ISSN 1994-3237
Volume 45(2), 2012

Abstract Volume

Earth Sciences Pakistan 2012

Baragali Summer Campus, University of Peshawar
June 23-24, 2012

Journal of Himalayan Earth Sciences

National Centre of Excellence in Geology
Universtiy of Peshawar
Khyber Pakhtunkhwa, Pakistan

Landslide hazard assessment in Mansehra District using remote sensing and GIS

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Mansehra district is prone to landslide because of climate conditions, geological and geomorphologic characteristics of the region. In October 2005, Kashmir earthquake triggered several thousand landslides in the Himalaya region of Northern Pakistan and India. In future, there are still great threats of further happening of such landslide events in this region. Therefore, it is very important to prepare detailed landslide susceptibility maps of the region helpful for any pre-emptive measures. In this study, the relationships between the landslides and various instability factors contributing to the occurrence of landslides were investigated using Remote Sensing and Geographical Information System (GIS) based approaches. For the preparation of landslide inventory maps slope, aspect, elevation, landuse/landcover, distance to stream, distance to road, distance to fault line, lithology, and soil types were used as raster layers in ArcGIS, and ranked using a numerical scale corresponding to the physical conditions of the area.

In order to investigate the role of each instability factor in controlling the spatial distribution of landslides, Weighted Liner Combination Method was used. An index based approach is adopted both to put the various classes of all the parameters in order of their significance to the process of land sliding and weight the impact of on parameter against another. Using primary and secondary level weights, a contentious scale of numerical indices is obtained with which the study area is divided into different classes/zones of land sliding susceptibility from extremely low susceptible to very high susceptible classes. The results showed a strong relationship between the landslides occurrence and various instability factors.

The emerging global navigation satellite systems: An application paradigm for disaster management scenarios

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This research contribution is drafted in the background of emerging Global Navigation Satellite System (GNSS) like the fully functional GPS by US and GLONASS by Russia. The European Union has the vision to fully deploy its constellation of Galileo by 2015 and at the same time China is planning to complete its Beidou system for global coverage by 2020. The market trends and the application areas of GNSS technology are growing at a fast speed and the recent past has witnessed the wide spread of GNSS technology in the military and civilian paradigms too. The year 2020 promises the availability of more than 100 satellites for the global coverage and will provide many frequency signals for the civil users. GNSS provides the positioning, timing and navigation information to all the users, all the time and at all points on the globe by using at least four satellites in view and applying the principle of Triliteration. The applications of GNSS technology are dependent on human imagination and last two decades have witnessed its mushrooming effect from hand held navigators to aerospace, marine, aviation, agriculture, environment, energy, transportation, help and rescue, disaster management, telecommunications, robotics, vehicle management and many more.

This research article gives the broad spectrum about the applications of GNSS technology in the field of Disaster Management, emergency and rescue. Authors have discussed different experimented disaster management GNSS-based applications around the world and suggest a similar frame for Pakistan.

Petrography and geochemistry of basalts from Ranikot and Bara Nala sections, Laki Range, Lower Indus Basin, Pakistan

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Volcanic rocks of basaltic composition are exposed in various sections of the Laki Range in the Lower Indus Basin which comprises of sedimentary rocks ranging from Upper Cretaceous to Recent (Fig. 1). The presence of thin horizons of volcanic rocks in at the Cretaceous-Tertiary boundary in the region is a peculiar and hence the focus of this study. In the Rani Kot area, the basaltic rocks are exposed in the core of an anticline, and are composed mainly of plagioclase, clinopyroxene, glass and ore mineral(s) as primary constituents. An orange brown secondary material, probably after olivine and amygdaloidal carbonate filling are the secondary phases. The basaltic rocks are generally fine-grained and porphyritic, with sub-ophitic to ophitic clinopyroxene, while the intersertal glass is charged with ore due possibly to devitrification. Different discrimination diagrams based on major element geochemistry indicate that these basalts are tholeiitic and belong to Continental Flood Basalt type.

In the Bara Nala section, where the oldest sedimentary rocks of the Lower Indus Basin are exposed, there are three volcanic flows. One of these occurs within the Pab Sandstone of Upper Cretaceous age, whilst two are within the Khadro Formation of Early Paleocene age. There is a strong similarity in the petrography of these flows, and those of the Ranikot and there is not much difference in their major element geochemistry either. However, the analyses from the Bara Nala range from tholeiitic to alkaline in composition. In view of the presence of Late Cretaceous volcanic rocks in Kutch and several places in Sindh (Kazmi and Jan, 1997), it is likely that the Late Cretaceous-Early Paleocene volcanic rocks of the Kirthar Range may be an extension of the Deccan volcanic province.

References

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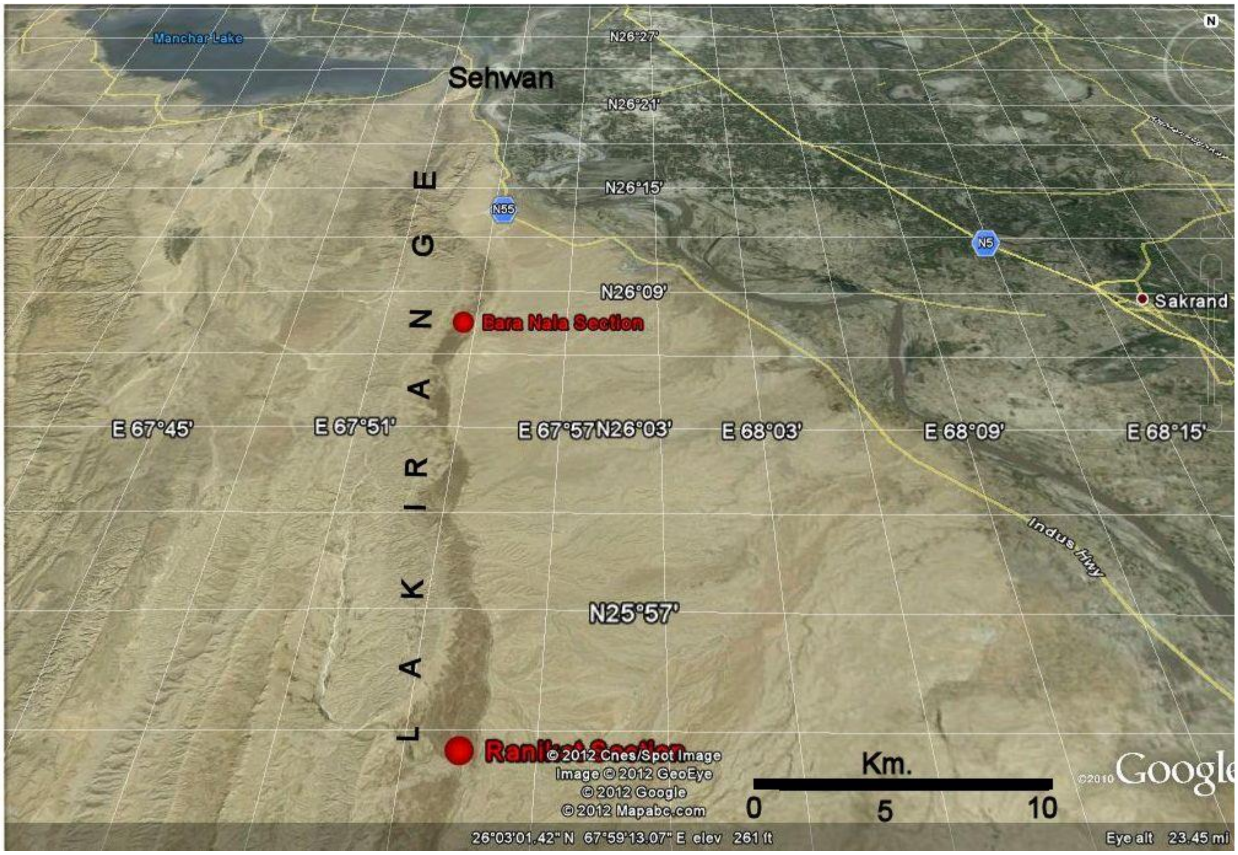

Fig. 1. Map showing the location of Basalts within the Laki Range.

The use of porphyroblast inclusion trail asymmetries to reconstruct deformation history in metamorphic rocks: insights from the Barrovian sequence of the Kaghan-Naran valley, north Pakistan

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Multiply deformed and metamorphosed rocks commonly preserve a record of lengthy periods of deformation and associated several phases of porphyroblast growth. This is evident from several sets of foliations and lineations reported from a number of orogenic terrains around the globe. However, when it comes to the interpretation of foliations and associated lineations, controversies arise in terms of their tectonic control and kinematic models. To resolve the tectonic origin of foliations and lineations, sophisticated structural techniques have been devised and their refinements over the years allow the users to track the tectonic history of a given orogenic terrain as accurately as possible.

The purpose of this research is to reconstruct 'original' geometrical orientation of foliations and lineations that are preserved in porphyroblasts in the form of inclusion trails from the multiply deformed and metamorphosed sequences of the Kaghan-Naran valley, north Pakistan. No such studies have been carried out to date in the proposed region. Yet, the metamorphic rocks of the Kagahn-Naran valley are crucial in many ways not only to decode the sequential two-phase exhumation tectonics of this important region within the Himalaya, but also to understand the synchronous collision-extension history of this world-class orogenic system. Inclusion trail geometries in porphyroblasts can help us to thoroughly investigate fine-scale processes involved in crustal-scale mechanics, where synorogenic two-phase collision and exhumation have been proposed.

Two conflicting hypothesis have been postulated for the asymmetric inclusion trail geometries: porphyroblast rotation and non-rotation. Porphyroblast non-rotation assumes that porphyroblast preserve successive sets of foliations with respect to fixed geographic coordinates during progressive deformation in case not obliterated internally. Hence, multiple deformation phases can be deduced and correlated from sample to sample and from one region to other. Rotation model postulates that during simple shear, porphyroblasts synchronously grow and trap single foliation during progressive shearing. In this study, not only the two models are tested but the inclusion trail geometries preserved in porphyroblasts are also measured and an attempt is made to reconstruct the deformation and associated metamorphic sequences of the Kaghan-Naran valley.

Two main FIA sets are obtained through 'asymmetry switch' method. The first FIA is E-W trending mostly obtained from garnet porphyroblasts, and corresponding to the N-S bulk shortening of the Indian Plate with Kohistan-Island Arc. The second FIA set is N-S trending and obtained from both garnet and staurolite porphyroblasts and formed as a result of E-W bulk shortening. The two distinct shortening directions match well with the FIA data obtained from the Swat area.

Facies analysis, depositional model and sequence stratigraphy of the Upper Permian Chiddru Formation, Salt Ranges, Upper Indus Basin, Pakistan

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We analyzed the outcrop data from two key stratigraphic sections (the Nammal Gorge and the Chhidru Nala) in the Salt Ranges, Upper Indus Basin of Pakistan to understand the depositional dynamics of the Upper Permian Chhidru Formation. In present study three microfacies and two lithofacies types have been identified. The microfacies are sandy mudstone, sandy mudstone-wackestone, and sandy wackestone-packestone and the lithofacies types include feldspathic greywacke and quartz-wacke. The characterization of these facies supports deposition in a proximal inner shelf to distal middle shelf settings of a siliciclastic-carbonate mixed platform in the study area. Based on the fusuliniid biostratigraphy two 3^{rd} order depositional sequences (TST/RST) are identified that encompass six 4^{th} order depositional sequences (parasequences), each bounded by a marine flooding surface. Of particular interest, are the lowermost (253.8my) and the uppermost (252.5my) sequence boundaries, which show significant global signature of eustatic sea level changes in local depositional signals while the parasequence boundaries are the results of interplay between local tectonics and sediment supply.

Disaster mitigation through conservation of heritage buildings in Peshawar city

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This paper presents the disaster mitigation through conservation of historical building of Sethi House Peshawar. The house is approximately two centuries old brick masonry structure with internal woodwork of great heritage importance. Historical (Monumental) buildings are unique as their evaluation or analysis cannot be done by any standard structural scheme: this makes it difficult to evaluate their reliability and performance. The reason is that in addition to many uncertainties that are common to all existing buildings and particular to old buildings, no statistical data is available on the behavior of similar buildings. The rehabilitation of these structures requires that the repairing material and method of construction should be similar to the original material and method of construction to conserve the aesthetics of the structure.The scope of work included, repair and rehabilitation of cracked arches of basement hall and Level 1 and 2 rooms, roof treatment and perforated bricks masonry parapet walls using hydrated lime, brick-surkhi and jute as mortar. The application of above mentioned materials improved both the strengthening capacity of the building as well as the aesthetic appearance and has ultimately decreased the associated seismic risk, for there were no damages observed due to bed-joint sliding, rocking and/or toe crushing. There was no in-plane and out of plane cracking observed in the Structure. Also the wall density ratio for all the floors was found to be greater than the minimum requirements of Building Codes of Pakistan SP-2007.

GIS based landfill site selection for Faisalabad city

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Shortage of land for waste disposal and inappropriate landfill site is one of the biggest problems in urban areas. This problem could be solved by applying new technologies like Geographic Information Systems. Most of the landfill sites in Pakistan are selected randomly, and waste is burned in air which has impacts on nature and human lives. The main aim of this research is to determine a suitable landfill site with less impact on environment. In this research, a potential site for an appropriate landfill area for Faisalabad city was determined by using Geographic Information System (GIS) as a tool to aid the decision making process. To achieve this purpose, thematic layers, and different tabular data such as topography, land use, roads network, ground, and surface water, infrastructure, and urban areas were collected. Thematic maps were used to create the vulnerability map for the area and the results were compiled to the buffer zones around sensitive areas. Multi-criteria analysis (MDA) was used to measure the relative importance weighting for each criterion. Each map layers were formed with the aid of GIS and final suitability map was created by overlay analyses of each criterion map. According to obtained results, high and low suitable areas were determined in the study area.

Structural investigation and geological mapping of a part of eastern Salt Range around Basharat Village, Punjab, Pakistan, using GIS/RS

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The present study is meant to address the structural geology of the Basharat area (32° 52′ 0.37″ N to 32° 37′ 32.68″ N; 73° 01′ 53.71″ E to 73° 97′ 51.56″ E) Jhelum district, Punjab, Pakistan. The study area lies in the easternmost extension of the Salt Range-Potwar Plateau. The primary mapping technique adopted for the structural investigation is GIS/RS. A GPS device was utilized in order to mark different lithostratigraphic units as well as the structural points of interest. Two GIS softwares, i.e., Google Earth and Global Mapper were integrated together for the preparation of the geological map of the area at a scale of 1:25,000. POIs were transferred from the GPS device to the Google Earth and via picking up the colour tone of different formations, the stratigraphic assemblages were mapped. Finally, Corel draw was used for the map digitization.

The study area is contained in the Sub Himalayas after Gansser (1964) or in the External Zone of Coward et al. (1988). The Himalayas is a spectacular fold and thrust belt formed as a result of the collision between Indian and Eurasian plates. The Indian plate separated from the African plate and started its northward drift towards Eurasia in Cretaceous time. This drift resulted in the intra-oceanic subduction within the Neo-Tethys and resulted in the formation of a series of magmatic arcs (Kohistan, Laddakh, Nuristan and Kandhar). The collision between India and Eurasia started in Eocene time as the Indian Plate collided and under-thrusted the Kohistan Island Arc. The Himalayan Thrust System from north to south is divided into five tectono-stratigraphic units including Karakoram Block, K.I.A., Northern Deformed Fold, and Thrust Belt, Southern Deformed Fold, and Thrust Belt, Salt Range, and Punjab Plain delineated by regional faults represented by Main Karakoram Thrust (MKT), Main Mantle Thrust (MMT), Main Boundary Thrust (MBT) and Salt Range Thrust (SRT). This indicates that major tectonic transport is from north to south and thus the study area lies in the foreland portion of the Himalayan Thrust System.

The study area comprises predominantly of molasses ranging in age from Miocene to Pliocene represented by Rawalpindi and Siwalik Groups in the north-western portion. The Eocene Cherat Group has large, prominent and continuous exposures in the middle part while the older successions are exposed in the southern half of the mapped area. The latter include Palaeocene Makarwal Group, Permian Nilawahan Group and Cambrian Jhelum Group along with Pre-Cambrian Salt Formation. The Siwalik Group is represented by the Chinji and Nagri Formations underlain by Rawalpindi Group. Nammal and Sakesar Formations of the Cherat Group lie above the Patala Formation which is the sole representative of the Makarwal Group in the study area. The Permian Nilawahan Group consists of Tobra, Dandot and Warchha Formations. The group is separated by an unconformity from underlying Cambrian successions which are represented by Khewra, Kussak, Jutana and Baghanwala Formations of Jhelum Group. Salt Range Formation of Pre-Cambrian age is the oldest while Pliocene Nagri Formation is the youngest formation encountered in the mapped area.

According to Baker et al. (1988), the eastern Salt Range exhibits the geometry of a fault bend fold. The study area is thoroughly influenced by activity along the Salt Range Thrust. The major trend of the hinges of the ridges is northeast-southwest which indicates that it experienced strong northwest-southeast compressive stresses. The area comprises of five anticlines, six synclines, two fore-thrusts, one backthrust and the major decollement Salt Range Thrust (Fig. 1).

Traversing from the south-eastern boundary to the north-western one the first major structure is Salt Range Thrust which has juxtaposed the oldest Salt Range Formation over Jhelum Plain. To the north, there are two forethrusts, i.e., Lower and Upper Chhammal Thrusts enclosing Chhammal Syncline (Fig. 2). There is a series of anticlines and synclines up to the Siwaliks which disappear under the cover of alluvium in the north. All these anticlines and synclines are oriented northeast-southwest, sharing their limbs between them and occur one after the other in following order northwards, i.e. Lower Takwen Syncline, Lower Takwen Anticline, Takwen Syncline, Upper Takwen Anticline, Upper Takwen Syncline, Saloi Takwen Anticline, Saloi Syncline, Saloi Anticline, Lahr Syncline and Wahali Anticline. The only backthrust of the area is located in the north-eastern part termed as Diljabba Thrust having northwest vergence. The research work has been summed up in form of a map and two cross sections, i.e. AB and CD which depict the structural geology of the area (Fig. 2, 3). The discussion concludes that the mapped area has undergone severe deformation in the northwest-southeast direction. The intensity of folding and faulting is much higher in the southern portion indicated by the dip angles of the folds and faults as compared to the northern half. The vergence of the forethrusts indicates that the tectonic transport direction is towards southeast.

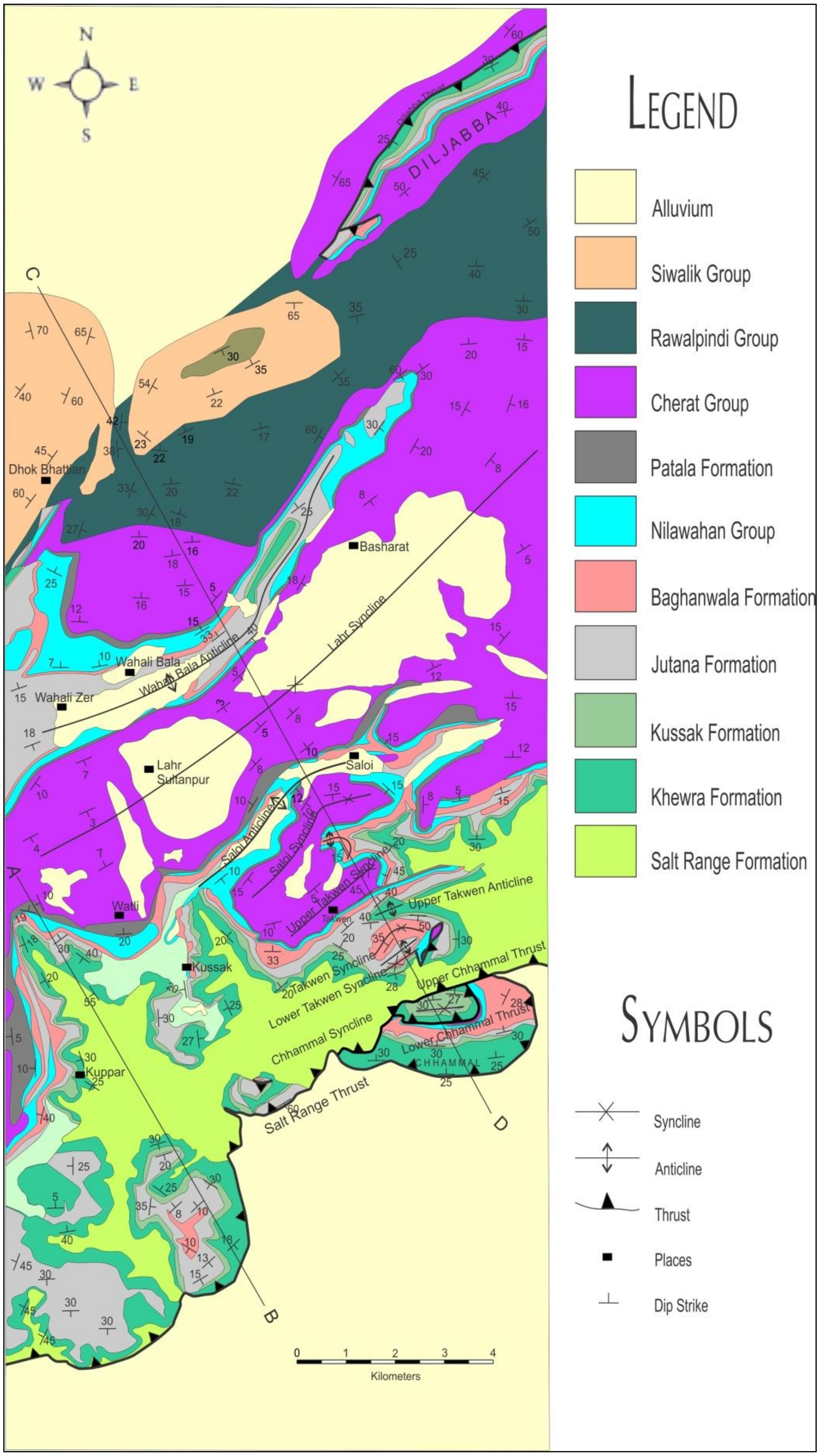

Fig. 1. Geological map of the study area.

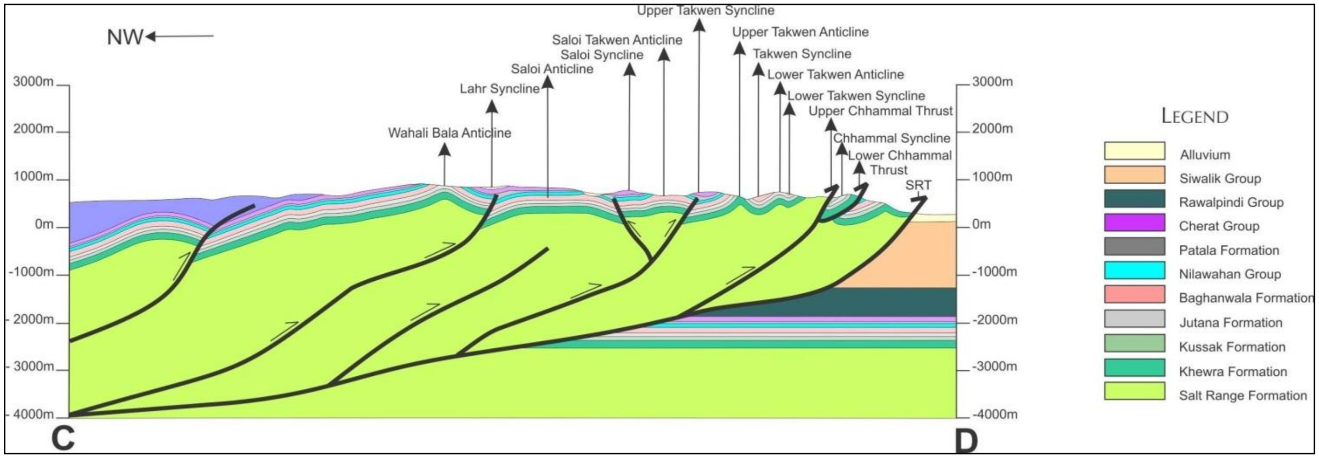

Fig. 2. Cross Section along traverse line

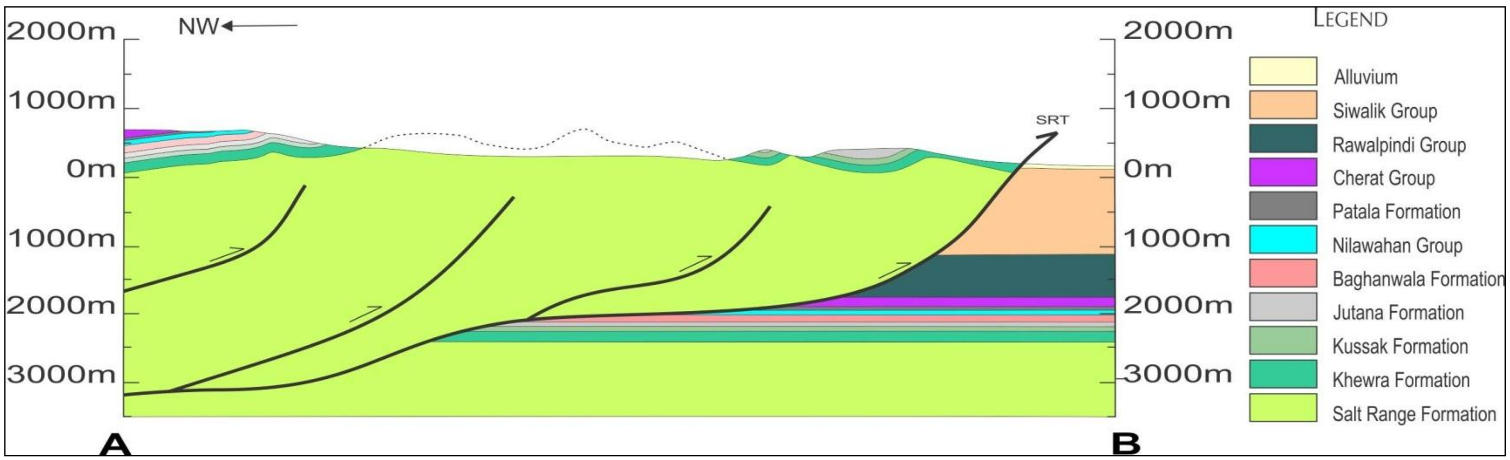

Fig. 3. Cross Section along traverse line AB.CD.

Occurrence of man-made disasters during operation against Talibanization in FATA

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After the 9/11 twin towers incident in the united states, the geographical position of the world changed due to declaration of war by the Americans against talibanization. Due to the invasion of the Afghanistan region by NATO forces, the border region of Pakistan with the Afghanistan i.e. FATA also witnessed heavy operations due to the presence of miscreants in those regions. At the first instance, inhabitants of the area had to vacate the areas as the Army had to undertake operation in FATA regions. The locals of the area suffered from huge losses in the shape of lives, property and houses. The geological position of the FATA areas is such that presence of facilities in the shapes of educational institutions, hospitals and roads are minimum. The people of the area live a very simple life. The locals usually built their houses mostly of mud and stones. Stone construction consists of a packing of dry stone masonry walls due to the presence of stone in abundance there. The road networks that are present over there, is mostly shingled roads and seldom black topped. This study presents the type of damage to buildings and roads infrastructure that was damaged during the talibanization period and the operation carried out by the Pakistan Army.

Comparative analysis of the Joint system in the Permian rocks of western and central Khisor Range, Trans-Indus ranges, Pakistan

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This study intends to portray the descriptive and kinematics framework of joint sets observed in the western and central domains of the Khisor Range, Trans-Indus ranges, KPK. Paleozoic to Cenozoic aged rocks exposed in the Khisor Range. The joint system has been studied in the sandstone beds of Chidru Formation in the western and Amb Formation in the central domain of the Permian age Zaluch Group rocks, at different stratigraphic horizons. Two anticlines such as Paniala Anticline in the western domain and Paharwala Anticline in the central domain selected for the desired studies, where Chhidru and Amb formations are dominantly exposed, respectively. Map extension of the joint system observed several meters in length along which there has been imperceptible "pull-apart" movements more or less perpendicular to the fracture surface. T-intersection and X-intersection of joint patterns in the western and central domains observed, respectively. Compressional, tensional and occasionally transitional tension fractures are observed in both flanks. Micro-joints with inconspicuous opening observed on the forelimb of Paniala Anticline in the form of hairline. Some of the non-systematic / random joints are also observed in both domains, which are neither parallel nor perpendicular to the fold axes of both anticlines; they may be induced by restricted fold-related strain. Variant joint orientations observed according to the structural location on a fold and reveal whether a joint forms during the progression of the fold. These anticlinal folds that advanced along simple geometric pathway may evolve synfold-related joint sets, with characteristic structural features such as the orientation and joint density. Most of the joints are systematic but some non-systematic joints are also present, particularly in the western domain. This variation in joint-system reflects the fold growth history and reveals the fluid flow and storage potential of the region as well.

Frontal structural style of the Khisor Range, northwest of Bilot: Implications for hydrocarbon potential of the northwestern Punjab Fore Deep, Pakistan

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Khisor Range of the Trans-Indus ranges is a south-vergent fold-thrust belt that defines an east-west to north-northeast trending structural geometries and protrudes southward into the northwestern Punjab foreland deep. This range is characterized by eastwest to north-northeast trending parallel to en echelon, plunging anticline and syncline pairs that appear asymmetric to overturn in the form of fold train and dominantly south vergent. The frontal foothills of the Khisor Range comprise a latest partially emergent thrust fault named as Khisor Thrust. Surface projection of the emergent structural elements to depth suggests a thin-skinned structural mechanism for evolution of the Khisor Range where gliding horizon for the frontal thrust sheet has been located within the Nilawahan Group rocks of Permian age at a maximum depth of 3~4 km. The structural growth of the Khisor Range is dominantly attributed to the south directed transferal deformation mechanism along the basal detachment horizon being exposed at the foot of the Permian Warchha Sandstone. Along this basal detachment surface the Warchha Sandstone is emplaced over the Siwalik Group rocks southward on top of the northwestern frontier of the Punjab Foreland. Thrusting, generally commenced subsequent to deposition of the Siwalik Group rocks, for the reason that these rocks are involved in the latest thrusting phase of deformation. The Khisor Range front is the latest and dynamic frontal fracture zone of the northwestern Himalaya where deformation still continues in the course of southward progression. The Khisor Thrust demarcates the northwestern proximity of the Punjab Foreland and is predominantly underlain by the shallow marine rocks of Permian to Triassic age in the vicinity of Bilot. The stratigraphic framework of the Khisor Range is significantly associated and correlative with the Surghar and Salt ranges with some exceptions. Permian strata of the Khisor Range comprise of Nilawahan and Zaluch groups rocks, where the top of the Nilawahan Group consists of the Sardhai Formation and bottom of the Zaluch Group consists of the Amb Formation. The Sardhai Formation observed 40m thick and consists of dark gray to blackish gray and black carbonaceous shale while the basal parts of the Amb Formation consists of dark gray carbonaceous and calcareous shale of more than 20m thick, which is conflicting to the stratigraphic setting of the Surghar and Salt ranges. The structural geometries and stratigraphic framework of the Khisor Range suggests that the northwestern Punjab fore deep is pertinent for the hydrocarbon exploration as thick carbonaceous shale facies of both formations are possible potential source rocks.

Structural geometries of the frontal fracture zone of the northwest Himalayan orogenic belt of Pakistan

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The Marwat-Khisor and Salt ranges of the northwestern Pakistan depict the most latest and frontal fracture zone of the Himalayan deformation. These ranges define an east-west to northeast bearing fold-thrust belt bordering the outskirts of the Bannu Basin and Potwar Plateau in the south. Imperative structural elements of the Khisor Range are the Paniala, Saiyiduwali, Mir Ali and Khisor anticlines along with a frontal fracture zone in the form of Khisor thrust zone whereas Marwat Anticline construct the key topographic expression of the Marwat Range. All these anticlinal folds are generally asymmetric, overturned exhibiting south facing geometry. Construction of the balanced structural cross sections across the Marwat-Khisor ranges suggest that the structural style is thin-skinned encompassing decollement related thrust-fold assemblages, kinematically related to a regional basal decollement located at the foot of the Jhelum Group rocks. The Marwat Anticline initially developed as a medium amplitude detachment fold. This anticline was later on displaced southward over a non-emergent fault ramp to produce fault bend fold geometry. This episode was followed by a new ramp from the basal decollement in the south, forming fault-bend anticlinal folds in the overlying strata and at last emerged as Khisor Thrust at surface juxtaposing Jhelum Group against the rocks of Siwalik Group creating the latest frontal fracture zone of the northwestern Himalaya.

Kinematic evolution of the Paleozoic rocks exposed in Nowshera region, Khyber Pakhtunkhwa

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Microscopic to mesoscopic structures preserved in the Paleozoic age rocks of the Nowshera and Panjpir formations show the early ~ 47±3 Ma NW-SE horizontal bulk shortening tectonic event across the western hinterland zone of Pakistan. A consistent NE-SW trend of tectonic stylolites, foliations, stretching lineations and synchronously developed veins, which are perpendicular to theses structures indicates NW-SE horizontal bulk shortening in the study area. This event predates the ~ 31 to 23 Ma ESE-WNW trending F_4 deformation events related with the development of the Swabi Synclinorium and rocks exposed to the north-east of Nowshera region. NE-SW microscopic to mesoscopic structures preserved in Nowshera and Panjpir Formations appears to have been responsible for the generally NE-SW trending structures of ~47±3 Ma age associated with F_1/F_2 deformation event recognized previously by detailed micro to meso structural analyses in the western hinterland zone of Pakistan. The Paleozoic rocks exposed in the northeastern part of the Peshawar basin pivoted anticlockwise in Swabi region relative to the same age rocks exposed to the west in Nowshera region around the ESE-WNW trending fold axis of the Swabi Synclinorium.

