increase by 13 %, 9 % and 11 %, respectively. Similarly, evaluation of extreme discharge using Gumbel distribution at Chatara shows that flood magnitude of 10, 50 and 100 years return periods will increase by 34 %, 44 % and 47 % in 2050-2059 period compared to 1981-2010. Similar changes are also projected for each sub catchments of the Koshi basin. A sample river reach has been selected in the Sunkoshi River to assess how the inundation area would increase in future under climate change scenario using HEC-RAS model. It shows that inundation area would increase by about 20 % in 2050-2059 period. It suggests that flood hazard will increase in future under climate change scenario

Role of mid-channel bars of Karnali River for flood hazard level in Chisapani and downstream area, western Nepal

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The Karnali River between Chisapani, Kailali and Indian border is the domain of this study. Karnali River braids as it flows south from Chisapani leaving a very big island, which politically incorporates 11 VDCs. The study area covers the island section sandwiched between two branches of the Karnali River. Flood frequency analysis for 25, 50 and 100 year return period was done by using Gumbel's distribution, Log Pearson Type III distribution and Log Normal distribution method based on Maximum Instantaneous flow recorded at Chisapani station. Based on the calculated discharge values, one dimensional hydraulic model (HEC-RAS) was used to model steady flow through the river channel network. Hazard maps at the scale of 1:150,000 for various return periods (25yrs, 50yrs and 100yrs) were prepared in ArcGIS. Furthermore, the involvement of mid channel bars in the flooding of the area has been addressed and some major mid-channel bars were identified that cause flooding in the areas.

Geochemistry of alluvial sediments from Karnali River fan: an approach to understand Holocene weathering trend in the Terai plain, western Nepal

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Alluvial fan of Karnali River has been accommodating molassic sediments after debouching the river from the Himalaya into the Gangetic plain (Terai plain) in Rajapur-Tikapur area, Kailali district, Nepal. Samples taken from 10 m thick sediment sections during field survey were analyzed at the Department of Earth and Atmospheric Sciences, Cornell University, USA in order to understand the Holocene weathering trend in the Gangetic plain (Terai plain) situated close to mountain front. In addition to geochemical analysis, the method for the study has approached using the technique of x-ray clay mineralogy and petrography of the sediments. Weathering front having geochemical changes with depth are found more intense in the proximal fan than in the distal fan area. The triggering forces in the space related factor for the intensity of alteration might be mechanized by the locus of river incision and sedimentation interaction.

Shallow aquifer characterization of southern part of Kathmandu valley

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Shallow wells have been the major drinking water source for the Kathmandu valley since centuries. The hydrogeological setting and rehcarge dynamics of the valley makes shallow aquifer very important aspect of water resource in the valley and it receives attention from researchers. This study mainly focuses on the quantitave analysis of water quality of shallow wells of southern part of Kathmandu valley and characterizes shallow aquifer using geology and water quality. Existing shallow and deep wells were selected from Kirtiur, Sanepa, Patan, Harishiddi, Godavari, and Bungmati area. Some samples were taken from river for comparative analysis. Ion-Chromatography was used for outlining aquifer type and stable water isotope analysis was performed to understand the recharge pattern of the area. Existing lithologs and geological maps were used to analyze subsurface geological setting. Two type of aquifer was delineated in the study area. Most of the area within core city contains Calcium Bicarbonate Type aquifer while some part of outskirt contains Sodium Bicarbonate Type. Heterogeneous lithological composition was observed ranging from clay to sand and gravel. Central part of the study area consist thick succession of silty and sandy clay up to 200 m thick which gradually decreases when we moves toward south and alternate layers of silty clay and gravel were observed. Wide range of isotopic value suggest both local and dynamic recharge system present in the study area. This study presents detail characterization of the shallow aquifer, explains its recharge pattern and gives the relation between the lithological composition and recharge dynamics, giving better understanding of groundwater dynamics of southern part of the Kathmandu valley.

Role of groundwater in the disaster preparedness plan: a case study of Kathmandu valley

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Groundwater supply is an essential component in any disaster preparedness plan for Kathmandu valley. Currently, groundwater supply contributes about 40 % of the total municiapal water supply in Kathmandu valley. In the event of natural disasters like earthquakes, groundwater may be the only water resource available. Considering the existing conditions and the facilities available at the abstraction points, however, reliability of this resource being exrracted and put into use in the post disaster period howecer needs some serious planning and preparedness. Currently though large number of groundwater abstraction points are available in the vicinity of the the proposed IDP sites, most of the sites do not have any prepredness plan in the event of disaster. In the absence of preparedness plans, is another disater being invited after the natural disaster?

Geomorphic signatures of active tectonics from Sylhet city and adjoining areas Surma basin, Bangladesh

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With a population of five million, Sylhet city is one of the densely populated regions of Bangladesh. Situated at the northeastern part of Bangladesh, the area lies in a very complex geological setting, the uplifting Shillong Plateau in the north, the Chittagong Tripura Fold Belt (CTFB) in the south-east and the subsiding Surma Basin in the east. The complexity of structural setting and previous studies suggest that the NE Bangladesh is tectonically active. Apart from the anticlinal structures and depressed areas, the study area represents relatively flat topography. In such flat topography, tectonic signatures are often buried or obscured by anthropogenic activities. Geomorphology can be applied as a useful scientific tool to infer active tectonics from such region. In this study, geomorphic indicators of active tectonics are identified by using remote sensing techniques. River morphology, valley morphology and anticipated growth of folds from the structural maps and imageries have been used to identify geomorphic evidence of active tectonics in this area. Mueller Index has been used to measure the sinuosity of Surma, Dauki and Goyain Rivers at different reaches. Sinuosity measurement reveals that topographic influence is the major controlling factor in river morphology (81.21 % - 99.48 %) in comparison with hydraulic factors (0.52 % - 18.79 %). Four reaches of Surma River and two reaches of Goyain River show sinuosity value very close to 1.00 indicating the straightness of the river beheaded abandoned channel is identified in the north-western side of Sylhet Anticline. The abandonment may be due to the probable development of E-W oriented ridge system that is already prominent in Jaintiapur area. Other geomorphic indicators like incised channels, marshy zones, sudden changes in river flow direction, compressed meanders and river channel confluence are identified which provided clues to active tectonics in the study area.