Kinematic evolution of the Middle Jurassic Samana Suk Formation, Hazara Division, Khyber Pakhtunkhwa, Pakistan

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Penetrative finite strain was calculated for the Middle Jurassic Samana Suk Formation exposed along the Abbottabad-Nathiagali road section using elliptical ooids as passive strain markers. Strain analyses of deformed ooids using the Fry and Rf/Phi methods constrain the kinematic evolution of NE-SW trending structures consisting of map scale fold axes and faults in the Nathia Gali Block. The overall deformation axes obtained at several localities by systematic determination of strain ellipses on 29 digital photomicrographs from 12 oriented samples using the Fry and Rf/Phi methods are quite similar to the structures that accommodated NW-SE directed horizontal bulk shortening in the Block. Orientation of strain ellipses (φ) in studied samples lies in range 47^{Oo} to 89^{O}. Average orientation of these strain ellipses is 67.7^{Oo}. The strain ellipticity (R) ranges from 1.06 to 2.05 with the average ellipticity of 1.31. Strain magnitude calculated from all sample shows ~ 7.41% to 16.77 % shortening. The average shortening that took place across the study area is ~ 12.3%. Ooids distortions show lengthening in the direction of map scale fold axes. The NE-SW trending Bagnotor fault, Fold axes (major and minor), tectonic stylolites and longest axes of deformed ooids indicate overall NW-SE shortening.

Microfacies analysis and sequence stratigraphic modeling of the Samana Suk Formation, Chichali Nala, Trans Indus ranges, Punjab, Pakistan

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The depositional environment and sequence stratigraphy of the Samana Suk Formation based on field and petrographic data is presented. The Formation is mainly composed of limestone with subordinate sandstone and marl. The limestone is medium to thick bedded and nodular at places with interbeds of sandstone and thin conglomerate intervals. The sandstone is reddish brown in color, quartzose and bioturbated.

Four carbonate microfacies and one calcareous sandstone lithofacies have been identified, these microfacies include; 1) Laminated Lime Mudstone, 2) Bioclastic Lime Mud-Wackestone, 3) Bioclastic Wacke-Packstone, 4) Bioclastic Grainstone; a) Bioclastic Peloidal Grainstone Sub- microfacies, b) Bioclastic Ooidal Grainstone Sub-microfacies. On the basis of these four microfacies and a lithofacies the Samana Suk Formation is interpreted to represent deposition on the inner ramp having microfacies of near shore to beach, lagoonal, barrier shoal and deeper sub-tidal ramp. Vertical successions of microfacies indicate fluctuating sea level changes marked by transgressive/regressive cycles.

Two second order and four third order sequences have been recognized within the Samana Suk Formation. Their regional correlation based on sea level curve helped to understand facies dynamics. Hardgrounds are present within the formation at various intervals representing condensed section.

Identification of target areas for base metal (Ni, Cr and Co) mineralization based on GIS and QEMSCAN analysis of stream sediments in the ultramafic-mafic terrains along the Shyok Suture Zone, North Pakistan

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This study demonstrates the strength of a GIS-based approach to the analysis of a stream sediment geochemical dataset and automated quantitative mineralogy using Quantitative Evaluation of Minerals by Scanning Electron Microscopy (QEMSCAN) to identify target areas for Ni-Cr mineralization along the Shyok Suture Zone, North Pakistan. A huge geochemical database (>2000 samples), generated as a result of extensive sampling campaigns by the Australian Aid Program (1992-1993), has been utilized for this study to identify prospect areas for mineralization.

The geochemical data was synthesized through Arc GIS 9.0 and generated spatial catchment maps with high concentration of Ni, Cr and Co directly related to mafic-ultramafic rocks along the Shyok Suture Zone. Representative stream sediment samples collected from these areas were subjected to advance mineralogical techniques in order to identify modal mineralogy and mineral associations. The dominant mineral phases are identified as pyrite, chalcopyrite, galena, pentlandite, cobaltite and chrome spinel. The high concentration of Ni, Cr and Co and mineral content in the studied samples suggests that the mafic-ultrmafic rocks of the Teru, Yasin, Pakora and Bagrot areas along the Shyok Suture Zone have high potentials for metallic mineralization.

A geochemical model has been established by correlating the results of the present study with those of known base metal mineralization in Chilas and Jijal along the Indus Suture Zone. It is hoped that this model will aid in the exploration of base metal deposits in the remote areas like northern Pakistan.

An appraisal of uranium source potential of granites, associated felsic rocks, kaolin and calcretes of Nagar Parkar area, Tharparkar Pakistan

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In this study geochemistry of Nagar Parkar intrusives has been discussed in detail with particular reference to uranium. The uranium content of southern and eastern plutons is relatively higher as compared to the northern part of the complex. It has been a general tendency that the uranium concentration in pink granites is more pronounced. Negative disequilibrium was observed in some samples of granites and kaolins, indicating labile uranium from the system. Major element data revealed that the alkali and alumina contents are in accordance with the uranium productive granites, while silica concentration is higher than the favorable range. So the chances to host any primary mineralization within the granites are not very high. Trace elements pattern and low aegirine-riebeckite concentrations propose that the pink granites have strong crustal input, and may be more favorable for uranium concerns. The uranium data of kaolins indicates the availability of active (leachable) uranium in the system, and subsequent redistribution by circulating ground water might have created a zone of concentration within the kaolins. Additionally calcretes and lignite related Paleocene sandstones in the Thar coal basin, immediately north of the granitic terrain are the prospective hosts for the labile uranium. Rate of disintegration of the rocks, size and relative age also suggest that the pink granites are more likely the source for any secondary mineralization in a nearby host. The granites may be considered as moderate source for any subsequent small scale uranium deposit.

Comparison of granites from the Nagar Parkar (Pakistan) and Malani (India) with reference to uranium and thorium abundances

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U and Th data revealed that the granites of both the suits may be considered as a moderate source for the small scale uranium deposit. Negative disequilibrium in the Nagar Parkar granites and the higher U-content in the wide and extensive zones of kaolin in the low lying inter-plutonic areas suggest mobility of uranium from the system. Higher U and Th concentrations, pronounced hydrothermal activity, relatively higher abundances of trace and REE, and presence of UO_2 in zircons in Malani granites enhance the probability of the creation of primary mineralization. U, Hf and Ta are generally lower as compared to Th, Zr and Nb in the granites of both the suits. Malani granites show relatively higher abundances of favorable trace and REEs, particularly Siwana, which also have higher U/Th ratios (0.11- 4.5). It has been found that the U and Th concentrations increase as a function of high heat production. Nagar Parkar as well as Malani granites contain certain accessory minerals (especially zircon, sphene, apatite, additionally alanite and epidote in Nagar Parkar granites) which can favorably accommodate uranium in their structure. The increase in U–content from east to west in Malani and moderate uranium enrichment in Bara Formation and calcretes in Tharparkar are indicative of probable transport, suggesting mobility of uranium from the system. Therefore, lignite-related sandstones of Bara Formation in Thar coal basin, adjacent to both the igneous suits and calcretes in the desert environment may be the prospective hosts for secondary uranium deposits.

Landuse-land cover change assessment in Swat valley

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The objective of this research was to determine the rate of environmental degradation and changes associated changes in the landuse of Swat valley. LandSat5 TM and LandSat 7 ETM + imagery for the same season were acquired from USGS GLOVIS for the years 1992 and 2011, respectively. The selection of the images was based on availability and quality of the data. The images were then subjected to Band Rationing (i.e. NDVI, NDSI) and Tassled Cap Transformation. The images were classified into seven land cover-land use classes i.e. water bodies, agricultural land, pastures (all grazing land including, shrub lands and grass lands), open forest, dense forest, mixed classes (urban, barren rock and soil) and snow (Fig. 1). The results of the study suggest significant decrease in dense forest cover (13.42 %), snow (8.45 %) and pastures (10.76 %), and significant increase in agricultural landuse (14.59 %) and mixed class (14 %). The decrease in the forest cover and pastures and consequent increase in the agricultural landuse is more likely because of urbanization and legislation. Further studies are needed to establish a link between the decreasing trend observed in snow cover and increasing temperatures. Swat is an ideal place for conducting such studies, as it represents three major ecological zones of the Himalaya-Karakorum-Hindukush System. Therefore, it is recommended that further studies on ecosystem level shall be carried out in the area.

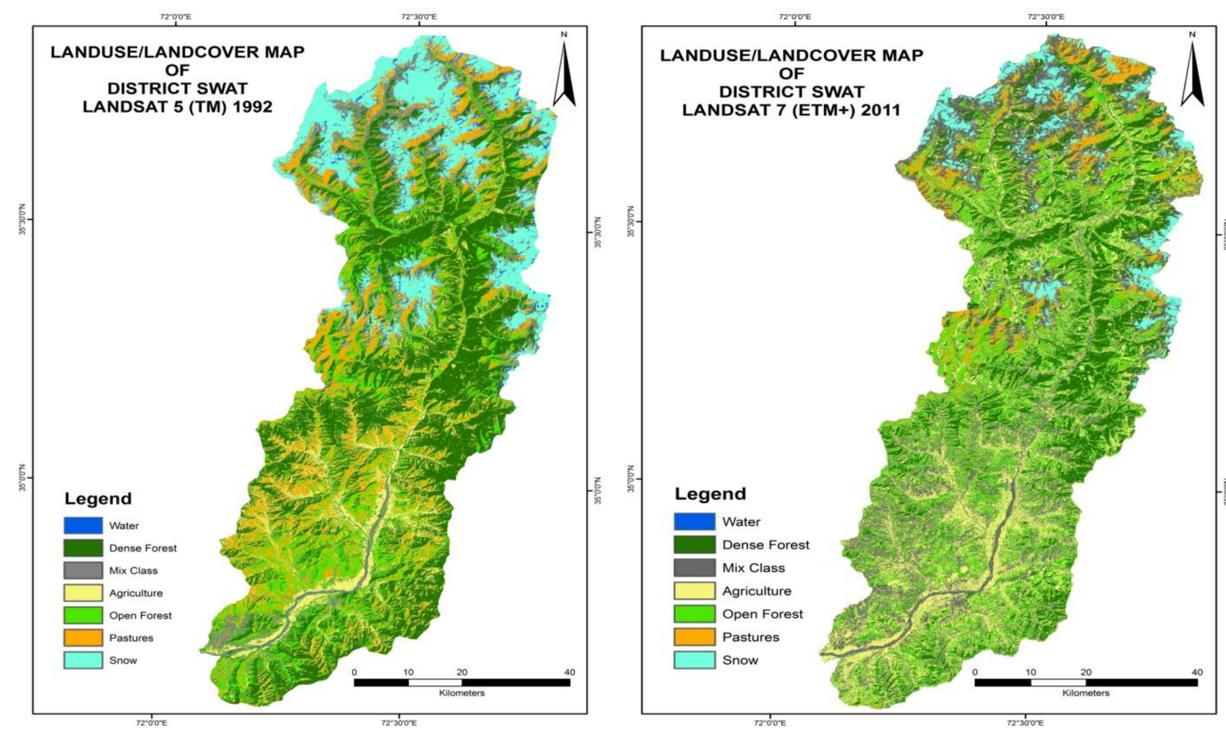

Fig. 1. Comparison of Land Use-Land Cover (processed) images for the years 1992-2011

Role of concrete industry as remedy for the plastic waste disaster

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A modern lifestyle, alongside the advancement of technology has led to a large number of man made disasters. One of these disasters is the increasing rate of plastic waste production, which is a serious environmental problem through out the Globe. The purpose of this paper is to evaluate the role of concrete industry in the growing plastic waste disposal crisis .The reuse of plastic waste is not only helpful in the mitigation of environmental health but it also helps in safeguarding natural resources. The current environmental situation demands that the waste materials must be recycled in order to maintain a pollution free healthy environment. The present study covers the use of waste and recycled plastic as replacement of coarse aggregates in concrete. The purpose of the study is to investigate the changes in mechanical properties of concrete with the addition of plastics in concrete. Along with the mechanical properties, thermal characteristics of the resultant concrete are also studied.

Integration of seismic and rock physics interpretation to confirm Hydrocarbon bearing zone of Meyal area

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A two-dimensional seismic interpretation was carried out in the upper Indus Basin Meyal area to confirm the reservoir characteristics of Chorgali Formation and to define potential locations for test drilling. Time and Depth contour maps of Chorgali Formation helped us to confirm the presence of anticlinal structure in the given area. Surface contour map of Chorgali Formation gives the real shape of sub-surface structure which is anticlinal. This anticlinal structure acts as a trap in the area, which is best for the hydrocarbon accumulation. The corresponding 3D time and depth surface maps also confirmed the above findings. Poisson's ratio and elastic moduli of Chorgali Formation are calculated from Seismic data. Poisson's ratio can be correlated with the elastic moduli (White, 1983). For dry rocks, Poisson's ratio varies directly with Young bulk and shear moduli. Whereas for rocks having fluids, Poisson's ratio tends to increase with decreasing Young bulk and shear moduli (John et al., 2005). This quantitative relationship may provide a simple rule to guess whether the rocks are dry or wet. This theory gives the result that Poisson ratio is inversely proportion to the Elastic Moduli, which means that Chorgali Formation is wet and have fluids, which by correlating with well interpretation can said to be as Hydrocarbons.

Mineralogy, geochemistry and genesis of Manganese ores of Pranghar area, Mohmand Agency, FATA, Pakistan

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The Study area is a part of the Kot-Pranghar Mélange Zone, which is comprised of rocks of ophiolitic sequence and is located at the northern tip of the Indian plate in the vicinity of Indus Suture Zone (ISZ) or Main Mantle Thrust (MMT) along which a thick imbricated mélange zone of greenschist, blueschist, and serpentinite intervenes between the Kohistan Arc and the Indian Plate. The manganese (Mn) ores of Pranghar are present at Nasir, Razim Dherai and Manrai. These occur as medium-bedded lenses/pods up to a meter thick and several meters in lateral extension. These Mn-ores are associated with serpentinites, greenschists, epidote-amphibolites and quartzites. Medium to thick-bedded quartzite generally overlies and the epidote-amphibolite underlies the manganese ore bodies in the study area. Mineralogically, the manganese ores are mainly composed of braunite with subordinate amount of hematite in the fine-grained quartz matrix. The proportion of hematite is highly variable. It is found in higher amount in the ores of Razim Dherai and Manrai areas. The occurrence of brauniteis also confirmed by the x-ray diffractometer.

Geochemically, these deposits are different in terms of MnO and Fe_2O_3 concentration. Nasir area manganese ores have higher concentration of MnO ranging from 20.23 to 42.88 wt%as compared to that of Manrai-Razim Dherai (i.e., 11.04 to 40.60 wt %) while Fe_2O_3 is present in higher amount (i.e., 3.05-23.72 wt%) in the Mn-ores of Razim Dherai and Manrai areas as compared to that of Nasir area (i.e., 0.37-2.87 wt%).Rest of the major oxides exhibit more or less same concentration in the Mn-ores of these areas. Trace elements such as Pb, Zn, Cu, Cr, Ni, Co are also having more or less similar amount in all these three Mn-Ore bodies. Various discrimination diagrams as proposed by several workers in order to distinguish manganese ores of various origins have been used to understand the hydrothermal or hydrogenous input during the formation of these Mn-ores. By plotting of the major and trace elements data in these diagrams, it is concluded that the hydrothermal solution is responsible for the formation of the studied ores.

Based on field evidences and geochemical and mineralogical data it is suggested that the studied Mn-ores formed due to exhalation of hydrothermal fluid along the mid ocean ridge in the Tethys Ocean where it was precipitated as concordant bodies due to physiochemical changes. Later on these deposits were obducted onto Indian plate continental landmass, as a part of ophiolitic sequence during Himalayan orogeny. It is also found that Mn ore of Nasir area has more economic significance than the Manrai-Razim Dherai areas.

Seismic risk reduction of unreinforced brick masonry buildings using Ferrocement overlay

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Ferrocement overlay is the surface application of steel wire mesh and plaster. The technique, which is low in cost and simple in application, may effectively be used to increase the vertical and lateral load carrying capacities of unreinforced masonry that results in reduction of seismic risk. This article presents a state-of-the-art review on ferrocement overlay and its application to unreinforced masonry buildings in Pakistan to reduce seismic risk. Various experimental tests performed on application of ferrocement overlay to local masonry have been discussed. Based on these test, it is concluded that ferrocement overlay increases the seismic capacity of single and double unreinforced masonry buildings in Pakistan by two times and thus substantially reduces the seismic risk.

Bara Thrust Zone, Southern Khyber Agency, Northern Pakistan: Insight for the tectonic boundary between the Attock-Cherat-Khyber and the Kalachitta-Samana Hill Ranges

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This study presents the first geological map for Survey of Pakistan topographic sheets of 38-O/1 and 38-O/5. The studied area falls at the south-western margin of the Peshawar Basin covering parts of the administrative units of the Peshawar District, Khyber Agency and FR Kohat. The area marks the junction between two tectonic blocks; Khyber in the north and the Samana block in the south, characterized by three sub-parallel thrusts in the vicinity of the Bara River, which we term as the Bara Thrust Zone. The Khyber block in the mapped area consists of three major units including Shagai Formation, Khyber Limestone and Landikotal Slate, with minor Carboniferous-Permian limestone in the NW part of the mapped area and some undifferentiated ?Jurassic-Cretaceous rocks in the middle. The Kotal-Samana block consists of the Jurassic Samana Suk Formation and the Paleocene Hangu, Lockhart and Patala Formations. The two tectonic blocks do not have direct contact exposed in the area. Rather, this contact is concealed under the Miocene Murree Formation. Presumably, the Murree Formation was unconformable deposited on rocks belonging to the two blocks. However, subsequently the Murree Formation was involved in the MBT related and younger deformation phases. The original unconformable contact at the base of the Murree Formation is preserved at a few places in the mapped area including Shin Qamar, and Tapu Killi, where it is deposited on top of the Patala Formation. Elsewhere, the Murree Formation occurs in the footwall of thrust faults. The most northerly exposure of the Murree Formation is along a NW trending line from Azarai Khandarai in the east, through Malik Din Khel, Mir Baz Garhi to Sara Palai, at the southern banks of the Bazar Nala. Much of the margin of the Murree Formation at the eastern parts of the mapped area is covered by alluvial fans related with the Bara River and its tributaries. From Mir Baz Garhi towards the NW, the Murree Formation is thrust over by the Precambrian Shagai Formation. This thrust is termed here as the Bazar Thrust and has a SSW vergence. Southern most exposures of the Murree Formation are in the footwall of the Bara Thrust. Unlike the Bazara Thrust, here Murree Formation is thrust over by Paleocene Lockhart Formation of the Kotal-Samana Block along a north-vergent thrust. About 10 km wide exposures of the Murree Formation between the Bazar Thrust in the north and the Bara Thrust in the south is internally breached by another prominent thrust on the northern banks of the Bara River, termed here as the Shin Qamar Thrust. This thrust is also north vergent like the Bara Thrust and likewise thrusts Samana block i.e., Paleocene Lockhart Formation over the Murree Formation. However, unlike the Bara Thrust, the Shin Qamar Thrust carries Palaeocene units as well as the Murree Formation in its hangingwall with the original unconformable contact being the Palaeocene and the Miocene being intact. Amongst all the major thrust faults exposed in the studied area, the Bara Thrust is most complicated in terms of its kinematics, vergence and stratigraphy involved in thrusting. Whereas the eastern half of the Bara Thrust is between Lockhart Formation and the Murree Formation, the segment west of Isakai, has Jurassic Samana Suk thrust over Lockhart-

Patala Formations. Another prominent thrust (Tazikhel Thrust) trending NE joins the Bara Thrust from the SW parts of mapped area forming a thrust wedge comprising Samana Suk Formation. Unlike the Bara Thrust, the Tazikhel Thrust has a south-southwest vergence. It is notable that Dara-Adam khel part of the Kotal-Samana Block has characteristic mushroom-shaped fold structures cored by Samana suk Formation with their divergent overturned limbs breached by oppositely verging thrust faults. We interpret the Isakai structure to be a mushroom-shaped east plunging fold structure with Bara-Tazikhel thrusts as the breached divergent limbs of this fold structure.

Our major results of this study are as under:

1. Four major faults occupy the junction between the Khyber and Kotal-Samana blocks SW of Peshawar, collectively defining the Bara Thrust Zone.
2. Of these, the south-verging Bazar Thrust, with hanging wall comprising Precambrian Shagai Formation (equivalent of the Dhakhner-Hazara Formations) and the footwall comprising the Murree Formation together with the underlying Kotal-Samana lithologies (Palaeocene Lockhart and Patala Formations) marks the extension of the Hissartang Thrust of the Attock-Cherat Ranges.
3. With the recognition of the Bazar Thrust as the extension of the Hissartang Thrust, this study completes the delineation of the hinterland-foreland boundary in the NW Himalayas of Pakistan.
4. The presence of the Murree Formation at the northern flanks of the Hill Ranges and its involvement in thrust faults confirms post-Miocene development of the Hill Ranges related with Main Boundary Thrust phase of deformation.
5. The Isakai triangular Samana suk faulted block between Bara and Tazi khel faults is a fault-breached mushroom fold structure characteristic of the Kotal-Samana Hill ranges.

Characterizing hydrocarbon traps through surface geology and subsurface geophysics in the Talagang area, Potwar Plateau, north Pakistan

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Hydrocarbon traps in the Potwar Plateau are generally structurally controlled; however, local stratigraphic traps are also reported. The structural traps are the product of the Tertiary Himalayan orogeny. This firmly suggests that the structural traps in the Potwar should be analyzed under the framework of fold-and thrust-belt system. For the last about two decades, the Potwar Plateau received much attention in terms of petroleum exploration. In this regard, a number of petroleum national and multinational companies are seriously been involved to understand the structural complexities of the area. However, very limited data is published highlighting the trap configurations and their 2D and 3D geometries.
In this study, a key area known as Talagang, located in the centre of the Potwar Plateau, is selected to decipher the 2D structural geometries of the structural traps. For this purpose, surface geological maps and 2D (after permission from DGPC) subsurface geophysical seismic sections along and across the strike of the beds are integrated. The surface structural cross-section shows gentle-dipping pair of anticline (Jhatla) and syncline (Khichh) with open interlimb angle, therefore, the same, at least part of, is well manifested in the N-S trending seismic sections. However, the E-W trending strike-seismic section shows prominent anticlinal structure. The geometry of this fold is not picked in the N-S dip-seismic section, therefore, it can be inferred that this fold can best be viewed in the E-W strike section. From here, it is interpreted that the axis of this fold is *ca*. N-S, means that this fold is formed by E-W crustal subsurface shortening. Surface expression of E-W shortening is manifested in the form of many folded structures exposed in the eastern part of the Potwar and in the western Trans-Indus Ranges, where N-S trending Surghar-Shinghar Anticline and the Makarwal Anticline are excellent surface examples of N-S trending folds. Thus, it can be further interpreted that the N-S trending structures overprint over the E-W as shown here. This can also suggests the formation of domal (type-1 of Ramsay and Huber fold interference classification, 1987) structures, may be responsible for the trap of hydrocarbons.

Utilization of seismic and petrophysical data for hydrocarbon potential evaluation of Bijnot-01 Well, Fort Abbas Area Central Indus Basin, Pakistan

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Migrated seismic lines 944-FABS-39, 40, 41, 44 and 931-FABS-11 of Fort Abbas area, Punjab Platform and well logs of well Bijnot-01 are used for seismic interpretation and petrophysical evaluation respectively. In this research, four reflectors are identified with Top Jurassic, Top Cambrian, Top Infracambrian, and Top Basement. Only one fault is interpreted on the seismic sections on the basis of the breakup of reflectors. The time and depth contour maps are also generated to delineate the lateral extension of the reservoir and its closure. The Fort Abbas area lies in the extensional regime resulting in horst and graben structures, however, the prospective zone for hydrocarbons are mostly found in horsts. Petrophysical evaluation of well Bijnot-01 is carried out to highlight the reservoir area. Well log data of the Gamma Ray, Spontaneous Potential, Density, Neutron and Sonic Logs are used for identification of lithology, calculation of volume of shale and Porosity, saturation of hydrocarbons, and water and finally the reservoir estimation. On the basis of petrophysical evaluation, it is noted that clastic reservoir Jodhpur Sandstone has good shows of oil. The major reason for well failure is its location as it was drilled downdip making it unsuccessful. According to current studies, Bijnot-01 has a very good trap and seal for the accumulation of hydrocarbons. For good economic potential of hydrocarbons like in the Baghewala-01 well of the Bekaner Nagur Basin, India, an updip drilling of the Bijnot-01 well is suggested.

Study of shear strength of rocks from Kohat area formations

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Shear strength plays a vital role in the designing of mining and civil structures within or on the rocks. The parameter can be determined either through direct or indirect methods. Many mining and civil structures have been constructed and many are under consideration in the area majorly in limestone. Shear strength of the rock type of the area has been determined using indirect methods previously. However it is extremely necessary to apply direct methods for comparison purposes. In this study shear strength of Kohat Limestone was determined from direct method using shear box apparatus. Tests were carried out under constant normal load condition (CNL). Nine samples were tested under constant normal load up to 0.020% of ∂_C (uniaxial compressive strength). Barton model was fitted to laboratory test data. Joint wall roughness coefficient (JRC) was obtained from the impression of joint wall roughness and compared with Barton standard profiles. Since these were fresh joints, therefore uniaxial compressive strength (UCS) was used as joint wall compressive strength (JCS). JRC and JCS values were same for all the samples. Microsoft Excel built in optimization tool so called "Solver" was used to optimize the basic friction angle, Analysis of the results were compared with indirect method for determination of the said parameter. It was observed that the frictional angle determined for Kohat Limestone using direct method is close to that from indirect methods but on higher side.

Mountain Geo-Risk Assessment Model for Community Based Disaster Risk Management in Pamir Region

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The research titled 'Mountain Geo-Risk Assessment Model' is being carried out in three countries of Central Asia namely Afghanistan, Tajikistan and Kyrgyzstan under the project PAMIR (Poverty Alleviation through Mitigation of Integrated high mountain Risk) with the specific objectives of generating and appraising knowledge on the linkages between environment, disaster risk and poverty in selected communities alongside the Pyanj River (Tajikistan/Afghanistan) and Trans Alai valley (Tajikistan, Kyrgyz Republic) to increase resilience of mountainous communities to geo-hazards and to provide a platform for negotiating strategies on integration of environmental sustainability into policies among stakeholders of all levels, creating awareness on causes and effects of un-sustainable environment and disseminating knowledge on efficient interventions.

The problems that the target areas face are scarce renewable land resources, overuse of limited land for agricultural purposes, outdated irrigation systems, reduced soil fertility, food security issues, deep poverty and increased natural hazard threats

In order to develop policy recommendations on effective and multi-dimensional measures, trans-disciplinary research is necessary focusing on linkages between disaster risk, environmental degradation and poverty. Mountain communities of Kyrgyzstan, Tajikistan and Afghanistan should be empowered to reduce the risk from and vulnerability to the natural hazards they face through better and more accurate information.

Our multi-step approach implemented by a team of professionals including two geologists, a civil engineer, a GIS Specialist and a social mobilizer first seeks to identify risks through:

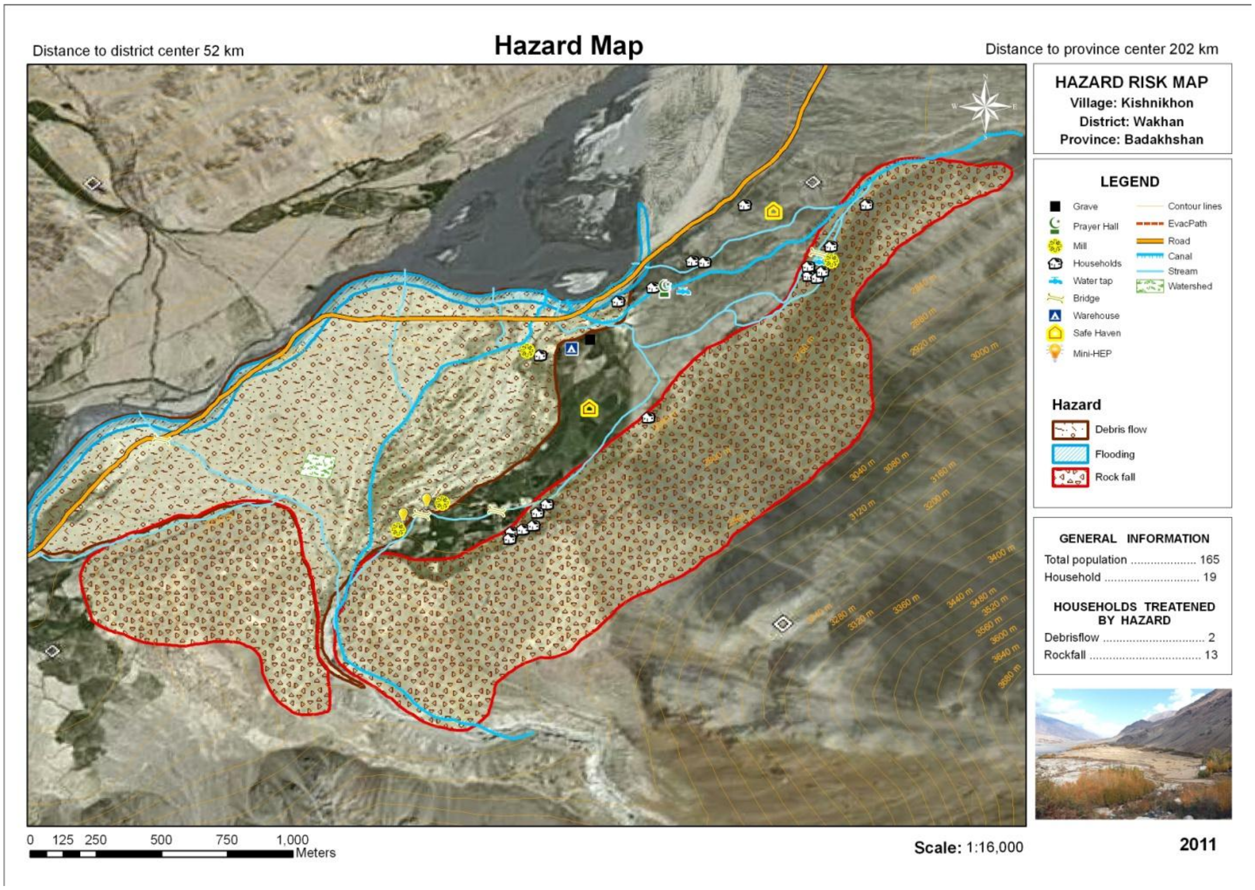
- The application of community-based natural hazard and vulnerability risk assessments (HVRA) which integrated both scientific and indigenous knowledge.
- The second step of this approach generates risk knowledge by taking assessment information, risk analysis, applying GIS-based risk mapping and risk modelling as a means to determine priority villages as well as re-producible and impactful risk reduction interventions.
- Finally, the risk information is disseminated by applying a suite of activities to build capacity, reduce vulnerability and, where possible, even reduce the physical risk of hazards threatening local communities and authorities.

The research study also focuses on remote geo-hazards such as GLOFs, Surging glaciers, composite and landslide lakes etc through remote sensing techniques as well as existing GIS data on remote geo-hazards and helicopter surveys.

The final expected outcomes of the study include

- A comprehensive village database which can be used by a village for disaster preparedness planning, mitigation and response activities
- Generates maps of village infrastructure, hazard impact zone and the threat posed by these hazards (Hazard/Risk Maps)
- Provides a map and statistical base for mitigation activities
- Graphic evacuation routes and safe havens

These will help communities on local level and policy makers on national level to bridge the gap in their response and DRR interventions respectively.



Petrographic, geotechnical and structural investigation of Sher Dara dam site, Swabi, Khyber Pakhtunkhwa, Pakistan

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The igneous rocks around Sher Dara village, Swabi, NW Pakistan are the southeastern extension of the Ambela granitic complex of Peshawar plain alkaline igneous province (PPAIP). The area is a potential dam site for the construction of a small dam and is under consideration of the relevant authorities. The present study encompasses petrographic, geotechnical studies of the foundation and abutment rocks and structural geology of the surrounding area. A correlation of the petrographic characteristics of the mentioned rocks with their mechanical properties has also been attempted.

A detailed petrographic investigation both in hand specimen and thin section leads to a three-fold sub-division of the studied granitic rocks in the area. These include: alkali granite, granite and microporphyritic granite. Geotechnical tests including determination of unconfined compressive strength, unconfined tensile strength, water absorption capacity, specific gravity and porosity were carried out. On the basis of results obtained from UCS and UTS tests, all the studied samples fall in the category of very strong rocks and can provide a suitable foundation for building an engineering structure like a dam. Correspondingly, the values of their specific gravity, porosity and water absorption are within the range permissible for their use as construction material.