Bheri-Babai Diversion Multipurpose Project

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Irrigation infrastructures aimed to utilize available water has been developed intensively in most of the medium river systems of Nepal whereas water available in the snow fed large rivers lie far less utilized. Realizing this fact, Government of Nepal has decided to implement Bheri-Babai Multiple Diversion Project (BBDMP). Recognizing its significance at the national level, Government of Nepal has classified BBDMP as a "Project of National Pride" thereby according it a priority of highest order. BBDMP is a multipurpose project aimed to divert 40 m^3/s of water from Bheri river to Babai river to irrigate 51,000 Ha agricultural land in Bardiya and Banke districts of Nepal and also to install 48 MW hydropower to generate about 400 GWH hydroelectric energy annually. Main infrastructure comprises of (i) Headworks, (ii) Headrace Tunnel (HRT) and (iii) Powerhouse & accessories sub-components. Because of complexity of the project and availability of funds, the project is planned for component-wise implementation. Considering the geology of the tunnel alignment and associated technical complexity the Headrace tunnel sub-component is planned to be implemented first. The tunnel alignment lies in Surkhet and Bardia districts of mid-western development region of Nepal. Inlet portal of the tunnel lies in Ramghat VDC of Surkhet district and outlet portal lies in Belwa VDC of Bardiya district. Geologically the project area lies in the region occupied by rocks of the Siwalik Group. Only about 2.5 km access road needs to be constructed to access the construction site from the highway. The 12 Km long Headrace tunnel with a finished diameter of 4.2 m is to be constructed using a double shield type of Tunnel Boring Machine (TBM) and lined with precast concrete segments. Construction works has been initiated and is expected to be completed in 4.5 years.

Hydrogeological and physicochemical factors affecting the water quality of Nepal, and their classification

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Nepal is rich in water resources in comparison to its size and population. It has more than six thousand rivers, streams and small lakes formed by river blockade. Saptakoshi, Saptagandi, Karnali and Mahakali are the major snow-fed river systems in Nepal which are originating in the Tibet and the Himalaya. Kankai, Kamala, Bagmati, Babai and Rapati rivers are spring fed rivers originating in Mahabharat range. Groundwater has been formed and deposited in the valleys and Terai plain region.

Formation of natural water or water quality is a very complex process starting from evaporation from the ocean, sea, lakes, water surfaces of other water objects, contacting with aerosols, different minerals, living organisms and non-living things, organic and inorganic substances. Composition of water or water quality has been changed with respect to contact media, ground water infiltration depth, type of rocks, minerals, ionic concentration, porosity, length travelled by water, contact or travelling time, natural and anthropogenic factors.

Water is used for drinking, cooking, washing, irrigation, hydroelectric power generation, atomic power generation, navigation, fire fighting, gardening, street washing, laboratory, ecosystem and biodiversity conservation, environment protection and nature conservation as a whole. Different water users and consumers dictate the water quality. Natural factors (hydrometeorological, hydrogeological, hydrogeographical, physicochemical, biological, micro-biological etc.) and anthropogenic factors are the significant factors affecting the natural water quality

Morphotectonic survey along the Surket-Ghorahi fault

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The trace of the Main Boundary Thrust from Surkhet to the west to Ghorahi to the east is characterised by a succession of geomorphic features establishing its local morphotectonic activity (e.g. Nakata et al., 1984). This "Surkhet-Ghorahi" fault is approximately 120 km long. We surveyed most of the fault, from west to east, and mapped a topographical scarp/pressure ridge along most of the active fault trace. It dislocates the terraces of the Bheri River in the vicinity of the village of Botechaur and induced the formation of sag ponds in the Suketal area. These two sites appear, among others, as most promising sites for neotectonic study.

In Botechaur, the topography was surveyed using a Total Station in order to prepare a high resolution Digital Elevation Model of the alluvial terraces. Seven levels of terraces, paleocourses of the Bheri River, were mapped in this area, and labelled T0 to T4, where T0 is the present day floodplain of the river. The fault clearly offset T1, T2, T3 and T4 terraces. Detrital charcoals were therefore sampled within 2 m-deep pits across topsoils, over bank deposits and higher energy pebble-cobble units in order to date their deposit and abandonment. Further work on some complementary sites along strike will help document the fault slip per earthquake and date the last event on the fault. These future studies will help understand the behaviour and seismogenic potential of the fault, a necessary input to better assesses the seismic hazard in western Nepal.

Landslide hazard mapping in the lower Badigad watershed of western Nepal

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Badigad watershed lies in Midlands of western Nepal. Geomorphologically, the watershed consists of gentle topography but high rainfall and active Badigad fault and effects of MCT can be clearly seen in the watershed in the form of numerous erosion activities, landslides and debris flow hazard influencing the watershed every year.

The annual rainfall in the region varies from 1,550 to 2,489 mm indicating high precipitation zone that eventually leads to high level of water induced natural hazards. Every year, the road connecting Rudrabeni to Wamitaksar usually get blocked from landslide and debris flow in Lumdi Khola and many other areas. In this study, inventory of various water induced disasters in the lower portion of the Badigad watershed is carried out and a landslide hazard map of the region is prepared. Eleven thematic parameters such as Slope, Aspect, Curvature, Relief, Distance to Drainage, Distance to Transportation Route, Geology, Wetness Index, Distance toThust-fault, Rainfall and Landuse is used to prepare landslide hazard map. Information value and weights-of-evidence methods were used for thelandslide hazard mapping.

The hazard map shows that the area between Wamitaksar and confluence to Kali Gandaki generally falls within the high to very high hazard classes. The western and northern parts of the study area falls in very low to moderate hazard classes.The landslide hazard map was validated with respect to the actually occurring landslides. It is observed that maximum number of landslides (~ 53 %) fall within the very high hazard class followed by high (24 %), moderately high (~16 %) and low (~7 %) hazard. The very low hazard class consists of only around 0.6 % landslides. Finally, the landslide hazard map thus prepared is validated with area under the success rate curve. The success curve shows that the resulted zonation map has success rate of 0.938 indicating the 93.8 % accuracy.

Seismic site effects due to 2009 L'Aquila seismic sequence in the upper Aterno valley, Italy

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An earthquake of magnitude Mw 6.3 hit the Abruzzo region of central Italy on 6 April 2009 at 3:32 am. The epicenter of the earthquake was very close to the urban center of L'Aquila, a town of about 73000 inhabitants. The main shock along with several aftershocks were well recorded which makes the seismic sequence one of the well recorded near-fault normal fault events globally. The main shock caused substantial structural damages mainly in the city center and nearby villages. The early morning earthquake killed about 300 people leaving 1500 injured with economic damages of more than 25 billion euro. The observation on damage patterns has clearly pointed out strong influence of local geological condition. Locally, higher concentration of damages was observed in relatively modern reinforced concrete structures located on recent sediments (e.g. Onna, Castelnuovo village) than in similar neighboring structures on older sediments (Tussio, Monticchio village).

In this contribution, therefore, wealth of data on weak and strong motions, sub-surface geology and geotechnical characterization are used to assess the seismic site effects of the upper Aterno valley due to the near-fault events. Both one dimensional (1D) and two dimensional (2D) dynamic numerical analyses are adopted to investigate the response of soft alluvial deposits. In this model study, first, the ground surface motion computed by assuming linear soil behavior was compared to the small-magnitude (M_L=3-3.5) aftershocks recordings. It was found that 2D modeling provides a satisfactory understanding of the amplification phenomena in the array. Moreover, 2D analyses performed slightly better than 1D predictions. Based on this calibration study, further site response analyses were carried out and the computed ground motion was compared with the aftershock recordings of moderate magnitude (M_W=4-5.6). In contrast, the results from these events do not show the analogous performance as obtained in the linear range. More specifically, shape of acceleration response spectra is generally satisfactorily simulated whereas discrepancies are observed in terms of PGA as well as maximum spectral amplitude. It is speculated on the possible explanations of these discrepancies.

The Melamchi water supply project, Nepal

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The Melamchi water supply project is being implemented by the Government of Nepal with objectives to alleviate the chronic shortage of water in Kathmandu Valley on a sustainable and long term basis and to improve the health and well-being of the people in the Valley. The project consists of the headworks and a diversion tunnel mainly in the Melamchi valley, except for the last 5 km which is in the Kathmandu valley and water purification facilities in Kathmandu valley. The project works includes from the intake at chainage 0.0 to the Sundarijal portal at chainage 25.986 km. The tunnel is being excavated from adits at Ambathan, Gyalthum, Sindhu and Sundarijal out fall. The planned capacity of the tunnel is 6 m^3/s. The main diversion tunnel is 25.58 km long with a cross-sectional area of 12.7 m^2. The tunnel intake is at an elevation of about 1416 m and the outlet is about 1,408 m. Most of the tunnel length is expected to be unlined generally with only shotcrete throughout, but with considerations for selective tunnel lining in sections with weak rock formation.

The tunnel excavation is done by drill and blast techniques. The ground conditions are mainly gneiss with mica schist and laminated quartzite of the Higher Himalayan sequence of the Nepal Himalaya. The Gneiss is generally moderately weathered and laminated quartzites are present in parallel to the foliation of the gneiss and the rock is in some places faulted with zones of gauge.

The headworks are located within the gorge below Ghwakan, just upstream of the confluence of Melamchi River and Ribarma Khola. The main structure at the headwork consists of the diversion weir, river-training structures, intake structure, headworks diversion tunnel and sediment exclusion basin. A gravity concrete weir dam 5 to 7 m high with an indicated crest at El. 1,425 m will be built across the Melamchi River. The control system and the sediment exclusion basin have a design capacity of 6m3/s. The dual sediment exclusion basins have a total length of 70 to 80 m. This paper will describe the actual construction of the project, the challenges of the contract and the site conditions and how they are being overcome, and how finally the long awaited promise of a water supply for the people of Kathmandu is being achieved.

Geochemical characteristic of the Sylhet succession northeastern Bengal basin, Bangladesh

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The Sylhet basin of Bangladesh lies south of the Shillong massif and the western part of the Indo-Myanmar ranges. Chemical compositions of the Sylhet sedimentary rocks have been determined to investigate provenance, weathering and sediment sorting. High values for the Chemical Index of Alteration (mostly ~70-87) in the Sylhet sediments indicate moderate to intense chemical weathering in their source under non-steady state conditions. Chondrite normalized REE patterns are very similar to UCC, PAAS and Himalayan source rocks, with enriched LREE, flat HREE and negative Eu anomalies, suggesting derivation from felsic upper crustal sources in the Himalayas. Strong positive correlation between $Al2O_3$ and REEtot suggest that REE distributions are mainly controlled by the clay content rather than heavy minerals. High Th/U ratio mostly indicates highly weathered nature of the Sylhet detritus. Chemical similarity of the Sylhet and equivalent Siwalik sequence of Nepal represent similar sources of the rising Himalaya. Higher quartz contents, higher CIA, and chemical uniformity of the Sylhet sediments may reflect recycling of detritus from the Siwaliks, further weathering during alluvial storage, and homogenization of detritus during their lengthy transport to the Sylhet depocenter.

High precision GPS/GNSS network in central-west Nepal transect: some preliminary results

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A 7-station network of high precision GPS/GNSS (global positioning system/global navigation satellite system) is operating in central Nepal through collaboration between Tribhuvan University and the Nepal Academy of Science and Technology (NAST) and with technical advice and data processing by USA researchers at Central Washington University and UNAVCO. Five of the stations are located in a southwest-northeast transect in West Nepal from Beltari (Nawalparasi district) in the south to Ghermu (Lamjung district) in the north. Two stations are in the Kathmandu Valley – one at the Kirtipur Campus of Tribhuvan University [KIRT] and one on the grounds of NAST [NAST]. The five transect stations span a total distance of approximately 116 km from south of the Main Frontal Thrust (MFT) to north of the Main Central Thrust (MCT). The transect and KIRT stations operated 2008-2013 and then were restarted in January 2015. The NAST station has been running since July 2013.

In the Eurasian reference frame (EURA_I08), which compares movements to more "stable" northern Eurasia, the transect stations are all moving NNE at approximately 12° azimuth with horizontal velocities of 37 mm/yr in the south (BELT) and dropping to 30 mm/yr to the north (GHER). This suggests a shortening of 7 mm/yr across the region south of the High Himalaya. Half of this shortening occurs between the two most northern stations (Ghermu [GHER] and Besisahar [BESI]), which lie only 16 km apart horizontally (along approximately the same azimuth as the station motion). The three southern stations record essentially no net vertical motion (only seasonal cycles most likely reflecting changes in ground water storage). The two northern stations are again behaving differently with BESI rising at 2.8 ± 0.9 mm/yr and GHER uplifting 4.8 ± 1.3 mm/yr. This velocity field suggests interseismic strain accumulating above a steeper crustal ramp, which will presumably be released during the next major plate boundary earthquake.

The KIRT station also records the major plate motion but overprinting this signal is indication of downslope creep or subsidence. KIRT differs from the expected horizontal plate motion by 5 mm/yr towards 35° azimuth. Rather than showing near-zero vertical velocity, KIRT is dropping by 12.7 ± 1.2 mm/yr. This discrepancy holds true when KIRT is compared to the closest station (Department of Mines and Geology station near Kakani, Nuwakot [KKN4]) or to the transect station a similar distance south of the High Himalayan front (Damauli, Tanahu [DMAU]). Because the Kirtipur campus is located on hillslope, downslope creep is the most likely explanation for the movement. However, Kathmandu valley is also likely experiencing subsidence from ground water withdrawal. Later in 2015, when the NAST station (located on flat Kathmandu valley fill) has accumulated a full two years of data, it will be more possible to differentiate between these hypotheses.

The automated system 'Huys' for current seismic hazard assessment

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The "Huys" enables us to determine for individual monitoring parameters and their complex area S current seismic hazard and the time interval Δt hazard on the territory of the Republic of Armenia for earthquakes with Mmax≥M≥3.5. I calculated value of the current seismic hazard Zcur (in conventional unit) on the territory of Armenia. If the value is equal to or greater Zcur values of the critical seismic hazard Zcrit (in the same conventional unit) obtained for the area of long-term seismic hazard in Armenia, with a high probability in the territory of Armenia and neighboring areas could be an earthquake with magnitude M≥3.5. Magnitude Mmax for zone S is determined by plotting the cumulative number and magnitude of earthquakes, showing the amount of stored energy that can be released in the current time period Δt in a given area S (Guttenberg-Richter), as well as by graphics and cumulative amount of energy released strain earthquakes with M≥2.5 (by Benioff).