A detailed investigation reveals that petrographic details such as grain size, presence of discontinuities, features suggestive of grain boundary recrystallization and intra-grain deformation play an important role in affecting geotechnical properties of rocks. It has been observed that the role of grain size in determining geotechnical properties is more as compared to the other petrographic features.

Topographic map, on which geology of the area has been plotted, was prepared at 1:12800 scale. The joints on both the abutments of the dam were studied and mapped. A cross section was drawn along the dam axis to decipher the behavior of the surface features in the subsurface.

Geotechnical properties of the rocks in the abutments and foundation of the dam site and the structural geology reveal that the area is feasible for the construction of a small dam. However, the granitic rocks at the site have closely spaced joints. Furthermore, the area falls in the high intensity zone of the seismic hazard distribution map of Giardini et al. (1999). Hence in order to avoid any hazard, appropriate precautionary measures must be taken in designing and constructing the proposed dam structure.

Hazard mapping of Mansehra District to identify suitable sites for Urban/Agricultural development using GIS/RS tools

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Pakistan, like many south Asian countries, is home to a multitude of natural hazards. In the aftermath of the October, 2005 earthquake, there was a strong realization of the need of a reliable database consisting of hazard maps, inventories, demographic statistics, critical facilities and vital installation maps. In this context, we prepared a database, several hazard maps of the Mansehra District using GIS/RS tools. Such mapping not only delineated the hazard prone areas but also identified suitable sites for urban and agricultural development. The research primarily relied on secondary datasets that were acquired from a variety of sources.

Our analyses demonstrate that the dominant form of hazard in the district is land sliding. Areas exposed to land sliding are randomly distributed. About 622 km^2 of the district (13% of the total land) falls under High Risk zone. Another 2266 km^2 of the district (46% of the total land) falls under Moderate risk from a landslide hazard perspective. The remaining 2054 km^2 area of the district (44% of the total land) makes up the No or Low risk zone.

The study concludes that the land of the district has huge potential for developing the forest and agriculture sector. Taken together, our hazard and agro-forestry analysis yields four prominent land uses: 1) about 759 km^2 or 15% of the total land is determined to be fit for residential purposes, 2) one third of the total land (1681km^2 or 34%) is found to be suitable for agriculture, 3) one fifth of the total land (1043 km^2 or 21%) is robust for pastures and, 4) another one third of the total land (1460 km^2 or 30%) can be assigned to forests.

Our analysis further show that at the current population growth rate (2.17) the available residential land (759 km^2) would not be sufficient after fifty years to support the rapidly growing population.

Efficiency and capability of existing geo hazards related courses in present times

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This paper presents the Efficiency and capability of existing geo hazards related courses in present times. Geo hazards related courses are not being taught in many departments, colleges, institutions and universities of Khyber Pakhtunkhwa. If they exist in few faculties, even there the courses are discrete. There exists a lot of variation in the course content and its utility and the student response to them. Instructing staff mostly deals with the post hazards effects and solutions for the future disaster scenarios via different hazard models and patterns. It is concern that whether the existing courses are enough for the better understanding of the disaster and coping with them effectively. This research discusses different course module and their utility for the students as well as the institutions.

Impact of sedimentation by across the stream hydraulic structures on human life

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Objective of this research is to elaborate the effect of sedimentation by across the stream hydraulic structures on human life. Sediment deposition in Kohat Toi, Kohat is largely being left unstudied. In this study the different sediment deposits along obstruction i-e barrages and causeways has been investigated. The research revealed that a simple hydraulic structure puts drastic but mostly positive effect on the surrounding. The causeways and barrages have increased the cultivable area the water level resulting in eliminating the risk of droughts and flood on the Kohat City. These sediments are deposited on the upper stream and down stream of these structures hence increasing the useable land and becoming source for the low cost minerals i-e shingle, sand and aggregates.

Evaluation of slates from Attock-Cherat Range for use as structural lightweight concrete aggregate

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Lightweight aggregates are materials having densities less than the usual aggregates and used worldwide to reduce the dead load in bridges, dams and high raise buildings; moreover lightweight aggregate concrete have many comparative advantages in comparison to normal concrete, like fire resistance, thermal insulation, moisture resistance and sound proof structures. For this research samples were collected from different locations following two routs "Kaka Sahib to Akora Khattak (N33°55'56" E 072°02'38") and Attock to Peshawar (N33° 53'55.5" E072°17'08.8"). The Attock slates are located on the northern foothills of the Attock-Cherat Range of Khyber Pakhtunkhwa and Punjab. These slates have been evaluated chemically and physically for their use as structural lightweight concrete aggregate. XRF analyses showed some of the samples having little higher values of iron and loss on ignition, but are still within the permissible limits. Samples were bloated in a rotary kiln. After bloating physical tests were carried out according to the American Standards for Testing Materials (ASTM) specifications. Physical tests including iron staining, bulk density, specific gravity, water absorption, organic impurities, freezing thawing and alkali aggregate reactivity were conducted. Then concrete mix design for structural concrete was designed according to ACI 2112-98 and ASTM 330; concrete cubes, cylinders, and blocks were casted and their compressive, flexural and splitting tensile strength were determined. The results of all these tests were then compared with the ASTM standard values which showed the suitability of these slates for use as structural lightweight concrete aggregate.

Geochemistry of the sandstone of Jurassic Loralai Formation, Sulaiman Fold-Thrust Belt, Pakistan: Implications for provenance and source area weathering

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The Jurassic Loralai Formation is part of the Sulaiman Fold-Thrust Belt, Pakistan, which is predominantly composed of limestone with minor shale, marl and sandstone. Sandstone succession has been discovered in the Feroz-e-Kan and Ziarat Morh sections, southwest of the town of Muslim Bagh. Geochemical analyses of these sandstones were carried out in order to classify and understand the source area weathering and provenance. Geochemically, the sandstone is classified as litharenite. Compared to the Upper Continental Crust (UCC), the sandstones are depleted in SiO_2, and Al_2O_3, and enriched in K_2O and MgO. The Chemical Index of Alteration (CIA) (range: 71.08–83.68) reflects moderate weathering of the source area, and the Chemical Index of Weathering (CIW) (range: 73.87–94.56) indicates high level of weathering. Trace elements analyses indicate depletion of the Large-ion Lithophile elements (LILE), as compared to the UCC. Enrichment of the Zr in the sandstone samples indicates derivation from the zircon-rich source rocks. The Ferromagnesian Trace Elements (FTE), however, show depletion, which suggest very minor input from the mafic and ultramafic source. Plots of the sandstone samples in the tectonic discrimination diagrams indicate derivation from the passive margin setting having quartzose sedimentary and intermediate igneous provenance. We propose that igneous and metamorphic rocks were the major contributors, which were recycled. Therefore, terrigenous detritus of the sandstone has been derived from the Indian Craton, situated to the east-southeast of the study area of the Sulaiman Fold-Thrust Belt.

Structural styles in the Salt Range and Potwar Plateau, northern Pakistan: constraints from physical (centrifuge) modeling

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The ENE-trending Himalayan fold-thrust belt in Pakistan exhibits contrasting deformation styles both along and across strike. Centrifuge analogue modeling has been used to investigate these structural variations. For modeling purposes, the Salt Range and Potwar Plateau (SR/PP) stratigraphy is grouped into four mechanical units. From bottom to top, these are the Salt Range Formation, carapace unit (Cambrian-Eocene platform sequences), Rawalpindi Group and Siwalik Group. These stratigraphic units of alternating competence, composed of thin layers of plasticine modeling clay and silicone putty, rest on a rigid base plate that represents the crystalline basement of the Indian plate. The models are built at a linear scale ratio of $\sim 10^{-6}$ (1mm=1km) and deformed in a centrifuge at 4000g. To examine the effects of frontal/or lateral ramp systems of various geometries, the ramp systems are pre-cut in the model stratigraphic package before each experiment. The models are subjected to horizontal shortening by collapse and lateral spreading of a "hinterland wedge" which simulates overriding by the Himalayan orogen (above the Main Boundary Thrust). The models are deformed in stages so that the kinematic evolution of structures can be monitored. Matched models are serially sectioned transversely and longitudinally to constrain the structure in 3-D. The models of the central and eastern SR/PP show that the accretionary wedge develops a prominent culmination structure with fault-bend fold geometry over the frontal ramp. The main ramp, localized by a basement normal fault, is responsible for the deflection of the hanging-wall package to the surface and repetition of the whole stratigraphic sequence. In the presence of a basement ramp/step deformation readily transferred to the ramp region. As a result, the fault-bend fold over the ramp formed out-of-sequence with respect to other folds and thrusts. Although the main decollement in the models remained within the ductile Salt Range Formation, the eastern SR/PP is characterized by more internal deformation including detachment folds, fault-propagation folds, and pop-up and pop-down structures. Model results show that the transition from fault-bend fold to detachment-fold and fault-propagation-fold geometry in the prototype may take place in a transfer zone marked by an S-bend structure (Chambal Ridge and Jogi Tilla) at the surface and the lateral ramp in the subsurface. The deformation style in the models illustrates the importance of mechanical stratigraphic and basement ramp systems in the evolution and the structural styles of the SR/PP.

GIS-based landslide susceptibility zonation mapping along the Muzaffarabad-Chakoti road in western Himalayan region of Pakistan

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Landslides, and slope failure are one of the natural phenomena that are witnessed in the Himalayan region of Pakistan, causing threat to infrastructure, agriculture lands and settlements. Landslides and roadside slopes failure frequently disturb road construction activities in Himalayan region. Therefore, it is necessary to produce comprehensive landslide hazards susceptibility zonation mapping for an effective disaster management and future planning & development activities in the Azad Jammu and Kashmir region. In this study, we choose a 55-Km road-section along Muzaffarabad-Chakoti road in Jhelum river valley of Azad Jammu and Kashmir area which is a strategic road link to India. Landslides frequently occur in moonsoon rainy season every year and road services are disconnected for several days. There are several concepts, methodology and techniques have been reported for landslide susceptibility zonation mapping. In this study area, we apply weight-of-evidence statistical approach to generate landslide susceptibility zonation in a small watershed area along the Muzaffarabad-Chakoti road in the Himalayan mountain terrain. The various fundamental parameters responsible for landslide occurrence are: slope, aspect, land use, lithology, drainage density and (proximity to road, fault and stream). Relevant thematic layer maps representing various causal factors that affect landslide occurrence have been prepared using Geographic Information System (GIS) techniques. A total 159 landslides of different types and various dimensions have been identified in the study area, which have covered a total of 947 Km^2 areas. A landslide susceptibility zonation map was generated by superimposing landslide inventory map with various parameters contributing to landslide occurrence. The landslide susceptibility zonation maps were divided in four segments, low, moderate, high and very high susceptibility zone. Landslide susceptibility zonation maps are essential tool for an effective disaster management, and future planning and development activities in the Himalayan region.

Crustal study of Bagh and adjoining areas of Azad Jammu and Kashmir based on gravity data

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The gravity survey has been carried out in the Bagh and adjoining areas of Azad Jammu and Kashmir to delineate the subsurface structural elements and thickness of crust.The geological model computed on the basis of gravity data demarcated the Kashmir Boundary Thrust (KBT) within the Murree Formation of Miocene age that dips at an angle of 65º NE in the sedimentary wedge. This fault shows the reverse behavior in study area and joins the Indus Kohistan Seismic Zone (IKSZ) at a depth of 14 Km. The IKSZdips at an angle of 81º NE in the crystalline basement and penetrates up to the Moho depth. In the northeast of KBT, Main Boundary Thrust (MBT) is demarcated between Murree Formation of Miocene age and carbonate rocks of Cambrian to Eocene age that dips at an angle of 44º NE. In this area carbonate rocks are highly imbricated and thrusted over the Murree Formation. The gravity model also suggests that the total thickness of the crust in Bagh area is 51 Km and in Khurshid Abad the thickness extends up to 53 Km. The thickness of sedimentary wedge in Bagh and Khurshid Abad is 14 Km and 16 Km respectively. The thickness of the crust increases due to the stacking of thrust sheets along KBT and MBT. These faults are developed due to the compressional stresses caused by the collision of Indian and Eurasian plates. Thepresent study indicates that these faults are tectonically active and medium range and long range earthquakes are expected in the study area.

Geochemical evaluation of Kathwai area coals, District Khoushab

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The area is located on Khoushab-Kathwai-Nowshera Road. To determine the rank of coal, laboratory tests such as proximate analysis (moisture, volatile matter, fixed carbon and ash), ultimate analysis (elemental composition of organic fraction on weight percent basis; carbon, hydrogen, oxygen, nitrogen and sulfur), heating value, hard groove grindability index (HGI) and petrographic analysis were carried out. The basic knowledge and understanding of coal structure, crucial to understanding of the physical properties of coal and chemistry of conversion processes such as gasification, liquefaction, combustion and carbonization, is gathered through petrology and petrography of the samples. The petrographic analysis of the coal sample was carried out by using the Olympus BX51 microscope, equipped with polarizing accessories, a research grade instrument designed for analytical investigations. Macerals were observed under refracted light. Coal fragments were polished down to less than half a micrometre before they were observed under the microscope. From the results obtained through chemical analysis and petrography (i.e. microscopic and macroscopic study), it is finally concluded that the given coal sample belongs to sub-bitumeous rank with grade-A and is suitable for use in power generation and cement industry, after blending it with the coal having low sulphur content and high HGI value.

Geochemical evaluation of limestone deposits of Pakistan

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Limestone is the most abundant and massively used industrial commodity globally as well as in Pakistan. Type localities and type sections were sampled from top to bottom of the vertical succession of beds of each limestone rock unit for chemical and mineralogical analysis. The results of laboratory studies were then compared with the British standard specifications and it was found that these limestones, namely, Lockhart, Margalla Hill, Samanasuk, Sakesar and Nammal are of great economic importance and commercially exploitable. For each limestone, bulk samples were taken from top to bottom beds in vertical depositional succession at the respective type sections selected for sampling. Limestone and calcium carbonate are used in a wide range of products e.g. glass, ceramics, paper, sugar, plastic, paint, rubber, polishes, dentifrices, putty, insecticides, as a fillerin adhesives, matches, pencils, food, cosmetics, pharmaceuticals and antibiotics. Collected samples were processed, prepared and analyzed chemically for SiO_2, $A1_20_3$, CaO, MgO, Na_2O, K_2O and loss on ignition in accordance with ASTM C 25 - 06. This research work has shown that abundant quantities of limestone spread allover Pakistan is of great industrial usage and bear potential for industrialization and economic revival of Pakistan.

Hydrocarbon Prospects in the Khyber Pakhtunkhwa: Future strategies

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Recently, the Khyber Pakhtunkhwa (KPK) has emerged as a significant contributor in the energy sector of Pakistan following major Oil and Gas discoveries in the Province. In addition to hydro energy supply, this Province is now contributing significant amount of hydrocarbons (18.32% oil and 2.14% gas) in the primary energy supply of Pakistan. Most of the area of KPK is still lying unexplored and therefore, there is a potential of future hydrocarbon prospects in the Province. This study, while providing an overview of the Oil and Gas prospects of the KPK, is aimed to suggest future exploration strategies and target areas.

The Indus Basin, a major hydrocarbon-bearing, sedimentary basin of Pakistan, is having all the major discoveries so far. The Kohat sub-basin, a northwest extension of the Indus Basin in KPK, is the main hydrocarbon producing Basin of the Province.

Despite the fact that the first hydrocarbon discovery was made in the adjacent Potwar sub-basin in 1915, the discovery of hydrocarbon in the Kohat sub-basin is relatively recent and started with a breakthrough discovery from Chanda-1 by Oil and Gas Development Company Limited in 1999. Following this discovery, around 10 hydrocarbon fields have been discovered in the Kohat sub basin since then. The year wise hydrocarbon production has increased from 1.2 to 7.8 million US barrels of crude oil and 20161 to ~125259 MCF of natural gas over the time span of about 05-06 years from 2005-6 to 2010-11. The balance recoverable known reserves are 82 million US barrels of crude oil (31% of the country's total) and 2.3 TCF of natural gas (8.5% of the country's total). Worldwide, discovery ratio amounts to one success per ten wells drilled, however, the discovery ratio in Kohat sub-basin is better than international standards. The high success ratio and the increasing trend in the hydrocarbon production are positive indicators of the future potential of this province.

It is proposed that the hydrocarbon contribution of this province may considerably be improved to meet the growing energy demand of the country by adopting the latest available techniques for conventional hydrocarbon exploration, by selecting new target areas, and by considering the unconventional hydrocarbon resources, such as tight gas.

Now that the provinces have been declared as equal and joint owners of the natural resources after the 18th amendment to the constitution of Pakistan, the responsibility on KPK has increased many folds to be able to further develop and manage its natural resources. It is time to streamline policies involving all the stakeholders. It is emphasized that all policy matters must involve full participation in the decision-making process, of the highly qualified, geoscientists of the academic institutions of the Province.

The orientation of Foliation Intersection Axis (FIA) preserved in garnet porphyroblasts from the Hunza Karakorum as a collision footprint between Kohistan-Ladakh Island Arc and Eurasian plate

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The Karakoram Metamorphic Complex (KMC) marks the southern margin of the Karakorum plate and mainly consists of metasedimentary rock sequences. These metasediments are mainly pelitic with carbonate layers, cut across by granitic sheets. The complex is bounded by the Indus Suture Zone in the south and Karakoram Axial batholiths in the north. This study focuses on detailed microstructural analyses of the metapelitic rocks of the KMC exposed along the Karakorum Highway of the Hunza region. Foliation Intersection Axis (FIA) method of Bell et al., (1995) and matrix foliation overprinting relationship were used to deduce the tectonic history of the KMC. FIA technique measures the axis of curvature of curved inclusion trails preserved in porphyroblasts (garnet and staurolite), whereas, the foliation overprinting relationship further establishes the latest phases of deformation in the given area. A total of 16 samples were collected, however, 11 samples preserved sufficient quality of inclusion trails to work further on FIA technique. Two dominant trends (sets) were measured by ‘asymmetry switch’ of inclusion trail geometry. The older E-W trending FIA (set 1) formed as a result of bulk N-S shortening, whereas, the younger FIA set (set 2) trending NE-SW direction formed as a result of bulk NW-SE shortening. At least two phases of deformation were observed in matrix from the Hunza Karakorum (1) an early phase of intense deformation resulting in the formation of continuous generally E-W and WNW-ESE striking foliation (Fig. 1a,b,c; stage 6 of Bell and Rubenach, 1983 classification) formed in response of N-S shortening, and (2) the latter phase is responsible for the formation of upright to isoclinal folding with an axial planer NE-SW foliation falls in stage 2 to 3 of Bell and Rubenach (1983) scheme (Fig. 1d). The first event represents the south verging tectonics and crustal thickening followed by younger NW-SE shortening event. The geometry of an early FIA set (E-W) preserve an overall clockwise asymmetry, whereas the younger FIA set (NE-SW) preserves counter-clockwise asymmetry, while looking towards west. The data set obtained from this study is significant because it has close similarity to the FIA data obtained from the Nepal Himalaya (Fig. 2; Sapkota and Bell, 2012).

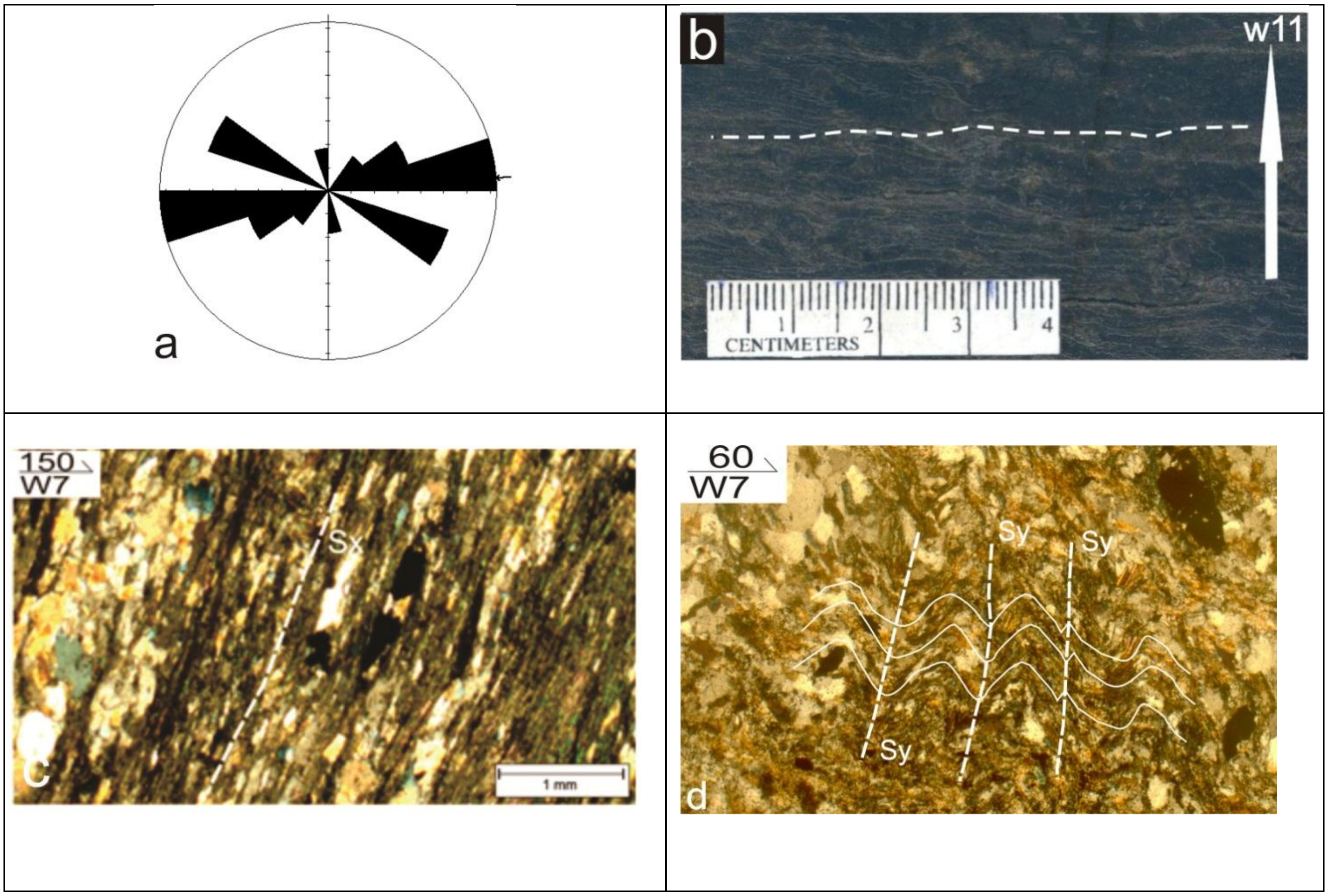

Fig. 1. (a) Rose diagram showing the strike of main foliation measured form horizontal thin sections. (b) Showing microphotograph of continuous foliation in N section of sample W7. (c) Photograph showing trace of foliation in the horizontal slab of sample W6 with north arrow. (d) Open to tight fold with evenly spaced axial plane cleavages in sample W7.

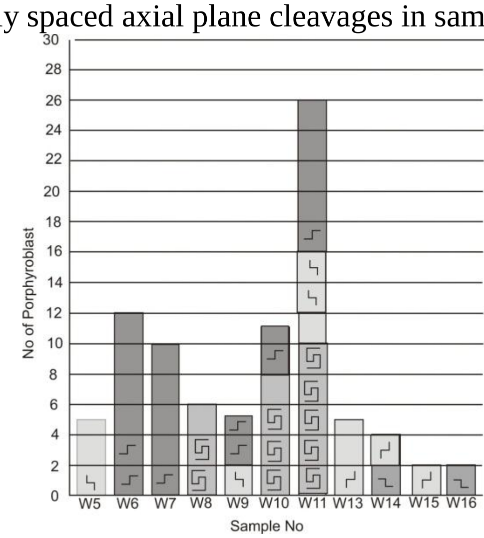

Fig. 2. Graph showing steep to flat (and vice versa) geometry of inclusion trails with respect to sample number. W5 to W11 shows CW asymmetry (FIA set 1) whereas; sample W13 to W16

shows CCW asymmetry (FIA set 2).

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Siting of locations for aquifer recharge in Upper Kurram Valley using Geographic Information Techniques

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Water is an essential part of life. The exploitation of groundwater is as ancient as civilization itself. Majority of the inhabitants of Upper Kurram valley depend on groundwater for drinking and agriculture practices. Drastic declination in water table has occurred in the recent past due to high runoff and low recharge, overexploitation of available water resources,andurbanization.

Through this research, an attempt has been made to identify the potential zones for groundwater extraction, demarcation and natural recharge and devising proper artificial recharge mechanism using GIS and RS tools. In order to observe pre- and post-monsoon water table level in the study area, primary and secondary data was used for the year of 2008. Yearly monitoring of water table reveals that of 0.5m to 2.8m variation occurred in groundwater table in Upper Kurram valley. The water levels are divided into five arbitrary depth zones, on the basis of water table depth. Water table is deepest in the central part of the study area and shallow along the Kurram, Zeran and Kirman rivers.

To identify the potential natural recharge areas, different thematic layers were considered namely, surface slope, land cover, proximity to settlement and road, drainage network, soil and geology. These themes were assigned proper weights and ranks on the basis of their relative contribution to groundwater recharge in the area following the guidelines of ASCE and FAO. Thematic layer were integrated in GIS environment using Overlay analysis. Results reveal that the suitable areas for natural recharge make 14% of the study area, which corresponds to nearly 137 km^2.

To augment the groundwater, artificial recharge techniques can be used to enhance the groundwater capacity. Three artificial recharge mechanisms namely, small dams, percolation pond and plantation were considered and their suitability analysis was performed using seven parameters namely surface slope, settlement, soil, geology, roads, drainage and land use. Results reveal that suitable percentage areas for small dams is 3%, for plantation is 9% and 20% is suitable for percolation pond.

The study can be helpful for government as well as for private organization to understand the groundwater situation in Upper Kurram valley. This study is also supportive in the selection of potential sites for artificial recharge techniques to enhance the declined groundwater situation. Study can be helpful to increase the groundwater availability for domestic as well for agriculture uses.

Microfacies and and diagenetic fabrics of Samana Suk Formation at Harnoi section, Abbottabad, Khyber Pakhtunkhwa

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A detailed geological investigation of the Samana Suk Formation in the Harnoi Section of Abbottabad District, Pakistan was carried out to elaborate its microfacies analysis and diagenetic pattern. Thirty three samples were studied from a 60m-thick unit of the Samana Suk Formation and three microfacies with five sub microfacies were identified. These microfacies included; Grainstone (ooid grainstone, Peloidal grainstone and Intra-ooid grainstone as sub microfacies), Mudstone (partially dolomitized mudstone and Dolomicrite as sub microfacies) and Bioclastic wackstone. The environment of deposition as depicted from the microfacies is beach, bars and shoal for Grainstone Microfacies, restricted lagoon for Mudstone Microfacies and inner to middle shelf for Bioclastic Wackstone Microfacies.

A variety of cement morphologies has been identified from early to late diagenetic phases. Micrite and spar have been developed in different diagenetic settings. Diagenetic features like stylolites, calcite veins, fractures, deformation and ferroan calcite formation are observed. Varying degree of dolomitization has been developed at various levels within the rocks.

Geotechnical aspects of Attabad landslide dam

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The devastating landslide of 4 January 2010 at Attabad in Hunza valley involved a massive movement of over 50 Mm^3 of rock and debris that created a blockade on the Hunza River. The landslide could not be readily linked with any specific triggering mechanism; it can be associated with the Astore Valley Earthquake 2002 that resulted in initiation of cracks near the top scarp. The landslide dam resulted in submerging about 22 km of Karakorum Highway (KKH). The crest of landslide dam with its height ranging from 162 to 200 m above the river bed across the valley resulted in creation of lake by impoundment of about 450-500 Mm^3 of water within first few months. The impounded water is posing a permanent threat to the stability of adjoining slopes on upstream of the landslide dam that may generate a wave resulting in overtopping of the dam. Furthermore, the lake is also endangering lives and properties downstream in case of overtopping and/or a dam break. The landslide dam is still surviving even after a period of more than two years against initial predictions of dam-break within first few months. Water level in the lake is being lowered by widening and deepening the spillway in stages to minimize the realignment of KKH. The material involved in the landslide consists of hard rock and fine matrix. The hard rock is mainly granodiorite with size of individual pieces ranging from few centimeters to tens of meter, whereas, fine matrix primarily consists of rock flour with traces of silt and clay. Present study discusses the causes of occurrence of Attabad landslide, geotechnical investigation of material involved in the sliding, and performance of the landslide dam since its occurrence. The study also compares the performance of Attabad landslide dam with similar dams that occurred in the world. Laboratory tests suggest that the fine matrix has low plasticity, a small clay-size fraction (particle size $\leq$ 0.002 mm), and very low hydraulic conductivity. The low hydraulic conductivity of fine matrix suggests that possibility of failure due to piping may be very little.

On the relationship between antitaxial vein growth and deformation bands in fine-grained sandstone

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The formation of antitaxial calcite veins in sandstone and their kinematic evolution have received less attention, partly because of their complex growth with respect to wall rock. The modes of deformation in which these antitaxial veins nucleate and deform are still not well understood. For this purpose we have investigated complex network of antitaxial veins and associated shear bands in a hand specimen sample. Since, veins and shear bands accommodate volume gain and loss, respectively; therefore, systematic study of strain partitioning and kinematic track is developed, consistent with the deformation history of the rock under study. Three sets of antitaxial veins and one set of shear band have been recognized. Set 1 consists of veins that are truncated against younger veins and shear bands (Fig.1). Set 2 consists of all those veins that are oriented at low- to high- angle with respect to set 1 veins. These veins cut across set 1 veins or vice versa. This suggests that both set 2 and set 1 form synchronously. Internal geometry of both set 1 and 2 veins form calcite fibers that are asymmetric and interpreted to have developed by repeated growth of fibers, at least in two stages, in two directions (Fig. 1). Set 2 veins have shear sense opposite to that of set 1 veins. The fibers are smoothly curved from median to the margins and this geometrical relationship suggests that the change in the rotation of the kinematic axes was gradual. Power law relationship on length vs frequency of veins suggests that both set 1 and 2 veins propagated sequentially.

Shear bands cut set 1 and 2 veins and are categorized under set 3. These bands are evenly spaced, consist of pulverized/opaque material, parallel to each other and accommodated shearing. Veins belonging to set 4 are relatively thick and cross cut set 1, 2 and 3. The spatial distribution of set 4 veins is low as compared to set 1 and 2 veins. Micro-textural study shows that these veins are filled with blocky crystals of quartz or calcite and are different than set 1 and set 2 veins. At the margins of set 4 veins, asymmetric remnants of calcite fibers are preserved with distinct shear sense. This firmly suggests that set 4 veins initially formed as ‘antitaxial ‘veins with asymmetric fibers, however as the deformation progressed, new material in the form of either quartz or calcite intruded. Detailed fabric analysis of calcite fibers indicates that both set 1 and 2 veins dilated perpendicular to the wall rock and then subsequently sheared in opposite direction. Since, set 1 and 2 veins have an angle ranging between 60^o and 120^o, therefore, we propose that the stretching direction switched gradually with a maximum angle of 120^o. The margins of the veins show asymmetry and distinct shear sense, this further suggests that once formed, both sets 1 and 2 were subjected to shearing. These two sets were then subject to shearing followed by the formation of set 4 antitaxial veins.

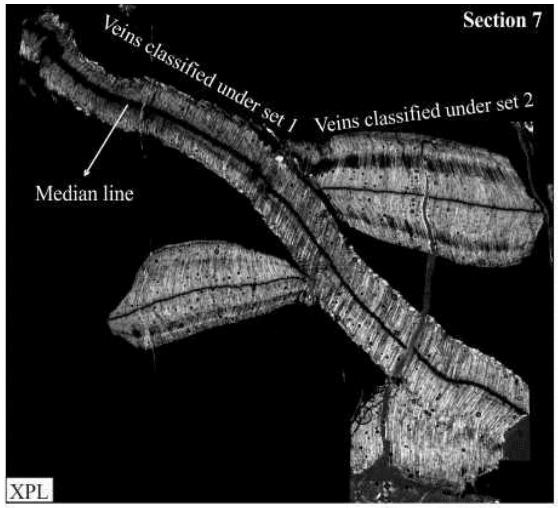

Fig. 1. Micrograph showing cross-cutting relationship between set 1 and 2 veins. In this particular case, set 2 is older. Note that the calcite fibers are continuous from wall to wall with a centered median line and designated as ‘antitaxial veins. Base of the phot is 1.5cm.

Physico-chemical analysis and determination of heavy metals in drinking water of union council, Islampur, Swat

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In Pakistan, majority of population is using ground, tube wells and spring water for drinking purposes. The contamination of these water bodies is a big challenge for safe drinking water quality due to high concentration of toxic elements.