As a result of the retrospective testing by three monitoring parameters (level of underground water pressure, subsurface radon emission, the intensity of the geomagnetic field) and their complex, the good convergence of the distances between the epicenters of earthquakes tested and calculated areas (locations) of the current seismic hazard, as well as between the calculated times of earthquakes and their real time have been obtained for the 24 seismic events with magnitude M≥3.5 occurred in the territory of the Republic of Armenia in the period from 1992 to 2012.

The methodology for current seismic hazard assessment

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On the territory of the Republic of Armenia, seismic hazard assessment was performed by using daily data multiparameter monitoring seismic, geologic and seismotectonic data, and was assisted by special computer programs and expert systems. The methodology includes the following successive steps:

1. The study of historical seismicity, geological and seismotectonic conditions in the region.
2. The study of seismicity of the region.
3. Isolation of the useful anomalies by the "Geophysical block" monitoring parameters.
4. Determining the probability of seismic implementation current anomalies.
5. Isolation of the seismogenic anomalies using the "Dynamic Fields" program.
6. Probabilistic assessment of the area, the magnitude and the time period of the current seismic hazard using the program "Expert."
7. Probabilistic assessment of the area, the magnitude and the time period of the current seismic hazard using the "Huys" program.
8. Comprehensive assessment of the current seismic hazard.

The methodology is retrospectively tested on the example of the local low-energy perceptible earthquake (Armenia, Gavar swarm of earthquakes, 12.01.2007, M_{max}=3.7). Its retrospective application of the final stages of preparation and realization of already occurred earthquake selected as an example has shown a sufficiently high efficiency, even in the case of low-energy local perceptible earthquake. The basic parameters of the "future" seismic event - location, time and strength - are determined with sufficient accuracy.

An assessment of the state of drinking water and its management aspects in Dhaka city, Bangladesh

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This paper was aimed to assess the present state of drinking water and to know the level of user satisfaction prevailing among the user of Dhaka Water Supply Authority (DWASA) and services provided by Directorate of Public Health and Engineering (DPHE) in a selected areas of different groups of people in Dhaka city. The paper has focused on the demand and supply gap, collection pattern of water, its supply practices and wastages by different group of people, finding alternative options to meet the crisis management etc. The Poor people especially living in the low lying areas, slums, squatters and river bank areas are suffering to the worst for getting quality drinking water and suffer from various water borne diseases. During research many challenges and opportunities were found out to access drinking water around Dhaka city. The DWASA partially failed to provide safe drinking water and facing acute difficulties to supply required amount of water regularly to the city dwellers. The DWASA should put emphasis on surface water collection and distribution through treatment plant to maintain satisfactory underground level of water. They should replace the old pipes into bigger diameter pipes, installing more number of new pumps. System loss should be reduced strictly with penalty through surveillance team. Availability of water filter with cheaper price should be ensured by Government. Industry and tannery should be relocated outsight of the city to avoid water contamination and availability of quality water. The Government should encourage the entrepreneurs by providing SME loan with less interest rate and five years tax holiday to establish more number of bottle drinking water factories outskirts of Dhaka city and near the river bank with the monitoring of Bangladesh Standard Testing Institute (BSTI), DWASA and DPHE to provide safe drinking water.

Landslide susceptibility mapping along the Barjugad-Martadi road corridor

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Landslide is major destructing phenomenon on the road in hilly and mountainous terrain and it is of utmost importance to understand such hazard and its underlying factors. Barjugad-Martadi road being the least accessible recently track opened road of far-western Nepal, its corridor is facing major problems caused by landslides and toe cutting by Budhiganga River and its tributaries. Landslide Susceptibility mapping of Barjugad-Martadi Road is based on statistical method of bivariate analysis to understand slope instability in which landslides are taken as the major parameter of slope instability. Other parameters used in the study are geology, drainage distance, land cover, slope gradient, slope aspect, road distance and elevation which complement the bivariate analysis. The major objective of this study was to generate a landslide susceptibility map by applying statistical index method for the study area. The results of the analysis were validated by new data sets of landslides. All parameter data are used in ArcGIS where weightage maps are produced and consequently Susceptibility Zonation map are prepared. The prepared maps of different classes of susceptibility zones helps to identify vulnerable areas. Predictive capacity of the applied methodology was calculated based on success rate in which recent landslides were used for the validation. The predictive capacity was calculated to be ~80 %. Thus applied methodology was able to prepare landslide susceptibility map which can provide information on vulnerable areas where special treatment on slope failures can be done. This study is based on field observation, existing project report, available GIS data and information, and is highly recommended to be studied further with more detail investigations before implementation of upgrading works of this road.

Tsunami hazard assessment along the coast of Lingayen Gulf Pangasinan, Philippines

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This study discusses the tsunami simulation performed in Lingayen Gulf using two different earthquake scenarios. Three bathymetry datasets (GEBCO 1 arc-min, GEBCO 30 arc-sec, and GEBCO 30 arc-sec updated with digitized bathymetry points) were used and the resulting tsunami heights and travel time calculation were compared. The results further complement the objective of the existing tsunami sensor installed in Lingayen Gulf, which aims at giving timely warning when a tsunami strikes the coastal communities. The simulation results demonstrated that the two earthquake scenarios produced different tsunami heights and travel times. Also, the uses of GEBCO 1 arc-min and GEBCO 30 arc-sec bathymetry datasets have remarkable differences on the resulting tsunami heights and travel times. Whereas, the uses of GEBCO 30 arc-sec and GEBCO 30 arc-sec updated with digitized bathymetry points have negligible differences. The existing tsunami sensor is effective as an alarm system in the inner bay, while it is ineffective in the outer bay. A combination of the existing and a proposed site of tsunami sensor along the Lingayen Gulf would advance to a robust tsunami early warning system to the affected coastal communities.

Coal potential of Patala Formation, Dandli area, Kotli district Azad Kashmir, Pakistan

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Detailed geological mapping was carried out in Dandli area. Middle Cambrian to Late Miocene rocks are exposed in this area. The coal bearing Patala Formation of Upper Paleocene age is well exposed on both limbs of the doubly plunging Tattapani-Karela anticline and also on the eastern plunge of the doubly plunging Devigarh-Palana anticline. These anticlines are considered as the continuation of the Riasi anticline in Jammu, India. Structurally, the Kotli area lies to the south east of the Hazara-Kashmir Syntaxis. The 73.2 m thick Patala Formation contains two coal seams. The exposed thickness of individual seams range from 01 m to 1.2 m and in the underground, it reaches up to 4 m at some places. Pakistan is suffering from energy crises for the last few decades for its growing industry. Coal is one of the primary sources of energy. The Dandli coal has medium volatiles and low moisture with generally low ash content and good fixed carbon. Sulfur content varies from 0.15 to 03 % and occurs in the form of pyrite nodules. The chemical analyses reveal that Dandli coal is good carbon bituminous to semi-anthracite variety. The resource of this medium to high grade coal of this area have been calculated to be about 14.5 million metric tons.

Taxonomy, paleoecology and phylogenetic relationships of family Cervidae from the Siwaliks of Pakistan

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Fossil remains of the family Cervidae are poorly known from the Siwalik. On the bases of fossil remains, the different species of tribe Cervini (*Axis*, *Cervus* and *Rucervus*) are identified and described till-to-date. Establishing a robust taxonomical and stratigraphical framework of the fossil record of Cervids from the Siwaliks and reassessment of phylogenetic relationships with other Eurasian Cervids as well as reconstruction of the dispersal history and phylogeography of the tribe Cervini needs a further detail work. The present paper is an attempt to resolve the systematic position of already described species, their phylogenetic relationships with the tribe Pliocervini and other Eurasian Cervid species as well as the reconstruction of dispersal routes of these species to and from the Siwaliks. Moreover, this paper also deals with the biostratigraphic correlation of above mentioned species with neighbouring provinces, i. e Mediterranean regions, Central Asia and China.

Middle Jurassic tempestites in Thakkhola region, Kaligandaki valley, Nepal

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In the Thakkhola region, in upper part of the Kali Gandaki valley of northern Nepal, Triassic-Cretaceous sequence occurs, which is record of eastern Neotethys Ocean, and is manifested for example by famous Spiti Shales with numerous Late Jurassic ammonites, known since XIX century. According to the newest lithostratigraphical scheme these shales belong to the Nupra Formation, which is underlying by Middle Jurassic Bagung Formation (Bajocian–lowermost Callovian). Mentioned formations are small part of the Late Triassic–Early Cretaceous sequence of the highest tectonic unit of the Himalaya, so-called Tibetan (Himalayan) Tethys. One of the best places for stratigraphical and sedimentological study of this Middle Jurassic unit is western slope of the Kali Gandaki valley near Jomsom village (with stratotype of the Early Jurassic Jomsom Formation). The Bagung Formation is developed as thin- and middle-bedded limestones with marls and shales intercalations. The limestones contain abundant in invertebrate marine fossils (including bivalves – especially oysters, crinoids, gastropods) and build coquinas/shell beds in some places. Their sedimentological features evidently indicate storm-origin events of typical tempestites manifested by sharp soles, large lithoclasts near the lowermost parts of beds, with gradation of bioclasts (mainly bivalve shells fragments) up to micritic limestones in the uppermost parts of these leyers. Shallow-water environment is supported by lower part of the Bagung Formation which, as transitional beds between Jomsom and Bagung formations, are represented by thin-bedded oolitic limestones with cross-bedding structures and oolitic-bioclastic limestones, both documented high energy environments of their origin. In wider context of the full section of the uppermost Triassic–Jurassic deposits of the Thakkhola region, these units are a middle part of deepening-upward sequence started from the latest Triassic fluvial-paralic-laggonal deposits, then Early–Middle Jurassic shallow-water carbonate platform and finally basinal/pelagic Late Jurassic fossiliferous black shales (Spiti Shales = Nupra Formation) of the northern Peri-Gondwanan realm.

Debris flows in the central sector of the northern slopes of the main Caucasus ridge: peculiarities of the current situation

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Since the second half of the 20th century, debris flows in mountain areas and piedmont areas of the North Caucasus have demonstrated a sustained trend of increasing in number, frequency and power. Thus, damage caused to urban sites and developed areas has also been on the increase. The reason for this trend is the changes in the climatic background - the decreasing of solid precipitation in winter and shortening of the winter season, increasing of liquid precipitation in spring and summer and elongation of the spring-summer period , which have led to the degradation of mountain glaciation.

Masses of previously frozen single-grained materials (primarily, moraine) get exposed. They deconsolidate and mature for subsequent shifting and movement along the movement paths (channels). Increasing storm rainfall in the foothills and intermontane kettles, which have previously been in "rain shade" (rainless), leads to the saturation of the upper layers of the Quaternary Formation. This initiates landslide and debris flow processes, including in locations, where they have not been observed, or have been rare, in the historic period.

Human activities also lead to the increase of debris flow disaster risks. Such activities primarily have to do with the development of recreational infrastructure without regard to concrete engineering geological settings and without sufficient surveying when designing related facilities, or with deviations from the design by builders.

Unwillingness of developers to invest into engineering protection and application of inadequate measures (e.g. the Sulimovsky brook in Krasnaya Polyana) constitute delayed risks, which mean disastrous consequences in the future. The issue of short-term forecasts of debris flow processes is extremely pressing. In the last decades there have only been single known instances of reliable and, most importantly, timely forecasts of debris flow threats, which have realized in real events (the Dzhaylyk, Dhyly-Suu, Bulungu events). Those successful forecasts were the result of engineering explorations of potentially debris-flow hazardous stream flows, carried out by *OAO Sevkavgiprovodhoz*. Morphological hydrological and engineering geological situations in the basins and in origination areas (sites) were assessed. The transformation nature of the flows and their capabilities to reach vital facilities were evaluated. An analysis of glaciation dynamics in the Western and Central parts of the Caucasus Northern slope as of the first decade of the 21st century (I.S. Bushuyeva, 2013) scientifically, with available data processed, confirmed the fact, already well known among specialists as well as among mountaineers, of glacial retreat in the Caucasus, that had "started upon the last maximum advance of glaciers in the first half or in the middle of the 19th century", which "corresponds with the present day notion of the global glacial changes", as "in the last decades practically all glaciers on Earth have been retreating". The Caucasus glaciers in this period have decreased in length down to 2.5 km and have moved up to 1 km up to higher altitudes.

This can be illustrated by the example of the Terskol Glacier tongue (Prielbrusye, Kabardino-Balkar Republic). In August, 2014 a clear photograph, taken in August, 1884, was found and the point from where it had been shot was located. (I.S. Bushueva publishes another photo from Dechy's publication of 1905, where "the glacier terminus is poorly visible, so it is hard to reconstruct its location"). As then the glacier floated over an almost vertical granodiorite riegel (rock-bar), whereas now it hangs over a bare wall, it is not hard to determine that for 130 years it contracted by approximately 650 m (±20 m) (for glacier terminus, the reaction time to a climatic signal is on average 10-50 years . "High debris flow activity" has been registered in the now often frequented Terskol river valley lying below the rock-bar by all researchers in the last decades.

Thus a historically unprecedented situation has developed in the Caucasus Mountains whereby it favors the entrainment by water flows of new masses of hard material of periglacial zones. The transport conditions for these masses along channels have changed (making it possible for them to reach vital facilities) as a result of increased water-cutting of debris flow initiation sites, which, in turn, is connected with the climatic trend of global warming.

The Caucasus region as well as other mountain systems on the Earth currently undergoes a cycle of the increase in frequency of debris flows, caused by gravitational forces, and in the power they manifest. Such events are related to the reaction of steep mountain areas and piedmont areas to the changes in the climatic conditions.

The overwhelming majority of scientific forecasts

informs the public of and prepares it for the continuation of this trend in the nearest decades. Examples of real debris flows indicate an extreme variety and individuality of triggering causes, conditions for initiation, formation and discharge not only in debris flow hazardous tributary basins (catchments) of major transporting arteries as a whole, i.e. tributaries along which debris flows travel down in the vast majority of cases, but also in areas of upper third-order catchment valleys and even their parts. It is therefore unjustified to expect a single model suitable for calculating all gravitational processes.