The study was conducted with objectives to assess the drinking water quality, a human health criterion and the concentration of a pollutant in water and different heavy and light metals intake and exposure is expected to pose a significant problem to human health of the union council Islampur, district Swat. Forty samples were collected from different sources i.e. tube wells, springs, open wells and tap water. These samples were analyzed for various physico-chemical parameters and their minimum and maximum value are given with each parameter, such as pH (5.98 to 7.55), conductivity (13.5-699), dissolved oxygen (DO) (3.17-3.23), salinity (0.01-0.03), total dissolved solid (TDS) (527-633), total suspended solids (TSS) (5-10), alkalinity (69.3-404), hardness(132.8-798), chloride (4.7-173), and phosphate (000). The samples were also analyzed for light and heavy metals such ascalcium (Ca)(21.25-141.72), magnesium (Mg)(111.55-655.08), sodium (0-5) (Na), potassium (K) (1-8), lead (Pb) (1.657-0.415), chromium (Cr) (0.112-0.25), zinc (Zn) (0.002-2.381) and Nickel (Ni) (0.029-0.090) respectively. The results were compared with Pak-EPA, US-EPA and WHO standards and some of the elements were exceeding their permissible limits such as E.C 50%, TDS78%, TSS78% Hardness18-80%, calcium70%, magnesium45-70%, alkalinity87%. The results indicatethat the overall situation of the drinking water quality of union council Islampur district Swat is not satisfactory according to the Pak-EPA and WHO (2004) standards.

The study indicates that human health problems in Islampur, Swat area are associated with high concentration of heavy metal concentration and is the main reason for the cause of high risk to the majority of population in the area.

Surface and Groundwater Pollution in Sindh and Mitigation Options

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Sindh province is located in the southeastern part of the country and its climate is semi arid to arid. There is great variability in rainfall and the annual average precipitation is 160 mm. This province constitutes the lower Indus plain with a population of about 40 millions. Its peculiar location and topography makes it prone to floods, droughts and sea water intrusion. Groundwater salinity is widespread throughout Sindh. In many parts of the province, groundwater is also polluted with arsenic, fluoride and pathogens. While almost all surface water bodies (canals, lakes and ponds) are highly polluted with sewage, industrial and other wastes. In some areas surface water is also turbid with poor taste and odor. As a result, there is scarcity of fresh and clean water for drinking and other purpose. Moreover, the untreated surface water is supplied from these polluted sources by municipalities to the most of population in Sindh. Consequently, a large section of the population is suffering from gastroenteritis, arsenicosis, skin lesions and dental fluorosis. Present study is based on 200 drinking water samples collected from surface and groundwater sources in nine districts of Sindh (Thatta, Jamshoro, Hyderabad, Matiari, Tando Mohammad Khan, Tando Allayar, Tharparkar, Badin and Nawab Shah). These water samples were analyzed for physical and chemical characteristics to determine (i) suitability for drinking purpose (ii) identify pollution types (iii) trace their geogenic and anthropogenic sources and (iv) suggest mitigation measures.

Flood 2010 damages in Khyber Pakhtunkhwa

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The flood of 2010 incurred damages in all four Provinces of Pakistan, which were estimated to be many times greater than those caused by the Kashmir Earthquake 2005. More than one thousand people were killed; millions of people were made homeless and displaced. Millions were left without food and clean drinking water and were later on exposed to different kinds of diseases.The flash flood swept away all kinds of man-made structures,which came along its course. These included different types of buildings, bridges, roads, water diverting and retaining structures, electricity and telephone towers. This paper focuses on the assessment of damages of buildings and bridges in the province of Khyber Pakhtunkhwa. Stone masonry buildings and adobe buildings (mud construction) were the worst-hit structures and followed by structures made with burnt-bricks laid in mud-mortar. Foundation settlement was also one of the causes of the damages in the buildings. Bridges including suspension and reinforced concrete were also damaged partly because of their structural deficiencies and partly because of inadequate hydrological studies.

Energy saving & retarding land pollution by using waste Polymers in mortar

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Land pollution may in turn slowly destroy our natural environment which is already at risk. Waste generated from polymers is a major contributor to land pollution. Polymer waste is generally dumped in open spaces and become a breathing space for mosquitoes and flies. This results in unhealthy environment and epidemic diseases. It is therefore, necessary to manage or recycle these wastes. An efficient practice may be to incorporate polymer waste in mortar. This paper investigates the possibility of using different polymers in cement mortar to produce thermal resistant mortar. Polymers selected for study are scrap polyvinyl chloride pipes (PVC pipes) and raw material of polyethylene terephthalate bottles (PET bottles). Scrap rubber tire waste is also not recyclable or reusable and only 5% of tire waste is recycled rest is dumped into open grounds, which again is hazardous to environment. In this study performance of mortar incorporating 10%, 20% and 30% polymers as volume replacement of fine aggregate was investigated. Results showed that incorporating polymer waste in mortar increases thermal resistance of mortar, compressive strength on the other hand is deteriorated. Based upon findings of the experiments performed it can be concluded that polymers can be used in mortar to increase its thermal resistance and subsequently reducing environmental pollution.

Miscellaneidae: A biostratigraphic tool for hydrocarbon exploration

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The family Miscellaneidae of larger foraminifera is restricted to the Paleocene and earliest Eocene of the Tethyan carbonate platforms. The two species (*Miscellanea miscella* and *Miscellanea juliettae*) of this family are common in the Paleocene of the Indus Basin. Due to the small size and diagnostic morphological differences, the *M. juliettae* can be easily distinguished from the *M. miscellae*. The *M. julietta* is restricted to the shallow benthic Zone 3 (SBZ3; Thanetian) and is thus a diagnostic larger foraminifera of the hydrocarbon-bearing Lockhart Formation.

Mianwali and Tredian formations; An example of the Triassic progradational deltaic system in the western Salt Range, Pakistan

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The Nammal Gorge in the Western Salt Range, Pakistan, nicely preserves a record of the interacting Triassic progradational deltaic system and fluctuating relative sea level. The lithofacies analyses show carbonate accumulation at the bottom, followed by shale/mud that grades upward into mixed-carbonates, and clastics of the Mianwali Formation and concludes in fluvial-continental sandstones of the Tredian Formation. Bioturbation, ripple marks and mudcracks are observed in Mianwali Formation, while cross bedding is dominant in the overlying Tredian Formation. Soft sediment deformation (internal contortion) are observed and large scale slumps are visible in the Lower part of the Tredian Formation. The petrographic analyses show that the carbonates have shallow marine fauna and have wacke- to packestone texture, while the sandstones are quartz rich with moderate textural and compositional maturities. The two units show deposition in a progradational deltaic setting. An open marine setting, marked by limestone beds, established subsequent to the Permo-Triassic paraconformity that gradually built up into a progradational deltaic system. The thick shales of the Mianwali Formation represent the prodelta shale/muds that were deposited on top of the open marine carbonates. The interbedded sandstones, and shale of Mianwali Formation might represent the prograding clinoforms and/or topsets. The associated carbonates might have been deposited in the less siliciclastic input times in the lagoons or abandon delta lobes. The lower part of the Tredian Formation was deposited in the channel bar, mouth bar and delta lobe setting. The thick sandstone of the Tredian Formation was deposited in a delta plain/fluvial setting with dominant fluvial character.

Tectonic map of the centeral Sulaiman fold belt and its structural implications

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The Sulaiman lobe represents about 400 km wide and as much long zone of foreland deformation along the western terminus of the Indian subcontinent. The fold-and-thrust belt has a curved, convex to the south, expression, in part due to oblique to the plate convergence vector plate geometry, and undergoes through an early stage of foreland thrusting. It is considered as the most prolific hydrocarbon province of Pakistan. However, it is not yet fully mapped/understood, as a seismically active and economically significant zone of hydrocarbon exploration, in the central and southern parts of the fold belt, in-part due to political instability in the Mari-Bugti districts. Mainly, Tertiary and Mesozoic strata comprising marine platform sequence and Neogene Molasse sediments are exposed in this region. These strata are gently folded and gradually uplifted, towards north, along blind thrusts, in the southern Sulaiman fold belt. Further north, the central Sulaiman fold belt is characterized by relatively complex deformation with the presence of folds and faults. Reconnaissance mapping based mainly on Landsat interpretation (Bannert et al., 1992) interprets nappe style of deformation with consideration of large offset thrust faults in this region. I have mapped the area with combined Satellite Image interpretation, surface geology, and subsurface borehole and seismic reflection data (Jadoon, 2010). This data suggests absence of emergent thrusts with offset exceeding 10 km and allow to recognize reverse fault of limited displacement and offset in the central Sulaiman fold belt. The emergent faults are generally of 10-50 km length with offset of 1-2 km. Many of them are foreland and hinterland verging, bounding tight anticlines of Cretaceous and younger strata as pop-ups. They are interpreted to be related to the seismically active deformation of a roof-sequence and evolution of a passive-roof duplex, in the central Sulaiman fold belt. Some of these faults are observed to show a dominant component of dextral strike-slip displacement, suggesting imprints of transpression and rotation along the western edge of the Indian plate. The map, so produced is hereby introduced to the academician and geoscientists engaged in exploration alike, as a contribution for our understanding of the evolving Sulaiman fold belt in Pakistan and for its significance in Hydrocarbon exploration.

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Fractal pattern of different alteration zones in porphyry copper deposits of Reko Dik, Chagai belt, Pakitan.

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Fractal is a mathematical set that has a fractal dimension that usually exceeds its topological dimension and may fall between integers. They represent the idea of detailed self-similar repetition at same scale or they may nearly be the same at different scales. Fractals are geometrical objects with the fractal dimension (*D*). Their fractal geometry deals with the objects and spaces. They occupy space (x,y,z) of any dimension greater than or equal to the dimension of the objects.

In this study, hydrothermally altered zones of porphyry copper deposits of Reko-Dik, Chagai Belt, are taken into account to see whether alternation patterns follow any fractal law. Rowan et al. (2006) carried out detailed spectral analyses of different alteration zones nicely exposed around the Reko-Dik. We have used the same images as base map in our calculations for spatial analysis. A refined box-counting method is used, where the number of boxes (*Nr*) containing the alteration versus the box size (*r*) repeatedly tested. To start with, the scaling properties of box size (*r*) were taken at 0.5 km interval, following 0.5 km addition in each analysis ending at 5 km. The spatial distributions of hydrothermally altered zones show following fractal dimension values: (*D*) for argillic ($D = 1.0\pm0.05$), phyllic (muscovite + jarosite) ($D = 1.2\pm0.04$), phyllic (muscovite) ($D= 0.8\pm0.05$), propylitic ($D = 1.2\pm0.04$), and siliceous ($D = 0.8\pm0.07$). Further work is in progress to refine the *D* values using improved box-counting method (Roy et al., 2007).

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Age and regional palynostratigraphic correlation of the Sardhai Formation, Salt Range, Pakistan

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Palynological assemblages from the Sardhai Formation in the Salt and Khisor ranges of Pakistan have yielded abundant bisaccate pollen and few spores. The well-preserved specimens of *Florinites*? *balmei* are particularly abundant. The presence of this bilaterally symmetrical monosaccate pollen grain, and the stratigraphic context suggest that the Sardhai Formation correlates with the Khuff transition beds of Oman and the basal Khuff clastics of central Saudi Arabia. Hence, the unit is assigned to the Middle Permian, Wordian. *Florinites* ?*balmei* was first described by Stephenson and Filatoff in 2000 from the basal Khuff clastics of Saudi Arabia, and it has since been reported from Oman, Kuwait, southeastern Turkey, Iraq, United Arab Emirates and Qatar. This suggests that the plant that produced *Florinites* ?*balmei* had a narrow palaeogeographic distribution in the Mid-Permian which may be useful in reconstructing the problematic tectonic and paleogeographic history of this complex region.

Petrography and preliminary geochemistry of alkaline mafic dykes in the Nagar Parkar igneous complex, southeastern Sindh

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The Nagar Parkar Igneous complex comprises a series of late Proterozoic granitic rocks emplaced in a basement of amphibolitic rocks. These have been intruded by steeply dipping mafic dykes that are locally in swarms of parallel sheets or networks. Individual dykes are generally no more than a 5 m in thickness and 300 m in length, but some are larger and up to 2 km in length. Our recent field studies show that the mafic dykes themselves are locally intruded by granitic dykes; leading to assume that the latest phase(s) of the granitic magmatism overlapped with the mafic magmatism.

The mafic dykes may have chilled margins, and show considerable mineralogical and textural varaitions. They are fine- to medium-grained and holocrystalline to hypocrystalline; many are porphyritic and some display flow alignment in phenocrysts. One of the dykes in the Ranpur area contains up to 8 cm long, euhedral to subhedral plagioclase phenocrysts in medium- to fine-grained matrix and another near Karai shows some layering which is unusual, considering the small size of the body. The dykes can be divided into two groups on the basis of the principal mafic mineral: amphibole-bearing and titanifeous augite-bearing. Both the types contain zoned plagioclase (labradorite-andesine, commonly sausurritized), opaqueoxide, sphene, apaptite and secondary minerals. Some of the augite-bearing rocks also contain olivine. Field relations are not clear, but the amphibole-bearing dykes appear to be older than the augite-bearing group.

Major element geochemistry suggests that the two groups are not different significantly. Analyzed rocks are alkaline and characterized by high TiO_2 and Na_2O+K_2O contents. Fourteen of the 15 analyses are olivine-normative, with six also being nephelene-normative. Trace element and REE analyses of two pyroxene-bearing and one amphibole-bearing dykes show that the latter is enriched in all the trace and RE elements. However, their mantle normalized trace element and chondrite normalized REE patterns are similar. They show distinct troughs for K, Ce, P, and Ti, and positive spikes for Ba-Rb, Nb-Ta, Sr, Sm-Zr, and Y and have some similarities with continental alkali basalts. Chondritenormalized patterns show depression on Ce, Sm, and Dy, and rise on Nd, and, in the case of the augite-bearing samples, Eu and Ho. Thus, the two groups of rocks may have been derived from two magmas of rather similar composition and from the same source region.

Experimental investigation on the seismic disaster mitigation of unreinforced brick masonry buildings in Northern Pakistan

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The Himalayan region is considered to have the potential to produce earthquakes of magnitude 8.0 or greater once every 100 years. Since the occurrence of an earthquake cannot be prevented; therefore, seismic disaster mitigation remains the only option for the civil society. Unreinforced masonry (URM) buildings, constructed with stone or brick, are very common in Northern Pakistan part of Himalayan belt. The seismic performance of stone masonry was found very poor in October 2005 Kashmir earthquake and was the main source of fatalities as most of the collapsed buildings in the area were constructed with stone masonry. Unreinforced brick masonry (URBM) buildings, however, performed much better than stone masonry buildings, and survived collapse in most of the highly affected areas except Balakot town and in some parts of Muzzafarabad. The performance of URBM would have been much better if buildings were designed and constructed using engineering principles of earthquake disaster mitigation instead of experienced based thumb rules developed by the masons. Taking the lessons from the earthquake disasters of October 2005, the authors carried out an experimental investigation to evaluate and quantify the seismic performance of unreinforced brick masonry (URBM) shear walls constructed using stone dust mortar being widely used in Northern Pakistan, and thus to further promote the research and development for earthquake disaster prevention. In-plane shear-compression tests were carried out on twelve walls, using quasi-static cyclic loading. The effect of geometry and extent of gravity load on various parameters used to quantify seismic performance such as equivalent viscous damping for evaluating energy dissipation capacity, ultimate ductility and drift ratio of the walls is examined and discussed. Finally, drift ratios for performance levels corresponding to various damage levels, for unreinforced brick masonry walls are proposed on the basis of experimental results.
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Revised Lithostratigraphy of the Late Paleocene- Early Oligocene Nisai Group, Pishin Belt, Pakistan

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The Pishin Belt, Pakistan, comprises sedimentary successions of Late Paleocene through Pleistocene age. We define the Late Paleocene-Early Oligocene Nisai Group as the shallow marine succession that nonconformably overlies the Muslimbagh-Zhob Ophiolites and is conformably overlain by the Oligocene Khojak Formation. Based on our field observations, in four measured sections, we propose to subdivide the group into three distinct and mapable lithostratigraphic units of the formation rank, which, from base to top, are; Akhtar Nika Formation, Jabrai Formation and Nisai Formation.

The lower Akhtar Nika Formation comprises rhythmically interbedded limestone and shale succession possessing characters of turbidites. The limestone beds are composed of fragmented and recycled larger foraminifera, miliolids and red algae of Late Paleocene to Early Eocene age. The middle Jabrai Formation dominantly comprises of soft greenish to olive coloured mudstone with minor shale, calcareous sandstone, coquina limestone and thin coal seams. The upper Nisai Formation dominantly comprises thick bedded, nodular limestone with coral reefs and buildups in its uppermost part. The uppermost units of the Nisai Formation possess foraminifera of Early Oligocene age.

Although the Nisai Group is clearly divisible into three distinct, and mapable, lithostratigraphic units of formation rank and exposed throughout the Pishin Belt, the overall thickness of the group is highly variable and in places reaches up to 2170 meters.

Bookshelf faulting in the Ziarat earthquake sequence, Northern Baluchistan, October 2008

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The damaging earthquakes occurred in 2008 in the Pishin/Ziarat region NE of Quetta, where 300 people were killed by landslides and by the collapse of adobe structures. The deformation velocity field derived from GPS measurements before and after the earthquake indicates that earthquakes were associated with a shear zone trending NW/SE underlying the fold systems that near Pishin and Mach trend approximately eastward. The Pishin/Mach shear zone defines a transition in geological structure from the partitioned thrust/wrench fault system of the Northern Kirthar ranges to its south, to the Sulaiman lobate thin-skinned tectonics in the Quetta transverse zone to its north. The forces responsible for dextral shear are thought to originate from a 15° restraining bend on the plate boundary near Chaman. The SE extent of the shear zone is uncertain but possibly, it is responsible for the damaging earthquake of 1909 near Sukkur, >200 km to the SE. From GPS measurements we estimate the slip rate on the Pishin/Mach shear zone is 5-10 mm/yr, a range that is consistent with the kinematics of the restraining bend geometry. It is inferred that at least 8 parallel faults ≈15 km apart, length 15-20 km exist in the shear zone. The likelihood of maximum of Mw 6.5 earthquake due to fault dimensions and events will occur in every 10-20 years.

Deposition of the Late Cretaceous Moghal Kot Formation on a fault-controlled slope setting, Sulaiman Foldbelt, Pakistan

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The Late Cretaceous, Moghal Kot Formation is well exposed in the Sulaiman Fold-belt of western Pakistan. It is 50-650m thick and is dominated by mudstones, shales and marls with subordinate thin to medium-bedded quartzose sandstones, deposited on the western continental margin of the Indian Plate during the Late Cretaceous (Late Campanian to Maastrichtian). Detailed sedimentary logs of five measured section in the study area, provide data for facies analysis, dispersal patterns and environmental interpretations.
Four facies, recognized within the Moghal Kot Formation include; Slump, and debris flow facies, Laminated mudstones facies, Bioturbated mudstones/shales, and marls facies, Lenticular, and erosive sandstones facies and laterally continuous thin-bedded sandstones facies. The facies can be grouped into two main facies associations; (slope facies association and lower shelf delta /prodelta facies association). All of these facies were deposited by turbidity flows.
The vertical and lateral distribution of facies within the Late Cretaceous succession (Moghal Kot, Fort Munro and Pab formations) reveals overall upwards-shallowing and also demonstrates a transition from fluvio-deltaic, inner shelf to fault controlled slope setting. The abundance of slumped units in the lower part of the Moghal Kot Formation suggests that the slope was unstable and active (more likely fault- controlled). Palaeoflow was predominantly towards the W and NW from the uplifted Indian basement to the east.

Petrology of the mantle rocks from the Muslim Bagh Ophiolite, Balochistan, Pakistan

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The Muslim Baghophiolite shows a nearly complete ophiolitic sequence ranging from residual peridotite at the base to the Mantle–Crust Transition Zone in the middle which grades into the crustal rocks at the top. The mantle section comprises the foliated peridotite that grade into the transition zone dunite. The foliated peridotite is mainly harzburgite with minor dunite and lherzolite. The dunite present is either interlayered with harzburgite or occurs as envelopes around harzburgite containing mostly podiform chromite deposits. The harzburgite and dunite of the lower mantle section have often been referred to as depleted peridotite resulting from large degrees of partial melting from a lherzolite parent and also that they are partly formed by the processes such as magma–mantle interaction. The transition zone comprises residual dunite with impregnations of wherlite/pyroxenite and is interpreted to be formed by a combination of mantle and crustal processes; reflecting predominantly mantle processes at its base and preserves evidence of crustal fractionation at the top. The chromite occurs in the mantle dunites and is mostly podiform and vein-like and may have been formed by melt-rock reaction. The petrology of mantle rocks displays a porphyroclastic texture with harzburgite poor in modal clinopyroxene and dunite poor in pyroxene, indicating that the peridotite is melt residue. This residual nature is confirmed by the higher Cr # in spinel and Mg # in orthopyroxene and olivine from the foliated peridotite suggesting their derivation by higher degree of partial melting from a depleted mantle source. These petrological and mineral chemical characteristics may have been inherited from processes within a supra-subduction zone tectonic setting.

Sandstone and conglomerate petrology of the Neogene succession, Pishin Belt, northwestern Pakistan

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The siliciclastic Neogene succession of the Pishin Belt comprises the newly proposed Miocene Dasht Murgha Group, Miocene-Pliocene Malthanai Formation and Pleistocene Bostan Formation which were deposited as fluvial succession in the foreland setup. Thin section studies and modal analyses revealed that sandstones of the Dasht Murgha Group and Malthanai Formation are lithic arenite and show recycled and transitional recycled orogenic source. Sandstone detritus has been derived mainly from the sedimentary and metamorphic terrains, sedimentary rocks being a more pronounced source terrain than the metamorphic rocks, particularly in the Malthanai Formation, however, the volcanic terrain has also provided its detritus but in minor proportion. Composition of conglomerate of the Dasht Murgha Group, shows that the Eocene Nisai Group and Oligocene Khojak Formation are the main source terrains, whereas, the Jurassic Loralai Formation and Muslim Bagh-Zhob ophiolite are the subordinate source terrains. Conglomerate of the Malthanai Formation shows similar composition with additional contribution from the Dasht Murgha Group. Conglomerate of the Bostan Formation shows that its detritus has mainly been derived from the Nisai Formation, Khojak Formation, Muslim Bagh-Zhob ophiolite, as well as Dasht Murgha Group and Malthanai Formation. Detritus of the Triassic Wulgai Formation, Jurassic Loralai Formation and Cretaceous Parh Limestone has also contributed in subordinate amount. Detrital modes of the sandstones and petrology of the conglomerates show that the detritus for the Neogene succession has mainly been derived from the Pre-Miocene sedimentary and meta-sedimentary terrains of the Pishin Belt from the west, which include Eocene Nisai Formation and Oligocene Khojak Formation; and Sulaiman Belt from the east, which include Triassic Wulgai Formation, Jurassic Loralai Formation and Cretaceous Parh Limestone. Also mafic and ultramafic detritus has been provided by the Muslim Bagh and Zhob ophiolite exposed along the western margin of the Indian Plate.

The study of basaltic magma eruption at the Tor Zawar, Ziarat, Pakistan

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The unusual report that on 27 January 2010 a small eruption of basaltic lava occurred at Tor Zawar, Ziarat, 75 km NE of Quetta, Pakistan, was extremely surprising because no eruptions from this magmatically inactive area had ever been reported. Two petrographically distinct basalt types were indentified in the vesicular eruptive products. Preliminary investigation of the mantle melt modeling suggested that the lavas had been largely derived from a source in the garnet-spinel transition zone, i.e. well within the lithosphere. It was proposed that localized asthenospheric melting resulted in relatively depleted melts, which were substantially contaminated by fusible lithospheric mantle en route to the surface; and that re-melting of local basaltic rocks by short circuiting of a ruptured high-tension electrical cable was unlikely.

However, our further investigation lead us to discover two more occurrences of similar nature; the 2nd at Tor Zawar, Ziarat District, only 300 m apart from the first event, and 3rd at Jang Tor Ghar, Muslim Bagh, Pakistan. The 2nd event of Tor Zawar, Ziarat occurred sometime during the month of January 2011 and the 3rd event of Jang Tor Ghar, Muslim Bagh on 12th February 2011. The site of all three are near the base of steel pylons, and earthing cables, supporting high-voltage overhead electric transmission line installed at the hillside outcrops, which acted as means to transmit atmospheric lightning at the outcrop. At the Tor Zawar, Ziarat District, the steel pylons are installed at the outcrops of the volcanic conglomerate of the Late Cretaceous Bibai Formation, whereas, in the Jang Tor Ghar, Muslim Bagh, within the alluvium mostly comprising ultramafic fragments of the Muslim Bagh Ophiolites. The lightning strikes transmitted enough energy to partially melt the outcrops and alluvium at the base of steel pylons, which solidified to produce light brown to black coloured basaltic glass of highly vesicular to moderately vesicular nature. Field evidence and the textural, petrographic and geochemical characteristics of the samples from these ‘flows’ lead us to reject the earlier proposal that these were magmatic events involving material derived from deep crustal or mantle sources. Instead, we conclude that these materials resulted from localised melting of basaltic clasts within volcanic conglomerates of the Bibai Formation. The melting was induced by discharges on to the rock surface of lightning that had been transmitted through steel supporting pylons and earth wires of the overhead transmission line. We also conclude that these products of partial surface melting were generated in a manner similar to that responsible for creating rock-fulgurites.

The Makran Zone of active mud volcanoes, Pakistan- Tectonic and seismic implications

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The Makran Accretionary Belt, Pakistan, has a much larger number of mud volcanoes then those reported earlier. Using high resolution satellite images, over 70 active mud volcanoes were identified and mapped. These mud volcanoes occur within a well defined zone; known as the Makran Zone of Active Mud Volcanoes (MZAMV), which is parallel to the regional trend of the accretionary belt. Mud volcanoes within the zone occur as clusters, which form linear belts parallel to the regional thrusts and anticlines. The MZAMV zone also includes the offshore mud volcanoes found in the shallow shelf area, including the recurrently emerging mud islands. Occurrences of thick mud volcanoe deposits of Pleistocene (or even older age) are also present within this zone, which display recognizable features that are characteristic of the fossil mud volcanoes. We suggest that the MZAMV developed, and evolved in response to the continued compression within the Makran Acrretionary Belt, which in turn is a response of the subduction process and that mud diapirism has been an ongoing phenomena since Pleistocene or even earlier times. The enhanced mud extrusion events in mud volcanoes and/or emergence of island(s) have relevance with seismic phenomena and therefore, may be closely monitored, as they may be precursors of future seismic events.

Lessons we learned from the landslides induced by the 2005 Kashmir earthquake and Attaabad, Hunza area: Its applications for the future

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Landslides may damage any civic structure and cause the loss of lives when they occur in a catastrophic way. During the second half of the 20th Century, there has been a rapid increase worldwide in the economic losses due to natural disasters and in the number of damaging landslide events (EM-DAT, 2010). Similar trends have been observed for the number of landslide events at national and regional scales (Cendrero et al., 2006). According to the database created by the Centre for Research on the Epidemiology of Disasters, landslides and related processes killed approximately 61,000 people in the world over the period 1900–2009 (EM-DAT, 2010). Moreover, it should be emphasized that the high numbers of small- to medium-scale landslides, which are widespread in many parts of the world, normally cause much higher costs to human society than high-magnitude catastrophic events, which tend to occur quite rarely.

Over the course of the 20th century, Pakistan has faced a major natural disaster almost every ten years with their frequency increasing especially during the recent time. However, when they affect local communities, which have only limited resources to prepare for and respond to them, their effects can be nonetheless disastrous. In major parts of Azad Jammu & Kashmir (AJK), Khyber Pakhtunkhwa (KPK) and Gilgit-Baltistan (GB), where people mostly practice agriculture at subsistence level and food security at household and village levels is therefore very low, even small scale natural hazards can seriously affect the local communities. The 2005 Kashmir earthquake which occurred on October 8th, 2005 in Balakot-Muzaffarabad and Bagh areas induced more than 600 landslides, causing severe damage and isolating villages in the epicentral mountainous areas. The earthquake has killed more than 73,000 people, including 23,000 people by landsliding. This earthquake occurred in an area with many previous landslides, and thus the area still has unstable or metastable landslide mass. It was one of the major earthquakes to give various scientific data of earthquake induced landslides in such an area; earthquakes that induced distributed landslides in the past decade or so include the 2004 in Niigata Prefecture in central Japan, 1999 Chi-Chi earthquake in Taiwan, the 1995 Hygoken-nanbu earthquake in Japan, the 1994 Northridge earthquake and the 1989 Loma Prieta earthquake in the USA. In the Hunza region, specifically Attabad area along the Hunza River, has experienced another landslide in January, 2010, about 1900 m long and 60 m wide that killed 19 people, and will likely to experience, a rather bewildering variety of landslide hazard in future also where fracture controlled landslides, rock blocks, and rock columns along the edge of steep cliffs are common features of the Karakoram batholith. Two exceptionally large landslides in the Kohistan batholiths along Hunza River deserve special attention. The pre-historic Salmanabad landslide, which dammed the Hunza River (approximately in 1890) and Mumhill glacier avalanche, near Shiskat village (1977). Both these landslides occurred in the most highly jointed, fractured, foliated and faulted Kohistan batholith.

Different landslide scenarios are more or less likely to occur as a result of different specific rainfall or earthquakes conditions, and no part of the community can be considered safe from such landslides. Unfortunately, we currently lack the understanding to accurately forecast what might happen in each possible rainfall or earthquake scenarios. Prudence would certainly dictates, however, that we anticipate renewed landslide activity during or after future periods of prolonged and (or) intense rainfall. Future earthquakes, of course, also could trigger landsliding in the area.

Disaster Management in Pakistan has so far focused on response rather than preparedness. It has also been biased towards material aspects at the cost of increased knowledge and awareness. Finally, there has been no comprehensive management and the existing bodies have traditionally favoured areas of political and economic importance over remote rural areas. Therefore, of primary interest to the general public and various governmental entities is the current state of hazard in parts of AJK, KP and Gilgit-Baltistan of Pakistan. While many preliminary reports of these areas do not represent a detailed evaluation of those hazards, a few reasonable observations can be made:

(1) Historical accounts and geologic evidence show that landsliding of a variety of types and scales have been occurring in the northern areas of Pakistan for many thousands of years, and on a frequent basis, up until the present. There is no reason to believe this pattern of landslide will stop.

(2) The 2005 Kashmir earthquake related landslides could still remobilize most likely as a deep slump. This type of movement most likely be relatively slow, but still could pose serious hazards to property and, perhaps, life.

(3) The landslide scenarios could impact any part of the areas mentioned above and community. Future landslide activity could move into the same areas (e.g. Attabad landslide, Hunza area) that recently have been damaged or could damage or all of the developed areas.

(4) Finally, earth scientists should strive to compile landslide overview map of all landslide-prone areas in the regions that should summarize geologic, hydrologic, and topographic data essential to the assessment of national hazard problems. The map must delineate areas where large number of landslides exist and areas which are susceptible to landsliding.

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Desktop GIS application for hostel management of Punjab University Lahore

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To provide effective solution to escalating spatial problems of hostel management this paper provides a lay out of latest technologies which is applicable for not only interactive decision making, but also beneficial for risk management. The architectural plane of eight hostels of University of the Punjab, New campus Lahore and Google Earth imagery were selected to prepare geodatabase for spatial and non-spatial entities using ArcGIS 10. To manage effectively spatial and non-spatial data of a hostel requires the understanding and manipulation of a large number of variables. The spatial nature of the hostel and their associated resources were linked to students, departments and hostel management in Geographic Information System (GIS). Three storys buildings of these hostels were digitized as three different layers with other basic layers. Student's data linked with rooms for query and visualization. Hostel management system also provided facility to manage immovable assets glued to the hostel property allotted to students and management staffs. ArcReader 10 was used for the data disbursement to different hostel offices and related department for the management of hostel assets and illegal hostelized any time.

Overview of mineral sector of Pakistan

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As evident from the geological environment and present state of exploration and mineral discoveries made, so far, Pakistan has vast potential for varieties of minerals. These includes: 1) huge resources of Thar Coal Sindh, 2) well-known copper and precious metal potential of district Chagai Baluchistan, Waziristan and Gilgit-Baltistan, 3) marble and granite deposits of Khyber Pakhtunkhwa (K.P.), 4) rare earth elements in carbonatites in K.P., 5) world famous gemstones of K.P, AJ&K and Gilgit-Baltistan, and 6) huge potential of industrial rocks and minerals (rock salt and coal) in Punjab. In spite of having all these resources the country is importing metals and alloys, gold and fertilizer minerals. As a result of expanding economy the import of mineral based product continue to increase with time, rapidly. In order to encourage indigenous production of minerals and products for domestic use, government has been encouraging investment in exploration and development in the mining sector. The utilization of latest exploration techniques may bestow Pakistan with discoveries of world class concealed or sub-surface deposits as yet undetected by previous exploration programmes. It is very likely that future mineral discoveries with modern techniques of exploration, in the given area, may include such precious, base metals and rare elements which are highly prized in the present market. By using the aeromagnetic and geophysical techniques, future exploration may be able to find extension of known deposits.

Tectonically the country has been divided into eleven metallogenic zones. These inclued Chaghi Raskoh Magmatic Arc which is famous for world class copper-gold deposits, Chaman Ornach Nal Transform fault famous for antimoney occurances in Qila Abdullah, Lasbela- Khuzdar-Muslim Bagh- Zhob-Waziristan ophiolites zone which is famous for copper-gold, manganese etc. Sediment Hosted Lead-Zinc deposits, Kirthar Thrust & Fold Belt having coal deposits and decorative stones, Indo-Pakistan Shield rocks of Sargodha and Nagar Parkar, Sulaman Fold and Thrust Belt famous for gypsum and industrial rock, Salt range and Kala-Chitta Hills having rock salt, gypsum coal etc. Gondwanic domain rocks of Haripur, Sherwan famous for gemstones and industrial rocks, Kohistan Magmatic Arc having matelic minerals, ophiolites and melange zone having high quality gemstone etc. Karakoram Block having various economic minerals.

For development of these mineral resources through private national / international investment an investment friendly National Mineral Policy (NMP) has been formulated with the consences of all the provinces and stake holders. The NMP offers various incentives for investment in the mineral sector and all the provinces have formulated investment friendly mineral concession rules to enhance its shares in the GDP and make it competative in the international market. Due to existance of these investment friendly polices various international companies have started exploration and mining in Pakistan which includes production of copper and gold from Saindak copper project Balouchistan and production of lead-zinc from Duddar deposit Balouchistan by the Chinese company M/S MCC. Detail exploration has been completed by the multinational Tethyan Copper Company (TCC) in district Chagi Balochistan. Moreover, various international companies have started work on development of various blocks in Thar coal fields Sindh which will lead to mining and power generation. Various investment oppurtunities are still available in coal mining and power generation, base metal exploration and mining, decorative stones and gemstones mining.

Identification of high risk landslide slopes and disaster management of Hattian Bala and adjacent landslide areas, Azad Kashmir (Pakistan): Applying AHP (Analytic Hierarchical Process) method

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Landslide often occurs under certain topographic and geologic conditions. On the 8th October 2005 a magnitude 7.6 earthquake and subsequent aftershocks for the following months struck the Lesser Himalaya of northern Pakistan devastating the region of Kashmir and parts of Khyber Pakhtoonkhwa. It is estimated that around 87350 people died in Pakistan, of which, 26500 were directly hit by landslides. Within these statistics are the largest single-cause loss of life event triggered by the earthquake; the 68×106 m^3 Hattian Bala rock avalanche that destroyed a village and killed around 1000 peoples.

Based on interpretation of aerial photos of landslide slopes and micro-morphological components that reflect activity of mass movement, a landslide hazard rating system has been developed by application of the Analytic Hierarchical Process (AHP). The AHP method decomposes the process of subjective decisions of people into layers and expresses the process qualitatively**.** This study adopted AHP for landslide hazard assessment by the hierarchical structuring and weighting of the factors that contribute to the reactivation of landslides. Factors and items were determined by brainstorming of experts in geomorphology and landslide investigation works. The first hierarchical level is landslide hazard evaluation. Five geomorphic factors which comprise the second hierarchical level were selected as follows; 1. Distinctiveness of main scarp. 2. Surface feature of landslide body. 3. Position of landslide body on the slope. 4. Position of cracks in the landslide body. 5. Stability conditions of landslide toe. Those correspond to three principle factors; geomorphologic evolution process, landslide activity and destabilizing possibilities. The third hierarchical level consists of the optional items under each geomorphic factor of second level. Factor 5 consists of 5-1 credibility of the landslide toe and 5-2 instability perceived from the sharp end of the landslide toe as level IV.

The final weight coefficient for each item is calculated by multiplying the values of hierarchical level II, III and IV. Hazard levels are classified into hazardous, slightly hazardous, moderate and safe categories, according to the score that accommodates the total weight for each landslide.

Based on this system, a total of 32 deep-seated landslides were identified in the Hattian Bala landslide and its adjacent areas.

Low cost PC-based seismic refraction recording system

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A 24 trace seismic refraction recording system has been developed for MS Windows platform. The heart of this system is a two-channel component which digitizes the seismic signals using the 16 bit PC sound card. It is a complete software based data acquisition solution with only two geophones connected to the audio input of a laptop. The sampling frequency, record length, number of traces per record and other recording parameters can be specified using a setup interface. A special spread geometry has been designed for data acquisition, where one geophone is fixed at the origin while the other moves away at increasing offsets. Data is acquired for each moving geophone offset using a hammer or weight drop as an energy source. The first geophone trace is processed to automatically detect events and pick the first arrival time which is used as the starting instant for the second geophone trace. All samples before this time are clipped while an equal number of zero samples are padded at the end to complete the trace length. The final trace from the second geophone is added to the field record. In this way for each offset point a trace is added and a 24 trace record is completed. All the acquired traces are displayed on screen in real time (Fig. 1). The software provides interactive tools for deletion and retake of any bad traces. Using digital signal processing techniques automatic gain control, notch filter and band pass filter have been incorporated for initial processing of raw data to enhance the weak events from far offsets and suppress any coherent noise. The final record is saved in SEG-2 format. This system completely simulates a 24 channel seismic recorder, commonly used for shallow seismic refraction surveys.

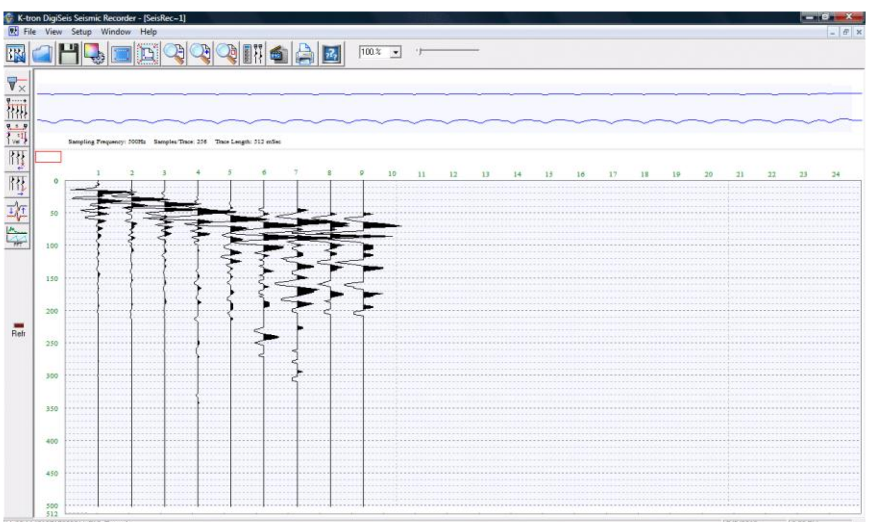

Fig. 1. PC based Seismic refraction recorder interface showing some recorded traces.

Analysis of microfacies and diagenetic framework of the Lockhart Limestone, Northeast of Kohat City, Pakistan

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The present study is intended to describe the carbonate microfacies of the Paleocene Lockhart Limestone in area northeast of the Kohat City. The succession is 65m thick and predominantly medium to thick bedded, nodular to brecciated and extremely fossiliferous. Thin interbeds of marl are observed in the main lithological unit. The lower contact of the Lockhart Limestone is faulted with the Samana Suk Formation of the Jurassic age while conformably overlain by the Patala Formation of Paleocene to Eocene age. The major lithological unit is mainly comprised of an abundance assemblage of the larger benthic and smaller planktonic foraminifers with accretion of ostracods, dasycladacean algae, echinoderms, gastropods and corals. On the basis of field and laboratory observations, two distinct types of microfacies have been identified as i) Dasyclad-Miliolid Foram Wacke-Packstone microfacies of the inner shelf, sub tidal lagoon, ii) Larger Foram Packstone microfacies of the middle shelf. The Limestone represents a carbonate cyclic sequence marked by three, transgressive, deepening up cycles representing a gradual sea level rise compensated by vertical accumulation of microfacies. The commencement of each cycle is clearly marked by the input of land-derived siliciclastic sediments and near shore restricted marine faunal/floral assemblage in the inner shelf microfacies gradually thinning up section where the microfacies become deeper offshore. The diagenetic modification is observed in the shape of compactional framework, dolomitization, aragonitic to calcitic alteration and spar-filled fractures in the main lithological unit of the Lockhart Limestone.

Slope stability hazard evaluation and mitigation scheme for Sohbat Charra slide zone District Battagram

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On October 8th, 2005 Kashmir earthquake, the emergency response to Allai and its surrounding areas was severely affected by the hazard generated due to Sohbat Charra slide zone. Keeping in view the earthquake disasters of the October 2005 due to land sliding, in this study the stability of slopes at Sohbat Charra slide zone at Allai District Battagram have been evaluated by taking soil and rock samples from the site and testing them in the laboratory. The input parameters needed for the analysis mainly included, the shear strength parameters i-e cohesion, angle of internal friction and unit weight of the formation materials, which were obtained from laboratory tests. Software Slope/W part of GeoStudio, 2004 and standard charts have been used for the analysis of slope. On the basis of soil properties and slope stability analysis of the site, suitable measure has been suggested for stabilizing the Sohbat Charra slide zone and thus to mitigate future problems due to earthquakes scenario in the area.

Siting of rainwater harvesting locations in District Haripur using Geographic Information Techniques

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Rainwater harvesting is important step towards maximizing the water availability and land productivity in the arid and semi arid areas of Pakistan. However, the selection of appropriate sites for rainwater harvesting on a large scale presents a great challenge. GIS and RS technologies proved best in identifying the potential sites for rainwater harvesting in Ghazi Tehsil, district Haripur covering 348 sq km area, which has great potential due to its feasible climatic and topographic conditions. The area receives good rainfall annually but, due to hilly terrain the runoff is high and most of the rainwater is being lost. In spite natural gift of rainfall water the local community of the study area is used to practice the rainfed agriculture, therefore, the rainwater harvesting is given priority in order to enhance agricultural output. Soil Conservation Service's (SCS) Curve Number (represents the effects of rainfall against Hydrological Soil Group and landcover) was computed using HECgeoHMS tool of ArcGIS 9.3. The curve number was then used as input parameter in runoff estimation method to compute the surface runoff potential for different combination of landcover and Hydrological Soil Groups (HSG) in the study area, which helped in the results to identifying the potential sites for rainwater harvesting. It was observed that runoff was higher at the mountainous areas and low at the plain. Various thematic maps of the area such as surface slope, drainage network, rainfall, landcover, landuse, soil, geology and buffer maps at a scale of 1:50,000 were generated in GIS to perform weighted overlay analysis. Reclassification of above mentioned layers were performed and weights were assigned according to technical guidelines, suggested by Integrated Mission for Sustainable Development (IMSD), Indian National Committee for Hydrology (INCOH), Food, and Agricultural Organization (FAO) and also keeping in view the study area topographic and climatic conditions, in order to identify the potential sites for rainwater harvesting. About 20 percent of the area is suitable, 52 percent is less suitable and 29 percent is not suitable. Relative suitability was assigned to the results of suitable sites for rainwater harvesting. This was further used as input in order to identify the potential sites for different rainwater harvesting structures like farm ponds, Check dams, Nigarims and gully Plugs. The study results revealed that 10 percent of the area was suitable for farm ponds, 5.74 percent area for check dams, and 21.5 percent for Nigarims and percent of the area suitable for Gully Plugs. The small dams organization Peshawar conducted field survey and suggested two on sites namely Site A (*Khairbara*) and Site B (*Kotehra*) in the study area. In order to compare the GIS derived and field based results, it was evident that field based derived results were exactly overlaid on GIS results of Check Dams and Gully Plugs and Nigarims.

Crustal study of the core of Hazara Kashmir Syntaxis based on geophysical Data in Azad Jammu and Kashmir

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The geological study based on geophysical data has been carried out in the core of the Hazara Kashmir Syntaxis. The present study based on geophysical data demarcated the northwest-southeast trending Bagh Basement Fault (BBF) and Kashmir Boundary Thrust (KBT) in the core of Hazara Kashmir Syntaxis (HKS). The thick skinned Bagh Fault on surface is running within the Murree Formation that dips at an angle of 45^0 NE and penetrated upto Moho depth. The study also delineated the NW – SE trending KBT in the northeast of BBF. In Muzaffarabad area the carbonate rocks of Cambrian to Eocene age are thrusted over the Molasse of Murree Formation along this fault and from Muzaffarabad to Bagh it is also running within the Murree Formation. The seismicity, landsliding, shearing, crushing and cracks along the KBT, Jhelum strike slip fault and Main Boundary Thrust (MBT) indicated that the area in the core of HKS is tectonically active. After the 8th October, 2005 earthquake a NW – SE trending rupture developed between Kawai and Davalian. The seismicity in the crystalline crust under the rupture and magnetic and gravity variation across the Kawai Davalian fault also confirm that this fault joins the Indus Kohistan Seismic Zone (IKSZ) which is penetrated upto Moho depth

Fault seal analysis of the Thatta-Badin Block

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Thatta-Badin Block is situated in the lower Indus basin. The dominant feature of the area is extensional tectonics, the traps are normal faults in all oil, gas and condensate fields. Early Cretaceous Sembar shale is the source rock, whereas the overlying lower Goru sands, having up to 25% porosity act as reservoir rock. Further up, the Late Cretaceous upper Goru shale provides excellent seals. Being extensional regime there is normal faulting which at depth, as observed in this work, converts into listric faults striking towards northwest-southwest. In clastic (sand/shale) sequences, fault sealing capacity is broadly predictable. Juxtaposition pattern of the units at the fault is of prime interest. In many traps, juxtaposition seal of shale against sand is a main component of the trap geometry. However, areas of sand against sand can also contribute to the trap because of the presence of fault rocks which impede fluid flow. The generation of fault rock is intimately linked to the sliding of different lithologies past one another (Yielding et al., 1997). In an area like Thatta-Badin Block, where fault bounded structures are to be explored, fault seal analysis gains a lot of importance. This analysis provides information about whether or not a fault is providing a good seal to the reservoir units. A number of techniques have been introduced to do this analysis like juxtaposition diagram and Allan diagram (Allan 1989); both of which tells about the juxtaposition of various units in the foot wall across the fault against the hanging wall, besides some algorithms have also been introduced of which the most important ones are Shale Smear Factor (SSF; Lindsay et al., 1993), Shale-Gouge Ratio (SGR; Bouvier et al., 1989; G., Yielding et al., 1997) and Clay Smear Factor (CSP: Bouvier et al., 1989; Fulljames et al., 1997). The SSF provides information regarding reservoir-reservoir juxtaposition across the faults in terms of sealing, whereas SGR provides information about the sealing capacity of the fault rock type. These two factors have been calculated at every point on the fault plane of the F1 fault and this analysis has been carried out and zones of good sealing have been found.

Fault seal analysis of Thatta-Badin Block is carried out manually by mapping the fault, and various reservoir and shale beds precisely that constitutes the Lower Goru Formation. There are zones both vertically and laterally where the fault is not proving a good seal. Fault sealing analysis is of vital importance in now day exploration activities while exploring an extentional regime with clastic reservoir.

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2010 Floods in Pakistan: Damage assessment along Kabul River

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Floods are amongst the most devastating natural hazards in the world, due to significant social and economic damages than any other natural phenomenon. In 2010, Pakistan faced devastating floods in its history. Assessment of severity shortly after the occurrence of the disaster is very important. This assessment can easily be done using remote sensing techniques that provide cheap and quick way to get the general idea of the scale of disaster. The study envisage the damage caused by these floods along River Kabul, at parts of Nowshera, Charsadda and Peshawar districts of Khyber Pakhtunkhwa using freely available remote sensing and GIS data. The study reveals that an area of more than 250km^2 came under flood damaging completely or partially settlements distributed over 26 km^2, crop lands at 162 km^2, 85 km roads and 9 bridges.

Detection of hydrocarbon seepages using hyper spectral remote sensing in FR DI Khan, Pakistan: A case study

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Hydrocarbon seepages have been detected using wide variety of techniques in various studies all around the globe. These studies are primarily based on the concept that hydrocarbon seepages cause surface alteration of soils, and minerals and stress on vegetation in the seepage area. The current study envisages detection of hydrocarbon seepages using hyperspectral remote sensing.
Hydrocarbon seepages have been reported in many locations in, and around Federally Administered Tribal Areas (FATA) of Pakistan where hydrocarbon seepages, and their effects on rocks, and soils have been observed and documented. Hyperspectral data of Hyperion has been used to map these seepages in Frontier Region Dera Ismail Khan (FR DI Khan) of the tribal belt of Pakistan. Spectral Angle Mapper (SAM) and Mixture Tuned Matched Filtering (MTMF) algorithms have been used for classification. In this study, hydrocarbon seepages have been successfully identified and confirmed in the field.

Paleoenvironments and reservoir charecterization of the Middle to Late Permian Wargal Formation, NW Paksitan: Implications for hydrocarbon exploration

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Permian rocks of Pakistan are the prolific hydrocarbon reservoirs and are productive in all parts of the Indus Basin, particularly, in the upper Indus Basin (i.e. Chak Naurang, Dhulian, Dhurnal, and Meyal oil fields). Carbonates of the Middle to Late Permian Wargal Formation constitute important petroleum reservoirs in the Salt Range area (of the upper Indus Basin). Elsewhere, e.g. in the North Sea, the use outcrop data and microfacies analysis techniques for constructing the dynamic depositional models has significantly increased the knowledge to characterize reservoir rocks. In this study we carried out a detailed
microfacies analysis of the Wargal Formation and reconstructed the depositional settings which ranges from marine nearshore, intertidal to shallow subtidal environments, with energy conditions ranging from moderate to high. The important diagenetic processes recognized are bioturbation, micritization, dissolution, silicification, cementation, dolomitization, fracture fillings, chemical compaction, and secondary porosity development. The diagenitic fabrication and quantification of the porosity/permeability values suggest that facies of the Wargal limestone possess a high reservoir potential.

How to explore gemstones in Pakistan?

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Gemstones in Pakistan have formed due to metamorphic and hydrothermal activities. The most common gemstones of the area include ruby, emerald, peridot, aquamarine, tourmaline and topaz. Ruby occurs in marble of the Karakoram metamorphic belt at Hunza and Nagar, and higher Himalaya at Nangimali in Neelum Valley of Azad Jammu and Kashmir. Fluid inclusion studies show two phase primary inclusions of CO_2 with Tm -56.90°C to -64°C and Th 11.6°C to 30°C in Hunza ruby and Tm -63°C to -64°C and Th 33°C to 34°C in Nangimali ruby confirming their growth from CO_2 fluids during metamorphism. Phlogopite, chromian muscovite and pyrite appear to be the pathfinder minerals for ruby. Emerald mineralization occurs in talc-carbonate schists of the ophiolitic mélange in Swat area, dolomite and pegmatite in Gandao and Khaltaro areas of Mohmand Agency and Gilgit-Baltistan region respectively. High abundances of trace elements such as Cr, V, Be, Li, Sr and La in rocks and stream sediments may indicate emerald mineralization. Peridot occurs in sheared dunite, located just above the Indus suture zone in Sapat Valley of Kohistan. Magnetite trails found in the sheared dunite indicate peridot mineralization. Aquamarine, tourmaline and topaz occur in Gilgit-Baltistan region. Their host rocks are zoned pegamtites. The criteria to find these gemstones include the analysis of muscovite for Rb, Ba, Nb, Ta, Sn, Li, Cs, Mn and Mg. These elements are the indicators to distinguish barren pegmatites from the gemstones-bearing ores.

Timing of shallow level emplacement of the Sillai Patti carbonatite complex, North-West Pakistan: Constraints from fission-track dating of apatite using the absolute approach

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The Sillai Patti carbonatite complex is located about 20 km west of Malakand, near Sillai Patti village. It is the second largest carbonatite complex of the Peshawar Plain Alkaline Igneous Province of northern Pakistan; the first one being the Loe-Shilman complex. At Sillai Patti the carbonatite occurs in the form of a sheet striking in the NNE-SSW direction and dipping southwards. The carbonatite body is about 12 km long and 2-20 m thick, and has been predominantly intruded along the faulted contact of metasediments and granite gneiss but locally within the metasediments.

Conduction of fission-track dating studies on the apatite crystals using the external detector method and absolute approach yielded an average fission-track age of 29.15 ± 0.91 Ma and a pooled fission-track age of 29.10 ± 1.02 Ma for the Sillai Patti carbonatite of Malakand area. These ages are concordant with the K-Ar age of 31 ± 2 Ma on biotite and fission-track age of 32.1 ± 1.9 Ma on zircon from the same carbonatite body. This concordance of apatite fission track (AFT), zircon fission track (ZFT) and K-Ar biotite ages, therefore, robustly suggests that they all document the age of emplacement of the Sillai Patti carbonatite complex. Age concordance, the porphyritic textures of the carbonatites and apatite fission track modeling, all indicate rapid cooling from emplacement temperatures.

The fission track ages on apatite from the Sillai Patti area are also concordant with the $^{206}Pb/^{238}U$ age of 29.26 ± 0.12 Ma on zircon and Ar-Ar age of 28.4 ± 1.1 Ma on muscovite from the alkaline granitic dyke of Lower Swat area, K-Ar age of 31 ± 2 Ma on biotite from the Loe-Shilman carbonatite, fission track age of 29.3 ± 1.2 Ma on apatite from the Jambil carbonatite of Lower Swat area and fission-track age of 30.0 ± 1.5 Ma on apatite from the Loe-Shilman carbonatite. The strong resemblance of the fission-track apatite age of this study with the fission-track as well as other high temperature radiometric ages from the other localities of the alkaline belt of northern Pakistan also strongly documents that the Sillai Patti carbonatite complex was emplaced at high crustal level (shallow burial depths) and cooled there relatively rapidly to near surface temperatures.

Earthquake induced Slope Stability Analysis for Muzaffarabad area using factor of safety methods

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The research work is based on earthquake induced slope stability analysis for Muzaffarabad area which is a part of Hazara Kashmir Syntaxis that lies within the NW Himalayan Fold and Thrust Belt. Three slope stability models were developed for steeply dipping natural and soil cut slopes at different sites around the study area under available soil geotechnical data, also three different records of strong motion horizontal acceleration data with varying PGA values were used.
Slope stability analysis is carried out with the help of factor of safety methods which includes Limit Equilibrium Methods and Finite Element Method. Limit Equilibrium Methods are basically used to find out the stability of the slope at equilibrium state and Finite Element Method is used to find out the amount of disturbance or instability of the slope under earthquake loading. Earthquake induced slope stability is measured in terms of critical acceleration, which depends on the mechanical soil properties and slope geometry.
The results indicate that soil cut slopes with high cohesive strength in the area are less prone to fail under intensive ground shaking, no matter how much the slope is steep. Soil cut slopes with low cohesive strength in the area are more susceptible toward ground shaking.
From slope stability analysis, the maximum ground acceleration at Muzaffarabad area inferred to be greater than 0.9 g for steep natural and soil cut slopes because the computational results indicates that the failure of the soil slopes containing even moderate shear strength properties are imminent under such ground strong motions.

Housing and constructions on soil slopes containing steep angel and low strength in study area should not be allowed. Although, these slopes can be stable for high slope angles under static conditions, they are prone to failure during earthquakes.

Seismic Hazard Evaluation for the Diamer Basha Dam Site, NW Himalayan Fold and Thrust Belt, Pakistan

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The NW Himalayan Fold-and-Thrust Belt, Pakistan is considered to be seismically one of the most active zone of the world. The Diamer Basha Dam (DBD) local seismic network was put in operation in August 2007. It is situated in the eastern part of NW Himalayan Fold and Thrust Belt, in order to record local seismicity and to give information about the micro as well as the macroseismic earthquake activity in the area. It is also providing crucial close distance data for precisely locating stronger earthquakes in the region that are otherwise recorded also by regional and global seismic networks. The network consists of ten short period three component digital seismic stations.

Seismic Hazard Assessment (SHA) for the site of DBD has been carried out by using the DBD local seismic network data along with the global data. SHA has been carried out using the usual convention of Probabilistic Seismic Hazard Assessment (PSHA) and Deterministic Seismic Hazard Assessment (DSHA). The seismotectonic model comprising of three seismic source zones with the estimation of maximum possible magnitudes m_{max} of 7.8 (Zone 1), 7.4 (Zone 2) and 7.8 (Zone 3) respectively, has been established. The deterministic seismic hazard assessment (DSHA), using 6 attenuation equations, has been carried out for Peak Ground Acceleration (PGA) for DBD. The Main Mantle Thrust (MMT) yielded the highest median PGA value. The Probabilistic Seismic Hazard Assessment (PSHA) was also performed, which was necessary in order to obtain the Operating Basis Earthquake (OBE) and the Maximum Design Earthquake (MDE) as defined in ICOLD (1989) guidelines. A PGA of 0.33g with a 10% probability of exceedance in 50 years have been assigned for DBD using PSHA.

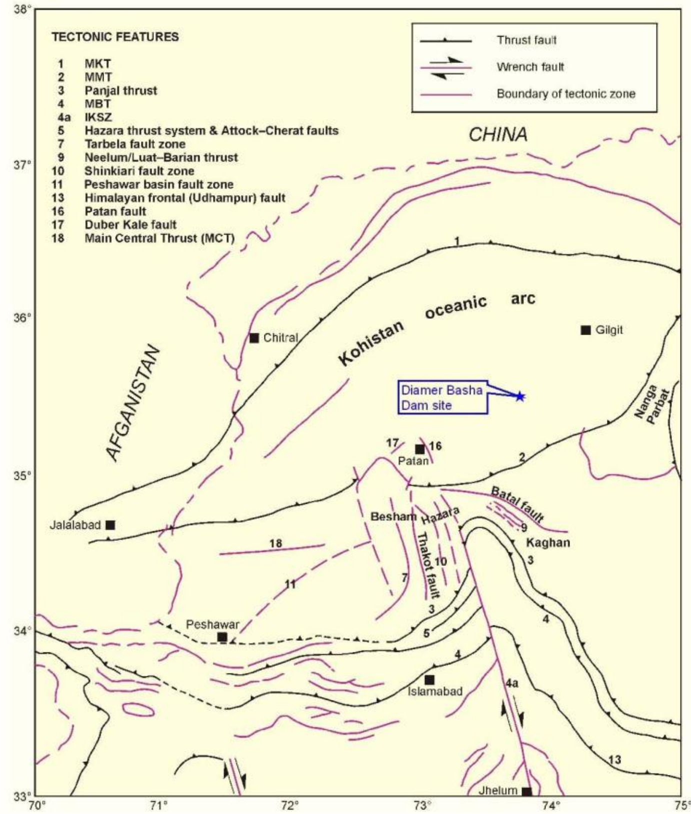

Fig. 1. Location map of Diamer Basha Dam (DBD) site along with the major tectonic features within the area (modified after Kazmi and Rana, (1982).

Neotectonic studies and structural modeling of a part of the Nanga Parbat syntaxis using seismological, geological and remote sensing data

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This work comprises of neo-tectonic studies and structural modeling of a part of the Nanga Parbat Syntaxis (NPS) using remote sensing, geological and seismological data. Geological analyses include detailed literature review of active faults bounding the NPS and their kinematic history while seismological interpretation includes the detailed analysis of earthquake data including source and Fault Plane Solution (FPS) or Focal Mechanism Studies (FMS). The seismological data obtained from local and international observatories e.g. United States Geological Survey (USGS) and International Seismological Center (ISC), UK. In addition, the freely available satellite images on websites e.g. the Glovis imagery web data source have been used for the fault identification. Landsat satellite images with spatial resolution of upto [60m] were used. The seismological, structural/geological and remote sensing data interpretation for the study area (an area between 74^o-75.5^o N longitude to 34.5^o-36^o E latitude), confirms the presence of several neotectonic features. Amongst of these the Raikot fault is proved to be the most active feature and is responsible for majority of the seismic activity at the western margin of the syntaxis especially. A careful study of most reliable duration of seismological data i.e. 2004-2010 shows that most of the earthquakes are occurring at the depth of 10-60 km with relatively low- to moderate- size (3.0-6.0 M_b) earthquakes. This proves our hypothesis that seismicity pattern of low- to moderate- magnitude earthquakes are occurring over a longer period of time and can produce greater deformation. It also shows that although the syntaxis is tectonically very active due to the presence of several neotectonic features, but release of strain energy is currently of low level, which might be indicative of any major earthquake event in the near future by the sudden burst of accumulated strain energy along the active Raikot-Sassi fault zone in particular. FMS for seven earthquakes in the area have shown that the western and eastern margins of NPS are surrounded by strike-slip faults and coincide with our geological interpretation. Small component of normal faulting in all these FMS is also evident, which might be indicative of localized strain adjustments along the active faults. Geologically, these faults were initiated as thrust faults along the Main Mantle Thrust (MMT), however, due to rapid Neogene uplift of the basement rocks, the MMT has been reactivated as dip- and strike-slip faults accommodating domal uplift of the syntaxis.

Current status risk assessment activities in emme – Pakistan

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The latest available data on the building typology of Pakistan is the "Building and Population Census of Pakistan, 1998". This housing data was synthesized and transformed to make it useful for acquiring estimates of seismic vulnerability. The distribution of buildings throughout the country is shown in the GIS environment.

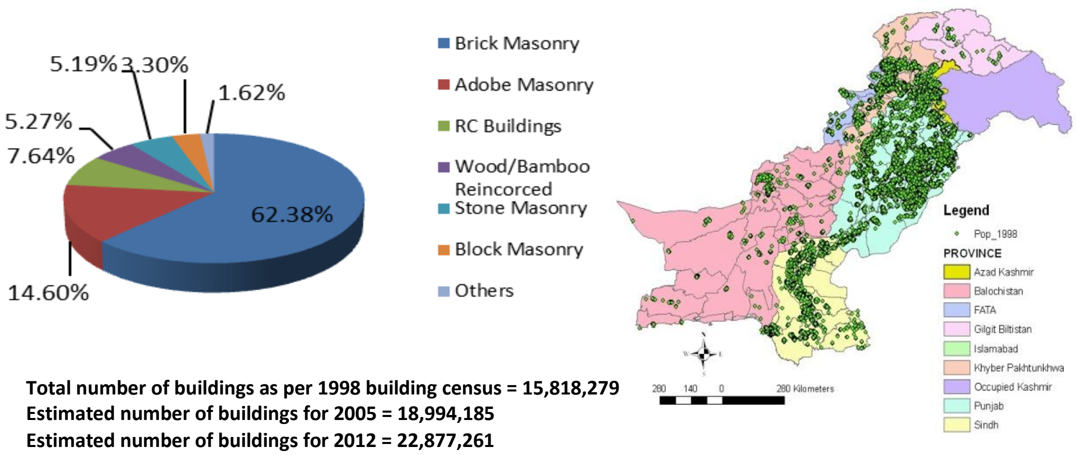

Fig. 1: Building typologies and its distribution along Pakistan.

Intensity based fragility curves for above identified building type were developed using the post-earthquake data from Kashmir earthquake 2005. To develop the fragility curves the method suggested by Giovinazzi (2005) was adopted.

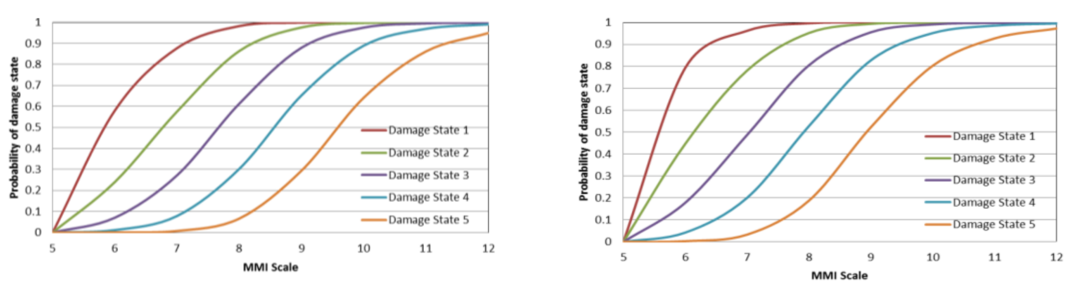

Fig.2.Fragility Curves for Brick and for Adobe Masonry Buildings.

Validation of the developed model was carried out using ELER for 2005 Kashmir earthquake. Reported number of damaged buildings due to 2005 Kashmir Earthquake was 454,905 whereas simulation from ELER estimated was 383,772 damaged buildings, about 15% less.

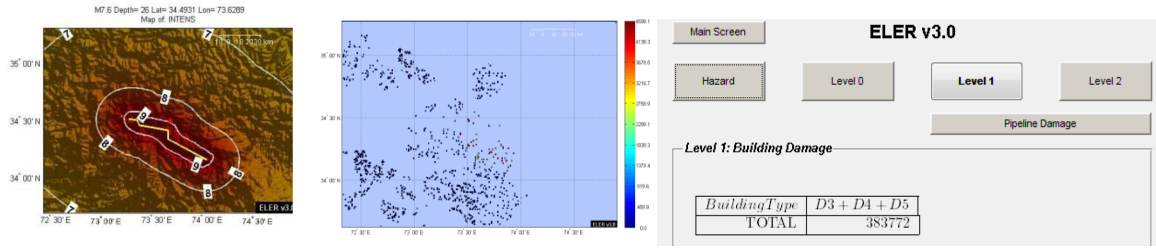

Fig. 3: 2005 Kashmir Earthquake Building Damage Simulations and its Geospatial Distribution.

Reference

Giovinazzi, S. 2005. The vulnerability assessment and the damage scenario in seismic risk analysis. PhD thesis, University of Florence (I) and Technical University of Braunschweig (D).

A review on the mineral and coal resources of northern and southern Punjab, Pakistan

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The Northern and Southern Punjab includes sedimentary basins like the Potwar (Upper Indus) Basin and part of Sulaiman (Middle Indus) Basin. The Northern and Southern Punjab has high potential of minerals/rocks like indigenous iron, radioactive minerals, rock phosphate, coal, gypsum, rock salt, laterite/bauxite, ochre, silica sand, natural gas and oil, dolomite, limestone (marble), sandstone, gravel, sand, silt and different type of clays, etc., and low potential of celestite and potash salt.