When there are no fixed stationary observations of debris flow processes, of properties and settings, determining behavioral peculiarities and character of debris flows, on the one hand, and when the possibilities of remote observations for short-term debris flow danger forecasts without the knowledge of a concrete field situation are overestimated, on the other, a lot depends, as in other fields of human activities, on the professional engineering level of those, who assess debris flow risks and parameters of the processes and also on the timeliness of danger warning. Forecasts by experts, as practice shows, may well be of acceptable accuracy.

The nature (with its acts including debris flows) is more powerful that the mankind with its current capabilities. We have to come to terms with it. Thus debris flow mitigation structures should be based on the principle of maximally ensuring the passage of expected (estimated) debris flows through existing [natural] or artificial channels into natural transporting first-order watercourses (for the North Caucasus these are the Cherek, Chegem, Baksan, Malka, Ardon, Belaya rivers, etc.).

The study of debris flow threats in destabilizing the modern civilization must become a paramount task of research and should result in adequate engineering protection measures.

Assessment and prediction of earthquake-induced geohazards along the submarine pipelines in the Black Sea

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Offshore pipeline and production units are increasingly developed in recent years in connection with the development of offshore gas and oil fields. Submarine pipelines "Blue Stream" (2002), "Dzhubga-Lazarevskoye-Sochi" (2011) and "South Stream" were built and is being built in the Black Sea. Subsea production facilities are usually located in the areas with relatively simple geological conditions while submarine pipelines may cross areas affected by submarine geohazards. To ensure normal functioning of the submarine structures hazards and risk assessment of geological processes should be carried out in areas of their deployment.

The analysis of published and archival data permits to conclude that within the Black Sea basin the following processes that are hazardous to sea constructions may develop: earthquakes, gravity flows, landslides, mud volcanism, sinking (construction subsidence into the soft grounds), migration of deposits. Earthquakes provide the trigger effects by activating the majority of the mentioned above processes. It should be emphasized that seismic effects proper of such earthquakes are characterized by small duration and are of no great danger to the lengthy flexible gas pipeline construction with a large period of free oscillations.

Assessment of seismic hazard for the submarine gas pipelines is aimed at finding out the sources that may cause their possible damage both due to direct seismic impacts and indirect impacts associated with the manifestation of seismicity. The principal secondary events caused by strong earthquakes are the following:

- quick tectonic displacements on faults of different orientation;
- initiation of slumping and turbidity currents on the continental slope
- liquefaction
- origination of tsunami on the shelf.

One can assign to the category of events caused by endogenic processes and associated with strong earthquakes the gas blowouts from gas and the mud volcanism.

Strengthening of avalanche and mudflow processes in the west Caucasus (Russia) in connection with climate change and economic activity

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Justification of avalanche-induced mudflow danger and a tendency of its change in the regions of western Caucasus is made. An air temperature, atmospheric precipitation and snow cover is analyzed. Average annual air temperature increased for 1971-2010 on 0.35 °C. The annual sum of an atmospheric precipitation for 1977-2007 increased on the average by 103 mm, or for 9.1%. During all seasons of year in all considered territory there was the increase in atmospheric precipitation reaching the greatest sizes in the fall. The number of days with snow cover was reduced by 10-15 % at the heights of 2000-2500 m. and increased at more considerable heights. On MS Gornay (the pass Goytkh), located in the Northwest Caucasus at the height of 325 m, the number of days with snow cover was reduced by 11 days. Strengthening of avalanche activity at the heights more than 2000 m and reduction at low heights is established. The attention is focused on weak study of mudflow processes. In recent years, in connection with increase in the average annual sum of an atmospheric precipitation and the increased anthropogenic influence on environment mudflow activity considerably increased. The number of catastrophic mudflows and high waters which were accompanied by large destructions and loss of human life increased. Mudflow danger increase in Mzymta the river basin of in a consequence of deforestation and violation of stability of hillsides when building numerous objects is especially noticeable.

Catastrophic tectonic event in the Kerch-Taman mud volcano area of the territory of the Kerch-Taman mud volcano zone

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Catastrophic tectonic event in the Kerch-Taman mud volcano area of the territory of the Kerch-Taman mud volcano zone is distinct for high neotectonic activity. Mud volcanoes erupt here both on land and in the Sea of Azov. In the latter case, islands of hundreds of meters in diameter and up to several meters high are formed from eruption products. These islands are short lived though active water erosion destroys them in the course of several months. Mud volcanoes are located in cryptodiapiric folds in Cenozoic deposits. Folds are grouped into long narrow sub parallel anticline arrays divided by wider flat synclines. Anticlines are situated in the frontal parts of thrusts formed under tangential compression, and these structures are genetically interrelated. On land, anticlines are usually directly manifested in relief as topographic highs. In summer 2011, a geological event that had not been observed previously was recorded in the region. On June 19, 2011, while implementing scheduled coastal geological studies on the route, a dangerous phenomenon of endogenic origin was revealed. This was an intensive and high amplitude neotectonic rise in the coastal part of the Sea of Azov with both the sea floor and land involved. The epicenter of the rise is projected farther into the maritime part, where its amplitude was likely to be at least +5 m. The length of the studied rise along the shore line was 435 m and was clearly recorded by retreat of water seaward. The width of the rise remaining after abrasion processes was 50 m. Its formation is related to tangential tectonic stresses that shaped the contemporary structure of Taman Peninsula. Tectonic stress discharge was expressed in this case in the form of plastic deformation of competent clays comprising the geological section of Taman Peninsula. Such a deformation is usually accompanied by seismic events.

Seismicity and content of oil and gas in Caspian region

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The forms of solid bodies (magmatic, metasomatic and hydrothermal) are the forms of former cavities, which used to be filled by fluids. The forms of liquid and gaseous bodies are the forms of reservoirs, which are filled with fluids now. The relation between the gas bursts and the focuses of strong earthquakes (k>13, M>5.5) was observed during drilling oil-and-gas wells in the Caspian region. The gas bursts often damaged the wells. We paid special attention to the earthquake focuses in order to show the common features of forming the ore fields and forming the oil field. The geologists researching the ore fields had already concluded a long time ago that the ore fields were the systems of three elements which included the ore deposit, the feeding channel, along which the ore fluid got a deposit, and the deep hearth inside which the ore melt and the fluids were formed. The geologists researching the oil fields are just beginning to accept the idea of the similarities between the ore fields and the oil-and-gas fields. The upper element, i.e. the oil-and-gas deposits, of the three-element system has been researched the most. Recently, data on the feeding channels, by means of which hydrocarbons get the deposits, have been obtained owing to seismic prospecting (method of common depth point). The feeding channels in Western Siberia (the Urengoy sineclise) are named the gas chimneys. The question about the deep hearth of the hydrocarbon formation is raised. But the hearth of the hydrocarbon formation is not researched enough yet. We think the hearths of the hydrocarbon formation are the seismic focuses, and that is shown in the vacuum-explosive model, which is the most realistic model to date.