Coal in Punjab is found in Makarwal and Salt Range. It is developed in Tobra Formation of Lower Permian in the Buri Khel area of Western Salt Range, Hangu Formation of Cretaceous-Paleogene (K-Pg) boundary to Early Paleocene in the Makarwal, and Patala Formation of late Paleocene in the Eastern and Central Salt Range. In Dera Ghazi Khan and Rajan Pur districts, some coal showings are reported like the coal from Late Eocene Domanda Formation of Rakhi Munh, Mahoi and Zain BMP post areas of Dera Ghazi Khan District and Upper Tuso, Nabi Bakhsh Thal Nala and Khan BMP post area of Rajan Pur District, Late Eocene Drazinda Formation from Haft Gath/Shaheed Ghat area (Zinda Pir Ziarat area) of D.G. Khan District and Oligocene Chitarwata Formation in Khandor BMP post area of D.G.Khan District. Deep coal is also reported near Multan. Further the Cholistan areas are most significant for coal and have vast areas for exploration of petroleum, and water resources. Working coal mines in Punjab are the Makerwal (22 million ton), and Salt Range (213 million ton) coalfields of Punjab with total reserves of about 235 million ton. Due to energy crises, it is necessary to find new coalfields and also to properly utilize already explored coalfields.

Some commodities are being utilized and some are being exported but most of the commodities are waiting for their utilization and developments. Cement raw materials are present in the Daman areas of D.G.Khan and Rajan Pur districts. Therefore, the installation of more cement industries can help in improving the socio-economic condition of the area. Further terrestrial water resources are two much and rain water is going into sea creating flood and loss in the agricultural lands and population, so building of smaller dams along with major dams are vital for Pakistan because its population is increasing rapidly. Huge gypsum deposits in Pakistan are found in Sulaiman foldbelt but are not properly utilized so far. Punjab is rich in energy resources like coal, solar, terrestrial water, biomass and wind but is still deficient in energy. All these deposits need to be exploited for the development of the country.

Discovery of celestite deposits in the Sulaiman (Middle Indus) Basin, Balochistan, Pakistan

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Celestite deposits have been found for the first time in the Early Eocene Drug Formation of the Lal Khan, Lakha Kach, Gadumra and Bahlol areas of Barkhan, Sham and Pirkoh areas of Dera Bugti, Chamalang areas of Kohlu and Toi Nala areas of Musa Khel districts, Balochistan, Pakistan. This is the third deposit in Pakistan and has great significance as the previous known celestite deposits in Pakistan like Thano Bula Khan (Sindh) and Daud Khel (Punjab) are going to be exhausted shortly. Celestite is one of the fluxing materials used in metallurgy and HF acid preparation. Due to smallness of its deposits in the country, it is in high demand in Pakistan. Celestite deposits are found on the synclinal limbs. The present discoveries which are being described here are highly valuable in mineral wealth of Pakistan. This celestite ($SrSO_4$) is orthorhombic with tabular or prismatic, white, faint blue tinge, translucent, pearly, cleavable and coarse fibrous, and with a specific gravity of about 3.9 and hardness about 3.5.

Two principal types of celestite deposits are found in the Sulaiman Basin. Vein type deposits are found in the shale of uppermost portion of Early Eocene Drug Formation in the Gadumra, Lal Khan and Sham areas. The width of individual vein in Gadumra, Lal Khan Village and Sham localities is 10 centimeters, exposed length varies from 10 meters to 50 meters, however, it seems more extensive. Its extensions seem to be consistent with the host formation however it needs ground follow up. The contact of ore body and wall rock is sharp. Disseminated crystals in limestone are also found in the upper part of Drug Formation (and also below the vein type deposits) in the Gadumra, Lal Khan Village and Lakha Kach localities. The dissemination of celestite in the limestone is less than 30 cm in Lal Khan and Lakha Kach village. Chemical analyses show SrO 38.50 to 39.21%, SO_3 42.64 to 42.96 %, BaO 7.63 to 7.99% and CaO 1.10 to 1.12%. Celestite contains small amounts of calcium and barium. Reserves estimation of Sulaiman basin localities is tentative because no exploratory holes have been drilled to ascertain the shape and size of ore bodies at depth. The ore bodies are scattered in the area and mostly covered by scree. However, estimated reserves of Lal Khan village is 2000 tons, Gadumra area is 2000 tons, Lakha Kach areas is 5,000 tons, Sham area of about 2000 tons, Toi Nala area of about 1000 tons, Chamalang and Bahlol area of about 1000 tons and Pirkoh area of about 100 tons. The celestite nodules are also found in the Late Eocene Kirthar limestone and shale of Karkh area of Khuzdar district. Both discoveries are compelling for further exploration in Sulaiman and Kirthar basins.

The veins of celestite deposits are of varying lengths and widths while disseminated celestite crystals are found in the fracture zones, cracks, joints and cavities in limestone. The dissemination in the limestone of Drug Formation is due to replacement of the limestone (calcite). The celestite apparently formed from geodynamically mobilized hydrothermal (epithermal) solutions containing strontium sulphate. The genesis of mineralization might be due to geodynamics/ plate tectonic orogeny which is responsible for the epithermal (hydrothermal) solution created from host rocks or the vicinity formations that may contain anomalous strontium sulphate content, since igneous rocks are not exposed in the immediate vicinity. The celestite deposits of Sulaiman Range are related to gypsum deposits because the celestite deposits in Drug Formation are located just below the Baska gypsum, and celestite occurrences of Domanda shale are located just below the Domanda gypsum bed. It is possible that sulphate is originated from gypsum deposits and strontium from hydrothermal solutions from host rocks or gypsum associated strata.

Discovery of fluorite deposits from Loralai District, Balochistan, Pakistan

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Fluorite deposits have been found for the first time in the Jurassic Loralai limestone of Gadebar, Daman Ghar, tor Thana, Wategam, Mekhtar, Balao, Mahiwal areas of Loralai District, Balochistan. The first largest deposit of fluorite (over 0.1million ton) are located in Dilband and in its vicinity in Kirthar foldbelt. The second largest deposit of 6750 tons of green fluorite is located in Mula-Zahri Range of Kirthar foldbelt. The third largest deposit of fluorite is found in Loralai district and its vicinity in Sulaiman foldbelt. The fluorite of Loralai area occurs as veins and as dissiminated grains along faults and fractures which is hosted by the Jurassic Loralai limestone forming the anticlinal core. Fluorite has many colors such as pink, blue, light-grey, green and light-yellow. Chemical analysis shows CaF_2 varies from 95.20-95.40%, $CaCO_3$ from 3.20-3.40% and SiO_2 from 1.40-1.44%. Average weight % concentration of Ca is 49%, F is 45%, SiO_2 is 2.30%, CuO is 0.5%, Al_2O_3 is 2%, Fe_2O_3 is 0.08% and LOI is 1.47%. This type of fluorite can be used for acid preparation and also as gemstones. Mining of fluorite is in progress in the Mekhtar (Balao, Inde, Sande and Zhizhghi), Tor Thana and Zarah areas. The estimated reserves are about 50000 tons. Attractive gem quality fluorite crystals are found in light-green, yellow and light-blue colors from Mekhtar, Wategam Zarah of Loralai district. It is also suggested that the Jurassic strata especially limestone of Kirthar and Sulaiman foldbelts and adjoining western indus suture Zone seems to be significant for further fluorite prospecting.

Natural resources of Khyber Pakhtunkhwa, Gilgit-Baltistan and Azad Kashmir, Pakistan

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The convergence of Indo-Pakistan subcontinent (northward moving) plate with Asian (stable) plate created many tectonometallic zones, basins and consequently significant mineralizations in the area. The reported area includes different tectonometallic and sedimentary basins like the Kohat (Upper Indus) basin, northern part of Sulaiman (Middle Indus) basin, Khyber-Hazara Metamorphic Zone (part of Lesser and Higher Himalaya crystalline zone), Northern Indus Suture, and northernmost part of Western Indus Suture, Kohistan-Ladakh magmatic arc, Karakoram block and Kashmir basin. The investigated area has high potential of minerals/rocks like indigenous iron, copper, gold, lead, zinc, chromite, radioactive minerals, rock phosphate, gypsum, rock salt, laterite and ochre, silica sand, granite, quartzite, nepheline syenite, natural gas and oil, limestone, marble, slatstone, serpentine, sandstone, gravel, sand, silt and different type of clays, etc, and low potential of antimony, asbestos, barite, fluorite, magnesite, soapstone, bauxite, mica, feldspar, graphite, potash salt, arsenic, tungsten, platinum group, nickel, cobalt, vanadium, thorium, Rubidium, Rare metals (Nb, La, Y, V and etc.), and Rare Earth elements (Ce, Nd, Pr, Sm, Gd), etc. The study area also contains precious gem minerals like emerald, aquamarine, fluorite, garnet, moonstone, pargasite, peridot, quartz, ruby, spinel, kyanite, topaz (pink topaz), tourmaline, etc.

In Khyber Pakhtunkhwa Province coal is found in Hangu-Orakzai, Cherat, Gulakhel, Shirani and Dara Adamkhel. In Azad Kashmir it is confined to the Kotli area. Minor coal showings are also reported in Reshit-Chapursun Valley of Gilgit-Baltistan areas. Stratigraphically the coals of Pakhtunkhwa, Azad Kashmir and Reshit Chapursun (Gilgit-Baltistan) Valley are confined to the Hangu Formation (Cretcaeous-Paleogene K-Pg boundary to Early Paleocene), Patala Formation (Late Paleocene) and Ashtigar Formation (Jurassic) respectively. Working coal mines in Khyber Pakhtunkhwa are Hangu/Orakzai (81million ton), Cherat (7.74 million ton), Gulakhel (30 million ton), and Dara Adamkhel (recently mining started) coalfields, and non-developed is Shirani coalfield (1 million ton) with total reserves of about 119.74 million ton; and working coal mines in Azad Kashmir are Kotli coalfields with total reserves of about 8.72 million ton. Due to energy crises it is necessary to find new coalfields and also utilize explored coalfields and introduce semi-mechanization in coal mining to keep up production as well as its cost at competitive levels.

Some commodities are being utilized and some are being exported but most of the commodities are waiting for their utilization and development. Further terrestrial water resources are two much and rain water is going into sea creating flood and loss in the agricultural lands and population, so smaller dams along with major dams are vital for Pakistan because its population is increasing rapidly. In short, the mineral, gem and coal deposits and terrestrial water resources of the area need further exploitation for the development of the areas, provinces and ultimately for Pakistan.

Paleobiogeography and first collision of Indo-Pakistan subcontinent with Asia

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The timing of isolation, migration and collision of Indo-Pakistan subcontinent are problems for biogeoscientists. Here, both the geological and biological evidences from Pakistan are explained for the understanding of this issue. During Late Triassic (220 Ma) the lands united as Pangea. The breakup of Pangaea started in Middle Jurassic (170 Ma) while the breakup of Gondwana started in Late Jurassic (160 Ma). By the Late Jurassic (160 Ma), in a narrow seaway separated the east coast of Africa from Madagascar and the rest of the East Gondwana block. When major faults or rifts occurred, these have many subsidiary faults or rifts. In this way the rifting between east Gondwana (Madagascar, Indo-Pakistan subcontinent, Antarctica, and Australia) and west Gondwana (South America and Africa) created both rift on the west and also in the east of Madagascar. Consequently, Madagascar is separated from Africa and also from Indo-Pakistan during Late Jurassic. Indo-Pakistan started northward journey at Jurassic-Cretaceous boundary (145Ma). Most of Cretaceous passes as journey and isolation. Indo-Pakistan migrated rapidly covering more than 6000km in about 70-80 million years, and contacted first time with Afghan block of Asia at Latest Cretaceous about 75-70 Ma. Due to this geoevent, the Western Indus Suture (on northwestern part of Sulaiman basin) close to Zhob and its adjoining areas of Afghan block began to rise. Consequently, the Early Eocene detritals/clasts of Chamalang (Ghazij) group molasse (Shaheed Ghat, Toi and Kingri formations; shale, sandstone, conglomerate and coal) began to come from this uplifted areas of Afghan block (hinterland) and Zhob (Western Indus Suture Zone). The trend of this detritals were N-S, NW-SW, instead of previous/pre Eocene detritals source of Sulaiman and Kirthar basins which was generally East to West (from Indo-Pakistan Shield). This shifting of source rocks of detrital materials show the uplift of area by glancing contact of Indo-Pakistan plate with Afghan block of Asia during 75Ma and hard contact at 55Ma, because even global events rightly or wrongly attributed to collision appear to have lagged $\geq$20 Ma after the widely accepted time for collision inception. Detrital sedimentary records along convergent plate margins are widely regarded as key repositories, for precisely containing the timing of both major and minor tectonic events.

The long journey in long period of Indo-Pakistan have affected its biota, paleoclimates, etc. The first fossil to so far Pakistan has produced about 3000 fossils (some articulated, some associated and some isolated) of cranial, vertebral and appendicular elements of latest Cretaceous dinosaurs and crocodiles, collected from fluvial two red mud horizons (alternated by sandstone horizons) of Vitakri Formation. This include *Khetranisaurus*, *Sulaimanisaurus*, and *Pakisaurus* of (slender) Pakisauridae and *Marisaurus* and *Balochisaurus* of (stocky) Balochisauridae herbivorous titanosaurian sauropods, *Vitakridrinda* (slender and large bodied), and *Vitakrisaurus* (small bodied) of carnivorous Vitakrisauridae theropod, and *Pabwehshi* and *Sulaimanisuchus* of carnivorous Sulaimanisuchidae mesoeucrocodiles. A few fossils of Late Jurassic *Brohisaurus* titanosaur were documented from Kirthar foldbelt. Further, the trackways from the Middle Jurassic Samanasuk Limestone of Surghar Range represent a herd of wide gauge *Malakhelisaurus* titanosaurian sauropods confronted by a narrow gauge running *Samanadrinda* theropod. Some opinions show the contact of Indo-Pakistan subcontinent and Madagascar during the Late cretaceous but the latest Cretaceous fauna of Pakistan do not show such highest degree of resemblance with Madagascar and South America as it should be if connected. The trispinous distalmost caudal centra and moderately inclined skull of Pakistani titanosaurs, and complex skull of *Vitakridrinda* and pes of *Vitakrisaurus* theropods show so far endemic characters. The dinosaurs and crocodiles in Gondwanalands got broad distribution prior to fragmentation.

Revised lithostratigraphy of Sulaiman and Kirthar basins, Pakistan

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Sulaiman (Middle Indus) Basin consists of more than 15km thick exposed Mesozoic to recent succession. Triassic Khanozai group represents Gawal (shale, thin bedded limestone) and Wulgai (shale with medium bedded limestone), Jurassic Sulaiman group represents Spingwar (shale, marl and limestone), Loralai (limestone with minor shale), and Chiltan (limestone) formations, Early Cretaceous Parh Group represents Sembar (shale with a sandstone body), Goru (shale and marl), and Parh (limestone) formations, and Late Cretaceous Fort Munro group represents Mughal Kot (shale/mudstone, sandstone, marl and limestone), Fort Munro (limestone), Pab (sandstone with subordinate shale) and Vitakri (red muds and greyish white sandstone) formations. The Paleocene Sangiali group represents Sangiali (limestone, glauconitic sandstone and shale), Rakhi Gaj (Girdu member, glauconitic and hematitic sandstone; Bawata member, alternation of shale and sandstone), and Dungan (limestone and shale) formations; Early Eocene Chamalang (Ghazij) group represents Shaheed Ghat (shale), Toi (sandstone, shale, rubbly limestone and coal), Kingri (red shale/mud, grey and white sandstone), Drug (rubbly limestone, marl and shale), and Baska (gypsum beds and shale) formations, and Late Eocene Kahan group represents Habib Rahi (limestone, marl and shale), Domanda (shale with one bed of gypsum), Pir Koh (limestone, marl and shale) and Drazinda (shale with subordinate marl) formations, Oligocene-Pliocene Vihowa group represents Chitarwata (grey ferruginous sandstone, conglomerate and mud), Vihowa (red ferruginous shale/mud, sandstone and conglomerate), Litra (greenish grey sandstone with subordinate conglomerate and mud), and Chaudhwan (mud, conglomerate and sandstone) formations, and Pleistocene-Holocene Sakhi Sarwar group represents Dada (well developed conglomerate with subordinate mud and sandstone) and Sakhi Sarwar Formation (poorly developed conglomerate with subordinate mud and sandstone, while in centre of valleys the mud is dominant) concealed at places especially in the valleys and plain areas by the Subrecent and Recent fluvial, eolian and colluvial deposits.

Kirthar (Lower Indus) basin shows mostly the same lithological units like Sulaiman basin during Mesozoic and Quaternary but vary in Tertiary strata such as; Paleocene Ranikot group represents Khadro (sandstone, shale, limestone and volcanics), Bara (sandstone with minor limestone, coal and volcanics) and Lakhra (limestone and shale) formations; Early Eocene Laki group represents Sohnari (lateritic clay and shale, yellow arenaceous limestone pockets, ochre and lignite seams) and Laki (shale, limestone, sandstone, lateritic clay and coal) formations and Late Eocene Kirthar group represents Kirthar (limestone, marl and shale) and Gorag (resistant and peak forming limestone with negligible shale and marl) formations; Oligocene Gaj group represents Nari (sandstone, shale, limestone) and Gaj (shale with subordinate sandstone and limestone) formations and Miocene-Pliocene Manchar group/Vihowa group which are concealed in the valleys and plain areas by the Subrecent and Recent fluvial, eolian and colluvial deposits.

Coal of Shirani area, D.I. Khan District, Khyber Pakhtunkhwa, Pakistan

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Due to the present energy crises in Pakistan, the government and power generation sectors have shown keen interest for the exploration of indigenous coal resources. Coal deposits are extensively found in all provinces of Pakistan, Azad Kashmir and Gilgit-Baltistan areas. In Khyber Pakhtun Khawa coal is found in Hangu-Orakzai, Cherat, Gulakhel/Kurd-Sho, Dara Adamkhel and Shirani areas which belong to Early Eocene and Cretaceous-Tertiary boundary to Early Paleocene age. The Shirani area (F.R.D.I.Khan) lies in the north eastern part of Sulaiman foldbelt which consists of exposed Mesozoic to recent following sequence. Jurassic Sulaiman group represents Spingwar (shale, marl and limestone), Loralai (limestone with minor shale), and Chiltan (limestone) formations, Cretaceous Parh Group represents Sembar (shale with a sandstone body), Goru (shale and marl), and Parh (limestone) formations, and Fort Munro group represents Mughal Kot (shale/mudstone, sandstone, marl and limestone), Fort Munro (limestone), Pab (sandstone with subordinate shale) and Vitakri (red muds, greyish white sandstone and some carbonaceous shale and coal) formations. The Paleocene Sangiali group represents Sangiali (limestone, glauconitic sandstone and shale), Rakhi Gaj (Girdu member, glauconitic and hematitic sandstone; Bawata member, alternation of shale and sandstone), and Dungan (limestone and shale) formations; Eocene Chamalang (Ghazij) group represents Shaheed Ghat (shale), Toi (sandstone, shale, rubbly limestone and coal), Kingri (red shale/mud, grey and white sandstone), Drug (rubbly limestone, marl and shale), and Baska (gypsum beds and shale) formations, and Kahan group represents Habib Rahi (limestone, marl and shale), Domanda (shale with one bed of gypsum), Pir Koh (limestone, marl and shale) and Drazinda (shale with subordinate marl) formations, Oligocene-Pliocene Vihowa group represents Chitarwata (grey ferruginous sandstone, conglomerate and mud), Vihowa (red ferruginous shale/mud, sandstone and conglomerate), Litra (greenish grey sandstone with subordinate conglomerate and mud), and Chaudhwan (mud, conglomerate and sandstone) formations, and Pleistocene-Holocene Sakhi Sarwar group represents Dada (well developed conglomerate with subordinate mud and sandstone) and Sakhi Sarwar Formation (poorly developed conglomerate with subordinate mud and sandstone, while in centre of valleys the mud is dominant) concealed at places especially in the valleys and plain areas by the Subrecent and Recent fluvial and eolian deposits.

The coals of Balochistan are developed in a Latest Cretaceous Vitakri and Pab formations and Early Eocene Toi Formation, and Shirani coal is the northeastern extension of Toi coal basin (Chamalang/Ghazij group) of Balochistan. The Shirani coal is found in the green shale and sandstone of deltaic Toi Formation which is overlain by the mollase type Kingi formation (red muds with subordinate trough crossbedded sandstone). The present research reveals that the northern part of Shirani area like the Khoara Khel, Shin Mandai and its close vicinity areas show best exposures of 3 carbonaceous shale horizons in Toi Formation. The central horizon show a half foot thick coalseam which may increase at depth. At Khoara Khel the private company is trying to mine the coal but so far no positive results. The central part of Shirani area like Nispura and Ragha Sar areas show no best exposures of coal, however in the southern part of Shirani area no best exposures of coal are found except 1 foot thick carbonaceous shale in the Early Eocene Toi Formation on the bank of Toi River close to Mughalkot. Further minor coal showings are also found in the Latest Cretaceous Pab and Vitakri formations, Early Eocene Baska

Formation, Late Eocene Domanda and Drazinda formations and Oligocene Chitarwata formation in Shirani areas. Field study and other data show that the Toi coalseams are generally thin and lenticular which indicates that the major parts of these coals are deposited in the near shore and marginal marine environments of deposition.

Intensity distribution data of the 19 January 2011, MW 7.2 Dalbandin earthquake, Baluchistan

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The M_W 7.2 Dalbandin earthquake on 19 January 2011 at 01:23 AM local time (18 January 2011, 20:23 UTC) occurred south of the Makran-Baluchistan volcanic arc at a depth of ≈70 kilometers and was followed by two globally recorded aftershocks. It appears to have occurred on a normal fault within the subducting Arabian-Ormara plate where it descends beneath a southern promontory of the Eurasian plate. The earthquake is the largest well-instrumented intermediate focus earthquake in western Baluchistan in the past century. Though, only M_W 7.2, the earthquake was felt by people in an area that exceeded five million square kilometers and given the low seismicity of the region provided an excellent opportunity to examine the attenuation of felt intensities from a major earthquake in the region. The 2011 Dalbandin M_W=7.2 earthquake was notable for its felt area and for the apparent absence of significant damage even in the epicentral region. Although, no empirical attenuation parameters were calculated for the earthquake from perceived intensities, the combination of minor epicentral damage with a significant felt area alone provides the most significant indicator of an intermediate focus earthquake. An unexpected ancillary result from the earthquake was the wealth of felt reports from the mega-city of Karachi that permitted us to form conclusions about the amplification of sediments in different parts of the city.

Estimation of groundwater balance for Pabbi region, Khyber Pakhtunkhwa

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This paper presents the methodology for estimation of groundwater balance for Pabbi region, Khyber Pakhtunkhwa. Due to heavy rainfall in summers, excessive irrigation and seepage from irrigation canals, the adjacent areas of Kabul River have suffered from water logging for a long time. It has been found that the recharge to groundwater storage due to seepage from canals and their distributaries in Pabbi region is 26 mm/year. According to the data collected from Metrological Department, Peshawar, mean annual rainfall of Pabbi region is 262.70 mm/year and recharge due to rainfall is calculated as 60.63 mm/year. Discharge through the tube wells and hand pumps in the area are found as 35 mm/year and 14 mm/year respectively. It has been concluded that 37.63 mm of groundwater level is increasing per year in Pabbi region.

Specialized refractories in Pakistan

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Refractories are ceramic materials which are employed to withstand primarily the effects of high temperature operations usually involved in metallurgical processes in blast furnaces, Kilns, high temperature reactors and exhausts of furnaces and engines. The refractories are also expected to remain stable under chemical and physical impacts encountered during their use in high temperature operations. The refractories may be produced in the regular shaped pieces like bricks, tubes, plates etc or as ramming and cemmenting powders. The refractory particles are bound together with the help of fluxes or synthetic binding materials when producing regular shaped bodies.

The major materials required for this industry are magnesite and chromite ores or magnesia obtained from other sources. Extensive deposits of magnesite as well as chromite are found in Pakistan.

Huge reserves of high grade refractory magnesite ore have been found and proved in the Kumhar area of Sherwan, just 22 kilometers northwest of Abbottabad. The deposit can be accessed by metalled road. According to latest estimates the minable reserve of just two lenticular magnesite bodies are 2.98 million tons. There are about thirteen more magnesite bodies of different sizes with geological reserves of 12.39 million tons.

Kumhar magnesite is qualitatively one of the best in the world with highest 98% MgO contents and lesser impurities of CaO, $Fe_2 O_3$ and SiO_2 etc. It has therefore been declared most suitable for use as refractories after detailed geological and chemical studies.

Magnesite finds extensive use in specialized refractories which are used in iron and steel, cement, lime and other industeries. For this purpose magnesite is first calcined deeply to convert it to a stable form of magnesium oxide (periclase), which would not absorb CO_2 or moisture even at lower temperatures. The magnesium oxide in the inert form in the presence of small percentage of iron oxide and silica acts as basic refractory substance.

Pattern, rate, and timing of surface rupturing earthquakes acorss the northwest Himalaya

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An elegant model sensibly links interseismic strain accumulation, historic and paleoseismic earthquakes, and intermediate- to long-term shortening in the central Himalaya. Records of historic and paleoseismic earthquake include more frequent, blind earthquakes ($<M_w$ 8.4) and less frequent, emergent earthquakes ($>M_w$ 8.5) on the Himalayan Frontal thrust (HFT). These earthquakes relieve the majority of the interseismic strain accumulation and faults within the central Himalayan accommodate little strain [Bettinelli et al., 2006; Kumar et al., 2006; Larson et al., 1999; Lavé et al., 2005]. Active deformation of the northwestern Himalaya reveals a different story. An asymmetric anticline marks the deformation front in Kashmir and the HFT is inferred to be blind. The Salt Range thrust system (SRT) defines the thrust front in Pakistan to the west, which includes active folds in the footwall of the SRT proper [Yeats and Thakur, 2008]. Within the orogenic wedge to the north of the deformation front, active shortening occurs along a system of surface-rupturing reverse faults, extending from the Balakot-Bagh fault, source of the Mw 7.6 Kashmir earthquake of 2005 in Pakistan Kashmir, to the Reasi fault in Indian Kashmir to the southeast [Gavillot, 2010; Hebeler, 2010; Hussain et al., 2009]. Farther north, faults in the Kashmir Valley cut Quaternary deposits [Madden, 2010; Nakata, 1989]. Active deformation thus occurs on faults distributed more than 120 km across the orogen from the deformation front in the foreland into the northwest Himalayan orogen.

Northwest Himalayan thrust front

Gee [1989] summarizing his earlier work in a series of maps along the Salt Ranges demonstrated that the SRT deforms young surficial deposits and is an active fault. New mapping and preliminary OSL dates from deformed Holocene sediments exposed along the westernmost SRT reveal that the last surface rupture on this fault occurred with the last several thousand years. Our observations of 1000's years between surface rupturing events is with consistent with the low SRT shortening rates (4 to 13 mm/yr).

It is simply unknown whether the HFT ruptures to the surface in the Kashmir Himalaya, Tilted fluvial strath terraces across the frontal structure imply that a fold defines the deformation front.

However, ~20 m-high escarpments oriented perpendicular to rivers suggest that unrecognized thrust fault(s) reach the surface locally. Contacts relations within the Siwalik sediments on the limb of the frontal anticline implies fold growth between 0.78 Ma and 1.5 Ma [Ranga Rao et al., 1988; Raynolds, 1980]. Folded river terraces and dip data suggest that the thrust at depth is a southwest-dipping backthrust rather than a north- or northeast-dipping forethrust as is seen along strike along the SRT and in India to the southeast.

Active faults at intermediate distances from the thrust front

A seismically active emergent thrust fault system extends stepwise from the Balakot-Bagh fault (BB; source of the Mw 7.6, 2005 Kashmir earthquake [Kaneda, 2008; Kumahara and Nakata, 2006]) southeast more than 200 km to the Reasi fault (RF) [Hussain et al., 2009]. Both the BB and RF are reverse faults; the BB locally cuts the 17 – 12 Ma Kamlial Formation. A balanced cross-section indicates a minimum of 20 km fault displacement on the BB, yielding a minimum 1.2-1.7 mm/yr long-term slip rate, lower than the 1.4 -4.1 mm/yr slip rate inferred from faulted Quaternary fluvial terraces [Kaneda, 2008]. The penultimate earthquake occurred between 500 and 2200 y.r. B.P. [Kondo et al., 2008].

The RF is a ~70 km-long, ~50° northeast-dipping reverse fault system, which lies ~40 km north of the deformation front in the Kashmir Himalaya [Gavillot et al, 2010]. Two strands define the Reasi fault. The northern strand, Main Reasi fault (MRF), places Precambrian Sirban Limestone on folded unconsolidated conglomerates. Younger alluvial deposits cover the MRF. A preliminary OSL age of 80 ± 6 ka from a 350 m-high Bidda terrace in the upper plate of the MRF, yields a minimum long-term uplift rate of 4.4 ± 0.3 mm/yr, a slip rate of 5.7 ± 0.4 mm/yr, and a shortening rate of 3.7 ± 0.3 mm/yr for the RF. To the south, the Reasi (Riasi) frontal fault (RFF) includes a fault scarp that offsets Holocene deposits. Trenches excavated across the RFF reveal a distinct angular unconformity, steeply dipping strata cut by low-angle thrusts, and an unconformity below relatively undeformed strata [Hebeler et al., 2010]. Trench relations can be explained by surface rupture of the RF ~4,500 yrs ago. The age of this unconformity is constrained to be ~4,500 yrs old based on calibrated calendar C-14 ages from detrital charcoal. These results and those from the BB [Kondo et al., 2008] imply recurrence intervals of $\geq$ 2,000 yrs).

Active faults in the hinterland

Active faulting also occurs within the Kashmir Valley (KV) [Maddenet al., 2010], an intermontane basin ~100 km north of the deformation front. Three northeast-dipping reverse faults cut Quaternary terraces on the southwest side of the KV. Deformed terraces along the Rambira River exhibit ~13 m of vertical separation across one of the faults (the 40-km-long Balapora fault (BF)). Weakly developed soils and the lack of loess suggest deposition after the last glacial maximum (22-17 ka), possibly as young as 10-6 ka. Given the 60° fault dip, we estimate a preliminary BF shortening rate of 0.3 to 1.3 mm/yr. Fault and stratal relations in trenches suggest at least 2 surface rupturing events in the latest Quaternary.

Given a ~34 mm/yr India-Asia convergence rate in the NW Himalaya [Bettinelli et al., 2006], active structures within the NW Himalaya absorb roughly 15 to 50% of that convergence. In contrast to the central Himalaya where deformation is focused at the HFT, up to ~20% of the shortening occurs on structures north of the HFF, within the NW Himalayan orogenic belt. Recognition of internal surface-rupturing reverse faults indicates probabilistic models for seismic hazards in the NW Himalaya ought to account for great earthquakes on the Main Himalayan thrust (the basal décollement), moderate earthquakes on upper plate faults, and potentially events in the down-going Indian plate.

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Geophysical and remote sensing-based approach to model regolith thickness in a data-sparse environment

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Mapping regolith thickness to bedrock is important for environmental modeling in general and for seismic hazard assessment in particular. However, regolith thickness is often ignored in such studies because of its presumed difficulty of mapping in many terrains. To overcome this imitation we developed a generic remote sensing and geophysics based approach to model regolith thickness for areas with limited possibility of direct field observations. The approach was tested in a seismically-active and depositional landscape in northern Pakistan.

Regolith thickness was sampled at exposed bedrock outcrops along the river bed and scarps. At unexposed sites the regolith-bedrock interface was identified through electrical resistivity survey, thus providing an indirect measurement of regolith thickness. A geomorphic classification of landforms and topographic attributes were derived from a remote sensing-based (ASTER) digital elevation model and SPOT-5 satellite imagery. Landform was the most important predictor (adjusted R2=72.1%), showing the importance of geomorphic interpretation. Amultivariate linearmodel based on landform, elevation and distance to streamwas able to predict the regolith thickness (adjusted R2=91.7), including field-observed abrupt changes at landform boundaries.

Preliminary study of the rocks of Bagrot Valley, Gilgit-Baltistan, Pakistan with emphasis on gold and base metals mineralization

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Bagrot valley, a study area of this research, is located in Giligit district of the Gilgit-Baltistan province in the northern areas of Pakistan. The geology of the area is mainly comprised of the Chalt volcanics and diorites belonging to Kohistan island arc (KIA). Chalt volcanics covers most part of the study area. These are strongly deformed, metamorphosed, and intensely sheared along shear zones. The diorites occur in the southern part of the study area and have intrusive contact with the Chalt volcanics. Yellowish-brown color staining due to the oxidation of sulfide bearing phases, especially pyrite and chalcopyrite, to limonite is very prominent along the shear zones within the Chalt volcanics and also along the contact zones with diorite. At places the development of malachite and azurite are also noticed in association with the Cu-bearing sulfides. These sulfide bearing zones are <1m to >10m thick and are extended up to >100m.