Structural and petroleum geodynamic situation in heterogeneous sedimentary basins: a case of Black Sea, Caucasus

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Azov-Black Sea region is one of the oldest oil and gas producing regions of Russia. Here are explored and put into the development of dozens of oil and gas fields, are actively being sought new hydrocarbon accumulations. However, in recent years there has been a marked increase in the backlog of proven reserves of fossil fuels on crude oil production decreased efficiency of geological exploration. The solution to these problems is impossible without the development of new models of petroleum and petroleum accumulation in the Earth's crust, without generating sufficient objective criteria forecast oil and gas. Based on the analysis of multifaceted geological and geophysical material broad development overthrust-and-thrust structures, not only within the mountain-folded structures of the North-West Caucasus, but and adjacent areas of the West Kuban trough, Epihercynian Scythian plate, and the Black Sea basin. Tectonic schemes and structurally balanced sections and geological model of dislocations were constructed. The features of the morphology of thrust dislocations formed in the various structural-tectonic zones, patterns of their spatial distribution and formation. A comparative analysis of overthrust-and-thrust structures of the Black Sea-Caspian and other regions proved that the development overthrust-and-thrust structures of the North-West Caucasus, Black Sea basin and the Scythian plate went on a single model and single geodeformation field stress due to collisional processes in the Caucasus segment of the Alpine Orogen. The features of the structure of oil and gas traps in diverse tectonic zones of the region under study, the conditions of formation and distribution regularities of possible oil and gas accumulations, including within complex dislocated zones (North-West Caucasus). With specific examples to demonstrate the role overthrust-and-thrust structures in the localization of oil and gas deposits. Identified promising areas of exploration. The proposals for optimizing hydrocarbon exploration techniques in areas of the dislocation of lateral compression.

Seismogenic and gravitational deformations at south slope of NW Caucasus

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South slope of North-Western Caucasus and Back Sea area near the Caucasus show high seismic activity. Most active part of the coast situated between Anapa and Novorossiysk city at the western end of Caucasus, where huge structures formed by collapses and landslides can be seen. Those structures have some special features connected with seismogenic and gravitational deformations. We explored the area in 2014. We received the map and main morphological dimensions of those deformations and some ideas regarding genesis and sequence of processes. The coast between rivers Sukko and Durso have total seismogenic and gravitational destruction, no any bedrock in initial position had been found. All deformations are well-visible at relief and at space shots. We can see two main types of deformations. First type is complex seismogenic and gravitational flow of totally disintegrated bedrocks. Most complete bedrock blocks have below several dozens of meters size, rest part is the mix off sand, clay and crushed stone. Second type looks like collapse and landslide massifs with the relief usual for such landscapes. We can see different depth and processing of erosion network at those massifs and at nearby territory. Sonar maps of Black Sea show that large landslides moved down up to 50 m depth isobath. Most interesting, young and large landslides formed capes Utrish and cape Maliy Utrish with total dimensions (length/width) about 3.3/3.1 km and 5.1/3.6 km with underwater parts and total vertical development about 500 m. Landslides connected with strong earthquakes with the magnitude above 8, and can have two ages according with archeological and geomorphological data. More old massifs have about 3000 years age, more young massifs had been crated about 1700-1900 years ago. Paleoseismological explorations can be useful because nobody waits for new so strong and dangerous earthquakes and huge landslides here.

Potential benefits of installing a temporary short-period seismic array in central Nepal

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The central region of Nepal is well-known for its infrequent but large earthquakes. What is less well constrained is the smaller magnitude seismicity of the area. This seismicity can help illuminate fault zones that may pose a future hazard, however, these small earthquakes are difficult to constrain without a local network. We give an overview of the available data sets relevant to the area, which include Global Seismic Network stations in the far field, the Nepal National Network in the medium range, and a temporary PASSCAL deployment, HIMNT, in the near field. Additional data includes active source data collected in several river beds in central and eastern Nepal. We discuss possibilities for integrating these data sets, as well as ways to complement the existing data with a temporary deployment of short-period seismometers. We hope to install this array in the same area where the active source acquisition took place, to obtain a model of the regional velocity structure to provide context for the active source study. Other objectives of this study include microseismicity distribution and receiver functions. Such a deployment could also supplement the temporary array of broadband seismometers currently being deployed by others in western Nepal.

Morphology of the great 1950 Assam earthquake surface rupture

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On 15th August 1950, the great Assam earthquake (Mw. 8.7) shook border regions between northeastern Indian, Tibet, and China for several minutes, triggering large landslides and numerous aftershocks over a wide area in the Abor and Mishmi Hills. Using morpho-tectonic field observations and high-resolution satellite images analysis we show that the earthquake produced a >200 km-long surface rupture along the Eastern Himalayan Syntaxis. It ruptured both the Main Himalayan Frontal Thrust (MFT) and the Mishmi Thrust all the way to the surface, producing clear tectonic scarps cutting Quaternary alluvial terrace risers at high angle. Quantitative study of the geometry, height, and shape of the scarps using precise topographic data gives constraints on both co-seismic and cumulative offsets associated with the 1950 event and its predecessors. Maximum co-seismic vertical displacements (up to 9-m-high) are found on the Mishmi Thrust, along the front of the Mishmi Hills. Vertical displacements are less than half as large along the MFT, which has been previously inferred to be the main source of the earthquake. We interpret these differences in the co-seismic displacements are a result of large changes in dip between the two fault planes that ruptured during the event.

High resolution topography and multiple seismic uplift on the Main Frontal Thrust in the Bardibas-Ratu river area, eastern Nepal

Cagil Karakas[1,*], Paul Tapponnier[1], Aurelie Coudurier Curveur[1], Sorvigenaleon Ildefonso[1], Mingxing Gao[1], Somanath Sapkota[2], Dilli Ram Tiwari[2], Laurent Bollinger[3] and Yann Klinger[3]

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Primary surface ruptures of the Ma 8.4, 1934 Bihar-Nepal and 1255 AD earthquake are clear along the Himalayan Main Frontal Thrust from at least 85° 49' to 86° 27' E in eastern Nepal. We show new high-resolution, quantitative evidences of surface rupture, relative and co-seismic uplift in the Ratu river area. We present a map of uplifted terrace surfaces and abandoned paleo-channels truncated by the MFT, based on field observations, interpretation of stereoscopic air photos and high-resolution satellite images, topographic maps and newly acquired Digital Elevation Models from Total station and Terrestrial Lidar Scanner (TLS) surveys. We identify at least five distinct uplifted terrace levels rising parallel to the riverbed on top of folded Siwaliks. A few sets of measurements may be taken to imply characteristic increments of throw during a sequence of five or more events of riverbed abandonment possibly related to co-seismic uplifts. High-resolution DEM extraction from new UAV surveys, kinematic GPS profiles and 14C ages of newly collected charcoal samples will help improve our knowledge on the slip history over the length of the Bardibas thrust.