The rocks of the area, especially the sulfide bearing zones, are the main focus of this study in regard to gold, silver and base metal mineralization. To understand the chemical potential of the rocks of the area, bulk samples (>10kg) were collected in the field from both fresh rocks and sulfide bearing zones. These samples were treated for the chemical concentration of Au, Ag, Cu, Pb, Zn, Ni, Cr, Co, and Cd. The samples were crushed to 2mm size in jaw crusher and then pulverized to -100 mesh size by the tungsten carbide ball mill. Representative portion of each sample was digested with hydrofluoric acid, aqua regia (3HCl:1HNO3) and other acid mixtures. These working solutions were used for the determination of base metals by Perkin Elmer 700 electrothermal atomic absorption spectrometer (AA) while gold was determined by the same technique after its extraction in methyle isobutyle ketone (MIBK). Au, Ag, Cu, Pb, Zn, Ni, Cr, Co, and Cd are present in the range of <5- 95ppb, 0.5- 11ppm, <0.5-198ppm, <0.5-3ppm, 2-36ppm, <0.5-75ppm, 22-72ppm and <0.5-4ppm respectively. It is concluded from the field and geochemical investigations that the rocks of the study area gave indications of gold, Ag and some base metals mineralization. Therefore, detailed study in regard to the economic potential and genesis of the mineralized sheared zone of the study area is needed to be carried out.

Crustal study of Muzaffarabad area based on gravity data

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The geological study based on gravity data has been carried out in the Muzaffarabad city. The geological model computed by geophysical experiment delineated the thickness of crust and the subsurface structural elements i.e. Main Boundary Thrust (MBT) and Jhelum strike slip Fault (JF). These thin skinned faults are developed due to compressional stresses which are generated on the eastern and western limbs of HKS due to collision of Indian and Euraian plates. In the study area MBT lies between Muree Formation of Miocene age and Hazara Slates of Precambrian age and dips at an angle of 73^0SW and penatrated throughout the sedimentary/metasedimentary wedge. In the study area model also delineated the Jhelum left lateral strike slip fault which joins the MBT at the depth of 12 km. The model computed 15 km thick sedimentary/metasedimentry wedge and 53 km total thickness of the crust in study area. The study also delineated the 38 km thick crystalline crust of Indian shield which is dipping at an angle of 5^0NE in the Muzaffarabad city.

Environmental geochemistry of the Kohistan region, northern Pakistan

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This study investigates the environmental geochemistry of the Kohistan region, where mafic and ultramafic rocks of Kohistan island arc and Indus suture zone and meta-sedimentary rocks of Indo-Pakistan plate are exposed. For this purpose, water (surface water and groundwater), soil and plants samples were randomly collected from the Jijal, Dubair, Alpuri, Pazang, Lahor and Besham area. These samples were analyzed for physio-chemical parameters. Drinking water results were evaluated for health risk indices, while soil and plant for pollution quantification factor. Hazard quotient index was < 1 for all heavy metas in the drinking water, except Arsenic. Furthermore, results were evaluated with univariate and multivariate statistical analyses. Among the selected plant species (*Plectranthus rugosus, Selaginella jacqumonthi* and *Rumex hastatus*) were the best heavy metals accumulators as compared to others. Therefore, these plant species may be used for phytoremediation and mineral exploration.

Evaluation of the global attenuation relationships in the light of Pakistan specific earthquake strong motion catalog

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Ground-motion prediction equations (GMPEs), commonly known as the attenuation equations, are indispensable elements of seismic hazard analysis. These are the empirical relationships derived from available accelerogram data. These are used to estimate the values of strong-motion parameters (e.g. peak ground acceleration, peak ground velocity, and peak ground displacement) at the site of interest for input in seismic designs of structures. These equations describe the decay of strong motion parameters with distance from the source. GMPEs are applicable to regions for which they have been developed. These attenuation relations are area specific, i.e., they depend upon the tectonics and geology of the area where the strong-motion data comes from. This implies that attenuation relations developed for an area with a specific geological and tectonic setting may not be suitable for use for areas with different inherent geological and tectonic conditions. The accelerogram databank that is used to derive GMPEs continues to expand, but it is very unevenly distributed among different regions of the globe. This data is lacking in quantity and in quality for most regions of the world (including Pakistan) due to limited number of installed accelerographs. In such areas where GMPEs are yet to be established, one or more models derived for other regions preferably with similar or nearly similar regional tectonic settings are used. In the absence of GMPEs derived from locally collected strong-motion data, researchers working on seismic hazards in Pakistan have no option but to use GMPEs derived for other regions in the world.

Strong-motion data recorded by the Pakistan national strong-motion network has been compiled and processed systematically, along with detailed geophysical and geotechnical site measurements for all of its stations. The catalog information of 9 seismological agencies and other sources were examined to obtain reliable source, geometry and distance parameters for each event. The digital and analog strong-motion data were processed by a uniform methodology to remove the high- and low-frequency noise. The seismological and spectral information of 110 strong-motion records are available with us for use in this study. In this article, we present the fundamental features of this database and explain our methodology in GMPEs calculations. We present several comparisons of our database with other related studies to verify our approach during the computational stage of the seismological parameters. The database has enabled us to derive empirical magnitude conversion relationships to estimate moment magnitude in terms of different magnitude scales.

Microfacies and diagenetic framework of the Loralai Formation, Khader Zai Nala section, western Sulaiman Range, Pakistan

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The present investigation was focused on the detailed study of the microfacies and diagenetic framework of the shallow shelf Loralai Formation, Khader Zai Nala section, Bargha Shirani, Western Sulaiman Range, District Zhob, Balochistan, Pakistan. The Loralai Formation belongs to the Middle Jurassic carbonate rocks with its wide distribution in the host area of studied sections, adjoining District Loralai and around. The present authors studied this formation in detail for the first time covering its microfacies assemblages and diagenetic attributes. The petrographic analyses manifested that its most significant microfacies include: intraclastic rudstones, intraclastic grainstones, bioclastic grainstones, ooidal grainstones, peloidal grainstones, bioclastic packstones, ooidal packstones, and bioclastic mudstones. Its diagenetic attributes were, also, elaborated. A variety of cement morphologies has been identified from early to late diagenetic phases. This study, also, demonstrated the formation's significant reservoir quality in the western Sulaiman Range and adjoining areas. It is revealed by the excellent display of predominant grainstone microfacies. The secondary porosities due to dissolution, moldic, and vuggy porosities, and secondary porosities due to fracturing and extensive dolomitization have also been recorded from the measured section. The fractured limestone horizons, subjected to various phases of fracturing at different levels of this formation, displayed enhanced effective porosity and permeability due to induced interconnections. It is believed that the deposition of the Loralai Formation has taken place in the shallow shelf environments and it has developed reservoir quality at various stratigraphic levels in the investigated section.

Hydrogeological analysis of abandon hydrocarbon wells

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A new method for hydro geological analysis of hydrocarbon well is done in this project. There are many hydrocarbon wells drilled all over the world and ratio of success to failure is 3:10. It means, only 30% of them turn over to a successful production and rest the rest are plugged and abandoned. Among these abandon well most of them are located in such places where the major problem is water. If these well are used as water wells then it will be very effective for the local peoples. But either this water which comes to the surface from a formation which is proved to be a good reservoir is sufficient enough to use for drinking or agricultural purposes. For this purpose one should know the amount of Total Dissolved Solvents (TDS) (mg/l) in the water.

Spontaneous Potential Log and Deep Resistivity Log are used to find the resistivity of formation water and formation water saturation. The resistivity of formation water at formation temperature is calculated by using Bateman & Konen formula of calculating Rw at formation temperature.

$$R_w \text{ at formation temperature} = R_w \text{ at } 75^o \times 81.77 / (T_f + 6.77)$$

This resistivity is then converted into conductivity and used in a formula to convert into TDS (mg/l).

$$\text{TDS (mg/l)} = \text{Conductivity } \mu\text{S/cm} \times 0.67$$

It is found that the formation water has a TDS in the range of 400mg/l which is suitable of drinking purposes to 1800mg/l which is suitable for agricultural purposes. Now the next step is that whether the formation have sufficient amount of water present in it or not. So formation water saturation is found from Archie (1942) formula.

$$Sw = [(a/Ø^m) \times (Rw/Rt)]^{1/n}$$

From here it is clear that in many abandon hydrocarbon wells, formation water is present in huge amount and at high pressure. According to geology in an average reservoir one third of the pore is filled with hydrocarbon and remaining is with water. If no hydrocarbon is found there then the whole pore is filled with water. As the well is drilled to 2000m to 3000m then due to the over burden pressure, naturally water come to the surface by its self.

This whole theme is applied on Dhamraki-01 with the help of well data and seismic reflection survey analysis. Following assumption has been made: Dhamraki-01 is a dry well and its current status is P&A (plug and abandon). It has four different layers of sandstone which are alternatively separated by impervious layers of shale and all of these sandstones are completely sandwich between Upper shale of Goru formation and Talhar shale from bottom. This will act as confined aquifer. By using above discussed method in Dhamraki-01 well TDS (mg/l) is found to be in the range of 400mg/l to 1800mg/l.

This TDS of formation water lies in the range of drinking and for agriculture purposes. The chances of presence of carcinogenic compounds in sand are very low, and in shale and clay are high. If volume of shale in this formation increases than chances of carcinogenic compounds will increase in this formation water, but it has been found that this formation has very low values of volume of shale which is 15% to 20% so carcinogenic compound may not be presence. For further detail it can be found by the help of core sample analysis of Goru Sand.

So if these plugged well are reopen just for public use than the huge amount of money which have been spent on this abandon well would not be completely lost.

Preliminary investigations of the rocks of Shigari Bala area, Skardu, Gilgit-Baltistan, Pakistan in the perspective of gold and base metal mineralization

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Shigari Bala area, a part of the Skardu district, is the main focus of this study. It is located southwest of Skardu town in the Gilgit-Baltistan province. Tectonically the study area is a part of the Laddakh arc domain of the Kohistan-Laddakh island arc (KLIA). The geology of the study area consists of meta-sediments and meta-volcanics intruded by diorites belonging to the Kohistan batholith. The meta-volcanics (greenschists) are green colored, highly foliated and sheared rocks having greater resemblance with the Chalt volcanics. The meta-sediments are fine-grained, green to gray colored rocks with well-developed fabrics. Diorite occurs as intrusive bodies within the meta-volcanics where the honfelsic rocks are found at the contact zones. The Cu-bearing sulfide mineralization is dominantly chalcopyrite with lesser amount of bornite along with pyrite is noticed within the diorites and also along sheared zone within the hornfelse. At certain places porphyry type copper mineralization is well observed within the diorite, where leaching of the Cu-bearing phases to malachite and azurite is common.

Due to the presence of visible copper mineralization in the study area, the geochemical investigations of the rocks of the area was carried out in regard to gold, silver and other base metals. For this purpose, bulk samples (>10kg each) from the various rocks, especially mineralized diorites, have been collected during field. These samples were crushed to smaller size by the Jaw-crusher and then powdered to -100 mesh size by the tungsten carbide ball mill. Representative portion of each sample was selected for chemical analysis by quartering and conning method. The known quantity of powdered sample was digested by using hydrofluoric acid and aqua regia ($1HNO_3$:3HCL) for the analysis of gold, silver and other base metals. The analysis of Au, Ag, Cu, Pb, Zn, Ni, Cr, Co and Cd were performed by the Perkin Elmer 700 electrothermal atomic absorption (AA). Gold was extracted in methyle isobutyle ketone (MIBK) before its determination by AA. The concentration of Au, Ag, Cu, Pb, Zn, Ni, Cr, Co and Cd occur in the range of 1ppb to 545ppb, <0.05ppm to 5ppm, 8ppm to 254ppm, <0.1ppm to 9ppm, <0.1ppm to 131ppm, 2ppm to 40ppm, 4ppm to 88ppm, 2ppm to 82ppm, and <01ppm to 3ppm respectively. The occurrence of copper-bearing sulfides and the geochemical anomaly of Cu and Au in the diorites of the study area are indicative of the existence of possible source rock for Cu and Au. The detailed study of the area in regard to the genesis of mineralization and its economic potential is underway

Design of an open source mineral resource management system

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The breadth or domain of mineral sector includes, but is not limited to, mineral resource mapping, mineral resource modeling and visualization, mine planning and design, mine management, mineral and mining cadastre system. Although, there are many software solutions for various aspects related to mineral sector, but a comprehensive and coherent solution, seizes to exist. These are 1) cover and integrate the entire and diverse domain of mineral sector, and 2) provide a platform that would accommodate the requirements of the stakeholders of the mineral sector. Therefore, an integrated open source software mineral resource management system (MRMS) is needed to be designed and developed such as 1) open source software (OSS) solutions purview almost all conceivable domains, and 2) contemporary OSS's have the characteristics and capabilities needed for an integrated software solution for the mineral sector. This paper envisions the design of an open source MRMS. The proposed MRMS is based on the characteristics and capabilities of integration, customization and binding of various open source geospatial softwares including open source libraries, services, applications, spatial database management systems, and an open source ERP. Core architecture of MRMS will not only provide the common capabilities for the independent islands of mineral resource mapping, geo-data management, mineral and mining cadastre, mineral resource modelling, mineral resource visualization, mine planning, mine design, and mine management, but will also link the entire domain of mineral sector as an integrated system.

Sedimentology and biostratigraphy of the Paleocene Lockhart Limestone in the vicinity of Abbottabad, Khyber Pukhtunkhwa

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A total of 40 thin sections were made from 87 m-thick succession of the Paleocene Lockhart Limestone exposed at Dhudial area on Thandiani road, Abbottabad, to establish the microfacies, biostratigraphy and diagenetic alterations of the unit. The Limestone is well distributed throughout the Hazara Basin and is dominantly a carbonate succession that is bluish grey to dirty grey, planar bedded in lower part, thick-massive bedded in upper part with subtle nodularity, and sandy at places. The identified microfacies include; Mudstone, Bioclastic Wackestone, Foraminiferal Wacke-Packstone and Bioclastic-Lithoclastic Packstone microfacies with bioclasts and lithoclasts as dominant allochemical constituents. The bioclasts include foraminifers, mollusks, echinoderms, bryozoans, ostracods and algae, while the lithoclasts are comprised of quartz grains. The recognized benthic foraminifers are *Lockhartia conditii*, *Lockahrtia tipperi*, *Miscellanea miscella*, *Operculina*, *Discocyclina ranikotansis*, *Miliolids* and other uniserial, biserial and planktonic formaninifers. The Limestone has extensive diagenetic imprints that include compaction, cementation, microbial micritization, neomorphism, dolomitization, deep burial related pressure dissolution (stylolites) and tectonic deformational (fractures) features. Based on the textural and faunal assemblages, the limestone is interpreted to have been deposited on an open-shelf with occasional terrigenous input.

Lava effusion in Ziarat, Balochistan, Pakistan

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The geological and tectonic legacy of Balochistan has endowed it with massive mountain belts, arcs, syntaxes as characterized by severe bending of the mountain belts from the ongoing convergence of the Indo-Pakistan, Eurasian and Arabian plates. The Province is a seismically active and tectonically unstable region. The eruptive/effusive vent activity on 27th January 2010 at the Tor Zawar Mountain at Sari, Ziarat is a unique testimony substantiating the earlier risk/hazard findings for the area, as no previous post-Tertiary volcanic activity has ever been reported earlier in the history of the Indo-Pak subcontinent. Integrated geological, and geophysical surveys were undertaken during January-April 2010 to investigate the short lived toothpaste lava to map, detect, and delineate the changes resulting in the sub surface lithological and structural disposition at the vent site. A holistic approach is adopted for the interpretation and analyses of the total magnetic field intensity, electrical resistivity, and ground penetration radar surveys along with the geology, petrography and the geochemical analyses of the molten material, which are presented along with a probable model.

The synthesis of the magnetic, resistivity soundings, and profiling and ground penetration radar survey indicate the presence of highly magnetic dual lobe sources, resistive, and prominent reflectors from the radar soundings in and around the vent site. The resistivity pseudo sections delineate the lateral and vertical molten flows which have apparently solidified at shallow depth. The GPR mapping due to ideal ground conditions has optimum penetration with high definition reflector topography, internal scatterers and hyperbolas. The radar imaging explicitly shows folding of the overlying fine-grained clastics whereas fracturing in the compact, hard, and brittle rock units of compact gravels/limestone and volcanics due to the pressure exerted by the intrusion.

The geological map of the study area (latitude 30º 15´ to 30º 45´ longitude 67º 15´ to 67º 45´) characterizes the presence of older volcanic rocks which are remnants of past volcanic episodes. This makes it rather difficult to further resolve the present research findings that whether the subsurface discordant features/intrusive mapped are the result of solely the present day volcanic activity or the resultant effect incorporating both the older volcanics remelting and fusion with the present day ascending hydrothermal solution/magma. However, based on the present survey the lava effusion appears as an interactive play, and involvement of the older volcanics, ascending magma from depth and dual tectonic-magmatism generating the eruptive activity. The epicentral/focal locations, and migration of the past, and present events in the area strongly suggest the role of regional tectonics and a positive connectivity of the weaker Sibi re-entrant, Quetta-Kalat fault zone and the Quetta transverse zone.

Petrochemistry of Aghajari Formation sandstones in folded Zagros zone, Iran

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The petrographic and chemical analyses of 15 sandstone samples from the Upper Miocene-Pliocene Aghajari Formation of the folded Zagros zone, Iran, were carried out by the polarizing microscope and inductively coupled plasma mass spectrometer (ICP MS) respectively. The framework grains of the Aghajari Formation sandstones are rich in quartz followed by lithic grains and depleted in feldspar and mica (predominantly white mica). The sandstones are dominantly lithic-arenite and sublith-arenite in composition with abundant low-grade metamorphic and sedimentary lithics, low feldspars and no volcanic detritus. This suggests that the sands were derived from transitional and quartzose recycled orogen provinces. The Aghajari Formation sandstones have low to moderate SiO_2 contents (28.68–59.68%; on average 47.18%), while TiO_2, Al_2O_3, Fe_2O_3 + MgO and CaO have average amount of 0.25%, 4.85%, 2.2% and 27.19% respectively. The Aghajari Formation sandstones are generally enriched in CaO and depleted in Al_2O_3, Fe_2O_3 and Na_2O. The chemical index of weathering (CIW) values for the Upper Miocene- Pliocene Aghajari Formation sandstones vary from 76 to 85 with an average value of 82, indicating high weathering of the source areas. The geochemical characteristics suggest an active continental margin to passive margin setting for the Aghajari Formation sandstones, and preserve the signatures of a recycled provenance. The La/Sc (~2.31), Th/Sc (~0.56), La/Co (~1.03), Th/Co (~0.25), and Cr/Th (~64.84) ratios as well as chondrite-normalized REE patterns with flat HREE, LREE enrichment, and negative Eu anomalies indicate derivation of the Aghajri Formation sandstones from intermediate and felsic rock sources.

Sedimentology and sedimentary environments of terrigenous deposits of Aghajari Formation in southeast of Sarvestan, Fars Province (Folded Zagros, Iran)

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The Upper Miocene-Pliocene Aghajari Formation, also known as Upper Fars, extends throughout the Folded Zagros and is 2996 m thick at type section. For detailed lithofacies analysis, a 2266 m thick section was measured in SW of Sarvestan in the Fars Province. In this section, 17 lithofacies and 6 architectural elements were identified. The lithofacies were divided into a major group and a minor group. The major group consists of coarse-grained (Gh, Gp, Gt, Gcm and Gmg), medium-grained (Sh, Sp, St, Sl, Sm, Sr and Ss) and fine-grained (Fm, Fl and Fsm) lithofacies. The minor group contains evaporite and mixed clastic-carbonate lithofacies. The architectural elements identified are CH, GB, SB, LA, SG and FF). Based on these analyses, the Aghajari Formation in the studied section is interpreted to represent fluvial deposition marked by meandering ephemeral sandy river to sandy-gravelly meandering and gravelly meandering river. The evaporites and clastic-carbonate lithofacies contain fossils and are interpreted as playa and shoreface deposits respectively. The sedimentary structures include horizontal bedding, planar and trough cross beddings, load-casts, imbrications, fining-upward, burrows, scour, and fill and mud balls. The paleocurrent data in the studied area indicate NW-SE flow direction.

Correlation between petrographic characteristics and physico-mechanical properties of granitic rocks from the Utla area, Gadoon (Swabi), NW Pakistan

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Granitic rocks are widely used as dimension stone and construction material. However, the suitability of rocks for use in construction depends on their mechanical properties. The latter are in turn generally controlled by the petrographic characteristics including grain size, shape of grains, fabric (arrangement of mineral grains and degree of interlocking), type of contacts, mineralogical composition and the degree of weathering. The intrinsic properties of rocks, including mineralogy and texture, can be used to assess the engineering properties of stones.

A vast body of extensively exposed and readily accessible granitoids occurs around the Utla area of Gadoon, northwestern Pakistan. Samples representing different textural varieties of granitic rocks were collected. These rocks are petrographically divided into a) massive coarse grained (CG), b) fine grained (FG) and c) foliated coarse grained granites (CGF). Following a detailed petrographic examination, physico-mechanical properties including unconfined compressive strength, unconfined tensile strength, water absorption, specific gravity and porosity of the collected samples were determined. The average uniaxial compressive strength of all the three types of samples (CG = 45.98MPa, FG = 42.44MPa and CGF = 32.11MPa) falls in the range of those rocks which are designated as moderately strong. The measured porosity and water absorption capacities of both the massive and foliated varieties of the coarse grained granite are also within the range of values permissible for use as construction material.

The petrographic features and physico-mechanical properties are statistically analyzed to see a possible relationship between them. Among the three, the massive coarse grained variety yields the highest strength values most probably because of (i) greater variation in its grain size, (ii) lower abundance and non-alignment of micaceous minerals, and (iii) lower values of water absorption and porosity. These results reveal that a multitude of petrographic features including grain size, grain shape, grain size distribution, modal mineralogy and preferred orientation of grains collectively govern the physico-mechanical behavior of the studied rocks.

Water management perspective within watersheds: Experiences from Rawal watershed area

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Watersheds are critical for sustainable development and subsequent management of water based socio-economics at command areas. These not only control water supply volumes (runoff) but also qualities through their landuse systems. Bearing in mind the human inability of producing water to meet sectoral demands (agriculture, municipalities, industrial and ecological), the due respect is required for water effluent areas i.e. watersheds. However, due to anthropogenic reasons, the landuse systems within these areas are being changed at rapid rates and consequently leading towards increased inside demands for water. If water resources within these areas are not wisely utilized, there will be serious implications for downstream water users, where established water related demands would be challenged.

The water saving techniques/ technologies, so far have been mainly incorporated only in command areas while generally ignored for management of water cycle within watersheds. Watershed management traditionally remained limited to afforestation, forest conservation, construction of check dams and gabion netted structures only, but under changing landuse and increasing water demands both within and outside watershed areas, there is dire need to introduce and adapt various techniques, which has proven water saving potential. This is because each drop of water conserved/ saved within watersheds will remain available to command area users for ensuring food securities.

The Rawal Watershed area stretched between Islamabad and part of Punjab province is one such watershed whereby water management is being demonstrated through various appropriate water smart technologies on pilot scale. This paper highlights the application of selected water smart technologies in watersheds (e.g., pressurized irrigation systems, watercourse lining, raised bed farming, gravity fed drip irrigation etc.), so that water productivity can be enhanced and sustainable runoff can be promoted for downstream areas.

Biostratigraphy of the Patala Formation, Makarwal area, Surghar Range, northern Pakistan

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73 meters thick Patala Formation is well exposed in Makarrwal area with its sharp contacts with underlying Lockhart Limestone and overlying Nammal Formation. 30 samples were collected from bottom to top at equal intervals for the study of age diagnostic microfauna. 09 species of larger foraminifera were recorded including *Miscellanea miscella, Lockhartia haimei* and *Alveolina veredenburgi*. On the basis of the fauna recorded, the age of the Patala Formation in this area (according to modern Shallow Benthic Biozones) is SBZ 4-5 and boundary between SB-4 and SB-5 zones (between Thanetian and Ilerdian) is marked within Patala Formation at a level of 61 meters from its lower contact with Lockhart Limestone.

Economic potential of Jurassic to Eocene limestone deposits of District Abbottabad

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Limestone is a valuable and economic raw material widely used in the world for construction and other different industries; major uses being in construction and chemical industries. District Abbottabad has extensive deposits of limestone ranging in age from Jurassic to Eocene comprising of four different formations (Saman Suk, Kawagarh, Lockhart and Margalla Hill). These limestones have been evaluated on the basis of their mineralogy, chemistry and physical properties for their use for cement manufacturing, concrete and other chemical industries. Chemically, the studied limestones are compared with normal and argillaceous limestones. Most of the studied limestones have permissible amounts of SiO_2 to be used in various industries. Some of the samples have higher values of silica, but not as high as to be regarded as argillaceous limestones. Al_2O_3 and Fe_2O_3 are also within the permissible limits. Na_2O and K_2O are found only in traces. MgO is occasionally high at some places and its values are negligible to be considered for an impurity. The studied limestones of District Abbottabad are generally free of dolomitization and have no other deleterious substances. CaO is high in most of the studied limestones, except some samples from Lockhart limestone and Margalla Hill limestone. Mineralogically, the studied limestones are calcitic with varieties of grain sizes. Quartz is found in small amounts. Iron leaching is also noticed in some cases. Mechanically, the limestone deposits are evaluated for their potential uses in various industries like concrete, asphalt and roadstone etc. The results of all the tests performed are compared to those of ASTM standards. The average mechanical test results are hence within the ASTM limits. Generally, the studied limestone deposits of district Abbottabad are suitable for use in a number of industries.

Remote sensing based seismic site characterization using earthquake damage data

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Seismic site characterization maps are important for all stages of earthquake management, i.e. mitigation, preparedness, response and recovery. However, for many of the seismically active areas, seismic site characterization is rarely available, as it requires substantial investment in geological and geotechnical data acquisition and interpretation. This study evaluates a remote sensing based method to generate seismic site characterization map at 30 m spatial resolution. Geographic object based image analysis was applied to topographic attributes computed from an ASTER DEM to demarcate terrain units of mountains, piedmonts and basins. Classified terrain units were verified through a field based landform map resulting in an accuracy of 70%. To evaluate the importance of classified terrain units for seismic site characterization, and their role in earthquake induced building damage, the classified terrain units were compared with 2005 Kashmir earthquake damage data derived from field visits and SPOT-5 imagery. This shows that 81% of the less, moderate, and severe damage intensity zones correspond with mountains, piedmonts and basins, respectively. Classified terrain units were assigned VS^{30} to generate a seismic site characterization map. The methodology can be used for any land based seismic active region, to generate seismic site characterization maps at regional scale and use for earthquake damage prediction.

Damage assessment of flood affected mud houses in Pakistan

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The torrential floods 2010 in Pakistan played havoc with the people and property of Pakistan in general and of Khyber Phukhtunkhwa (KP) in particular. More than two million houses were damaged partly or totally. The most affected housing stock was mud houses, which were mostly collapsed leading to death of people and live stock. In this study, the damaged mud houses in flood affected areas have been analyzed and the major causes of the failure of such houses were documented on the basis of field study and observations. Some improvements have been suggested for reconstruction of mud houses on the basis of international and regional building codes and studies. It has been observed that if these improvements are incorporated in the construction of houses, the flood related damage can be minimized to greater extent. This can surely lead to the enhanced safety of people lives and property.

Lithofacies and palaeoenvironments of the Carboniferous-Permian Nilawahan Group, Salt Range Pakistan

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The sedimentological investigation of the Permian Nilawahan Group (i.e. Tobra, Dandot, Warchha and Sardhai formations) has helped in identifying 13 lithofacies; including three in the stratigraphically lowermost Tobra Formation, three in the overlying Dandot Formation and seven in the Warchha Sandstone. These lithofacies have been further grouped into three facies associations: 1. The glacial and glacio-fluvial facies associations of the Tobra Formation. 2. The tidally influenced shallow marine facies associations of the Dandot Formation and the fluvial channel bar and flood plain facies associations of the Warchha Sandstone. The uppermost Sardhai Formation represents recessive- profile, and is sporadically found in the Salt Range and due to the incompetent lithology, the unit is rarely exposed and hard to differentiate into lithofacies/facies associations at the present locations.

The lowermost of the Nilawahan Group succession i.e. the Tobra Formation represents glacial to glacio-fluvial depositional environment, which is overlain by deltaic and tidally influenced Dandot Formation. The arid fluvial condition is represented by the Warchha Formation and nearshore marine environment by the Sardhai Formation. The Sardhai Formation is overlain by the Zaluch Group carbonates. The Carboniferous-Permian succession of Pakistan thus represents the warming as a result of the demise of the Carboniferous-Permian glaciation and the northward drift of the southern Tethyan shore during Early and Middle Permian.

Fault-related dolomite fronts in the Aptian-Albian platform limestone (NW Spain): Implications on conceptual dolomite models

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Field characteristics, petrographic and geochemical signatures, as well as some petrophysical aspects of fault-related dolomite bodies in the Ranero area (Karrantza Valley, NW Spain) are studied. These dolomite bodies are hosted by Albian slope to platform carbonates, which were deposited in the Basque-Cantabrian Basin (Fig. 1). Replacive and void-filling dolomite phases – postdating palaeo- and hypogene-karstification are interpreted to have originated from hydrothermal fluid pulses, and are spatially related with faults and fractures. Hydrothermal calcite cements pre- and postdate dolomitization. Mineralogical and geochemical investigations (XRD, ICP-MS/AES, XRF, stable and Sr isotopes) helped in distinguishing various dolomite and calcite phases. Dolomite phases can be grouped into ferroan (early) and non-ferroan (late). Dolomites are generally stoichiometric and exhibit a broad range of depleted $\delta^{18}O$ values (-18.7 to -10.5‰ V-PDB), which advocate for multiphase dolomitization and/or recrystallization at relatively high temperatures (150-200°C). The observation that bed-parallel stylolites pre- and post-date dolomites suggests that dolomitization occurred during the Late Albian regional tectonic activity and related fluid expulsions. Based on carbonate chemistry, authigenic silicate chemistry and replacement relationships, two contrasting types of dolomitizing fluids are inferred. Both arguably may have initiated as sulphate-dominated brines and/or basin compactional fluids, but they seemingly undergo sulphate reduction in contact with host rocks of contrasting compositions (Fe-rich silicate vs Fe-poor carbonate) thus, evolving either to acidic and ferroan (limestone replacive) or to neutral, Fe-poor and sulfidic (Fe-dolomite replacive). Fluid drives are not well constrained by our data, but both fluid types are focused along major faults that cross cut the platform edge and are associated with diapir tectonics.

Fig. 1. Fault-related dark-grey colored dolomite bodies (indicated by arrows) in the light grey colored limestone.

Coal resources of Pakistan and their depositional environments

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Owing to the present energy crises in the world and particularly in Pakistan, the government and power generation sectors have shown keen interest in the indigenous coal resources for its utilization in the electric power generation, cements and other related industries. The development of coal will have an importance multiplier effect by creating a number of supporting industries, which will provide additional employment for skilled labour, income for the mining community and experience with new and modern technologies. Production of domestic coal will reduce the demand for imported fuels which drains an inordinate percentage of Pakistan scarce foreign exchange resources.

Coal deposits are extensively developed in Pakistan. It is found in all the four provinces of Pakistan, Azad Kashmir and Gilgit-Baltistan areas. In Sindh it occurs in Sonda, Lakhra, Thatta, Indus East, Badin, Meting Jhimpir, Jheruck-Ongar and Thar, which is one of the largest coalfields in the world. In Balochistan it is found in areas of Sor Range-Deghari, Sinjidi, Pir Ismail Ziarat, Khost-Shahrig-Harnai, Duki, Mach-Abegum, Johan, Kach and the recently developed coalfields of Chamalang-Bala Dhaka and Bahlol. Coal is also found in Punjab in areas of Makarwal and Salt Range. In Khyber Pakhtunkhawa coal is found in Hangu-Orakzai, Cherat, Gulakhel/Kurd-Sho, Shirani and Dara Adamkhel areas. In Azad Kashmir it is confined to the Kotli area. All these coals are young and Tertiary in age. Limited coal resources are also found in Reshit-Chapursun Valley of Gilgit-Baltistan areas and Bori Khel of Western Salt Range, Punjab. These coals are comparatively older and are confined to Jurassic and Permian in age respectively.

Coal from different areas of Pakistan generally ranges from lignite to high volatile bituminous. These coals are friable, with relatively high content of ash and sulphur. Pakistan has huge coal resources about 185 billion tones. Out of which 3.3 billion tones are proved and 11 billion tones are indicated reserves, the bulk of it (about 98%) is found in Sindh Province.

Stratigraphically, the coals of Pakistan are developed in different stratigraphic horizons. In Balochistan coal is developed in a single stratigraphic position i.e., Toi Formation of Chamalang (Ghazij) Group of Early Eocene, while in Sindh it is confined to two different stratigraphic position i.e., in the Bara Formation of Middle Paleocene and Sohnari member of Laki Formation of Early Eocene age. In Punjab coal is developed in three stratigraphic position i.e., Tobra Formation of Lower Permian in the Western Salt Range, Hangu Formation of Early Eocene in the Makarwal and Patala Formation of late Paleocene in the Eastern and Central Salt Range. In Khyber Pakhtunkhawa, Azad Kashmir and in the Reshit Chapursun (Gilgit-Baltistan) Valley coal is confined to the Hangu Formation (Early Paleocene), Patala Formation (Late Paleocene) and Ashtigar Formation (Jurassic) respectively.

Field, petrographic and other data show that these coals are generally thin and lenticular with prohibitively high sulphur and ash content which indicate that the major part of these coals are deposited in the near shore and marginal marine environments of deposition.

Viable use of rubber waste in concrete to reduce environmental pollution

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Solid waste management is one of the major challenges in the modern era. Solid domestic waste is dumped on low lying ground, and then it is burnt to reduce its volume to lengthen the life span of the dumpsite. However, these practices could be hazardous to environment; therefore, scientists have explored new ways to effectively manage these wastes. Tyre wastes have no exception; it can not be readily recycled or reused. They are dumped in open grounds round the world. In Pakistan they pose a bigger threat as they are burned, which results in emission of harmful gases in the atmosphere. So, it is necessary to reuse these rubber wastes to reduce environmental pollution. Rubber wastes can be used in concrete as a partial replacement of aggregates resulting in lightweight concrete. Using rubber waste in concrete enhances the impact resistance, thermal and sound insulation at affordable strength. This piece of article reviews the viable use of rubber waste in concrete industry to solve the problem of disposal of rubber waste.

Multipede microstructures of the Swat region of NW Himalaya: Tectonic witness of late E-W bulk crustal shortening

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In this study, we focused on the origin and tectonic significance of millipede inclusion trail microstructures preserved within garnet porphyroblasts of typical Barrovian-type schist from the Swat region of the Himalayas in Pakistan. Two possible kinematic models were assessed envisaging bulk coaxial shortening and progressive simple shear. Three D microstructural analysis of three samples hosting the millipedes reveals a poly-phase deformation history that produced three sub-orthogonal foliations (called Sx, Sy, Sz). Successive inclusion of Sx and Sy in garnet porphyroblasts produced two sets of millipedes with distinctive subvertical and subhorizontal orientations, respectively. This kinematic reconstruction is supported further with a numerical simulation using finite difference code of millipede formation in a spherical porphyroblast subjected to a superposition of two orthogonal shortening directions.

Measurements of inclusion-trail curvature axes or FIA (Foliation Intersection/Inflexion Axes in porphyroblasts) in 61 additional samples from the study area, which contain straight, sigmoidal or spiral inclusion trails, reflect two principle orogenic episodes. During the first episode, FIAs developed with WNW-ESE (set 1) and E-W (set 2) trends associated with thrusting and collision tectonics. A younger FIA (set 3) with NNE-SSW trend developed as a result of subsequent bulk E-W crustal shortening and associated regional-scale folding. Sigmoidal or straight inclusion trails defining this FIA set can be correlated with the millipede microstructures based on their similar trends and timing relative to matrix fabrics. These results are consistent with the meso- and macro-scale structures in the region and significant in terms of establishing relative timing of formation of different structures in the region. Well developed preferred vertical and horizontal orientations of both sigmoidal and millipede inclusion trails imply that their development involved limited or no relative rotations between porphyroblasts. Sigmoidal trails formed in zones where bulk shearing caused progressively reoriented matrix foliations around stable garnets, while millipedes formed simultaneously in local coaxial-strain pods.

Pseudosection-derived *P-T* estimates for Saidu, Kashala, Marghazar and Manglaur formations, Swat area, NW Himalayas

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Conventionally, the *P-T* estimation or geothermobarometry is based on well-calibrated geo-thermometers and geo-barometers with specified assumptions. For example, envisaging the garnet-biotite thermometer, both of these minerals are required to be in contact to assume Fe-Mg exchange reaction having occurred (DiPietro, 1991). If unable to find such an assemblage in a rock mass, then this technique fails. A relatively new technique, namely, *P-T* pseudosection is making more space in the literature due to its robustness and elimination of the assumptions that are commonly made in the conventional techniques coupled with the introduction of the Rayleigh Fractionation method for determination of the effective bulk rock composition at different growth stages of porphyroblasts and hence the accompanying metamorphism (Evans, 2004).

A *P-T* pseudosection is a mean of retrospection of the conditions of metamorphism that a rock records through time. It is a map of stable mineral assemblages which nucleate during metamorphism in a *P-T* space (Sayab, 2006; White et al. 2008). It is based on a fixed bulk rock XRF composition of a given rock sample. In this study, we constructed *P-T* pseudosections of the representative key samples from different formations including, Z53 from the Marghazar formation, Z23 from the Manglaur formation, Z8/Z12 from the Kashala formation and M22 from the Saidu formation. The latest version of THEMOCALC (ver. 3.33; Powell and Holland, 1988; updated 26 October 2009) with an internally consistent data set of Holland and Powell (1998; data set tcds55, updated 22 November 2003) was used. The pseudosections are modelled in the chemical system (MnO-Na_2O-CaO-K_2O-FeO-MgO-Al_2O_3-SiO_2-H_2O) MnNCKFMASH. Garnet intersecting composition isopleths (X_{Fe}, X_{Mn}, X_{Ca}) are used for geothermobarometry which are based on the electron microprobe (EPMA) analysis from the garnetcore, inner core and rim regions and plotted in divariant fields using THERMOCALC. In addition, the average thermobarometry calculations for samples Z12 and Z61 are conducted using the average *P-T* mode of THERMOCLAC (Powell and Holland, 1994).

For sample Z53, the garnet core is estimated to have grown at 6.3–6.7 kbar/535–540°C.The garnet core compositional isopleths in samples M22 intersect at 4.6–4.9 kbar/507–513°C. Intersection of compositional isopleths for sample Z23 from core, median and rim regions correspond well with respect to mineral assemblage in garnet and pseudosection stability fields. The garnet core isopleths (X_{Mn}, X_{Fe}, X_{Ca}) uniquely interest in the Grt-Bt-Pl-Chl field at 4.0–4.2 kbar/495–500°C. The garnet median region isopleths intersect in Grt-Bt-Pl-Chl-Zo field at 5.3-5.8 kbar/522–526°C, in agreement with the appearance of zoisite inclusions in this region. *P-T* pseudosection for sample Z8 exhibit narrow stability fields as compared to other pseudosections and this may be due to the presence of a variety of metamorphic mineral assemblage including garnet, zoisite,staurolite, kyanite and rutile. For sample Z8, the garnet core composition isopleths intersect at 5.4-6.8 kbar/543-570^{o}C in Grt-St-Pl-Chl, Grt-St-Pl-Chl-Zo and Grt-St-Chl-Zo fields. The relationship of three (X_{Mn}, X_{Fe}, X_{Ca}) intersection isopleths with these fields is in excellent agreement, where staurolite and zoisite inclusions are present in the garnet. The *P-T* conditions of matrix minerals along with garnet rim yielded 9.2±1.4 kbar/595±19^{o}C with 2σ errors, and are acceptably consistent with the observed mineral assemblage (Grt-Zo-St-Ky-Chl).For sample Z12, the calculation by THERMOCALC of the *P-T* conditions using the composition of garnet rim and the matrix minerals average 10±0.8 kbar/618±28^{o}C with 2σ errors. Average *P-T* conditions for sample Z61 revealed 8.6 ± 2.0 kbars/ 747±32 ^{o}C based on the garnet rim along with K-feldspar, muscovite and biotitegeothermobarometry.

The results are interesting, firstly because garnet isopleths fall in the stability field of modelledmineral assemblages which are also observed under the microscope. Secondly, the samples host two sets of garnet porphyroblasts with truncated and continuous inclusion trails with respect to the matrix. Garnet isopleths geothermobarometry reveal initially an isothermal increase in pressure (in samples hosting porphyroblasts with truncated trails) followed by further increase in pressure and temperature (in samples with porphyroblasts with continuous trails) eventually culminating at the peak of metamorphism. This *P-T* history suggests progressive burial due to subduction as a result of continued plate convergence. The *P-T* trajectory recorded by sample Z61 is dramatic and points to the phase of decompression with further rise in temperature but a slight drop in pressure. This decompression seems to be associated with the extension due to the reactivation of Main Mantle Thrust (MMT) as a north-directed normal faultfollowing crustal over-thickening as recorded by the sigma type K-feldspar porphyroclasts/blasts showing north-side-down shear sense (Shah et al. 2011).

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Post Flood Drinking Water quality Assessment of Charsadda District Using GIT's

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Flooding is a regular event in the areas of Khyber Pakhtunkhwa settled along the banks of River Kabul. The Northern parts of Pakistan remained victim of heavy summer monsoon rains from 22 July 2010 to 27th August 2010. In 2010, monsoon system showed a drastic shift and resulted in heavy rainfalls that caused mega floods in Kabul River. This research focused on analyzing water quality after flood disaster in the densely populated district Charsadda. An integrated Remote sensing and GIS study proves to be an essential tool to evaluate and quantify the impacts of land use / land cover on ground water quality. Spatial distribution maps of various pollution parameters were used to demarcate locational distribution of water pollutants in a comprehensive manner. The process of pollution risk assessment requires assimilation of data that were spatially variable in nature, making geographical information systems (GIS) an ideal tool for such assessments. Raster and vector-based data were used within a GIS framework to produce maps indicating areas of potential hazard to water quality and coupled with existing models to predict and quantify risk frequency and impact.

Water samples were collected from the wells of flooded area in Charsadda, lab tests were performed and water quality parameters were checked against World Health Organization (WHO) standards. Water Quality Index was calculated and Department of Environment (DOE) classification was done showing the water quality. Water Quality Index calculated for the chemical and biological parameters revealed that after flood rating of pH, TSS and chlorides have been detoriated where as TDS, alkalinity and sodium shows an improve condition. Other parameters such as conductivity, hardness, sulphates, potassium, nitrite, Total plate count and Coliform bacteria shows the same quality of water. After DOE classification the water is classified showing almost the same quality rating as in WQI except sulphate quality was detoriated and chlorides remain in the same class. If the water quality of Charsadda was compared with the WHO standards then according to TSS, conductivity, total plate count and Coliform bacteria its unfit for drinking. The major contamination in the water was found through the biological parameters which shows a very high value and should be considered for further human consumption.

GeoEye-1 imagery was used to detect flood inundated area. Samples were overlayed on imagery to identify and classify water affected area. Finally maps were drawn to show the water quality and flood effected area in Charsadda district.

Geospatial site suitability of medicinal plants in Chang Mai province, Thailand

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Medicinal plants play an important role in the health care of people around the world, especially in developing countries. The demand for Medicinal plants will continue to increase in developing and industrialized countries because of population growth and awareness about the benefits of natural products to provide economical, safe and effective alternatives to expensive industrially synthesized drugs. Information should be produced on the soil and environmental conditions to which they are adapted, systems in which they can be grown, nutrient management, harvest techniques and processing. Attention should also be given to the potential danger of pests and diseases cropping up with intensive cultivation of medicinal plants.

For the suitable sites multiple parameters need to be considered. The specific criterion taken for this research was soil drainage, soil texture, soil pH, humidity, temperature, rainfall, slope and digital elevation model. Chiang Mai Province was chosen the study area because of its diversity of forests and capacity to grow many medicinal plants. The Remote Sensing and GIS was applied as a technical method for better visualization and interpretation of suitable sites for selected medicinal plants. The medicinal plants selected were of great importance because of their medicinal use. The knowledge of all those medicinal plants was acquired from the local community. Also the expert knowledge was incorporates in the GIS model by the Analytical Hierarchy Process. Both of the interaction shows their interests in the present research.

The Suitability analysis shows some surprising results. Like 90% of the province was found suitable for Turmeric Plant where as for basil plants and Aloe Vera plants 31.19 % and 31.57 % area were the calculated suitability in Chiang Mai Province. Macadamia Nuts plant suitability was found to be 44.97% of total area and 42.72% for Green Tea Plant. The Chiang Mai Province is found to be potentially suitable for all these plants and can generate good GDP if it is planned in the future.

Late Cretaceous mantle plume activity in Ceno-Tethys: Evidenced by intra-plate volcanism in the Naik Area, Balochistan, Pakistan

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Basaltic pillow lavas near the Naik village in Balochistan are found in the tectonic slivers of the Bagh complex in the north of the Muslim Bagh ophiolite complex (Fig. 1). Two lenticular bodies of porphyritic and amygdaloidal basalt are found intercalated within the Hyaloclastite mudstone units of the Bagh complex (Siddiqui et al., 1996). The K-Ar ages of the volcanic rocks included in the Hyaloclastite-mudstone unit is about 81 Ma (Sawada et al., 1995). The lower basaltic flow is pillowed (30 cm to 1 m in diameter). The size of the pillow lava body is 30x300 m. The upper body of basaltic flow is massive in nature and 15x150 m in size.

The volcanics are amygdaloidal in nature and exhibit porphyritic, cumulophyric and intergranular textures. Their principal constituents include titaniferous augite, aegirine augite, hornblende, phlogopite, plagioclase (An_{37-88}), devitrified volcnic glass, noseam and olivine. Wide range of anorthite contents in the plagioclase is due to albitization. Apatite ilmenite magnetite and hematite occur as accessories and chlorite, calcite, stilbite, antigorite and clay are secondary. The volcanics are mainly basanites and tephrites, mildly to strongly alkaline, and akin to the intra-plate volcanic rock series. Low Mg # and low Cr, Ni and Co contents of the analyzed rocks suggest that the parent magma of the volcanics was not directly derived from a mantle source, but resulted from fractionation in an upper level magma chamber, en-route to eruption. Their LILE and HFSE, enriched primordial mantle-normalized patterns with marked positive Nb anomalies confirm their within-plate geochemical signatures and extraction from an enriched mantle source. The Zr versus Zr/Y relations suggest that the volcanics were derived from 10-15% melting of an enriched mantle source. It is suggested that these Late Cretaceous intra-plate volcanics may be related to the mantle plume activity of the Reunion hotspot, and were erupted during the passage of Ceno-Tethys ocean floor prior to the passage of the Indian plate over it.

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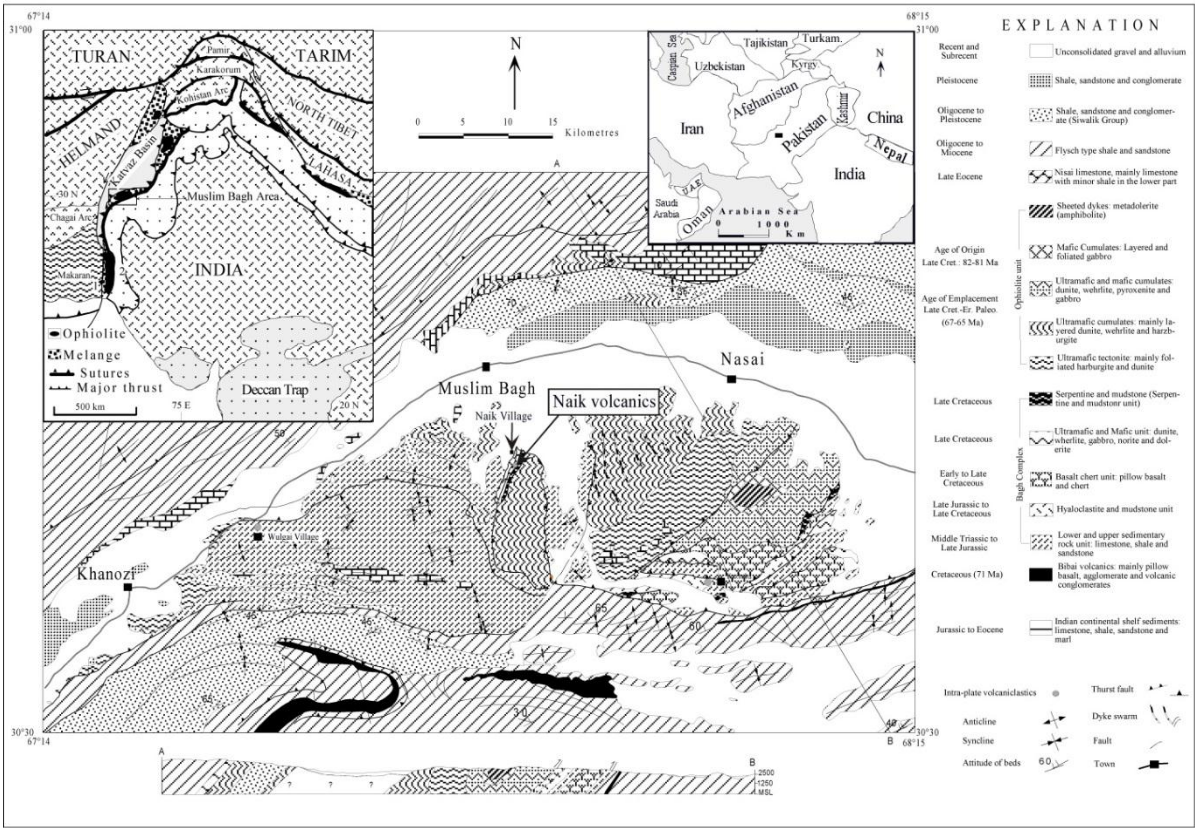

Fig. 1. Geological map of the Muslim Bagh area showing the location of the Naik volcanics, Balochistan, Pakistan (modified and reproduced after Siddiqui et al., 2011).

Preliminary study of the rocks of Golo Das and surrounding areas, Gilgit-Baltistan, Pakistan in the perspective of gold and base metals mineralization

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The study area, covering Golo Das and surrounding areas, is a part of Ghizar district in Gilgit-Baltistan province, Pakistan. Geologically the study area is located at the northern margin of Kohistan island arc adjacent to the Shyok Suture Zone / Main Karakorum thrust and is mainly composed of the rocks of Shamran / Teru volcanics, Chalt volcanic group and meta-sediments intruded by Kohistan batholiths. Field studies show that the Chalt volcanics are green in color, highly foliated and sheared rocks with intensive quartz veining along the shear zones. At some places these veins contain sulfide bearing phases, especially pyrite in higher amount. The Shamran / Teru volcanics are fine-grained, green to greyish-green colored compact rocks. Sulfide mineralization in the form of chalcopyrite, tetrahedrite and pyrite is noticed along shear zones and in the vicinity of thick marbalized beds and silicified alteration zones within the Shamran / Teru volcanics. The leaching of these sulfides into malachite and azurite is very common. At certain places pods like iron ore, containing magnetite, limonite and specularite, were also found in the vicinity of the marbalized and silicified alteration zones. The dioritic intrusions, a part of the Kohistan batholiths, are well exposed in the area and exhibit chilling effects in contact with the Shamran / Teru volcanics.

Bulk samples (>10 kg) were collected from the fresh rocks and altered/sulfide zones for laboratory investigations. These samples were crushed through jaw crusher and then pulverized to -200 mesh size by the tungsten carbide ball mill. Representative portion of the sample was treated with aqua regia ($3HCL:1HNO_3$) for base and other metals (i.e., Ag, Cu, Pb, Zn, Cr, Ni, Co, Cd) while the gold (Au) was extracted in the methyle isobutyle ketone (MIBK). The concentrations of Au, Ag and other metals were determined by Perkin Elmer 700 electrothermal atomic absorption spectrometer . Au is ranging from 3ppb to 112ppb, Ag from <0.1ppm to 3ppm, Cu <1ppm to 3496ppm, Zn from <0.1ppm to 50ppm, Pb from >1ppm to 7ppm, Ni from <1ppm to 48ppm, Cr from <1 to 182ppm, Co from 3ppm to 56ppm and Cd from 1ppm to 6ppm. The field and geochemical studies suggest that the alteration/sulfide zones in the study area have possible potential for the occurrence of gold. Detailed study of these alteration zones and other rocks in the area is in the process to get information about the genesis of mineralization.

Physico-chemical and heavy metal concentration in the drinking water of Narangi and surrounding areas of District Swabi, Pakistan

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Contaminated drinking water is being the cause of many health problems in different parts of the world. This has affected human health with serious diseases such as lungs cancer, skin cancer, kidney problems and also respiratory problems. This study was conducted to find out the quality of water in Narangi and its surrounding areas (Permoli, Merali and Sherdara), where the main sources of drinking water are dug wells, tube wells, hand pumps and springs. Representative water samples were collected from different sources in the study area in order to determine the physico-chemical parameters and heavy metal concentrations. Physical parameters such as pH (6.1-7.4), EC (90.2-585 µs/cm), TDS (47.0-307 mg/L), Turbidity (0.10-100 NTU), and temperature (18-24 ˚C) were determined with the help of electro chemical analyzer. While anions nitrates (0.4 – 12.5 mg/L), nitrite (4 – 48 mg/L), sulfate (5 – 88 mg/L), phosphate (0.18-1.45 mg/L), and chloride (0.5-32.5 mg/L)were determined with the help of DR2800 spectrophotometer. Heavy metals, Cu (0.17 – 70.7), Ni (<0.05 – 11.15), Cd (<0.05 – 2.39), Co (<0.05 – 0.78), Cr (<0.05 – 9.43), Zn (<0.05 – 2897), Pb (<0.05 – 30.66), Mn (<0.05 – 19) and Fe (<0.05 – 188) in µg/L were determined using atomic absorption spectrometer AAnalyst-700. The values of different parameters of water from different sources indicated that all the physical parameters, anions and heavy metal concentrations were within the permissible limits set by WHO(2004). On the basis of findings it is concluded that drinking water of Permoli, Mirali, Sherdara, and Narangi areas have low concentrations of physical parameters, anions and heavy metals. Therefore, no health related hazard, concerning the studied parameters in drinking water, can be envisaged.

Mathematical modeling of oil field, exploited under solution gas drive

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Oil and gas Industry plays an important role in economic development of a modern society. Main task for our country is to develop its petroleum economics. Discovery of new oilfields in Pakistan need significant capital investment, for drilling and exploration on land and offshore areas. Therefore application of new technology is important to stabilize and enhance petroleum production from pre-existing oil fields. Different forecasting methods of oil exploitation are used in today's upstream oil industry business. In the presented paper a mathematical model was developed and tested for short term forecasting of oil and gas production. Subsurface oil can be exploited on different oil drives, which mainly include: solution /dissolved gas oil drive, water drive, gas cap drive, gravity drive and combination drive. Field geological characteristics of Pakistani and Ukrainian oil fields, for devised model, were studied and production data was analyzed on computer for different oil drives. In presented model pre-existing production data of Khaskheli oil field (Baden, Pakistan) and Papeli oil field (Ukraine) was used. We proved for the first time, existence of linear relationship between cumulative volume of oil production (ΣQ_o) along Y-axis and logarithm of cumulative gas production ($\ln\Sigma Q_g$) along X-axis, at certain time interval, for oil fields exploited at solution gas drive. This simple model is based on five to ten years oil and gas past production history. Future oil and gas production for next few years can be forecasted by simply extending pre-existing straight line further as dashed line, which will give us forecasted values for ΣQ_o and $\ln\Sigma Q_g$ on Y and X coordinates. The model was tested on Khaskheli (Pakistan) and Papeli (Ukraine) oil fields. Constructed model was found applicable, with greater accuracy, for oil fields, exploited under dissolved gas drive.

Structural geology of Sulaiman ranges around Mughal Kot village, FR D.I. Khan, Pakistan

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The current research complies to describe the structural geology of the eastern part of the Sulaiman Range in the vicinity of the Mughal Kot area, F.R., D.I. Khan, Khyber Pakhtunkhwa Pakistan. The studied area is covered by the Geological Survey of Pakistan toposheets No. 39 ½ and 39 ⅓. Tectonically, the study area is deformed due to counter-clockwise rotation of the India since 55 Ma ago and caused the closure of smaller basins, i.e. the Seistan and Katawaz basins, convergence in Baluchistan region, and collision of various crustal blocks in Iran and Afghanistan that led to the formation of fold and thrust belts including the Sulaiman Range. The western transform border of Indo-Pakistan plate is separated from eastern, and central Afghanistan by major strike-slip faults which are still active and have led to the progressive displacement of the blocks relative to each other. The northern limit of the Sulaiman fold belt lies in the tribal areas of Waziristan Agency, where these rocks plunge into the rocks of the Kohat Plateau and the Waziristan tribal area that is located to the southwest of the Indo-Pakistan Craton near the junction of the western ophiolite belt. The greater width of the Sulaiman range suggests that it is a thin-skinned structure thrusted southwards on a weak decollement above a low-angle, northwestwards dipping basement. Bouger and isostatic gravity anomalies suggest that the 250 Km wide fold and thrust belt is underlain by a15-25 Km thick, extended transitional crust.

The rocks exposed in study area range from late Jurassic to Plio-Pleistocene, influenced by transpressional deformation due to oblique collision of the Indian plate with the Afghan block during Paleocene. The Sulaiman fold and thrust belt has developed due to transpression tectonics caused by the left lateral strike-slip motion along the Chaman Fault Zone, which marks the boundary between the Afghan block and the northwestern margin of the Indian plate. The structural fabric of the area is mostly controlled by N-S trending Chaudwan and Domanda fault system. Being located in the vicinity of the Sulaiman range, the study area is influenced by the Takht-e-Sulaiman ranges strike-slip fault that trends north-south. The promising features of the area are represented by the Drazinda Syncline and Domanda Anticline, which are broad and large-scale folds in en-echelon fashion. The trend of these folds is northeast-southwest which indicates a general northwest-southeast compression.

During the current field investigation two small-scale faults have been mapped which are associated with major structures such as Domanda Anticline. In the central part of Domanda

Anticline, a north-south trending back-thrust is present along which Ghazij Shale is thrust over the younger Eocene sediments in the west. Another small-scale fault is mapped within the south-western closure of Domanda Anticline along which Habib Rahi Limestone is thrust over the Domanda Shale in the west.

Preliminary report on the newly discovered phosphate deposits of Soban Gali, Paswal Mian and Banseri areas, District Abbottabad, Khyber Pakhtunkhwa

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Hazara area is well known for the phosphate mineralization having the economical deposits. The discovery of phosphate in Hazara area has opened new vistas for the fertilizer industry to use the indigenous phosphate rock and save the valuable foreign exchange. The newly discovered phosphate deposits of Soban Gali, Paswal Mian, Banseri and surrounding areas are situated north of Abbottabad on the Abbottabad-Sherwan road at a distance of about 25 km. The mineralization is restricted to early Cambrian rock units of Abbottabad and Hazira/Galdanian Formations. The phosphate beds are thick to thin and are associated with Cherts at most of the places. In Abbottabad the phosphate is found at the basal part of the dolomite member of the Abbottabad formation. The phosphate deposits found in the Soban Gali, Paswal Mian and Banseri areas are comparatively new. The mineralization has occurred quite close to the contact of the dolomite and quartzite member of the Abbottabad formation. The largest phosphate deposits occur in Soban Gali and Benseri areas. The P_2O_5 percentage ranges from 25-40 in the Ilyas mine and Banseri mine areas. The phosphate is light grey to reddish and white in color, dense, heavy and hard. It follows thick dolomite beds for hundred of meters and is locally mined by non-technical methods. Detailed geological survey for reserved estimation and modern techniques for mining is required.

Hydrocarbon prospects and reserves in Salt Range/Potwar Plateau

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Hydrocarbons are being explored in the Salt Range and Potwar Plateau (SRPP), the Himalayan foreland in North Pakistan, since more than a hundred years. The exploration for hydrocarbons and geological mapping over the time has generated tremendous amount of surface geology and subsurface borehole and seismic reflection data which has been interpreted recently through several publications. We have used this data for delineation of structural geometry of oil-fields and their characterization in the SRPP. In general, the prospects are interpreted as thin-skinned structures over a decollement, developed as fault-related anticlines. Eleven oil fields are structurally classified and characterized as 2 detachment folds, 2 fault-propagation folds, 5 pop-up structures, and a triangle zone. Subsequently, information regarding hydrocarbon production and recoverable reserves are analyzed and compared with the structural styles to assess the petroleum potential of particular prospects. Accordingly, 44, 46, 08, and 44 million US barrels of oil has been produced till 1995 from the structures listed above respectively. Whereas, the balance recoverable reserves are estimated as 6, 016, 15, and 7 US billion barrels respectively. The analysis has helped us understand the structural styles of oil-fields as fault-related structures over blind thrusts and show the triangle zone, as the most prolific prospect so far, in the SR/PP.

Monitoring magnitude and direction of movement in landslides with optical remote sensing.

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Landslides are a widespread natural hazard. Remote sensing is these days used to detect landslide locations, by visual interpretation or semi-automated analysis of multi-temporal images. Instead of only being able to sense the status quo, a continuous monitoring of movement would greatly add to knowledge on landslides and help risk assessment in landslide prone areas.

In this paper, we aim to not only detect landslides, but also monitor its movement over time. We first assess the capabilities of the adopted methodology to detect motion and provide an overview of what level of detail can be detected, and what imagery (high spatial resolution or high temporal resolution) is needed to do so.

For the application we focused on landslides in Kashmir (Pakistan) and on the Koyulhisar landslides in the North Anatolian Fault Zone (Turkey). We used sub-pixel correlation of optical ASTER and Quickbird imagery to detect spatial shift of pixels. These observations were linked with elevation data to evaluate the sense of direction obtained by remote sensing. Observations from the field (Pakistan) as well as GPS data were in addition used to validate magnitude and direction of movement.

Disaster risk management in Pakistan before and after the 2005 earthquake

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Pakistan is a disaster prone country and poor risk management made it more vulnerable to a wide range of hazards including, avalanches, cyclones/storms, earthquakes, floods, glacial lake outbursts, landslides, river erosion and tsunami.

The 8th October 2005 earthquake in Pakistan found the country totally unprepared. The epicenter of this 7.6 magnitude earthquake was near the Muzaffarabad and tremors were felt in cities like Kabul and Delhi. Almost half of the homes in Muzaffarabad were destroyed; North West Frontier Province (NWFP) was hit very badly. Reports indicated a death toll of more than 70 thousands and almost 50 thousand people injured during this strongest earthquake in the region. The shallowness of the earthquake (10 km focal depth) and frequent aftershocks contributed significantly to the destruction.

This earthquake led the government to completely rethink their disasters management strategy. This work is an effort to discuss the vulnerability of communities in Pakistan and the factors leading towards the susceptibility to natural disasters. We have tried to portray the natural and non-natural factors which influence disaster vulnerability, to describe the stance of Pakistani government during natural disasters occurred in the past and proposed what necessarily steps should be taken by the government to minimize the risk imposed by the natural disasters.

Preliminary studies of heavy minerals and exploration of placer gold in the Siwaliks sandstone of Karak anticline and adjoining areas Karak, Khyber Pakhtunkhwa

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Karak anticline is a well exposed geological structure which is located in the south east of Karak city in the province of Khyber Pakhtunkhwa (KPK). It starts from Karak city in the north and extends upto Banghar syncline in the south. The northern and southern limbs of Karak anticline are bounded by Mitta Khel fault and Banghar syncline, respectively. Karak anticline and its adjoining areas are generally composed of Chinji, Nagri, Dhok Pathan and Soan Formations of the Siwalik Group. However, Nagri and Dhok Pathan formations are dominantly exposed in the study area. These formations consist of sandstone, shale and conglomerates of clastic sediments of molasse and placer type.

The area has been investigated for the first time for exploration of heavy minerals, gold, silver and base metals. The samples collected from these formations were crushed to sand size and then treated with shaking table to separate concentrates, middlings and tails. The concentrates and were further investigated for heavy minerals, gold, silver and base metals. In Chinji, Nagri, Dhok Pathan and Soan Formations, the heavy minerals, identified with the help of binocular microscope are mainly zircon, garnet, tourmaline, apatite, epidote, hornblende and tremolite. The heavy minerals are present in variable amount in Chinji, Nagri, Dhok Pathan and Soan Formations. The concentrates, middlings and tails were pulverized to -200 mesh size by the tungsten carbide ball mill. Representative portion of each sample of concentrates, middlings and tails was treated with aqua regia and other acid mixture and the solutions were analyzed for Au, Ag and base metals (Cu, Zn, Pb, Cr, Ni, Co, Mn and Cd) by atomic absorption spectrometer in the geochemistry laboratory of NCE in Geology, University of Peshawar. The concentration of gold ranging from <0.1 to 11.5ppm, Cu from 0.5 to 225ppm, Co from 5.2 to 110ppm, Zn from 9.1 to 120.4ppm, Cd from 2.2 to 16.4ppm, Pb from 2.4 to 110.4ppm, Ag from 0.5 to 47.8ppm, Mn from 57.8 to 736ppm, Ni from 0.8 to 176ppm and Cr from 26.0 to 555.5ppm. The present study, therefore, suggest that the Karak anticline has the potential for economic concentration of heavy minerals, especially zircon, gold and silver.

Distribution and hydrocarbon potential of Datta sands in Upper Indus Basin, Pakistan

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In Dhulian field, main targets were Ranikot and Lockhart formations, deeper drilled wells to Datta Formation may give more prospects because Datta is proven reservoir in the area. Although in Khaur field, Sakesser was main target it may deeper to Datta as targeted reservoir may give more prospects.While in Pariwali and Meyal fields no reservoir test have been taken for Datta Formation so it is suggested that if Datta Formation is considered as reservoir for above fields may enhanced reserves.

It is suggested that identified structures will drilled up to Datta Formation as targeted reservoir around the production fields of Western Potwar.

Grading of Bentonite of some quarries in Pakistan

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Bentonite is a well known material being used as drilling mud and seepage control barrier in water retaining structures around the world. Pakistan has large and abundant reservoirs of bentonite clay suitable for their various industrial applications. Here the performance of bentonite clays from different areas of Pakistan is evaluated and compared with imported clays parameters like, Liquid Limit and free swelling are selected to evaluate local bentonite. Carboxymethyl Cellulose (CMC) and Soda Ash (SA) were used as additives to enhance the properties of local bentonites and bring them at par with imported bentonite used commercially. The liquid limit and free swelling percentages of the local bentonite improved almost 50 percent at a control pH. Nine percent addition of CMC to Jhelum's bentonite improved liquid limit and free swelling to their optimum values. Similarly bentonite from Attock also showed their optimum values at 12 percent addition of CMC at a control value of pH. The Jhelum, Attock, and Jundola bentonite showed better results on Soda Ash addition. Bentonite from these three locations can be beneficially used for drilling as well as leakage control when CMC and Soda Ash are used as additives in specified percentages.