Seismic reflection data acquisition in central and eastern Nepal: towards constraining the subsurface geometry of the Main Frontal Thrust

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We show preliminary results from seismic reflection data acquisition campaign in the Siwaliks of Nepal. Our main goal was to image the Main Frontal Thrust (MFT), the most frontal surface expression of the Himalayan orogen. These surveys are intended to image the geometry and infer the kinematics of the fault, to assess the behavior at longer timescales, and evaluate how the many surface fault strands interact at depth. We have undertaken three field seasons, totalling 5 months, of data acquisition. The first two field seasons were done around the town of Bardibas in central Nepal. The last field season was done in various locations around eastern Nepal. Over 100 km of data were acquired in transects across the Main Frontal Thrust. The surveys were conducted using a 6300 kg vibroseisminibuggy during 2014 and 2015. The data were acquired using 264 channels with 5 m spacing. Vertical stacks of 4-12 sweeps were done at each station to improve the signal to noise ratio of the data. Standard data processing was applied to the data to generate brute stacks. These steps include application of source-receiver geometry, sorting by CDP, and velocity analysis, application of NMO and stacking of these CDP gathers. The seismic lines mostly follow dry riverbeds and are generally orthogonal to the range front. Around Bardibas, the seismic lines encompass a ~5 km southward step in the deformation front. In eastern Nepal the survey focused on four main targets: the Churya Mountains and the Triyuga valley; the Sagarmatha anticline; the MFT range front in eastern Nepal, between BiringKhola (near Hokse) and SharduKhola (near Dharan); and finally a seismic profile targeting the Singhamuni fault in the Tokla Tea Garden near Kakarvitta. Measurements of bedding attitudes were done throughout the area to complement the seismic data.

Mainstreaming landslide risk reduction into the road sector in Lao PDR

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Lao PDR is one of the mountainous country in the Greater Mekong Sub-region which has been subjected to frequent landslides caused by a combination of fragile geology and heavy rainfall during the monsoon session that are characteristic of tropical region. Most common landslides are shallow and localized slope failures in roadside cuttings slope. Landslides on roads cause frequent hold-ups to traffic, and this has a direct economic impact to road users and wider community. A study was performed by the Asian Disaster Preparedness Center (ADPC) to assess the landslide risk to the road sector which was initiated by the Government of Lao PDR under a World Bank funded project entitled 'Mainstreaming Disaster and Climate Risk Management into Investment Decisions'. Main objective of the study was to develop a landslide inventory framework to establish a system for routine inventory of landslides occurring along the national and provincial roads and to mainstream landslide risk management interventions into the road sector planning and investment decisions. The framework will facilitate risk sensitive decision making in the road sector so that suitable proactive cost effective and resilient mitigation measures can be taken timely in order to reduce disruptions to road network due to occurrence of landslides in future. The framework looks at the roles and responsibilities of different levels of Department of Roads (DoR) under Ministry of Public Works and Transport (MPWT) in inventory preparation, data storage and sharing mechanism and follow up, utilization of inventory data in managing a reliable road transportation system in Lao PDR. Thus, the landslide inventory will greatly improve the understanding of DoR/MPWT on the gaps and requirement for strengthening landslide mitigation capacity at all levels (national, provincial, district and local communities). Therefore, in order to ensure the continuity of the framework, DoR has to mainstream the landslide risk management into their day to day work by strengthening the capacity of officials of the road sector at all levels and integrating the framework in its strategy, policy and planning and budgeting procedures. This will greatly help to reduce potential losses in road annual maintenance cost and improve the road traffic safety in future.

Exploring the role of science in earthquake risk reduction policy and practice: a case study from Nepal

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The role that science can play in disaster risk reduction is receiving increasing attention amongst the international community, with calls to make science more 'useful, useable and used.' Examples to date have tended to focus on more developed countries where resource is less of a constraint; or on more predictable hazards such as floods where there is a clear role for science to play, for example in early warning. The role of earth science in earthquake risk reduction is less clear, with earthquakes often seen as an engineering problem involving technical solutions and the effective enforcement of building codes.

We held focus group discussions with scientists, practitioners, donors and government officials in earthquake-prone Nepal to explore: 1) how scientific knowledge currently informs the development and implementation of earthquake risk reduction (EQRR) policy and practice; 2) the scientific needs of the EQRR community at national and local levels and whether these needs are being met; and 3) the opportunities and barriers associated with the use of earth science in EQRR.

The findings highlight a high level of knowledge and expertise in primary and secondary earthquake hazards in Nepal. However, with the exception of the national building code, there was limited evidence of the instrumental use of earthquake science in DRR policy and practice. This may reflect the nature of the physical hazard, which cannot be predicted, and a perception that science, as a result, is limited in terms of what it can say. Where scientific products do exist, e.g. seismic hazard maps, these were inherently uncertain, difficult for non-technical experts to interpret, and lacked the level of detail required to usefully inform national- or regional-level planning or community-based activities. As a result, earthquake science was used in a very limited way: politically to get EQRR on the agenda of national and local government; and at basic levels for awareness raising in communities.

Geomorphic relationships to stream system dynamics

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An understanding of the inherent relationships of geology, geomorphology and climate are needed in order to evaluate the environmental impacts of various land uses. A water resource assessment was undertaken with an explicit attempt to link inherent landscape characteristics to an understanding of stream and freshwater aquatic habitat conditions and to understand the effect of existing land uses on the condition of those resources. Initial observations will be presented.

Landslide disaster scenario in Nepal: a study from Koshi River basin

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Landslides are the most frequently occurring water induced disaster, with their effects on larger area and population, in the Koshi River basin. It has been noticed that number of landslide events are progressively increased in the recent decades. The landslide hazard in the Koshi River basin in Nepal was evaluated through GIS techniques using information value method. Geology, slope, aspect, precipitation, curvature, drainage density, land use and past disaster sites are the major intrinsic and extrinsic factors considered for the hazard analysis. Consequently, landslide hazard maps were prepared in respect of the present condition as well as for the projected climate change condition for 2030's and 2050's. Landslide hazard is divided into five levels, namely very low, low, medium, high and very high hazard based on the weight of the included factors. Landslide vulnerability analysis in the basin was carried out considering various factors like caste, ethnicity, education, population, settlement cluster and the secondary data of past sliding events. Furthermore, the landslide hazard and vulnerability maps were added to assess landslide risk in the Koshi River basin.

Of the river sub-basins, almost entire of the Arun and Tamor River sub-basins and the Sunkoshi River corridor lies in very high hazard zone. Areal coverage by very high hazard zone increases in projected scenario of landslide hazard for 2030s and 2050s. Most of the areas of the river basin are vulnerable to landslide whereas most of the high and very high landslide hazard risk zones are concentrated in the high mountain and the middle mountain regions.

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Journal of Nepal Geological Society
Registration No. 1/042/043
US Library of Congress Catalogue Card No.: N-E-81-91064
ISSN 0259-1316

Published by: **Nepal Geological Society**
PO Box 231, Kathmandu, Nepal
Email: info@ngs.org.np
Website: http://www.ngs.org.np